18th European Conference on Composite Materials (ECCM-18)

Athens, Greece
25 - 28 June 2018

Volume 1 of 8

ISBN: 978-1-5108-9693-2

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Red Hook, NY 12571

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Applied Mechanics Laboratory
Department of Mechanical and Aeronautical Engineering
Engineering School, University of Patras
Building 2
Patras University Campus
Rio, Patras, 265 00, Greece

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08:00

Secretariat opens

08:25-08:50 Hall: **Trianti**

Opening Ceremony

08:50-09:50 Hall: **Trianti**

Plenary Lecture 1

Chair: **T.-W. Chou**

Composite Materials – where we are and where to go
Karl Schulte

09:50-10:35 Hall: **Trianti**

Keynote Lecture 1

Chair: **V. Kostopoulos**

Nanocarbon fabrics for energy storage in structural composites
Juan Jose Vilatela

09:50-10:35 Hall: **Mitropoulos**

Keynote Lecture 2

Chair: **K. Schulte**

In-process Monitoring and Quality Assurance of Aerospace Composites
Nobuo Takeda

10:35-11:00 Hall: **Exhibition Area**

Coffee Break

11:00-13:00 Hall: **Trianti**

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level

Chairs: **K. Kose, S. Pinho**

3.10-01 Characterising Voids and Wrinkles in Curved Carbon Fibre Reinforced Polymer Parts using μ-CT and Optical Microscopy
A. Ramesh, M. Battley, T. Allen (University of Auckland, New Zealand), C. Hickey (R&D and Design, New Zealand)
Two techniques were developed to characterise defects in composites. The first method utilises μ-CT scans and determines geometric features of voids. The second method analyses micrographs to identify the edges of the plies within a laminate and characterises their wrinkle geometry.

3.10-02 Assessment of Failure Modes in Compression Loaded Laminates using Quasi In Situ Computerized Tomography Scans
J. J. A. D'haen, S. Kerscher (BMW AG, Germany), M. May, S. Hiermaier (Fraunhofer Institute for High-Speed Dynamics, Germany)
This research will investigate the failure evolution for a [45,-45,0]s stacking sequences using sequential computerized tomography scans. It is seen from results that the proposed methodology works well to investigate failure evolution. Furthermore, it is seen that the failure growth is repeatable for specimen with the same layup.

3.10-03 Experimental Characterisation of Macro-Crack Propagation in 3D Woven Composites, Size Effect and Associated Damage Gradient Models
V. Médeau (Université Paris Saclay & Safran Aircraft Engines & ISAE-SUPAERO, France), F. Laurin, J. Rannou, A. Hurmane (Université Paris Saclay, France), S. Mousillat (Safran Aircraft Engines, France), F. Lachaud (ISAE-SUPAERO, France)
The critical energy release rate G_C was identified on 3D woven carbon/epoxy composites, using CT and SENB specimens. The analysis relied on multiple instrumentation methods to monitor the crack growth and compared several methods for the crack detection and G_C estimation in order to obtain a robust process. (Cntd)

3.10-04 Detection of Crack Initiation for Fracture Toughness Evaluation of Thermoset and Thermoplastic Fibre-Reinforced Materials
M. G. R. Sause, M. Greisel, N. Schorer (University of Augsburg, Germany)
We compare the mode I and mode II fracture toughness values from data reduction of ASTM D 5528 and ASTM D 7905 to results obtained by acoustic emission measurements and digital image correlation analysis. For brittle and ductile materials, the acoustic emission onset values act as most relevant values.

3.10-05 Mode I Intralaminar Fracture Toughness Of 2D Woven Carbon Fibre Reinforced Composites: Pre-Crack Tip Radius Sensitivity
D. Dalli, G. Catalanotti, B. G. Falzon (Queen's University Belfast, United Kingdom)
An investigation of the pre-crack tip geometry sensitivity of Double Edge Notch Tension specimens used to determine the mode I intralaminar fracture toughness of 2D woven carbon fibre reinforced composites, using the size effect method

3.10-06 Experimental Verification of the Damage Model of Orthotropic Composite Materials under Multiaxial Loading
P. A. Dodonov, N. N. Fedonyuk (The Krylov State Research Centre, Russia)
This paper analyses test data for a layered polymeric composite material under combined loading. The tests were performed as per Arcan test principle. The materials tested in this study were based on glass- and carbon non crimp fabrics (NCF) with orthogonal fibers and vinyl-ether binder, (Cntd)

11:00-13:00 Hall: Mitropoulos

3.13 | Material and Structural Behavior – Simulation and Testing: Joining of Composites
Chairs: **Th. Loutas, A. Turon**

3.13-01 Challenges of hybrid laminar flow control (HLFC) in aircraft design and manufacturing
F. Martin de la Escalera, Y. Essa, M. Ángel Castello, U. Pillai (AERNNOVA Engineering Division SAU, Spain), A. Chiminelli, M. Lizaranzu (ITAINNOVA-Instituto Tecnológico de Aragón, Spain), P. Maimi (Universitat de Girona, Spain)
The purpose of this paper is to describe barriers and efforts made in the design of an aircraft in terms of reducing pollution emission into the atmosphere throughout the structural optimization of the aircraft's airfoils. In particular, the present work is focused on the design of a leading edge considering Hybrid Laminar Flow Control (HLFC) technology. The technological improvements of this topic are instilled through Clean Sky 2 platform. This will underpin innovative developments in the next generation of aircrafts; overcoming the risks and the technologies eventually to join the next market window to replace the current fleet.

3.13-02 On The Manufacturing and Testing of Dissimilar Adhesive Ti-CFRP Joints
W. M. van den Brink, P. Nijhuis (NLR, Netherlands), Y. Essa, F. M. de la Escalera Cutillas (AERNNOVA, Spain)
In this study, the manufacturing and testing of the coupons for the determination of the strain energy release rates during delamination crack growth in dissimilar (metal to composite) adhesive joints is investigated. It is part of the TicoAjo EU project and the results will be used for an application in aerospace (Cntd)

3.13-03 Surface Pretreatments on CFRP and Titanium for Manufacturing Adhesively Bonded Bi-Material Joints
W. Wang, J. A. Poulis, S. Teixeira De Freitas, D. Zarouchas (Delft University of Technology, The Netherlands)
Adhesive bonding is a highly desirable joining technique to join composites to metals. The surfaces of both composite and metal substrates have to be carefully treated before bonding them together, in order to avoid interface failure between the adherend's surface and adhesive. (Cntd)

3.13-04 Hybrid Materials - Joining of Polymers and Metals
D. Spancken, D. Laveuve (Fraunhofer LBF, Germany), J. Beck (Werkzeugbau S. Hofmann GmbH, Germany), N. Stötzner (Weber Fibertech GmbH, Germany), K. van der Straeten (Fraunhofer ILT, Germany), A. Büter (Fraunhofer LBF, Germany), F. Henning (Fraunhofer ICT, Germany)
The results of cyclic tests show little scatter indicating a stable and reproducible manufacturing process. The static and cyclic internal pressure tests of the test specimens show that the technology can be used for pressure tight applications.

3.13-05 On The Design and Analysis of Interlaminar Fracture Toughness Tests on Dissimilar Metal-Composite Adhesive Joints with Residual Thermal Stresses
P. Tsokanas, T. Loutas, V. Kostopoulos (University of Patras, Greece), Y. Essa, F. M. de la Escalera (AERNNOVA Engineering Division SAU, Spain)
DCB and ENF interlaminar fracture tests are designed and analysed for metal-composite adhesive joints with residual thermal stresses. The residual thermal stresses significantly affect the SERR and introduce ever-changing mode mixities during pure mode tests.

3.13-06 Analytical Model behavior for Bolted Metal-3D Woven Composite Joints
W. El Masnaoui (Université de Toulouse & SAFRAN Aircraft Engines Villaroche, France), A. Daidie, F. Lachaud (Université de Toulouse, France), C. Paleczny (SAFRAN Aircraft Engines Villaroche, France)
This research work deals with development of a simplified beam model for 3D woven-metal bolted joints behavior. An analytical model called "bending beam model" applied to homogenous materials has been identified and investigated. Its adjustability to our application was confirmed through comparisons (Cntd)

11:00-13:00 Hall: Skalkotas

2.08 | Materials Science: Graphene – Graphene-Based Composites

Chair: **C. Galiotis**

2.08-01 Hybrid, Graphene-Reinforced Poly(Ether Ether Ketone) Nanocomposites

D. G. Papageorgiou, M. Liu, Z. Li, I. A. Kinloch, R. J. Young (University of Manchester, United Kingdom)

In this work, we investigate the viscoelastic properties and creep mitigation of poly(ether ether ketone) (PEEK) reinforced with graphene nanoplatelets (GNPs) and PEEK reinforced with a hybrid graphene and short glass (GFs) or carbon fibre (CF) filler.

2.08-02 Enhancing Mechanical Properties of Graphene / Epoxy Nanocomposites using Few-Layer Graphene Produced by Liquid Phase Exfoliation

K. Oba (Graduate School of Waseda University, Japan), Y. Arao (Tokyo Institute of Technology, Japan), A. Hosoi, H. Kawada (Graduate School of Waseda University, Japan)

In this study, few-layer graphenes (FLGs) were produced by new liquid phase exfoliation (LPE), exfoliation of graphite with weak acid salts. A high concentration dispersion of FLGs in low-boiling point solvents is successfully carried out, achieved by binding molecules with a dispersing function. (Cntd)

2.08-03 Multifunctional Thermoplastic Elastomer Nanocomposites Reinforced by Graphene

M. Liu, D. G. Papageorgiou, I. A. Kinloch, R. J. Young (University of Manchester, United Kingdom)

A series of graphene-reinforced thermoplastic elastomers were prepared with graphene nanoplatelets (GNPs) of different particle diameter. The reinforcing mechanisms were investigated by a number of characterisation techniques and analysed by the shear-lag/rule-of-mixtures theory.

2.08-04 Development of Multifunctional Peek Nanocomposites Based on Graphene

S. Quiles-Díaz, A. Martínez-Gómez, P. Enrique-Jimenez, H. J. Salavagione, A. Flores, F. Ania, M. A. Gómez-Fatou (Consejo Superior de Investigaciones Científicas (CSIC), Spain)

In this communication we present the preparation of multifunctional poly (ether ether ketone) (PEEK) nanocomposites with graphene. PEEK is a high-performance semicristalline thermoplastic matrix, and its proper combination with graphene can lead to nanocomposites with electrical conductivity, (Cntd)

2.08-05 Graphene-based Advanced Adhesives with High Thermal and Electrical Conductivity

S. Tsantzalis, C. Kostagiannakopoulou (University of Patras, Greece), K. Kouravelou, A. Vavouliotis, A. Baltopoulos (Adamant Composites, Greece), V. Kostopoulos (University of Patras, Greece), U. Lafont (ESTEC, The Netherlands)

As the multifunctional performance of adhesives is of great importance for aerospace applications, an extensive study was carried out with the purpose of enhancing thermal and electrical conductivity of insulating adhesives by using GNPs. (Cntd)

2.08-06 Characterization of Multifunctional Composites Obtained from Carbon Fiber/Epoxy Prepregs Containing Graphene Related Materials

V. Rodriguez-Garcia (FIDAMC & Universidad Politécnica de Madrid, Spain), S. Calvo, M. R. Martinez-Miranda (FIDAMC, Spain), T. Blanco (Airbus Operations S.L., Spain) , R. Guzman de Villoria, M. R. Gude (FIDAMC, Spain)

Multiscale composite laminates have been manufactured using carbon fiber/epoxy prepregs containing graphene related materials (GRM) in the matrix. The influence of three different types of GRM in physic-chemical and mechanical properties is evaluated.

11:00-13:00 Hall: Multi-Purpose Room

3.06 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Impact – Crash – Blast

Chairs: **G. Pinter, P. Robinson**

3.06-01 Estimation of the Load Produced by the Electro-Thermal Behaviour of Lightning Strike Protection Layers on a Composite Panel

A. Bigand (Airbus Operations SAS & (Université Fédérale de Toulouse MP, France), C. Espinosa (Université Fédérale de Toulouse MP, France), J. M. Bauchire (Université d'Orléans, France), F. Flourens (Airbus Operations SAS, France), F. Lachaud (Université Fédérale de Toulouse MP, France)

The lightning damage mechanism for carbon laminate aeronautical structure is a complex multi-physical phenomenon. The lightning current entering into the surface metallic protection, called LSP (Lightning Strike Protection) and the carbon plies generates Joule's effects and magnetic forces which both induce mechanical forces (Cntd)

3.06-02 Evaluation of Soft-Skin Effect Performance of Carbon Fiber Reinforced Thermoplastics

Y. Zhang, B. Xiao, I. Ohsawa, J. Takahashi (University of Tokyo, Japan)

This research evaluated the advantages of carbon fiber reinforced thermoplastics (CFRTP) in design of body-contacting product with developed apparatus and indexes. Experimental analogy was adopted to investigate the characteristics of contacting force on human body (Cntd)

3.06-03 High Speed Digital Image Correlation for Impact Performance of Thermoplastic and Thermoset Composites
J. Liu, C. Kaboglu, H. Liu, B. R. K. Blackman, A. J. Kinloch, J. P. Dear (Imperial College London, United Kingdom)
The impact performance of thermoplastic and thermoset composites has been investigated by conducting gas gun tests, initial velocities up to 110 m s-1, employing with 3D Digital Image Correlation (DIC) technology. Woven fabric Carbon Fibre Reinforced Polyether-ether-ketone (CF/PEEK) and Carbon Fibre (Cntd)

3.06-04 Infrared Thermography for Damage Monitoring at Intermediate Strain Rates: Application to Transverse Cracking Evolution in Cross-Ply Laminates
J. Berthe (France)
A new approach is considered relying on the use of passive infrared thermography to capture the transverse cracking appearance. It has been applied to study the evolution of the matrix crack density with respect to the loading rate increase.

3.06-05 Experimental Investigations on the Impact Behavior of Woven Thermoplastic Glass Fiber-Reinforced Laminates
F. Schimmer, N. Motsch, J. Hausmann (Institut für Verbundwerkstoffe GmbH, Germany)
Within this study, low velocity impact tests of quasi-isotropic woven glass fiber-reinforced polyamide 66 plates under varying environmental conditions are conducted and evaluated by focusing on force-time characteristics as well as backlight analyses.

3.06-06 Influence of Temperature and Impact Energy on Low Velocity Impact Damage Severity in CFRP
J. Korbelin, M. Derra, B. Fiedler (Hamburg University of Technology, Germany)
This study focuses on the effect of temperature and impact energy on the damage in CFRP under low velocity impact. The results indicate, that visual damage severity does not correlate with the residual compressive strength when taking temperature into account.

11:00-13:00 Hall: MC 3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chairs: **N. Boyard , J.-L. Bailleul**

5.07-01 Low-Cost Fabrication of Fiber Reinforced Plastics by Ultrasonic Processing
A. Gomer, W. Zou, N. Grigat, J. Sackmann, W.K. Schomburg (RWTH Aachen University, Germany)
This paper presents a new approach for the fabrication of CFRP using ultrasonic processing. Besides the process introduction, examples of fabricated specimen are given and their mechanical testing is described.

5.07-02 Ultrasonic Welding of CF/Epoxy to CF/Peek Composites: Effect of the Energy Director Material on the Welding Process
E. Tsiangou, S. Teixeira de Freitas, I. Fernandez Villegas, R. Benedictus (Delft University of Technology, The Netherlands)
With its short heating times, ultrasonic welding is a highly promising technique for joining thermoplastic (TPC) to thermoset (TSC) composites, to prevent thermal degradation of the thermoset adherend. A neat thermoplastic coupling layer is co-cured on the surface to be welded to make the TSC "weldable." (Cntd)

5.07-03 Improving Weld Uniformity in Continuous Ultrasonic Welding of Thermoplastic Composites
B. Jongbloed, J. Teuwen (Delft University of Technology, The Netherlands), G. Palardy (Louisiana State University, USA), I. Fernandez Villegas, R. Benedictus (Delft University of Technology, The Netherlands)
Continuous ultrasonic welding (CUW) is an innovative high-speed joining method for thermoplastic composites. Currently, thin flat energy directors (EDs) are used to focus the heat generation at the weld line. The resulting fracture surfaces exhibit large areas of intact ED, resulting in a non-uniform weld, (Cntd)

5.07-04 Effect of Ultrasonic Welding Process on the Crystallinity at the Welding Interface of CF/PPS Joints
N. Koutras, I. F. Villegas, R. Benedictus (Delft University of Technology, The Netherlands)
The influence of the ultrasonic welding process parameters, namely the force and the vibration amplitude, on the crystallinity degree at the welding interface of CF/PPS (carbon fibre reinforced poly(phenylene) sulphide) joints was investigated.

5.07-05 Safe and Sound Thermoplastics: Quality Assured Ultrasonic Welding in Fuselage Skin Production
F. J. C. Fischer, A. Schuster, M. Willmeroth, R. Glück, M. Engelschall, L. Larsen, M. Kupke (German Aerospace Center-DLR, Germany)
At the Center for Lightweight Production Technology (ZLP) fully-automated patch-preforming has been established for individualized lay-up of variable ply books. This technology may be an opportunity for flexible customization in high rate production of future single aisle aircrafts made of thermoplastic composites. (Cntd)

5.07-06 Increasing the Joint Strength of Ultrasonic-Spot Welded Fiber-Reinforced Laminates by an Innovative Process Control Method
S. Tutunjian, O. Eroğlu, M. Dannemann, N. Modler, F. Fischer (Technische Universität Dresden, Germany)
The possibility to use the consumed power by the ultrasonic welder to control the temperature in the welded spots of thermoplastic composites is investigated. A significant increase in the weld strength and process stability is observed.

11:00-12:40 Hall: MC 2

5.08 | Processing and Manufacturing Technologies: Manufacturing Upscaling and Automation

Chair: **J. Bloemhof**

5.08-01 Highly Automated Manufacturing Process Chain for Large Double Curved CFRP Aircraft Parts

M. Malecha, C. Frommel, M. Koerber, M. Mayer (Institut für Bauweisen und Strukturtechnologie, Germany)

Large aircraft parts from CFRP materials introduce new challenges for manufacturing. We present our concept and technical solutions for manufacturing of a rear pressure bulkhead in an integrated and higly automated process including on-line quality assurance.

5.08-02 Automated Manufacturing of Large Fibre-Metal-Laminate Parts

D. Nieberl, M. Mayer, T. Stefani, M. Willmeroth (German Aerospace Center, Germany)

The automated manufacturing of fibre-metal-laminate fuselage parts offers potential improvements in cycle time, process stability and quality. A possible solution for an automated lay-up via collaborating robots with in-line quality assurance is presented and discussed.

5.08-03 Concept Study on Optimized Auxiliary Material Designs and Application Techniques for Vacuum Bagging of Full-Scale CFRP Rocket Boosters

J. Faber, C. Schmidt-Eisenlohr (German Aerospace Center, Germany), T. Dickhut, P. Ortmann (MT Aerospace GmbH, Germany)

In case of CFRP rocket booster case manufacturing advanced vaccum bagging technologies have been developed based on a 3D shape design method for auxiliary material packages.

5.08-04 Design, Manufacturing, and Testing of an Automated Winding Machine for WrapToR Composite Truss Structures

C. J. Hunt, M. R. Wisnom, B. K.S. Woods (University of Bristol, United Kingdom)

The development of an automated winding machine for production of WrapToR truss structures is presented. These ultra-efficient composite structures are then tested to failure and compared with conventional composite tubes.

5.08-05 Through-Thickness Permeable Prepregs for Robust Manufacturing

W. T. Edwards, P. Martinez, T. Centea, S. R. Nutt (University of Southern California, USA)

This paper introduces a method for producing customized unidirectional prepreg formats. Fundamental consolidation mechanisms in such formats are identified, and results highlight the importance of through-thickness permeability for robust out-of-autoclave laminate fabrication.

11:00-12:40 Hall: Kokkalis

2.13 | Materials Science: Nano Composites

Chairs: B. Fiedler, S. Anastasiadis

2.13-01 Finite Element Analysis of Damage Properties of Carbon Nanocoil / Epoxy Composites

K. Sanada, S. Okada (Toyama Prefectural University, Japan)

The damage properties of carbon nanocoil (CNC) /epoxy composites have been investigated numerically. To predict the damage evolution in CNC/epoxy composites, the finite element analyses were performed using a three-dimensional unit cell model of the composites with aligned straight CNCs. (Cntd)

2.13-02 Understanding Interlaminar Toughening Mechamisms in Structural Carbon Fiber/Epoxy Composites Interleaved with CNT Veils

Y. Ou, C. González (IMDEA Materials Institute & Universidad Politécnica de Madrid, Spain), J. J. Vilatela (IMDEA Materials Institute, Spain)

A facile and scalable infusion protocol was successfully built to make CNT/CF/epoxy composite, by which void-free laminates can be manufactured without utilizing expensive techniques. In addition to showing interlaminar toughness improvements as high as 30%, (Cntd)

2.13-03 Carbon Fibre-Carbon Nanotube Multiscale Composites - Nanoengineering of the Fibre Surface for Protection in Extreme Processing Conditions

W. Szmyt (FHNW University of Applied Sciences and Arts Northwestern Switzerland & Paul Scherrer Institute & University of Basel, Switzerland), L. Marot (University of Basel, Switzerland), M. Calame (University of Basel & EMPA Swiss Federal Laboratories for Material Science and Technology, Switzerland), C. Padeste (Paul Scherrer Institute & University of Basel, Switzerland), C. Dransfeld (FHNW University of Applied Sciences and Arts Northwestern Switzerland & University of Basel, Switzerland)

Growth of carbon nanotubes (CNTs) on carbon fibre (CF) results in a secondary nanoscale reinforcement of a composite. CNT growth however tends to deteriorate CF mechanical properties. We examine protective films applied onto CF prior to CNT growth.

2.13-04 A New Strategy for Balancing Sensitivity and Stretchability in Strain Sensor with Well-Controlled High-Density Cracks

Y. Xin, J. Zhou, X. Xu, G. Lubineau (King Abdullah University of Science and Technology (KAUST), Saudi Arabia)

In summary, through increasing the crack density of SWCNT paper, the performance in sensitivity, stretchability, and linearity were improved. We also use a TPE film as the substrate to design a compressible strain sensor, using a pre deformed network of cracks stabilized by annealing. (Cntd)

2.13-05 Strain Measurement of Carbon Nanotubes in Aligned Multi-Walled Carbon Nanotubes/Epoxy Composites under Tensile Load using Raman Spectroscopy
A. Aoki, T. Ogasawara (Tokyo University of Agriculture and Technology, Japan), Y. Shimamura, Y. Inoue (Shizuoka University, Japan)
This study examined the strain of multi-walled carbon nanotubes (MW-CNT) in aligned-MW-CNT/epoxy composites subjected to uniaxial tensile load using Raman spectroscopy to elucidate the load-transfer mechanism between MW-CNTs and epoxy.

11:00-13:00 Hall: Lecture Room

2.01 | Materials Science: Bio-composites
Chairs: K.- Y. Lee, A. Le Duigou

2.01-01 Modeling Natural Fiber Composites Microstructures for Predicting their Water Aging
R. Léger (Université de Montpellier, France), C. Mattrand (Université Clermont Auvergne, France), A. Mooti (Ecole Centrale de Nantes, France), S. Corn (Université de Montpellier, France)
This work proposes an original approach devoted to generate realistic virtual microstructures in order to predict numerically the hygroscopic behavior of composites reinforced with natural fibers.

2.01-02 Numerical Investigation of Mechanical Response of Bio-Inspired Nacre-Like Composites Under Impact Loading
S. Cui, Z. Lu, Z. Yang (Beihang University, China)
Natural biological materials have achieved multifunctional properties for special purposes in the long course of organism survival. Among them there are some materials that show excellent toughness compared to their constituents yet do not sacrifice much stiffness and strength, for instance nacre, (Cntd)

2.01-03 Noncytotoxic Biocomposite Hydrogel Fabricated by Digital Light Processing 3D Printing
H. Lee, H. Kwak, K. Na, S. Shin, D. Shin, J. Hyun (Seoul National University, Korea)
Three dimensional (3D) printing is an effective method to produce scaffolds that are able to support cells for tissue engineering and regenerative medicine. Scaffolds are normally printed using thermoplastic polymers, metal powders, biopolymers, and decellularized materials from tissues (Cntd)

2.01-04 Impact and Hardness Optimisation of Cellulose Fibre-Reinforced PLA/PP Composites Inspired by the Babassu Nut Pericarp (Orbignya Speciosa)
N. Graupner, G. Staufenberg, J. Müssig (City University of Applied Sciences Bremen, Germany)
The pericarp from the fruit of the babassu palm Orbignya speciosa provides a good combination of hardness and impact strength which is difficult to achieve in artificial materials, making the babassu nut pericarp a promising source for bio-inspiration. (Cntd)

2.01-05 Influence of Thermoforming Parameters on The Mechanical and Aesthetic Behaviour of Flax Polypropylene Laminates
Y. Dobah (University of Bristol, United Kingdom & University of Jeddah, Saudi Arabia), C. Ward, A. Shterenlikht, F. Scarpa (University of Bristol, United Kingdom)

2.01-06 Biomass and Waste-derived Sustainable Mycelium Composite Construction Materials with Enhanced Fire Safety
T. Bhat (University of New South Wales, Australia), M. Jones, E. Kandare (RMIT University, Australia), R. Yuen (City University of Hong Kong, Hong Kong), C. H. Wang (University of New South Wales, Australia), S. John (RMIT University, Australia)
Mycelium has attracted significant academic and commercial interest due to its ability to up-cycle agricultural and industrial waste products into low cost, environmentally sustainable composite materials with almost zero additional energy input. (Cntd)

11:00-12:20 Hall: MC3.2

1.01 | Applications: Aerospace
Chair: **Ch. Rekatsinas**

1.01-01 Durability of Composite Materials in Deployable Structures for Space Applications
Y. He (University of Bristol, United Kingdom), A. Suliga, A. Brinkmeyer (Oxford Space Systems, United Kingdom), M. Schenk, I. Hamerton (University of Bristol, United Kingdom)
Advanced composite materials are an excellent option for flexible deployable space structures, such as deployable antennas and booms. However, the harsh environment in space can degrade the performance of composite materials, thus limiting their wider application. (Cntd)

1.01-02 Effects of Cryogenic Temperature on Mechanical Properties of Carbon Fiber/Epoxy Composites
H. Shi, Q. Lei, X. He, K. Yang, B. Sun, H. Sun (Aerospace Research Institute of Matterials & Processing Technology, China)
In order to study the effects of cryogenic temperature on mechanical properties of carbon fiber/epoxy composites with different composition, T700 unidirectional carbon fiber/epoxy composites are prepared by autocalve process, T700 braiding fabric/epoxy composites and M40-level braiding fabric/epoxy composites (Cntd)

1.01-03 Interstage 2-3 of Vega C Launcher: Composite Grid Structure Technology

G. Giusto, P. Spena, G. Totaro, F. De Nicola, F. Di Caprio (CIRA Italian Aerospace Research Centre, Italy), A. Zallo, M. Cioeta (Avio s.p.a, Italy), S. Mespoulet (European Space Agency, Italy)

This paper presents the general aspects of design and manufacturing inherent to the development of the Interstage 2-3 of the new VEGA C launcher, characterized by an innovative composite grid architecture adopted in Europe for the first time.

1.01-04 Design and Experimental Assessment of a Multi-spherical Composite-Overwrapped Pressure Vessel for Cryogenic Storage

I. G. Tapeinos, A. Rajabzadeh, D. S. Zarouchas, R. M. Groves, S. Koussios, R. Benedictus (Delft University of Technology, Netherlands)

A cryogenic storage tank should be designed in a way that makes the best possible use of the available space within an aircraft. A composite-overwrapped pressure vessel (COPV) based on intersecting spheres (multi-sphere) provides a more volumetrically efficient solution compared to packed cylinders (Cntd)

11:00-13:00 Hall: **MC 3.3**

3.07 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Vibration and Damping

Chair: **S. Ogin**

3.07-01 Hybrid CFRP-Elastomer-Metal Laminates: Influence of Lay-Up Parameters on its Damping Behaviour

W. V. Liebig, V. Sessner, A. Jackstadt, K. A. Weidenmann, L. Kärger (Karlsruhe Institute of Technology, Germany)

In this work, the damping behaviour of hybrid carbon fibre-reinforced plastics/elastomer/metal-laminates is investigated with regard to the influence of multilayer composite parameters, such as lay-up and visco-elastic material behaviour of the constituents. (Cntd)

3.07-02 Experimental Verification of Innovative Multi-Phase Materials Combining High Viscoelastic Loss and High Stiffness

A. P. Unwin, P. J. Hine, I. M. Ward (University of Leeds, United Kingdom), M. Fujita, E. Tanaka (The Kaiteki Institute, Japan), A. A.Gusev (ETH Zürich, Switzerland)

In this work we present experimental data for a range of composite materials where the aim was to achieve high viscoelastic loss without significantly sacrificing composite stiffness.

3.07-03 Flutter Analysis of AGARD Composite Wing

S. Kilimtzidis, D.E. Mazarakos, V. Kostopoulos (University of Patras, Greece)

A numerical subsonic and transonic flutter study was developed in order to investigate the reliability of flutter data measured in the Langley transonic dynamics tunnel for the AGARD 445.6 wing structure. The AGARD wing is an experimental structure that promotes the evaluation of existing and emerging unsteady codes-methods (Cntd)

3.07-04 Damping Behavior of Carbon Nanotube Reinforced Nanocomposites: Micromechanical Modeling and Experiments

S. Doagou-Rad, J. S. Jensen, A. Islam (Technical University of Denmark, Denmark)

The damping characteristics of polymeric nanocomposites reinforced with carbon nanotubes is studied using micromechanical modeling and experiments. Two damage dissipation mechanisms namely interfacial and viscoelastic damping contribute to the damping properties of the polymeric nanocomposites. (Cntd)

3.07-05 Combined Experimental-Numerical Approach for the 3D Vibration Analysis of Rotating Composite Compressor Blades: An Introduction

T. Wollmann, M. Dannemann, A. Langkamp, N. Modler, M. Gude (Technische Universität Dresden, Germany), L. Salles (Imperial College London, United Kingdom), N. Hoffmann (Imperial College London, United Kingdom & Hamburg University of Technology, Germany), A. Filippatos (Technische Universität Dresden, Germany)

A combined experimental-numerical approach to determine the 3D vibration behaviour of rotating composite compressor blades is introduced. An overview of the main components required for this non-contact 3D modal analysis is given.

3.07-06 Scheme for Crack Localization in Composite Plates Combining the eXtended and the Wave Finite Element Methods

K. D. Sfoungaris, D. G. Chronopoulos (University of Nottingham, United Kingdom), S. P. Triantafyllou (University Of Nottingham, United Kingdom)

A hybrid Wave Finite Element-eXtended Finite Element method for the study of the vibrational properties of a cracked plate is developed. Results indicate that combination of said methos yields accurate results with very little computational burden.

11:00-12:20 Hall: MC 3.4

2.04 | Materials Science: Fiber-Hybrid Composites

Chairs: **G. Czél, Y. Swolfs**

2.04-01 Influence of Reinforcement Materials on Explosion Resistance of Carbon Fiber Reinforced Plastic

A. I. Dulnev, E. A. Nekliudova (Krylov State Research Centre, Russia)

This paper presents the results obtained from a computational- cum-experimental investigation into resistance of carbon fiber plastic samples manufactured using different reinforcement materials to non-contact underwater explosion. It is experimentally demonstrated that quadraxial carbon fabric samples (Cntd)

2.04-02 Improvement of Intrusion and Crash Behaviour of Aluminium Beams by Carbon Composite Patches

Y. Lebaupin, M. Piccand (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), J. Friedli (Novelis Switzerland SA, Switzerland), B. Caglar (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), R. Pasquier (Novelis Switzerland SA, Switzerland), V. Michaud (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

This study investigates the intrusion and crash performance of hybrid fibre-metal laminates based on aluminium and carbon or glass reinforced polymers, as compared to reference aluminium parts, made from AA6451 or 7075 automotive grade alloys.

2.04-03 Design and Testing of Co-Cured Bonded CFRP-Steel Hybrids with Nanostructured Interfaces for Interlaminar Fracture Toughness

J. Striewe, R. Grothe J. Kowatz, T. Tröster, G. Grundmeier, G. Meschut (Paderborn University, Germany)

The present work investigates co-cured bonded hybrid systems consisting of a high-strength steel with innovative surface modifications and a carbonfibre-reinforced (thermoset) plastic (CFRP) regarding interfacial fracture toughness. As main surface modification, zinc oxide (ZnO) nanorods are formed (Cntd)

2.04-04 Nanotube-Grafted Glass Fibers and Composites Thereof

G.-Y. Kim, G. Lee, W.-R. Yu (Seoul National University, Korea)

Glass fibers are widely used as a reinforcing material in composites due to their excellent strength and insulating properties. Many researchers have sought to improve the mechanical properties and interfacial shear strength of glass fiber-reinforced composites. (Cntd)

11:00-13:00 Hall: Conference 1

2.09 | Materials Science: Green Composites

Chairs: **S. Goutianos, A. Mautner**

2.09-01 Crashworthiness Characteristics of Carbon-Flax Composite Tubes for Aerospace Applications

K. Strohrmann (Technical University of Munich, Germany), S. Schmeer (Technical University of Kaiserslautern, Germany), G. Fortin, H. Hamada (Kyoto Institute of Technology, Japan), M. Hajek (Technical University of Munich, Germany)

The specific energy absorbing capabilities of composite tubes with woven flax and carbon layers were analyzed and evaluated using quasi-static and dropping-weight compression tests. Four different lay-ups were manufactured, each with eight woven layers of either flax, carbon or both in 0°fiber (Cntd)

2.09-02 Translaminar Fracture Toughness of Discontinuous, Aligned Flax Fibre Composites

C. Canturri, L. Q. N. Tran, C. L. C. Tan, W. S. Teo (Singapore Institute of Manufacturing Technology, Singapore)

This paper describes the results of an investigation into Mode I translaminar critical strain energy release rate of continuous laminates and slit-cut laminates of flax-epoxy prepreg laminates.

2.09-03 Effects of Interleaved Flax Layers on the Dynamic Characteristics of Glass Composites

M. Cihan, A. J. Sobey, J. I.R. Blake (University of Southampton, United Kingdom)

2.09-04 Nanostructure and Nanomechanics of Cellulose Nanofibre Nanocomposites

F. Martoïa, P.J.J. Dumont (Université Lyon, France), L. Orgéas, J.-L. Putaux (Université Grenoble Alpes, France)

In this study, we report an original multiscale model for the prediction of the elastic properties of NFC-reinforced nanocomposites and nanopapers. The model takes into account the complexity of the networks formed by NFCs and their associated deformation mechanisms.

2.09-05 Extraction of Hemp Fibres for Load Bearing Composites. Minimisation of the Extraction Impact of Processes such as Scutching or "All Fibre" Extraction Devices on the Fibres Mechanical Properties

P. Ouagne, M. Grégoire, L.Labonne, P. Evon (Université de Toulouse, France)

2.09-06 Effect of Hydrothermal Ageing on the Mechanical Properties of Flax Fibre/ Bio-Based Resin Composites

X. Saridaki, E. Kollia, D. Karagiannis, S. Tsantzalis (University of Patras, Greece), M. Wonneberger, F. Dungern (Invent GmbH, Germany), V. Kostopoulos (University of Patras, Greece)

The aim of the present study is to evaluate the influence of hydrothermal ageing of flax fibre-reinforced bio-based epoxy resin laminates on the mechanical properties of the composites.

11:00-12:20 Hall: **MC3.5**

2.10 | Materials Science: High Temperature Polymer Composites

Chair: **G. Bernhart**

2.10-01 Thermo-Mechanical Stiffness and Media Resistance of Endless Carbon Fiber Composites with Polyphenylene Sulfide (PPS)/Polyether Sulfone (PES) Blend Matrices
T. Krooß, M. Gurka (Institut Für Verbundwerkstoffe, Germany)
Immiscible thermoplastic PPS/PES blends were investigated regarding their morphological features and resulting thermomechanical properties in carbon composite samples. The PES fraction dependent morphologies lead to different thermomechanical and media dependent properties.

2.10-02 Long-Term High Temperature and Fire Degradation of Carbon/Polyimide Composites
S. A. Tsampas (GKN Aerospace Engine Systems, Sweden), Patrik S. Fernberg (Swerea SICOMP, Sweden), R. Joffe (Luleå University of Technology, Sweden)
In this study the effect of elevated temperature and long-term thermal exposure on the mechanical performance as well as the fire reaction of carbon fibre-reinforced polyimide composites (T650/NEXIMID MHT-R) were assessed.

2.10-03 Ablation Performances of Carbon Composite based on Different Resins under Severe Aero-Thermal Flux
E. Arnaud (ISAE ENSMA & Naval Group Research, France), D. Halm, D. Bertheau (ISAE ENSMA, France), J. Beaudet (Naval Group Research, France)
Comparison of the ablative and thermal performances of phenolic, epoxy and silicone rubber reinforced with short carbon fibers composites assessed under an oxy-acetylenic torch and a severe aerothermal flux

2.10-04 Thermo-Oxidative Degradation of PEEK at High Temperatures
P. Tsotra, M. Toma, A. Pascual, F. Schadt, C. Brauner, C. Dransfeld (FHNW University of Applied Sciences and Arts Northwestern Switzerland, Switzerland)
In this study, the thermo-oxidative degradation of poly(ether ether ketone) (PEEK) during very short cycles, in the range of 30 up to 300 s, at temperatures higher than 400°C was investigated by differen-tial scanning calorimetry (DSC). It was observed that the melting point and crystallinity (Cntd)

13:00-14:00 Hall: **Exhibition Area**

Lunch Break

14:00-14:45 Hall: **Trianti**

Keynote Lecture 3

Chair: **K. Friedrich**

Effects of Confinement on Polymer Structure and Dynamics: The Case of Polymer Nanocomposites
Spiros H. Anastasiadis

14:00-14:45 Hall: **Mitropoulos**

Keynote Lecture 4

Chair: **V. Kostopoulos**

Future Composite Joining in Aerospace – the dream of the fully bonded Airframe and how to turn it into reality
Thomas Kruse

14:45-16:05 Hall: Trianti

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level

Chairs: **K. Kose, S. Pinho**

3.10-07 Extension of an Anisotropic Damage Model for CMCs to Non-Proportional Multi-Axial Loadings Accounting for Crack Closure and Friction

E. Baranger (Université Paris-Saclay, France)

Extension of an anisotropic damage model to account for crack closure and friction under multi-axial non-proportionnal loadings. Application to ceramic matrix composites.

3.10-08 Composite Failure Model with Elastic Nonlinearities and Strain Rate Effect

E. V. Lomakin (Lomonosov Moscow State University & Moscow Aviation Institute, Russia), B. N. Fedulov, A. N. Fedorenko (Lomonosov Moscow State University, Russia)

This research is directed to the formulation of a number of assumptions to build up a theory for failure prediction in laminated composites, which are generalized enough to serve as the basis for explanation of current models and further development of modelling theory. (Cntd)

3.10-09 Energy-Based Prediction of Progressive Ply Cracking in Multiple Plies of General and Thin-Ply Laminates under In-Plane and Bending Loads using a Homogenization Method

M. Hajikazemi, W. Van Paepegem (Ghent University, Belgium)

An energy-based failure criterion is developed to predict progressive ply cracking under arbitrary in-plane and bending loads while the effects of thermal and moisture residual stresses are taken into account. This failure criterion is used in conjunction with a variational stress transfer model to make a design tool (Cntd)

3.10-10 Evaluation of Damage Initiation Models for 3D-Woven Fibre Composites

C. Oddy (Chalmers University of Technology, Sweden), T. Ekermann (KTH Royal Institute of Technology, Sweden), M. Ekh, M. Fagerstrom (Chalmers University of Technology, Sweden), S. Hallstrom (KTH Royal Institute of Technology, Sweden)

Three dimensional (3D) fibre-reinforced composites have shown weight efficient strength and stiffness characteristics as well as promising energy absorption capabilities. In the considered class of 3D-reinforcement, vertical and horizontal weft yarns interlace warp yarns. (Cntd)

14:45-16:45 Hall: Mitropoulos

3.13 | Material and Structural Behavior – Simulation and Testing: Joining of Composites

Chair: **S. Goutianos, A. Turon**

3.13-07 Characterization of an UV-Laser Treatment Process for Adhesive Bonding of CFRP

B. Rauh (Airbus, Germany), S. Kreling (Technische Universität Braunschweig, Germany), M. Geistbeck (Airbus, Germany), K. Dilger (Technische Universität Braunschweig, Germany)

In aerospace industry, composite materials allow advanced lightweight designs. Adhesive bonding as joining technology would offer new perspectives in this development. Due to surface contaminations that remain on composite surfaces after demoulding, pre-treatment of these surfaces is necessary to allow robust bonding. (Cntd)

3.13-08 Effect of Laser Surface Treatment on the Adhesive Properties of Bonded CFRP Joints

S. Harder, P. Goralski (Hamburg University of Technology, Germany), N. Scharnagl (Helmholtz Zentrum Geesthacht, Germany), P. Hergoss (Fraunhofer IAPT, Germany), H. Schmutzler (Lufthansa Technik AG, Germany), B. Fiedler (Hamburg University of Technology, Germany)

In this work, the effect of an Ytterbium fibre laser treatment on the adhesive properties of scarf bonded carbon fibre reinforced plastics (CFRP) joints has been investigated. The surfaces were scarfed and afterwards laser treated. The effect of laser treatment on the surface morphology was investigated (Cntd)

3.13-09 Improving Secondary Bonding of Composite Plates by Using Laser-Based Surface Patterning

G. Lubineau, R. Tao (King Abdullah University of Science and Technology-KAUST, Saudi Arabia), M. Alfano (University of Calabria, Italy)

The application of composite materials grows rapidly nowadays, so does the need for fast and reliable methods for joining and repairing composite materials. Secondary bonding of cured carbon fiber reinforced polymer (CFRP) laminates using structural adhesives has attracted great attention. (Cntd)

3.13-10 Analysis of Novel Hybrid Joints for Composite Struts

J. Jones, L. F.Kawashita, B. Chul Kim, S. R. Hallett (University of Bristol, United Kingdom)

This paper considers a novel joining solution for a composite-metal hybrid strut component that predominately experiences axial loads (tension and compression). The hybrid interface proposed may achieve high structural integrity through a mechanical interaction between filament wound fibre-tows (Cntd)

3.13-11 **Carbon Fiber-Reinforced Polymer Pultrusions Adhesively Bonded Inside Aluminum Joints: Experimental and Numerical Study**

N. P. Lavalette, Otto K. Bergsma, D. Zarouchas, R. Benedictus (Delft University of Technology, The Netherlands)

The objective of this work is to determine which numerical model is able to predict the joint strength the most accurately, and to examine the influence of several design parameters on the strength and weight of the joints.

3.13-12 **On the Influence of Overlap Topology on Tensile Strength of Composite Bonded Joints: A Multi-Stacking Design**

J. Kupski, S. Teixeira de Freitas, D. Zarouchas, R. Benedictus (Delft University of Technology, The Netherlands)

The goal of this study is to investigate new designs of composite bonded joints in order to improve their strength under tensile loading. Multiple stacked overlaps are compared with single overlap designs. The concept of multiple stacking is well known as ply-interleaving technique for co-curing dissimilar materials. (Cntd)

14:45-16:45 Hall: Skalkotas

3.06 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Impact – Crash – Blast

Chair: **G. Pinter**

3.06-07 **High Strain Rate Interlaminar Tensile Properties of Fibre-Reinforced Polymer Composites using a Novel Image-Based Inertial Impact (IBII) Test**

J. Van Blitterswyk, L. Fletcher, F. Pierron (University of Southampton, United Kingdom)

This paper presents the design and experimental validation of a novel image-based inertial impact (IBII) test to measure the interlaminar tensile stiffness and strength of fibre-reinforced polymer composite materials at high strain rates. Ultra-high-speed imaging is combined with full-field measurements (Cntd)

3.06-08 **Crushing of Composite Tubular Structures and Energy Absorption for Aircraft Seats Development**

J.-E. Chambe (Université de Toulouse, France), O. Dorival (ICAM Site de Toulouse & Université de Toulouse, France), C. Bouvet, J.-F. Ferrero (Université de Toulouse, France)

With the perspective of designing an aircraft seat and respecting safety regulations, the structure of the seat must allow for a swift dissipation of the energy perceived during a crash. To that end, a study focused on various composite tubular structures is carried out with the aim of evaluating their ability to dissipate the energy.

3.06-09 **Tensile Rate-Dependency of Carbon/Epoxy and Glass/Polyamide-6 Composites**

S. W. F. Spronk, F. A. Gilabert, R. D. B. Sevenois, D. Garoz (Ghent University & SIM vzw, Belgium), Wim Van Paepegem (Ghent University, Belgium)

Limits on the maximum strain rate for correct data-acquisition are quantified for dynamic tensile tests using a hydraulic pulse test bench. The rate-dependency of carbon/epoxy and glass/polyamide-6 is investigated based on valid data up to 200 /s.

3.06-10 **Static and Ballistic Performance of Helicoidal, Cross-ply and Quasi-Isotropic Laminates**

J.L. Liu, T.M. Woo, V.B.C. Tan (National University of Singapore, Singapore)

In attempts to mimic the configuration of crustacean exoskeleton, previous research has shown that stacking unidirectional laminates helicoidally with small inter-ply angles improves its delamination resistance and increased the transverse load bearing capability of the laminates. (Cntd)

3.06-11 **A Fragments Distribution Analysis to Understand Force Variations During a CFRP Crushing Test**

S. Rivallant, A. Gonzalez, F. Tostain, C. Espinosa (Université de Toulouse, France)

This paper presents an analysis of fragments due to the crushing of composite laminates. Firstly an identification of the fragments is presented. Most fragments created during the crushing are identified: length, location in the thickness and in the length of the laminate. (Cntd)

3.06-12 **Impact Damage Resistance and Tolerance of Z-Pinned Composite Laminates**

L. Francesconi (Santa Clara University, USA), G. Loi, F. Aymerich (University of Cagliari, Italy)

The study examines experimentally the effect of Z-pinning on the impact response, compression after impact (CAI) strength, and damage resistance and tolerance of cross-ply and quasi-isotropic carbon/epoxy laminates.

14:45-16:45 Hall: Multi-Purpose Room

3.08 | Material and Structural Behavior - Simulation and Testing: Fatigue of Composites

Chair: **A.Vasilopoulos, Th. Loutas**

3.08-01 **Characterization of CFRP Laminates under Tensiontension Fatigue using 3D Digital Image Correlation**

N. Schorer, M. G. R. Sause (University of Augsburg, Germany)

Low-cycle tension-tension fatigue tests with accompanying digital image correlation (DIC) and acoustic emission (AE) were conducted on cross-ply CFRP laminates to characterize the initial occurrence of inter-fibre failure.

3.08-02 In-Situ Image Processing of Fatigue Damaged Cross-Ply Laminates Coupled with Simulation to Predict Residual Strength Degradation
M. Drašković, A. Pickett, P. Middendorf (University of Stuttgart, Germany)

3.08-03 A Cycle-By-Cycle Fatigue Damage Analysis of Biaxial Composite Structures Utilizing Acoustic Emission
D. S. Zarouchas (Delft University of Technology, The Netherlands), J. A. Pascoe (Imperial College London, United Kingdom), R. C. Alderliesten (Delft University of Technology, The Netherlands)
In the present work, a fatigue damage analysis of biaxial Carbon Fibre Reinforced Polymer (CFRP) specimens loaded at two different stress levels and a fatigue ratio, R=0.1, was performed. A cycle-by-cycle approach was used, utilizing results from Acoustic Emission (AE) measurements. (Cntd)

3.08-04 X-Ray Tomography based Finite Element Modelling of Non-Crimp Fabric Based Fibre Composite
K. M. Jespersen (Technical University of Denmark, Denmark & Waseda University & Kanagawa Institute of Industrial Science and Technology-KISTEC, Japan), L. E. Asp (Chalmers University of Technology, Sweden), A. Hosoi, H. Kawada (Waseda University, Japan), L. P. Mikkelsen (Technical University of Denmark, Denmark)
The current study presents a workflow to import a fibre bundle structure of a non-crimp fabric based fibre composite obtained by X-ray CT to a solvable 3D model in the finite element software ABAQUS. The considered fibre composite is similar to that used for the load carrying parts of wind turbine blades, (Cntd)

3.08-05 A Comprehensive Modelling Approach of Fatigue Induced Cracking in Carbon Fibre Reinforced Laminates at Different Stress Ratios
G. Just, I. Koch, M. Gude (Technische Universität Dresden, Germany)
The work presented here focusses the analysis of multi-scale damage of endless fibre reinforced composites under reversed cyclic loading. Carbon fibre reinforced cross-ply laminates were subjected to fatigue loading at four different stress ratios. The evolution of crack density and the crack angles (Cntd)

3.08-06 Modelling Fatigue Delamination Propagation in Laminated Composites with an Incremental Fatigue Onset Strategy
M. Zhu, L. Gorbatikh, S. V. Lomov (KU Leuven & SIM M3 program, Belgium)
In this paper a fatigue cohesive zone model is developed for simulation of fatigue delamination propagation. The propagation is modelled as a sequence of incremental onset events. A fatigue damage law is proposed based on the G-N curve measured in fatigue onset tests.

14:45-16:25 Hall: MC3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chairs: **N. Boyard, J.L. Bailleul**

5.07-07 Investigation of Continuous Induction Welding of C/PAEK Laminates
G. Bernhart, G. Erb (IRT Saint-Exupery, France)
Welding of thermoplastic materials requires a temperature at welding interface that is higher than polymer melting temperature. Induction heating of laminates manufactured with unidirectional C/PAEK plies was investigated in this work. Results gained during static tests, show that heating arises in the volume of the material (Cntd)

5.07-08 Controlling the Edge Effect using a Bypass Conductor for Induction Welding of Carbon Fibre Thermoplastic Composites
M. Hagenbeek, J. Vilà Bramon, I. Fernandez Villegas (Delft University of Technology, The Netherlands)
Carbon fibre thermoplastic composites can be induction welded thanks to the electrical conductive nature of carbon fibre. Due to a locally contrained current flow more heat is generated at the edges of the composites. To counteract this so called edge effect (Cntd)

5.07-09 Influences of Laminate Parameters on the Induction Heating Behavior of CFRPC
S. Becker, P. Mitschang (Institut für Verbundwerkstoffe GmbH, Germany)
Induction heating provides a fast and contactless heating of thermoplastic carbon fiber reinforced polymer composites (CFRPC) and helps to make welding processes more efficient. Within this study the influences of fiber volume content (FVC) on the inductive heating behavior of thermoplastic CFRPC is assessed. (Cntd)

5.07-10 Effects of Carbon Fiber Heating Element on Resistance Welding Behavior of Woven CF/PPS Laminates
D. Tanabe (National Institute of Technology, Japan), F. Kubohori, K. Tamura, Y. Yamamoto, K. Nishiyabu (Kindai University, Japan)
This study aims to reveal the effects of various carbon fiber heating elements on resistance welding behavior of woven CF/PPS laminates. The effects of processing conditions such as applied current, conducting time and pressure, and also material conditions such as aspect ratio of joining area, PPS layer thickness (Cntd)

5.07-11 In-Situ Consolidation of Integrated Thermoplastic Fuselage Panels: The Future in Structural Comercial Aerocomposites
F. Rodriguez-Lence, M. I. Martin, K. Fernandez Horcajo (FIDAMC, Spain)
FIDAMC (Foundation for the Research, Development and Application of Composite Materials) has been investigating different technologies, under the frame of several research projects funded by Clean Sky initiatives and Spanish governmental entities, (Cntd)

14:45-16:45 Hall: MC2

5.10 | Processing and Manufacturing Technologies: Process Modeling I: Molding Simulations

Chair: **S. G.Advani**

5.10-01 Resin Impregnation Behavior in Continuous Carbon Fiber Reinforced Thermoplastic Polyimide Composites

S. Kazano, T. Osada, S. Kobayashi, K. Goto (Tokyo Metropolitan University Minami-Osawa, Japan)

In this study, CFRTPs using continuous carbon fiber yarn as a reinforcement and a thermoplastic polyimide which is excellent in heat resistance as a matrix resin were produced by Micro-Braiding, Film Stacking and Powder method.

5.10-02 New Simulation Technology for Compression Molding of Long Fiber Reinforced Plastics: Application to Randomly-Oriented Strand Thermoplastic Composites

S. Hayashi (JSOL Corporation, Japan)

A new simulation technology has been developed where fibers modelled by beams are coupled to a matrix modelled by solids that undergo r-adaptive remeshing. This technique has great potential to simulate compression molding of long fiber reinforced plastics with high accuracy.

5.10-03 Material Characterization for Compression Resin Transfer Molding Process Simulation

M. Vollmer, N. Tagscherer, S. Zaremba (TUM Technical University of Munich, Germany), D. Schultheiß (KDX Europe Composites R&D Center GmbH, Germany), P. Mertiny (University of Alberta, Canada), K. Drechsler (TUM Technical University of Munich, Germany)

The paper discusses experimental procedures to generate the needed input for CRTM simulation and presents results of a comprehensive material characterization.

5.10-04 A Mathematical Model to Predict Degree of Impregnation Considering Pressure and Tension Distributions

J. H. Myung, J. Yoon, W.-R. Yu (Seoul National University, Republic of Korea)

Unidirectional (UD) continuous carbon fiber (CF)-reinforced thermoplastic tapes are produced by passing CFs through an impregnation tank containing a thermoplastic resin. Impregnation is known to affect the mechanical properties (tensile strength, bending strength, elastic modulus, etc.) of CF UD tapes. (Cntd)

5.10-05 Permeability Characterization of Porouspreform during VARTM using Fractals

D. Adhikari, S. Gururaja (Indian Institute of Science, India)

Accurate characterization of permeability of the complex architecture of porous preform is the first step towards efficient and cost-effective resin impregnation to yield composite parts via vacuum assisted resin transfer molding (VARTM). (Cntd)

5.10-06 Development of a Procedure for Accurate Simulation of the Resin Transfer Moulding Process

G. Stamatopoulos, D. Modi, C. Lira (National Composites Centre (NCC), United Kingdom), N. Pantelelis (Synthesites, Belgium), M. Stojkovic (National Composites Centre (NCC), United Kingdom)

Numerical simulations can aid cost-effective optimisation of manufacturing processes such as Resin Transfer Moulding (RTM). To realise the full potential of numerical simulations, it is critical to validate the underlying models, algorithms, methods and datasets. (Cntd)

14:45-17:05 Hall: Kokkalis

2.08 | Materials Science: Graphene – Graphene-Based Composites

Chairs: **C. Galiotis, D. Papageorgiou**

2.08-07 Poly (Vinyl Alcohol)/Multilayer Graphene Composite Structures via Additional Manufacturing Route for Effective EMI Shielding Solutions: Study of Mechanical, Thermal and Electrical Properties

J. Joseph, P. Vijay, A. Sidpara, J. Paul (Indian Institute of Technology, India)

Advanced telecommunication devices now in common use have raised the levels of electromagnetic pollution around us demanding effective electromagnetic interference (EMI) shielding solutions. EMI shielding protects sensitive electronic equipments as well as living tissues from stray electromagnetic emissions. (Cntd)

2.08-08 Interlaminar Toughening of Carbon Fibre Reinforced Polymers using Graphene / Thermoplastic Inserts

C. S. Nagi (QinetiQ & University of Surrey, United Kingdom), S. L. Ogin, I. Mohagheghian, C. Crean (University of Surrey, United Kingdom), A. D. Foreman (QinetiQ, United Kingdom)

This paper outlines preliminary work developing graphene modified thermoplastic inserts to be used for the toughening of CFRP. The paper outlines laminate manufacture, mechanical testing and fracture analysis of graphene modified CFRP.

2.08-09 Graphene Reinforced Titanium (<150μm) Matrix Composites and its Properties

M. Gürbüz, T. Mutuk (Ondokuz Mayıs University, Turkey)

Recently, composite materials play a major role in the production of materials with superior properties in engineering applications. Composite materials for component are chosen components is because of weight saving for its relative stiffness and strength. (Cntd)

2.08-10 Graphene/Polyelectrolyte Layer-By-Layer Thin Films for Multifunctional Coatings
C. Vallés, R. J. Young, I. A. Kinloch (University of Manchester, United Kingdom), L. Burk, R. Mulhaupt (Albert-Ludwigs-University of Freiburg, Germany)
A layer-by-layer approach was developed to fabricate thin, highly ordered and conductive multilayer coatings, through alternating self-assembly of negatively charged TRGO and a positively charged polyelectrolyte (PEI) on a substrate to fabricate (PEI/TRGO)n coatings

2.08-11 3D Visualization of 'Real' Graphene in Nanocomposite and the Related Micromechanics
Z. Li, X. Ma, Y. Yu, T. J. A. Slater, R. J. Young, T. L. Burnett (School of Materials, United Kingdom)
Epoxy nanocomposites with different loadings of graphene nanoplatelets (GNP) are prepared. The X-ray computed tomography (CT) is used to identify and resolve individual GNP flake in the nanocomposites. It is found that the GNPs have variable geometry, defects density, waviness, number of layers (Cntd)

2.08-12 Polymer Composites Filled with DNA-Functionalized Graphene Nanoplatelets: Effects of DNA Modification on the Curing Behavior and Properties of PDMS-Based Matrices
M. G. Santonicola, E. Toto, S.Laurenzi (Sapienza University of Rome, Italy)
We present our recent progress on the development of biocompatible nanocomposites made of a silicone-based polymer matrix with tunable elasticity and DNA-functionalized graphene nanoplatelets for applications in biomedical and sensing devices.

2.08-13 EMI Shielding Effectiveness of Graphene Nanocomposites: Effects of Filler Loading and Thickness
S. Kashi (Deakin University, Australia), V. Perumal (RMIT University, Australia), R. Varley (Deakin University, Australia)
The excellent physical properties of graphene can be exploited to both reinforce and give functionality to polymeric matrices such as electromagnetic interference (EMI) shielding. Incorporation of graphene in a polymer imparts electrical conductivity and permittivity to the matrix (Cntd)

14:45-16:45 Hall: Lecture Room

2.01 | Materials Science: Bio-composites

Chairs: **A.Bismarck, A. Le Duigou**

2.01-07 COMBOO - A Novel Core Material for Composite Sandwich Structures from Renewable Sources
A. Loth, R. Förster (Beuth University of Applied Sciences, Germany)
COMBOO is a novel bamboo based honeycomb like core material for sandwich structures from renewable sources, with promising mechanical properties compared to conventional core materials. Fibre reinforcements with natural fibers and linseed oil based resins improve the ecological footprint.

2.01-08 Cactus-Based Solids and Bio-Composites for Energy Dissipation in Defence and Biomedical Applications
I. Zampetakis, A. Hetherington, A. Perriman, F. Scarpa (University of Bristol, United Kingdom)
Novel multiscale cactus fiber bio-composites and bio-inspired cactus based solids for applications in energy dissipation for defense applications

2.01-09 High Performance Composites Produced from Polyfurfuryl Alcohol: Enhancing the Process Ability at Short Cycle Times by Applying Hydrophilic Reinforcement
K. Resch-Fauster (Montanuniversitaet Leoben, Austria), J. Džalto (Institut für Verbundwerkstoffe GmbH, Germany), A. Anusic (Montanuniversitaet Leoben, Austria), P. Mitschang (Institut für Verbundwerkstoffe GmbH, Germany)
Approach for decreasing the processing times of PFA composites by applying hydrophilic bio-based fibers

2.01-10 Damping Behaviour of Bio-Inspired Natural Fibre Composites
W. Woigk, K. Masania, S. Gantenbein, E. Poloni, A. R. Studart (ETH Zurich, Switzerland)
Structural materials such as metals and fibre-reinforced plastics are stiff engineering materials used in many industrial fields. However, their high stiffness leads usually to the inability to dissipate energy via vibration damping. (Cntd)

2.01-11 Paper-Based Composites for Packaging Applications
M. Fortea-Verdejo, A. Ho (Universität Wien, Austria), H. Qian, R. K. Y. Li (City University of Hong Kong, Hong Kong), A. Bismarck (Universität Wien, Austria & Imperial College London, United Kingdom)
Hierarchical papers from nanocellulose and pulp fibres derived from bagasse are used to produce hierarchical PLA composites suitable for packaging applications, due to their high tensile strength and low oxygen transmission rate. This could offer a biobased and biodegradable solution for the waste problem we are currently facing.

2.01-12 (Ultra-)Low Grammage Bacterial Cellulose Nanopaper-Reinforced Polylactide Composite Laminates
M. Hervy (Imperial College London, United Kingdom), F. Bock (Imperial College London, United Kingdom & Hamburg University of Technology, Germany), K.-Y. Lee (Imperial College London, United Kingdom)
One of the rate-limiting steps in the large-scale production of cellulose nanopaper-reinforced polymer composites is the time consuming dewatering step to produce the reinforcing cellulose nanopapers. In this work, we present a method to reduce the dewatering time of bacterial cellulose (BC)-in-water suspension (Cntd)

14.45-16.45 Hall: MC3.2

1.01 | Applications: Aerospace

Chair: **Ch. Rekatsinas**

1.01-05 Optical Fiber Sensor Based In-Process Monitoring and Quality Assurance of Recent Aerospace Composites

N. Takeda, S. Minakuchi, A. Hamamoto (University of Tokyo, Japan)

1.01-06 Tunable Electro-Thermal System based on Orientation and Layup of Highly-Aligned Carbon Nanotube Webs

X. Yao (Queen's University Belfast, United Kingdom), S. C. Hawkins (Queen's University Belfast, United Kingdom & Monash University, Australia), B. G. Falzon (Queen's University Belfast, United Kingdom)

Directly drawn carbon nanotube (CNT) webs were previously studied, by the authors, as a promising heating element for an electro-thermal anti-icing/de-icing system. Further tailoring of these electro-thermal properties may be achieved by the novel approach of exploiting the effect of the orientation (Cntd)

1.01-07 Nanocomposite Layers for Spacecraft Protection: From Multiscale Numerical Model to Experimental Data

S. Laurenzi, F. Zaccardi, M. Semeraro, M.G. Santonicola (Sapienza University of Rome, Italy)

In space environment, the surfaces of a spacecraft interact with the surrounding charged particles. Depending on the orbit, this interaction can induce a significant absolute charge on the structures and/or a differential charge collected among components. These phenomena generate electrostatic discharges (Cntd)

1.01-08 Hierarchical Carbon Nanotubes Grown on 3D Woven Glass Fiber Preforms for Multifunctional Structural Composites Beams

F. Turgut (Istanbul Technical University, Turkey), G. Neje, B. Behera (Indian Institute of Technology, India), E. Ozden-Yenigun (Istanbul Technical University, Turkey & Royal College of Art, United Kingdom), H. Cebeci (Istanbul Technical University, Turkey)

Delamination and poor interfacial properties between matrix and reinforcement are main problems of laminated composite materials, and also limit their use in aerospace industry where durable, multifunctional and lightweight materials are of recent demand. (Cntd)

1.01-09 Improving Interlaminar Strength of Composite Laminates by Coating the Fibers with Cellulose Nanocrystals-Bonded Carbon Nanotubes

A. V. Kumar, A. Budhani, M. Tran, A. Asadi (Texas A & M University, USA)

Cellulose nanocrystals were used to disperse carbon nanotubes. Then they were introduced in composites to increase the interlaminar strength.

1.01-10 A Potential Failure Mode of Honeycomb Enhanced Silica-Based Thermal Protection Material

Z. Fang, K. Mao, L. Luo, X. Liang, H. Sun, Y. Zhang, H. Guo (Aerospace Research Institute of Materials & Processing Technology, China)

Honeycomb enhanced silica-based thermal protection materials are widely employed in the thermal protection system for various spacecrafts. The qualities of the material are evaluated by mechanical tests, nondestructive tests and arc-jet tests. After one ablation test, the surface of the material was fragmented, (Cntd)

14:45-16:05 Hall: MC3.3

2.13 | Materials Science: Nano Composites

Chair: **B. Fiedler**

2.13-06 Dispersion and Reagglomeration in Nanocomposites: The Effects of Plasma Functionalization and Morphology

P. Sangha, S. L. Evans, R. Pullin, M. J. Eaton (Cardiff University, United Kingdom)

Creating homogeneous dispersions in graphene/epoxy networks are essential to obtain good material properties, however the natural tendency of these materials to agglomerate results in this being difficult to achieve and maintain over time. This work investigates reagglomeration of graphene in epoxy over the period of a week.

2.13-07 Polymer Nanocomposites Reinforced with Porous Single-Walled Carbon Nanotube Preforms

Y. Oh, M. K. Um (Korea Institute of Materials Science (KIMS), Republic of Korea), M. F. Islam (Carnegie Mellon University, USA)

Since single walled carbon nanotubes (SWCNTs) exhibit exceptionally high Young's modulus and tensile strength, they have been considered an ideal additive for the reinforcement of the polymer composites. However, most polymer composites reinforced with carbon nanotube have shown limited mechanical improvement (Cntd)

2.13-08 CNT-Initiated Patterning of Poly(Urethane-Urea) in Ultrahigh Density Forests

J. L. Gair Jr. (U.S. Army Research Laboratory, USA), D. L. Lidston (Massachusetts Institute of Technology, USA), R. H. Lambeth, D. P. Cole, A. J. Hsieh (U.S. Army Research Laboratory, USA), H. A. Bruck (University of Maryland, USA), A. J. Hall, M. L. Bundy (U.S. Army Research Laboratory, USA), B. L. Wardle (Massachusetts Institute of Technology, USA)

The present work seeks to understand how increasing CNT volume fraction affects the molecular and morphological behavior of PUU synthesized in situ in densely-packed aligned-CNT forests.

2.13-09 Viscoelastic Response of High Volume Fraction Carbon Nanotube-Polymer Nanocomposite with Tailored Wettability and Controlled Morphology
Z. Semih Pehlivan (Sabanci University, Turkey), D. Ürk, Hülya Cebeci, O. Bulut (Istanbul Technical University, Turkey), F. Ç.Cebecia (Sabanci University, Turkey)
In this study, as grown VACNTs by CCVD method are subjected to a mechanical densification by a knock-down process to achieve high volume fractions. Through this process, the preferential alignment of CNTs is preserved in the horizontal direction and an easy delamination of VACNTs from the substrate (Cntd)

14:45-16:05 Hall: MC3.4

2.04 | Materials Science: Fiber-Hybrid Composites
Chair: **Y. Swolfs**

2.04-05 Ply Fragmentation in Interlayer Hybrid Composites Modelled Directly from the Fibre Break Statistics
F. Mesquita, Y. Swolfs, S. V. Lomov, L. Gorbatikh (KU Leuven, Belgium)
A fibre break model is developed to investigate ply fragmentation in unidirectional hybrid carbon/glass composites in tension. Ply fragmentation is more likely to occur when thinner carbon plies are used and it depends not only on the design of the laminate but also on the fibre break statistics.

2.04-06 In-Situ Fibrillation for Improved Mechanical Properties in Aramid-Glass Fibre Reinforced Polyamides
N. Candau, S. Galland, C. J. G. Plummer, V. Michaud (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), C. Pradille (Mat-xper, France), J.L. Bouvard, N. Billon (Mines ParisTech-PSL, France), H. Frauenrath (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland)
A new class of hybrid polyamide composites containing highly dispersed fibrillated aramid fibers that are covalently bonded to the matrix have been processed. A noticeable improvement in both crystallization kinetics and mechanical properties have been observed.

2.04-07 Approach for the Analytical Description of the Post-Damage Behaviour of Steel and Carbon Fibre Reinforced Hybrid Composites
B. Hannemann, J. Rehra, S. Schmeer, U. P. Breuer (Institut für Verbundwerkstoffe GmbH, Germany)
The presentation covers an approach to analytically describe the complex failure behaviour of a hybrid composite comprising two completely different types of continuous reinforcing fibres, namely brittle carbon fibres and highly ductile metal fibres.

14:45-16:45 Hall: Conference 1

2.09 | Materials Science: Green Composites
Chair: **A. Pegoretti**

2.09-07 Natural Fibers Actuators for Smart Bio-Inspired Hygromorph Biocomposites
A. Le Duigou (Université de Bretagne-Sud, France), J. Beaugrand (Biopolymères Interactions Assemblages-BIA, France), F. Scarpa (University of Bristol, United Kingdom), M. Castro (Université de Bretagne-Sud, France)
'Top-down biomimetic process" enables to solve engineering concerns thanks to solutions found in Nature. The motivation of the present work is to exploit the observed "natural" weakness of natural fibers i.e. their hygroscopic behaviour, so it can be used as a driving force in autonomously self-shaping smart materials. (Cntd)

2.09-08 Toughening Epoxy Composites Using Nano- and Microcellulose Modifiers
X. Deng (Imperial College London, United Kingdom & Singapore Institute of Manufacturing Technology, Singapore), A. J. Kinloch, S. Pimenta (Imperial College London, United Kingdom), G. T. Schueneman (The Forest Products Laboratory, U.S. Forest Service, USA), S. Sprenger (Evonik Nutrition & Care GmbH, Germany), A. C. Taylor (Imperial College London, United Kingdom), W. S. Teo (Singapore Institute of Manufacturing Technology, Singapore)
The fracture properties and toughening mechanisms of cellulose- and cellulose-rubber hybrid-modified epoxy polymers and glass-fibre (GF) composites are investigated. The cellulose modifiers used are microcrystalline cellulose (MCC) and cellulose nanocrystals (CNC), (Cntd)

2.09-09 Cellulose Nanopaper Composites Based on Nanocellulose from Elephant Manure
A. Mautner, K. Weiland (University of Vienna, Austria), A. Bismarck (University of Vienna, Austria & Imperial College London, United Kingdom)
Cellulose nanopapers are promising scaffolds for composites in which the nanopapers determine the mechanical performance of the composites. This study aims to find alternative raw materials for the preparation of nanocellulose and nanopapers.

2.09-10 Towards "Green" Viscoelastically Prestressed Composites
Y. Qin, K. S. Fancey (University of Hull, United Kingdom)
Viscoelastically prestressed polymeric matrix composites (VPPMCs) provide a means to improve mechanical properties without the need to increase composite component weight or section dimensions. In contrast with (conventional) elastically generated prestress, processing and product geometry limitations can be avoided, (Cntd)

2.09-11 Preparation of Self-Reinforced Poly(Lactic Acid) Composites Using Melt-Blown Microfibrous Mats

D. Vadas, D. Kmetykó, K. Bocz, G. Marosi (Budapest University of Technology and Economics, Hungary)

In this work, SR-PLA composites were produced using melt-blown PLA nonwoven mats as starting material. PLA was processed by the solvent-free melt-blowing technology. The obtained PLA mats were then processed via hot compaction technique and formed into SR-PLA composites.

2.09-12 Self-Reinforced Poly(Lactic Acid) Composites – Processing Conditions for Industrial Applications

J. Beauson, G. Schillani, B. Madsen (Technical University of Denmark, Denmark), L. Van der Schueren, G. Buyle (Centexbel, Belgium), H. Knudsen (Comfil ApS, Denmark)

This paper focuses on defining the optimal temperature conditions to process self-reinforced PLA composites developed in the European H2020 project BIO4SELF, which aims to use PLA composites in industrial applications.

14:45-16:45 Hall: MC3.5

Special Session 1 | In-Progress Monitoring and Quality Assurance of CFRP Structures

Chair: **N.Takeda**

SS1-01 Monitoring of Cure and Thermal Shrinkage in Interlayer-Toughened CFRP Laminates

K. Ogi, K. Mizukami (Ehime University, Japan), H. Matsutani, N. Sato (Toray Industries, Japan)

This paper presents in-process monitoring of cure and thermal shrinkage in unidirectional (UD) CF/Epoxy laminates with interlayers. The transverse strain during a cure-process was in-situ measured using an FBG sensor embedded in UD laminates with interlayers (IL) and without interlayers (NIL). (Cntd)

SS1-02 Data Assimilation for Estimation of Internal State of Composites

R. Matsuzaki, J. Ishizuka, T. Tachikawa (Tokyo University of Science, Japan)

The present study investigated internal state estimation during heat curing of composite materials. For estimation of the internal state with surface measurements, we used a data assimilation technique that integrated temperature measurements with numerical simulations of heat curing. (Cntd)

SS1-03 Cure Shrinkage And Shape Distortion of L-Shaped Composites with Interlaminar Toughened Layers

S. Minakuchi, K. Sawaguchi, N. Takeda (University of Tokyo, Japan)

This presentation reports decrease of spring-in angle due to viscoelasticity of interlaminar toughened layers. Fiber-optic-based strain measurement and finite element analysis are utilized to clarify the deformation mechanism.

SS1-04 Prediction of Microscale Resin Flow and Void Formation in Resin Transfer Molding using a Particle Method

S. Yashiro (Kyushu University, Japan), D. Nakashima (Shizuoka University, Japan)

This study developed a numerical procedure predicting the liquid flow to fiber bundles and void formation in RTM. The impregnation process predicted with an adequate inter-particle potential force for wettability agreed well with the observation.

SS1-05 Concurrent Measurements of Temperature and Strain using Tilted-FBG Sensors for Process Monitoring of CFRP Laminates

M. Sato, N. Nakamura (Tokyo University of Agriculture and Technology, Japan), S. Takeda (Japan Aerospace Exploration Agency-JAXA, Japan), T. Ogasawara (Tokyo University of Agriculture and Technology, Japan)

This study demonstrates the applicability of tilted-Fiber Bragg Grating (TFBG) sensor on the Structural health monitoring and process monitoring of CFRP structures. The measurement of strain and temperature were attempted utilizing TFBG sensor.

SS1-06 Homogenization Analysis for Thermo-Elasto-Viscoplasticity of CFRTP Laminates

K. Goto, M. Arai, N. Nogawa, S. Songglod (Nagoya University, Japan), T. Matsuda (University of Tsukuba, Japan), T. Ishikawa (Nagoya University, Japan)

The thermo-elasto-viscoplastic behavior of carbon fiber-reinforced thermoplastic (CFRTP) laminates was evaluated using the homogenization theory taking into account the time dependence of the relation between stress and strain. The thermo-elasto-viscoplastic constitutive equation was newly proposed (Cntd)

16:45-17:10 Hall: Exhibition Area

Coffee Break

17:10-19:10 Hall: Trianti

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level

Chairs: **K. Kose, S. Pinho**

3.10-11 Numerical Simulation of Two-Dimensional Crack Propagation
A. Cameselle-Molares, A. P. Vassilopoulos (École Polytechnique Fédérale de Lausanne-EPFL, Switzerland), J. Renart, A. Turon (Universitat de Girona, Spain), T. Keller (École Polytechnique Fédérale de Lausanne-EPFL, Switzerland)
A numerical investigation was carried out to simulate the experimental results previously obtained concerning two-dimensional in-plane crack propagation in laminated glass fiber-reinforced polymer (GFRP) plates. The plates were designed with an embedded circular pre-crack and subjected to quasi-static (Cntd)

3.10-12 Mode I Fracture Specimens Exhibiting Oscillatory Crack Migration
D. Mollenhauer (U.S. Air Force Research Laboratory, USA), S. Baril-Gosselin (National Research Council, Canada), E. Iarve (University of Texas at Arlington, USA), C. Li (National Research Council, Canada), D. Rapking, E. Zhou, M. Braginsky (University of Dayton Research Institute, USA)
Oscillatory damage propagation in cross-ply PMC double cantilever beam specimens was examined through analysis. Models include discrete representations of transverse matrix cracks via X-FEM and delamination damage via cohesive interface elements.

3.10-13 A Geometrically Nonlinear Floating Node Method for Damage Modelling of Composites
J. Zhi (National University of Singapore, Singapore), B.Y. Chen (Delft University of Technology, The Netherlands), T.E. Tay (National University of Singapore, Singapore)
Tremendous efforts have been put into the study of structural integrity and the understanding of failure mechanisms in composites. Geometric non-linearity, receiving few attention in coupon-level simulations, can play an important role in the design and analysis of larger structures. (Cntd)

3.10-14 The Effect of Damage on the Impact Resistance of Composite Materials
C. A. Edwards (University of Surrey & DSTL, United Kingdom), M. Helliker, B. J. J. (DSTL, United Kingdom), D. A. Jesson (University of Surrey, United Kingdom), R. L. Livesey (DSTL, United Kingdom), S. L. Ogin, M. Oldfield (University of Surrey, United Kingdom)
The current solution to a lack of understanding on the effects of repetitive low-level damage on armour is to periodically recall it. This paper reports preliminary studies on the effect of minor damage and the resulting impact resistance of a woven glass fabric reinforced polymer composite.

3.10-15 Prediction of random transverse cracking in laminates using deterministic and probabilistic fracture criteria
V. Vinogradov (Newcastle University, U.K.)
The paper addresses the problem of multiple transverse cracking in brittle cross-ply laminates subjected to a mechanical and/or thermal loading. The variational stress analysis and an energy based finite fracture criterion are chosen for this purpose. Using a deterministic fracture criteria, (Cntd)

3.10-16 Finite Element Analysis and Experimental Testing of Non-Crimped Fabric Laminates Under "Compact Tension"
D. Gouskos (Imperial College London, United Kingdom)
The translaminar fracture toughness properties of triaxial [+45o/0o/-45o] carbon fibre/epoxy NCF plates are examined through a "Compact Tension" load case. Numerical simulations were performed with the use of LaRC05 failure model in ©Abaqus CAE 2017.

17:10-18:50 Hall: Mitropoulos

3.13 | Material and Structural Behavior – Simulation and Testing: Joining of Composites

Chair: **St. Goutianos**

3.13-13 A New Path to Lightweight Sheet Metal Structures Strengthened by In Situ Joined Fibre Reinforced Thermoplastic Tapes
H. Husmann, P. Groche (TU Darmstadt, Germany)
A novel joining technique for the local reinforcement of sheet metal structures using continuous fibre reinforced thermoplastic tape is presented. For this purpose, residual stresses subsequent to a conjoint forming are used to form a frictional connection.

3.13-14 Application of Mesh Sheet Energy Directors to Ultrasonic Welding and Single Lap Joint Strength of CF/PPS Composites
S. Takeda (Japan Aerospace Exploration Agency, Japan), J. D. Tanks (Tokyo Institute of Technology, Japan), S. Sugimoto, Y. Iwahori (Japan Aerospace Exploration Agency, Japan)
Ultrasonic welding technology for thermoplastics has developed quickly in recent years. For aircraft structural applications, this joining technique shows promise over standard epoxy adhesives, resistance welding, or mechanical fastening in terms of scalability and efficiency. (Cntd)

3.13-15 FEM Analysis of Stresses in Adhesive Single-Lap Joints with Non-Linear Materials Under Thermo-Mechanical Loading
N. J. Al-Ramahi (Luleå University of Technology, Sweden & Middle Technical University, Iraq), R. Joffe (Luleå University of Technology & Swerea SICOMP AB, Sweden), J. Varna (Luleå University of Technology, Sweden)
This work presents a numerical model which is dealing with thermo-mechanical loads of single lap joints that is valid independently on the material model and type of the applied load.

3.13-16 Enhancing the Fracture Toughness of Adhesively Bonded Joints using 3D Printed Structured Interfaces
L. García-Guzmán, Luis Távara, J. Reinoso, J. Justo, F. París (Universidad de Sevilla, Spain)
The recent appearance of Additive Layer Manufacturing (ALM or 3D printing) techniques for composites allows different kind of interfaces to be designed. To explore the applicability of such techniques, the present investigation focus on a well stablished test used to measure the interlaminar fracture toughness (Cntd)

3.13-17 Theoretical and Experimental Investigation of a Double-Lap Adhesive Joint with Glass Fiber Reinforced Polymer to Plywood Interface
C. Lester, M. Rosemeier, M. Bätge, A. Antoniou (Division Structural Components, Fraunhofer IWES, Fraunhofer Institute for Wind Energy Systems, Germany)
A full-scale wind turbine blade test load introduction frame must be modified for application in sub-component testing. A generic small-scale load introduction frame, a double-lap joint, was designed and proved as a concept through analytical, numerical and experimental validation.

17:10-18:50 Hall: Skalkotas

3.08 | Material and Structural Behavior - Simulation and Testing: Fatigue of Composites
Chair: **D. Zarouchas, V. Carvelli**

3.08-07 Similarities and Differences in Microdamage Mechanisms During Tensile Quasi-Static and Cyclic Loading of NCF Composites
H. Ben Kahla (Luleå University of Technology, Sweden & Université de Lorraine, France), J. Varna (Luleå University of Technology, Sweden), Z. Ayadi (Université de Lorraine, France)
The present work focuses on a comparative study of damage mechanisms and their effect on the stiffness reduction for [-45/90/45/0]s CF/EP NCF laminates under quasi-static and tension–tension cyclic loading.

3.08-08 Progressive Damage Modelling of Notched Carbon/Epoxy Laminates Under Tensile Fatigue Loadings
J. Llobet, P. Maimí, A. Turon (Girona University, Spain), B.L.V. Bak, E. Lindgaard (Aalborg University, Denmark), Y. Essa, F. M. de la Escalera (AERNNOVA Engineering Solutions Iberica S.A, Spain)
This work aims to simulate the initiation and propagation of intralaminar and interlaminar damage in open-hole carbon/epoxy laminates subjected to tension-tension fatigue loadings. The model is defined in the framework of damage mechanics and implemented as a user material subroutine in Abaqus/Explicit. (Cntd)

3.08-09 Effects of Load Interruption on the Fatigue Life of GFRP Composites
A.Vahid Movahedi-Rad, T. Keller, A. P. Vassilopoulos (Ecole Polytechnique Fédérale de Lausanne-EPFL, Switzerland)
The paper investigates the effect of load interruptions on the fatigue life of angle ply glass fiber reinforced composite laminates.

3.08-10 Methodical Approach for Simulating the Vibration of Damaged Fibre Reinforced Composite Rotors under Consideration of Aerodynamic Influences
I. Koch (Technische Universität Dresden, Germany), B. Beirow (BTU Cottbus-Senftenberg, Germany), A. Filippatos (Technische Universität Dresden, Germany), A. Kühhorn (BTU Cottbus-Senftenberg, Germany), M. Gude (Technische Universität Dresden, Germany)
Two fundamental possibilities have been presented to determine the aerodynamic damping of damaged composite disks. The first and more sophisticated considers the aeroelastic coupling and hence, the computation of aerodynamic damping by means of aerodynamic influence coefficients, (Cntd)

3.08-11 A Model for the Mixed Mode Crack Propagation in Composite Laminates under Cyclic Loadings
P. A. Carraro, M. Quaresimin (University of Padova, Italy), J. A. Glud (Aalborg University, Denmark), J. M. Dulieu-Barton, O. T. Thomsen (University of Southampton, United Kingdom & Aalborg University, Denmark), L. C.T. Overgaard (Aalborg University, Denmark)
A criterion for the mixed mode fatigue propagation of intra- and inter-laminar cracks in composite laminates is presented. The model is based on the observation of the damage mechanisms at the micro-scale. A multi-scale strategy is adopted.

17:10-19:10 Hall: Multi Purpose Room

3.06 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Impact – Crash – Blast
Chair: **F. Aymerich**

3.06-13 Experimental Characterisation and Modelling Of RTM-6 Visco-Elastic Behaviour at High Strain Rates in Tension
T. Fourest, J. Berthe (DMAS, ONERA, France)
To accurately predict the response of Carbon Fibre Reinforced Polymers (CFRP) structures subjected to high speed loading such as crash and impact, the visco-elastic behaviour of the material should be taken into account. An approach to study the dependency of CFRP material is to study the strain-rate dependency (Cntd)

3.06-14 Evaluation of the Strain Rate Dependent Behavior of a CFRP using two Different Hopkinson Bars
H. Paul, M. Isakov, N. Ledford (Ernst-Mach-Institut, Germany), S. Nagasawa (Subaru Corporation, Japan), M. May (Ernst-Mach-Institut, Germany)
Results for one CFRP material characterized comprehensively in different rate dependent configurations using the Split Hopkinson Bar method will be shown. The importance of carefully designing the specimen, mounting concept and testing approach for each configuration will be highlighted.

3.06-15 Effect of Temperature and MWCNTS on Low Velocity Impact Response of CFRP Laminates
A. Calzolari (ITW Test and Measurement Italy, Italy), F. Sarasini, J. Tirillò, L. Lampani (Sapienza University of Rome, Italy)
This experimental work addresses the effect of temperature and MWCNTs on the response of carbon fibre reinforced epoxy matrix (CFRP) laminates under low impact velocity. The test temperature ranged from +80 °C down to -40 °C while two sample configurations were examined, namely cross-ply and quasi-isotropic. (Cntd)

3.06-16 Dynamic Characterization of Interlaminar Toughness in Carbon Fibre Epoxy Composite Laminates
M.A. Riezzo (IMDEA Materials Institute & Universidad Politécnica de Madrid, Spain), M. Simmons (Hexcel Composites, United Kingdom), C. González (IMDEA Materials Institute & Universidad Politécnica de Madrid, Spain), F. Sket (IMDEA Materials Institute, Spain)
In this work, the rate dependence of mode I interlaminar fracture laminates for three different materials systems, two unidirectional UD carbon-fibre epoxy composite laminates and one RTM plain woven fabric laminate have been investigated over a wide range of loading rates (0.5 mm/min – 500 mm/s) (Cntd)

3.06-17 Deformation and Failure of Multi-Layered Fibre-Metal-Laminates Subjected to Highly-Dynamic Loadings Conditions
J. Richter (Technische Universität Dresden, Germany), J. Wiegand (Compact Composite Impact Engineering Ltd, United Kingdom), M. Kuhtz, A. Hornig, M. Gude (Technische Universität Dresden, Germany)
The deformation and failure behaviour of FML subjected to impact loading conditions are investigated. For this, experimental results from drop weight tower tests are numerically evaluated using LS-DYNA and different material modelling approaches.

3.06-18 Micro-Scale Impact Test System for Assessing Damage Propagation in Cross-Ply Thermoplastic Laminates
A. Yudhanto, H. Wafai, G. Lubineau (King Abdullah University of Science and Technology (KAUST), Saudi Arabia), N. Verghese, R. Yaldiz (T&I Composites, The Netherlands)
We developed a micro-scale impact test system to observe transverse crack and delamination in cross-ply laminates under impact. The system mainly consists of custom-made 3-point bending test setup with two stiff springs, high-speed camera and force measurement instruments. (Cntd)

17:10-18:30 Hall: MC3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chair: **V. Michaud**

5.07-12 Effect of Processing Parameters on Quality and Strength in Thermoplastic Composite Injection Overmoulded Components
M. A. Valverde (University of Bristol, United Kingdom & Technical University Dresden, Germany), R. Kupfer (Technical University Dresden, Germany), L. F. Kawashita (University of Bristol, United Kingdom), M. Gude (Technical University Dresden, Germany), S. R. Hallett (University of Bristol, United Kingdom)
Overmoulding allows for the manufacture of thermoplastic composites with high mechanical properties and geometric complexity. The quality of overmoulded CF-PPS ribbed plates, manufactured at a range of processing conditions, is investigated via mechanical testing and optical microscopy.

5.07-13 Influence of Process Parameters on the Quality of Carbon/pekk Laminates Manufactured by Out-Of-Autoclave Consolidation
F. Saffar (Université Paris Saclay & IMT Lille Douai, France), C. Sonnenfeld, P. Beauchêne (Université Paris Saclay, France), C-H. Park (IMT Lille Douai, France)
We present the identification of the process parameters of out-of-autoclave manufacturing to obtain a good consolidation of thermoplastic laminates. A monitoring technique of the laminates manufacturing allows to identify two major consolidation phenomena: the one at Tg and the other at Tm.

5.07-14 Impact of Processing Parameters on Void Content and Mechanical Properties of PEEK/CF Thermoplastic Composites
D. Saenz-Castillo, S. Calvo, F. Rodriguez-Lence (FIDAMC, Spain), A. Güemes (Polytechnic University of Madrid, Spain)
CF/PEEK laminates with different porosity levels have been manufactured and characterize to obtain relations between void conten, ultrasonic C-Scan and material properties.

5.07-15 Effect of Process- and Annealing-Induced Shrinkage on the Thermomechanical Properties of Glass Fiber-Reinforced Polypropylene
M. Mulle, H. Wafai, A. Yudhanto, G. Lubineau (King Abdullah University of Science and Technology (KAUST), Saudi Arabia), R. Yaldiz, W. Schijve, N. Verghese (SABIC, T&I Composites, the Netherlands)
The influence of static hot-press- and double-belt press-induced shrinkage and annealing on the thermomechanical behavior of unidirectional laminates made of continuous glass fiber-reinforced polypropylene is investigated using embedded FBGs.

17:10-18:30 Hall: MC2

5.10 | Processing and Manufacturing Technologies: Process Modelling II: Cure Kinetics

Chair: **N. Boyard**

5.10-07 Heating Rate Limits in Fast Cure Processing of Thick Carbon Fibre Laminates

G. Voto (Cranfield University, United Kingdom), L. Sequeira (Hexcel Composites Ltd., United Kingdom), A. A. Skordos (Cranfield University, United Kingdom)

A 1-D Finite Element cure model has been implemented in a Microsoft Excel spreadsheet to facilitate the design of accelerated cure process using simulation. The limits of what can be achieved through cure cycle optimisation are established.

5.10-08 Analysis of Residual Stresses Inherited During Manufacturing of Carbon-Epoxy Composites with Concentrator

D. A. Bondarchuk, B. N. Fedulov (National Research University, Russian Federation)

In the present study, the effect of specimen sizes on the residual stresses inherited during manufacturing of IM7/8552-1 carbon-epoxy composites with concentrator was investigated. The first part of the research is devoted to the understanding of residual stresses in regular specimens during cure cycle (Cntd)

5.10-09 Optimal Cure Cycles for Manufacturing of Thick Composite Parts using Multi-Objective Genetic Algorithms

G. Struzziero, J. Teuwen (Delft University of Technology, Netherlands)

The paper addresses the multi-objective optimization of the cure stage of a Vacuum Assisted Resin Transfer Molding process for ultra-thick components manufacturing

5.10-10 Numerical Simulation and Analysis of Curing Deformation of Stiffened Composite Structure

T. Jiang, S. Li, Q. Wang, X. Liu, Z. Guan (Beihang University, China)

A non-liner elastic finite element analysis method for predicting the curing deformation of composite structures was established in this paper. The method simulated the entire curing process of composite materials and simplified resin during the curing process into two states: rubbery state and glassy state. (Cntd)

5.10-11 High Accuracy Prediction of Temperature Profiles in Composite Parts During Autoclave Curing

K. Noma, M. Kamiya (Mitsubishi Heavy Industries, Ltd., Japan)

This paper addresses high accuracy prediction of temperature profiles in composite parts during autoclave curing by using finite element process modeling software, COMPRO. To improve prediction accuracy of thick composite part made of thermoset matrix composites, the appropriate measuring method for thermo-physical properties (Cntd)

17:10-19:10 Hall: Kokkalis

2.08 | Materials Science: Graphene – Graphene-Based Composites

Chair: **D. Papageorgiou**

2.08-14 Axial Reinforcement of Unidirectional Composites by Self-aligned Graphene

J. Chu, R. J. Young, T. J. A. Slater, T. L. Burnett, B. Coburn, Z. Li (University of Manchester, United Kingdom)

It is shown that the addition of 2% by weight of graphene to the matrix of a UD-reinforced carbon fiber epoxy composite can lead to a significant enhancement in axial mechanical properties. It is found that the stiffness of the composites can be increased by the order of 10 GPa accompanied by an increase in strength of 200MPa.

2.08-15 Alignment of Magnetite-Graphene Nanoplatelets in Epoxy Matrices using Low Magnetic Fields

K. Gkaliou, J. Hall, P. R. Davies, S. Pattisson, C. Dyer, M. J. Eaton (Cardiff University, United Kingdom)

Graphene nanoplatelets (GNPs) are an attractive nano-filler due to remarkable mechanical, electrical and thermal properties. Their high anisotropy has inspired researchers to focus on their alignment in polymer matrices. Such polymer composites would present interesting and desirable anisotropic behavior. (Cntd)

2.08-16 Effects of Microstructureal Arrangement of Graphene Sheets on Thermal Conductivity of Polymeric Composites

S. L. Bai, Y. Zhao, Y. Zhang, H. Fang (Peking University, China)

The strategies to fabricate three-dimensional (3D) graphene structures as well as their filled polymeric composites are summarized based on our recent works and other publications. The focus is put on thermal conductivity of graphene filled polymeric composites.

2.08-17 Influence of Carbon Nanoparticle Geometry in Epoxy Matrix on Mechanical Properties and Failure Initiation Regarding the Size Effect

C. Leopold, T. Augustin, T. Schwebler (Hamburg University of Technology, Germany), W. V. Liebig (Karlsruhe Institute of Technology KIT, Germany), H. Wittich, B. Fiedler (Hamburg University of Technology, Germany)

The influence of a carbon nanoparticle modification on damage behaviour and mechanical properties of epoxy is investigated regarding size effects, by comparing the different damage mechanisms in dependence of the nanoparticle morphology.

2.08-18 The Effect of Specific Surface Area of Graphene Nanofillers on Interlaminar Fracture Toughness of Multi-Scale Fiber-Reinforced Epoxy Composites
C. Kostagiannakopoulou, N. Papachristopoulos, V. Kostopoulos (University of Patras, Greece)
The goal of the present study is to investigate the influence of Specific Surface Area (SSA) of Graphene Nano Platelets (GNPs) on the fracture properties of carbon fiber reinforced polymer (CFRP) laminates. The results indicate that the introduction of GNPs into the epoxy matrix improved Mode I (Cntd)

2.08-19 A Strategy Towards Synergy by Combining Long Vertically-Aligned Carbon Nanotubes and Graphene in Epoxy Nanocomposites
S. Kumar, J. Owen (Queen's University Belfast, United Kingdom), S. C. Hawkins (Queen's University Belfast, United Kingdom & Monash University, Australia), B. G. Falzon (Queen's University Belfast, United Kingdom)
Due to the miniaturization of electronics devices, the demand for polymer nanocomposite materials, with enhanced electrical and thermal properties, has attracted significant interest. Graphene and carbon nanotubes (CNT) have emerged as promising nanostructured fillers for polymer nanocomposites (Cntd)

17:10-19:30 Hall: **Lecture Room**

2.01 | Materials Science: Bio-composites
Chairs: **A. Bismarck, A. Le Duigou**

2.01-13 Moisture Induced Hygroscopic and Mechanical Properties of Hemp Reinforced Biocomposite
S. Requile, A. Le Duigou, A. Bourmaud, C. Baley (University Bretagne Sud, France)
Biocomposites reinforced with hemp fibres present a high potential for valorisation in new industrial applications due to their intrinsic mechanical characteristics. To reach certain markets, it is unavoidable to validate their behaviour and durability in humid and water environments.

2.01-14 Mechanical behaviour of Hemp Fibre Composites in Relation to their Microstructure by Micro Strain Mapping, Computed Tomography, and Biochemical Analysis
C. A. Fuentes, P. Willekens (KU Leuven, Belgium), J. Petit (Wageningen University and Research, The Netherlands), J. Witters, Y. Ruan (KU Leuven, Belgium), J. Müssig (HSB – City University of Applied Sciences Bremen, Germany), L. M. Trindade (Wageningen University and Research, The Netherlands), A.W. Van Vuure (KU Leuven, Belgium)
This manuscript describes the effects of alterations in biochemical composition on structural morphology and the mechanical behaviour of elementary and technical fibres of hemp used for composite applications. Full-field strain measurement at the micro-scale during tensile loading was used for evaluating both, (Cntd)

2.01-15 Experimental Investigation on the Mechanical Properties of Microcrystalline Cellulose Reinforced EVOH and Nylon Composites
G. Graninger, S. Kumar, B. G. Falzon (Queen's University Belfast, United Kingdom)
Microcrystalline cellulose is combined with EVOH and Nylon to create engineering thermoplastic composites. The influence of varied process parameters introducing different shear forces on the dispersion and mechanical properties is investigated.

2.01-16 Dimension Stability and Thermomechanical Characterization of Maize Starch Reinforced with Agave Salmiana Fiber Composites
A. Reyes-Samilpa (Instituto Politécnico Nacional, México), R. Fangueiro (Campus de Azurém, Portugal), J. A. Reyes-Agüero (Universidad Autónoma de San Luis Potosí, México), M. C. Gutiérrez (Instituto Politécnico Nacional, México)
Variety Xa'mni of Agave salmiana fiber was used as reinforcement material on bio-composites made of plasticized maize starch. Formulation with 30% content of these fibers showed enhanced thermomechanical properties compared to pure polymeric matrix.

2.01-17 Valorization of Waste Fibres from Posidonia Oceanica Seaweeds in a Bio-Composite: Influence of Fibre Treatment and Ageing on Properties
E.Y. Mahamat Saleh, L. Belec, S. Berlioz, J.F. Chailan (Université de Toulon, France)
The valorization of Posidonia Oceanica seaweed as a filler in a bio-based epoxy matrix is studied. The relevancy of different alkali treatments of fibres is analyzed. Physicochemical and thermo-mechanical tests are performed. The hygrothermal behaviour of the bio-composite is characterized.

2.01-18 Better Through Synergy: Hybridised Cellulose for Nanopaper Composites
F. Mayer, A. Mautner (University of Vienna, Austria), K.-Y. Lee (Imperial College London, United Kingdom), A. Bismarck (University of Vienna, Austria & Imperial College London, United Kingdom)
Nanopapers for laminate composite manufacture were prepared from blends of differently treated bacterial cellulose nanofibres. The mechanical properties of these hybridised nanopapers were investigated via tensile testing.

2.01-19 Natural Fiber Composites with Encymatically Enhanced Fibre Matrix Adhesion
H. M. Brodowsky (Leibniz-Institut für Polymerforschung Dresden, Germany)
The interphase between fibre and matrix plays an essential role for the composites' properties. Conventional reinforcing fibers such as glass, aramid or carbon fibres are usually treated with a sizing or coating in order to improve the adhesion to the polymer matrix. (Cntd)

17:10-18:10 Hall: MC3.2

1.01 | Applications: Aerospace

Chair: **T. Tsotsis**

1.01-11 Experimental Study of Composite Structures Repairs Using Additive Manufacturing Technologies

J. Justo (Universidad de Sevilla, España), F. Moreno, M. Jiménez, F. Simón (Element Materials Technology Seville, España), F. París (Universidad de Sevilla, España)

This study aims to establish a basis for a new automated repair system that improves the quality of the final parts and optimizes their cost, minimizing the time and material waste used in the development of repair patches.

1.01-12 Experimental and Micromechanics-Based Numerical Analysis of High-Velocity Impact on Laminated Composite Plates

D. K. Siorikis, C. V. Nastos, N. A. Chrysochoidis, T. C. Theodosiou, C. S. Rekatsinas, D. A. Saravanos (University of Patras, Greece), C. Codines, F. Abdi (Alpha Consulting Services, Italy), E. M. Gonzalez (Airbus, Spain)

A computationally efficient model for the simulation of high-velocity impact events on composite laminated plate structures is developed, which utilizes a micromechanics-based model for the prediction of material properties and intraply failure. GENOA multi-scale progressive analysis is exploited, (Cntd)

1.01-13 Effects of Moisture on Out-of-Autoclave Composite Repairs for Primary Aircraft Structures

H. M. Chong, S. P. Ng, E. Kok, S. Daynes, S. Feih (Singapore Institute of Manufacturing Technology, Singapore)

This paper reports on the effects of moisture on uncured prepreg prior to out-of-autoclave composite repairs for aircraft primary structures. Short term exposure (up to 30 minutes) of typical environment atmospheric conditions was found to cause a failure of the repair.

17:10-19:10 Hall: MC3.3

2.13 | Materials Science: Nano Composites

Chair: **J.J. Vilatela**

2.13-09 Characterization of Chemically modified Nanodiamond Reinforced Natural Rubber Nanocomposite

T. Kato, S. Morimune-Moriya (Chubu University, Japan)

Nanodiamond (ND) reinforced natural Rubber (NR) nanocomposites were prepared and the structures and the properties of the nanocomposites were investigated. We prepared three kinds of chemically modified ND in order to obtain the strong interaction between ND and NR. (Cntd)

2.13-10 Cure Kinetics and Phase Morphology of CNT Modified Multi-Phase Epoxy Nanocomposites

H. Ma (Queen's University Belfast, United Kingdom), M. A. Aravand (Queen's University Belfast & Northern Ireland Advanced Composites and Engineering (NIACE) Centre, United Kingdom), S. C. Hawkins (Queen's University Belfast, United Kingdom & Monash University, Australia), B. G. Falzon (Queen's University Belfast & Northern Ireland Advanced Composites and Engineering (NIACE) Centre, United Kingdom)

This study is to characterise the multiphase epoxy nanocomposites containing functionalised carbon nanotubes (CNTs) and phase-separating thermoplastic (TP) microparticles. Two types of nanocomposite were prepared based on two epoxy resins, (Cntd)

2.13-11 Tuning Polymer Crystallinity

K. Chrissopoulou (Foundation for Research and Technology, Greece), H. Papananou, E. Perivolari, S. H. Anastasiadis (Foundation for Research and Technology & University of Crete, Greece)

We show the control of the degree of polymer crystallinity in poly(ethylene oxide), PEO, nanohybrids when layered silicates with galleries of ~1nm or when nanoparticles of different sizes, i.e., smaller, comparable and larger than the polymer radius of gyration are utilized as additives.

2.13-12 Mechanical, Thermal and Morphological Characteristics of Poly(Methyl Methacrylate) (PMMA) Nanocomposites Reinforced with Cu-Cr Layered Double Hydroxide

M. Kumar, H. Rocha, J.P. Nunes (University of Minho, Portugal), G. Pugazhenthi (Indian Institute of Technology, India)

The enhancement of polymer nanocomposites properties may be attained by achieving a more uniform distribution of nanofiller in the matrix as well as through the improvement of the compatibility between them. The nanocomposite properties are greatly dependent from the research being made on the role played (Cntd)

2.13-13 The Effect of Organic Nano-Particles on the Hydrothermal Ageing of Nanoclay-Epoxy Nanocomposites. A Parametric Study

D. Tsimourtos, E. Kollia, C. Kostagiannakopoulou, V. Kostopoulos (University of Patras, Greece)

2.13-14 Graphene Filled Polyetheretherketone (PEEK) Composites

A. Alvaredo-Atienza, J. P. Fernández-Blázquez (IMDEA Materials Institute, Spain), P. Castell (Fundación AITIIP, Spain), R. Guzmán de Villoria (FIDAMC, Spain)

Graphene nanoplatelets (0.5, 1, 5, 10% wt.)/PEEK composites were made by a semi-industrial extrusion-compounding process followed by an injection-moulding. The nanofiller were homgeneiously distributed for all the samples, however, only the 0.5 and 1%wt. samples were dispersed. (Cntd)

17:10-19:10 Hall: MC3.4

2.06 | Materials Science: Fire and Lighting Strike

Chair: **S. Tsampas**

2.06-01 Experimental Study of Lightning Direct Effects on Carbon Fiber Reinforced Epoxy, Bismaleimide and Peek Composites

S. Kamiyama, T. Ogasawara (Tokyo University of Agriculture and Technology, Japan), Y. Hirano, T. Okada (Japan Aerospace Exploration Agency-JAXA, Japan), T. Sonehara (Shoden Corporation, Japan)

This study examined lightning strike damage to cross-ply carbon fiber reinforced epoxy (CF/epoxy), bismaleimide (CF/BMI), and polyetheretherketone (CF/PEEK) composite laminates to clarify the effects of the resin properties on lightning strike damage to CFRP laminates.

2.06-02 Polyaniline: An All Polymeric New Lightning Strike Protection Material for FRP Composites

V. Kumar, T. Yokozeki (University of Tokyo, Japan), T. Goto, T. Takahashi (Yamagata University, Japan), S. Das (University of Tokyo, Japan)

In the current work, an all polymeric conductive adhesive resin system as LSP and GFRP prepared by the same electrically conductive resin are checked for their effectiveness against simulated lightning strike protection. Polyaniline is used make thermosetting resin electrically conductive and this resin system (Cntd)

2.06-03 Chemical Deposition of Copper as a Novel Solution for Lightning Strike Protection of Carbon Fibre Reinforced Polymer Parts

S. de Juan (FIDAMC & Universidad Carlos III de Madrid, Spain), B. Lopez-Romano (FIDAMC, Spain), E. Gordo, A. Jiménez-Morales (Universidad Carlos III de Madrid, Spain)

In this research, chemical deposition of copper is proposed as a novel competitor for lightning strike protection (LSP) of carbon fibre reinforced polymer (CFRP) structures. Specimens were cut off from flat epoxy/carbon fibre panels manufactured by resin transfer moulding (RTM) and auto-catalysed copper deposition (Cntd)

2.06-04 Decomposition Modelling of Carbon Fibers-PPS Composites Exposed to Fire

Y. Carpier, F. Barbe, B. Vieille, A. Coppalle (GPM Rouen, France)

A methodology is proposed to identify the thermal properties of a composite material and its constituants exposed to radiant heat flux with a cone calorimeter. In order to avoid compensation effects between the parameters, they are identified in several steps with genetic algorithms at different scales (Cntd)

2.06-05 Thermomechanical Damage Models for Type IV Hydrogen Vessels Subjected to Fire

C. Mercadé, D. Halm, T. Rogaume (University of Poitiers, France)

Numerical tools able to accurately simulate the time to failure of a composite pressure vessel submitted to a severe thermal heat flux are presented. They are able to capture the transition between burst and leak, depending on the inner pressure

2.06-06 Post-Mortem Investigation of Thermal Damage in Carbon/Epoxy Composite Materials Caused by Simulated Lightning Strikes

G. Zhou, A. Ashby, J. Golding, X. Bao (Loughborough University, United Kingdom), W. Sun (3C-Power Ltd, China)

This work investigated experimentally the thermal damage characteristics of carbon/epoxy laminates caused by simulated lightning strikes using TGA aided SEM-EDS and FTIR-ATR. A range of locations were selected on each damaged panel and the FTIR ATR examinations of those locations provided the infrared spectra (Cntd)

17:10-19:10 Hall: Conference 1

2.07 | Materials Science: Foams - Cellular and Lattice Materials

Chair: **L. Sorrentino**

2.07-01 Characterisation and Modelling of Polymeric Foams for Applications in Energy Absorbing Structures

I. Carranza (University of Surrey & McLaren Automotive Ltd., United Kingdom), A. D. Crocombe, I. Mohagheghian, P. A. Smith (University of Surrey, United Kingdom), A. Sordon, G. Meeks (McLaren Automotive Ltd., United Kingdom)

Two polymeric foams have been characterised to develop a simple calibration process for extracting the parameters which are required by the material model available in the commercial FE package Abaqus. Indentation tests with DIC were conducted to study the validity of the proposed method.

2.07-02 Simulation and Optimization of the Load Introduction Geometry of Additively Manufactured Lattice Structure Specimens

S. Drücker, S. Inman, B. Fiedler (Hamburg University of Technology, Germany)

2.07-03 Composite Foams with Anisotropic Structural and Functional Properties

L. Sorrentino (Consiglio Nazionale delle Ricerche, Italy), M. D'Auria (Consiglio Nazionale delle Ricerche & Università degli Studi del Sannio, Italy) R. Pantani (Università di Salerno, Italy), D. Davino (Consiglio Nazionale delle Ricerche & Università degli Studi del Sannio, Italy)

Composite polymeric foams were reinforced with particles properly assembled along preferential directions by means of a magnetic field during foaming. The peculiar distribution of particles imparted strong structural and functional properties.

2.07-04 Experimental Dynamic Properties of ABS Cellular Beams Produced Using Additive Manufacturing

A. Grammatikopoulos, J. Banks, P. Temarel (University of Southampton, United Kingdom)

Specimens with a cellular (box-shaped) cross section are produced using additive manufacturing and subjected to both 3-point bending tests and impact exctitation tests to determine the quasi-static and the dynamic flexural moduli.

2.07-05 Development of Porous Polymer Materials Based on Dicyclopentadiene from High Internal Phase Emulsion with Surface Modification

D. Rusakov (University of Vienna, Austria), P. Khakhulin (Tomsk Polytechnic University, Russia & University of Vienna, Austria), A. Menner (University of Vienna, Austria), A. Bismarck (University of Vienna, Austria & Imperial College London, United Kingdom)

Emulsion templated high porosity polydicyclopentadiene (PDCDP) has been prepared by Ring Opening Metathesis Polymerisation (ROMP). Unsaturated double bonds in the macroporous PDCDP surface were modified by Heck reaction for aminatation and radical addition reaction to introduce trifluoro-methyl groups. (Cntd)

2.07-06 Pushing Lots of Air Into PEEK and PEKK

A. Menner, D. Rusakov (University of Vienna, Austria), A. Bismarck (University of Vienna, Austria & Imperial College London, United Kingdom)

Here we present our first high porosity PEEK and PEKK foams obtained by a modified TIPS process, which is based on the temperature dependent solubility of PEEK and PEKK in specific aprotic high boiling point solvents. Up to 90% porous PEEK and PEKK with pore sizes of approx. 2 µm have been achieved.

17.10 -18.30 Hall: MC3.5

3.04 | Material and Structural Behavior - Simulation and Testing: Ductille and Pseudo-Ductille Composites

Chairs: **M. Wisnom, S. Pimenta**

3.04-01 The HiPerDiF (High Performance Discontinuous Fibres) Technology for the Manufacturing of Pseudo-Ductile Quasi-Isotropic Aligned Discontinuous Fibre Composites

M. L. Longana (University of Bristol, United Kingdom), H. N. Yu (University of Bath, United Kingdom), K. D. Potter, M. R. Wisnom, I. Hamerton (University of Bristol, United Kingdom)

The HiPerDiF (High Performance Discontinuous Fibres) technology is used to produce aligned discontinuous hybrid fibre quasi-isotropic composites with pseudo-ductile behaviour

3.04-02 Pseudo-Ductility in 0-Degree Fibre Dominated CFRP Through Ply Weakening

J. Sun, M. F. Pernice, O. Bacarreza, P. Robinson (Imperial College London, United Kingdom)

Previous research has demonstrated pseudo-ductile tensile response can be achieved by introducing periodic across-width ply cuts, perpendicular to selected 0° plies, in both unidirectional (UD) and quasi-isotropic (QI) laminates. The inserted discontinuities initiate progressive delamination at the interface (Cntd)

3.04-03 Experimental Investigation of Low-Velocity Impact

M. F. Pernice, P. Robinson (Imperial College London, United Kingdom)

This work investigates the response of pseudo-ductile composite laminates containing ply weakenings in the 0-degree plies to low-velocity impact damage.

3.04-04 Tailored Circumferential Reinforcement of Composite Cylinders for Yield-Type Response and Improved Pressure Pulse Tolerance

D. S. Dancila, A. Srinivas (University of Texas at Arlington, USA)

A composite materials tailoring concept for progressive failure under tensile loading has been previously developed, modeled, and experimentally validated under quasi-static and impulsive loading by one of the authors and his collaborators. The concept relies upon a sequential failure process (Cntd)

18:30-19.30 Hall: MC3.2

ESMC Council Meeting

20:00

Welcome Reception

08:00

Secretariat Opens

08:50- 09:50 Hall: **Trianti**

Plenary Lecture 2

Chair: **C. Galiotis**

Challenges and Opportunities for Composite Materials Transitions in Aerospace
Thomas K. Tsotsis

09:50-10:35 Hall: **Trianti**

Keynote Lecture 5

Chair: **S. Pinho**

Composite materials for lightweight automotive applications
Leif Asp

09:50-10:35 Hall: **Mitropoulos**

Keynote Lecture 6

Chair: **V. Lopresto**

Challenges in Composites for Marine Structures in Extreme Environments
Yapa D. S. Rajapakse

10:35- 11:00 Hall: **Exhibition Area**

Coffee Break

11:00-13:00 Hall: **Trianti**

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level

Chairs: **A. Antoniou, S. Goutianos**

3.10-17 A 3D Separable Cohesive Element for Modelling the Coupled Failure in Laminated Composite Materials
X. Lu (National University of Singapore, Singapore), B. Y. Chen (Delft University of Technology, Netherlands), V. B. C. Tan, T. E. Tay (National University of Singapore, Singapore)
The interaction between matrix cracks and interface delamination is a major failure mechanism in composite laminates and has been a subject of active research in recent years. Although coupled failure behaviour of composite laminates between matrix cracks and delamination has been observed (Cntd)

3.10-18 The Interlaminar Fracture Toughness of Carbon/Epoxy Laminates Interleaved with Polyamide Particle Layers
W. T. Wang, H. Yu, K. Potter, B. C. Kim (University of Bristol, United Kingdom)
Toughening epoxy based composite materials using thermoplastic particles is a cost-effective approach to improve their poor delamination resistance. In this paper, the interlaminar toughening effect of different thermoplastic microparticles (Cntd)

3.10-19 On the Use of the Weak Penalty Method for Cohesive Zone Modelling of Delamination Failure
T. van Westendorp (Eindhoven University of Technology, The Netherlands), F. Larsson, M. Fagerström (Chalmers University of Technology, Sweden)
The contribution deals with the spurious traction oscillations that quite often occur when modelling crack growth with cohesive elements. A remedy for these oscillations, previously verified for elastic interfaces, is herein presented and confirmed for problems involving crack growth

3.10-20 Crack Growth Delamination of a Multidirectional Laminate at a +45°//-45° Interface

C. Blondeau, G. Pappas, J. Botsis (Ecole Polytechnique Fédérale de Lausanne, Switzerland)

Ply orientation influence on crack growth & toughening mechanisms in FRPs at a +45°//-45° interface, is explored by evaluating R-curves & fiber bridging tractions. DCB specimens, under mode I, show migrations among inter- (unstable) & intra- (stable with fiber bridging) laminar crack growth.

3.10-21 Simulation of Damage on Carbon Fibre Laminates using the Ladevèze Material Model

V. Loukodimou (Cranfield University & National Structural Research Centre (NSIRC), United Kingdom), M. C. Kazilas (Adhesives Composite & Sealants (ACS) & Brunel University London, United Kingdom), A. A. Skordos (Cranfield University, United Kingdom)

As composites are increasingly utilised in high performance operations in many industries, numerous research investigations have focused on the prediction of damage mechanisms that can deteriorate the structural integrity of these structures. (Cntd)

3.10-22 Modelling of Thermomechanical Behaviour of a Wound Carbon/epoxy Composite Exposed to Fire

A. Benelfellah (DRII, IPSA, France), D. Halm, T. Rogaume, D. Bertheau (Université de Poitiers, France), M. Gratton (INSA, France)

Hydrogen is expected to be highly valuable energy carrier for the 21th century as it should participate in answering main society and economical concerns. To exploit the benefits of this energy at large scale, further research and technological developments are required to secure its storage, especially during fire exposure. (Cntd)

11:00-13:00 Hall: Mitropoulos

3.13 | Material and Structural Behavior – Simulation and Testing: Joining of Composites

Chair: **Th. Loutas**

3.13-18 Low-Velocity Impact Simulation of a Woven Composite from a Bottom-Up Multiscale Modelling Strategy

J. I. Mugica, M. Herráez (IMDEA Materials, Spain), F. Naya (Ecole Polytechnique F´ede´rale de Lausanne, Switzerland), C. S. Lopes, C. D. Gonzalez (IMDEA Materials, Spain)

The constitutive behaviour of a glass/PP woven fabric is deduced based on a multiscale modelling method to predict its low-velocity impact response. A numerical-experimental correlation validates such a strategy.

3.13-19 A Parametric Study of Ultra-Thin Chopped Carbon Fiber Tape Reinforced Thermoplastic in Double-Shear Tests

L. Meng, I. Ohsawa, J. Takahashi (University of Tokyo, Japan)

In this research, a parametric study considering the effects of molding method (bulk molding and sheet molding) and tape thickness (44 μm, 88 μm and 132 μm) were conducted to identify the failure characteristics of pin-loaded ROS material in double shear tests. In addition, the failure process was characterized (Cntd)

3.13-20 Centrifuge Testing of Pre-Bond Contaminated Composite-to-Metal Adhesively Bonded Joints

K. Tserpes (University of Patras, Greece), M. Hoffmann (Fraunhofer Institute for Manufacturing Technologies and Advanced Materials, Germany), E. Moutsompegka (University of Patras, Greece), M. Schlag, K. Brune (Fraunhofer Institute for Manufacturing Technologies and Advanced Materials, Germany)

The effect of pre-bond contamination scenarios related to production and repair processes on the adhesion strength of composite-to-metal joints is investigated by means of the novel centrifuge testing technique. The composite substrates have been subjected to contamination with release agent, (Cntd)

3.13-21 Numerical Investigation of a Layered Hybrid Load Introduction Element for Thin-Walled CFRP Structures

A. Herwig (Braunschweig University of Technology, Germany), C. Schmidt (Leibniz Universität Hannover, Germany), P. Horst (Braunschweig University of Technology, Germany)

3.13-22 Multi-Spot Ultrasonic Welding of Thermoplastic Composite Single-Lap Joints: Effect of Spot Spacing and Number of Spots on Weld Strength

T. Zhao, I. Tsakoniatis, C. Rans, I. F. Villegas, R. Benedictus (Delft University of Technology, The Netherlands)

Thermoplastic composite spot welded joints are more well-suited for carrying shear load rather than peel load. However, peel load is difficult to be eliminated in single-lap joint configuration. In this paper, a series of mechanical tests were carried out to study the effects of the spot spacing (Cntd)

3.13-23 Load Transfer by Friction in Bolted Composite Joints under Cyclic Loading

F. Hermsdorf, H. Rapp (Bundeswehr University Munich, Germany)

Tests with double-lap bolted joints using carbon epoxy laminates under different temperature and surface friction conditions show a high load carrying capacity. Preload losses are compensated by an increase of coefficient of static friction.

11:00-13:20 Hall: Skalkotas

3.08 | Material and Structural Behavior – Simulation and Testing: Fatigue of Composites

Chairs: **A. Bernasconi, G. Pinter**

3.08-12 Influence of Process Conditions on the Fatigue Behaviour of Autoclave Moulded Laminates

L. Maragoni, P. A. Carraro, M. Quaresimin (University of Padova, Italy)

In this work, laminates manufactured using different process parameters are tested under tensile fatigue, highlighting a large influence of the resulting microstructure on the long-term damage evolution.

3.08-13 Flexural Fatigue Performance of Carbon Epoxy Composites with and without Resin Flow Channels
K. M. Karumbaiah (University of Auckland, New Zealand), C. Kracke (BMW Group, Germany), M. Battley, S. Bickerton, T. Allen (University of Auckland, New Zealand)
The increasing use of composites in high-volume sectors such as automotive necessitates faster manufacturing techniques, such as high-pressure resin transfer moulding (HP-RTM). The integration of resin flow channels into the HP-RTM moulds can assist with the production of complex geometry parts by reducing total flow resistance (Cntd)

3.08-14 Analysis of Delamination Evolution in Multidirectional Laminates Under Fatigue Loading
M. Quaresimin, P.A. Carraro, L. Maragoni (University of Padova, Italy)
In the present work the results of an extensive experimental investigation, aimed at studying the occurrence of matrix cracks and induced delaminations, are presented. Four different glass-epoxy lay-ups were tested under tensile-tensile fatigue loading and the damage progression was fully characterized.

3.08-15 Proposition of a Unified Model to Predict Strength and Fatigue Lifetime of 3D Woven Composite Structures with Polymer Matrix
F. Laurin, M. Kaminski (Université Paris-Saclay, France), L. Angrand (Safran Aircraft Engines, France), R. Desmorat (Université Paris-Saclay, France)
A unified damage and failure approach has been proposed to estimate the failure of 3D woven composite materials subjected to static and/or fatigue loadings. Indeed, the existing damage and failure approach developed by Onera for static loading has been extended in the present paper to predict the damage evolution (Cntd)

3.08-16 Calculations Strategies to Forecast Lifetime of Oxide/Oxide Composite Structures under Complex Loadings
O. Sally (Université Paris-Saclay & Safran Ceramics, France), C. Julien, F. Laurin, R. Desmorat (Université Paris-Saclay, France), F. Bouillon (Safran Ceramics, France)
A damage model able to predict the behaviour of oxide/oxide composites under static and fatigue loadings is proposed. An associated cycle jumps method is developed to reduce computational cost during cyclic fatigue loadings. The whole strategy is then implemented in a FE solver to simulate composite parts. (Cntd)

3.08-17 Short Glass Fibre Reinforced Polyamide Under Low Cycle Fatigue
A. Primetzhofer, G. Stadler (Montanuniversität Leoben, Austria), G. Pinter (Montanuniversität Leoben & Polymer Competence Center Leoben GmbH (PCCL), Austria), C. Schneider, F. Grün (Montanuniversität Leoben, Austria)
The feasibility of strain controlled fatigue tests was examined for short fibre reinforced plastic. A good applicability of the considered models is found for the investigated material. Although for material with a more pronounced viscoelastic material behaviour further, investigations need to be done.

3.08-18 Accelerated Estimation of Fatigue Performances of Thermoplastic Composite Materials by Self-Heating Monitoring
L. Muller, J.-M. Roche, A. Hurmane (ONERA, France), C. Peyrac (CETIM, France), L. Gornet (UMR CNRS, France)
In this paper, self-heating tests are applied to a balanced 2D-woven carbon/thermoplastic composite material. In addition, quasi-static tensile tests are performed to characterize the mechanical properties of material, as well as to monitor the evolution of and the thermal field.

11:00-12:20 Hall: **Multi-Purpose Room**

3.06 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Impact – Crash – Blast

Chair: **L. Sorrentino**

3.06-19 Non-Linear Constitutive Law for a Glass-PA66 Fabric Composite Dedicated to Numerical Simulations in Crash Studies
M. A. Mbacke (IRT Jules Verne, France), P. Rozycki (Ecole Centrale de Nantes/GeM, France)
The paper deals with the implementation of a non-linear constitutive law for a glass-PA66 fabric composite in Abaqus/Explicit via a user subroutine (VU-MAT). This model is dedicated to numerical simulations in crash studies.

3.06-20 Discrete Crack Modelling of Damage Propagation in Composites Subjected to Low Velocity Impact
T. E. Tay, J. Zhi (National University of Singapore, Singapore)
Understanding damage mechanisms developed in laminates during low velocity impact is critical for damage tolerance analysis of composite structure. However, many models employ continuum damage mechanics (CDM) in material property degradation and cohesive elements because the damage patterns are complex. (Cntd)

3.06-21 Numerical and Experimental Analysis of High-Veloc-Ity Impact Behaviour of Carbon Fibre Reinforced Thermoplastic Composites
M. A. A. Mohsin, L. Iannucci, E. Greenhalgh (Imperial College London, United Kingdom)
The low, medium and high-velocity impact resistance of fibre reinforced thermoplastic and thermo-setting composites have continually attracted interest in automotive, aerospace and military applica-tions. This research aims to characterise the high-velocity impact (HVI) response of a carbon fibre reinforced thermoplastic (CFRTP) composite system (Cntd)

3.06-22 Predicting the Impact Performance of Low-Cost 3D Woven Composite Components
K. Warren, S. Varadhan, J. Goering, H. Bayraktar (Albany Engineered Composites, USA), R. White, S. Snell (Engenuity Limited, United Kingdom)
An investigation of the energy absorption behavior of a low-cost three-dimensional woven composite is discussed. Experiments have been conducted and numerical simulations have been developed to predict the structural performance of the composite.

11.00-12.40 Hall: MC3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chair: **V. Michaud**

5.07-16 Simulations of the Stamping, Compaction and Consolidation of Thermoplastic Composites based on Solid-Shell Finite Elements

N. Hamila (INSA Lyon, France), E. Guzman-Maldonado (IRT Jules Verne, France), H. Xiong (LMS Samtech Samcef, Belgium), P. Boisse (INSA Lyon, France), J. Bikard (Solvay R&I, France)

5.07-17 The Manufacturing of Carbon-Fiber Paper Reinforced Thermoplastic Core Sandwiched Panels under Several Degrees of Consolidation

B. Xiao, I. Ohsawa, J. Takahashi (University of Tokyo, Japan)

A feasible and efficient manufacturing method on carbon fiber reinforced thermoplastic sandwich panels.

5.07-18 Effect of In-Situ Treatment on the Quality of Thermoplastic Composite Tubes Made by Automated Fiber Placement (AFP)

S. V. Hoa, J. F. Simpson, D. I. Rosca, D. M. Hoang, F. Shadmehri (Concordia University, Canada)

The paper presents the method of repass in automated manufacturing of thermoplastic composite tubes. This method helps to improve the surface finish of the composite structure. The effect of repass on the void content, and on the short beam shear strength of samples made from the tubes were also investigated.

5.07-19 Investigation on the Effect of Cooling Rate on the Mechanical Properties of Polypropylene Self-Reinforced Composites

F. Hassani, P. J. Martin, B. G. Falzon (Queen's University Belfast, United Kingdom)

Cooling rate is considered to be one of the most important processing variables which affect the final properties of self-reinforced composites. The effect is more pronounced when the base material is semi-crystalline. The current study investigates the effect of this parameter on the final properties (Cntd)

5.07-20 Failure Criterion for Thermoplastic Composites for Characterization of Manufacturing Process

B. N. Fedulov (Moscow Aviation Institute, Russia), E. V. Lomakin (Moscow Aviation Institute & Lomonosov Moscow State University, Russia)

This research describes the possibility to analyze the quality of thermoplastic composite details in terms of strength and integrity and focuses on manufacturing process. The main idea of presented work is to understand the type of transformation of plasticity model for neat thermoplastic matrix (Cntd)

11:00-12:20 Hall: MC2

5.10 | Processing and Manufacturing Technologies: Process Modelling III: Deformation and Draping

Chairs: **J. Bloemhof, J.-L. Bailleul**

5.10-12 Numerical Modeling of Single-Step Thermoforming of a Hybrid Metal/FRP Lightweight Structure

J.-P. Ziegs, D. Weck, M. Gude, M. Kastner (TU Dresden, Germany)

We present simulation results for the simultaneous forming process of metal and composites. A multi-scale modeling approach for the fiber-reinforced plastic (FRP) is proposed, starting from the thermo-mechanical properties of the polymer matrix and the anisotropic elastic response of the reinforcement (Cntd)

5.10-13 Modelling and Simulating the Forming of a Unidirectional Dry Reinforcement Designed for Primary Aircraft Structures

L. Bouquerel (CNRS, UMR & Hexcel Reinforcements, France), N. Moulin, S. Drapier, P. Boisse (CNRS, UMR, France), J. M. Béraud (Hexcel Reinforcements, France)

The aim of this work is to model and to simulate the forming of a flat stack of HiTape (Hexcel Reinforcements). Characterisation of the bending and inter-ply sliding behaviours has been done. Simulation is performed in the finite element code Z-set.

5.10-14 Characterising the Forming Mechanics of Pre-Consolidated Nylon-Carbon Composite

P. Harrison, M. S. Fernandes Alvarez (University of Glasgow, United Kingdom), N. Correia, P. Mimoso, C. Cristovão, R. Gomes (INEGI, Portugal)

Preliminary bending and shear tests are performed on a nylon-carbon fibre pre-consolidated cross-ply 0/90/90/0 laminate. The aim is to produce data for use in macro-scale forming simulations. A novel variation on the usual uniaxial bias extension tests is devised. (Cntd)

5.10-15 Flow Induced Sample Deformations in Out-of-Plane Permeability Measurement

B. Willenbacher (Institut für Verbundwerkstoffe GmbH, Germany), A. Kabachi (ETH-Zürich, Switzerland), D. May, P. Mitschang (Institut für Verbundwerkstoffe GmbH, Germany), P. Ermanni (ETH-Zürich, Switzerland)

For efficient design of out-of-plane injection processes, simulative and experimental approaches for compaction and permeability characterization have been combined to accurately describe textile behavior during such processes.

11:00-13:00 Hall: **Kokkalis**

3.14 | Material and Structural Behavior – Simulation and Testing: Multiscale Modelling

Chair: **W. Van Paepegem**

3.14-01 Multiscale Damage Analysis of a Plain Carbon Weave Incorporating Material Variability
L. F. Varandas (Queen's University Belfast, United Kingdom), A. R. Melro (University of Bristol, United Kingdom), G. Catalanotti, B. G. Falzon (Queen's University Belfast, United Kingdom)
This paper presents a multiscale analysis which compares the mechanical response of an idealized discretization of a plain-weave carbon epoxy fabric, with an intra-tow fibre volume fraction variable fabric by incorporating material variability along each tow length.

3.14-02 Multiscale Simulation of Textile Reinforcements for Composite Applications
O. Döbrich, T. Gereke, C. Cherif (Technische Universität Dresden, Germany)
Since the modern lightweight industry is heading towards full automatization and absolute flexibility, the motivation for a simulative prediction of composite properties is on the agenda. Therefore, a completely virtual development chain for fiber reinforced composites is introduced.

3.14-03 Multiscale Observation and Modeling of Crack Initiation in Woven Composites
M. Hirsekorn, A. Doitrand, R. Naylor, C. Fagiano (Université Paris Saclay, France)
Based on experimental observations by digital image correlation, mechanical models are proposed for damage onset and evolution in woven polymer matrix composites from the initiation of the first damages at the microscale to crack and debonding evolution at the mesoscale.

3.14-04 Multiscale Simulation of Short Fiber Reinforced Plastics for Hybrid Composites
A. Hürkamp, T. Gebken, A. Müller, K. Dröder (TU Braunschweig, Germany)
In this paper, we present a multiscale approach for short fiber reinforced plastics coupling process simulation with structural analysis. Finally, the computational results are validated, and a concept for the fabrication of hybrid composites is presented.

3.14-05 Multi-Scale Approach to Predict the Orthotropic Elasticity Tensor of Carbon Fibres and Woven Carbon Composites by Ultrasonic Insonification
R. D. B. Sevenois, S. W. F. Spronk, D. Garoz, F. A. Gilabert (Ghent University & SIM vzw, Belgium), E. Verboven, M. Kersemans, W. Van Paepegem (Ghent University, Belgium)
Identification of UD properties via contact ultrasound. Reverse engineering of fibre properties using multiple micromodels and forward prediction of the woven properties using a mesoscale model from the properties of individual fibres and matrix.

3.14-06 Interlaminar Shear Strength Enhancement under Out-of-Plane Compression of Fabric Reinforcements - A Review on Meso and Macro Scale
C. Düreth, D. Weck, R. Böhm, M. Thieme, M. Gude (Technische Universität Dresden, Germany), C. H. Wolf, S. Henkel, H. Biermann (Technische Universität Bergakademie Freiberg, Germany)

11:00-12:40 Hall: **Lecture Room**

2.14 | Materials Science: Polymer Matrix Materials (carbon Fibre/nanotube composites)

Chair: **E. Thostenson**

2.14.01 Thermal and Electrical Conductivity of Epoxy-Carbon Fiber Prepreg Laminates filled with Different Sizes of Graphite Particles
S. Bard, G. Bakis, M. Radtke, V. Altstädt (University of Bayreuth, Germany)
Thermal and electrical conductivity of carbon fiber reinforced polymers produced from prepregs has been improved by the incorporation of graphitic filler in the epoxy matrix

2.14-02 Mechanical and Fracture Properties of Epoxy Syntactic Foams Modified with Milled Carbon Fibre
S. He (Imperial College London, United Kingdom), D. Carolan, A. Fergusson (Imperial College London & FAC Technology, United Kingdom), A. C. Taylor (Imperial College London, United Kingdom)
Syntactic foams are lightweight but brittle materials typically used as the core for composite panels. Foams comprising of ~60 vol% hollow glass microspheres (GMS) in an epoxy matrix were modified by the addition of milled carbon fibre (MCF). Weight ratios of up to 30% MCF:GMS were used. (Cntd)

2.14-03 Multifunctional Polymer Composites Reinforced with Discontinuous Carbon Fibers for Thermal Energy Storage
G. Fredi, A. Dorigato, L. Fambri, A. Pegoretti (University of Trento, Italy)
The paper deals with the development of multifunctional semistructural composites with thermal energy storage (TES) capability. Discontinuous carbon fibers and paraffin microcapsules (Tm = 43 °C) were added to a Polyamide 12 and an epoxy matrix. The obtained samples were fully characterized.

2.14-04 Broadband Dielectric Spectroscopy of Composites of Hybrid Multi-walled Carbon Nanotube-Cu Nanoparticle filled Polystyrene

V. Bovtun, J. Petzelt, D. Nuzhnyy, M. Kempa, M. Savinov (Czech Academy of Sciences, Czech Republic), Z. Abd Razak, C. Wan, T. McNally (University of Warwick, United Kingdom)

Broadband dielectric spectra (0.1 Hz - 3 THz) of polystyrene-carbon nanotubes-Cu nanoparticles composites show significant dielectric dispersion. With Cu addition, their percolation threshold decreased from 0.12 to 0.089 vol.%. Microwave shielding and absorption is analyzed

2.14-05 UV-Cured Fiber Reinforced Composite Laminates: A Detailed Study of Photonic and Chemical Parameters for Optimized Mechanical Properties

P. Carion, C. Croutxé-Barghorn, G. l'Hostis, A. Ibrahim, X. Allonas (University of Haute Alsace, France)

In this work, 6 layers laminates made out of glass/polyester prepregs were manufactured using an UV LED irradiation process and their mechanical properties were determined by measuring ILSS values. Influence of PI concentration has been thoroughly investigated in order to obtain laminates with enhanced mechanical behavior. (Cntd)

11:00-12:40 Hall: MC3.2

1.01 | Applications: Aerospace

Chairs: **D. Zarouchas, D. Mazarakos**

1.01-14 PLATFORM: Study of the Integration and Characterization of New Materials Manufactured with Carbon Nanotubes in Current Manufacturing Processes in the Aeronautical Sector

L. Sánchez-Vicente, M. R. Gude, S. Calvo-del Valle, M. Martínez-Miranda, B. López-Romano (FIDAMC, Spain), I. Gaztelumendi-Lizarraga, S. Flórez-Fernández (TECNALIA, Spain), A. Vavouliotis (ADAMANT COMPOSITES Ltd., Greece), P. Latko-Duralek (TMBK Partners Sp. z o.o., Poland)

1.01-15 An Approach for the Automated Production of Dry Textile Carbon Fiber Non-Crimp Fabric Preforms using an Adapted Diaphragm Forming Process

M. Endrass, M. Körber, G. Braun (German Aerospace Center DLR, Germany)

This paper deals with the development of a new, adapted diaphragm forming process for the manufacturing of an Aero Flap Support (AFS) preform for a new type of Airbus wing. For this purpose an automation approach was developed and validated by a manufactured automation mock up.

1.01-16 Statistical Evaluation on the Out-of-Plane Thermal Deformation of CFRP Laminates due to Fiber Orientation Error

S. Tanaka, M. Arai, K. Goto (Nagoya University, Japan), T. Ikeda (Chubu University, Japan)

Carbon fiber reinforced plastic (CFRP) exhibits high specific stiffness and low coefficient of thermal expansion. Thus, it is regarded as a suitable material for high-precision, large reflectors for space observation systems. However, it was made clear that non-negligible out-of-plane thermal deformation would be generated (Cntd)

1.01-17 Validation of Aeronautic Structures by Single Multiaxial Testing

J. Serra, Jean-E. Piérré, J.-N. Périé, J.-C. Passieux, C. Bouvet, B. Castanié (Institut Clément Ader, France), C. Petiot (Airbus Group, France)

1.01-18 Design of Composite Filament Wound Pressure Vessels: Management of Singularities in Multi-Sequence Dome Lay-Up Simulations

L. Bizet, (CNES - 52, France), P. Saffré (Université Savoie Mont Blanc, France), K. Mathis (CNES - 52, France), D. Halm, M. Gueguen. (ENSMA, France), P. Francescato (Université Savoie Mont Blanc, France)

Composite pressure vessels made by filament winding processes are commonly used in aerospace design due to weight saving compared to metal parts. This technique involves complexities in analyzing the geometry especially in the dome section. Tools already exist to predict the geometrical characteristics like winding angle, (Cntd)

11:00-13:00 Hall: MC3.3

3.01 | Material and Structural Behavior – Simulation and Testing: Analysis and Design of Damage Tolerant Composite Structures

Chair: **S. Pinho**

3.01-01 Virtual Testing of Thermoplastic Composites: Towards a Hybrid Simulation-Physical Testing Pyramid

B.H.A.H. Tijs (GKN Aerospace: Fokker & Delft University of Technology, The Netherlands), C.S. Lopes (IMDEA Materials Institute, Spain), A. Turon (University of Girona, Spain), C. Bisagni (Delft University of Technology, The Netherlands), J. Waleson, J.W. van Ingen, S.L. Veldman (GKN Aerospace: Fokker, The Netherlands)

This paper summarizes the implementation of a Virtual Testing methodology in an industrial environment to predict the mechanical behaviour of composite material through the different scales of the conventional physical testing pyramid.

3.01-02 Virtual Test Bench to Characterize Load Bearing Behavior of Laminates with Out-of-Plane Ply Deflections and Localized Wrinkles
S. S. Venkat, M. P. Hartmann (TUM Technical University of Munich, Germany)
This study initially focuses on the methodologies developed for the fabrication of carbon fiber reinforced laminates with graded out-of-plane ply waviness and with localized folding or wrinkling of a ply. Literature review has shown that there have been methods developed to fabricate laminates with similar defects. (Cntd)

3.01-03 High-Fidelity Testing and Integrated Modelling of Composite Substructures and Components
D.J. Bull, J.M. Dulieu-Barton, O.T. Thomsen (University of Southampton, United Kingdom)
Many innovative developments that facilitate lightweighting, energy efficiency, safer and more damage-tolerant designs involving composite structures, are only applicable at the structural levels. They cannot readily be incorporated into composite structures like e.g. airframes or wind turbine blades (Cntd)

3.01-04 Experimental Analysis of the Failure of a 3D Woven Composite Belted Lug
C. Garcia (Université Paris-Saclay & Safran Landing Systems, France), A. Hurmane, F.-X. Irisarri, F. Laurin (Université Paris-Saclay, France), S. Leclercq (Safran Landing Systems, France), R. Desmorat (Université Paris-Saclay, France)
The study focuses on the failure of landing gear lugs. To delay the failure by shear-out that is classical for such parts, Safran Landing Systems suggested an innovant concept of belted lug. The aim of the paper is to analyze the experimental failure of the belted lug.

3.01-05 Gradual Damage behaviour of Polar Orthotropic Glass-Fibre Reinforced Epoxy Rotors; Experimental and Simulation Analysis
A. Filippatos, A. Langkamp, P. Kostka, I. Koch, R. Böhm, M. Gude (Technische Universität Dresden, Germany)
The gradual damage behaviour of polar orthotropic glass-fibre reinforced epoxy disc-rotors and the resulting damage-dependent dynamic behaviour is experimentally investigated and described under propagating damage from a combination of out-of-plane and in-plane loads. (Cntd)

3.01-06 A Correlation Approach between Altering Modal Properties of Gradually-Damaged Composite Rotors and Resulting Dynamic Response Sequences
M. Nguyen, A. Langkamp, M.Gude, A. Filippatos (Technische Universität Dresden, Germany)
Glass fibre reinforced epoxy rotors, made using the Tailored Fibre Placement (TFP) method have been subjected to stepwise, increasing loading over a multi-stage test procedure. The introduced stresses cause gradual damage and non-linear corresponding changes of the dynamic behaviour (Cntd)

11:00-13:00 Hall: **MC3.4**

2.13 | Materials Science: Nano Composites
Chairs: **D. Papageorgiou, M. Zappalorto**

2.13-15 Aggregately Conductive Composite Materials
S. Van Hoa, A. Naghashpour (Concordia University, Canada)
The paper introduces the concept of Aggregately conductive materials. These are conductive not homoegeneously, but on the aggregate scale. This property can help to detect, locate and quantify defects in composite structures.

2.13-16 Probing the Electric Response and Functionality of MWCNT/ Fe3O4/ Epoxy Hybrid Nanocomposites
S. G. Stavropoulos, A. Sanida, G. C. Psarras (University of Patras, Greece)
In this study, a set of hybrid systems was developed varying the filler type and content (MWCNT's and Fe3O4), and their electrical response was investigated by means of Broadband Dielectric Spectroscopy (BDS), which has been proved to be a powerful tool for the investigation of molecular mobility, (Cntd)

2.13-17 Thermomechanical and Electrical Properties of Metallocene LLDPE/CNT Nanocomposites
I. Charitos, G. Georgousis, E. Kontou (National Technical University of Athens, Greece)
A series of CNT nanocomposites, based on a metallocene polyethylene matrix, were prepared and experimentally studied. It was proved that the polyethylene matrix type employed, leads to improved mechanical and electrical properties, compared to the matrix prepared by conventional catalysts.

2.13-18 Energy Storage and Harvesting in SrTiO3/ Epoxy Nanodielectrics
G. C. Manika, G. C. Psarras (University of Patras, Greece)
The stored and harvested energy of SrTiO3/epoxy nanodielectrics was examined under DC conditions. Their coefficient of energy efficiency (neff) was determined varying filler content, DC field and temperature. Maximum achieved value for neff is 69.41%.

2.13-19 Improved Structural and Functional Properties of Carbon Fibre Composites for Lightning Strike Protection
A. Duongthipthewa, Y. Su, L. Zhou (The Hong Kong Polytechnic University, Hong Kong)
Lightning is one of the most unpredictable and harmful forces of nature that strikes commercial aircraft more than once a year. Most composite aircraft structures have been designed to withstand lightning strikes with less adverse effects by depending on conductive metallic mesh. (Cntd)

2.13-20 Mechanical and Electrical Properties of Thermoplastic Composites Interleaved with CNTs Grown onto Polymeric Nanofibers
B. Bozali, A. Karaali, H. Cebeci (Istanbul Technical University, Turkey), E. Ozden-Yenigun (Istanbul Technical University, Turkey & Royal College of Art, United Kingdom)
The interlaminar toughening effect of thermoplastic nanoprepreg interlayer in thermoplastic laminated composites was investigated. In this study, with a modified chemical vapor deposition (m-CVD) method, the growth of CNTs onto PBI nanofibers as PBI/CNT nanocarpets were achieved and characterized in terms of CNTs quality (Cntd)

11:00-13:00 Hall: **Conference 1**

3.05 | Material and Structural Behavior – Simulation and Testing: Durability – Ageing – Creep – Environmental Effects

Chairs: **S. Ogin, S. Grammatikos**

3.05-01 The Effects of Fibre Architecture on Water Absorption Induced Degradation in CFRP Laminates

F. Almudaihesh, R. Pullin, K. Holford, M. Eaton (Cardiff University, United Kingdom)

The fibre architecture not only plays a significant role in the mechanical properties and the damage mechanisms of carbon fibre reinforced polymers but also on the water ingress mechanism. Unidirectional and 2D woven CFRP were evaluated after water absorption. (Cntd)

3.05-02 Effect of Hygrothermal Cycles on Mechanical Performance of Composite Adhesively Bonded Joints

S. Rincon Urbina, D. Ayre, H. Y. Nezhad (Cranfield University, United Kingdom)

This paper numerically and experimentally studied mechanical performance of composite adhesively bonded single-lap joints in the presence of hygro-thermal cycles, under static tensile loading. Joint performance was predicted by the development of a coupled experimental-numerical approach based on cohesive zone modeling. (Cntd)

3.05-03 Long Term Deep Sea Exposure Effect on the Mechanical Properties of Filament Wound Composites

A. Z. Papadakis, G. K. Konstantinidis, N. G. Tsouvalis (National Technical University of Athens, Greece)

Filament wound composite materials are increasingly used in deep sea applications such as pressure housings, underwater pipelines, AUV's, etc. Their long term exposure in deep sea conditions would possibly lead to material properties degradation. (Cntd)

3.05-04 Relaxation-Driven Water Diffusion in Epoxy Resin Filled with Various Carbon Nanoparticles

O. Starkova (University of Latvia, Latvia), S. Chandrasekaran (Technische Universität Hamburg, Germany & Lawrence Livermore National Laboratory, USA), T. Schnoor (Technische Universität Hamburg & Saint-Gobain, Germany), A. Aniskevich (University of Latvia, Latvia), K. Schulte (Technische Universität Hamburg, Germany)

Water sorption-desorption-resorption and swelling were studied for a model epoxy system based on DGEBA resin and triamine curing agent. Four types of carbon nanofillers were incorporated into the epoxy matrix: multiwall carbon nanotubes, graphite nano-platelets, expanded graphite platelets, and carbon black. (Cntd)

3.05-05 Prediction of Statistical Life Time for Unidirectional Carbon Fiber Reinforced Thermoplastics under Creep Loading

M. Nakada, Y. Morisawa, Y. Miyano, K. Uzawa (Kanazawa Institute of Technology, Japan)

The tensile strength along the longitudinal direction of unidirectional CFRP is one of the most important data for the reliable design of CFRP structures. First, the test method for the creep strength as well as the static strength at elevated temperatures for the longitudinal direction of unidirectional CFRTP (Cntd)

3.05-06 Life Assessment of GFRP Composite and Thermoset Epoxy through Creep after Marine Environment Exposure

S. Ivan, M. Cavasin (Element Materials Technology, United Kingdom), S. Giannis (Element Materials Technology & AMPnP Consultants Limited, United Kingdom), I. Dlouhy (Institute of Physics of Materials CAS, Czech Republic), B. Thomson (Element Materials Technology, United Kingdom)

Long-term life prediction using tensile creep on a GFRP laminate as well as its matrix resin under temperature and synthetic ocean water exposure was performed with the aim of establishing a low resource accelerated testing methodology based on TTS.

11:00-13:20 Hall: **MC3.5**

Special Session 2 | Office of Naval Research- Marine Composites

Chairs: **Y. Rajapakse, V. Lopresto**

SS2-01 Effect of Low Temperature on the Post-Impact Compression Response of Composite Sandwich Structures

M. Elamin, B. Li, K. T. Tan (University of Akron, USA)

Compression after impact (CAI) behavior of composite sandwich structures is studied at extreme low temperature arctic conditions. Results evidently show that the CAI strength is reduced in arctic conditions and the susceptibility to global structural failure is ultimately higher.

SS2-02 Effect of Temperature and Moisture on the High-Velocity Impact Performance of Glass/Carbon Hybrid Composites

V. Sánchez Gálvez, F. Gálvez, D. Cendón, R. Sancho, C. González (Universidad Politécnica de Madrid, Spain)

High performance composites (carbon and glass fiber reinforced polymers) are nowadays extensively used in applications requiring strength, stiffness and fatigue resistance as demanded in marine applications. However, an important drawback of such materials is related with the low damage tolerance behavior, (Cntd)

SS2-03 Dynamic Performances of Basalt Fibre Laminates at Room and Low Temperatures

I. Papa, V. Lopresto (University of Naples F. II, Italy)

Basalt fibre laminates in vinylester resin were obtained by resin infusion technique. Rectangular specimens were cut from the panels and impacted at penetration and at increasing energy values, at room and the low temperature of -50°C, at the aim to investigate the damage onset and propagation.

SS2-04 Carbon/Polyamide 6 Thermoplastic Composites for Underwater Applications
M. Arhant, P.-Y. Le Gac, M. Le Gall (IFREMER, France), C. Briançon, (CETIM, France), C. Burtin (Ecole Centrale de Nantes, France), P. Davies (IFREMER, France)
Thick carbon/polyamide 6 composite cylinders have been manufactured by Laser assisted tape placement and tested for implosion at pressures higher than 600 bar

SS2-05 Comparative Assessment of Hybrid Composite Sandwich Panels under Blast Loading
E. Rolfe (Imperial College London, United Kingdom), H. Arora (Swansea University, United Kingdom), P. A. Hooper, J. P. Dear (Imperial College London, United Kingdom)
This research is concerned with full-scale air blast testing of two composite sandwich panels with hybrid composite face-sheets. High speed 3D digital image correlation was used to record the displacement of the rear skins of the sandwich panels during the blast event and foil strain gauges (Cntd)

SS2-06 Comparative Computational Study of Composite Sandwich Panels with Varying Auxetic Core Topologies and Orientations Subjected to Air Blast Loading
C. A. Burnett, Z. Kazancı, B. G. Falzon (Queen's University Belfast, United Kingdom)
This paper presents a computational comparison of composite material sandwich panels subjected to air blast loading. An evaluation of different auxetic cores has been conducted to determine how back sheet deflection changes.

SS2-07 Thermoplastic Infusible Resin Systems: Candidates for the Marine Sector?
N. Nash, C. B. Sirerol, I. Manolakis, A. J. Comer (University of Limerick, Ireland)
This work investigated the feasibility of the use of a novel infusible thermoplastic resin (Elium 150 from Arkema) for composite laminate manufacture by resin infusion methods and possible application in the shipbuilding sector. (Cntd)

13:00-14:00 Hall: **Exhibition Area**

Lunch Break

14:00- 14:45 Hall: **Trianti**

Keynote Lecture 7
Chair: **V. Kostopoulos**

Thermoplastic Composites: Where are we and which challenges do we still have to tackle?
Rinze Benedictus

14:00- 14:45 Hall: **Mitropoulos**

Keynote Lecture 8
Chair: **A. Bismarck**

Void Reduction in Composite Processing: Mechanisms, Processes and Predictive Modeling
Surech Advani

14:45-16:45 Hall: **Trianti**

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level
Chair: **L. Asp, Th. Loutas**

3.10-23 A Virtual Test Lab for Unidirectional Composite Coupons
O. Falcó (IMDEA Materials Institute, Spain), B. Tijs, B. Romano (GKN Aerospace: Fokker, The Netherlands), C. S. Lopes (IMDEA Materials Institute, Spain)
A reliable virtual testing framework for unidirectional laminated composites is presented that allows the prediction of failure loads and modes of general in-plane coupons with great realism.

3.10-24 Biaxial Transverse Compression Testing for a Fibre Reinforced Polymer Material T. Bru (Swerea SICOMP & Chalmers University of Technology, Sweden), L.E. Asp (Chalmers University of Technology, Sweden), R. Olsson, G.M. Vyas (Swerea SICOMP, Sweden)

Experimental investigation of the behaviour of unidirectional laminates under uniaxial and biaxial transverse compressive stresses using full field strain measurements. A procedure to extract the transverse shear response from the compression tests is also presented.

3.10-25 The Transition from Out-Of-Plane to in-Plane Kinking due to Off-Axis Loading

D. Wilhelmsson (Chalmers University of Technology, Sweden), F. Edgren (GKN Aerospace Sweden AB, Sweden), R. Gutkin (Volvo Car Corporation, Sweden), L. E. Asp (Chalmers University of Technology, Sweden)

An experimental study on NCF composite specimens show that a sudden drop occurs in compressive strength between an off-axis angle of 10° and 15°. In-plane shear stress due to off-axis loading seem to have a limited contribution to kinking until the kink-component in-plane becomes dominant.

3.10-26 Size-Effect and Intralaminar Fracture of Fibre Reinforced Composites: Latest Advances

G. Catalanotti (Queen's University Belfast, United Kingdom)

3.10-27 Validation and Improvements of a Mesoscale Finite Element Constitutive Model for Fibre Kinking Growth

S. Costa (Swerea SICOMP & Chalmers Université of Technology, Sweden), M. Fagerström (Chalmers Université of Technology, Sweden), R. Gutkin (Volvo Car Corporation, Sweden), R. Olsson (Swerea SICOMP, Sweden)

A fibre kinking model developed by the authors has been improved to become more computationally efficient and stable in order to handle multi-axial load cases and large structures.

3.10-28 Measure and Simulation of the Effect of Matrix Damage on Compressive Strength in the Fiber Direction of CFRP

O. Montagnier (Ecole de l'Air, France), C. Hochard, A. Cocchi, G. Eyer (Aix Marseille Université, France)

The influence of transverse damage on compressive strength in fiber direction for carbon fiber reinforced epoxy materials is investigated by an experimental approach. Two experimental methods are proposed. The first study focuses on tubular samples. Theses samples are damaged by cyclic torsional load (Cntd)

14.45-16.25 Hall: **Mitropoulos**

3.11 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Micromechanics

Chair: **V. Carvelli, Y. Swolfs**

3.11-01 Analysis of Fiber/Matrix Interface Debonding in Steel Fiber Composites under Transverse Loading

B. Sabuncuoglu (Hacettepe University, Turkey), S.A. Tabatabaei, S. V. Lomov (KU Leuven, Belgium)

In this study, this debonding behavior of steel-fiber composites from the epoxy matrix is analyzed and compared with the conventional composites with glass and carbon fibers. The analyses are performed by constructing finite element models in micro-scale where fibers, matrix, and interface properties between them are modeled (Cntd)

3.11-02 Numerical Evaluation of the Microdamage Kinetics of Cross-Ply Gfrps Based on Stochastic Micro-Meso Modeling

S. B. Sapozhnikov, A. A. Shabley (South Ural State University, Russia)

The general purpose of the paper is to estimate the possibility of substitution of time-consuming explicit FEA investigations of nonlinear mechanical behaviours of FRPs by the fast and effective FARGR-calculations.

3.11-03 Effect of Boundary Conditions on Microdamage Initiation in Thin Ply Composite Laminates

L. Di Stasio (Université de Lorraine, France & Luleå University of Technology, Sweden), J. Varna (Luleå University of Technology, Sweden), Z. Ayadi (Université de Lorraine, France)

The Energy Release Rate (ERR) and the contact zone size for a fiber/matrix interface debond are studied for a thin-ply glass fiber/epoxy laminate. The main objective is to analyze the effect on the debonding process of the presence of a traction-free specimen surface or an adjacent material, (Cntd)

3.11-04 FE Modeling of Inhomogeneities in Laminated Fibrous Composites based on Micro-Computed Tomography

K. Ilin, S. V. Lomov, J. Ivens (K.U. Leuven, Belgium)

The paper describes the methodology for creating a 3D finite element model based on the μCT image and the VoxTex software, which transforms the μCT image into a voxel model in which the fibrous structure of the reinforcement (local fiber volume fraction and fiber direction) is identified for each voxel. (Cntd)

3.11-05 A Numerical Framework to Analyze Fracture in Composite Materials: From Simulated Crack Resistance Curves to Homogenized Softening Laws

M. Herráez (Universidad Politécnica de Madrid & IMDEA Materials Institute, Spain), C. González (Universidad Politécnica de Madrid & IMDEA Materials Institute, Spain), C. S. Lopes (IMDEA Materials Institute, Spain)

A numerical framework to obtain the crack resistance curve (R-curve) and its corresponding softening law for fracture analysis in composite materials under small scale bridging has been developed. The R-curve is computed for this material using a micromechanical embedded model (Cntd)

14:45-16:45 Hall: **Skalkotas**

3.06 | Material and Structural Behavior – Simulation and Testing: Dynamic Loading – Impact – Crash – Blast

Chair: **N. Chrysochoidis**

3.06-23 Discrete FE Modeling to Simulate Micro-Fracture Modes in Progressive Crushing of Fiber Reinforced Composite Tubes
M. Nishi, K. Saito (JSOL Corporation, Japan), B. Ren (Livermore Software Technology Corporation, USA)
We propose a discrete FE modeling scheme which can capture the micro-fracture process leading to the ultimate crushing mode. Numerical studies with different laminate configurations reveal that the proposed model can capture the crushing mode in different circumstances.

3.06-24 A New Numerical Approach to Predict Energy Absorption of Composite Structures under Crush
M. Engul (Bogazici University, Turkey), N. Ersoy (Bogazici University, Turkey & University of West England, United Kingdom)

3.06-25 High Strain Rate Modeling of Woven Composite using Stack Shell Method
C. Srivastava, B. Ravindran, G. Lampeas (University of Patras, Greece)
The mechanics of damage in woven composites during impact is complex and understanding them requires intense effort both experimentally and numerically. Majority of the research uses material models developed to aggregate properties and study the behavior under impact loading. (Cntd)

3.06-26 Uncertainty Quantification and Management in the Analysis of a Low Velocity Impact and Compression After Impact Tests using Progressive Damage Models
A. Turon, I. Ruíz, A. Martínez, D. Trias (Universitat De Girona, Spain), P. Peters, M. Fouinneteau (Airbus Operations SAS, France)

3.06-27 A Novel Approach for the Strain Rate Dependent Modeling of Woven Composites
N. Feld (Safran Tech, France), F. Coussa, B. Delattre (Groupe PSA, France)
A strain-rate dependent model is proposed for thermoplastic GFRPs. Relying on a strict mechanisms separation hypothesis, it accurately represents the nonlinear behavior of such composites until failure. Identification and validation procedures are implemented to justify the model's capabilities.

3.06-28 Prediction of Low Velocity Impact and Compression After Impact on Laminate Composite with Thermoplastic Matrix
C. Bouvet (Université de Toulouse, France), P. Garcia Pérez, F. Dau (Arts et Métiers ParisTech, France), L. Ballere, P. Peres (Ariane-Group, France)

14.45-16.45 Hall: **Multi-Purpose Room**

3.08 | Material and Structural Behavior – Simulation and Testing: Fatigue of Composites

Chair: **A. Bernasconi, G. Pinter**

3.08-19 Testing and Modelling Strategy for Application-Oriented Service Strength Analysis of Composite Materials in Hybrid Adhesive Joints
K. Tittman (Technische Universitat Dresden, Germany), J. Wacker (Technische Universitat Darmstadt, Germany), I. Koch, M. Gude (Technische Universitat Dresden, Germany), T. Melz (Technische Universitat Darmstadt, Germany)
Application orientated dimensioning and assessment methods need be developed further for hybrid adhesive joints. This refers in particular to fatigue loading of hybrid joints under multi-axial stress states which generate significant out-of-plane stresses in the fibre reinforced component. (Cntd)

3.08-20 Open Hole Tensile and Compressive Fatigue Strengths of Interlaminar Toughened CFRP Laminates using Benzoxazine Resin as Matrix
S. Yamanaka, M. Nakada, Y. Miyano (Kanazawa Institute of Technology, Japan), T. Matsumoto (JXTG Nippon Oil & Energy Corporation, Japan)
The open hole tensile (OHT) and open hole compressive (OHC) static and fatigue tests were conducted for the interlaminar toughened and un-toughened quasi-isotropic CFRP laminates using benzoxazine resin as the matrix. The influence of toughened interlayer as the interlaminar on the OHT and OHC static (Cntd)

3.08-21 High Cycle Vibration Fatigue of CFRP under Elevated Ambient Temperatures
G. Voudouris, D. D. Maio (University of Bristol, United Kingdom), Ibrahim Sever (Rolls-Royce plc, United Kingdom)
Vibration Fatigue of Carbon Fibre Reinforced Polymers (CFRP) composite components couples both the thermal and the mechanical properties of the material. In fact, the fatigue life depends greatly on capacity of these properties to change according to both input load and environmental conditions. (Cntd)

3.08-22 Effect of Temperature on Damage Mechanisms in an Acrylic-Matrix and Glass-Fiber-Reinforced Composite under Monotonic Tensile and Fatigue Loadings
E. Boissin, C. Bois, J.-C. Wahl (University of Bordeaux, France), T. Palin-Luc (ENSARM, France)
Effect of temperature on the damage scenario in an acrylic-matrix and glass-fiber reinforced composite was studied under quasi-static and fatigue loadings. Tests show that the temperature has a significant effect on the damage scenario in both cases, this one being different at 15°C and 40°C.

3.08-23 Analysis of the Coupling between the Effects of Transverse Tension and Shear on the Matrix Damage's Evolution in a UD Ply of an Unbalanced Hybrid Woven Carbon/Glass-PEEK Composite

N. Boulebbad-Gomez (Airbus Helicopters - Aéroport International Marseille Provence & Aix-Marseille University, France), C. Hochard, N. Lahellec (Aix-Marseille University, France), J.-P. Charles (Airbus Helicopters - Aéroport International Marseille Provence, France)

3.08-24 Cyclic Fatigue Behavior of Glass Fiber Reinforced Epoxy Resin at Ambient and Elevated Temperatures

David Kraus, Volker Trappe (Bundesanstalt für Materialforschung und -prüfung-BAM, Germany)

The fatigue behavior of ±45° glass fiber reinforced epoxy resin under cyclic mechanical and constant thermal loading in the range 296 K to 343 K is investigated in this stud The fatigue behavior of ±45° glass fiber reinforced epoxy resin under cyclic mechanical and constant thermal loading in the range 296 K to 343 K is investigated in this study. The specimen damage is measured in-situ using optical grayscale analysis.

14.45-16.05 Hall: MC3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chair: **V. Michaud**

5.07-21 Laser Transmission Welding of Thermoplastic Polyurethanes: A Robust Process with High Reliability

R. Staehr, V. Wippo, P. Jaeschke, O. Suttmann, L. Overmeyer (Laser Zentrum Hannover e.V., Germany)

This paper introduces the laser transmission welding process as an advantageous joining technique and investigates its characteristics for welding thermoplastic polyurethanes (TPU). Laser power, feed rate, and clamping pressure are all variable parameters that influence the weld seam quality, (Cntd)

5.07-22 Automated Continuous Fabrication of Load-Path Adapted Thermoplastic Fiber Prepregs

F. Gabriel (TU Braunschweig, Germany), D. Nebel (Fraunhofer Project Center Wolfsburg, Germany), A. Fürst (TU Braunschweig, Germany)

This paper proposes an approach to provide the automated continuous fabrication of load-path adapted thermoplastic fiber prepregs in a large-scale calendaring process.

5.07-23 Development of Discontinuous Fibre Reinforced Thermoplastic Feedstocks for High Performance 3D Printing

L. G. Blok (University of Bristol, United Kingdom), H. Yu (University of Bath, United Kingdom), M. L. Longana, B. K. S. Woods (University of Bristol, United Kingdom)

A 3D printing reinforced thermoplastic filament is being developed using aligned dry 3mm carbon fibre preforms from the HiPerDiF method. This work shows the first steps; the matrix selection and characterisation of aligned discontinuous fibre reinforced thermoplastic composites.

5.07-24 Overmolding of a Thermoplastic Composite in Industrial Conditions – Parameters Influence on the Adhesion Quality

J.-L. Bailleul, S. Le Corre (Ecole Polytechnique de l'Université de Nantes, France)

14:45-16:45 Hall: MC2

3.14 | Material and Structural Behavior – Simulation and Testing: Multiscale Modeling

Chairs: **K. Tserpes, W. Van Paepegem**

13.14-07 Stochastic Multiscale Computational Framework for Fibrous Composites Considering many Physical and Geometrical Random Parameters

N. Takano (Keio University, Japan), A. Ohtani (Kyoto Institute of Technology, Japan), A. Nakai (Gifu University, Japan)

A stochastic homogenization procedure based on first-order perturbation method and finite element method is presented to predict the macroscopic properties, microscopic strain and damage propagation for fibrous composite materials.

3.14-08 Do Transverse Cracks Affect the In-Situ Strength and Fibre Breaks Accumulation in Longitudinal Plies of Cross-Ply Laminates?

A. Melnikov, Y. Swolfs, S. V. Lomov, L. Gorbatikh (KU Leuven, Belgium)

The study was done by using the fibre break model for longitudinal layers and analytical solutions for stress fields due to cracks in transverse layers of cross-ply laminates. Strength and fibre breaks distribution in the longitudinal layers were compared with unidirectional composites.

3.14-09 Multi-Scale Damage Modeling Of 3D Ceramic Matrix Composites from in-Situ X-Ray Tensile Tests

V. Mazars (LCTS & Safran Ceramics, France), G. Couégnat, O. Caty (LCTS, France), S. Denneulin (Safran Ceramics, France), G. L. Vignoles (LCTS, France)

SiC/SiC composites are actively developed to be used in hot parts of civil aircraft engines to improve efficiency and reduce the environmental impact. To understand and to predict the location of damage in such materials is critical. The present paper proposes a multi-scale finite element modeling (Cntd)

3.14-10 Modelling the Effect of Porosity on the Mechanical Properties of Unidirectional Composites. The Case of Thick-Walled Pressure Vessels
J. Rojek, S. Joannès (CNRS UMR, France), M. Mavrogordato (University of Southampton, United Kingdom), L. Laiarinandrasana, A. Bunsell (CNRS UMR, France), A. Thionnet (CNRS UMR & Université de Bourgogne, France)
X-ray microtomography shows significant porosity in a thick-walled CFRP hydrogen pressure vessel. Void content depends strongly on composite orientation and through-thickness position. A numerical model is proposed for a realistic damage simulation.

3.14-11 Multiscale Homogenization of a Glass-Pa66 Fabric Composite Behavior for Crash Studies
P. Rozycki (Ecole Centrale de Nantes, France), M. A. Mbacke (IRT Jules Verne, France), A.T. Dau (Ecole Centrale de Nantes & IRT Jules Verne, France)
The paper deals with a double homogenization to numerically represent the behavior of a woven thermoplastic composite in order to decrease the number of experimental mechanical tests. The sensitivity of the composite to both temperature and hygrometry is also taken into account.

3.14-12 Damage Mechanism and Effective Properties of Multi-Material Boundary Layers
F. Hirsch, M. Kästner (Technische Universität Dresden, Germany)
A finite element model is presented to investigate a rough aluminum-polymer interface with randomly distributed glass fibers. The application of numerical homogenization techniques allows to derive effective traction-separation relations from the micromechanical simulations

14:45-16:25 Hall: **Kokkalis**

1.02 | Applications: Automotive and Rail
Chairs: **D. Mazarakos**

1.02-01 Design of a Real-Sized Composite Drive Shaft and Critical Points from Beginning to End
K. Cinar (Namik Kemal University, Turkey), N. Ersoy (Bogazici University, Turkey), M. Akif Unal (Borusan ARGE, Turkey)
In this study, the replacement of a metal drive shaft by a composite counterapart was investigated. The drive shaft considered here is a thin walled tube with an internal diameter of 60 mm and a length of 1200 mm. These dimensions correspond to the dimension of a regular metal drive shaft. (Cntd)

1.02-02 Testing and Finite Element Analysis of a High Level Leafspring Surrogate /Demonstrator Component
P. Albrecht (TCS Composites AT Europe, Henkel AG & Co KGaA Standort Heidelberg, Germany), M. Wienand (Process Engineering A&S, Henkel AG & Co KGaA Standort Heidelberg, Germany), J. Becher, C. Derdas (Global Engineering Center,AT-PD, Henkel AG & Co KGaA Standort Munich, Germany)
The testing and fatigue testing results of a composite leafspring demonstrator under flexural fatigue at a R=0.1 and a f=1.5Hz and static loading. The static, S-N behavior, and stiffness degradation behavior of the specimens are discussed and some static FE modelling aspects are also addressed

1.02-03 Development of Composite Drive Shaft Tube for Automotive Industry
Gizem Arslan Özgen (Tirsan Kardan Research and Development Center & Izmir Institute of Technology, Deparment of Mechanical Engineering, Turkey), Metin Tanoğlu (Izmir Institute of Technology, Deparment of Mechanical Engineering, Turkey), Engin Aktaş, Kutay Yücetürk (Izmir Institute of Technology, Department of Civil Engineering, Turkey)
Weight, vibration, fatigue, and critical speed limitations have been recognized as serious problems in drive shafts in automotive industry for many years. Conventional drive shaft is made up into two parts to increase its fundamental natural bending frequency. This present work deals with the replacement of conventional steel drive shaft with a composite counterparts. The benefits of eliminating the two piece shafts are significant reductions in weight, noise, vibration and harshness (Cntd)

1.02-04 Manufacturing Process Optimization for Composite-Steel Multimaterials Design
L. Mera, R. Mano, T. Delgado, L. Blanco (AIMEN Technology Centre, Spain)
The present work deals with different aspects of the manufacturing process optimization of thermoset composites- steel components, on the grounds of process speed, and joint resistance. A range of composite prepreg systems, and innovative surface treatments had been considered in this study so to ensure the optimum performance (Cntd)

1.02-05 Development of Production Costs of CFRP Parts
T. von Reden, D. Schueppe (Carbon Composites e. V., MAI Carbon, Germany), A. Hohmann (Fraunhofer IGCV, Germany)
The production cost is one of the most decisive decision gates for the usage of CFRP parts. MAI Carbon works on this topic since 2012. An analysis of the latest developments in the field of production technologies shows a strong decrease of costs. For mass production costs under 20 €/kg are possible.

14:45-16:25 Hall: **Lecture Room**

2.14 | Materials Science: Polymer Matrix Materials (Modelling/Fibre Composites)
Chairs: **V. Carvelli, P. Robinson**

2.14-06 A Finite Strain Elasto-Plastic Material Model for Semicrystalline Polymers Incorporating Kinematic and Isotropic Hardening
S. Felder, J.-W. Simon, S. Reese (RWTH Aachen University, Germany)
A finite strain, hyperelastic-viscoplastic material model formulation for semicrystalline polymers, incorporating isotropic and kinematic hardening, which is valid for large deformations and large deformation rates in the context of isothermal processes, is presented.

2.14-07 Development of Constitutive Model for Carbon Nanotube/shape Memory Polymer Composite

J. Kim, Y. An, S. Hong (Seoul National University, Korea), J. O. Hwang, J .K. Park (Agency for Defense Development, Korea), W.-R. Yu (Seoul National University, Korea)

We developed a new three-dimensional (3D) constitutive model for analyzing the shape memory performance of CNT-SMPCs based on the Arruda-Boyce model. A new constitutive equation was implemented in a COMSOL simulation program and was able to predict the shape memory performance of SMPs and CNT-SMPCs with a fair degree of accuracy.

2.14-08 Solvent-Free, Liquid Processable BT Resin/Glass Fibre Reinforced Composites

R. J. Iredale, I. Hamerton (University of Bristol, United Kingdom)

A novel, liquid processable BT resin blend is successfully infused onto glass fibres functionalized with three different surface treatments. The thermomechanical properties of the resulting composites are assessed.

2.14-09 Analysis and Interrelation Between Swelling Behavior and Surface Roughness of Glass Reinforced Cyanate Ester Composites

P. Kelverkloglou, E. Kollia, S. Tsantzalis, V. Kostopoulos (University of Patras, Greece)

The water absorption behaviour of composites and especially of woven glass reinforced cyanate-ester polymers, the swelling properties and the resulted surface roughness have been studied in this work. The swelling behaviour was investigated via absorption tests in distilled water at four different temperatures (Cntd)

2.14-10 Mechanical Behaviour of Jute Fibre-Reinforced Polyester Composite: Characterization of Damage Mechanisms using Acoustic Emission

A. Alia (University of Lyon & University of Setif, Algeria), G. Fantozzi, N. Godin (University of Lyon, France), H. Osmani (University of Setif, Algeria), P. Reynaud (University of Lyon, France)

In this paper, a mechanical characterization of a woven jute fabric reinforced polyester composite is conducted under both monotonic and cyclic fatigue tensile loading. Two stacking sequences were considered: [0]8 and [+45/-45]2S. Tensile static tests were performed at a constant rate of 0.1mm/min and fatigue tests were performed (Cntd)

14:45-16:25 Hall: MC3.2

2.13 | Materials Science: Nano Composites

Chairs: **D. Papageorgiou, E. Thostenson**

2.13-21 Development and Characterization of Epoxy Resin/ Silicon Carbide Composite Nanodielectrics

T. G. Velmachos, G.C. Psarras (University of Patras, Greece)

In this study, three series with a total of seventeen specimens were manufactured varying the filler's concentration and size. The samples were characterized by means of Scanning Electron Microscopy, Broadband Dielectric Spectroscopy (0,1 Hz – 1 MHz and 30-200 degrees Celsius range) and Dynamic Mechanical Analysis (Cntd)

2.13-22 Path-Dependence in Evolution of Electrical Conductivity in Curing Hybrid Nanocomposites: Important Effects Revealed When Studying Silver Nanobelts in a DGEBA/TETA Epoxy Matrix

G. Rivers, P. Lee-Sullivan, B. Zhao (University of Waterloo, Canada)

In-situ analysis of nanocomposites during curing uncovers: 1) disruptions to the developing electrical conductivity from polymer dynamics which produce reductions in final conductivity, and 2) the addition of silver nanobelts reduces the disruptions.

2.13-23 Structural and Optical Properties of Se-doped CdS Nanorods Grown by PVD Method

M. A. Baghchesara, R. Yousefi, M. Cheraghizade (Islamic Azad University, Iran)

In this work, the optical properties of Se-doped CdS and undoped CdS nanorods, were grown on Si substrate using physical vapor deposition (PVD) method, were investigated. The average diameter sizes of the Se-doped CdS and undoped CdS nanorods were 416 and 1100 nm, respectively. (Cntd)

2.13-24 Thin Film UV-Curable Acrylate Polyurethane/MOF Mixed Matrix Membranes for CO2 Separation

A. Shojaei, H. Molavi, S. A. Mousavi (Sharif University of Technology, Iran)

2.13-25 Fabrication, Characterization and Functionality of BaFe12O19/Epoxy Nanocomposites

A. Sanida, S. G. Stavropoulos (University of Patras, Greece), Th. Speliotis (NCSR "Demokritos", Greece), G. C. Psarras (University of Patras, Greece)

In this study BaFe12O19/epoxy composite nanodielectrics were fabricated and studied. The morphological investigation was conducted by Scanning Electron Microscopy (SEM). The dielectric response was examined by means of Broadband Dielectric Spectroscopy (BDS). (Cntd)

14:45-16:45 Hall: MC3.3

3.01 | Material and Structural Behavior – Simulation and Testing: Analysis and Design of Damage Tolerant Composite Structures

Chair: **S. Pinho**

3.01-07 Life Prediction Analysis of Thick Adhesive Bond Lines Under Variable Amplitude Fatigue Loading
A. E. Antoniou, M. M. Vespermann, F. Sayer (Fraunhofer IWES Institute for Wind Energy Systems, Germany), A. Krimmer (EUROS GmbH, Germany)
Wind turbine rotor blades are exposed to arbitrary wind loadings and consequently their adhesive bond lines along the blade span. Residual stresses, developed due to the manufacturing curing process, are superimposed as steady state components on the wind loadings, shifting the fatigue stress ratios (Cntd)

3.01-08 Structures Under Various Mechanical Loads
C. Hochard, O. Montagnier, N. Lahellec (Université Aix-Marseille, France)
A non-linear cumulative Continuum Damage Mechanics and a Fracture Characteristic Volume model for unidirectional and woven plies laminates undergoing static and fatigue loads have been developed for describing the evolution of the matrix damage and fibre failure of laminated structures.

3.01-09 Interlocking Thin-Ply Reinforcements for the Improvement of CAI Strength
J.-A. Pascoe, S. Pimenta, S.T. Pinho (Imperial College London, United Kingdom)
We designed and tested a new interlocking concept for improving interlaminar toughness and CAI. We will show results for mode I and II toughnesses, post-impact delamination areas, and CAI, and compare them against a non-interlocked baseline laminate.

3.01-10 Comparative Study of Strain Energy Storage Mechanisms between Carbon Fibre-Reinforced Peek and Epoxy Composites Subjected to Static and Cyclic Loading
T. P. A. Hernandez, A. R. Mills, H. Yazdani Nezhad (Cranfield University, United Kingdom)
Experimental studies were performed on the strain energy storage response of aerospace grade PEEK and toughened Epoxy carbon fibre-reinforced composite prepreg laminates having identical carbon content. The strain energy stored up to failure was recorded at the highest point of deflection (Cntd)

3.01-11 Residual Strength Estimation based on Topology Optimization Algorythm
L. L. Firsov, A. N. Fedorenko, B. N. Fedulov (Moscow Aviation Institute, Russia)
The purpose of this study is to develop a model to predict residual strength of composite materials with barely visible impact damage (BVID) which is the key factor for the composite structures certification. The portion for the energy from impact is used to form microcrack system in matrix, (Cntd)

3.01-12 Effect of Variability of Mechanical Parameters on the Deformation Behaviour and Failure of Fibre Reinforced Plastic Materials
L. Kovács (eCon Engineering Ltd, Hungary), G. Romhány (Budapest University of Technology and Economics, Hungary)
Presented work introduces a Monte-Carlo sampling based approach that aims to model the effect of variability of the baseline composite material on the behavior of a composite bicycle frame. Scatter in material data can lead to significant variation in the utilization of the assessed structure.

14:45-16:45 Hall: MC3.4

5.10 | Processing and Manufacturing Technologies: Process Modelling IV: Constitutive Models and Analysis

Chair: **C. Binetruy**

5.10-16 Modelling Stress Response of Glass-Fibre Composites During Shear Flow using 3-Dimensional Fibre Orientation Evolution and Fibre Migration Data
V. Perumal, Rahul K. Gupta, Sati N. Bhattacharya (RMIT University, Australia), F. S. Costa (Autodesk Australia Pty Ltd, Australia), S. Kashi (Deakin University, Australia)
Constitutive models for stress predictions in fibre filled composites have considered the effects of evolving fibre orientation distribution. However, studies incorporating effects of fibre concentration migration have been limited. This work is aimed at evaluating the combined effects of fibre orientation evaluation (Cntd)

5.10-17 Analysis of the Influence of the Adhesive on Process Distortions of Co-Bonded Stringer Foot Specimens
L. Moretti, G. Dusserre, B. Castanié, P. Olivier (Université de Toulouse, France)
Process induced distortions prediction is a major issue for structural parts like self-reinforced panels. They may cause important displacements for parts of large dimension and compromise the quality of the assembly. Development of numerical process models is necessary (Cntd)

5.10-18 A Strategy for Cost-Effective Compensation of Process Induced Deformations in Composite Structures
M. Lipcan (Airbus Helicopters Deutschland GmbH & Technical University of Munich, Germany), J. M. Balvers (Airbus Helicopters Deutschland GmbH, Germany), M. P. Hartmann (Technical University of Munich, Germany)
Undesired deviations of the geometry "as built" from the nominal geometry "as designed" are inherent to composite structures made up of carbon fibre reinforced plastics. This paper presents a methodology of filtering simulated deformations with respect to not only given tolerances, (Cntd)

5.10-19 **Kinematically Enhanced Constitutive Modelling: A Viable Option for the Simulation of the Manufacturing of Full-Scale Composite Parts**

J. P. H. Belnoue, D. S. Ivanov, S. R. Hallett (University of Bristol, United Kingdom)

Earlier work carried out the University of Bristol has shown the possibility to accurately predict consolidation-driven defect formation in composite parts using a ply-by-ply approach. However, using this method, a typical model for a lab-scale specimen can easily reach the hundreds of thousands of degrees of freedom, (Cntd)

5.10-20 **Application of a Generalised Cellular Solid Model for Predicting the Fibre-Bed Effective Properties in Viscoelastic Modelling of Fibre Reinforced Composites**

S. Malek (University of Technology Sydney, Australia), R. Vaziri (University of British Columbia, Canada), A. Poursartip (University of British Columbia, Canada)

Process modelling has been a successful strategy for simulating the behaviour of composites during their manufacturing process. The simplest approach for modelling the viscoelastic behaviour of thermoset composites (unidirectional or woven) (Cntd)

5.10-21 **Theoretical and Experimental Validation of Critical Thermal Properties of Advanced Vacuum Bagging for Composite Manufacturing**

A. Haeberle (University Bremen, Germany), A. Herrmann (CTC GmbH, Germany), P. Fideu (Airbus Operations GmbH, Germany)

Within the development of a new vacuum bagging material for CFRP curing processes, the thermal behavior along the process chain needs to be validated. This has exemplarily been done with a theoretical and experimental comparison of a critical heat introduction.

14:45-16:05 Hall: Conference 1

7.02 | Recycling and Sustainability: Recycling of Fibers and Composites

Chair: **S. Pimenta**

7.02-01 **Development of a Closed-Loop Recycling Process for Highly Aligned Discontinuous Carbon Fibre Thermoplastic Composites**

R. J. Tapper, M. L. Longana (University of Bristol, United Kingdom), H.-N. Yu (University of Bath, United Kingdom), I. Hamerton, K. D. Potter (University of Bristol, United Kingdom)

In this study the effects of a closed-loop recycling methodology are evaluated for degradation using thermoplastic ocmposites based on discontinuous fibres. The process comprises two fundamental steps: reclamation and remanufacture. The material properties are analysed over two recycling loops

7.02-02 **High Quality Carbon Fibers from End-Of-Life Fiber Reinforced Plastics - A New Recycling Technology**

V. A. de Oliveira, F. Goettmann (Extracthive Process Designers, France)

In this work, we present the preliminary study and process optimization that led to a new industrial-friendly technology to recycle Carbon Fiber Reinforced Plastics. The versatility tests prove that the chosen process is compatible with different thermoset and thermoplastic resins.

7.02-03 **Recycling of Composites by Recovering Carbon Fibres from Prepregs, and their Re-Use**

A. Fernández (IMDEA Materials Institute, Spain), C. González (IMDEA Materials Institute & CENIM, Spain), F. López (E.T.S. de Ingenieros de Caminos, Spain), J. Molina-Aldareguia, C. S. Lopes (IMDEA Materials Institute, Spain)

A composites recycling process based on pyrolysis is designed in order to obtain recycled carbon fibres with optimal microstructure, surface quality and mechanical properties. The fibres are then reused to remanufacture laminates with properties similar to brand-new composites.

7.02-04 **Recycling and Re-Purposing Decommisioned Construction Polymer Composites for Construction Applications**

S. Grammatikos (Norwegian University of Science and Technology, Norway), S. Tsampas (GKN Aerospace Engine Systems, Sweden), J. Petterson (Swerea SICOMP AB, Sweden), T. Luping (Chalmers University of Technology, Sweden), I. Löfgren (T. Concrete Group AB, Sweden)

Fibre reinforced polymer composites (FRPs) are being increasingly used in aerospace and automotive applications due to their high specific mechanical properties. The construction industry has also started taking advantage of the potential of FRPs for both structural and non-structural purposes. (Cntd)

14:45-16:45 Hall: MC3.5

Special Session 2 | Office of Naval Research- Marine Composites (continue)

Chairs: **Y. Rajapakse, V. Lopresto**

SS2-08 **Multiscale Based Failure Criteria for Fibrous Composites**

Y. W. Kwon, J. Darcy (Naval Postgraduate School, USA)

A new set of failure criteria were developed for fibrous composite materials, which are based on stresses and strains of the constituent material level (i.e., fiber and matrix materials) rather than the composite material level. The criteria were applied to a multiscale analysis of fibrous composite materials (Cntd)

SS2-09 **Flexural Properties and Impact Damage Behavior of Nylon 6/woven Basalt Fibers Composite**

P. Russo, G. Simeoli, F. Cimino (National Research of Council, Italy), I. Papa, V. Lopresto (University of Naples F. II, Italy)

Polyamide 6 (PA6) basalt fabric composite laminates were prepared and analyzed in terms of flexural and low velocity impact properties. The BS/PA6 exhibits good flexural performances and a high rigidity in all tests. These data, complemented by morphological inspections and indentation depth measurements (Cntd)

SS2-10 Polymeric Nanocomposites With Binary Nanoparticle Reinforcements and Hybrid Composites for Marine Applications
M. Hosur, A. Tcherbi-Narteh, D. Watson, M. Zaheeruddin, K. McIntosh, S. Jeelani (Tuskegee University, USA)
This paper presents the work on nanophased polymers made with hexagonal born nitride, nanoclay and graphene nanoplatelets, and hybrid composites consisting glass and carbon fabrics and their characterization.

SS2-11 Prediction of Statistical Creep Failure Time for Unidirectional CFRP
Y. Miyano, M. Nakada (Kanazawa Institute of Technology, Japan)
This paper is concerned with the statistical prediction of flexural creep failure time in the longitudinal direction of unidirectional CFRP based on the visco-elasticity of matrix resin. The flexural creep failure time of unidirectional CFRP was predicted statistically using the flexural static strengths (Cntd)

SS2-12 Failure Mechanics of Polymeric Foam Cores for Sandwich Structures
M. Battley, T. Allen, A. Ramesh, C. Lewis, O. Heycoop, M. Garg, L. Healy (University of Auckland, New Zealand)
Quasi-static and dynamic testing has been undertaken of material coupons and sandwich panel structures for a range of polymeric foams. The results are being used to establish and validate constitutive models for the foam materials.

SS2-13 Eliminating the Need for Gel-Coat Surfaces in Composites
L. Sivanathan (University of Bristol & Jo Bird & Co Ltd, United Kingdom), G. Atkins (Jo Bird & Co Ltd, United Kingdom), C. Ward, A. Koutsomitopoulou (University of Bristol, United Kingdom)
This work aims to demonstrate one such case, where the gel coat is substituted for a polyester veil (in this case a patterned wood effect) and a novel UV resistant resin, employing a closed moulding infusion process.

14:45-16:15 Hall: Kokkalis Foyer

Poster Session

16:45- 17:10 Hall: Exhibition Area

Coffee Break

17:10-18:50 Hall: Trianti

3.10 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Lamina and Laminate Level

Chair: **L. Asp**

3.10-29 Experimental and Computational Study of Multidirectional Glass/Epoxy Laminates Subjected to Multiaxial Loading
T. Laux (University of Southampton, United Kingdom), K. W. Gan (University of Southampton, United Kingdom & University of Southampton Malaysia Campus USMC, Malaysia), J. M. Dulieu-Barton, O. T. Thomsen (University of Southampton, United Kingdom)
A nonlinear constitutive model based on non-associative plasticity for unidirectional (UD) composites subjected to multiaxial in-plane loading is proposed. The model can be calibrated using a relatively simple biaxial experiment based on a novel Modified Arcan Fixture (MAF) and Digital Image Correlation (DIC). (Cntd)

3.10-30 Experimental and Numerical Progressive Failure Analysis in Open-Hole Tensile Tests of Quasi-Isotropic Composite Laminates
S. Ahmadvasha Aghbash, F. E. Öz (Boğaziçi University, Turkey), M. Mehdikhani, S. V. Lomov (KU Leuven, Leuven), N. Ersoy (Boğaziçi University, Turkey & University of West England, United Kingdom)
A Finite Element Analysis (ABAQUS/Implicit) was performed to predict the progressive failure behavior (intralaminar failure and delamination) of Open-Hole Tension (OHT) specimens with [+452/902/-452/02]s layup. Initiation and evolution of delamination were modelled based on the Cohesive Zone Model. (Cntd)

3.10-31 Strength of UD-Laminates Depending on the Fiber Volume Content: Experimental Tests and Modelling
S. Galkin, L. Kärger (Karlsruhe Institute of Technology-KIT, Germany)
Fiber volume content influence the stiffness and the strength of composite parts. In the present work, experimental and modelling approach is presented to evaluate the significance of the fiber volume content transverse and in shear direction.

3.10-32 Effect of Defects on Matrix Cracking in Carbon Fiber-Reinforced Composites Investigated by Means of Digital Image Correlation at Different Scales
M. Mehdikhani (KU Leuven & SIM M3 program, Belgium), E. Steensels, A. Standaert, K. A. M. Vallons (KU Leuven, Belgium), L. Gorbatikh, S. V. Lomov (KU Leuven & SIM M3 program, Belgium)
A multi-scale DIC methodology is developed for in-situ characterization of matrix cracking in CFRPs, influenced by presence of manufacturing defects, namely voids.

3.10-33 Robust Damage Prediction of Laminated Open-Hole Structures

J. Germain, J. Rannou, F. Laurin (Université Paris Saclay, France), D. Martini (Dassault Aviation, France)

In order to propose a robust approach to predict damage in laminated open-hole structures, a continuum damage model with a fair level of complexity is proposed. Its formulation and identification procedure are presented. Numerical difficulties occurring in FE computations are discussed.

17:10-18:50 Hall: **Mitropoulos**

3.11 | Material and Structural Behavior – Simulation and Testing: Fracture and Damage – Micromechanics

Chair: **V. Carveli**

3.11-06 Transverse Compressive Properties of Novel Carbon/Glass Hybrid Thermoplastic Composite Rods

K. Naito, C. Nagai, Y. Tanaka (National Institute for Materials Science, Japan)

In this present study, the transverse compressive properties of the three types of hybrid rods having differing carbon/glass ratios (24K1P, 24K2P, and 24K3P) were evaluated.

3.11-07 Numerical and Experimental Study of Single Fiber Push-Out Test: Influence of Fiber/Matrix Interface Mechanical Properties

D. I. Batsouli, D. A. Dragatogiannis (National Technical University of Athens, Greece), S. Corujeira Gallo, Z. Zhang, H. Dong (University of Birmingham, United Kingdom), G. Kotsikos (European Commission, Belgium), C. A. Charitidis (National Technical University of Athens, Greece)

Single fiber push-out experiments are used to characterize the mechanical behaviour of fiber/matrix interface and have attracted significant attention due to their versatility. The effect of the interface mechanical properties on the corresponding composite mechanical behaviour is complex (Cntd)

3.11-08 Fibre Lock-Up and Other Mechanisms at Large Fibre Rotations, and their Effect on Axial Compression of Composites

R. Olsson (Swerea SICOMP, Sweden)

Closed form bounds for the kink band angle and fibre lock-up angle in fibre kinking are provided by considering the 3D geometry of square and hexagonal fibre arrays in the initial and locked-up position. The stiffness after lock-up is also derived.

3.11-09 Interface Crack Growth Under Transverse Compression: Nearby Fibre Effect

C. Sandino, E. Correa, F. París (Universidad de Sevilla, Spain)

The influence of the presence of an undamaged fibre on the interface crack growth associated with the inter-fibre failure under uniaxial compression is studied by means of a two-fibre BEM model, in order to analyse the alterations brought about by the variation of the position of the undamaged fibre (Cntd)

3.11-10 Discrete Damage Modeling for a Transverse Compression Experiment of a Polymer Matrix Composite

M. Flores (Air Force Research Laboratory, USA), N. Sesar (North Carolina State University, USA), B. Wheeler (Microtesting Solutions LLc., USA), A. Sharits, D. Mollenhauer (Air Force Research Laboratory, USA)

Strengthening the fundamental understanding of micromechanical methods in continuity is a critical aspect in developing and designing future composite systems. Virtual testing has provided additional understanding of the behavior of materials on a microstructural scale. (Cntd)

17.10 -18.50 Hall: **Skalkotas**

3.03 | Material and Structural Behavior – Simulation and Testing: Delamination

Chair: **P. Robinson, N. Chrysochoidis**

3.03-01 Fracture Mechanics Analysis of Composites with Ply-Drops - Measurement of Delamination Fatigue Crack Growth Rate

S. Goutianos, B. F. Sørensen (Technical University of Denmark, Denmark)

Ply-drops must be taken into account in the design of composite structures due to the initiation and propagation of delaminations at ply-drop locations. This damage mode is experimentally investigated in tension-tension fatigue and the fatigue delamination growth rate is measured for two (external and internal) (Cntd)

3.03-02 Experimental Determination of the Crack Resistance Curves and Cohesive Laws of Thin-Ply Nano-Reinforced Laminates

C. Furtado (Universidade Do Porto & INEGI Portugal), R. Kopp, X. Ni (Massachusetts Institute of Technology, USA), C. Sarrado (University of Girona, Spain), L. B. Wardle (Massachusetts Institute of Technology, USA), P. P. Camanho (Universidade Do Porto & INEGI Portugal)

3.03-03 Mode I Cohesive Law Characterization Procedure in Adhesive Joints

F. Mujika, N. Insausti, I. Adarraga, A. Arrese (Universidad del Pais Vasco/Euskal Herriko Unibertsitatea, Spain)

A method is proposed for the experimental characterization of damage propagation in adhesive joints. The Double Cantilever Beam test configuration is used to propagate damage stably while load, load point displacement and load point rotation are recorded. (Cntd)

3.03-04 Application of Low Frequency Guided Waves to Delamination Detection in Large Composite Structures: A Numerical Study
S. Shoja, V. Berbyuk, A. Bostrom (Chalmers University of Technology, Sweden)
The aim of the current work is to identify the challenges in computational modelling of ultrasonic guided wave propagation in large structures and developing methods to overcome them. The work includes investigating the application of GW in composite laminates and sandwich materials with the aim of delamination detection. (Cntd)

3.03-05 Identification of a Novel Cohesive Zone Law in an Interface Finite Element for Simulating Delamination with R-Curve Effects
S. M. Jensen, M. J. Martos, B. L. V. Bak, E. Lindgaard (Aalborg University, Denmark)
This paper is concerned with modelling of quasi-static delamination in fibrous laminated composites exhibiting R-curve effects. The objective of the work is two-fold; initially a novel cohesive law is formulated which enables R-curve modelling over conventional cohesive laws. (Cntd)

17:10-18:10 Hall: MC3

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites
Chair: **N. Takeda**

5.07-26 Pre-Assembly and Handling of Limp Endless Fibre-Reinforced Thermoplastic-Metal Preforms
R. Schnurr, J. Beuscher, F. Dietrich, K. Dröder (Technische Universität Braunschweig, Germany)
The paper describes a pre-assembly process for the production of plastic-intensive hybrid preforms for further processing in thermoforming. Starting from the challenges of automated handling of heated organic sheets, handling concepts for hybrid semi-finished products are investigated.

5.07-25 Improving the Quality of Thermoplastic Composite Corners Using Laser-Assisted Tape Placement
D. Peeters, D. Jones, R. O'Higgins, P. M. Weaver (University of Limerick, Ireland)
The quality of thermoplastic corners made out-of-autoclave using laser-assisted tape placement in combination with winding is assessed. The influence of the radius, rotational speed and acceleration on the corner strength are investigated.

5.07-27 Process Developement for Manufacturing Hybrid Components using an In-Mould Infrared Heating Device
J. P. Beuscher, R. Schnurr, A. Müller, M. Kühn, K. Dröder (Technische Universität Braunschweig, Germany)
An in-mould IR heating device has been developed to improve manufacturing processes for material hybrid components dominated by thermoplastic materials. This approach makes use of a substitution of steel with transparent ceramics at local areas of the mould and an the integration of IR-radiators. (Cntd)

17:10-18:50 Hall: MC2

5.10 | Processing and Manufacturing Technologies: Process Modelling V: Optimization and Analysis
Chair: **C. Binetruy**

5.10-22 Thermomechanical Optimization of an Innovative Low Inertia Mold with Rectangular Heating Channels
J. Collomb (Université Savoie Mont Blanc & CT1 compagny, France), P. Balland, P. Francescato (Université Savoie Mont Blanc, France), Y. Gardet, D. Leh (CT1 compagny, France), P. Saffré (Université Savoie Mont Blanc, France)
In order to be able to meet industries expectations, especially aeronautical and automotive industries, in terms of production rate, aspect and structural quality for high performance composite injected parts, it is necessary to produce reactive and thermally efficient molds. (Cntd)

5.10-23 Application and Evaluation of Meta-Model Assisted Optimisation Strategies for Gripper Assisted Fabric Draping in Composite Manufacturing
C. Zimmerling (Karlsruhe Institute of Technology (KIT), Germany), J. Pfrommer (Karlsruhe Institute of Technology (KIT) & System Technologies and Image Exploitation (IOSB), Germany), J. Liu (Karlsruhe Institute of Technology (KIT), Germany), J. Beyerer (Karlsruhe Institute of Technology (KIT) & System Technologies and Image Exploitation (IOSB), Germany), F. Henning (Karlsruhe Institute of Technology (KIT) & Fraunhofer - Institute of Chemical Technology (ICT), Germany), L. Kärger (Karlsruhe Institute of Technology (KIT), Germany)
Meta-model assisted optimisation techniques significantly reduce the computational load during numerical manufacturing optimisation. This work introduces state-of-the-art machine learning approaches to fabric draping processes. Different meta-modelling techniques are compared including deep neural networks, (Cntd)

5.10-24 Optimisation of Hot-Forming Process Through In-Plane Constraints: Numerical and Experimental Studies
P. Bussetta, R. Gomes (INEGI, Portugal), S. Chen, O.P.L. McGregor, L.T. Harper (University of Nottingham, United Kingdom), P. Harrison (University of Glasgow, United Kingdom), C. Correia (INEGI, Portugal)
The hot-forming process for thermoplastic composites is a very promising fabrication route for high volume applications. Reliable and fast numerical tools are needed to optimise the forming process and to support industrial exploitation. This paper presents the experimental validation of a finite element-based optimisation routine (Cntd)

5.10-25 **Composite Parts: Gap Between Available Models and Industrials Needs**

J. Stolz (Faserinstitut Bremen e.V., Germany), P. Fideu (Airbus Operations GmbH, Germany), A. Herrmann (Faserinstitut Bremen e.V., Germany)

Highlighting of gaps between industry expectations and available tools for process modeling and tool design of large scaled RTM parts. Consideration of thermo-mechanical analysis with cure dependency of material and requirements for large scaled tools.

5.10-26 **Finite Element Analysis for Sheet Metal Reinforced Hybrid Structures Produced via Non-Kinematical Constraint Manufacturing Processes**

B.-A. Behrens, A. Chugreev, J. Moritz, F. Bohne, H. Schulze (Leibniz Universität Hannover, Germany)

The present contribution deals with FE based process design of the manufacturing process for hybrid components with non-kinematical knitting rotation. An extensive material characterization has been carried out for the glass mat reinforced thermoplastic material. (Cntd)

17:10-18:50 Hall: Kokkalis

1.02 | Applications: Automotive and Rail

Chair: **D. Mazarakos**

1.02-06 **Wood-Based Composite Sandwich Structures**

J. Susainathan, F. Eyma, E. De Luycker, A. Cantarel, B. Castanié (Université de Toulouse, France)

Low carbon impact is a shared goal of all transportation industry. One way to match this expectation consists in the introduction of lightweight materials with high specific properties such as composites materials. A sandwich structure with a plywood as a core material combined with metallic or composite skins (Cntd)

1.02-07 **Automotive View on Local Material Properties – Impact on Part Performances and their Prediction via Simulations**

B. Eck, G. Le Lan, R. Schaefer (Faurecia Composite Technologies, France)

In this article an example of a simulation chain for the creation of composite parts produced with the forming process (pre- or thermoforming) and stressed in a crash load case is presented. The different elements of the approach (process simulation and optimization for a defect reduction / elimination (Cntd)

1.02-08 **A Thermoplastic Polymer Coating for Improved Impact Resistance of Railways CFRP Laminates**

S. Cuomo (University of Naples F. II, Italy), F. Rizzo (University of Bath, United Kingdom), G. Pucillo (University of Naples F. II, Italy), F. Pinto, M. Meo (University of Bath, United Kingdom)

Due to the superior specific mechanical properties and low density of composite materials, their demand has risen prolifically within several industrial fields over the last decade including railway industry. The latter considers composite materials as a much more attractive alternative to standard metallic solutions. (Cntd)

1.02-09 **Suitability Assessments for Composite-Metal-Hybrid Material Systems for Automotive Crash Structures**

M. Dlugosch (Fraunhofer Ernst-Mach-Institute, Germany), D. Lukaszewicz (BMW Group, Germany), J. Fritsch, S. Hiermaier (Fraunhofer Ernst-Mach-Institute, Germany)

A new objective and efficient methodology for making suitability assessments for hybrid material systems in automotive crash structures is introduced. Global maps of structural loading for a multitude of crash load cases are created and analyzed using specially defined suitability criteria.

1.02-10 **Innovative Chromium-Like and Cool Touch Plastic Solutions for Automotive Interiors**

M. João Lopes, B. Moura, S. Silva, D. Menezes (CeNTI, Portugal), S. Melo (Simoldes Group, Portugal)

Regarding the vehicle interior, the current strategy of the automotive components' manufacturers is to maintain the user's perceptive sensation of cool touch, commonly associated with metal surfaces. However, the internal components, used in automotive industry don't present the same cool touch as metals at room temperature. (Cntd)

17:10-18:50 Hall: Lecture Room

3.14 | Material and Structural Behavior – Simulation and Testing: Multiscale Modelling

Chair: **K. Tserpes**

3.14-13 **A Peridynamics Model for the Mechanical Analysis of Chopped Carbon Fiber Tapes Reinforced Thermoplastics**

P. Qu (University of Tokyo, Japan & Liaocheng University, China), Y. Wan, J. Takahashi (University of Tokyo, Japan)

Based on the peridynamics theory which employs a nonlocal model, a particle model was proposed for the numerical analysis on the tensile mechanical properties of randomly orientated discontinuous carbon fiber reinforced thermoplastics (RODCFRTPs). The multi-scale structure and the random damage propagation of the RODCFRTPs (Cntd)

3.14-14 **Multiscale Virtual Testing Analysis for Thermoplastic Composites Using Response Surface Models for Design Optimization**

O. Friderikos, E. Baranger (Université Paris-Saclay, France), D. Guillon (Technocampus Composites Z.I. du Chaffault, France)

A mutliscale methodology has been introduced for determining the early stages of damage evolution in Quilted Stratum Process (QSP) thermoplastic composite parts and answer critical design questions on why, where, and when damage and fracture initiates. (Cntd)

3.14-15 Composite Matrix Design with Efficient Computational Chemistry Approaches
C. M. Krauter (Schrödinger GmbH, Germany), J. L. Gavartin (Schrödinger Inc., United Kingdom), J. M. Sanders, T. J.L. Mustard, A. Goldberg, A. R. Browning, M. D. Halls (Schrödinger Inc., United States)
Efficient and accurate atomistic scale simulation of thermophysical and mechanical properties of composite matrix properties using a two-epoxy, one-amine curing resin in the presence of a thermoplastic-toughener as an example.

3.14-16 Through Thickness Thermal Conductivity Prediction Study on Carbon Reinforced Composites
F. Petropoulos, C. Kostagiannakopoulou, G. Sotiriadis, P. Kelverkloglou, V. Kostopoulos (University of Patras, Greece)

3.14-17 On Quantifying the Effect of Noise in Radial Basis Function Based Stochastic Free Vibration Analysis of Laminated Composite Beam
S. Naskar, S. Sriramula (University of Aberdeen, United Kingdom)

17.10-18.10 Hall: MC3.2

2.02 | Materials Science: Ceramic Matrix Composites
Chair: **S. Mileiko**

2.02-01 Mechanical Behavior of Oxide/Oxide Ceramic Matrix Composite Bolted Joints
M. Broutelle (IRT Saint-Exupéry & Université Fédérale Toulouse Midi-Pyrénées, France), F. Lachaud, A. Daidié (Université Fédérale Toulouse Midi-Pyrénées, France), L. Barrière, C. Dupleix-Couderc (IRT Saint-Exupéry, France), F. Bouillon (SAFRAN Ceramics, France)
The mechanical behavior of a bolted joint made of ceramic matrix composite has been characterized through tests and a numerical modelling. The damage observed is modelled through constitutive laws implemented on a finite element code.

2.02-02 Microstructure-Sensitive Damage Formation/Propagation in Continuous Ceramic Fiber Reinforced Ceramic Matrix Composites
D. Patel (UES, Inc., USA), D. Rapking (University of Dayton Research Institute, USA), T. Parthasarathy (UES, Inc., USA), M. Braginsky, J. Pierce (University of Dayton Research Institute, USA), J. Simmons, C. P. Przybyla (Air Force Research Laboratory, 'USA)
In this work, we have sought to quantify the pertinent material structure a SiC fiber reinforced SiC CMC and understand how that structure relates to the transverse cracking strength experimentation and simulation.

2.02-03 Bio-Based Silicon Carbide Ceramics from Extruded Thermoset-Based Wood Polymer Composites
C. Fürst (Wood K plus (Kompetenzzentrum Holz), Austria), B. Plank, S. Senck (University of Applied Sciences Upper Austria, Austria), M. Mihalic, C. Unterweger (Wood K plus (Kompetenzzentrum Holz), Austria)
Bio-based silicon carbide ceramics are prepared from extruded thermoset based wood polymer composites. The extruded green bodies are carbonised forming open porous carbon templates which are converted by liquid silicon infiltration into SiC ceramics.

17:10-18:30 Hall: MC3.3

3.01 | Material and Structural Behavior – Simulation and Testing: Analysis and Design of Damage Tolerant Composite Structures
Chair: **S.T. Pinho, C. Hochard**

3.01-13 Parametric Characterisation of Z-Pin Reinforcement using High-Definition FE Modelling
A.R. Melro, B. Zhang, I. K. Partridge, S. R. Hallett (University of Bristol, United Kingdom)
A high-fidelity model of a through-thickness reinforced composite with a z-pin was generated in order to study and characterise the increase in damage tolerance brought by this type of reinforcement. Different loading conditions representing different mode-mixities were applied to the model and the apparent increase in toughness, (Cntd)

3.01-14 Coupon Scale Modelling of the Bridging Mechanics of High-Rate Loaded Z-Pins
B. Zhang, A.R. Melro, I. K. Partridge, S. R. Hallett (University of Bristol, United Kingdom)
This work presents an advanced finite element model that can be used to investigate and understand the high-loading-rate bridging mechanisms of z-pins. Ply-by-ply meshes are used to consider the microstructure of a z-pin array reinforced laminate, with the pin and resin pocket explicitly modelled. (Cntd)

3.01-15 Rate-Dependent Modelling of the Meso-Mechanics of Z-Pins Bridging Mixed Mode Delaminations
H. Hijazi (Imperial College, United Kingdom), H. Cui (Cranfield University, United Kingdom), G. Allegri (Imperial College, United Kingdom), S. R. Hallett (University of Bristol, United Kingdom), N. Petrinic (University of Oxford, United Kingdom)
This paper presents a rate dependent reduced order model that simulates the bridging performance of Z-pins when subject to mode I and II loading. The model is based on presenting the Z-pin as a Timoshenko beam using Peridynamic formulation. (Cntd)

3.01-16 Development of Damage Tolerant Composite Laminates Using Ultra-thin Interlaminar Electrospun Thermoplastic Nanofibres

H. Y. Nezhad, R. Prevost (Cranfield University, United Kingdom), A. Yoosefinejad (Munro Technology Limited, United Kingdom), J. Watson, Y. Zhao, D. Ayre (Cranfield University, United Kingdom), S. Lotfian (Cranfield University & University of Strathclyde, United Kingdom)

17:10-18:50 Hall: **MC3.4**

2.14 | Materials Science: Polymer Matrix Materials (Epoxy- based Composites)

Chair: **A. Baltopoulos, Q. Li**

2.14-11 Development Characterization and Functionality of Epoxy Resin/Barium Oxide Composite Materials

A. C. Konstantinou, A. Sanida, A. C. Patsidis, G. C. Psarras (University of Patras, Greece)

The dielectric response of BaO/epoxy nanodielectrics were examined by means of BDS. Their permittivity (ε') and dielectric loss (tanδ) was determined, as a function of temperature and frequency varying filler content.

2.14-12 Evaluation of Cure Cycle Interruption on Thermoset Epoxy Polymer Matrices

A. Amate-Illescas, Z. Martín-Moreno, J. Sánchez-Gómez (Airbus Operations, Spain)

Chemical degree studied on Universidad Complutense in Madrid finalised on 2005. Different works as trainee on a Research Institute CSIC (Centro Superior de Investigaciones Científicas) inside the Polymer department, focused on the characterisation of different polymer materials (PE, PET, PP, rubber) (Cntd)

2.14-13 The Prospect of Using a Low Cost Ionic Liquid as a Delivery Medium for Thermally and Mechanically Stable Thermoset Resins

M. Nikzad, S. S. Nisha, J. A. Miller, I. Sbarski (Swinburne University of Technology, Australia)

Epoxy resins, the most important industrial reactive oligomers, are widely used in the composite materials production. Nevertheless, most often, modifications of epoxy networks are required to improve their performance or fine-tune for given applications. Recently, ionic liquids (ILs) have gained a lot of interest, (Cntd)

2.14-14 Manufacturing Affordable Composites using Solid Epoxy Resins

N. Yousefi, H. A. Maples (University of Vienna, Austria & Imperial College London, United Kingdom), T. James (Formax, Cutters Close Industrial Estate, United Kingdom), A. Bismarck (University of Vienna, Austria & Imperial College London, United Kingdom)

In this work, a low-cost carbon fiber composite using solid epoxy resin has been developed. The resin formulations were performed by mixing solid epoxy resin and hardener at a certain temperature. The addition of an accelerator reduced the curing time of the resins from 8h (without accelerator) to less than 10 mins (Cntd)

2.14-15 Effect of Matrix Cracking on Mechanical Properties in FRP Angle-Ply Laminates

M. J. Mohammad Fikry, S. Ogihara (Tokyo University of Science, Japan), V. Vinogradov (Newcastle University, United Kingdom)

Fiber Reinforced Polymer laminates (FRP) have properties, which are highly dependent on the ply fiber orientations and which can be designed for optimum laminate performance. The purpose of this study is to investigate the effect of matrix cracking on the mechanical properties of angle-ply FRP laminates. (Cntd)

17:10-18:50 Hall: **Conference 1**

7.02 | Recycling and Sustainability: Recycling of Fibers and Composites

Chair: **S. Pimenta, J.L. Bailleul**

7.02-05 Effect of Superheated Steam on the Adhesion Properties of Recycled Carbon Fiber

G. Cai (University of Tokyo, Japan), M. Wada (Japan Fine Ceramics Center, Japan), I. Ohsawa (University of Tokyo, Japan), S. Kitaoka (Japan Fine Ceramics Center, Japan), J. Takahashi (University of Tokyo, Japan)

The interfacial adhesion properties of recycled carbon fibers subjected to superheated steam treatment were evaluated. The effects of thermal residual stress and surface chemical states on the interface adhesion between the resultant fibers and polymer matrix were studied.

7.02-06 Recycling of Long Carbon Fibers, Part I: Development of a High Aligned rCF-Sliver for a Binder Tape Manufacturing Process

S. Baz, L. Ausheyks, O. Reichert, A. Dinkelmann, H. Finckh, J. Hehl (Deutsche Institute für Textil- und Faserforschung Denkendorf, Germany), A. Poeppel (Honda R&D Europe, Germany), G. T. Gresser (Deutsche Institute für Textil- und Faserforschung Denkendorf, Germany)

For maximum utilization of carbon fiber properties and to use carbon fibers (CF) in a material saving but also load compatible way, it is necessary to process them with maximum orientation. For this purpose the recycled carbon fibers (rCF), which, to date, are mainly used in powder form or with less orientation in nonwovens, (Cntd)

7.02-07 Recycling of Long Carbon Fibers, Part II: Development of a Binder Tape Manufacturing Process for Processing in Automated Tape Laying

O. Rimmel, D. May, C. Goergen (Institut für Verbundwerkstoffe GmbH, Germany), A. Poeppel (Honda R&D Europe GmbH, Germany), J. Schlimbach, P. Mitschang (Institut für Verbundwerkstoffe GmbH, Germany)

This presentation describes a process chain for the recycling of long carbon fibers using a binder tape in automated tape laying.

7.02-08 Investigation of Mechanical Properties of Nonwoven Second Generation Composite Material Elaborated through a Mixture of Carbon Fibers and Filament Lengths
S. Jlassi, Florentin Berthet, G. Bernhart (Université de Toulouse, France)
The study aims to investigate the mechanical properties of ten different carbon fiber nonwoven reinforced thermoplastic composites. A design of experiments was carried out by using a Mixture Design methodology in order to produce nonwovens by carding and pre-needling.

7.02-09 End-Of-Life CFRP as a Raw Material in Steel and of Calcium Carbide Production
D. Schueppel (Carbon Composites e. V., MAI Carbon, Germany), J. Stockschlaeder, (RWTH Aachen, Germany), T. von Reden, (Carbon Composites e. V., MAI Carbon, Germany)
CFRP has become more and more an established material of lightweight design in the recent years. In addition to the established sectors such as aerospace, sports and leisure, the material has been increasingly used in in the automotive sector, energy sector and mechanical engineering. (Cntd)

7.02-10 Catalytic Degradation of a Carbon Fibre Reinforced Epoxy Resin with an Acetone/Water Solvent
Matthew J. Keith, Andrew Ingram (School of Chemical Engineering, University of Birmingham, United Kingdom), Gary A. Leeke (School of Water, Energy and Environment, Cranfield University, United Kingdom)
=NaOH, KOH and ZnCl2 are investigated as potential catalysts for the recycling of a CFRP with an acetone/water solvent. Resin decomposition was 95% with ZnCl2 only; FTIR spectra of organic products suggest this is due to scission of the C=N bond.

17:10-18:30 Hall: **MC3.5**

4.01 | Experimental Methods: Digital image/Volume Correlation

Chair: **M. Sause**

4.01-01 Bridging the Gap Between Modeling and Analysis for 3D Woven Composites using Digital Volume Correlation
A. Mendoza (Université Paris-Saclay & Safran Tech, France), J. Schneider (Safran Aircraft Engines, France), E. Parra, E. Obert (Safran Tech, France), S. Roux (Université Paris-Saclay, France)
The inherent weaving pattern of 3D woven composites is employed for the dialog between different descriptors. The continuity of information is achieved with Digital Volume Correlation and the key concept of conservation of the topology. A complete test scenario is devised in which different manufactured woven samples (Cntd)

4.01-02 Determination of the Mode I Strain Energy Release Rate in Carbon Fibre Reinforced Composites by Means of Digital Image Correlation Technique
A. Khudiakova, M. Wolfahrt (Polymer Competence Center Leoben GmbH, Austria), D. Godec (University of Zagreb, Croatia), G. Pinter (Montanuniversitaet Leoben, Austria)
The present research proposes a methodology to localize the crack tip in the double cantilever beam testing by applying the digital image correlation method.

4.01-03 A Systematic Approach to Transforming Composite 3D Images into Meso-Scale Computational Models
B. J. Blinzler, D. Wilhelsson, L. E. Asp (Chalmers University of Technology, Sweden), K. M. Jespersen (Waseda University, Tokyo, Japan), L. P. Mikkelsen (Technical University of Denmark, Denmark)
High performance polymer matrix composites (PMC) have a high specific stiffness and can be used to easily manufacture highly complex components. Many types of defects can occur during molding. Flaws and damage degrade the resulting mechanical properties of the composites material. (Cntd)

4.01-04 DIC Analysis for Linear and Nonlinear Out-Of-Plane Shear Property of Randomly-Oriented Thermoplastic Composites
T. Murakami (Shimadzu Corporation, Japan), T. Matsuo (University of Tokyo, Japan), T. Sumiyama, K. Sakaguchi (Toyobo Co., Ltd., Japan), M. Kan (Honda R&D Co., Ltd., Japan)
We proposed a new test method and test system that focused on the notch depth used in the double-notch compression test. Additionally, the special jig was developed to adjust function for the degree of parallelism between top of the specimen and platen and two dimensional digital image correlation (Cntd)

18:45-19:45 Hall: **Trianti**

General Assembly

20:00

Phd Student Event

08:50- 09:50 Hall: Trianti

Plenary Lecture 3

Chair: **V. Kostopoulos**

Industrial system evolution in composite manufacturing technologies and the need for tomorrow
Jelle Bloemhof

09:50-10:35 Hall: Trianti

Keynote Lecture 9

Chair: **V. Kostopoulos**

Hierarchical carbon fibre reinforced plastics with tailored nanoparticle modification – benefits and limitations
Bodo Fiedler

09:50-10:35 Hall: Mitropoulos

Keynote Lecture 10

Chair: **L. Asp**

New Aircraft, New materials, New repairs
Guillaume Ferrer

10:35- 11:00 Hall: Exhibition Area

Coffee Break

11:00-13:00 Hall: Trianti

5.07 | Processing and Manufacturing Technologies: Manufacturing Processes for Thermoplastic Composites

Chair: **M. Gude**

5.07-28 Hybrid Thermoplastic Composites for Automotive Applications – Development and Manufacture of a Lightweight Rear Floor Structure in Multi-Material Design

T. Link, S. Baumgärtner (Fraunhofer Institute for Chemical Technology (ICT), Germany), D. Dörr, M. Hohberg (Karlsruhe Institute of Technology (KIT), Germany), F. Henning (Fraunhofer Institute for Chemical Technology (ICT) & Karlsruhe Institute of Technology (KIT), Germany)

Within the publicly funded research project "SMiLE - System-integrated multi-material lightweight design for e-mobility" a structural hybrid thermoplastic rear floor part has been developed. Advanced simulation models are applied to optimize the manufacturing and to validate the technical feasibility of this innovative part. (Cntd)

5.07-29 Thermoplastic Composite Materials for High Voltage Insulator Applications

M. Volk (ETH Zurich, Switzerland), J. Wong (University of Calgary, Canada), S. Arreguin (ETH Zurich, Switzerland), C. Bär, F. Schmuck (Pfisterer Sefag AG, Switzerland), P. Ermanni (ETH Zurich, Switzerland)

This study investigates the potential of different thermoplastic composites based on commingled yarns for high voltage insulator applications according to IEC standards.

5.07-30 High-Speed Reactive Processing System for Polyamide-6 Cfrtp Manufacturing
S.-W. Kim, T. Park, M.-K. Um, J.-W. Yi (Korea Institute of Materials Science (KIMS), Carbon Composites Department, South Korea)
The paper is related to reactive processing system for PA-6 CFRTP manufacturing. The properties of polymer matrix, mechanical properties, and impregnation and interfacial interaction of the CFRTP are investigated.

5.07-31 Manufacturing of Glass Fibre/PBT-SpinCom Yarns for Innovative Composite Processing
C. Scheffler, J. Hiller, M. Krüger (Leibniz-Institut für Polymerforschung Dresden e.V., Germany), R. Haase, D. Weise (Fraunhofer Institute for Machine Tools and Forming Technology IWU, Germany), D. Garray (SIRRIS, Belgium), A. Spickenheuer (Leibniz-Institut für Polymerforschung Dresden e.V., Germany)
The aim of this work was the development of GF (glass fibre)/ PBT (polybutylene therephthalate) SpinCOM yarns that are commingled online during the spinning process using sizing formulations that enable textile processability as well as high fibre-matrix interaction. (Cntd)

5.07-32 Impregnation Behavior of Carbon Fiber Fabric Underneath the Rollers in Double Belt Press
O. Ishida (Kanazawa Institute of Technology, Japan), J. Kitada (Process Systems K.K., Japan), K. Nunotani, K. Uzawa (Kanazawa Institute of Technology, Japan)
The subject of this study is to investigate thermoplastic impregnation process of carbon fiber fabric under rollers in double belt press. An experimental model was developed and evaluated.

5.07-33 Compression Molding of Pultruded Carbon Reinforced Thermoplastic Composites
P. J. Novo (Polytechnic Institute of Leiria, Portugal), J. P. Nunes (Minho University, Portugal), J F. Silva (ISEP, Portugal), A. T. Marques (DEMec / FEUP, Portugal)
Historically, thermoset resins have dominated the composite industry but they start to be replaced by thermoplastics. In this study two different thermoplastic matrix carbon reinforced pre-impregnated materials were used, one produced in our laboratories (towpreg) and another obtained from co-extrusion process (PCT). (Cntd)

11:00-13:00 Hall: **Mitropoulos**

3.02 | Material and Structural Behavior – Simulation and Testing: Buckling and Stability

Chairs: **B. Falzon, O. Baccareza**

3.02-01 Dynamic Characteristics of Dielectric Polymer Beams Reinforced with Graphene Platelets (GPLs)
C. Feng, Y. Wang, Z. Zhao (RMIT University, Australia), Carlos Santiuste Romero (Universidad Carlos III de Madrid, Spain), J. Yang (RMIT University, Australia)
Theoretical formulation for the dynamic behaviours of dielectric beam is derived and solved. Comprehensive parametric study is conducted to investigate the effects of a number of influencing factors on the dynamic behaviours of the structure.

3.02-02 Influence of Elastic Properties Dependence of the Stress State on Buckling Conditions in Composite Structures
A. N. Fedorenko, B. N. Fedulov (Moscow Aviation Institute, Russia), E. V. Lomakin (Moscow Aviation Institute & Lomonosov Moscow State University, Russia)
The work presented is devoted to the study of possible usage of non-classic elastic models for problems of buckling and postbuckling of composite structures. The anisotropic elastic material model susceptible to the stress state and nonlinear shear was implemented within FEM software (Cntd)

3.02-03 Nonlinear Bending Compliance of Closed-Sectioned Composite Beam Structures by Local Compression Flange Buckling
F. Schadt, M. Rueppel, C. Brauner (FHNW University of Applied Sciences and Arts Northwestern Switzerland, Switzerland), K. Masania (ETH Zurich, Switzerland), C. Dransfeld (FHNW University of Applied Sciences and Arts Northwestern Switzerland, Switzerland), T. Ricard (North Thin Ply Technology, Switzerland)
We present a structural concept for passive spanwise bending shape-adaption that uses compression flange buckling in beams to achieve a tailored stiffness reduction in the elastic domain. Numerical and experimental studies show promising results.

3.02-04 A Procedure for the Estimation of the Shape Imperfections of a Composite Panel in order to Reproduce its Postbuckling Evolution
A. Blázquez, J. Justo, J. Reinoso, F. París (Universidad de Sevilla, Spain)
In the buckling and postbuckling of plates and shells, geometrical imperfections have a crucial influence. Two procedures to estimate imperfections from experimental measurements performed during the pre-buckling evolution of the panel are proposed.

3.02-05 Stability Analysis of Piezoelectric Laminated Plates Using Finite Strip Method
H. Amoushahi, H. Tanzadeh (University of Isfahan, Iran)
A semi analytical finite strip method was developed in present article for buckling of laminated composite plates with piezoelectric layers based on different plate theories. Displacement functions of plate were evaluated using a continuous harmonic function series in the longitudinal direction (Cntd)

3.02-06 Tip Angle Effect on Buckling and Deformation of Laminated Composite Anglegrid Plates
A. Ehsani, H. Dalir (Purdue School of Engineering and Technology, United States)
Grid structures are widely used in many engineering fields. Typically, a single grid plate is employed as an orthotropic layer to strengthen plates and shells or as an independent structural element. In contrast with conventional grids, laminated grid plates are constituted from several grid layers with various orientations. (Cntd)

3.02-07 Thermal-Mechanical Buckling of Composite Plates for Aerospace Applications

J. Gutiérrez Álvarez, C. Bisagni (Delft University of Technology, The Netherlands)

This paper presents an analytical formulation for the study of buckling of symmetric and balanced laminate composite plates under expansion restriction and load introduction. The problem is formulated in terms of in-plane displacement fields and solved using the Galerkin method.

11:00-12:40 Hall: Skalkotas

3.03 | Material and Structural Behavior – Simulation and Testing: Delamination

Chairs: **Th. Loutas, A. Antoniou**

3.03-06 A Novel Mixed-Mode Cohesive Zone Model for Delamination with Severe Fiber Bridging applied to Sandwich Panels and Monolithic Laminates

D. Höwer, K. C. Jois (RWTH Aachen University, Germany), B. A. Bednarcyk, E. J. Pineda (NASA Glenn Research Center, USA), S. Reese, J.-W. S. (RWTH Aachen University, Germany)

Due to their very high stiffness to weight ratio, sandwich panels with honeycomb core and carbon fiber reinforced plastic facesheets are becoming increasingly popular in aerospace applications. However, the honeycomb topology also provides modelling challenges (Cntd)

3.03-07 Higher Order Adaptively Integrated Cohesive Element

R. Russo, B. Chen (Delft University of Technology, The Netherlands)

The computational time of Cohesive Element (CE)-based method is prohibitive. This is because the steep and non-smooth stress gradient in the cohesive zone requires a very fine mesh. A new CE is here proposed, aiming to loosen the mesh constraint and reduce the computational time. (Cntd)

3.03-08 Failure Mechanisms Involved in the Unfolding Failure

J. M. González-Cantero (FIDAMC, Spain), E. Graciani (Universidad de Sevilla, Spain), B. López-Romano (FIDAMC, Spain), F. París (Universidad de Sevilla, Spain)

Unfolding failure, a delamination given in curved composite laminates when loaded under an opening bending moment, may be due to different failure mechanisms. The present work analyses the initiation of this kind of failure.

3.03-09 Experimental Investigation into Through-Thickness Compression Enhancement Effect on Mode II Fracture Energy using Bi-Axial Tests

X. Xu, T. Rev, X. Sun, M. R. Wisnom, S. R. Hallett (University of Bristol, United Kingdom)

Through-Thickness Compression (TTC) stresses can affect Mode II fracture energy, GIIC. This effect has been studied using IM7/8552 carbon/epoxy Quasi-isotropic (QI) laminates with 2 extra cut central 0˚ plies inserted into the layup. Bi-axial testing was adopted to demonstrate the TTC enhancement (Cntd)

3.03-10 Effect of Stacking Sequence on Local Buckling Behavior of Composite Laminates with Delamination

W. Xin, H. Jun, S. Yuru, L. Shengzhe, T. Riming, G. Zhidong (Beihang University, China)

This paper investigated the influence of stacking sequence on local buckling behaviors of laminates with delamination. The classical lamination theory was utilized to analyze the influence of the stacking sequence on local buckling behavior in delamination region. And a FEM numerical simulation was performed (Cntd)

11:00-12:20 Hall: Multi-Purpose Room

3.16 | Material and Structural Behavior – Simulation and Testing: Sandwich Structures

Chair: **A. Vasilopoulos, M. Cherny**

3.16-01 Modelling the Impact Behavior of Advanced Fiber-Reinforced Sandwich Structures with Polyurethane Foam Core

O. Weißenborn, S. Geller, R. Böhm, M. Gude (Technische Universität Dresden, Germany)

Within this paper, novel sandwich structures with top layers made of textile-reinforced plastics and polyurethane foam core are investigated with regard to their impact behavior. A design of experience approach is implemented by using statistical analysis of variance (ANOVA) to investigate the influence of foam core density, (Cntd)

3.16-02 Virtual Testing of Metallic Inserts for Sandwich Structures

J. D. D. Rodríguez-Ramírez, B. Castanié, C. Bouvet (Université de Toulouse, France)

In this research, a reduced virtual testing approach is used to study the insert's failure in sandwich structures. The model includes the post-failure behavior of the materials (honeycomb core, potting and skins). The experimental and numerical results shows a good agreement.

3.16-03 Virtual Testing of Composite Sandwich Structures in Aircraft Interior – An Industrial Case Study

R. Seemann, H. Hübner (DIEHL Aviation, Germany)

The present contribution presents a comparative study where two state-of-the art finite element modelling approaches for virtual testing of honeycomb sandwich panel joints are compared. This is done using the example of partially potted inserts under out-of-plane loading. (Cntd)

3.16-04 Nonlinear Dynamic Analysis of Composite Sandwich Plates with Damping

K. V. Nagendra Gopal, A. Biswapratap Pani (Indian Institute of Technology, India)

The geometrically nonlinear free and forced vibrations of sandwich plates with viscoelastic core are studied using the homotopy pertubation method and Struble's technique.

11:00-12:40 Hall: MC3

3.04 | Material and Structural Behavior – Simulation and Testing: Ductile and Pseudo-Ductile Composites

Chairs: **J. Costa Balanzat, S. Goutianos**

3.04-05 Pseudo-Ductile Response of ±45° CFRP Submitted to Flexural Loading

M. C. Serna Moreno, S. Horta Muñoz, A. Romero Gutiérrez (University of Castilla La-Mancha, Spain), C. Rappold (University of Castilla La-Mancha, Spain & GSI Helmholtz Centre for Heavy Ion Research, Germany), J. L. Martínez Vicente, P. A. Morales-Rodríguez, J. J. López Cela (University of Castilla La-Mancha, Spain)

This work investigates analytically and experimentally the flexural pseudo-ductile response of symmetric ±45º angle-ply laminates consisting of unidirectional and continuous CFRP plies. Most of the existing literature about pseudo-ductility deals with uniaxial testing. (Cntd)

3.04-06 Bearing Failure of Pseudo-Ductile Thin Ply Angle-Ply Laminates

X. Wu (University of Bristol, United Kingdom), M. Fotouhi (University of the West of England, United Kingdom), J. D. Fuller (University of Bristol & National Composites Centre-NCC, United Kingdom), M. R. Wisnom (University of Bristol, United Kingdom)

Unlike the conventional carbon fibre composites that often fail brittle and catastrophically, pseudo-ductile thin ply angle-ply carbon fibre composites have been designed to fail more gradually. These laminates have successfully demonstrated the metal-like stress-strain behaviour in both tension and compression, (Cntd)

3.04-07 The Effect of Test Temperature on the Pseudo-Ductility of Thin-Ply Hybrid Composites

G. Czél, M. Bugár-Mészáros (Budapest University of Technology and Economics, Hungary), M. R. Wisnom (University of Bristol, United Kingdom)

Two type glass/carbon hybrid specimens were tested at -50, 25 and 80 degree C to investigate the effect of temperature to their pseudo-ductility. Continuous and discontinuous carbon layer samples were designed to analyse different mechanisms.

3.04-08 Numerical Modelling of the Pseudo-Ductility Effect in ±45° Angle-Ply Laminates Under Biaxial Loading

S. Horta Muñoz, M.C. Serna Moreno (University of Castilla-La Mancha, Spain)

This work aims to reproduce numerically the pseudo-ductile response of ±45° angle-ply laminates under uniaxial and biaxial stress states. The numerical model is based on Hashin failure theory and its results are contrasted with experimental data.

3.04-09 Reduced Tensile Notch-Sensitivity in Pseudo-Ductile Thin-Ply Composites

M. R Wisnom (University of Bristol, United Kingdom), G. Czél (Budapest University of Technology and Economics, Hungary & University of Bristol, United Kingdom), M. Fotouhi (University of the West of England & University of Bristol, United Kingdom), J. Fuller (University of Bristol, United Kingdom), M. Jalalvand (University of Strathclyde & University of Bristol, United Kingdom), T. Rev, X. Wu (University of Bristol, United Kingdom)

The notched tensile response of thin-ply hybrid and angle-ply pseudo-ductile laminates is presented, and they are shown to exhibit greatly reduced notch sensitivity compared with conventional composites.

11:00-12:40 Hall: MC2

3.12 | Material and Structural Behavior – Simulation and Testing: High-Performance Discontinuous Fiber Composites

Chair: **S. Pimenta**

3.12-01 Effect of Charge Placement on Fibre Orientation, Distortion and Failure of a Carbon Fibre Reinforced Sheet Moulding Compound

S. F. Kite (University of Surrey, United Kingdom), O. Nixon-Pearson (University of Bristol, United Kingdom), S. L. Ogin, D. A. Jesson (University of Surrey, United Kingdom), I. Hamerton (University of Bristol, United Kingdom), G. Meeks, A. Sordon (McLaren Automotive Ltd., United Kingdom)

CF reinforced SMCs have the manufacturing issue of dimensional instability and unpredictable failure locations. This paper presents aspects of work examining the effect of charge placement on the distortion and strain distribution, with an investigation of the FOD by micro-CT.

3.12-02 Manufacture and Performance Evaluation of Hat-Stiffened Structure Made by Chopped Carbon Fiber Tape Reinforced Thermoplastics

B. Xiao, Q. Guo, I. Ohsawa, M. Fujita, J. Takahashi (University of Tokyo, Japan)

This study investigated the manufacturing process of CTT hat-stiffened structure using hand dispersion method. Three-point bending test was conducted to check its flexural stiffness and failure mode. After that, local slices were cut out from the respective bottom panel and upper hat part of the specimen. (Cntd)

3.12-03 Damage Tolerance of High Performance Continuous/Discontinuous Hybrid Carbon Fibre Composites

A. D. Evans, L. T. Harper, T. A. Turner, N. A. Warrior (University of Nottingham, United Kingdom)

Investigation of the damage tolerance of co-compression moulded discontinuous/continuous carbon fibre composites by CAI performance of hybrid architectures used to improve the strength retention compared to continuous laminates subjected to impact.

3.12-04 The Influence of Defects and Variability in Discontinuous Composite Materials

J. M. Finley, Joël Henry, S. Pimenta, Milo S.P. Shaffer (Imperial College London, United Kingdom)

A virtual testing framework is developed to quantify the influence of variability and defects on the performance of aligned discontinuous composites. Variability in fibre strength, fibre overlap length, and hybrid fibre-type arrangements all reduce material strength and ductility.

3.12-05 Energy Absorption Properties of CFRP Composites Tube with Discontinuous Plies

Z. Xin, Y. Duan (Xi'an Jiaotong University, China), J. Zhou (University of Liverpool, United Kingdom)

The carbon fiber reinforced plastic (CFRP) composite with overlapped discontinuous plies have been proven to exhibit advanced pseudo-ductility. This paper aims to use a similar concept to design CFRP square tube and investigate the effect of energy absorption capability with two cut-ply strategy: (Cntd)

11:00-12:20 Hall: Kokkalis

3.18 | Material and Structural Behavior – Simulation and Testing: Short Fiber Reinforced Thermoplastics

Chairs: K. Kose, J. L. Bailleul

3.18-01 The Effects of Polypropylene Film on Springbacked Carbon Fiber Reinforced Thermoplastics

D. Kobayashi, Y. Wan, J. Takahashi, I. Ohsawa (University of Tokyo, Japan)

Springback phenomenon is the deformation resulting from deconsolidation and expected for weight reduction of component design. We approached to solve problems of springbacked CFRTP by applying springbacked CFRTP to sandwich structure with several combinations of polypropylene (PP) film.

3.18-02 Experimental Investigation on the True Local Fatigue Strength of Shell-Core Shell Layered, Injection Moulded Specimens of Short Fibre Reinforced Polyamide

A. Bernasconi, E. Conrado (Politecnico di Milano, Italy), P. J. Hine (University of Leeds, United Kingdom)

Injection moulded plates made of short fibre reinforced polymers are often used to study the effect of fibre orientation on mechanical properties. Using specimens cut out of these plates with different orientations with respect to the injection flow, off axis tests can be performed. (Cntd)

3.18-03 Analysing the Effect of Fibrewaviness on the Stiffness of Tow-Based Discontinuous Composites

M. Alves, S. Pimenta (Imperial College London, United Kingdom)

A microstructure generator and a stiffness model that consider the 3D features of discontinuous composites were developed and validated against experiments. It is predicted that tow waviness may lead to in-plane stiffness reductions of up to 20%.

3.18-04 Microstructural Characterization of Frontal and Flowing Weld Lines in Injection-Molded Short Fiber-Reinforced Thermoplastics

M. B. Baradi (PIMM, ENSAM, CNRS, CNAM, France & R. Bosch GmbH, Germany), C. Cruz (R. Bosch GmbH, Germany), G. Régnier (PIMM, ENSAM, CNRS, CNAM, France), T. Riedel (R. Bosch GmbH, Germany)

In this work we present a microstructural characterization of the weld lines (WLs) produced by injection molding of 30 wt% glass fiber-reinforced PBT. We considered frontal and flowing WLs by using different insert shapes and two part thicknesses (1.5 and 3.0 mm). (Cntd)

11:00-12:20 Hall: Lecture Room

2.14 | Materials Science: Polymer Matrix Materials (Generic polymer composites)

Chairs: **A. Bismarck, E. Thostenson**

2.14-16 Emulsion Templated Macroporous Polymer as Micromixer

H. Barkan-Öztürk, A. Menner, A. Bismarck (University of Vienna, Austria)

Micromixers have found many application areas over the macro scale mixing, due to fast and controllable mixing process, higher yield and continuous production. The channel dimensions of those micromixers can be decreased until hundreds of micrometers and also added obstacles to the walls to increase the surface-to-volume. (Cntd)

2.14-17 Synthesis of Advanced PANI based Conductive Composites using Methacrylate Groups based Materials

S. Pati, T. Yokozeki, V.Kumar (University of Tokyo, Japan), T. Goto, T. Takahashi (Yamagata University, Japan)

A polyaniline based electrically conducting thermosetting composite has been synthesized by using a methylacrylate group material that imparts high mechanical properties

2.14-18 Effect of Phenol Derivatives on the Conductivity Enhancement of Poly(3,4-Ethylenedioxythiophene) Doped with Poly(-Styrene Sulfonic Acid) (PEDOT:PSS)
S. Konagaya (Nagoya Industrial Science Research Institute, Japan), Y. Tawara (Asahi Yukizai Corporation, Japan), M. Inoue, H. Furuhashi (Nagoya University, Japan), M. Terada (Nagoya University National Composite Center, Japan), T. Torimoto (Nagoya University, Japan)
The study was made of the addition effect of phenol derivatives on the conductivity enhancement of PEDOT:PSS films prepared from the aqueous coating mixture of phenol derivatives and PEDOT:PSS. This study made it clear that, 1) most of phenol derivatives used here had a good conductivity enhancement (Cntd)

2.14-19 Assessement of UREA Based Vitrimers as a New Matrix Material for Fibre Reinforced Polymers
I. De Baere, W. Denissen, W. Van Paepegem, J. Winne, F. Du Prez. (Ghent University, Belgium)
Vitrimers are covalently cross-linked polymeric materials which can be thermally processed in a liquid like state without losing their network integrity. In this work, composites using novel vitrimers based on the dynamic amine exchange reaction of vinylogous urea as matrix material, are assessed. (Cntd)

11.00-12.00 Hall: MC3.2

1.03 | Applications: Bio and Medical
Chairs: **A. Menner**

1.03-01 Design and Development of an Active Wheelchair with Improved Lifting Kinematics using CFRP-Compliant Elements
T. Ehrig, R. Koschichow, M. Dannemann, N. Modler, A. Filippatos (Technische Universität Dresden, Germany)
A growing number of people worldwide are permanently or temporarily dependent on a wheelchair. In order to improve the quality of life for wheelchair-users, it is important that the wheelchair offers the greatest possible comfort on the one hand and on the other hand enables many everyday situations without assistance, while being light enough to be lifted into a vehicle by the user alone. (Cntd)

1.03-02 Combining Additive Manufacturing and Carbon Fiber Patched Composites for Individualized and Sustainable Biomedical Applications
R. Kussmaul, M. Biedermann, J. Jónasson (ETH Zurich, Switzerland), D. Türk (Caltech, USA), M. Zogg, C. Klahn (Inspire AG, Switzerland), M. Meboldt, P. Ermanni (ETH Zurich, Switzerland)
Combining additive manufacturing (AM) with carbon fiber reinforced polymer (CFRP) patched composites unlocks potentials in the design of individualized lightweight structures. This work investigates two arising design opportunities for biomedical applications (Cntd)

1.03-03 Effect of Preparation Condition on Tensile Strength of HAp-Deposited Collagen Fibers
M. Tanaka, A. Kiyoshima, Y. Hasegawa, I. Kimpara (Kanazawa Institute of Technology, Japan)
This paper is aiming to evaluate the effects of the microstructural factors, such as the concentration of the cross-linking agent, HAp-deposition condition and the existence of the adhesive protein, on the tensile strength of collagen fibers.

11:00-12:20 Hall: MC3.3

3.09 | Material and Structural Behavior – Simulation and Testing: Fiber Resin and Laminate Design for Optimized Performance and Manufacture
Chairs: **A. Antoniou, S. Tsampas**

3.09-01 Additive Layered Manufacturing Simulation of Fibrous Thermosetting Composites
T. Mesogitis, A. Visrolia (National Composites Centre, United Kingdom)
A framework able to simulate the manufacturing process of continuous fibrous thermosetting composites manufactured by Additive Layered Manufacturing was developed.

3.09-02 A Rapid Method for Residual Cure Stress Analysis for Optimization of Cure Induced Distortion Effects
C. J. Cameron, S. Saseendran, F. Stig, M. Rouhi (Swerea SICOMP, Sweden)
The work describes a simulation method for rapid analysis of cure induced distortion suitable for implementation in an optimization framework.

3.09-03 A Case Study on Established and New Approaches for Optimized Laminate Design
H. Völkl, M. Franz, S. Wartzack (Friedrich-Alexander-University Erlangen-Nuremberg-FAU, Germany)
Optimized laminate design, although crucial for high-quality lightweight parts, still remains a challenge for engineers. The high number of mutually dependent parameters requires expert skills – and really good designs can only be obtained when load paths are considered appropriately (Cntd)

3.09-04 Can We Properly Measure the Compressive Behaviour of Composites with High-Performance Polymer Fibres?
Y. Swolfs, K. Schuurbiers, L. Gorbatikh (KU Leuven, Belgium)
Shear-loaded compression tests were performed on epoxy-based composites with aramid, PAR and PBO fibres. Finite element models were used to identify the buckling gauge length and predict the extent of the stress concentrations due to the grips.

11:00-13:00 Hall: MC3.4

4.03 | Experimental Methods: New Testing Methods

Chair: **S. Psarras**

4.03-01 Accelerated Approaches for Life-Time Prediction of Composites under Static Loads

S. Gloggnitzer, P. Guttmann, G. Pinter (Montanuniversitaet Leoben, Austria)

Novel test methods (SRCR, SSM) for the determination of the long term material performance of unidirectional reinforced composites are developed, investigated and discussed based on the results of classic creep rupture tests.

4.03-02 Numerical Investigation on Cruciform Composite Shape for the Biaxial Characterization Test

A. Kobeissi, L. Leotoing, D. Guines (Université de Rennes, France), P. Rahme (Lebanese University, Lebanon)

Composite materials are nowadays widely used in the industrial field. To mechanically characterize these materials, an in-plane biaxial test can be performed on cruciform specimen instead of using multiple classical tests. One of the major problems that limits the use of the biaxial test is the shape of the cruciform specimen. (Cntd)

4.03-03 Local Specific Bending Stiffness Identification of an Unhomogeneous Composite Plate via High-Resolution Wavevector Analysis

P. Margerit, A. Lebée, J.-F. Caron (École des Ponts, France)

An experimental procedure developed to identify the bending behavior of thin composite plates from the full-field measurement of their dynamical response.

4.03-04 Accelerated Fluid Diffusion and Ageing in Polymer Matrix Composites for Offshore Oil & Gas Applications

M. Cavasin (Element Materials Technology, United Kingdom & Politecnico di Torino, Italy), S. Ivan (Element Materials Technology, United Kingdom), S. Giannis (Element Materials Technology & AMPnP Consultants Limited, United Kingdom), M. Sangermano, M. Salvo (Politecnico di Torino, Italy), B. Thomson (Element Materials Technology, United Kingdom)

A comparative accelerated testing methodology has been assessed on GFRP. Gravimetric, DMA and tensile tests have been performed to evaluate the degradation of the material when exposed to harsh environments, such as seawater and aromatic oil.

4.03-05 Towards a Consensus on Mode II Adhesive Fracture Testing and Data Reduction Methods

M. Pérez-Galmés, J. Renart, C. Sarrado (University of Girona, Spain), A. Rodríguez-Bellido (AIRBUS Operations S. L., Spain)

In this work an experimental mode II test campaign of CFRP adhesive joints is carried out. The results among the ENF test, the ELS test, the 4ENF test and the MMB test, using data reduction methods based on LEFM and NLFM (J-integral) are compared.

4.03-06 Development of a Multiscale Test Method for the Investigation of Strain Rate Dependent Material Properties of High-Performance Fibers

R. Unger, A. Nocke, C. Cherif (Technische Universität Dresden, Germany)

The design of a new testing system requires a wide variety of considerations. It is shown which factors influence the development of a rotating disc as the drive of a tensile testing machine.

11:00-12:40 Hall: Conference 1

6.05 | Multifunctional and Smart Composites: Structural Power Composites – Energy Harvesting

Chair: **L. Asp**

6.05-01 Conceptual Design Framework for Laminated Structural Battery Composites

D. Carlstedt (Chalmers University of Technology, Sweden), W. Johannisson, D. Zenkert (KTH Royal Institute of Technology, Sweden), P. Linde (Airbus Operations GmbH, Germany), L. E. Asp (Chalmers University of Technology, Sweden)

A framework to estimate the mechanical and electrical performance of laminated structural battery composites is proposed. The developed framework is applied on different designs of an A4 sized demonstrator to evaluate the multifunctional performance.

6.05-02 Development of Multifunctional Structural Energy Storage Devices Using Graphene Nanoplatelets

A. Masouras, D. Giannopoulos, V. Kostopoulos (University of Patras, Greece)

Development of solid state supercapacitors with structural functionalities by the usage of coated carbon fabrics with graphene nanoplatelets and manganese oxide as electrodes and quasi solid polymer electrolyte.

6.05-03 Multifunctional Carbon Fiber/Epoxy Laminates for Thermal Energy Storage and Release

G. Fredi, S. Dirè, A. Dorigato, L. Fambri, A. Pegoretti (University of Trento, Italy)

This work aims at developing multifunctional composite laminates with thermal energy storage (TES) capabilities. Structural laminates were fabricated with an epoxy resin, a carbon fiber fabric, and a shape-stabilized phase change material (PCM) based on paraffin and carbon nanotubes (CNTs). (Cntd)

6.05-04 Polyethylene Glycol-Silver Nanowire/Expanded Vermiculite Shape-Stabilized Composite Phase Change Materials: Form Stabilization, Thermal Conductivity Enhancement and Thermal Energy Storage Behavior
Y. Deng, J. Li, T. Qian, W. Guan, Y. Li, X. Yin (China University of Geosciences, P.R. China)

6.05-05 Thermo-Mechanical Behaviour of Thermoplastic Composite Laminates with Thermal Energy Storage/Release Capability
A. Dorigato, G. Fredi, T. Meneghini, A. Pegoretti (University of Trento, Italy)
Multifunctional thermoplastic composites with thermal energy storage/release properties were produced by using a glass fabric, a polyamide 12 (PA12) matrix and two different phase change materials (PCMs), i.e. a microencapsulated paraffin wax and a carbon nanotubes shape stabilized paraffin. (Cntd)

11:00-12:40 Hall: **MC3.5**

Special Session 3 | H2020 – Dynamic Loading – Pushing the Boundaries of Aerospace Composite Material Structures
Chair: **T. Kotzakolios**

SS3-01 Electro-Mechanical Test Rigs for Analysing Impact Induced Wave Propagation in Composite Materials
S. Nitschke, A. Hornig, M. Gude (TU Dresden, Germany)
Impact induced elastic wave propagation in layered fiber polymer composites may lead to damage and failure in through-thickness direction. To experimentally investigate the occurring phenomena, three test rig concepts are proposed.

SS3-02 Extreme Fiber Sensing Capabilities for Composite Materials in Aerospace
J. Mertes, M. Haverdings, R. Evenblij (Technobis tft-fos, The Netherlands)
This work describes the use of a high-speed fiber optic interrogation unit based on integrated photonics in structural health monitoring. It overcomes the limitations of other high-speed interrogators with respect to dynamic range by employing a small scale demultiplexed interferometer. (Cntd)

SS3-03 Tensile Behavior of Basalt Fiber Reinforced Composites at High Strain Rates
A. Elmahdy (Ghent University, Belgium), E. Feldman (Israel Aerospace Industries, Israel), P. Verleysen (Ghent University, Belgium)
The aim of this paper is to study the tensile behavior of basalt fiber reinforced epoxy composites at low and high strain rates. Results showed that the maximum strength and strain increase significantly with the increase of strain rate up to 130 s-1.

SS3-04 Compressive Behavior of Epoxy Resin Filled with Silica Nanoparticles at High Strain Rate
M. Zarrelli (Institute of Polymers, Composites and Biomaterials, Italy), A. Elmahdy (Ghent University, Belgium), A. Zotti, S. Zuppolini, A. Borriello (Institute of Polymers, Composites and Biomaterials, Italy), P. Verleysen (Ghent University, Belgium)
The aim of this paper is to study the compressive behavior of silica nanoparticles modified epoxy resin at high strain rates. Results showed that the addition of silica nanoparticles improves the compressive yield strength and reduces the maximum strain of epoxy at low and high strain rates.

SS3-05 Fracture Toughness and Mechanical Characterization of Epoxy Nanocomposites based on Different Hyperbranched Polymers Typologies
A.Zotti, S. Zuppolini, M. Zarrelli, A. Borriello (National Research Council of Italy, Italy)
The effects of two different typologies of hyperbranched polymers on rheological, mechanical and fracture performances of a commercial epoxy resin has been studied. The synthesized polymers are an aromatic polyester (HBPG) and an aliphatic polyamide ester (HBPR).

12:40-13:40 Hall: **Exhibition Area**

Lunch Break

13:40- 14:40 Hall: **Trianti**

Keynote Lecture 11
Chair: **V. Kostopoulos**

Made to order: Composites with Controllable Stiffness
Alexander Bismarck and Paul Robinson

13:40- 14:40 Hall: Trianti

Keynote Lecture 12

Chair: **M. Quaresimin**

Overview of Graphene Polymer Composites with emphasis on current developments
Costas Galiotis

14:40-16:20 Hall: Trianti

3.04 | Material and Structural Behavior – Simulation and Testing: Ductile and Pseudo-Ductile Composites

Chairs: **J. Costa Balanzat, S. Goutianos**

3.04-10 Thin Ply Carbon/Glass Hybrid Laminates to Activate New Damage Mechanisms under Indentation
M. Fotouhi (University of the West of England & University of Bristol, United Kingdom), M. Jalalvand (University of Bristol & University of Strathclyde, United Kingdom), A. Prato, M. R. Wisnom (University of Bristol, United Kingdom)
This paper aims to hybridise composite laminates to introduce new type of damage mechanisms that are visible from the impacted face and can increase impact resistance of composites

3.04-11 Predicting Tensile Behaviour of Hybrid Carbon Fibre/SRPP Composites: How Far Can Analytical Models Take Us?
M. Selezneva, Y. Swolfs, A. Katalagarianakis (KU Leuven, Belgium), N. Hirano (Toray Industries, Japan), I. Taketa (Toray Carbon Fibers Europe S.A. CFE, France), T. Karaki (Toray Industries, Japan), I. Verpoest, L. Gorbatikh (KU Leuven, Belgium)
This paper explores the capabilities and limitations of an analytical modelling technique to predict tensile properties of carbon fibre/self-reinforced polypropylene hybrids.

3.04-12 Optimisation of Ductile Interlocking Composite Structures
O. Bacarreza, P. Robinson (Imperial College London, United Kingdom), M. S. P. Shaffer (Imperial College London, United Kingdom)
An investigation on how interlocking composite structures can be designed using a multiobjective optimisation algorithm is described and the trade-off between the ultimate stress and the associated strain of pseudo-ductile composite interlocking structures is illustrated.

3.04-13 Pseudo-Ductile Failure Mechanism Introduced into Finger Jointed Thermoplastic PES Interleaved CFRC
D. B. Anthony (Imperial College London, United Kingdom), O. R. Bacarreza Nogales (Imperial College London, United Kingdom), M. S.P. Shaffer (Imperial College London, United Kingdom), A. Bismarck (University of Vienna, Austria), P. Robinson (Imperial College London, United Kingdom), S. Pimenta (Imperial College London, United Kingdom)
Pre-cut UD carbon fibre prepreg composites, with an overlapped finger-joint architecture, were modified through the addition of polyethersulfone interleaves. A crack arresting failure mechanism and pseudo ductile response was observed in tension.

3.04-14 The Investigation of Modified 'Brick And Mortar' Composite Architecture with In-Plane Wavy Segments for Pseudo-Ductility
B. Zhang, O. Bacarreza, P. Robinson (Imperial College London, United Kingdom), C. Burgstaller (Transfercenter für Kunststofftechnik (TCKT), Austria)
Modified, continuous 'brick and mortar' composite architectures with in-plane wavy segments were tested in tension. Specimens demonstrated pseudo-ductile behaviour with failure strains higher than unidirectional carbon fibre/epoxy composites.

14.40-15.40 Hall: Skalkotas

3.03 | Material and Structural Behavior – Simulation and Testing: Delamination

Chairs: **P. Robinson, A. Antoniou**

3.03-11 Simulation on Delamination of 90/0 Laminate under Low-Velocity Impact Load by Surface-Based Cohesive behavior Contact in Explicit Analysis
X. Wang, Z. Guan, Z. Li, G. Han, S. Du (Beihang University, China)
Surface-based cohesive behavior contact with the friction behavior in the explicit is adopted to simulate the delamination of the [903/03]S laminate under low-velocity impact. For the intralaminar damage, the Puck's failure criterion is adopted and implemented by the subroutine VUSDFLD in the ABAQUS. (Cntd)

3.03-12 Delamination Prediction on CFRP Materials Subjected to a Lightning Strike
T. M. Harrell, O. T. Thomsen, J. M. Dulieu-Barton (University of Southampton, United Kingdom), L. Carloni (Global Lightning Protection Services A/S, Denmark)
This paper presents a coupled thermal-electric-mechanical model to predict the delamination damage of a Carbon Fiber Reinforced Polymer (CFRP) material when subjected to a lightning strike.

3.03-13 Competition Between Rate-Dependency of Bulk Laminates and Interlaminar Interface on the Responses of Thermoplastic Composites
D. Pulungan, P. Hu, A. Yudhanto, G. Lubineau (King Abdullah University of Science and Technology (KAUST), Saudi Arabia), R. Yaldiz (T&I Composites, The Netherlands)
Thermoplastic composites can be an alternative solution for automotive light-weighting and hence, the reduction of carbon emissions. Double cantilever beam (DCB) test is one of the primary standards tests used to evaluate the Mode I interlaminar fracture toughness of composite laminates. (Cntd)

14:40-16:20 Hall: Multi-Purpose Room

3.18 | Material and Structural Behavior – Simulation and Testing: Short Fiber Reinforced Thermoplastics

Chairs: **A. Bernasconi, J.L. Bailleul**

3.18-05 Fatigue Life Prediction of Short Fiber-Reinforced Thermoplastics
R. Pietrogrande (University of Padova, Italy & R. Bosch GmbH, Germany), M. De Monte (R. Bosch GmbH, Germany), P. A. Carraro, M. Quaresimin (University of Padova, Italy)
In the present work, an approach that aims at predicting the fatigue lifetime duration of short fiber-reinforced thermoplastics undergoing fatigue loadings is proposed. The effect of local anisotropy deriving from fiber orientation and fiber volume fraction is taken into account.

3.18-06 Thermo-Mechanical Constitutive Behaviour Models for Unfilled and Short Fibre Reinforced Polymers for Application in Heat Exchangers
A. Krairi, J. Schalnat, W. Van Paepegem (Ghent University, Belgium)
New constitutive behaviour models are proposed for both unfilled polymers and short fibre reinforced polymers (SFRPs) for application in heat exchangers. The two models allow to capture the loading (strain/stress) rate dependency and the temperature sensitivity of the materials.

3.18-07 Study of Crack Initiation and Crack Propagation of Short Fiber Reinforced Polyamide
J. Decker, O. Schwarzhaupt, L.M. Herkenrath, D. Spancken, A. Büter (Fraunhofer LBF, Germany)
This paper is about a study of the crack initiation and the crack propagation of short fibre reinforced polyamides following from cyclic loading. The crack initiation and propagation was investigated macroscopic by camera and microscopic by computer tomography.

3.18-08 Study of Notch Effect and Fibre Orientation on Fatigue Strength of Short Glass Fibre Reinforced Polyamide
G. Stadler, A. Primetzhofer (Montanuniversität Leoben, Austria), G. Pinter (Montanuniversität Leoben & Polymer Competence Center Leoben GmbH, Austria), F. Grün (Montanuniversität Leoben, Austria)
Short fibre reinforced polymer structural components, which are often applied in the automotive sector have, due to innovative lightweight designs in general, complex geometries with many notches. Therefore, the effect of notches interacting with the local fibre orientation on the life time prediction needs to be investigated. (Cntd)

3.18-09 Short Fibre Reinforced Thermoplastics – A Novel Standard to Determine Material Parameters under Tension, Pressure, Shear and Mixed Loadings
K. Kose (INPRO, Germany), M. DeMonte (R. Bosch GmbH, Germany), D. Spancken (Fraunhofer LBF, Germany), V. Trappe (Bundesanstalt für Materialforschung und -prüfung BAM, Germany), A. Zeiser (Hochschule für Technik und Wirtschaft HTW, Germany)
Tubular test specimens make a combination of tensile, compressive and shear loads feasible and provide a big improvement in determining the elasticities, strengths and fatigue stiffness needed for material models.

14:40-16:20 Hall: MC3

5.01 | Processing and Manufacturing Technologies: Additive Manufacturing

Chairs: **S. Tsantzalis, U. Lafont**

5.01-01 Characterization of Elastic and Resistance Behaviours of 3D Printed Continuous Carbon Fibre Reinforced Thermoplastics
M. Iragi (Mondragon Unibertsitatea, Spain), C. Pascual-Gonzalez (IMDEA Materials Institute, Spain), A. Esnaola, J. Aurrekoetxea (Mondragon Unibertsitatea, Spain), C. S. Lopes (IMDEA Materials Institute, Spain), L. Aretxabaleta (Mondragon Unibertsitatea, Spain)
The aim of this research is to evaluate the mechanical properties of 3D printed continuous carbon fibre polyamide composites using a novel composite Fused Filament Fabrication (FFF) printing process. The FFF process is one of the most popular 3D printing processes due to its simplicity, low cost of the printers (Cntd)

5.01-02 Application of an Arm-Based FDM System for Sandwich Panel Fabrication

D. Pollard (University of the West of England, United Kingdom), G. Herrmann, C. Ward, J. Etches (University of Bristol, United Kingdom)

Additive Manufacture is typically constrained to planar layers of material. This paper describes the implementation of an FDM system in an 8-DOF robotic cell and demonstrates its feasibility for the manufacture of curved and complex core components.

5.01-03 Development of Flame-Retarded PLA Compositions by 3D Printing of Core-Skin Structures

A. Regazzi, M.F. Pucci, L. Dumazert, S. Buonomo, B. Gallard, R. Ravel, J.-M. Lopez Cuesta (Univ Montpellier, France)

Fused Filament Fabrication (FFF) was chosen as a technique to produce plate samples. Injected samples were also manufactured for comparison purpose. The nature of the flame retardants (FR), their contents and their distribution in the samples were varied.

5.01-04 Nanocellulose as Reinforcing Agent for Biodegradable Polymers In 3D Printing Fused Deposition Modeling

D. Rigotti, A. Dorigato, A. Cataldi, L. Fambri, A. Pegoretti (University of Trento, Italy)

The aim of this work is the development of different kind of thermoplastic biodegradable polymers reinforced with nanocellulose and to study their applicability in Additive Manufacturing technology such as Fused Deposition Modeling (FDM).

5.01-05 Cork-Polylactide Composites Reinforced with Polyhydroxyalkanoates for Additive Manufacturing

S. P. Magalhães da Silva, J. M. Oliveira (University of Aveiro, Portugal)

The present work aims to give value to cork powder residues from cork industry by incorporating them into polymeric matrices. The toughening effect of PHA on PLA was also studied to overcome the brittleness of PLA and to take advantage of cork elasticity.

14:40-16:00 Hall: MC2

3.16 | Material and Structural Behavior – Simulation and Testing: Sandwich Structures

Chair: **A. Baltopoulos**

3.16-05 Comparison Between Springbacked Carbon Fiber Card Web Reinforced Thermoplastics and Carbon Fiber Paper Reinforced Thermoplastics Sandwich Structures on Bending and Impact Property

Y. Zhang, G. Yin, B. Xiao, Y. Wan, I. Ohsawa, J. Takahashi (University of Tokyo, Japan)

In this research, a kind of sandwich structure made by out of panel thermal deformation------so called "springback" is manufactured. Carbon fiber card web reinforced thermoplastics (CWT) and carbon fiber paper reinforced thermoplastics (CPT) are implied as the core part and the uni-directional carbon fiber reinforced thermoplastics (UD CFRTP) (Cntd)

3.16-06 Analysis and Material Preparations of Gradient Connections for Corrugated Sandwich Structure's Thermal Short-Circuiting

S. Meng, Z. Hu, J. Li, Q. Yang (Harbin Institute of Technology, China)

My research is to solve the thermal short circuit problem in the integrated thermal protection connection structure by designing and preparing the cold and hot connection structure with gradient transitional features, so I established analysis model and used laser pyrolysis to prepare the gradient material.

3.16-07 Experimental and Numerical Progressive Failure Analysis of Corrugated Core Type Composite Sandwich Structure

E. Calik, N. Ersoy, F. E. Oz (Bogazici University, Turkey)

The aim of this study is to investigate the failure mechanisms of corrugated core type Carbon Fibre Reinforced Polymer (CFRP) composite sandwich structure under quasi-static loading condition. A new corrugated core type composite sandwich structure is designed by using a special combination of laminates (Cntd)

3.16-08 Experimental and Numerical Investigation of the Effect of Temperature on the Behaviour Under Impact of Composite Sandwich Panels for Space Applications

M. Jean-St-Laurent, M.-L. Dano (University Laval, Canada), M.-J. Potvin (Canadian Space Agency, Canada)

The behaviour of carbon-epoxy composite sandwich panels with Nomex Honeycomb core under low velocity impact at extreme temperature has been studied experimentally. In parallel, a numerical model was developed and validated at different temperatures.

14:40-16:20 Hall: Kokkalis

3.12 | Material and Structural Behavior – Simulation and Testing: Short High-Performance Discontinuous Fiber Composites

Chair: **A. Bernasconi, J. L. Bailleul**

3.12-06 Predictions of Carbon Fibre Sheet Moulding Compound (CF-SMC) Mechanical Properties based on Local Fibre Orientation

L. M. Martulli (Toyota Motor Europe & KU Leuven, Belgium), M. Alves, S. Pimenta (Imperial College London, United Kingdom), P. J. Hine (University of Leeds, United Kingdom), M. Kerschbaum (Toyota Motor Europe, Belgium), S. V. Lomov, Y. Swolfs (KU Leuven, Belgium)

There is currently no commercially available models dedicated exclusively to strand based discontinuous composites, like SMC. Adopted techniques are developed for injection moulded short fibre reinforced plastics. How do they perform, and what are other possible predictive techniques?

3.12-07 Development of a FE Design Framework to Predict the Response of Discontinuous Composite Structures with Heterogeneous Microstructures
Y. Li, S. Pimenta (Imperial College London, United Kingdom)
Our physically-based framework predicts stochastic distributions of stiffness and strength of tow-based discontinuous composites, assigns mesh-independent random property fields to FE simulations, and determines failure index fields of structures.

3.12-08 Quantifying and Predicting the Effect of Heterogenenous Microstructures on the Performance of Discontinuous Composites
S. Pimenta, Y. Li, M. Alves, F. Gaudron, Tahreem (Imperial College London, United Kingdom), S.K. Nothdurfter, K. Schuffenhauer (Automobili Lamborghini S.p.A., Italy)
We predict the variability in stochastic stiffness fields, strength distributions, and notch sensitivity of tow-based discontinuous composites through a FE Monte-Carlo analysis, which we validate experimentally against a range of notched tensile tests.

3.12-09 Virtual Design of Car Components Manufactured with High-Performance Discontinuous Composites
K. Schuffenhauer, S.K. Nothdurfter (Automobili Lamborghini S.p.A., Italy), Y. Li, S. Pimenta (Imperial College London, London)
We investigate how material variability affects the performance of the engine bonnet of a Lamborghini Huracan Performante. We show that our FE Monte-Carlo framework can predict the reliability of the structure and identify several critical regions.

3.12-10 Modelling the Tensile Behaviour of Hybrid Fibre Architectures of Randomly Oriented Strand Composites
S. B. Visweswaraiah, V. Cadran, L. Lessard, P. Hubert (McGill University, USA)
Hybrid fibre architectures of randomly oriented strand composites (ROS) and laminate groups represent trade-off solutions of formability and mechanical performance for composite structures. The focus of this work is the proposition of a simplistic meso-structure model that generates the absolute and relative behavior (Cntd)

14:40-16:20 Hall: Lecture Room

2.16 | Materials Science: Wood-Based Composites
Chair: **D. Vlachos**

2.16-01 Toughing Polypropylene by Filling with Nanoscale Fillers
K. Nagata, S. Okuda, K. Sanada (Toyama Prefectural University, Japan), M. Ootsubo, K. Ogura, Y. Morimoto (Sugino Machine Limited, Japan)
We report on the results of examining the effect of fiber length on the tensile properties of PP composites of CNF and CNC dry powders developed this time. Furthermore, it has been demonstrated that the strength and the elongation at break are better in low-filled CNF composite than in PP, thus, PP can be toughened by the nanofibers.

2.16-02 Impact Strength Improvement of PP Based WPC by Hybridization with PP Impregnated PET Fiber
C. Pretschuh (Competence Centre for Wood Composites and Wood Chemistry (Wood K plus), Austria), M. Jerabek (Borealis Polyolefine GmbH, Austria), K. Renner (Budapest University of Technology and Economics, Hungary), D. Salaberger (University of Applied Sciences Upper Austria, Austria), T. Lummerstorfer (Borealis Polyolefine GmbH, Austria)
Polypropylene (PP) impregnated PET fiber pellets with an initial length of 15mm (L-PET PP) have been used as reinforcement of PP and PP based Wood Polymer Composites. Injection molded formulations showed a synergistic effect by using both fillers. L-PET PP acts as effective impact modifier.

2.16-03 Influence of Different Impact Modifiers on the Mechanical Properties of Cellulose Fibre Reinforced Polypropylene Composites
M. Mihalic, L. Sobczak, C. Pretschuh, C. Unterweger (Kompetenzzentrum Holz GmbH, Austria)
Through the addition of suitable impact modifiers, PP-cellulose composites can achieve a strong impact performance with still acceptable tensile properties. In addition the density is reduced compared to PP-talc composites, even though the impact strength of the latter is not reached.

2.16-04 Thermo-Mechanical Treatment to Modify Wood-Based Composites
C. Del Menezzi (University of Brasília & École Nationale Supérieure des Technologies et Industries du Bois, France), L. do Vale, M. Ribeiro, P. dos Santos (University of Brasília, Brazil)
This paper aims to present some results about the utilization of thermo-mechanical process to densify the following wood-based composites (WBC): medium density particleboard (MDP), medium density fiberboard (MDF) and oriented strand board (OSB). The paper focus on variables regarding the thermo-mechanical process (Cntd)

2.16-05 Impacts of the Synthesis Processes on UREA Formaldehyde Resins Performance
C. Gonçalves (Universidade do Porto & EuroResinas – Indústrias Químicas SA, Portugal), A. Gomes (ARCP – Associação Rede de Competência em Polímeros, Portugal), J. Pereira (Universidade do Porto & ARCP – Associação Rede de Competência em Polímeros, Portugal), N. Paiva, J. Ferra (EuroResinas – Indústrias Químicas SA, Portugal), J. Martins (Universidade do Porto & Campus Politécnico de Repeses, Portugal), F. Magalhães, A. Barros-Timmons (Universidade de Aveiro, Portugal), L. Carvalho (Universidade do Porto & Campus Politécnico de Repeses, Portugal)
This work presents the impact of different synthesis processes for producing urea-formaldehyde resins and their roles on the physico-mechanical properties and formaldehyde emissions of the resulting particleboards.

14:40-16:00 Hall: MC3.2

1.05 | Applications: Composite Repair

Chair: **T. Kruse**

1.05-01 Statistical Optimization of Composite Materials Laser Assisted Ablation Process for Bonded Repair Purposes

T.H. Loutas, D. Bonas, G. Sotiriadis, S. Psarras, V. Kostopoulos (University of Patras, Greece)

The repair philosophy in modern aircraft composite structures is steadily moving from bolted to bonded repairs. The conventional way to material removal is via manual mechanical machining. Very few attempts the last decade, have utilized pulsed lasers to a more automatic, more precise, less labor intensive process. (Cntd)

1.05-02 Optimizing Composite Repair Technics

S. Psarras, G. Sotiriadis, T. Loutas, V. Kostopoulos (University of Patras, Greece)

In this paper a brief analysis of the results of a laser ablation repair process is presented in order to investigate the strength and stiffness restoration of scarfed repaired composite specimens and compare them with pristine and damaged specimens.

1.05-03 Compressive Behavior of Composite Laminate with Delamination and a Quick Mechanical Repair

S. Yuru, W. Xin, L. Zengshan (Beihang University, China), G. Weishi (Shenyang Aerospace University, China), H. Yongjie, F. Rongtao, G. Zhidong (Beihang University, China)

In this paper, the compressive behavior of the ZT7H/QY9611 composite laminates containing single delamination and a corresponding quick mechanical repair method for field repairing have been investigated both experimentally and by numerical calculation method. (Cntd)

1.05-04 A New Approach for a Reliable Rework of Complex Composite Structures

P. Jaeschke, H. Dittmar (Laser Zentrum Hannover e.V., Germany), M. Wonneberger, F. von Dungern, S. Steeger (INVENT GmbH, Germany), M. Kogel-Hollacher, T. Beck (Precitec Optronik GmbH, Germany)

For the rework and the repair of composite structures, a new approach based on adapted laser technology as well as piezo technique has been developed. Within the frame of the joint research project "ReWork" pulsed laser radiation is used to ablate the single layers of a CFRP structure

14:40-16:00 Hall: MC3.3

4.02 | Experimental Methods: Micro- and Nano-Scale Test Methods

Chair: **D. Zarouchas**

4.02-01 Nanoindentation of Graphene-Reinforced Polypropylene Nanocomposites Laminated with Carbon Fibres

P. Enrique-Jimenez (Instituto de Estructura de la Materia IEM-CSIC, Spain), S. Quiles-Díaz, H.J. Salavagione, M.A. Gómez-Fatou (Instituto de Ciencia y Tecnología de Polímeros ICTP-CSIC, Spain), F. Ania, A. Flores (Instituto de Estructura de la Materia IEM-CSIC, Spain)

The mechanical properties of graphene-reinforced polypropylene nanocomposites laminated with alternating carbon fibre mats have been studied at a local scale by nanoindentation and results are correlated with morphological studies by means of scanning electron microscopy (SEM). (Cntd)

4.02-02 High Throughput Mechanical Micro-Scale Characterization of Composites and the Utilization of the Results in Finite Element Analysis

P. Laurikainen (Tampere University of Technology, Finland), S. Pötz (Polymer Competence Center Leoben GmbH, Austria), J. Jokinen, M. von Essen (Tampere University of Technology, Finland), Mari Lindgren (Outotec Research Center, Finland), P. Kallio, M. Kanerva (Tampere University of Technology, Finland), G. Oreski (Polymer Competence Center Leoben GmbH, Austria), E. Sarlin (Tampere University of Technology, Finland)

Single fibre tensile and microbond tests were used to analyse the glass fibre performance and strength of the interphase with a simple epoxy resin. Changes from ageing were also tested. The effects of resin property variations in a microbond test were analysed with finite element analysis.

4.02-03 Experimental Investigation of Load-Sharing in CFRP with In-Plane Waviness by Measured Local Fiber Stress

M.-J. Shi, T. Miyake, Y. Takata (Gifu University, Japan)

The objective of this study is to highlight the effect of manufacturing induced fiber waviness defect on load shearing between waved fibers and their neighbor fibers in tensile test. For this purpose, fiber stress distribution along the cross-section perpendicular to loading direction was measured (Cntd)

4.02-04 Local Characterization by Cyclic Indentation Test of Polymer Matrix in 3D Carbon Fiber Composites

M. Pecora, O. Smerdova, M. Gigliotti (Université de Poitiers, France)

In this work, local mechanical properties of PR520 epoxy resin matrix in 3D carbon fiber composite (in-situ) have been investigated through a cyclic indentation loading method and compared with that of the neat material. This loading enables to evaluate elastic as well as time dependent response of the material. (Cntd)

14:40-16:20 Hall: MC3.4

4.04 | Experimental Methods: Non Destructive techniques for Composites (VS, AE, Electric)

Chair: **N. Godin**

4.04-01 Acousto-Ultrasonic Damage Evaluation of Carbon Fibre Composites using Pencil Lead Break Sources

P. Duchene, S. Chaki, P. Krawczak (IMT Lille Douai, France)

A novel method based on acousto-ultrasonic analysis for damage assessment without mechanical load is presented. A description of the procedure and a case study are detailed on a composite material under fatigue load. Damage localisation is performed using parameter maps.

4.04-02 Multi-Sensor Acoustic Emission Analysis towards the Study of Oxide-Based Ceramic Matrix Composites Damage Behavior

N. Guel (IRT Saint-Exupéry & Université de Lyon & Université de Bordeaux, France), N. Godin (Université de Lyon, France), O. Caty (Université de Bordeaux, France), P. Reynaud (Université de Lyon, France), F. Bouillon (Safran Ceramics, France), S. Mahdi (IRT Saint-Exupéry, France)

Damage kinetics of oxide CMC is inspected through acoustic emission (AE) analysis and in-situ mechanical tests. Macroscopic mechanical tests were monitored with two kinds of AE sensors operating in different frequency range. AE signal data fusion limits device-dependent acoustic information.

4.04-03 Multiaxial Damage Identification of Angle-Ply Laminates using Acoustic Emission and Other Online Monitoring Techniques

K.-A. Kalteremidou, E. Tsangouri (Vrije Universiteit Brussel VUB, Belgium), A. Cernescu, B. R. Murray (Vrije Universiteit Brussel VUB & SIM M3 Program, Belgium), L. Pyl, D. G. Aggelis, D. Van Hemelrijck (Vrije Universiteit Brussel VUB, Belgium)

The aim of this research is the combined use of acoustic emission with other online monitoring techniques in order to identify the damage sequence of carbon fiber reinforced epoxies. Initially, common lay-ups were tested and their acoustic emission was monitored and analyzed (Cntd)

4.04-04 In-Situ Invetigation of Damage Mode Progression in Open-Hole Quasi-Isotropic Laminates

F. E. Oz (Bogazici University, Turkey), N. Ersoy (Bogazici University, Turkey & University of West England, United Kingdom), M. Mehdikhani, S. V. Lomov (KU Leuven, Belgium)

In this study, damage mode progression in open-hole (OH) Carbon Fibre Reinforced Polymer (CFRP) laminates are investigated. Two different quasi-isotropic (QI) CFRP laminates are tested with online damage detection techniques. Acoustic Emission (AE) is used primarily for this aim. (Cntd)

4.04-05 Electrical Monitoring of Concrete Using A Novel Structural Sensor Based on Conductive Cementitious Mortar

E. Qingnan Zhang (Chalmers University of Technology, Sweden), S. Grammatikos (Norwegian University of Science and Technology, Norway), I. Lofgren (T. Concrete Group AB, Sweden), L. Tang (Chalmers University of Technology, Sweden), L. Ye (SHT Smart High Tech AB, Sweden), J. Liu (Chalmers University of Technology, Sweden)

This paper presents the development of a durable structural sensor based on cement-mortar modified with graphene and other carbon-based fillers. The purpose of the structural sensor is to indirectly monitor curing and service performance of concrete via electrical resistivity measurements. (Cntd)

14:40-16:40 Hall: Conference 1

5.09 | Processing and Manufacturing Technologies: Online Process Monitoring and Controlling

Chair: **P. Olivier**

5.09-01 Production of Composites Base Material and Prepregs - Industry 4.0: How Optical Quality Control Contributs to Higher Yield

H. Oerley (Dr. Schenk GmbH Industriemesstechnik, Germany)

Automatic Optical Inspection Systems (AOI) are applied to control the production of composite materials. The information achieved with AOI systems provides an overview on the performance of the production in a Smart Factory.

5.09-02 Embedding Miniaturized Flexible Sensors for Online Monitoring of Fibre Composite Production

M. Hübner (University Bremen, Germany), M. Koerdt, E. Hardi, A. S. Herrmann (Faserinstitut Bremen e.V., Germany), W. Lang (University Bremen, Germany)

We embedded different inlays, representing a sensor, in CFRP and performed mechanical test. Based on the inlay which reduced the mechanical integrity the least, we manufactured a miniaturized flexible dielectric sensor for online cure monitoring.

5.09-03 Online Monitoring System for the Tack of Prepreg Slit Tapes used in Automated Fiber Placement

B. Böckl, C. Jetten, K. Heller, C. Ebel, K. Drechsler (Technical University of Munich, Germany)

A system for monitoring the tack of prepreg slit tape has been developed. It is based on measuring the friction force generated by the moving tape. First tests showed a dependency of the measured values on age, velocity and compaction force.

5.09-04 Online Flow Monitoring System Development for the Resin Transfer Moulding Process

A. Pouchias (Loughborough University & National Structural Integrity Research Centre (NSIRC), United Kingdom), P.R. Cunningham (Loughborough University, United Kingdom), J. Stein, M. Kazilas (TWI Ltd, United Kingdom)

This work is the initial stage of the development of an online flow monitoring system for the resin impregnation phase of the Resin Transfer Moulding process. Online monitoring of the process is proposed to provide an estimation of the component's state and to predict the defects, (Cntd)

5.09-05 Development of a Novel Type of Online Monitoring System for the Braiding Process

S. Maidl, A. Mierzwa, C. Ebel, K. Drechsler (TUM Technical University of Munich, Germany)

To reduce material waste and machine downtime, we have developed a cost-efficient bobbin carrier independent online monitoring system for the braiding process which is able to detect the development of braiding defects already in early stages.

5.09-06 Optimization of In-Plane Compaction of a Braided Layer

V. Reimer (Aachen University, Germany), A. Kotb Nazeer (German University in Cairo, Egypt), T. Gries (RWTH Aachen University, Germany)

Over-braiding has become a significant manufacturing technology for production of low cost and high volume FRPs. However, there is still potential to improve mechanical properties. Thus, a method was developed by optimizing the in-plane compaction during set-up process.

14:40-15:40 Hall: MC3.5

Special session 3 | H2020 – Dynamic Loading – Pushing the Boundaries of Aerospace Composite Material Structures

Chair: **T. Kotzakolios**

SS3-06 Instabilities due to Strain-Softening Solved Using the SPH Method

N. Djordjevic, R. Vignjevic, T. De Vuyst (Brunel University London, United Kingdom), S. Gemkow (Cranfield University, United Kingdom)

This work considered the strain softening effects in the SPH spatial discretization, combined with a local continuum damage model, which had been observed to lead to the instabilities in the classic FEM. The simulation results of one dimensional wave propagation problem demonstrate that the SPH method is inherently non-local (Cntd)

SS3-07 An Equivalent Damage Force Approach to Modelling of Strain Softening Materials

R. Vignjevic, N. Djordjevic, T. De Vuyst (Brunel University London, United Kingdom), S. Gemkow (Cranfield University, United Kingdom)

This paper is related to the problem of damage/deformation localisation typical for the finite element analysis of softening materials based on local constitutive models and continuum damage mechanics. This problem is characterised with change of the type of partial differential equations, (Cntd)

SS3-08 Assessment of Existing LS-DYNA Material Models for Reproduction of Experimental Quasi-Static Response of CYCOM 977-2 Material: Experiments and Simulation

E. Giannaros, A. Kotzakolios, G. Sotiriadis, V. Kostopoulos (University of Patras, Greece)

The present study investigates the numerical reproduction of quasi-static response of CYCOM 977-2 composite material. The aim is to assess the applicability and to find-out the limitations of existing orthotropic materials models of commercial code LS-DYNA for the prediction of CYCOM 977-2 composite material behavior (Cntd)

14:40-16:40 Hall: Kokkalis Foyer

Poster Session

16:20- 17:00 Hall: Exhibition Area

Coffee Break

17:00-18:40 Hall: Trianti

2.11 | Materials Science: Interfaces and Interphases

Chairs: **S. Goutianos, A. Bismarck**

2.11-01 Are Silanes the Primary Driver of Interface Strength in Glass Fibre Composites? (Exploring the Relationship of the Chemical and Physical Parameters which Control Composite Interfacial Strength)
J. L. Thomason, L. Yang, R. F. Minty (University of Strathclyde, United Kingdom)
The results presented provide support for the hypothesis that most of the apparent interfacial shear strength measured in fibre-reinforced composites can be attributed to a combination of residual radial compressive stress and static friction at the fibre-matrix interface.

2.11-02 Assessment of Interfacial Adhesion of Flax Yarns in Thermoset Matrices: Effect of Different Surface Modification Treatments
M. C. Seghini (Sapienza-Università di Roma, Italy & Université de Poitiers, France), F. Sarasini, J. Tirillò, M. G. Santonicola, R. Lavecchia, A. Zuorro, G. Maffei, T. Valente (Sapienza-Università di Roma, Italy), F. Touchard, L. Chocinski-Arnault, D. Mellier (Université de Poitiers, France), M. Zvonek, V. Cech (Brno University of Technology, Czech Republic)
The present work is an experimental investigation about the adhesion quality of flax yarns with epoxy and vinylester matrices. Fragmentation tests have been performed for untreated and treated flax yarns to assess the effect of physical and biochemical treatments on the interface properties.

2.11-03 Surface Modification of Carbon Fibres for Interface Improvement in Textile Composites
J. Qiu, J. Li, Z. Y. (University of Manchester, United Kingdom), H. Zeng (University of Manchester, United Kingdom & Zhongyuan University of Technology, China), X. Chen (University of Manchester, United Kingdom)
The performance of carbon fibre-reinforced composites is dependent to a great extent on the properties of the fibre-matrix interface. In this research, based on the reviewed surface modification technique and inspired by the in situ growth of three-dimensional graphene coatings on nanomaterials, (Cntd)

2.11-04 Surface Characterization of Fillers, Fibres and Polymers by iGC for Developing Composites
A. Kondor (Surface Measurement Systems, Ltd., United Kingdom), D. Burnett (Surface Measurement Systems, Ltd., USA), M. Naderi (Surface Measurement Systems, Ltd., United Kingdom)
Inverse Gas Chromatography (iGC) is a commonly used technique to characterize solid surfaces including surface energy, Lewis acid and base constants. This presentation summarizes recent studies where IGC has been used to investigate surface modification of filler materials and its correlation to adhesion phenomena.

2.11-05 Effect of the Interphasial Debonding on the Elastic Behavior of Unidirectional Glass-Fiber/Epoxy Composites
L. Riaño, L. Belec, Y. Joliff (Université de Toulon, France)
Due to the presence of the sizing substance during the fiber surface treatment, an interphase area is often present at the vicinity of the reinforcements. Using a FEA homogenization technique, this study presents the influence of the interphasial debonding on UD composites. (Cntd)

17:00-18:00 Hall: Mitropoulos

6.03 | Multifunctional and Smart Composites: Sensing and self Diagnosis

Chairs: **A. Filippatos, M. Zappalorto**

6.03-01 Nano Welding, A Tool to Make Stretchable Hybrid Conductor-Sensor Soft Material
R. Chellattoan, G. Lubineau (King Abdullah University of Science and Technology (KAUST), Saudi Arabia)
Stretchable sensors and conductors have potential applications in soft robotics and artificial skin technologies. Several approaches are available to design stretchable conductors or sensors. Here, weput forward the possibility of using electrical welding as a tool to transform a polymer sponge strain sensor to a conductor. (Cntd)

6.03-02 Novel Multi-Scale Carbon Nanotube Based Smart Composites: Processing, Characterization and Applications in Self-Sensing and Structural Health Monitoring
E. T. Thostenson, S. M. Doshi (University of Delaware, USA), A. Rider (Defence Science and Technology Group, Australia), Q. An, C. Murray (University of Delaware, USA)
In this research, a novel electrophoretic deposition (EPD) method is used to develop carbon nanotube based smart composites and its applications in in-situ sensing of composites and structural health monitoring of steel and concrete are discussed. Integrating carbon nanotubes with conventional micron-sized fibers (Cntd)

6.03-03 Nano-Engineered Hierarchical Composites with Multi-Functionalities: From Nanofiller Network Formation to Self-Sensing and De-Icing
H. Zhang, Y. Liu, A. Kernin, K. Wan E. Bilotti, T. Peijs (Queen Mary University of London, United Kingdom)
Hierarchical composites based on continuous micro-level carbon or glass fibre together with various forms nano-level materials such as carbon nanotubes (CNTs) and graphene have been explored extensively in last decade for next generation advanced composite materials, (Cntd)

17:00-18:00 Hall: Skalkotas

3.19 | Material and Structural Behavior – Simulation and Testing: Thin Ply Composites

Chair: **S. T. Pinho**

3.19-01 Fatigue Testing and Fatigue Life Prediction of Injection Molded Carbon-fibre Reinforced Plastics for Automotive Oil-pan Application

J. Kang, Bin Li, Jie Liang (Canmet MATERIALS, Canada), Carlos C. Engler Pinto Jr. (Ford Motor Company, USA)

We studied fatigue behavior of two injection molded carbon fibre-reinforced polyamide 66 composites with different stress ratios and stress levels at room temperature (RmT) and 120 C, i.e. the potential service temperature of the oil pan. Through analyzing the fatigue data, fatigue life models were established (Cntd)

3.19-02 Effect of Ply Thickness and Constituents on the Transverse Crack Propagation of Thin-Ply Composites: Damage Progression and Modelling

S. Kohler, J. Cugnoni, J. Botsis (LMAF, Switzerland)

Study of the ply thickness dependence of the damage mechanisms observed experimentally and numerically at the free edge and in the bulk of two QI composites tested in tension. The propagation of transverse cracks as well as their associated critical ERR are shown to vary with ply thickness.

3.19-03 Translaminar Fracture of Regular and Hybrid Thin Ply Composites: Experimental Characterization and Modeling

J. Cugnoni, G. Frossard, R. Amacher, J. Botsis (EPFL, Switzerland)

Thin-ply composites can reach outstanding strength but exhibit a fragile fracture. Hybrid fiber thin-ply laminates are developed to improve translaminar toughness by fiber bridging or controlled fiber fragmentation to promote dissipation by pullout.

17:00-19:00 Hall: Multi-Purpose Room

2.15 | Materials Science: Textile Composites

Chair: **M. Gude**

2.15-01 Analysis of Defaults Occurred During Bias Extension Tests on Non-Crimp Fabrics

J. Pourtier, B. Duchamp, M. Kowalski (IRT M2P, France), X. Legrand, P. Wang, D. Soulat (Université de Lille, France)

The formability of NCF have been studied in several scientist works [1–4]. However, most of those studies ignore the presence of a chemical binder system (polymer) needed in the industrial applications. This component is usually added on the fabric to stabilized their 3D geometry (inter-ply and intra-ply cohesion). (Cntd)

2.15-02 Characterisation of Through-The-Thickness Tufted Preforms During Manufacturing

I. Gnaba, P. Wang, X. Legrand, D. Soulat (University of Lille, France)

Textile composites are widely used to manufacture thicker and more complex parts. In aerospace, transport and energy industry, the 3-Dimensional fabrics have been developed to replace the multilayered reinforcements in some applications to increase the performance through-the-thickness. (Cntd)

2.15-03 Investigation of the Longitudinal Shear Behaviour of the Tufted Composites

C. Hui, C. Chen, P. Wang, X. Legrand (University of Lille, France)

Laminated composites are wildly used in many industrial fields such as transport, construction, energy and defence. Comparing with metal materials, laminated composite presents better mechanical performances such as high specific strength and stiffness. (Cntd)

2.15-04 Experimental Investigation of Triaxial Braided Composite Reinforcements Forming

S. Xiao (University of Lille, France & Dalian University of Technology, China), P. Wang, D. Soulat, X. Legrand (University of Lille, France), H. Gao (Dalian University of Technology, China)

The formability behavior of triaxial braids made by carbon fibers is firstly analysed in this paper. To conveniently present the characteristics, the fabrics produced by Flax/PA12 yarns are put forward as the contrast. Defects including interlayer sliding, misalignment and buckling can reprensent the formability behavior. (Cntd)

2.15-05 Optimal Design of Triaxial Weave Fabric Composites for Specific Strength and Stiffness Under Tension

Z. Z. Wang, A. Sobey (University of Southampton, United Kingdom)

Two top performance Genetic Algorithms from our previous study are benchmarked for multi-objective density optimisation of triaxial weave fabric composites. The optimal designs of maximum strength and stiffness with minimum surface density are achieved in this study.

2.15-06 Manufacturing and Performance of Hybrid Fabric Reinforcements and their Composites

A. Rajpurohit (Chomarat Textiles Industries & MINES ParisTech-PSL, France), V. Singery (Chomarat Textiles Industries, France), S. Joannes (MINES ParisTech-PSL, France), P. Sanial (Chomarat Textiles Industries, France), L. Laiarinandrasana (MINES ParisTech-PSL, France)

Hybrid textile reinforcements are manufactured and further used for composite manufacturing along with epoxy resin in a RTM process. Mechanical performance of interply and intraply hybrid composites is evaluated and compared in tensile and flexural loading. (Cntd)

17:00-19:00 Hall: MC2

5.11 | Processing and Manufacturing Technologies: Pultrusion and Filament Winding

Chairs: **A. Torres Marques**

5.11-01 Thermoplastic Composite Rod Manufacturing using Biaxial Braid-Trusion
M. Ghaedsharaf (Polytechnique Montréal, Canada), J-E. Brunel (Bombardier Product Development Engineering, Canada), L. Laberge Lebel (Polytechnique Montréal, Canada)
Braid-trusion is a composite manufacturing process combining braiding and pultrusion. This process produces constant cross-sections thermoplastic composite beams having angle-oriented fibers. During pultrusion, the braid is drawn through a series of dies by a pulling device. (Cntd)

5.11-02 Design and Manufacturing of Novel Thermoplastic CFRP Rods for Carbon Concrete Composites
D. Wohlfahrt, M. Thieme, R. Böhm, M. Gude (Technische Universität Dresden, Germany)
The paper shows the developing of a variant classification for the design of FRP rebars, manufacturing processes for thermoplastics CFRP rods also the results of tensile tests of different manufactured rod variants.

5.11-03 Comparative Evaluation of Braiding and 3D Complex Winding for Automotive Chassis Frames
Y. Liu (University of Manchester & Cygnet Texkimp, United Kingdom), P. Potluri, S. Shankhachur Roy, X. Li (University of Manchester, United Kingdom), C. Taylor, R. Shah (Axon Automotive, United Kingdom), A. Whitham (Cygnet Texkimp, United Kingdom), A. Fernando (University of Manchester, United Kingdom)
This paper compares and contrasts two potential preforming technologies for automotive chassis frame structures. Composite beams have been produced using the patented AxontexTM beam technology (braided material around low density square foam cores) and the novel 3D winding technology at Cygnet. (Cntd)

5.11-04 Determination of the Friction Coefficient in Dry-Fiber Filament Winding
S. Neunkirchen, R. Schledjewski (Montanuniversität Leoben, Austria)
A method to determine the friction coefficient between the roving and an aluminum mandrel in dry-fiber winding is presented. Influencing the friction by the application of adhesive sprays and the usage of bindered rovings is also investigated.

5.11-05 Effect of Alumina Tri-Hydrate Filler on the Mechanical and Optical Properties of Flame-Retardant Ultraviolet Cured Vinyl Ester Composites
I. Tena, I. Saenz-Dominguez (Mondragon Unibertsitatea, Spain), J. Torre (Irurena Group, Spain), M. Sarrionandia, J. Aurrekoetxea (Mondragon Unibertsitatea, Spain)
This research study is focused on the effect of alumina tri-hydrate(ATH) filler on the mechanical and optical properties of flame-retardant ultraviolet cured vinyl ester composites. In particular, vinyl ester formulation for out of die ultraviolet (UV) cured pultrusionhas been analysed.

5.11-06 Analysis of Axial Crushing Behaviour of Unsaturated Polyester and Vinyl Ester Composites Manufactured by Out Of Die Ultraviolet Cured Pultrusion
I. Saenz-Dominguez, I. Tena, A. Esnaola, M. Sarrionandia (Mondragon Unibertsitatea, Spain), J. Torre (Irurena Group, Spain), J. Aurrekoetxea (Mondragon Unibertsitatea, Spain)
This paper analyses the axial crushing behaviour, flexural properties and physical properties of novel unsaturated polyester and vinyl ester composites, manufactured by out of die ultraviolet (UV) cured pultrusion.

17:00-18:40 Hall: Kokkalis

2.05 | Materials Science: Fibers

Chair: **D. Anthony, T. Tsotsis**

2.05-01 Spider Silk Inspired Damping Fibres Drawn from a Supramolecular Hydrogel Composite at Room Temperature - A Step Closer to Sustainable Fibre Technology
D. U. Shah, Y. Wu, M. H. Ramage, O. A. Scherman (University of Cambridge, United Kingdom)
We report the aqueous self-assembly of hierarchical supramolecular polymer-colloidal hydrogel composites consisting of polymer-grafted silica nanoparticles, a cellulose derivative and cucurbit[8]uril.

2.05-02 Investigation of the Effect of Sizing on the Tensile and Interface Properties of Continuous Basalt Fibre and Polypropylene
P. G. Jenkins, Liu Yang, J. L. Thomason (University of Strathclyde, United Kingdom)
Mechanical performance of continuous basalt fibre was investigated by single fibre tensile and microbond interface testing, using PP matrix. Data were compared with typical E-glass fibres. Fibre surface topography and roughness was analysed by AFM.

2.05-03 Recycled Basalt Fibres: Fracture Toughness Evaluation and Strength Regeneration J. Tirillò, F. Sarasini, L. Di Fausto (Università di Roma, Italy), C. Gonzalez, A. Fernandez, C.S. Lopes (IMDEA Materials Institute, Spain)
The present work investigates how chemical treatments can be used to regenerate the strength of thermally degraded basalt fibres. In an attempt to shed light on the mechanisms controlling basalt fibre strength loss, FIB milling has been used to determine the fracture toughness of single basalt fibres. (Cntd)

2.05-04 Surface Aging of Carbon Fibers Activated by Anodic Oxidation: Influence on Surface Energy and Surface Chemistry
M. Bauer, B. Brück, J. Moosburger-Will, S. Horn (University of Augsburg, Germany)
To examine temporal stability of surface properties, carbon fibers activated by anodic oxidation were aged for defined time spans. Although the elemental composition shows no changes as a function of time, the polar component of the surface energy decreases for aging times longer than 23 days.

2.05-05 Dimensional Variations and Mechanical Behaviour of Natural Fibres from Various Plant Species in Controlled Hygro/Hydrothermal Conditions

W. Garat (Université de Montpellier & Université de Reims Champagne Ardenne, France), S. Corn, N. Le Moigne (Université de Montpellier, France), J. Beaugrand (Université de Reims Champagne Ardenne, France), A. Bergeret (Université de Montpellier, France)

This study addresses the characterization of natural fibres in controlled hygro/hydrothermal conditions. The analysis of their swelling and mechanical properties as a function of RH allows predicting the behaviour of biocomposites in service life.

17.00-18.20 Hall: Lecture Room

2.16 | Materials Science: Wood-Based Composites

Chairs: **D. Vlachos, U.D. Shah**

2.16-06 Utilization of Spent Sulfite Liquor in Combination with Wheat Flour for Particleboards Manufacture

A. M. Ferreira (Universidade do Porto, Portugal), J. Pereira (ARCP, Portugal), M. Almeida (Universidade do Porto, Portugal), J. Ferra, N. Paiva (Euroresinas-Industrias Químicas S.A., Portugal), J. Martins, L. H. Carvalho (Universidade do Porto & Instituto Politécnico de Viseu, Portugal), F. D. Magalhães (Universidade do Porto, Portugal)

Nowadays, the majority of adhesives used in particleboards manufacture are formaldehyde-based, a compound classified as human carcinogen. Due to health concerns, there is an increasing demand for safer and eco-friendly adhesives. In this work a low-cost formulation based on thick spent sulfite liquor (TSSL), (Cntd)

2.16-07 Injection Molding of Hybrid Cork-Wood Composites. Mechanical Properties of PP And PLA based Materials

M. Szostak, J. Andrzejewski (Poznan University of Technology, Poland)

Hybrid composites based on mixed cork-wood flour filler were prepared by injection molding in order to compare the efficiency of reinforcement in PP and PLA based composites. The basic thermomechanical properties and morphology of these hybrid composites were investigated.

2.16-08 Cellulose Metal Sulfide Based Nanocomposite Thin Films

M. Weißl, D. Reishofer (Graz University of Technology, Austria), B. Alonso, E. Belamie (UMR 5253 CNRS/UM/ENSCM, ENSCM-8, France), H. Amenitsch, A. Zankel, T. Rath (Graz University of Technology, Austria), Josef Innerlohinger (Lenzing AG, Austria), H. Plank, G. Trimmel, S. Spirk (Graz University of Technology, Austria)

Here, we present different strategies to realize cellulose based nanocomposite thin films by spin coating having metal sulfides as active component. Two strategies are followed, namely to create an interpenetrated network of metal sulfide nanoparticles in a cellulose based thin film as well as to prepare sandwich type structures (Cntd)

2.16-09 Recycled Wood Plastic Composite Floor Panels for Off-Shore Shipping Containers

H. B. Jøsendal, S. Grammatikos, M. H. Baghban (Norwegian University of Science and Technology, Norway)

Within the framework of this study, we aim at the replacement of plywood as ship containers floor material, with a lighter and friendlier-to-rainforests composite material. Wood fibre-reinforced thermoPlastic Composites (WPC) were developed using double-screw extrusion, consisting of recycled waste wood fibres (Cntd)

17:00-18:20 Hall: MC3.2

1.05 | Applications: Composite Repair

Chair: **S. Psarras**

1.05-05 Proofed Bonding - A Novel Method for Verifying Adhesion in Adhesively Bonded Composite Repairs

L. Heilmann, P. Wierach, M. Wiedemann (German Aerospace Center, Germany)

Full verification of the quality of adhesively bonded joints is not yet feasible with non-destructive test methods. In our paper we present a novel 2-in-1 test method, which enables full mechanical validation of the strength of adhesive bonds.

1.05-06 Influence of Conditioning Time and Wet Chemical Surface Treatment on Aircraft Repair

F. Röper, M. Wolfahrt (Polymer Competence Center Leoben GmbH, Austria), G. Kucher, A. Bubestinger (FACC Operations GmbH, Austria), G. Pinter (Montanuniversität Leoben, Austria)

Within this paper the impact of the conditioning time under aircraft-relevant ambient conditions as well as an alternative method for the surface preparation on adhesively bonded repairs will be investigated.

1.05-07 Effect of Thermal Welding Repair for Damaged Ultra-Thin Chopped Carbon Fiber Tape Reinforced Thermoplastics

H. Toyoda, W. Sato, J. Takahashi (University of Tokyo, Japan)

A UT-CTT specimen having a notch at the center was repaired by bonding patches to the damaged surface. Flexural test results show that the flexural properties of UT-CTT with a small notch can be recovered by repair bonding UD patch and ultrasonic welding is useful for bonding UD patches to UT-CTT.

1.05-08 Self-Warning Hybrid Composite Patches for Repairing Cracked Aluminium Panels

M. Jalalvand (University of Strathclyde & University of Bristol, United Kingdom), H. W. M. Lok Wu (University of Bristol, United Kingdom), F. Sheibanian (Amirkabir University of Technology, Iran), M. Fotouhi (University of the West of England & University of Bristol, United Kingdom), M. R. Wisnom (University of Bristol, United Kingdom)

In this paper, a new concept for health-monitoring of bonded patch repairs is presented. Aerospace structures using aluminium panels occasionally crack and bonded composite patches are one of the repair methods available to maintain the integrity of the structure. (Cntd)

17:00-18:40 Hall: **MC3.3**

ESMC Council Meeting

17:00-18:00 Hall:**MC3.4**

1.04 | Applications: Civil Engineering

Chair: **S. Grammatikos**

1.04-01 Micro-CT Analysis of Braided BFRP Composites for Civil Engineering Applications
S. Antonopoulou, C. McNally (University College Dublin, Ireland)
This paper focuses on the use of micro computed tomography (CT) methods for fibre composite material analysis and evaluation of braided Basalt Fibre Reinforced Polymer (BFRP) reinforcement.

1.04-02 Structural Behaviour of the Hybrid FRP Composite-Concrete Bridge Span Under Static and Dynamic Loading
T. W. Siwowski, A. Kozlowski, M. Rajchel (Rzeszow University of Technology, Poland)
The innovative hybrid idea of a FRP composite–concrete structural bridge system has been presented. The paper describes the first Polish FRP bridge and presents the results of its static and dynamic proof tests. The behavior of the bridge have been evaluated and compared to design assumptions.

1.04-03 High-Cycle Fatigue Numerical Modelling of Bond between FRP Rebar and Concrete
M. Rezazadeh (University of Minho, Portugal), V. Carvelli (Politecnico di Milano, Italy)
The study aims to simulate the nonlinearity in the bond of FRP rebar and concrete under high-cycle fatigue by developing a damage-based model for reproducing the bond stiffness degradation and the residual slip growth due to cyclic loading.

17:00-18:00 Hall: **MC3.5**

1.06 | Applications: Industrial Needs-Applications

Chair: **S. Tsampas**

1.06-01 Comparative Study of Orthogonal Decomposition of Surface Deformation in Composite Automotive Panel
K. Dvurecenska (University of Liverpool, United Kingdom), E. Hack (Empa, Switzerland), G. Lampeas (Athena Research and Innovation Center in Information Communication & Knowledge Technologies, Greece), T. Siebert (Dantec Dynamics GmbH, Germany), E. Patterson (University of Liverpool, United Kingdom)
Model validation is a major step in achieving computational models with good predictive capabilities. It is normal practice to validate simulation models by comparing their numerical results to experimental data. A critical issue when performing a validation procedure with information-rich data fields (Cntd)

1.06-02 PLATFORM: Introducing Industrial Perspective in Nanoenabled Composites
S. Flórez-Fernández, A. Martin Benito, R. Seddon (TECNALIA, Spain), A. Vavouliotis, Z. Kalogridi (ADAMANT COMPOSITES Ltd., Greece), M. Towpik (TMBK Partners Sp. z o.o., Poland), V. Kostopoulos, S. Tsantzalis (University of Patras, Greece), A. Boczkowska, P. Latko-Duralek (TECHNOLOGY PARTNERS, Poland)
PLATFORM project turns up for the need to efficiently and economically manufacture components using novel nano-enabled products at a scale suitable for industrial uptake. Currently, there is no facility in Europe for the manufacture of CNT continuous-sheet Buckypapers (cntd)

1.06-03 Prediction of Tensile Stiffness and Failure of Carbon Fibre Composite Laminae: A Multi-Scale Non-Deterministic Approach
F. Malgioglio (Siemens Industry Software NV & KU Leuven, Belgium), F. Mesquita, C. Breite (KU Leuven, Belgium), A. Matveeva, L. Farkas (Siemens Industry Software NV, Belgium), W. Desmet, S. V. Lomov, Y. Swolfs (KU Leuven, Belgium)
A non-deterministic virtual testing methodology is proposed to predict the longitudinal tensile properties of UD composites. A microscale model and a ply scale model are used to account for the material variability in terms of local volume fraction, misalignment and local strength.

19.15-19.30

Departure for Gala Evening

20:00

Gala Evening

08:50- 09:50 Hall: Trianti

Plenary Lecture 4

Chair: **V. Kostopoulos**

Nanocarbon-based Fuctional Composites
Tsu-Wei Chou

09:50-10:35 Hall: Trianti

Keynote Lecture 13

Chair: **V. Kostopoulos**

Polymeric composite material technologies for space application
Ugo Lafont

09:50-10:35 Hall: Mitropoulos

Keynote Lecture 14

Chair: **S. G. Advani**

Towards the prognosis of the remaining useful life of composite structures utilizing health monitoring data and probabilistic models – present challenges and future vision
Theodoros Loutas

10:35- 11:00 Hall: Exhibition Area

Coffee Break

11.00-12.40 Hall: Trianti

2.11 | Materials Science: Interfaces and Interphases

Chair: S. Goutianos

2.11-06 An Investigation of Fibre Sizing on the Interfacial Strength of Glass-Fibre Epoxy Composites
D. Bryce, Liu Yang, J. L. Thomason (University of Strathclyde, United Kingdom)
The microbond test was used to assess the effect of fibre sizings (full and silane-only) on the interfacial shear strength of glass-fibre/epoxy composites.

2.11-07 New Interface Element with Non-Coincident Nodes to Simulate Discrete Damage in Composite Laminate
A. Trellu (Université de Toulouse, & SEGULA Aerospace and Defence, France), C. Bouvet, S. Rivallant (Université de Toulouse, France), L. Ratsifandrihana (SEGULA Aerospace and Defence, France)
Composite failure phenomena remain complex and lead to over-sizing structures in many industries involving long and costly experimental campaigns. Numerical approaches are good alternative to decrease sizing costs. The Discrete Ply Model developed in Institut Clément Ader over these last 10 years shows good results (Cntd)

2.11-08 A Numerical Modelling Approach for Interphase Adhesion of Rain Erosion Protection Systems of Wind Turbine Blades
F. Sánchez, A. Olivares, L. Domenech (Universidad Cardenal Herrera-CEU, Spain), E. Cortés (AEROX Advanced Polymers, Spain)
Rain erosion damage on wind turbine blades, is a major cause for maintenance cost concern. The problem has been approached by developing new coating systems to diminish the erosion drawback. In this research, the Post-mould coatings specifically developed for the Leading Edge Protection (LEP) and usually moulded, (Cntd)

2.11-09 Water-Based Sizing Development: Investigation of the Self-Assembly of Nanoscale Bio-Inspired Adhesive Promoters Dedicated to High-Performance Composites
A.Martin, G. Mertz, H. Perrin, R. Dieden, D. Ruch (Luxembourg Institute of Science and Technology (LIST), Luxembourg), P. Dubois (Center of Innovation and Research in Materials and Polymers (CIRMAP), Belgium)
The paper presents an innovative methodology based on supramolecular assembly for the development of sizing dedicated to high-performance composite materials. Water-based solutions were developed, using bio-inspired dopamine molecules and SPEEK polyelectrolyte.

2.11-10 Gradient Interphases Between High-Tg Epoxy and Polyetherimide for Advanced Joining Processes
J. J. E. Teuwen (Delft University of Technology, The Netherlands), J. Asquier (Delft University of Technology, The Netherlands & SUPMECA-Institut Supérieur de Mécanique de Paris, France), P. Inderkum, K. Masania (ETH Zurich, Switzerland), C. Brauner (FHNW, Switzerland), I. F. Villegas (Delft University of Technology, The Netherlands), C. Dransfeld (FHNW, Switzerland)
CFRP parts are functionalized with thermoplastic surfaces in order to be assembled through welding as a cost-efficient alternative to traditional joining techniques. Details on the interphase formation between high-Tg epoxy and polyetherimide at different curing temperatures are reported.

11.00-12.40 Hall: Mitropoulos

6.03 | Multifunctional and Smart Composites: Sensing and self Diagnosis
Chair: **M. Meo**

6.03-04 In-Situ Load-Monitoring of CFRP Components Using Integrated Carbon Rovings as Strain Sensors
E. Haentzsche, A. Nocke, T. Onggar, R.-D. Hund, C. Cherif, O. Weißenborn, S. Geller, N. Modler (Technische Universitaet Dresden, Germany)
In this contribution, the characteristic of yarns that have intrinsically conductivity, e.g. carbon fibre, and their suitability to act as in-situ strain sensors are described. The objective of the based research project is the real-time in-situ sensing of global stresses in CFRP components.

6.03-05 Compression Sensing Using Fragmented Carbon Fibers by Means of Plastic Deformations in Partially Cured Epoxy Matrix R. Höhne, M. Müller, N. Modler (Technische Universität Dresden, Germany)
A novel carbon fiber strain sensor is developed providing the unique feature of a fracture-based, resistive measuring principle enabling a spatially resolved strain measurement. In this work, a 3-step sensor manufacturing process is established making use of plastic deformations of partially cured epoxy networks (Cntd)

6.03-06 New Optical Sensors to Detect Moisture Diffusion in Glass Fibres
C. Marro Bellot, M. Olivero, M. Sangermano (Politecnico di Torino, Italy), B. Thomson (Element, United Kingdom), M. Salvo (Politecnico di Torino, Italy)
Optical Fibre Sensors (OFSs) were embedded into epoxy. The sample was immersed in simulated sea water at 80 °C. OFS were able to detect the early stage water diffusion through the epoxy as an attenuation of the optical signal provided by the reflective tips. A notable signal drop occurred after nearly 24 hours.

6.03-07 Development of a New Generation of Embedded Sensors for Monitoring Structural Composites
A. Lamberti, A. Feng, F.G. Cougnon (Ghent University, Belgium), J. Missinne (Imec & Ghent University, Belgium), P. Smet, D. Depla, W. Van Paepegem (Ghent University, Belgium)
The demand of smart composite materials is increasing in all sectors. With it, the need of new sensor technologies for structural health monitoring purposes is also increasing. The requirements for the next generation of sensing devices are quite high. Ideally, they should be able to sense different physical parameters, (Cntd)

6.03-08 Structural Health Monitoring via Online Impedance Mapping Topography on Fiber Reinforced Composites (FRC) with Carbon Nanotube (CNT)-Modified Epoxy Resin
G. Foteinidis, A.S. Paipetis (University of Ioannina, Greece) I
In this study, a conventional composite was converted into a multifunctional material to provide crucial information for Structural Health Monitoring (SHM).

11:00-13:00 Hall: Skalkotas

6.04 | Multifunctional and Smart Composites: Smart Structures
Chair: L. Asp

6.04-01 Characterization of the Load Transfer between Fiber Reinforced Composites and Shape Memory Alloys for Active Hybrid Structures
S. Nissle, M. Gurka (Institute for Composite Materials, Germany)
For actuation purposes active hybrid structures made of FRP and SMA can enable new functions. But load transfer between SMA wires and the FRP structure is the sticking point. We show an approve for a better forecast of the load transfer by pull-out tests combined with optical stress measurement.

6.04-02 Development of an Interleaved Composite with a Twostage Shape Memory Capability for Deployable Structure Applications
P. Robinson, B. Zhang (Imperial College London, United Kingdom), A. Bismarck (Imperial College London, United Kingdom & University of Vienna, Austria), C. Burgstaller (Transfercenter für Kunststofftechnik (TCKT), Austria)
A thermoplastic interleaved carbon fibre epoxy composite is shown to provide an easy manufacturing route for expanded composite mesh. A two-stage shape memory composite has been developed and used to create a mesh that can deploy from the flat state into an expanded state.

6.04-03 Electric Field Enabled Manipulation of CNT Alignment in Epoxy Matrix: Methodology and Mechanical Characterization
J. R. Pothnis (Indian Institute of Science, India), D. Kalyanasundaram (Indian Institute of Technology, India), S. Gururaja (Indian Institute of Science, India)
The alignment of carbon nanotubes (CNTs) in polymer matrix is an effective way to utilize their anisotropic properties. In this study, a CNT alignment methodology based on the use of a non-uniform electric field is presented. The manipulation of CNT behaviour in an epoxy matrix was accomplished (Cntd)

6.04-04 Novel Thin and Flexible Carbon Nanotube based Piezoresistive Sensing Skins
S. M. Doshi, E. T. Thostenson, T. B. Lyness (University of Delaware, USA)
The processing and characterization of carbon nanotube-based thin and flexible sensing skins is discussed for a variety of applications such as structural health monitoring of fiber composite-steel joints and human motion analysis.

6.04-05 Smart Graphene Enabled Preforms
M. Reghat, N. Hameed (Swinburne University of Technology, Australia), L. Hyde, P. Middendorf (University of Stuttgart, Germany), R. Bjekovic (Hochschule Ravensburg-Weingarten, Germany), B. Fox, Y. Weizman, A. Ming Tan, F. Konstantin Fuss (Swinburne University of Technology, Australia)
The carbon fiber (CF) preforming process is one of the rate-limiting steps in composite manufacturing. Lack of control over the raw materials during the preforming process leads to inconsistent production. Batch-to-batch variations are unavoidable as molding environments remain undetected during the preforming process (Cntd)

6.04-06 Highly Aligned Carbon Nanotube Web for Structural Health Monitoring Applications
S. Kumar (Queen's University Belfast, United Kingdom), S. C. Hawkins (Queen's University Belfast, United Kingdom & Monash University, Australia), B. G. Falzon (Queen's University Belfast, United Kingdom)
This paper presents a novel approach for damage sensing in adhesively bonded joints using a carbon nanotube single layer web (CNT-SLW) which marks a significant departure from the direct mixing approach of CNTs with epoxy adhesives. In this work, very thin highly aligned CNT-SLW (thickness ~ 2.5 μm) (Cntd)

11:00-13:00 Hall: Multi-Purpose Room

2.15 | Materials Science: Textile Composites

Chair: **A. Kontsos**

2.15-07 The Influence of Nonwoven Interleaf Architectures on the Impact Performance of Composites
R. Archer, W. W. Sampson, P. Potluri (University of Manchester, United Kingdom)
This paper presents preliminary results from the study of the influence of interleaf architecture on the damage tolerance of composite laminates. Areal density of the interleaves (g m^(-2)) and the linear density of interleaf fibres have been identified as two paramters that influence the impact damage behavior. (Cntd)

2.15-08 3D Weaving and Consolidation of Carbon Fibre T-Piece Stringers
E. Archer, A. McIlhagger, E. Harkin-Jones, G. Neale, C. Ralph, M. Dahale, A. Hardman, C. McGarrigle (Ulster University, Northern Ireland), G. Stewart (Advanced Composites and Engineering Centre, Northern Ireland)
This paper investigates 3D woven composite T-section specimens for energy absorption in tensile and Quasi-static crush tests.

2.15-09 A Comparative Assessment of 3D Wovens and Non-Crimp Fabrics Under Three Point Bending
V. Gill, K. Potter (University of Bristol, United Kingdom)
Two tufted and un-tufted non-crimp fabrics and three 3D woven material systems were tested under quasi-static and dynamic three point bending. Material systems are comparatively assessed and ranked on the basis of their damage resistance and tolerance.

2.15-10 Integrated Investigation of the Role of 3D Architecture in the Mechanical Behavior of Knitted Textiles
E. Tekerek, D. Liu, B. Wisner, M. Matthew, D. Breen (Drexel University, USA)
The mechanical behavior of 3D architectured knitted textiles is investigated experimentally and computationally. In this aspect, different imaging methods including microscopy and digital image correlation (DIC) are used to investigate the multiscale behavior of such structures. (Cntd)

2.15-11 Structurally Integrated Shape Memory Alloys for Shape-Variable Adaptive Fiber-Reinforced Plastics
M. Ashir, M. Vorhof, A. Nocke, C. Cherif (Technische Universität Dresden, Germany)
Fiber-reinforced plastic (FRP) components with integrated textile-based actuators for lightweight kinematics represent innovative smart lightweight products. In contrast to metal-based kinematics and kinematics equipped with separate drives and actuators, adaptive FRPs provide an enormous saving potential (Cntd)

2.15-12 Mechanical Performance of Composite Materials Developed using Novel Re-Entrant Star Auxetic Fibrous Architectures
R. Magalhães, S. Rana, R. Fangueiro, C. Gonçalves, P. Nunes, G. Dias (University of Minho, Portugal)
In this research, novel high performance auxetic fabric structures (and composites) were produced using the flat knitting technology and their auxetic and tensile behaviors were characterized. The fabrics were produced using two types of high performance fibres (para-aramid and polyamide) and by varying the structural and process parameters. (Cntd)

11.00-12.40 Hall: MC3

2.12 | Materials Science: Metal Matrix Composites

Chair: **S. Ogin**

2.12-01 Nanocarbon Reinforced Lightweight Metal Composites
Q. Li (Imperial College London, United Kingdom), S. Nasiri, M. Zaiser (University of Erlangen-Nuremberg, Germany)

2.12-02 Synergetic Effect of Discontinuous Carbon Fibers and Graphite Flakes on Thermal and Thermo-Mechanical Properties of Aluminum Matrix Composites
N. Chamroune (ICMCB, France), J.-F. Silvain (ICMCB, France & University of Nebraska, USA)
Al/C composite materials with graphite flakes (GF) and carbon fibers (CF) were fabricated by solid-liquid phase sintering. Al/(GF+CF) composites were characterized by SEM, EDX, and X-ray tomography. GF/CF ratio allows to control the thermomechanical properties of Al/C composites.

2.12-03 Influence of Grain Size and Crystallographic Structure of Graphite on the Phenomenon of Fragmentation of TiC - Fe Composite Layers
L. Szymański, E. Olejnik (AGH University of Science and Technology & Innerco Ltd., Poland), M. Gajewska (AGH University of Science and Technology, Poland), P. Natkański (Jagiellonian University, Poland), T. Tokarski, G. Piwowarski (AGH University of Science and Technology, Poland)

2.12-04 Microstructure and Mechanical Properties of Tib2-Feal Composites Fabricated by Spark Plasma Sintering Technique
M. Yoshida (National Institute of Technology, Japan)
TiB2-FeAl composite specimens were fabricated by using the spark plasma sintering technique. Dense composite specimens were obtained with the amount of TiB2 up to 75vol% by the sintering at 1373K. It has been shown that TiB2 particles were dispersed uniformly in the FeAl matrix. (Cntd)

2.12-05 Strength and Fracture Toughness of Oxide-Fibre/Molybdenum-Matrix Composites
S. T. Mileiko (Russian Academy of Science, Russian Federation)
Composites with molybdenum matrix and three types of oxide fibres in the Al2O3-Y2O3 system are obtained. Those fibres are yttrium aluminim perovsckite YAlO3 (YAP), yttrium aluminium monoclinic Y4Al2O9 (YAM), and YAG-YAM eutectic. (Cntd)

11.00-12.20 Hall: MC2

5.11 | Processing and Manufacturing Technologies: Pultrusion and Filament Winding

Chair: **A. Torres Marques**

5.11-07 Power Ultrasonic in Closed Injection Pultrusion
F. Wilhelm, J. Wiethaler, R. Karl (Fraunhofer Research Institution for Casting, Composite and Processing Technology IGCV, Germany)
The aim of this work is to characterize the influence of power ultrasonic in combination with closed injection pultrusion to increase the impregnation quality. For this purpose, two examination methods are used. On the one hand the influence of power ultrasonic on the resin system is investigated in the laboratory. (Cntd)

5.11-08 Numerical Modelling and Optimisation of Fibre Wet-Out in Resin-Injection Pultrusion Processes
M. Sandberg, J. H. Hattel, J. Spangenberg (Technical University of Denmark, Denmark)
This study explores the use of flow-enhancers in resin-injection pultrusion processes. Using a numerical framework based on Darcy's law, FVM, and the level-set method, it is demonstrated how highly permeable areas can facilitate increased resin flow and thereby improve pulling speed.

5.11-09 Modelling the Effect of Non-Uniform Fibre Distribution on the Curing Behaviour in Resin Injection Pultrusion
F. S. Rasmussen, C. G. Klingaa, M. Larsen, M. R. Sonne, J. Spangenberg, J. H. Hattel (Technical University of Denmark, Denmark)
Use of numerical modelling to assess the influence of fibre distribution on the cure behavior in Resin Injection Pultrusion of an industrial glass-fibre/poly-utherene profile. The results show a significant change in the cure behavior from solely outside-in to partially inside-out curing.

5.11-10 Meso-Scale Process Modelling Strategies for Pultrusion of Unidirectional Profiles
O. Yuksel (University of Twente, The Netherlands & Bogazici University, Turkey), I. Baran (University of Twente, The Netherlands), F. Salling Rasmussen, J. Spangenberg (Technical University of Denmark, Denmark), N. Ersoy (Bogazici University, Turkey), J. H. Hattel (Technical University of Denmark, Denmark), R. Akkerman (University of Twente, The Netherlands)
The resin injection pultrusion is an automated composite manufacturing method in which the resin is injected in a chamber. The flow and the thermo chemical mechanical (TCM) models have been studied for the pultrusion process to improve the reliability of the final products. (Cntd)

11.00-12.40 Hall: Kokkalis

2.05 | Materials Science: Fibers

Chair: **J. Lamon**

2.05-06 Ammonia Plasma Treatment of Carbon Fibers: Influence on Interaction between Fibers and Polymeric Sizing

J. Moosburger-Will, E. Lachner, T. Neid, S. Horn (University of Augsburg, Germany)

A low pressure ammonia plasma treatment is used for nitrogen functionalization of carbon fiber surfaces, which results in improved wetting behavior and a more homogeneous coverage by the sizing layer. Bonding between fiber and sizing is not enhanced.

2.05-07 Development of Surface Structure of Stabilized Polyacrylonitrile Fibers During Slow Carbonization to Carbon Fibers

P. Gutmann, E. Laukmanis, J. Moosburger-Will, S. Horn (University of Augsburg, Germany)

During thermal conversion of PAN fibers to carbon fibers their circumference decreases to approx. half the starting value. Meanwhile, fiber topography shows only minor changes. The surface of the PAN fiber determines the surface of the carbon fiber.

2.05-08 Measurement Methodology and Phenomenology of Wet Compression of Textiles

P. Sousa, J. Ivens, S. V. Lomov (KU Leuven, Belgium)

This work studies the compaction behavior of woven carbon twill fabrics in dry and wet conditions and the effect of the methodology and phenomenology on the measurements. A wider characterization of the compaction behavior is achieved by studying three compaction cycles up to a pressure of 1 Mpa. (Cntd)

2.05-09 Viscoelastically Prestressed Composites - Where Next?

K. S. Fancey (University of Hull, United Kingdom)

Producing a viscoelastically prestressed polymeric matrix composite (VPPMC) involves (i) subjecting polymeric fibres to tensile creep, (ii) releasing the creep load, then (iii) moulding the loose fibres into a matrix. Following matrix solidification, the viscoelastically recovering fibres exert compressive stresses in the matrix. (Cntd)

2.05-10 Method of Determining the Tension Profile During Stabilization of PAN

F. Pursche, F. Pohlkemper, T. Gries (Institute of Textile Technology Aachen, Germany)

The production of carbon fibers is divided into a multi-zone stabilization and a multi-zone carbonization. The properties of carbon fibers are mainly influenced by the three main process parameters of the stabilization and carbonization : Dwell time, temperature and tension. (Cntd)

11:00-13:00 Hall: Lecture Room

5.02 | Processing and Manufacturing Technologies: Automated Placement Technologies

Chairs: **B. Blinzer, S.Comas**

5.02-01 Experimental Investigation of the Effects of Pre-Preg Gaps for the Automated Production of Fiber Metal Laminates

D. Nardi, M. Abouhamzeh (Delft University of Technology, The Netherlands), R. Leonard (Fibre Metal Laminates Centre of Competence, The Netherlands), J. Sinke (Delft University of Technology, The Netherlands)

The paper analyses the effects of pre-preg gaps in hybrid composite materials such as Glare, a member of Fibre Metal Laminates (FMLs). The investigation begins with the manufacturing of Glare specimens having gaps with different widths, followed by a non-destructive ultrasonic inspection. (Cntd)

5.02-02 Experimental Analysis of the Compaction Behavior of Thermoset Prepreg Tapes during Automated Fiber Placement R. Engelhardt, K. Brath, C. Ebel, K. Drechsler (Technical University of Munich, Germany)

Automated Fiber Placement process parameters and debulking frequency were varied with regard to their influence on laminate compaction. Triangulation surface scans were evaluated using linear regression modelling with the goal to increase the overall process efficiency.

5.02-03 Influence of Prepreg Aging and Tack on Lay-Up Effects/defects in Thermoset Automated Fiber Placement

K. Heller, B. Böckl, C. Ebel, K. Drechsler (Technical University of Munich, Germany)

The authors investigated the influence of prepreg aging on steering and bridging effects in thermoset Automated Fiber Placement (AFP) using a robot based AFP machine. Results show a strong correlation of steering defects on material out time because of the decreased tack.

5.02-04 Power Control of a Flashlamp-Based Heating Solution for Automated Dry Fibre Placement

P. Monnot (National Composites Centre, United Kingdom), D. Williams (Heraeus Noblelight Ltd., United Kingdom), M. Di Francesco (National Composites Centre, United Kingdom)

The growing demand for next generation commercial aircrafts dictates a step change increase in the manufacturing rates of composite components. Automated Fibre Placement has been recognised as one of the key automated processes with the potential to achieve such ambitious target rates. (Cntd)

5.02-05 Innovative Preform Design Exploiting Automated Fibre Placement

P. Zivkovic, C. Ward (University of Bristol, United Kingdom), G. Marengo (Rolls-Royce plc, United Kingdom)

This work examines the in-plane mechanical properties of a carbon fibre laminates, manufacture using Automated Fibre Placement, whereby specific tapes have been placed to create an in-plane 'pseudo weave'.

5.02-06 Viscoelastic Effects on Wrinkle Formation during Tow Steering in Automated Fiber Placement
N. Bakhshi, M. Belhaj, M. Hojjati (Concordia University, Canada)
Various defects that appear during tow steering in Automated Fiber Placement, significantly limit the application of this technology while preventing engineers from further optimizing the design of composite materials. This study is focused on the effect of viscoelastic properties that prepreg materials exhibit (Cntd)

11:00-13:00 Hall: MC3.2

5.03 | Processing and Manufacturing Technologies: Experimental Methods for Process Characterisation

Chairs: **N. Boyard, J. L. Bailleul**

5.03-01 Experimental Characterisation of In-Plane Shear Behaviour of Uncured Thermoset Prepregs
Y. Wang, D. Ivanov, J. P. H. Belnoue, J. Kratz, B. C. Kim, S. R. Hallett (University of Bristol, United Kingdom)
The generation of defects (such as wrinkles and tow pull off) in the course of the steering process of automated fibre placement (AFP) is one of the critical limitations of this technique for the manufacturing of composite laminates. The in- and out-of-plane properties of the prepreg materials used (Cntd)

5.03-02 Characterisation of Carbon Fibre Reinforced Powder Epoxy Composites for Wind Energy Blades
J.J. Murray, E.J. Pappa, D. Mamalis (University of Edinburgh, United Kingdom), G. Breathnach, A. Doyle, T. Flanagan (ÉireComposites Teo./Composites Testing Laboratory, Ireland), S. Di Noi (SE Blades Technology B.V., The Netherlands), C.M. Ó Brádaigh (University of Edinburgh, United Kingdom)
Unidirectional CFRPs are commonly used in the spar caps of wind blades to reduce their weight and to bear large tensile and compressive loads across the blade's length. Compared to conventional epoxies on the market, powder epoxies exhibit several properties that make them desirable for manufacturing turbine blades (Cntd)

5.03-03 Characterisation and Modelling of the Temperature and Rate Dependent Shear Behaviour of a Non-Consolidated Powder Impregnated Fabric
T. Baumard (Queen's University Belfast, United Kingdom & Université de Toulouse, France), G. Menary (Queen's University Belfast, United Kingdom), O. De Almeida, F. Schmidt (Université de Toulouse, France), J. Bikard (Solvay R & I, France)
The shear behaviour of a thermoplastic powder-coated semipreg is investigated by bias extension in a range of temperatures and rates relevant to the thermoforming process. Comparison with the preconsolidated material shows differences due to the matrix spatial distribution.

5.03-04 Influence of Penetration Depth on Lap Shear Strength of Induction Welded Steel/TP-FRPC Joints
P. Mitschang, S. Weidmann (Institut für Verbundwerkstoffe GmbH, Germany)
This study examines the influence of penetration depth of physically surface-treated steel sheets on bond strength of welded hybrid joints. The steel sheets were either treated line-shaped by a laser structuring or by compressed air blasting.

5.03-05 The Co-Cure of Honeycomb Sandwich Structures: Process Physics and Manufacturing Strategies
T. Centea, M. Anders, D. Zebrine, S. Nutt (University of Southern California, USA)
This paper describes major findings of research on co-cure of honeycomb sandwich structures, during which in situ observations, processing trials, and microstructural analysis were used to understand key physics and control defect formation.

5.03-06 Quantitative Analysis of a New SMC Generation during Compression Moulding
R. Cardinaud, N. Boyard, S. Le Corre (Université de Nantes, France), M. Sager (Plastic Omnium Auto Exterior, France)
We present the characterization of the compression moulding of new SMC generation from an instrumented device. We focused on the couplings between heat transfer, SMC flow and crosslinking using heat flux, temperature and pressure measurements.

11.00-12.20 Hall: MC3.3

3.17 | Material and Structural Behavior – Simulation and Testing: SHM for Composite Structures

Chairs: **D. Zarouchas, A. Kontsos**

3.17-01 Towards the use of Electrospun Piezoelectric Nanofibre Layers for Enabling In-Situ Measurement in High Performance Composite Laminates
S. Lotfian (Cranfield University & University of Strathclyde, United Kingdom), V. T. Kumar, C. Giraudmaillet (Cranfield University, United Kingdom), A. Yoosefinejad (Munro Technology Limited, United Kingdom), F. Brennan (University of Strathclyde, United Kingdom), H. Y. Nezhad (Cranfield University, United Kingdom)
The aim of this research is to highlight the effects from composite manufacturing on the piezoelectric properties of fibre-reinforced composite laminates internally modified by layers of low-density piezoelectric thermoplastic nanofibres in association with a conductive electrode layer for in-situ deformation measurement (Cntd)

3.17-02 Development and Evaluation of a Novel Piezoelectric PVDF Sensor as a Load Spectrum Counter

M. De, T. Pozegic, I. Hamerton (University of Bristol, United Kingdom), M. Fotouhi (University of the West of England, United Kingdom)

This project introduces a novel piezoelectric based sensor as a load spectrum counter that can measure the complex loading conditions over the structure's lifetime.

3.17-03 Data-driven Prognostics for Fiber Reinforced Composites Based on Multimodal NDE Monitoring

B. J. Wisner, M. Bahadori, K. Mazur, M. Shehu, M. Mathew (Drexel University, USA), H. Baid, F. Abdi (AlphaSTAR Corporation, USA), A. Kontsos (Drexel University, USA)

Multimodal Nondestructive Evaluation (NDE) is used in this investigation to estimate the evolving material state in carbon fiber reinforced composite specimens to subjected mechanical loading. Specifically, Acoustic Emission (AE) monitoring, Digital Image Correlation (DIC) measurements and passive Infrared Thermography (pIRT) (Cntd)

3.17-04 Multifunctional Composites for Damage Monitoring: Recent Activities and Open Issues

M. Zappalorto, L. Maragoni, M. Quaresimin (University of Padova, Italy)

Damage monitoring is a fundamental aspect in the design process of composite structures where high reliability is required without negatively affecting the life-cycle costs of the part. A summary of the recent activities carried out by the authors in the field of EHM is briefly presented.

11.00-12.40 Hall: MC3.4

4.07 | Experimental Methods: X-ray Computed Tomography

Chair: **U.D. Shah**

4.07-01 Cross-validation of Single Filament Failure by Acoustic Emission and High-Resolution Synchrotron Computed Tomography

P. Potstada (University of Augsburg, Germany), S. Rosini, M. Mavrogordato, I. Sinclair, S. M. Spearing (University of Southampton, United Kingdom), M. G. R. Sause (University of Augsburg, Germany)

In this work, we combined acoustic emission measurements and high-resolution synchrotron computed tomography experiments. Samples were prepared as double-edge notched tensile specimens with [902/02]s layup. With a voxel size of 0.65 µm, we were able to identify the presence of fibre breakage clusters (Cntd)

4.07-02 Single Fibre Characterization of Heavily Curved Polymer Fibres Using X-Ray Computed Tomography

D. Salaberger (University of Applied Sciences Upper Austria, Austria), T. Lummerstorfer, M. Jerabek (Borealis Polyolefine GmbH, Austria), J. Kastner (University of Applied Sciences Upper Austria, Austria)

Free fibre length after impact testing and undamaged microstructure including fibre orientation, were determined using CT methods based on single fibre extraction.

4.07-03 Micro-CT-Based Analysis of Fibre-Reinforced Composites: Applications

I. Straumit (KU Leuven, Belgium), I. Baran (University of Twente, The Netherlands), L. Gorbatikh (KU Leuven, Belgium), L. Farkas (Siemens Industry Software NV, Belgium), C. Hahn (Technische Universität München (TUM), Germany), K. Ilin, J. Ivens (KU Leuven, Belgium), L. Lessard (McGill University, Canada), Y. Liu (Polymers and Composites Technology & IMT Lille Douai, France), N. Nguyen (KU Leuven, Belgium), A. Matveeva (Siemens Industry Software NV, Belgium), M. Mehdikhani (KU Leuven & SIM M3 program, Belgium), O. Shishkina (Siemens Industry Software NV, Belgium), J. Soete (KU Leuven, Belgium), J. Takahashi (University of Tokyo, Japan), D. Vandepitte (KU Leuven, Belgium), D. Vasiukov (Polymers and Composites Technology & IMT Lille Douai, France), Y. Wan (University of Tokyo, Japan), E. Winterstein (Technische Universität München (TUM), Germany), M. Wevers, S. V. Lomov (KU Leuven, Belgium)

Analysis of the internal structure and mechanical properties of fibre reinforced composites is performed based on the micro-computed X-ray tomography (micro-CT) reconstruction of the composite reinforcement geometry. In all the cases, the analysis relies on structure tensor-based algorithms (Cntd)

4.07-04 Damage Evolution in CFRP Tubes under Torsion Studied by In-Situ X-Ray Computed Tomography

Y. Chai, Ying Wang, Z. Yousaf (University of Manchester, United Kingdom), N. T. Vo (Harwell Science and Innovation Campus, United Kingdom), T. Lowe, P. Potluri, P. J. Withers (University of Manchester, United Kingdom)

Understanding the relationships between braid micro-structure and damage evolution under torsion can help the design of reliable torsion resistant braid structure. Here, we performed in-situ torsion test of 45° braided carbon fibre reinforced plastic tube and employed time-lapse X-ray computed tomography (Cntd)

4.07-05 Understanding the Damage Accumulation and Tensile Strength in Carbon/Epoxy Composites using High Resolution Computed Tomography

S. Rosini, M. N. Mavrogordato, I. Sinclair, S. M. Spearing (University of Southampton, United Kingdom)

In situ synchrotron X-ray computed tomography is performed to investigate the fibre break accumulation mechanisms in untoughened aerospace grade carbon/epoxy coupons under quasi-static load. Implications for ongoing modelling efforts are discussed in terms of mechanisms and parametric calibration.

11.00-12.10 Hall: Conference 1

5.09 | Processing and Manufacturing Technologies: Online Process Monitoring and Controlling

Chairs: **R. Boehm, E. Thostenson**

5.09-07 Cure Monitoring of Highly Reactive Resin During High-Pressure Compression Resin Transfer Moulding
M. Etchells (National Composites Centre, United Kingdom), N.Pantelelis (Synthesites, Belgium), C. Lira (National Composites Centre, United Kingdom)
Presentation of ongoing work at the National Composite Centre (Bristol, United Kingdom) focusing on on-line cure monitoring of highly reactive resin during the high-pressure compression resin transfer moulding process.

5.09-08 A General Method for Optimal Pressure Sensor Placement to Detect Race-Trackings and Predict Their Criticality in the Resin Transfer Molding Process
C. Binetruy, N. Siddig, E. Syerko (Ecole Centrale de Nantes, France), P. Simacek (University of Delaware, USA), S. Advani (Ecole Centrale de Nantes, France & University of Delaware, USA)
A numerical methodology is presented to distinguish between the critical and non-critical race-tracking scenarios. The detection methodology is based on the use of pressure sensors and the computation of the pressure evolution over time during the injection process

5.09-09 Online Infrared Thermography: Applicationt Filament Winding Process Defects Detection
O. Colas, B. Courtemanche, A. Le Reun (CETIM, France)
In the scope of composite process monitoring, the present publication will expose the implementation of infrared thermography on a filament winding pilot line. For that final purpose, infrared thermography has been evaluated, implemented and validated on the process line. (Cntd)

11:00-13:00 Hall: MC3.5

5.04 | Processing and Manufacturing Technologies: Liquid Composite Molding

Chair: **S. G. Advani**

5.04-01 Sensitivity To Race-Tracking Of Compression Resin Transfer Moulding
J. Mendikute, M. Baskaran, M. Mateos, L. Aretxabaleta, J. Aurrekoetxea (Mondragon Unibertsitatea, Spain) Compression Resin Transfer Moulding (CRTM) is a cost-effective route for manufacturing composite materials.
The final part quality is potentially sensitive to changes in the local variations in preform permeability. In particular, local zones with higher permeability provide paths of lower resistance to resin flow, commonly named as race-tracking. Race-tracking can occur at edges, as well as due to the local variations of the fabric architecture induced by missing yarns. (Cntd)

5.04-02 Evaluation by Wicking Tests of Capillary Pressure as Function of Temperature for Uncured Resins
M. F. Pucci (Université de Montpellier, France), P.-J. Liotier, S. Drapier (Université de Lyon, France)
Silicone oil is the most common test liquid for permeability measurements but wicking of silicone oil into carbon reinforcements cannot be described with the common equations used for permeability estimation. These results also raise questions about the validity of unsaturated permeability estimation.

5.04-03 In-Plane Permeability Characterization Using an Inverse Method Based on Flow Front Visualization
B. Caglar (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland & Koc University, Turkey), D. Salvatori (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), E. Murat Sozer (Koc University, Turkey), V. Michaud (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland)
In this study, we propose a method to reduce the total number of required one-dimensional resin flow experiments for in-plane permeability (K) characterization of isotropic fabrics by achieving either: (i) a characterization and further statistical analysis of spatially varying permeability in the presence of fabric irregularity (Cntd)

5.04-04 Enhancing Permeability of a Woven Glass-Fabric Preform with 3D Spacers
D. Salvatori, B. Caglar, V. Michaud (Ecole Polytechnique Fédérale de Lausanne-EPFL, Switzerland)
Resin transfer molding (RTM) is a process for production of continuous fiber-reinforced polymer composites in which the liquid matrix is injected in a rigid mold containing the reinforcing fabric, which has to be fully impregnated prior to solidification. The impregnation time is inversely proportional to fabric permeability, (Cntd)

5.04-05 3D In Situ Characterisation of the Impregnation of Fibrous Networks
C. Balbinot (Université Lyon, & Université Grenoble Alpes, France), F. Martoïa (Université Lyon, France), L. Orgéas (Université Grenoble Alpes, France), P. Carion (Université Grenoble Alpes, France), F. Flin (Météo-France, CNRS, France), S. Rolland du Roscoat, J.-F. Bloch, M. Terrien (Université Grenoble Alpes, France), P. J. J. Dumont (Université Lyon, France)
The aim of the work is the study of impregnation phenomena within model networks performing in situ impregnation experiment in X-ray synchrotron microtomography. The 3D images obtained allows to follow the evolution of the flow front position and shape within different architectures of fibre bundles.

5.04-06 On the Selection of Alternative Out-of-Autoclave Manufacturing Methods for Composite Aircraft Components
M. Bodaghi, R. Gomes, J. Silva, R. Costa, N. Correia (INEGI, Portugal)
Given the increasing use of continuous fibre polymer composites (CFPC), the working hypothesis of this article is that substituting AC with Out-of-autoclave (OoA) manufacturing methods, in particular those that deliver autoclave-quality components, will become a major industry driver of composite materials. (Cntd)

13:00-14:00 Hall: **Exhibition Area**

Lunch Break

14:00- 14:45 Hall: **Trianti**

Keynote Lecture 15
Chair: **Th. Loutas**

Latest advances on SHM and NDT of aircraft composite structures using Linear and Non-linear Acousto-Ultrasonic methods
Michele Meo

14:00- 14:45 Hall: **Mitropoulos**

Keynote Lecture 16
Chair: **V. Kostopoulos**

Fiber Reinforced CMCs: A class of versatile and smart composite materials
Jacques Lamon

14:45-16:45 Hall: **Trianti**

3.16 | Material and Structural Behavior – Simulation and Testing: Sandwich Structures
Chair: **A. Antoniou**

3.16-09 Investigating the Effect of Static Preloads on the Impact Behaviour of Honeycomb Sandwich Structures
C. Fischer, Falk Hähnel, K. Wolf (Technische Universität Dresden, Germany)
The results of experimental and numerical investigations showed a significant influence of static compressive preloads on the impact behaviour of honeycomb sandwich. Some experimental and numerical results are presented in this paper.

3.16-10 Impact Behavior of Steel and Polymer Composites
J. Yang, M. Sung (Seoul National University, South Korea), S.-T. Hong (University of Ulsan, South Korea), W.-R. Yu (Seoul National University, South Korea)
Impact behavior of steel and polymer composites was investigated using Charpy test and Hopkinson bar test.

3.16-11 Bending and Compression Performance of Composite Tube Reinforced Foam Core Sandwich Structures
K. Cinar (Namik Kemal University, Turkey)
In some applications such as walls and roofs, it is important to supply low thermal conductivity and high bending stiffness to structures. Generally, foam materials are preferred, which have low thermal conductivity. However, bending stiffness and compression properties of foam materials are low. (Cntd)

3.16-12 Viscoelastic Bending of Symmetrical and Nonsymmetrical Composite Sandwich Beam with 3-Point Bending
Miroslav J. Cerny, Pavel Slapak (Czech Technical University in Prague, Czech Republic)
In this study, the viscoelastic bending of the sandwich beams will be treated. The sandwich beams will be of symmetrical and nonsymmetrical structure. The bearing layers are considered elastic, the internal core linear viscoelastic. The model of deflection for a sandwich beam with composite skins and a polymer core loaded by concentrated load is given. Theoretical results are compared with data from tests on sandwich beams.

3.16-13 Investigation of Skin-Core Debonding in Sandwich Panel Structures with PMI Foam Cores
G. Bragagnolo (University of Surrey & McLaren Automotive Ltd., United Kingdom), A. D. Crocombe, S. L. Ogin, I. Mohagheghian (University of Surrey, United Kingdom), A. Sordon, G. Meeks (McLaren Automotive Ltd., United Kingdom)
The choice of the materials used for the core and skin of a sandwich structure plays an extremely important role in the skin-core interfacial behaviour. In this paper, three PMI foams are used as core material and the effect of foam type in the skin-core interfacial response is examined.

3.16-14 Modified expanded cork core sandwich structure with improved performance
Paulo J. R. O Nóvo (University of Porto-FEUP & INEGI, Portugal), António T. Marquesa, (INEGI, Portugal)

14.45-16.25 Hall: Mitropoulos

6.02 | Multifunctional and Smart Composites: Self-Healing and Bio-Inspired Designs

Chair: **V. Michaud**

6.02-01 Urea-Formaldehyde Microcapsules Containing Epoxy Resin and Multi-Walled Carbon Nanotubes (MWCNTS)
M. Kosarli, K. Tsirka, G. Foteinidis, A. S. Paipetis (University of Ioannina, Greece)

6.02-02 Quantifying the Role of Mineral Bridges on the Fracture Resistance of Nacre-Like Composites
M. Grossman, F. Bouville, K. Masania, A. R. Studart (Department of Materials, Switzerland)
The quantitative understanding of the structure-property correlations observed in nacre could provide powerful guidelines for the design of lightweight composite materials. By fabricating nacre-like brick and mortar composites from aligned alumina microplatelets interconnected by titania mineral bridges, (Cntd)

6.02-03 Size Limitations on Achieving Tough and Healable Fibre Reinforced Composites through the Use of Thermoplastic Nanofibres
A. Cohades (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), L. Daelemans (Ghent University, Belgium), C. Ward (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland), T. Meireman, W. Van Paepegem, K. De Clerck (Ghent University, Belgium), V. Michaud (Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland)
Polycaprolactone (PCL) electrospun nanofibrous veils were interleaved in glass fibre reinforced epoxy composites in order to assess the possibility to provide both toughening and crack healing.

6.02-04 Fatigue Behavior of Open-holed CFRP Laminates with Self-Healing Functionalities
A.Kotrotsos, A. Sousanis, G. Sotiriades, V. Kostopoulos (University of Patras, Greece)
The current investigation deals with the fatigue behaviour of open-holed aerospace carbon fiber reinforced plastics (CFRPs) having self-healing functionalities. More precisely, the effect of Bismaleimide and Supramolecular polymers as self-healing agents into high performance is assessed.

6.02-05 Finite Element Analysis of Elastic Properties of Self-Healing Polymer Composites Containing Microcapsules
Y. Nassho, K. Sanada (Toyama Prefectural University, Japan)
This study examined the effect of microstructure on elastic properties of spread carbon fiber/epoxy laminates containing microcapsules. Finite element analysis was performed using a representative volume element models to predict the elastic properties of the laminates.

14.45-16.25 Hall: Skalkotas

6.04 | Multifunctional and Smart Composites: Smart Structures

Chair: **L. Asp**

6.04-07 Ceramic/Polymer Nanodielectrics: Towards a Multifunctional or Smart Performance
G. C. Psarras (University of Patras, Greece)
Ceramic/polymer composite nanodielectrics exhibit tunable mechanical, thermal, electrical and magnetic properties, energy storing ability in tandem with processabilty and corrosion resistance. By these means the produced nanocomposites are characterized by multifunctionality (Cntd)

6.04-08 Barium Titanate-Polydimethylsiloxane Nano/Micro-composites: Development, Characterization, Functionality and Energy Storage
A.C. Patsidis (University of Patras, Greece)
Ceramic–polymer composites incorporating ferroelectric and piezoelectric crystal particles, randomly distributed within the polymer matrix represent a novel class of materials. Composites including ferroelectric and/or piezoelectric particles are expected to exhibit functional properties (Cntd)

6.04-09 Damage Detection and Monitoring in Composites Using Piezoelectric Sensors
N. Chandarana (University of Manchester, United Kingdom), E. Ramasso (Université Bourgogne Franche-Comté, France), C. Soutis, M. Gresil (University of Manchester, United Kingdom)
This work shows the ability to use piezoelectric sensors in a an active and passive way, for detecting and monitoring early damage in a composite.

6.04-10 Hierarchical Composites for Advanced Multifunctional Structures
K. Tsirka, G. Foteinidis, L. Tzounis, D. Baltzis, A. S. Paipetis (University of Ioannina, Greece)
Hierarchical multiscale reinforcements of CNT coated carbon fibres were produced via CCVD and wet chemical treatments. The mechanical properties as well as the electrical and thermoelectric response of the multifunctional reinforcements were evaluated.

6.04-11 CFRPS with Embedded Carbon Fiber TEG Module as Energy Harvester Device

G. Karalis, L. Tzounis, A. S. Paipetis (University of Ioannina, Greece)

In the present work, a carbon fiber (CF) based thermoelectric device was constructed for a possible self-powered advanced composite application. A parametric study of the electric and thermoelectric response of carbon fiber structures was carried out aiming to optimize the thermoelectric performance of advanced composites. (Cntd)

14.45-16.25 Hall: Multi-Purpose Room

5.02 | Processing and Manufacturing Technologies: Automated Placement Technologies

Chair: **B. Blinzer, Th. Loutas**

5.02-07 Analysis of Fiber Steering Effects in Thermoplastic Automated Fiber Placement

T. Zenker, M. Schwab (Fraunhofer Research Institution for Casting, Composite and Processing Technology IGCV, Germany)

Non-geodesic layup (fiber steering) was experimentally investigated for the Thermoplastic Automated Fiber Placement process. Temperature distribution was analyzed by creating spatially resolved plots. An optical fiber angle sensor was used to characterize in-plane undulations.

5.02-08 Contribution of Resin Shrinkage to the Deformation of Laminates Made By 4D Printing

S. Van Hoa, A. V. A. Raju (Concordia University, Canada)

The paper discusses the contribution of resin shrinkage to the reconfiguration of unsymmetric laminates [0/90] made by 4 D printing. The process of 4D printing of composites takes advantage of the anisotropy of the composite structures to make curved laminates out of a flat stack of prepregs. (Cntd)

5.02-09 The Influence of the Tape Placement Process on Part Characteristics Based on Different UD-Tape Qualities

M. Schulz, C. Buschhoff , H. Janssen, C. Brecher (Fraunhofer Institute for Production Technology, Germany)

This paper investigates how a production technology can enhance characteristics composite tape. Up to three different qualities of unidirectional (UD) glass fiber reinforced polypropylene tape are processed with the laser-assisted automated tape placement process at the Fraunhofer IPT and evaluated.

5.02-10 Foundation Parameters Characterization for Prediction of Critical Steering Radius In Automated Fiber Placement

M. Belhaj, N. Bakhshi, M. Hojjati (Concordia University, Canada)

Automated fiber placement (AFP) improves the efficiency of composite structures by steering where properties such as stiffness can vary within the same part. However, steering of tapes often produces some manufacturing defects, including out-of-plane wrinkling. (Cntd)

5.02-11 Influence of the Production Parameters on the Transversal Permeability of Preforms Produced with Automated Fibre Placement

R. Graupner (Fraunhofer Research Institution for Casting, Composite and Processing Technology IGCV, Germany), K. Drechsler (Technical University of Munich, Germany)

The influence of AFP process parameters (activation temperature, compaction force) and different staggering configurations on the transversal permeability of dry fiber preforms is discussed. It is found that the permeability can be improved choosing suitable process parameters.

14.45-16.25 Hall: MC3

3.15 | Material and Structural Behavior – Simulation and Testing: Novel Composite Microstructures – Design and-or Prototyping

Chair: **S. Pinho**

3.15-01 Low Velocity Impact and Compression After Impact of Thin-Ply CFRP Bouligand Structures

L. Mencattelli, S.T. Pinho (Imperial College London, United Kingdom)

Several bio-inspired thin-ply CFRP helicoidal laminates mimicking the architecture of the mantis shrimp's dactyl club have been tested (LVI & CAI). This work demonstrates and explains the role of pitch angle on damage tolerance.

3.15-02 Improving the Damage Tolerance of CFRP Using a Biomimetic Crossed-Lamellar Microstructure

R. Häsä, S.T. Pinho (Imperial College London, United Kingdom)

We explore CFRPs with a microstructure inspired by the crossed-lamellar microstructure found in mollusc shells. We demonstrate that these novel composites have the potential to significantly increase the damage diffusion capability of CFRPs.

3.15-03 Damage-Tolerant Nacre-Inspired CFRP

S.T. Pinho, F. Narducci, K.-Y. Lee (Imperial College London, United Kingdom)

We design, manufacture and test nacre-inspired CFRP & hybrid CFRP/GFRP composites. We show that crack deflection, pull-out and damage diffusion can be successfully induced in these materials.

3.15-04 On the Importance of Spatial Distribution of Carbon Nanotubes for Suppression of Stress Concentrations and Toughness Improvement in Nanocomposites

Qiang Liu, S. V. Lomov, L. Gorbatikh (KU Leuven, Belgium)

We show that CNTs' distribution and orientation play an important role in suppressing stress concentrations and improving strength and toughness of nanocomposites.

3.15-05 UHMWPE Fibre Yarn Established Continuous Wavy Network Construction Reinforced Epoxy Foam Composite
D. Li, W. Song, V. Tagarielli, K.-Y. Lee (Imperial College London, United Kingdom)
Sandwich-structured composites consisting of continuous ultrahigh molecular weight polyethylene (UHMWPE) fibre yarn as through-thickness reinforcement for the epoxy foam core were fabricated in this work. Preliminary test showed that the introduction of continuous UHMWPE fibers improved the shear modulus (Cntd)

14.45-16.05 Hall: MC2

1.08 | Applications: Renewable Energy
Chair: **B. Fiedler**

1.08-01 Fatigue Life Analysis of Hybrid E-Glass/Carbon Fibre Powder Epoxy Materials for Wind Turbine Blades
E. J. Pappa, J. J. Murray (University of Edinburgh, United Kingdom), M. Walls (ÉireComposites Teo, Ireland), P. Alam (University of Edinburgh, United Kingdom), T. Flanagan, A. Doyle (ÉireComposites Teo, Ireland), S. Di Noi (SE Blades Technology B.V., The Netherlands), E. D. McCarthy, C. M. Ó Brádaigh (University of Edinburgh, United Kingdom)
This study is based on MARINCOMP, Novel Composite Materials & Processes for Marine Renewable Energy, a Marie Curie FP7 Project funded. In this work, a medium scale demonstrator of a hybrid glass/carbon fibre composite wind turbine blade spar cap/root joint was designed, manufactured and tested statically and dynamically. (Cntd)

1.08-02 Methodology for Consideration of Ageing in the Design of Tidal Turbine Blades
S. Paboeuf (Bureau Veritas Marine & Offshore, France), S. Durand, A. Favry, E. Billaudeau (Meca, France), P. Casari (Université de Nantes, France), L. Mouton (Bureau Veritas Marine & Offshore, France)
Due to a huge potential, more and more tidal turbine projects are developed in the world. The market study, performed by SEENEOH, shows that the majority of projects are horizontal axis turbines with composite materials blades. To assess the design of blades, some guidance notes and standards (Cntd)

1.08-03 Analysis of Liquid Impact Phenomena Affecting Rain Erosion Failure in Wind Turbine Blades. A Viscoelastic Parametric Study
C. Germoso (Instituto Tecnológico de Santo Domingo, Dominican Republic), F. Sánchez, L. Domenech (Universidad Cardenal Herrera-CEU, Spain), E. Cortés (AEROX Advanced Polymers, Spain), A. Falcó (Universidad Cardenal Herrera-CEU, Spain), F. Chinesta (ENSAM ParisTech, France)
Rain erosion damage, caused by repeated droplet impact on wind turbine blades, is a major cause for concern, even more so at offshore locations with larger blades and higher tip speeds. Analytical and numerical models are commonly used to relate top coating lifetime prediction and to identify suitable coating (Cntd)

1.08-04 Evaluation of Different Perforation Patterns for Laminate-Integrated Heating Foils in Wind Turbine Rotor Blades
J. E. Semar, D. May, P. Mitschang (Institut für Verbundwerkstoffe GmbH, Germany)
Three perforation parameters (pattern, diameter and perforation area) have been examined with respect to the heating power, permeability and shear strength of laminate-integrated heating foils for wind energy rotor blades.

14:45-16:45 Hall: Kokkalis

5.04 | Processing and Manufacturing Technologies: Liquid Composite Molding
Chair: **D. Anthony**

5.04-07 Experimental Investigation of Intra-Tow Fluid Storage Mechanisms in Dual-Scale Reinforcements
M. Imbert (GeM - Institut de recherche en Genie civil et Mecanique & EXCELCAR, France), S. Comas-Cardona (GeM - Institut de recherche en Genie civil et Mecanique, France), E. Abisset-Chavanne (Ecole Centrale de Nantes, France), D. Prono (EXCELCAR, France)
Fibrous reinforcements feature dual-scale porous microstructures. During injections (high speed RTM), these microstructures induce intra-tow resin storage. The latter is considered permanent in the literature. However, in order to optimize high speed processes, (Cntd)

5.04-08 Finite Element Framework for the Multi-Scale Simulation of Liquid Resin Infusion Processes with Integration of Capillary Effects
K. Andriamananjara, L. Chevalier, N. Moulin, J. Bruchon, P.-J. Liotier, S. Drapier (Universite Lyon, France)
Capillary and viscous dominated flows competing at the local scale will be used to provide equivalent capillary pressures. The goal is to yield a robust numerical modeling of infusion processes at the scale of industrial parts.

5.04-09 An In Situ Investigation of Void Generation and Transport During Resin Transfer Moulding by Means of Synchrotron X-Ray Laminography
J. Castro (IMDEA Materials Institute & Universidad Politécnica de Madrid, Spain), L. Helfen (Karlsruhe Institute of Technology, Germany & ESRF, France), C. González (IMDEA Materials Institute & Universidad Politécnica de Madrid, Spain), F. Sket (IMDEA Materials Institute, Spain)
In this work, Resin Transfer Molding (RTM) experiments were carried out using Synchrotron X-ray Computed Laminography (SXCL) techniques at the

European Synchrotron Radiation Facility (ESRF) to study the mechanism of microfluid within a dry fiber preform. A viscous epoxy resin was injected into E-glass (Cntd)

5.04-10 Mitigation Against Forming Defects by Local Modification of Dry Preforms

B. Vermes (Budapest University of Technology and Economics, Hungary), A. Thompson, J. P.-H. Belnoue, S. R. Hallett, D. S. Ivanov (University of Bristol, United Kingdom)

The current study suggests to use a print of liquid reactive resin into dry preforms to improve forming process. Several promising advantages of the method include non-interference with reinforcement geometry, flexibility and simplicity in implementation.

5.04-11 The Effect of Diffusion and Pressure on Porosity in Composites

G. Buccoliero, F. Lionetto (University of Salento, Italy), S. Pappadà (Consorzio CETMA, Italy), A. Maffezzoli (University of Salento, Italy)

This work is aimed to the development of a finite element model, able to evaluate the evolution of resin pressure gradient across the laminate as a function of temperature and degree of reaction. This model takes into account viscosity changes, during autoclave cure cycles, (Cntd)

5.04-12 International Benchmark Exercises on Textile Permeability and Compressibility Characterization

D. May (Institut für Verbundwerkstoffe GmbH, Germany), A. Aktas, A. Yong (National Physical Laboratory, United Kingdom)

The results of recently finished international benchmarks on textile in-plane and out-of-plane permeability as well as compressibility characterization are presented and a way forward towards standardization is drafted.

14.45-16.05 Hall: Lecture Room

2.15 | Materials Science: Textile Composites

Chair: **A. Kontsos**

2.15-13 Modified Homogenization Method with Relieved Periodicity in One or Two Directions

M. Ridlo Erdata Nasution (Sekolah Tinggi Teknologi Adisutjipto, Indonesia), N. Watanabe (Tokyo Metropolitan University, Japan)

Investigation of composites under tensile loading should consider the existence of periodicity in only longitudinal direction. Hence, the periodicity throughout both thickness and width directions are necessary to be omitted.

2.15-14 Towards A Virtual Characterization of a Biaxial Non-Crimp Fabric

D. Colin (Technical University of Munich, Germany), S. Bel (Université Lyon 1, France), T. Hans (KDX Europe Composites R&D Center GmbH, Germany), M. Hartmann (Technical University of Munich, Germany)

Non-Crimp Fabrics (NCF) are widely used due to their enhanced mechanical properties. However, the manufacturing process of this textiles involves many parameters that influence the mechanical behavior of the dry preforms. Studies on the stitching patterns, stitching length or gauge have been conducted (Cntd)

2.15-15 Multi-Scale Modelling of 3D Textile Composites with Different Orthogonal Mesostructures Including the Influence of the Composite Manufacturing Process

D. Vasiukov, K.-K. Parvathaneni (IMT Lille Douai & Université de Lille, France), S. V. Lomov (KU Leuven, Belgium), C.-H. Park (IMT Lille Douai & Université de Lille, France)

3D interlock composites with voids are presented. This study consists of manufacturing of composite plates with RTM process, mechanical testing, and numerical simulations. The geometries are generated from micro CT data and incorporate the local variation in structure due to manufacturing.

2.15-16 Textile Composite Forming Simulations using a Specific Shell Approach

B. Liang, J. Colmars, P. Boisse (Université de Lyon, France)

14.45-16.05 Hall: MC3.2

5.03 | Processing and Manufacturing Technologies: Experimental Methods for Process Characterisation

Chair: **N. Boyard**

5.03-07 Experimental Investigation of Process Induced Strain During Cure of Epoxy Using Optical Fibre Bragg Grating and Dielectric Analysis

U. A. Mortensen, T. L. Andersen, J. Christensen, M. A. M. Maduro (Technical University of Denmark, Denmark)

Process induced strain from a comercially availble epoxy is investigated in an experiment that combines optical Fibre bragg gratings, Dielectric analysis and temperature measurements

5.03-08 Development of a Resistance Welding Process for Thermoset Fiber Composite Components with Co-Cured Thermoplastic Boundary Layer

L. Zweifel, J. Brunner, S. Nakouzi-Queloz, C. Brauner, C. Dransfeld (FHNW University of Applied Sciences and Art Northwestern Switzerland, Switzerland)

Within this study, the resistance welding of thermoset composite with thermoplastic boundary layers was investigated. The specimens were prepared by co-curing a thermoplastic layer, which created an interphase with the epoxy matrix by reaction induced phase separation. (Cntd)

5.03-09 Experimental Analysis of Draping Process Generated Material Imperfections in Textile Preforms

R. Böhm, E. Kunze, S. Geller, M. Gude (Technische Universität Dresden, Germany)

Two dimensional textile reinforcements, e.g. non-crimp-fabrics (NCF), are preformed into complex three-dimensional shapes to be used in fibre reinforced parts for medium to high volume composite applications. The structural performance of NCF reinforced composite parts is significantly influenced by the local fibre architecture (Cntd)

5.03-10 Elliptic Paraboloid Flow Front Modelling for In-Plane Permeability Characterization of Textile Fabrics by the Radial Flow Technique

E. Fauster (Montanuniversitaet Leoben, Austria), D. C. Berg (Clausthal University of Technology, Germany), D. May (Institut für Verbundwerkstoffe GmbH, Germany), A. Endruweit (University of Nottingham, United Kingdom), Y. Blößl, R. Schledjewski (Montanuniversitaet Leoben, Austria)

This work addresses a novel approach for modelling the temporally advancing fluid flow front in radial flow experiments. In particular, fitting of an elliptic paraboloid model is suggested to model the entirety of flow front sensor data collected throughout radial flow experiments in a single step approach. (Cntd)

14:45-16.05 Hall: MC3.3

4.05 | Experimental Methods: Novel Test Methods and Concepts

Chair: **H. Wittich**

4.05-01 A Novel Approach for the Autonomous Inspection and Repair of Aircraft Composite Structures

I. Gray, M. J. Padiyar, I. Petrunin, J. Raposo, L. Zanotti Fragonara (Cranfield University, United Kingdom), V. Kostopoulos, T. Loutas, S. Psarras, G. Sotiriadis (University of Patras, Greece), V. Tzitzilonis (Exis Innovation Ltd, United Kingdom), K. Dassios, D. Exarchos, T. Matikas (University of Ioannina, Greece), G. Andrikopoulos, G. Nikolakopoulos (Luleå University of Technology, Sweden)

The paper presents the results of the first two years of the CompInnova project dealing with the development of an innovative approach for inspection and repair of damage in aeronautical composites. A newly designed robotic platform for autonomous inspection with combined infrared thermography (IRT) (Cntd)

4.05-02 Creating Fibre-Waviness Defects in Laminates and Predicting Their Remnant Strength Using a Strain-based Non-destructive Evaluation Technique

W. J. R. Christian, F. A. DiazDelaO (University of Liverpool, United Kingdom), K. Atherton (Airbus United Kingdom, United Kingdom), E. A. Patterson (University of Liverpool, United Kingdom)

A technique is demonstrated for creating controlled levels of fibre-waviness in specimens. A novel residual-strain based nod-destructive evaluation technique is also introduced and compared to an existing ultrasound based technique.

4.05-03 Damage State Assessment of Fiber Reinforced Metal Laminate (FRML) Composites

R. Carmi (NRCN, Israel), B. Wisner, P.A. Vanniamparambil (Drexel University, USA), R. Shneck (Ben-Gurion University of the Negev, Israel), A. Bussiba (NRCN, Israel), A. Kontsos (Drexel University, USA)

Fiber Reinforced Metal Laminate (FRML) composites are widely used as a structural material, mainly in the aerospace industry. One of the main challenges using FRML composites is to detect and asses/quantify damage during in-service conditions. (Cntd)

4.05-04 Integrating Full-Field Experimental Imaging Techniques to Predict the Performance of Compression Moulded Composites

J. M. Dulieu-Barton, D. Bull, O. T. Thomsen (University of Southampton, United Kingdom)

To understand the mechanisms contributing to material heterogeneity in discontinuous compression moulded composite materials, a data rich study combining digital image correlation (DIC), thermoelastic stress analysis (TSA) and X-ray computed tomography (CT) is presented.

14.45-16.25 Hall: MC3.4

5.05 | Processing and Manufacturing Technologies: Machining – Surface Treatment and Coatings

Chair: **S. Tsantzalis**

5.05-01 Analysis of Cutting Force and Surface Integrity in Low Frequency Vibration Drilling CFRP/Ti Stacks

Y. Chen, H. J. Yang, Y. S. Zhang (Nanjing University of Aeronautics and Astronautics, China)

During drilling CFRP/Ti stacks, the continuous chips of titanium alloy always scratch CFRP hole wall surface, which give rise to delamination and hole damage of CFRP. In order to address these problems, low frequency vibration drilling (LFVD) technology is applied to break chip of titanium alloy. (Cntd)

5.05-02 Experimental Study of Dust Emission During Trimming of CFRP Structures with PCD Tool

N. Nguyen-Dinh, R. Zitoune, C. Bouvet, S. Leroux (Université de Toulouse, France)

The size of the chips generated during machining of composites is influenced by the machining parameters. Specifically for CFRP made of thermoset matrix, chips are broken down to minute sizes and suspended in air. Due to the lighter weight, the chips in the form of dust particles can be emitted in the air (Cntd)

5.05-03 Atmospheric Plasma Treatment of Carbon Fibre / Epoxy Composites for Enhanced Structural Bond Integrity in Aerospace Applications

C. Dighton (BAE Systems & University of Surrey, United Kingdom), A. Rezai (BAE Systems, United Kingdom), S. L. Ogin, J. F. Watts (University of Surrey, United Kingdom)

This paper considers the effects that an atmospheric plasma treatment has on the surface properties of a carbon fibre/epoxy composite. It also considers the ability of the APT to remove a release agent known to be detrimental to bond strength.

5.05-04 Drilling Induced Exit-Ply Delamination Model Considering Torque

S. Ramesh (Rolls-Royce India Pvt. Ltd., India), S. Kubher, S. Gururaja (Indian Institute of Science, India)

Amongst all the drilling induced damage in laminated multi-directional fiber reinforced plastics (MD FRPs), exit-ply delamination is the most serious one. Exit-ply delamination is mainly caused due to the axial thrust force exerted by the chisel edge of the drill. (Cntd)

5.05-05 Investigation of Interlaminar Fracture Properties of Out of Autoclave Manufactured CFRPs Having CNTs Modified Carbon Fiber Reinforcements

P. Dimoka, C. Kostagiannakopoulou, N. Dodis, V. Kostopoulos (University of Patras, Greece)

This work investigates the development of Out-of-Autoclave (OoA) carbon fiber reinforced composite structures with the incorporation of carbon nanotubes-enriched sizing agent at various concentrations improving the interlaminar fracture toughness.

14.45-16.05 Hall: Conference 1

5.06 | Processing and Manufacturing Technologies: Manufacturing of Short and Long Fiber Composites

Chair: **K. Kose**

5.06-01 3D Real-Time In Situ Characterisation, Direct Numerical Simulation, and Analytical Modelling of Fibre Kinematics in Dilute Non-Newtonian Fibre Suspensions During Confined Compression

L. Laurencin (Université Grenoble Alpes & Université Côte d'Azur & Université Lyon & École Centrale de Nantes, France), P.J.J. Dumont (Université Lyon, France), L. Orgéas (Université Grenoble Alpes, France), P. Laure (Université Côte d'Azur, & MINES ParisTech, France), S. Rolland du Roscoat (Université Grenoble Alpes, France), S. Le Corre (Université Nantes, France), L. Silva (École Centrale de Nantes, France)

We report results of 3D X-ray microtomography imaging experiments, direct numerical simulation and analytical results for the evolution of fibre kinematics in dilute non-Newtonian fibre suspensions during confined and lubricated compression.

5.06-02 Sheet Molding Compounds (SMS) Composites Made Using Post-Industrial Carbon Fiber Prepreg Waste

S. Sultana (Georgia Institute of Technology, USA), A. Asadi (Texas A & M University, USA), J. Colton (Georgia Institute of Technology, USA), K. Kalaitzidou (Georgia Institute of Technology, USA)

The study focuses on converting high value post-industrial waste i.e., CF prepreg trim waste into composites for automotive applications using sheet molding compounding and compression molding.

5.06-03 Extrusion Compression-Mold Process for Discontinuous Recycled Carbon Fiber into Long Fiber Reinforced Composites - Continuous In-Line Feed of Discontinuous Fiber through Vent

T. Miyake, X. Shen (Gifu University, Japan), A. Nagura (Nagoya Municipal Industrial Research Institute, Japan)

A quasi-continuous covered sliver was fabricated, which enabled discontinuous carbon fibers to be directly fed into an extruder vent instead of continuous fiber rovings. The obtained extrusions showed almost the same fiber length and better fiber dispersion compared to usual LFT-D process.

5.06-04 Lightweight Alternatives to Glass Fiber/Epoxy Sheet Molding Compound (SMC) Composites: Basalt Fibers and Cellulose Nanocrystals
A.Asadi, F. Baaij (Georgia Institute of Technology, USA), R. J. Moon (Georgia Institute of Technology, USA), T. Harris, K. Kalaitzidou (Georgia Institute of Technology, USA)
Lightweight hybrid composite using cellulose nanocrystals, glass fibers and basalt fibers

14.45-16.05 Hall: MC3.5

2.05 | Materials Science: Fibers
Chair: S. G. Advani

2.05-11 Towards Accurate and Efficient Single Fibre Characterization to Better Assess Failure Strength Distribution
F. Islam, S. Joannes (MINES ParisTech-PSL, France), S. Bucknell, Y. Leray (Dia-Stron Ltd., United Kingdom), A. Bunsell, L. Laiarinandrasana (MINES ParisTech-PSL, France)
Different problems and limitations associated with single fibre characterization have been identified and discussed. A better representation of fibre strength behaviour has been proposed using statistical analysis.

2.05-12 Microscopic Characterization of the Nanostructure Of Polyacrylonitrile Based Fiber Cross Sections
C. Kunzmann, M. L. Basílio Graça Couto, J. Moosburger-Will, S. Horn (University of Augsburg, Germany)
We present nanoscale pore structure on the surface and in the volume of Polyacrylonitrile based fibers.

2.05-13 Investigation of the Interaction Between Carbon Fibers and Epoxy Based Sizing Using Potentiometric Titration and Atomic Force Microscopy
E. Laukmanis, A.R. Zambrano Colmenares, J. Moosburger-Will, S. Horn (University of Augsburg, Germany)
To shed light on the interaction between carbon fibers and epoxy-based polymer sizings, chemical desizing experiments by applying solvent extraction were performed on sized carbon fibers of different degrees of surface activation

2.05-14 Analytical and Numerical-Based Approach to Predict the Influence of Morphological Fluctuations on the Effective Transverse Elastic Behaviour of a Transversely Random UD Composite
J. Blondel (PSL-Research University & Manufacture Française des Pneumatiques Michelin, France), S. Joannès (PSL-Research University, France), E. Hervé-Luanco (PSL-Research University & (Université de Versailles, France)
Mechanical properties of fibre reinforced materials are homogenized by a Morphological Representative Pattern-based approach. A full range of fibre volume fractions with fibre packing effects can be covered. Closed-form analytical relations are given.

16:45-17:35 Hall: Trianti

Plenary Speaker 5
Albert Cardon Lecture
Chair:

How to transform a biocomposite weakness into a novel functionality? Toward novel smart bio-inspired Hygromorph BioComposites
Antoine Le Duigou

17:35-18:05 Hall: Mitropoulos

Closing Ceremony

Poster Area — Hall: Foyer Kokkali

1. Applications

P_1-01 Assessment of Aeroelastic Tailoring Effect on High-Aspect-Ratio Composite Wing Flutter Speed using an Open Source Reduced Order Model Solver

B. Kirsch, O. Montagnier (École de l'Air, France), E. Bénard (ISAE-SUPAERO, France), T. M. Faure (École de l'Air, France)

The present work presents an aeroelastic reduced order model suitable for the non linear anisotropic behavior of this kind of composite wing implemented in Fortranand Python using optimised open source solver. Along with validation test cases, a simple composite laminate specimen simulation is presented to assess aeroelastic tailoring effect.

P_1-02 Modified-Peek Matrix Carbon Fiber Composites for Aerospace Application

T. Hayashi, T. Ishikawa (Mitsubishi Chemical Corporation, Japan)

We have developed modified-PEEK resins, which resulted 20°C higher Tg than conventional PEEKs by adding a higher Tg material. In this study, we showed some properties of modified-PEEK matrix carbon fiber composites, such as mechanical property in higher temperature, fluid resistance and flammability. These results indicated that the modified-PEEK composites should be applicable for aerospace structural components.

P_1-03 Effect of Gaps Induced by Tow Misalignment in Composite Structures Fabricated with Automated Fiber Placement Methods

D. Del Rossi, V. Cadran, L. Lessard (McGill University, Canada)

Automated fibre placement is a good method for manufacturing large or complex parts. unfortunately there are some defects that appear only when using this method. This paper studies the effect of side-to-side gaps on the strength of composite parts. Coupons with different gap orientations where modelled and simulated. The results were compared with pristine coupons

P_1-04 Active Curing Monitoring by Means of DEA

Z. Martin, D. López, L. Navarrete (Airbus, Spain)

Active monitoring of the curing process by means of Dielectric Analysis (DEA) sensors is proposed with the aim of gaining knowledge about the curing process, and of optimizing the curing cycles. For instance, monitoring the mold filling and resin cure level by means of DEAs will enable to determinate the optimal time for de-molding allowing shortening the cure cycle, (Cntd)

P_1-05 The Identification of Failure Initiation Hotspots in Idealised Composite Material Component Models Using a "Bottom-Up Database" Method

X. Zou, S. Yan (Composites Research Group, Faculty of Engineering, University of Nottingham, United Kingdom), J. Rouse (Gas Turbine and Transmission Research Centre (G2TRC), Faculty of Engineering, University of Nottingham, United Kingdom), M. Matveev, S. Li, I. A. Jones (Composites Research Group, Faculty of Engineering, University of Nottingham, United Kingdom), M. Hamadi, M. Fouinneteau (Airbus Operations S.A.S., France)

Idealisations are inevitable for finite element simulations of complex composite structures especially airframes, where laminates are commonly modelled using shell elements for relatively low computational cost. (Cntd)

P_1-06 Kinematic-Dynamic Simulation and Test Campaign of a 2D Aerospace Structure Dedicated to LAGARD Project

E. C. Kaslis, D. E. Mazarakos, A. Ampatzoglou (University of Patras, Greece), D. E. Vlachos (Adamant Composites Ltd., Greece), V. Kostopoulos (University of Patras, Greece)

In this survey, the kinematic-dynamic analysis of a 2D deployable truss and the relevant test campaign are presented. This deployable truss is the main part of an octagonal 9-bay space deployable structure that was developed during ESA-LAGARD Project. The scope of the structure is the accommodation of parts of a space telescope for future ESA science missions. (Cntd)

P_1-07 Joining Efficiency in CFRP-Metal Hybrid Structure of Self-Piercing Riveted Joints for Automotive Applications

D.-H. Kam (Korea Institute of Industrial Technology, Republic of Korea), G. Kim (AsaN Co., Ltd, Republic of Korea), W. H. Choi (Top IND Co., Ltd, Republic of Korea), J. Hyuk Seo (Young Jin Co., Ltd, Republic of Korea), C. Kim (Korea Institute of Industrial Technology, Republic of Korea)

Carbon fiber reinforced plastic (CFRP) has been successfully introduced in automotive structural materials according to increasing competition in the electric and hybrid vehicle. CFRP is a super-eminently light-weight material in automotive industries and joining between CFRP and conventional metals is an issue raised drastically. (Cntd)

P_1-08 Effect of Composite Type, Layering Method, and Curing Light on Temperature Changes in Tooth Cavities during Photopolymerization

M.-J. Kim, I.-B. Lee (Seoul National University, Korea)

The purpose of this study was to investigate temperature change in the composite and the pulpal side of dentin of a restored cavity under various restoration conditions, including the use of different composite types, layering methods, and curing lights. (Cntd)

Poster Area — Hall: Foyer Kokkali

1. Applications

P_1-09 Impact of Composite Substrates' Modulus of Elasticity on Cell Behaviour

F. K. Kozaniti (Laboratory of Biomechanics & Biomedical Engineering, Department of Mechanical Engineering & Aeronautics, University of Patras, Greece), M. D. Georgiou (Department of Chemical Engineering, University of Patras, Greece), D. D. Deligianni (Laboratory of Biomechanics & Biomedical Engineering, Department of Mechanical Engineering & Aeronautics, University of Patras, Greece)

The interaction between cell and material is of crucial importance in the field of biomaterials and tissue engineering. The cell response to surface topography, chemistry and mechanics of the substrate has been extensively investigated [1,2]. Adhesion, spreading, migration, proliferation and differentiation are the cellular activities that are influenced by material properties. (Cntd)

P_1-10 Influence of Substrate Topography on Osteoblasts' Behavior: Comparing Solvent Cast and Electrospun Composite Scaffolds

M. D. Georgiou (Department of Chemical Engineering, University of Patras, Greece), F. K. Kozaniti, A. Manara (Laboratory of Biomechanics & Biomedical Engineering, Department of Mechanical Engineering & Aeronautics, University of Patras, Greece), P. Koutsoukos (FORTH/ICE-HT, Greece), D. D. Deligianni (Laboratory of Biomechanics & Biomedical Engineering, Department of Mechanical Engineering & Aeronautics, University of Patras, Greece)

The interaction between cell and material is of crucial importance in the field of biomaterials and tissue engineering. The cell response to surface topography, chemistry and mechanics of the substrate has been extensively investigated. Adhesion, spreading, migration, proliferation and differentiation are the cellular activities that are influenced by material properties. (Cntd)

P_1-11 Mechanical Performances of BFRP Mesh-Reinforced Sea Sand Mortar Thin Plate Exposed to Wet-Dry Environment

J. Deng, Y. Xie (Guangdong University of Technology, China)

Experimental results show that the effect of 12 month wet-dry cycling reduced the tensile strength of BFRP mesh-reinforced sea sand mortar thin Plate remarkably. The bending strength of the thin plates was significantly reduced by both indoor and wet-dry environmental exposure.

P_1-12 Single Fibre Pull-Out Tests of Polypropylene and Glass Fibres in Cement-Based Matrices at High Loading Rates

E. Wölfel, C. Scheffler (Leibniz-Institut für Polymerforschung Dresden e.V., Department Composite Materials, Germany), I. Curosu, V. Mechtcherine (Institute of Construction Materials, Technische Universität Dresden, Germany)

The influence of fibre type, mechanical properties and surface modification on the failure behaviour of cement-based composites under dynamic loading is analysed. Fibre characterisation results and investigations with the quasi-static and dynamic single fibre pull-out test are presented.

P_1-13 Modelling the Influence of the Scarf Ratio to the Integrity of Repaired Composite Structures

M. Papanaoum, O. Triantopoulos, S. Psarras, V. Kostopoulos (Department of Mechanical Engineering & Aeronautics, University of Patras, Greece)

In this project the effectiveness of stepped repair patches for damaged composite plates is investigated by using finite element models.

P_1-14 Multimaterial Offshore wind Turbines Structures with High Corrosion and Mechanical Requirements

S. Dasilva, L. Mera (Advanced Materials Department, AIMEN Technology Centre, Spain), T. Grandal (Robotics and Control Department, AIMEN Technology Centre, Spain), R. de la Mano, E. Rodríguez (Advanced Materials Department, AIMEN Technology Centre, Spain)

The present work deals with the use of multi-material steel-composite systems, specifically on the transition part of an offshore windmill. The main interest of the multi-material structures is based on mechanical and corrosion resistance improvement. (Cntd)

P_1-15 Manufacturing and Service Application Concerns that Influence Leading Edge Protection Rain Erosion Performance in Wind Turbine Blades

E. Cortés (AEROX Advanced Polymers, Spain), F. Sánchez (Universidad Cardenal Herrera-CEU, Spain), A. O'Carroll (University of Limerick, Ireland), B. Madramany (AEROX Advanced Polymers, Spain), M. Hardiman, T. M. Young (University of Limerick, Ireland)

In this research, the material parameters for the appropriate characterization of the coating-substrate interface are outlined by several laboratory tests, including Differential Scanning Calorimetry (DSC), pull-off testing, peeling–adhesion testing and nanoindentation testing. The rain erosion performance is assessed using an accelerated testing technique, whereby the test material is repeatedly impacted at high speed with water droplets in a Whirling Arm Rain Erosion Rig.

P_1-16 Mechanical Behaviour and Computed Tomography Damage Analysis of Fabric-Reinforced Composites Under Bending

H. Ullah (CESAT, Pakistan), V. V. Silberschmidt (Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, UK)

Fabric-reinforced polymer (FRP) composites are increasingly employed in aerospace structures and sports products. In these applications, they are usually subjected to large-deflection quasi-static and dynamic bending deformations. Such loading conditions induce damage within the material at various scale levels affecting their strength, stiffness and energy-absorbing capability. (Cntd)

Poster Area — Hall: Foyer Kokkali

2. Materials Science

P_2.01 Dimensional Stability of Particleboard Binded with Different Percentages of Starch and Adhesives
K.-C. Liew, Y.-F. Tan (Universiti Malaysia Sabah, Malaysia)

The downgrade of synthetic polymers due to health concerns regarding formaldehyde emission has pushed the society to turn their preferences to bio-based adhesives which were known to derived from natural resources. (Cntd)

P_2.02 Ecotoxicity of Cellulose-1-Butyl-3-Methylimidazolium Chloride Ionogels Composites Reinforced with Chitosan
M. M. Villar-Chavero, J. C. Domínguez, M. V. Alonso, M. Oliet, J. García, F. Rodriguez (Complutense University of Madrid, Spain)

The ecotoxicities of the ionogels with a matrix of 1-butyl-3-methylimidazolium chloride (BMIMCl) and cellulose, reinforced with chitosan with 54, 60, 69, 78 and 84% degrees of deacetylation (DD), were determined for marine aquatic media at 5, 15 and 30 minutes of exposure to the Vibrio fischeri. (Cntd)

P_2.03 Prediction of the Equilibrium Moisture Content Based on the Chemical Composition and Crystallinity of Natural Fibres
D. E. C. Depuydt (Dept. Materials Engineering, Campus Groep T, Composite Materials Group, KU Leuven, Belgium), N. Sweygers (Dept. Chemical Engineering, Process and Environmental Technology Lab, KU Leuven, Belgium), S. E. (Dept. Chemical Engineering, Renewable materials and nanotechnology research group, KU Leuven, Belgium), W. Thielemans (Dept. Chemical Engineering, Renewable materials and nanotechnology research group, KU Leuven, Belgium), L. Appels (Dept. Chemical Engineering, Process and Environmental Technology Lab, KU Leuven, Belgium), J. Ivens (Dept. Materials Engineering, Technology Campus De Nayer, KU Leuven, Belgium), A. W. van Vuure (Dept. Materials Engineering, Campus Groep T, Composite Materials Group, KU Leuven, Belgium)

The presented work investigates the relationship between the chemical composition and crystallinity of natural plant fibres and the equilibrium moisture content. Data from literature were verified with experimental data and were used to fit the model.

P_2.04 CFRP Composites made from Thermoplastic Resin Derived from Cellulose: Chemical Design Targeting Enhanced Fiber-Resin Adhesion
Y. Yasaka, R. Hoshino, O. Ishida (Kanazawa University, Japan), J. Kitada (Process Systems K. K., Japan), K. Uzawa, K. Takahashi (Kanazawa University, Japan)

CFRP specimens are prepared by hot pressing using a newly synthesized thermoplastic-cellulose-derivative as matrix resins. The cellulose derivative containes furoyl group in addition to normal alkyl groups on the anhydroglucose units.

P_2.05 Structural Approach for Prediction of Electrical Conductivity of Nano-Modified Glass Fibre Reinforced Plastics
A. Aniskevich, S. Stankevich, J. Sevcenko (University of Latvia, Latvia)

Electrical conductivity of epoxy resin modified by CNT, unidirectional GFRP layer, symmetrical lamina consisting of 8 layers was modelled using structural approach and compared with experiments.

P_2.06 Investigation of Robust Metal Oxide-Modified Carbon Felts as the Electrode of a Vanadium Redox Flow Battery
K. I. Jeong, S. S. Kim (Department of Mechanical Engineering, KAIST, Republic of Korea)

Vanadium redox flow batteries (VRFBs) are attracting attention as large capacity energy storage systems because of their long lifetime, unlimited capacity, and stability. Carbon felts are used as electrode materials which are one of the important components of VRFBs towing to their high electrical conductivity, large specific surface area, and chemical stability. (Cntd)

P_2.07 Preparation of Eco-Friendly Unsaturated Polyester Resin for FRP Composite
Y.-Y. Liu, C.-C. Hsieh, C.-Hsiang Tsai (Qualipoly Chemical Corporation, Taiwan)

Eco-friendly unsaturated polyester resins were successfully prepared by chemical modification of DCPD (dicyclopentadiene), and their application to FRP products, such as yacht, pipes, and tanks.

P_2.08 Study on Mechanical and Thermo-Physical Properties of Carbon Bonded Carbon Fiber Composites
Z. Yao, L. Zixing, Y. Zhenyu (Beihang University, China)

In this paper, FEM simualtions are carried out to predict the mechanical properties and thermo-physical properties of CBCFs at high temperatures, based on the 3D random fiber network model. (Cntd)

P_2.09 The Study of Property-Structure Relationships in Carbon Fibers using Electrochemical Polishing
S.-S. Tzeng, T.-H. Tsai (Tatung University, Taiwan)

It has been shown that some polyacrylonitrile(PAN)-based carbon fibers exhibit skin-core microstructure with a higher preferred orientation of graphene layers in the skin region. In this investigation, variations of the fiber properties across the fiber diameter were studied by reducing the fiber diameter using electrochemical polishing refining. (Cntd)

Poster Area — Hall: Foyer Kokkali

2. Materials Science

P_2.10 Study on Process-Induced Degradation of Cellulose Fibers in Thermoplastic Composites

M. Prambauer, O. Voronych, C. Burgstaller (Transfercenter für Kunststofftechnik GmbH, Austria)

In this work, the process-induced degradation of cellulose fibers was investigated. Polypropylene composites, reinforced with paper fibers were produced by twin-screw extrusion and injection molding. (Cntd)

P_2.11 Foaming what can't be Foamed: Macroporous Polyimides

D. Rusakov, A. Menner, A. Bismarck, Petr Khakhulin (University of Vienna, Austria)

High porosity polyetherimides (PEI) samples were produced by thermally induced phase separation technic. A few different high boiling aprotic solvents were used and their influence on the morphology and mechanical properties was defined. As result, bulk PEI samples with high porosity (80-90%) and homogeneous morphology were obtained.

P_2.12 Development and Mechanical Characterization of a Non-Isocyanate Rigid Polyurethane Foam

E. Kollia, K. Andreopoulou (University of Patras, Greece), V. Kostopoulos (University of Patras & Institute of Chemical Engineering Sciences, Foundation for Research and Technology, Greece)

The present work is a first attempt for development of non-isocyanate polyurethane rigid foam.The main achievement of the present study is that non-isocyanate rigid foams with reasonably good mechanical characteristics can be developed using a commercial available compound. Moreover, the addition of nanoparticles during the foaming process provides a mean to control density.

P_2.13 Investigation of Polymer Rheological Characteristics on Bubble Coalescence in Foaming Process using Finite Element Method

A. Mirzaee, M. Hojjati (Concordia University, Canada)

This paper used a Finite element model to simulate the behavior of bubble during its growth life in the extrusion process and considered the effect of rheological characteristics of the polymer melt on the behavior of the bubble specifically at the rupturing step. (Cntd)

P_2.14 Synthesis and Characterization of Intrinsic Superhydrophobic Polyimide Aerogels

Y. Zhao, J. Ma (Aerospace Research Institute of Materials and Processing Technology, China)

In the present work, mechanically strong polyimide aerogels were prepared via the sol-gel transformation of p-phenylene diamine (PPDA) and 4,4′-(4,4′-isopropylidenediphenoxy)bis(phthalic anhydride) (BPADA), followed by supercritical CO2 drying. Interestingly, the PI aerogel is white and it shows superhydrophobic property. (Cntd)

P_2.15 Reinforcing Effect of Poly-Furfuryl Alcohol on Freeze-Dried Microfibrillated Cellulose

E- M. Lems, S. Winklehner, C. Hansmann, W. Gindl-Altmutter, S. Veigel (University of Natural Resources and Life Sciences Vienna & University and Research Centre Tulln, Austria)

Lightweight foams are of general interest in a diversity of applications because of their low density and high specific surface area. Since there is a special interest to replace fossil-based polymers with polymers from renewable and biodegradable resources, cellulose nanofibrils and lignocellulosic nanofibrils were used to prepare bio-based foams (Cntd)

P_2.16 Compressive Properties of Two Chiral Auxetic 3D Cellular Structures

Q. Wang, Z. Lu, Z. Yang(Institute of Solid Mechanics, Beihang University, China)

Based on two novel 3D cross chiral structures (Structure-1 and Structure-2) with negative Poisson's ratio, three different geometrical configurations for each structure are fabricated successfully from Nylon powder via selected laser sintering. (Cntd)

P_2.17 Impact and Compression After Impact (CAI) Properties of Carbon Nanocomposites

K. Vrettos, C. Kostagiannakopoulou, G. Sotiriadis, V. Kostopoulos (Department of Mechanical Engineering and Aeronautics, University of Patras, Greece)

The goal of the present study was to investigate the influence of multi-walled carbon nanotubes (MWCNTs) and different types of graphene nanoplatelets (GNPs) on the impact behavior of carbon fiber reinforced polymer (CFRP) laminates. (Cntd)

P_2.18 Assessing the Dispersion of Nanoinclusions in Nanoreinforced CFRP Laminates using Electrical Resistance Measurements

E. C. Senis, I. O. Golosnoy, J. M. Dulieu-Barton, O. T. Thomsen (University of Southampton, UK)

In this work electrical resistance measurements were utilized as a mean to assess the dispersion of Graphene Oxide nanoinclusions into CFRP laminates.

P_2.19 Rheological and Thermal Properties of Graphene/Cyanate Ester Composite

P. Shi, Y. Wang, H. Guo, H. Sun, Y. Zhao (Aerospace Research Institute of Materials and Processing Technology, China)

A composite of graphene/cyanate ester (CE) was prepared. Rheological analysis, thermal conductivity and micro-analysis were conducted to assess the rheological and thermal performances of the composite. (Cntd)

P_2.20 Strong Nanopaperes based on Cellulose Nanofibrils and Graphene Oxide

H. Mianehrow, G. Lo Re, L. Berglund (KTH Royal Intitule of Technology, Sweden)

With respect to the importance of high performance bio-based composites, an attempt was made to prepare biocomposites based on cellulose nanofibers (CNF) and Graphene oxide (GO) to study the synergistic effect of their superior properties on the mechanical properties of the resultant biocomposite. (Cntd)

Poster Area **Hall: Foyer Kokkali**

2. Materials Science

P_2.21 Development of Graphene-Based Elastomer Composites for Improved Mechanical and Electrical Properties

M. G. Pastore Carbone, K. D. Papadimitriou, J. Gigante, A.C. Manikas, G. Trakakis , G. N. Tomara, S. N. Georga, C. A. Krontiras, C. Galiotis (University of Patras, Greece)

Elastomeric composites have achieved a unique position among innovative materials because of their extensive and potential applications. Recently, considerable interest has been devoted to graphite-derived elastomeric composites, due to their exceptional electrical, mechanical and gas-barrier properties. (Cntd)

P_2.22 Wood Fiber Composites with Added Multi-Functionality

Z. Al-Maqdasi (Luleå University of Technology, Sweden), G. Gong, B. Nyström (Swerea SICOMP AB, Sweden), R. Joffe (Luleå University of Technology & Swerea SICOMP AB, Sweden)

A study on the functionalization of wood plastic composites by the addition of graphene nanoplatelets is presented. Results on mechanical properties together with prelimenary assessment of efficiency of materials to transfer heat at differernt graphene loadings are presented.

P_2.23 Effects of Deformation Rate on Tensile Properties of Ramie Fiber/PLA/PBAT Composites

M. Nishida, F. Deng, H. Ito (Nagoya Institute of Technology, Japan), N. Fukuda (Aichi Center for Industry and Science Technology, Japan)

We made a composite using poly(lactic acid) (PLA) and poly(butylenes adipate-co- terephthalate) (PBAT) polymer blends reinforced with unidirectional ramie yarn. Their tensile properties were examined at several deformation rates from 0.2 mm/min to 20 mm/min.(Cntd)

P_2.24 On the Development of Self-Controlled Bio-Based Panels for Building's Thermal Management

A. Romano, A. Bras (Liverpool John Moores University, UK), S. Grammatikos (Norwegian University of Science and Technology, Norway), S. Wylie, P. Kot, A. Shaw (Liverpool John Moores University, UK)

EU is responsible for an annual generation of approximated 700 Mt of bio-based waste mass, of which only a small fraction is treated or exploited. At the same time, the demand for domestic energy consumption has never been greater. (Cntd)

P_2.25 Fatigue Behaviour in Different Moisture Conditions of a Woven Hemp Fibre Reinforced Epoxy Composite

R. Barbière, F. Touchard, L. Chocinski-Arnault (Université de Poitiers, France)

The purpose of this work is to characterise the influence of moisture on the fatigue behaviour of a woven hemp fibre reinforced epoxy composite. Fatigue tests were monitored by acoustic emission and post-mortem observations were performed with FEG-SEM and micro-tomography.

P_2.26 Study of Antimicrobial Capacity in Reinforced Composites with Mineral Filler

L. Nobre, J. Bessa (CVR – Centro para a Valorização de Resíduos, Portugal), F. Cunha (2C2T – Centro de Ciência e Tecnologia Têxtil, University of Minho, Portugal), R. Fangueiro (University of Minho, Department of Mechanical Engineering, Campus de Azurém, Portugal), R. Pereira (ELV Empresa de Lousas de Valongo, Portugal)

This work presents a study carried out with the objective of equipping a composite material with antimicrobial behavior. The composite material was composed by 70% of slate waste and the functionalization of them is applied, in order to further increase its market applications. (Cntd)

P_2.27 Mechanical Properties of Polypropylene (PP)/Wood Flour Composites: Effect of Pulverization with and without Water of Wood Flour

M. M.-U. Haque (Yamaguchi University, Japan & Islamic University, Bangladesh), K. Goda (Yamaguchi University, Japan), H. Ito (National Institute of Advanced Industrial Science and Technology, Japan), S. Ogoe, M. Okamoto, T. Ema, K. Kagawa (TOCLAS Co., Japan), H. Nogami (Okayama Prefectural Research Institute for Forest and Forest Products, Japan)

This study analyses the effect of pulverization of wood flour with and without water to the tensile properties and impact behaviour of polypropylene (PP)/wood flour (WF) composites. The composites were processed in an extruder and subsequent injection moulding. (Cntd

P_2.28 Thermally Conductive & Flame Retardant Epoxy-GF Novolac Prepregs for PCBS – Correlation of the Filler Network Morphology with Final Properties

C. Pawelski-Höll, S. Bhagwat, G. Bakis, V. Altstädt (University of Bayreuth, Germany)

Within the scope of this research, thermally conductive and flame retardant Epoxy Novolac formulations, as polymer composites and their GF-reinforced prepregs, were investigated, by correlating the 3-D conductive filler network formation with the resulting macro-scale thermal properties. (Cntd)

P_2.29 Compression After Impact of Carbon/Geopolymer Sandwich Panels

M. Kadlec, F. Martaus, R. Hron (VZLU – Czech Aerospace Research Centre, Czech Republic)

The study evaluated the impact resistance of a new geocomposite material. The results showed significant effect of the environmental conditioning and skin/core bonding on the compression strength.

P_2.30 Painting the Composite Materials by Powder Coating: Surface and Interface Investigations

A. Fahs, A. Lafabrier, A. Dupuis, T. H. Ho (Université de Toulon, France), G. Louarn (Université de Nantes, France), E. Aragon, J. F. Chailan (Université de Toulon, France)

Poster Area — Hall: Foyer Kokkali

2. Materials Science

P_2.31 Surface Modification of Fibres with Graphene Oxide for Interface Improvement In Composites
L. Zeng, X. Liu, X. Chen, C. Soutis (University of Manchester, UK)

Fibre surface modification by self-polymerized poly(dopamine) (PDA) and graphene oxide (GO) for improving bonding between fibre and matrix in composites. The XPS and SEM results indicated successfully coating of uniform PDA and GO on both carbon and aramid fibres. (Cntd)

P_2.32 Interface Investigation of CFRP and CFR Hybrid Polymer Composites
N. Koutroumanis, A. C. Manikas, P. Nektarios Pappas, C. Galiotis (University of Patras, Greece)

The critical role of the interfacial region between the matrix and the reinforcing medium on the performance of carbon fiber reinforced composites, is known and very well-documented in the relative literature. In this work, we aim to present a study of the interfacial quality in carbon fibre reinforced composites from two distinct point of views (Cntd)

P_2.33 Structural Evolutions of Fully Dense Amorphous Polymer-Derived Silicon Carbonitride Ceramics
J. Niu, S. Meng, J. Li, G. Zhang (Harbin Institute of Technology, China)

P_2.34 Microstructure of In-Situ Cast Aluminum Based Composite Strengthened with TiC Nano Particles
W. Maziarz (Polish Academy of Sciences, Poland), E. Olejnik (AGH University of Science and Technology, Poland), A. Wójcik, J. Grzegorek, P. Czaja (Polish Academy of Sciences, Poland), Ł. Szymański (AGH University of Science and Technology, Poland), P. Kurtyka (Pedagogical University of Cracow, Poland)

Paper concerns detailed SEM and TEM microstructure investigations of in-situ cast Al based composite reinforced with the TiC nanoparticles. Beside of TiC particles with cubic structure and 100 nm size other phases also were identified in the matrix.

P_2.35 Effect of Al Moderator Addition on In Situ TiC Nano Particles Formation in Cast Aluminum Based Composite
E. Olejnik (AGH University of Science and Technology, Poland), W. Maziarz (Polish Academy of Sciences, Poland), G. Piwowarski (AGH University of Science and Technology, Poland), A. Wójcik (Polish Academy of Sciences, Poland), Ł. Szymański (AGH University of Science and Technology, Poland)

This work concerns an investigation of influence of Al moderator addition on in situ TiC nano particles formation in Al matrix via casting process. The moderator addition was applied in order to change the parameters of crystallization process consisting of nucleation and growth of TiC phase.

P_2.36 Finite Element Simulation of Mechanical Properties of Novel Polymer Composites Reinforced with MXene Nanosheets
D. Zeleniakiene, P. Griskevicius, G. Monastyreckis (Kaunas University of Technology, Lithuania), A. Aniskevich (University of Latvia, Latvia)

A new family of 2D nanomaterials MXenes shows similar benefits for structural composites as graphene. The aim is to identify the suitable FE modelling methodology in support of the mechanical properties optimization for polymer composite reinforced with MXene and graphene nanoparticles.

P_2.37 Preparation of Polyimide Nanocomposites Reinforced with Various Modified Nanodiamond
K. Obara, S. Morimune-Moriya (Chubu University, Japan)

In this study, Nanodiamond (ND) was used as a filler for PI nanocomposites. We prepared polyimide nanocomposites reinforced with various modified nanodiamonds. And the structures and properties of the PI/ND nanocomposites were investigated.

P_2.38 Dielectric, Thermal and Functional Behavior of Barium Zirconate/ Epoxy Resin Nanocomposite System
Z.-M. Tsikriteas, A. Sanida, S. G. Stavropoulos, A. C. Patsidis, G. C. Psarras (University of Patras, Greece)

Nanocomposites of epoxy resin and BaZrO3 ceramic nanoparticles were prepared via a mixing process. The electrical response of the epoxy resin/ BaZrO3 composite specimens, as well as of barium zirconate nanoparticles was examined by means of broadband dielectric spectroscopy in a wide temperature and frequency range. (Cntd)

P_2.39 Simulation of Water Transport Through Graphene Slit Over a Range of Temperatures
T. Yamada, R. Matsuzaki (.Tokyo University of Science, Japan)

To clarify the influence of the channel width and temperature, we performed flow simulations of water between graphene slits using MD simulations. We found that different permeation mechanisms govern liquid and gas phase.

P_2.40 High Performance Fire Retardant Polypropylene Nanocomposites by Electron Induced Reactive Processing
C. Zschech, U. Gohs, D. Xiao, M. T. Müller, A. Leuteritz, U. Wagenknecht (Leibniz-Institute for Polymer Research Dresden e.V., Germany)

Flame retardant PP nanocomposites were prepared by melt compounding, EB treatment and EIReP. The flame-retardant properties of PP/AAPP/FO-MMT nanocomposites were studied in detail. The results suggest that the sustainable novel EIReP enables the preparation of flame retardant PP-nanocomposites with enhanced mechanical and flame retardant properties. (Cntd)

Poster Area — Hall: Foyer Kokkali

2. Materials Science

P_2.41 Kinetic Studies of Polyamide 6 Obtained by In Situ Mold Polymerization
J. N. Lagarinhos, J. M. Oliveira (University of Aveiro, Portugal)

In this study, new formulations of polyamide 6 (PA6) were developed from in situ polymerization through T-RTM technology. Crystallization kinetics studies of PA6 obtained by T-RTM and commercial PA6 were done and the results compared.

P_2.42 Photopolymer Fiber Composite Structures in Microgravity
N. Sarantinos, P. Loginos , P. Charlaftis , A. Argyropoulos , A. Filinis , K. (Materials Science Dept., Nanochemistry Laboratory, University of Patras, Greece), L. Adamos, V. Kostopoulos (University of Patras, Greece)

The AML Space Group focused on the concept of space manufacturing in this paper, by researching the effect of microgravity of the curing of polymers in micro-gravity and comparing them with Earth gravity conditions control specimens. (Cntd)

P_2.43 Morphological and Mechanical Properties of LDPE Film Incorporated with Sweet Basil Oil
P. Threeponatkul, A. Sittattrakul (Silpakorn University, Thailand), C. Kulsetthanchalee (Suan Dusit University, Thailand), J. Sukata, T. Daowadueng, P. Tawai (Silpakorn University, Thailand)

The addition of up to 1% wt of PE-g-MA into the blending between LDPE and β-cyclodextrin incorporated with sweet basil oil could improve miscibility of LDPE and β-cyclodextrin and mechanical properties would be higher.

P_2.44 In Situ Cure Monitoring Of 3D-Shaped FRP using Highly Flexible Optical Fiber Sensors
T. Kosaka, G. Fujioka, K. Kusukawa (Kochi University of Technology, Japan)

Recently, cure monitoring of FRP by embedded optical fiber sensors have been paid attention to as a promising in situ method for FRP molding. In order to apply the method to large-scale and complex shape FRP products, the effect of optical loss by local bending on the measurement accuracy when the optical fiber was embedded should be taken account to. (Cntd)

P_2.45 Development and Thermomechanical Properties of B4C, TiC and Graphite/ Epoxy Composites
S. Gioti, S. G. Stavropoulos, A. Sanida, G. C. Psarras (University of Patras, Greece)

In the present study, three series of epoxy composite systems were manufactured varying the filler type and content. The thermomechanical properties were investigated by dynamic mechanical analysis (DMA). (Cntd)

P_2.46 Development and Characterization of Titanium Boride/Boron Carbide/ Polymer Matrix Hybrid Nanodielectrics
A-K. A. Kallinikou, Th. G. Velmachos, G. C. Psarras (University of Patras, Greece)

Polymer matrix composites constitute a novel type of materials with considerable scientific and technological interest, due to their properties and the wide range of potential applications. In the present study a series of composite specimens were manufactured using commercially available materials. (Cntd)

P_2.47 Study of the Conductivity of Various Size Forms Carbon Particles used as Fillers of Epoxy Polymer Composites
J. Novotná, J. Salačová, B. Tomková (Technical University of Liberec, Czech Republic), J. Müllerová (Technical University of Liberec, Czech Republic)

Presented work is focused on influence of size of short and small carbon fibers and fillers at changes AC conductivity of epoxy composites. The electrical properties for the matrix do not have significant effect on the electrical properties for the composite.

P_2.48 Mechanical and Thermal Properties of Dope dyed P-Aramid Fabric/Surlyn Composites
Y. Kim, J. Cho, J. Choe (Shin Heung, South Korea), J. Lee (Yeungnam University, South Korea), H. Lee, H. Kwon (Korea Textile Development Institute, South Korea)

Thermosetting resin prepreg is disadvantageous to expensive and difficult to use in living goods and electronic devices. In the case of thermoplastic prepreg marketability is made for living goods and electronic devices. (Cntd)

P_2.49 Experimental Characterization of the Consolidation of a Commingled P-Aramid/Low Melting Fiber Composite
J. Choe, J. Cho, Y. Kim (Shin Heung, South Korea), J. Lee (Yeungnam University, South Korea), H. Lee, H. Kwon (Korea Textile Development Institute, South Korea)

Owing to a higher melt viscosity compared to the thermoset plastics the Impregnation of the textile reinforcement structure with a thermoplastic matrix is significantly difficult. Commingled yarns produced on the basis of covering texturing technique have the potential for a homogeneous distribution of reinforcement and matrix filaments over the yarn cross section. (Cntd)

P_2.50 Biaxial Knitted Preforms for Structural Composites
N. Ishmael, P. Potluri, A. Fernando (University of Manchester, United Kingdom)

Research on biaxial knitted preforms for composite applications is presented in the paper. The method to produce biaxial knitted structures, whereby a stitching yarn system holds high performance inlay yarns in the 0° and 90° machine directions is summarised. (Cntd)

Poster Area **Hall: Foyer Kokkali**

2. Materials Science

P_2.51 Influence of the Stitch Thread Tension on the Permeability of Carbon Fibre Non-Crimp Fabrics
D. Karanatsis (Hexcel Reinforcements UK Ltd & University of Nottingham, UK), T. James (Hexcel Reinforcements UK Ltd, UK), A. Endruweit, A. C. Long (University of Nottingham, UK)

In this work, the permeability of carbon fibre non-crimp (NCF) fabrics is measured, aiming at studying the effect of varying the stitch thread tension on the fabric architecture and examining the effect on the fabric permeability. Three different stitch tension values were selected for the manufacture of carbon fibre fabrics. (Cntd)

P_2.52 Multifunctional Epoxy Nanocomposites
H. Gu (Tongji UniveRsity, China

P_2.53 Effect of Hydrothermal Ageing on the Mechanical Properties of Flax Fibre/ Bio-Based Resin Composites
X. Saridaki, E. Kollia, D. Karagiannis, S. Tsantzalis (University of Patras, Greece), M. Wonneberger, F. Dungern (Invent GmbH, Germany), V. Kostopoulos (University of Patras, Greece)

The aim of the present study is to evaluate the influence of hydrothermal ageing of flax fibre-reinforced bio-based epoxy resin laminates on the mechanical properties of the composites.

P_2.54 Oxidation and Mechanical Properties of SiC/BN/SiBCN Composite at High Temperature
Z. Li, X. Zhang, P. J. Withers, P. Xiao (University of Manchester, UK), W. Liu, Q. Li, X. Cao, L. Cao (Beijing Institute of Aeronautical Materials Beijing, China)

P_2.55 Effect of Interface Gradation on the Impact Response of Composites based on PEN and Woven Aramid, Basalt and Carbon Fibres
L. Sorrentino (Consiglio Nazionale delle Ricerche, Italy), A. Biondi (Consiglio Nazionale delle Ricerche & Università di Napoli F. II, Italy), Antonino Squillace (Università di Napoli F. II, Italy)

P_2.56 Hybridization of PP Composites with Glass and Basalt Woven Fabrics
L. Sorrentino, G. Simeoli, P. Russo (Consiglio Nazionale delle Ricerche, Italy)

Poster Area **Hall: Foyer Kokkali**

3. Material and Structural Behavior – Simulation and Testing

P_3.01 High-Performance Composite T-Joints: Topological Design Strategy towards Strength Improvement and Weight Reduction
A. Bolouri, M. Fotouhi, C. Redmond, A. Turner, M. Elliott, H. Leppier, R. Yip (University of the West of England, UK)

A topological concept is presented in order to create novel designs for carbon fibre reinforced polymer (CFRP) T-joints resulting in enhanced structural performance. The improvement in the new T-joint design is correlated to the activation of new damage mechanisms.

P_3.02 Novel Method to design Carbon Fibre Reinforced Polymer for Damage Tolerance
H. Yin, L. Iannucci (Imperial College London, UK)

Modelling of the representative volume element (RVE) of the biaxial fabric (±45°), characterised by stress-strain curves in different material directions was performed by the Explicit FE method in LS-DYNA.

P_3.03 Experimental Study to Understand the Effect of Delamination Position on Impact Damage Tolerance using Unsymmetrical Laminates
A. Sasikumar, D. Trias, S. M. Garcia Rodriguez, J. Costa (Universitat de Girona, Spain)

Non-conventional unsymmetrical laminates have been designed and tested for studying their impact and compression after impact response. Results reveal the prospects of tailoring damage resistance and tolerance using unsymmetrical laminate design, and the need to move away from the unnecessary laminate symmetry constrains.

P_3.04 Impact Damage Mitigation using Bioinspired CFRP Laminate Architectures
L. Amorim, A. Santos (University of Minho, Portugal), M. Branco, V. Infante (LAETA, IDMEC, Portugal), J. P. Nunes, J. C. Viana (University of Minho, Portugal)

Carbon fibre reinforced polymers (CFRP) are widely used in advanced applications due to their high performance and low weigh. However, when exposed to some conditions, as shear, dynamic and impact loading, they may develop interlaminar damages. (Cntd)

P_3.05 Experimental Study on Relaxation Behavior of Composite Laminates Impact Damages
F. Jiang, Z. Guan, Z. Li, F. Liu (Beihang University, China)

In this paper, the relaxation of low-velocity impact damage on composite laminates is studied by experimental methods. The relaxation is the phenomenon that leads to damages that become less detectable over time: a damage being detectable at time of impact, can become undetectable after an interval of inspection due to mechanical, thermal cycling, wet and ambient ageing and temperature. (Cntd)

P_3.06 Crack Propagation Suppression in Composite T-joint Using Fiber-Reinforcement-Based Crack Arrester
S. Hisada, S. Minakuchi, N. Takeda (The University of Tokyo, Japan)

One of the difficulties in composite structural application is joining components. T-joint is one of the important elements in aircraft structures that transfers load between vertical and horizontal panels. In T-joint, there is a problem that cracks occur in the deltoid and readily propagate along the interface between the flange and the skin. (Cntd)

P_3.07 Laminate Strength of Basalt Fibers in Polyester Resin
E. R. Thorhallsson (Reykjavik University, Iceland), J. Ó. Erlendsson (VSB Consulting Engineers Ltd, Iceland)

The objective of this research carried out at Reykjavik University Structural Research and Composite Center, (SEL), was to examine whether a composite material made of polyester resin reinforced with basalt fibers, could be used for engineering structures. (Cntd)

P_3.08 A Comparative Numerical Study Aiming To Reduce Computation Cost For Mode-I Delamination Simulations
S. Ahmadvash Aghbash, M. Engül, F. E. Öz(Boğaziçi University, Turkey), R. Amali (University of West of England, United Kingdom), N. Ersoy (Boğaziçi University, Turkey, & University of West of England, United Kingdom)

This study presents a procedure which aims to find a solution that allows the use of coarser mesh in modelling the Mode I delamination behaviour of AS4/8552 Carbon-Epoxy laminates.

P_3.09 A Computational Model for Analysis of Interface Damage in Fibrous Composites
R. Vodička, E. Kormaníková (Technical University of Košice, Slovakia)

A general model for computational analysis of interface crack initiation and propagation is used to model the rupture of fibre composites at various scales. An initial onset of damage is usually considered between fibres and matrix at a micro-mechanical level. (Cntd)

P_3.10 The Study of the Mechanical Behavior of Composite Bulkhead for Development of a Methodology of Efficient Defects Identify Using Microfocus X-Radiography
A. N. Anoshkin, V. Yu. Zuiko , P. V. Pisarev , V. M. Osokin, K. A. Pelenev (Perm National Research Polytechnic University, Russian Federation)

In this paper, we consider the method of mechanical impact on a composite structural-like frame with the purpose of opening closed interlayer cracks to a minimum size that will allow to detect this defect by the X-ray diffraction method of nondestructive testing, provided that loading does not lead to the formation of new defects and further growth of existing defects

Poster Area **Hall: Foyer Kokkali**

3. Material and Structural Behavior – Simulation and Testing

P_3.11 Effect of Intratow Fibre Hybridization on the Fracture Toughness of Polymer Composite Materials
R. P. Tavares (Universidade do Porto & INEGI, Portugal & University of Girona, Spain), D. Gizik, C. Metzner, C. Weimer (Airbus Group Innovations, Germany), A. Turon (University of Girona, Spain), P. P. Camanho (Universidade do Porto & INEGI, Portugal)

Tow spreading technique is used to comingle two types of fibres to produce intratow hybrid unidirectional tapes. Different materials, with different hybrid volume fractions, were manufacture and tested and their properties are compared.

P_3.12 Moisture Sorption by Epoxy Resin filled with MWCNT of Different Thickness
T. Glaskova-Kuzmina, A. Aniskevich, J. Sevcenko (University of Latvia, Latvia), A. Borriello, M. Zarrelli (National Research Council of Italy, Italy)

The effect of environmental ageing on sorption and thermophysical characteristics of epoxy and epoxy-based nanocomposites filled with multiwall carbon nanotubes with different thicknesses was revealed and discussed.

P_3.13 Towards a Method for the Identification of Water Diffusion Parameters in Polymers and Composites
J. Cocaud (CNRS UMR & ESI Group, France), A. Célino, S. Fréour, F. Jacquemin (CNRS UMR, France)

The aim of this work is to study the relevance of the water diffusion parameters identified on Fickian and non-Fickian kinetics whose saturation levels are unknown and to reveal the consequences on the estimations of the linked quantities.

P_3.14 Investigating the Reversibility of Moisture Uptake on the Behavior of a Pultruded Polymer Composite used in Construction
M. Evernden (University of Bath, United Kingdom), S. Grammatikos (Norwegian University of Science and Technology, Norway), S. Papatzani (University of Brighton, UK & Hellenic Ministry of Culture, Greece)

This paper presents the effects of wet/dry cycling loading on the moisture uptake behavior of a Fibre Reinforced Polymer (FRP) composite used in the civil engineering sector. FRP samples of various dimensions were cut from an 'off-the-shelf' pultruded flat sheet and conditioned in a cyclic hygrothermal environment. (Cntd)

P_3.15 Behaviour of Bolted Composite Joints in Hygro-Thermal Environments
I. Pivdiablyk, P. Rozycki, L. Gornet (Ecole Centrale de Nantes, France), F. Jacquemin (Université de Nantes, France), S. Auger (Ingénierie des Assemblages, France)

Environmental conditions have an important impact on the physical and mechanical properties of polyamide 6 used as a matrix in the studied thermoplastic composite material. The controlled desorption and absorption procedures define the time needed to provide the moisture content for required relative humidity levels. (Cntd)

P_3.16 Development and Progression of Damage in Flax Fibre Reinforced Composites under Cyclic Hygroscopic Loading
K. Hendrickx, R. Vranken, A. W. Van Vuure, J. Ivens (KU Leuven, Belgium)

This study investigates the degradation of unidirectional flax fibre composites induced by cyclic hygroscopic loading. The damage development was visualized using computed tomography and the decrease in mechanical properties was determined.

P_3.17 Temperature Dependence of Statistical Static Strengths for Unidirectional CFRP with Various Carbon Fibers
A. Koma, M. Nakada, Y. Miyano (Kanazawa Institute of Technology, Japan)

The statistical static strengths under the tension loading along the longitudinal direction of unidirectional CFRP with various kinds of carbon fibers are measured at various temperatures and discussed in the role of the viscoelasticity of matrix resin. (Cntd)

P_3.18 Experimental Characterization of Satin Weave Composite Laminate at High Strain Rates using Split Hopkinson Bar Testing
B. Ravindran, C. Srivastava, G. Lampeas (University of Patras, Greece)

Composite materials exhibit superior mechanical properties over metallic materials and for this reason they attracted increased importance in recent decades. In the present work, two dimensional 5-harness satin carbon-epoxy woven composite laminates are investigated for high strain rate properties using Split Hopkinson Pressure Bar (SHPB) testing. (Cntd)

P_3.19 Numerical Analysis and Optimization of CFRTP Hat-Stiffened Structure
Q. Guo, B. Xiao, I. Ohsawa, M. Fujita, J. Takahashi (The University of Tokyo, Japan)

Numerical studies and design optimization of CFRTP hat-stiffened structure were studied. The method makes it possible for engineers to improve their designs with an integrated consideration between product performance and design parameters.

P_3.20 Investigation of Pre-Cured Carbon Fiber/Epoxy-Laminates for Modified Co-Curing Process
F. Rieger, T. Rief, N. Motsch, J. Hausmann (Institut für Verbundwerkstoffe GmbH, Germany)

A modified co-curing process using partly cured laminates is investigated. Experimental results on cure analysis and joining of pre-impregnated laminates are presented and compared to laminates produced by co-curing and co-bonding.

Poster Area **Hall: Foyer Kokkali**

3. Material and Structural Behavior – Simulation and Testing

P_3.21 Cost-Effective Partitioning of a Composite Bus Structure from the Perspective of Adhesive Joints
L. Takacs (eCon Engineering Kft., Hungary), Z. Kiss (Budapest University of Technology and Economics, Hungary)

In this paper the partitioning of a bus sandwich structure is investigated by modifying joint lines and joint types. A modeling approach is described how to take joint-stiffness in a global vehicle model into account and an evaluation method was shown to make a trade-off between weight and cost.

P_3.22 Optimization of Tow-Steered Perforated Variable Stiffness Composite Laminates for Vibration Tailoring using IGA
V. Khalafi (Aerospace Research Institute, Iran), J. Fazilati (Aerospace Research Institute, Department of Aeronautical Science and Technology, Iran)

The main contribution of the present paper is to develop a strong and efficient numerical tool in order to analyze the mechanical behavior and find the best lay-up of performed tow-steered square laminated panels to provide the best dynamic stability in terms of the highest natural frequencies. (Cntd)

P_3.23 Modelling Crack Network in Laminated Composites Using Complementary Observation Technics
H. Laeuffer, T. Briand, C. Bois, J.-C. Wahl (Univ. Bordeaux, I2M, CNRS, France)

This paper presentes several complementary experimental methods based on optical microscopy and micro-tomography observations under tensile loading to analyse transverse crack networks in laminated composites

P_3.24 Fracture Mechanics of Hybrid Composites with Ductile Matrix and Brittle Fibers: Influence of Temperature and Constraint Effect
J. D. Pujols González (INSA Rouen, France), C. Bouvet (Université de Toulouse, France)

The fracture behavior of hybrid composite consisting of 14 carbon-PEEK 5HS (Harness Satin) woven plies with two outer glass-PEEK woven plies obtained by consolidation process is investigated. On the one hand, single-edge-notch bending tests (SENB) and single-edge-notch tensile tests (SENT) have been conducted at room temperature (RT) (cntd)

P_3.25 Failure Behavior for the Subelement of Cylindrical Composite Lattice under Compressive Load
M.-H. Jeon, M.-S. Kang, I.-G. Kim (Chungnam National University, Korea), S.-W. Lee (Hankuk Fiber Co., Korea)

In this paper, the axial compressive test and failure analysis for suselement of cylindrical composite lattice structures were conducted to investigate its failure behavior. The subelement cut from the full-scale lattice structure contains five single unit cell. (Cntd)

P_3.26 Simulation of Cusp Formation in Composite Materials using the Thick Level Set Method
L. A. T. Mororo (Federal Institute of Education, Science and Technology of Ceara & Delft University of Technology, The Netherlands) F. P. van der Meer (Delft University of Technology, The Netherlands)

The Thick Level Set Method (TLS) is used to simulate the cusp formation process in composite materials. A plasticity model for polymers is implemented in TLS framework in order to deal with permanent strain.

P_3.27 Development of Mesh-Free Simulation Tool for the Optimization of Microscopic Composite Structure
R. Higuchi, T. Yokozeki (The University of Tokyo, Japan), T. Okabe (Tohoku University, Japan), T. Nagashima (Sophia University, Japan), T. Aoki (The University of Tokyo, Japan)

Recently, freedom in design of composite microstructure has been improved due to the development of the manufacturing technology of various shapes and diameters of carbon fibers. In other words, numerous candidates of composite microstructure should be considered toward a microscopic optimization of composite. (Cntd)

P_3.28 Carbon Nanotubes Grafted on Fibres Diffuse Damage in Composites Leading to their Improved Toughness at the Micro-Scale
Q. Liu, S. V. Lomov, L. Gorbatikh (KU Leuven, Belgium)

Grafting of carbon nanotubes (CNTs) on fibres is a promising route to improve the toughness of fibre reinforced polymer composites. This toughness improvement is generally attributed to the additional energy dissipated by the debonding and pull-out of CNTs from the matrix (Cntd)

P_3.29 Strategies for Improving Fracture Toughness of CFRP Composite Joints
A. Q. Vu, R. Tao (King Abdullah University of Science and Technology KAUST, Saudi Arabia), M. Alfano (University of Calabria, Italy), G. Lubineau (King Abdullah University of Science and Technology KAUST, Saudi Arabia)

Lightweight materials have been more and more applicable for various purposes. As recently reported, there will be a huge cost drop for carbon fiber applications which in turn will provide momentum for the fabrication of more carbon-fibers based composite structures. The classical mechanical fastenings, using rivets or bolts, have several drawbacks in joining composites. To bypass these disadvantages, the trend for using secondary bonding of carbon fiber reinforced polymer (CFRP) laminates adopting structural adhesives has attracted a lot of attention from the aerospace industry in recent times. However, in order to achieve strong and reliable joints, surface preparation has been identified as one of the most critical aspects of manufacturing. (Cntd)

P_3.30 Failure Analysis of Composite Bolted Joints by an Experimental and a Numerical Approach
B. Montagne, F. Lachaud, E. Paroissien (Université de Toulouse, France), D. Martini (Dassault Aviation, France)

An experimental database of supported single shear tests is analysed to find the main parameters that lead to the failure of the joint. The end distance is the most important parameter. It has a strong influence on both the bearing stress at failure and the failure mode. (Cntd)

Poster Area **Hall: Foyer Kokkali**

3. Material and Structural Behavior – Simulation and Testing

P_3.31 Failure Prediction of Composite Adhesive Scarf-Lap Joints Using Finite Fracture Mechanics
A. Ghorbani, P. A. Carraro, M. Quaresimin (University of Padova, Italy)

In the present study, a coupled stress and energy criterion, in the frame of Finite Fracture Mechanics, was proposed for predicting the failure load of composite bonded joints in the presence of brittle adhesives and failing in an adhesive manner. (Cntd)

P_3.32 Adhesive Bonded Composite Laminate Double Lap Joint and Progressive Failure Analysis
J. S. Kwon, D. G. Choi, J. S. Park, S. Y. Lee (Korea Aerospace University, Republic of Korea)

A comprehensive procedure for adhesive bonded composite laminate joint (ASTM D3528 Proc. B) is demonstrated by a failure analysis of test results. Tests were perform on the ASTM D5656 to characterize the adhesive shear properties for various adhesive thicknesses. (Cntd)

P_3.33 X-Ray Computed Tomography-Based Fe-Homogenization of Sheared Organo Sheets
O. Shishkina, A. Matveeva (Siemens Industry Software NV, Belgium), S. Wiedemann, K. Hoehne (INPRO, Germany), M. Wevers, S. V. Lomov (KU Leuven, Belgium), L. Farkas (Siemens Industry Software NV, Belgium)

Finite element models of thermoplastic woven organo sheets sheared to various angles were created from micro-CT images using voxel-based approach. Virtual assessment of the effect of shear on the homogenized composite elastic properties shows a good agreement with the experimental results.

P_3.34 The Application of a Reduced Volume Method for the Simulation of the Characterisation of a Carbon Fibre Pressure Vessel
M. P. Widjaja (BAM Federal Institute for Materials Research and Testing, Germany), S. Joannès, A. Bunsell (PSL - Research University, France), G. Mair (BAM Federal Institute for Materials Research and Testing, Germany), A. Thionnet (Université de Bourgogne, France)

Modelling a real-scale composite structures with pre-determined element size to include the micromechanical aspects would be unrealistic. Reduced volume method is then used to define the required number of elements and simulations.

P_3.35 On The Modeling of Coupling Failures in Laminated Composite
M.-Q. Le, P. Ladevèze, D. Néron, C. H.-Minh (Université Paris-Saclay, France)

In order to establish a reliable virtual testing strategy for composite design, the damage mesomodel for laminated composites has been developed at LMT-Cachan since the 1980s. The new version of the mesomodel has been recently proposed to make a physically sound prediction of composite structures involving extensive splitting. (Cntd)

P_3.36 Simplified Representation of Complex Structural Components for Finite Element-Analysis
L. Reichert, J. Krieglsteiner (Technische Universität Braunschweig, Germany), C. Schmidt (Leibniz Universität Hannover, Germany), P. Horst (Technische Universität Braunschweig, Germany)

Two methods to derive surrogate stiffness parameters of complex structural components for the use in linear FE-analyses are presented. Both, the analytical and FE-approach, offer a decreased error in the stiffness parameters compared to a conventional approach.

P_3.37 Molecular Dynamics Simulation Study on Charged Carbon Nanotube Shuttle using Graphene Nanoribbon
J. W. Kang (Korea National University of Transportation & Korea National University of Transportation, Republic of Korea)

Carbon nanomaterials – such as fullerenes, graphene, and nanotubes – have received much attention due to their applicability to mass storage devices. In this presentation, we investigate an archival memory that stores bits of data according to the different positions of a charged carbon nanotube shuttle within a carbon nanotube on a graphene nanoribbon. (Cntd)

P_3.38 Verification of Hot-Spot in Complex Composite Structures Using Detailed FEA
H. Molker, R. Gutkin (Volvo Car Corporation, Sweden), L. E. Asp (Chalmers University of Technology, Sweden)

Analysis of large complex composite structures with state of the art failure initiation criteria is difficult and simplifications are therefore needed. This is often done using shell models as these are computationally efficient. (Cntd)

P_3.39 Hyperelastic Modeling of Woven Structures Undergoing Large Deformations
M .R. Mansouri (Polymer Competence Center Leoben GmbH & Montanuniversität Leoben, Austria), P. F. Fuchs (Polymer Competence Center Leoben GmbH, Austria), C. Schuecker (Montanuniversität Leoben, Austria)

This work presents a compressible hyperelastic constitutive model for dry woven fabrics with two families of inextensible fibers. In recent works it was demonstrated that shear interaction of the fibers is the dominant deformation mode in state of the art characterization methods of dry woven fabrics as for example the bias-extension test. (Cntd)

P_3.40 Development of a Novel Hybrid Column - Aggregate Concrete In-Fill Fibre Reinforced Polymer (FRP)
E. Badifu, M. Saidani, A. Gand (Coventry University, UK)

Poster Area **Hall: Foyer Kokkali**

3. Material and Structural Behavior – Simulation and Testing

P_3.41 Fabrication of Micro-Nano Hierarchical Structures with Multiwall Carbon Nanotubes and Poly (Dimethylsiloxane)

H. Y. Hwang, S. H. Han (Andong National University, Republic of Korea)

We proposed very easy and cost-effective method to fabricate micro-nano hierarchical structures for synthetic dry adhesives. In order to make hierarchical structures, we suggested selective etching on the micro-pillar structure reinforced with aligned nano-materials. (Cntd)

P_3.42 Bio-Inspired Non-Self-Similar Hierarchical Composites

J. Henry, S. Pimenta (Imperial College London, UK)

Hierarchical brick-and-mortar composites were designed, manufactured and tested. Non-self-similar microstructures show improved damage tolerance via damage diffusion, permanent deformation, and a stable stress-plateau under repetitive loading.

P_3.43 The Influence of Core Materials upon the Selected Strength Properties of a Sandwich Composite

R. Szczepaniak, T. Cioć, A. Komorek, P. Kasprzak, P. Przybyłek, A. Krzyżak (Polish Air Force Academy, Poland)

The paper presents findings of selected strength tests of sandwich-type composite materials with herex or honeycomb core. For the sake of the investigation, three sets of composite sandwich-type samples, of different herex densities, were prepared. (Cntd)

P_3.44 Equivalent Mechanical Properties of Foam Reinforced in Thickness

M. El Moussaid, P. Sansen (ESIEE - Amiens, France), C. Lainé (Icotex Sicomin-Bray sur Somme, France), S. Panier (IUT GMP - Amiens, France)

The reinforcements in the thickness of the sandwich structures represent one of the technological solutions that improve the mechanical properties of this type of structures. We are talking about 3 D sandwich structures. (Cntd)

P_3.45 Transverse Failure Under Compression in Composite Laminates: Microscopical Observations

P. L. Zumaquero, E. Correa, J. Justo, F. París (Universidad de Sevilla, Spain)

Transverse failure is quite frequent in fibrous composite materials. This type of damage, known as Matrix/Inter-fibre failure at micromechanical level, is characterized by the appearance of small debonds at the fibre-matrix interfaces (interface cracks) that can progress along them until reaching a certain extension. (Cntd)

P_3.46 Challenges of Hybrid Laminar Flow Control (HLFC) in Aircraft Design and Manufacturing

F. Martin de la Escalera, Y. Essa, M. Ángel Castello, U. Pillai (AERNNOVA Engineering Division SAU, Spain), A. Chiminelli, M. Lizaranzu (ITAINNOVA-Instituto Tecnológico de Aragón, Spain), P. Maimi (Universitat de Girona, Spain)

The purpose of this paper is to describe barriers and efforts made in the design of an aircraft in terms of reducing pollution emission into the atmosphere throughout the structural optimization of the aircraft's airfoils. (Cntd)

Poster Area — Hall: Foyer Kokkali

4. Experimental Methods: New Testing Methods

P_4.01 Temperature-Dependent Thermal Properties Measurement by Solving Inverse Heat Transfer Problems

W. Pan, F. Yi, S. Meng (Harbin Institute of Technology, China)

Inverse heat transfer problems (IHTPs) are utilized to identify temperature-dependent thermal properties and varified by experimental data, indicating the potential for composite materials.

P_4.02 Simulation of Ultrasonic Array Inspection of Composites with Side Drilled Holes

C. Anand, R. M. Groves, S. Shroff, R. Benedictus (Delft University of Technology, The Netherlands)

In this paper ultrasonic signals from array transducers are simulated using the Thompson and Gray measurement model. The measurement model consists of a beam model, a system efficiency factor which characterizes the response of the electro-mechanical and electrical components of the system, and a flaw scattering model. (Cntd)

P_4.03 Influence of Curing Degree on the Mechanical Performance of Polymer Matrix Composites

M. Wolfahrt (Polymer Competence Center Leoben GmbH, Austria), G. Pilz (Montanuniversität Leoben, Austria), R. W. Lang (Johannes Kepler University Linz, Austria)

As a continuation of our previous work, which concerned the relationship between curing degree and key neat resin properties, an experimental study was carried out to evaluate the applicability and limitations of the results of the characteristic neat resin properties on polymer matrix composites. (Cntd)

P_4.04 Automated Test System for Crack Growth Rates Evaluation on Advanced CFRP

M. Jiménez, F. Moreno, R. Cabrera, D. Rodríguez, K. Muñoz, C. Arellano (Element Materials Technology Seville, Spain)

An automated dynamic test system has been developed and applied for the characterization of mode I fatigue delamination propagation. This crack detection and monitoring system has enabled to investigate crack growth rates of different advanced CFRP materials. (Cntd)

P_4.05 In-Situ Damage Investigation of Adhesively Bonded Composite Repairs

C. Hannesschläger (University of Applied Sciences Upper Austria, Austria), F. Röper, M. Wolfahrt (Polymer Competence Center Leoben GmbH, Austria), G. Kucher (FACC Operations GmbH, Austria), B. Plank, J. Kastner (University of Applied Sciences Upper Austria, Austria)

In aeronautic industries adhesive bonding is a common technique to repair composites. In this study interrupted in-situ observations by X-ray computed tomography (XCT) were used to investigate the crack initiation and propagation in scarf repaired CFRP-laminates. (Cntd)

P_4.06 Internal Structure Investigation of Discontinuous CFRTP Using X-Ray Micro-Ct Methods

Y. Wan, J. Takahashi (The University of Tokyo, Japan)

Two X-ray micro-CT methods are applied to investigate multi-scale structure discontinuous CFRTP and SMC CFRTP. The advantages and disadvantages of the introduced two methods are revealed practically.

P_4.07 In Situ X-CT Observation of Crack Initiation and Propagation in CFRP with a Full-Field X-ray Microscope

M. Kimura, Y. Takeichi, Y. Niwa, T. Watanabe (High Energy Accelerator Research Organization, Japan)

We have developed a new X-ray microscope using synchrotron radiation. Using phase-contrast imaging technique, we have succeeded in nondestructive and 3D observation of the initiation and propagation of cracks in CFRP with a resolution down to 50 nm under an applied stress.

Poster Area — Hall: Foyer Kokkali

5. Processing and Manufacturing Technologies

P_5.01 Assessment of Some New Polymeric Composites used for 3D Printing
D. Batalu, A. Bunescu (University Politehnica of Bucharest, Romania), P. Badica (National Institute of Materials Physics, Romania)

Commercial ABS and SLA resin were added with powders of different percentage. The composite polymers were tested for 3D printing, to find the optimal parameters. The obtained samples were analyzed by scanning electron microscopy (SEM), X-ray diffraction (XRD), and mechanical tests.

P_5.02 In Situ Resin Impregnation Behavior during 3D Printing of Continuous Carbon Fiber Reinforced Plastics
W. Yasunaga, T. Osada, S. Kobayashi (Tokyo Metropolitan University, Japan)

In situ resin impregnation during 3D printing of continuous carbon fiber reinforced plastics was investigated. Resin impregnation ratio measurement and tensile tests were conducted to optimize process parameters during 3D printing.

P_5.03 Enhanced Energy Absorption Properties in 3D Printed Polymer Matrix Composite
U. Morales, A. Esnaola, M. Iragi, L. Aretxabaleta, J. Aurrekoetxea (Mondragon Unibertsitatea, Spain)

The energy absorption under compression load of cellular 3D printed structures have been characterised for an unreinforced polyamide 6 and a short carbon fibre reinforced polyamide composite. The presence of the fibre reinforcement enhances all the characterised mechanical performances, without modifying the crushing mechanisms. (Cntd)

P_5.04 Improvement of the Transverse Mechanical Properties of CF Reinforced ABS 3D-Printed Parts Treated with Acetone Vapour
N. Blanco, I. Saad, J. Torrent (Universitat de Girona, Spain)

The effect of using acetone vapour to partially melt the thermoplastic filaments to improve their adhesion and transverse mechanical properties of 3D printed composite specimens is analysed. The results show that maximum stress and strain at failure of 3D printed composites can be improved when the material is treated with acetone vapour.

P_5.05 Simulation of Laser Heating of Thermoplastic Composite in an Automated Placement Process using Ray Tracing Method
O. Baho, J. Férec, G. Ausias (Université Bretagne Sud, France)

This paper investigates the energy quantity absorbed by APC-2. During the simulation process (AFP), the illuminated material's radiative properties are evaluated in terms of the angle of incidence, the wave length, and the deformation of the roller.

P_5.06 Influence of Out-Time on the Properties of Out-of-Autoclave AFP Prepregs
S. Rao, D. Bastienne, W.J. Cantwell (Khalifa University of Science and Technology, UAE)

In this work, the effect of out-time on the volatile content in CYCOM® 5320-1 unidirectional prepreg tape is investigated by exposing the prepregs to room temperature conditions for 2 hours to 24 hours. Simple statistical curve-fitting of the experimental data yielded a negative exponential relation between the volatile content and out-time. (Cntd)

P_5.07 Inline Control of Tape Width During Automated Tape Placement
R. Schledjewski (Montanuniversität Leoben, Austria)

Inline detection of tape contour during automated placement is used to identify the tape deformation and using phenomenological models to adapt processing parameters automatically.

P_5.08 Low Energy Curing Methods of Resins and Natural Fiber/Resin Composites Against Conventional Ones. Comparison on the Base of their Mechanical Performance
G. Petropoulos, E. Kollia, I. Fotiou, S.Tsantzalis, V. Kostopoulos (University of Patras, Greece)

The main purpose of the present study is to investigate and compare the mechanical and thermomechanical properties of different types of materials cured using conventional and low energy curing methodologies and estimate the energy consumption. (Cntd)

P_5.09 Process Modelling of Anionically Polymerised Polyamide-6 for Application in Thermoplastic Reactive Resin Transfer Moulding (R-RTM)
J. Humphry, N. Yang, L.-J. Vandi, R. Truss, D. J. Martin, M. T. Heitzmann (The University of Queensland, Australia)

The implementation of new reactive thermoplastic systems for the manufacture of composites requires an understanding of the effect of varying processing conditions. Time-Temperature Transformation (TTT) Diagrams may serve as a useful process guide.

P_5.10 Experimental Investigation of the Effects of Infrared Heating Mechanism on the Mechanical Properties of Autoclave Cured CFRPS
Y. O. Alpay, I. Uygur (Duzce University, Turkey), F. E. Oz (Bogazici University, Turkey)

In this study, effects of heating mechanism on the curing and mechanical properties of autoclave cured CFRPs were investigated. Infrared and conventional resistance heating were considered and compared. For this purpose, an infrared curing oven was constructed to simulate the autoclave cure cycle without pressure. (Cntd)

P_5.11 Natural Fibre Textile Characterization for Dual-Scale Flow Prediction
Y. Blößl, R. Schledjewski (Montanuniverstität Leoben, Austria)

In this work capillary rise experiments with a flax fibre fabric were performed to analyse the fluid flow on intra-tow level of the textile and to evaluate the effective capillary radii.

Poster Area — Hall: Foyer Kokkali

5. Processing and Manufacturing Technologies

P_5.12 Evaluation of Urethane Adhesive-Composite Joints Under Different Environmental Conditions
J. G. Quini, G. Marinuci (IPEN/CNEN-SP, Brasil)

Structural adhesives technology has changed the concept of joints bonding different materials in a unique solid assembly and making them part of the structures. These joints not only increase strength and stiffness but also reduce weight, which is important, for instance, for vehicles and airplanes. (Cntd)

P_5.13 Processing of (Glass) Fiber Reinforced Plastics with 2.45 GHz Microwaves: Current State, Challenges, and Perspectives
D. Teufl, S. Zaremba (Technical University of Munich, Germany)

This paper handles four points. First, a very brief introduction into the microwave. Second, a literature sum-up. Third, some practical challenges and their solutions. Last, an outlook with potential applications.

P_5.14 Manufacturing, Process Simulation and Mechanical Tests of a Thick Component Produced by Compression-RTM Process
A. Vita, V. Castorani, M. Germani (Università Politecnica delle Marche, Italy)

The aim of this article is to demonstrate the feasibility of the manufacturing of a 12mm thick CFRP component by Compression RTM

P_5.15 Multi-Scales Analysis of the Damage Induced During One-Shot Drilling of CFRP/Titanium Alloy
M. F. Ameur (Ecole Nationale Supérieure de Technologie Algiers & USTHB, Algeria), R. Zitoune (Université de Toulouse, France), M. Habak (Université de Picardie Jules Verne, France), M. Kenane (USTHB, Algeria)

One-shot drilling of multi-stacks made carbon fibers reinforced polymer (CFRP) and titanium alloy is a challenging machining process. In fact, due to the difference in the mechanical properties of both materials combined with the anisotropy of the composite, the mechanisms of material removal are accompanied by several damages. (Cntd)

P_5.16 Preparation of Self-Reinforced Composites by Injection Molding. Insert Overmolding
J. Andrzejewski, M. Szostak (University of Technology, Poland)

The use of composite inserts allowed for an effective combination of injection molding with the concept of self-reinforcing composites. The test results indicate a significant increase in mechanical properties. This concept expands the range of applications for srPET composites.

P_5.17 Electric Field-Induced Alignment of Thermal Conductive Filler in Acrylic Polymer for Enhanced Thermal Conductivity
I. Myojo, M. Nakano, J. Suehiro (Kyushu University, Japan), T. Iwaya, Y. Ishida (Toray Industries, Japan)

A recent trend in the integration of electric power devices has caused problems of heat management because of high heat generation from the device. Therefore, studies of new materials having high thermal conductivity have been motivated. (Cntd)

P_5.18 Direct Joining of Laser-Textured Titanium Alloys and CFTPCS
L. Blanco Salgado, A. Pedreira Estévez, P. Rey Rodriguez (AIMEN Technology Centre, Spain)

Transport industry is dominated by the light-weight challenge driven by both environmental concerns (increase the fuel efficiency and reduce the CO2 emissions) and cost reduction. Using mixtures of materials and multi-material design of components provides an opportunity to develop products which could achieve this challenge. (Cntd)

P_5.19 In Situ-Polymerizing Thermoplastic Epoxy Resin which Enables Molding Processes Corresponding to Various Forms of Thermoplastic Composites
H. Nishida, K. Nunotani, K. Uzawa (Kanazawa Institute of Technology, Japan)

Our laboratory has been investigating in situ-polymerizing thermoplastic epoxy resin, a liquid epoxy resin mixture in the initial state that can be allowed to polymerize linearly by heating to produce a thermoplastic polymer. This resin is very useful in the production of thermoplastic composites reinforced with continuous fibers at a high volume content (Cntd)

P_5.20 Influence of Formulation Parameters on the Properties of Thermoplastic Fabric Reinforced Composites
K. Moser, C. Burgstaller, T. Höftberger (Transfercenter für Kunststofftechnik GmbH, Austria), W. Stadlbauer (Fachhochschule Oberösterreich F&E GmbH, Austria)

The work deasl with thermoplastic composites from thermoplastics by influsion and compression moulding, as well as with different glass fibre reinforcements.

P_5.21 Development and Evaluation of Concepts for the Removal of Backing Foils from Prepreg for the Automated Production of UD Reinforced SMC Parts
D. Kupzik, F. Ballier, J. Lang, S. Coutandin, J. Fleischer (Karlsruhe Institute of Technology, Germany)

For the processing of small prepreg patches, methods for the removal of backing foil need to be found. In this paper, different approaches for the removal are presented and compared on the basis of experimental research.

P_5.22 Winding Trajectories for Dry Filament Wound Preforms
T. Sofi, R. Schledjewski (Montanuniversität Leoben, Austria)

The aim of this paper is to investigate the influence of two parameters (friction coefficient and initial winding angle) on the winding angle development along a conical surface. Then to obtain the feasible design space and generate different types of winding paths on the conical surface.

Poster Area **Hall: Foyer Kokkali**

6. Multifunctional and Smart Composites

P_6.01 Polymer Composite with Inherent Function of Damage Visualization: Mechanical Properties of Microcapsules

O. Bulderberga, O. Starkova, T. Glaskova-Kuzmina (University of Latvia, Latvia), P. Knotek (University of Pardubice, Czech Republic), A. Aniskevich (University of Latvia, Latvia)

The new concept of structural health monitoring for polymer composites is presented by bio-inspired "bruisable" GFRP composite with an inherent function of damage visual indication. The concept is undertaken by smart sensitive layer, based on fabric impregnated with a mixture of two suspensions — microcapsules with a leuco dye and microcapsules dye developer.(Cntd)

P_6.02 Investigation of the Electrical Resistivity of Damaged Carbon Fibers Sensors with Regard to SHM

N. Schmidová (Czech Technical University in Prague, Czech Republic), A. Horoschenkoff (University of Applied Sciences Munich, Germany), M. Růžička (Czech Technical University in Prague, Czech Republic)

This paper reports on a detailed investigation of the sensing potential of four different types of carbon fibers. Carbon fiber tows itself were used as damage sensors. It was revealed that the pitch carbon fibers investigated here have great potential for impact damage detection.

P_6.03 On the Preservation of the Mechanical Integrity of Fiber Reinforced Composites with Integrated Functions

K. Haag, J. Deitschun, D. Godlinski, V. Zoellmer, K. Koschek (IFAM, Germany)

The mechanical integrity of the composite is crucial to integrated functions in the context of structural health monitoring concepts. Using digital printing techniques for direct functionalization of glass fabrics, we show a promising attempt for the integration of different functionalities (cntd)

Poster Area — Hall: Foyer Kokkali

7. Recycling and Sustainability

P_7.01 Using Life-Cycle Cost Assessment of Fibre-Reinforced Automotive Parts as a Preliminary Decision Tool
V. Fernández, M. Ierides (Bax Innovation Consulting, Spain)

Fibre reinforced polymer composites provide several advantages over conventional materials; ability to produce complex shapes, resistance to extreme conditions, incorporation of smart functionalities, and most notably light-weighting potential – which enables energy savings in moving applications – to name a few. (Cntd)

P_7.02 A Simple Chemical Approach to Regenerating Strength of Thermally Damaged Glass Fibre for Reuse In Composites
S. T. Bashir, L. Yang, J. J. Liggat, J. L. Thomason (University of Strathclyde, UK)

This paper reports on the effect of alkaline treatments to regenerate the strength of thermally damaged glass fibres. These treatments can potentially be implemented to real thermally recycled glass fibres to allow their reuse in composite applications.

P_7.03 Spent Coffee Ground as Filler for Fibre Reinforced Composites Manufactured in a Direct Bulk Moulding Compound Process
J. Huether, P. Schumann, K. A. Weidenmann (Karlsruhe Institute of Technology KIT, Germany)

A unique material, combining recycled carbon fibres and spend coffee ground, is presented and its properties are compared to conventional materials. It is shown that this eco-friendly material will be able to compete with conventional composites.

P_7.04 Investigation of Catalysed Thermal Recycling of Glass Fibre Reinforced Epoxy
K. Pender, L. Yang, J. L. Thomason (University of Strathclyde, UK)

An investigation into catalysed thermal recycling of glass fibre reinforced epoxy was carried out to improve its commercial viability. CuO nanopowder was integrated with epoxy to assess its ability at reducing the epoxy thermal stability and in turn reducing the typically high thermal recycling temperatures required. (Cntd)

P_7.05 Fibrenamics Green: An Opportunity to a Sustainable Innovation
J. Bessa, L. Nobre, F. Cunha (CVR – Centro para Valorização de Resíduos, Portugal), R. Fangueiro (University of Minho, Portugal)

This work presents potential applications of use the several types of waste into new value added products. Actually, a high volume of different types of waste, coming of several industries was generated, without any type of recycling and recovery.(Cntd)

P_7.06 Resource and Energy Efficient Manufacturing of Au-Tomotive Lightweight Parts Made of Recycled Fiber Reinforced Composite Material
J. Schwingel, J. Wellekötter (University of Stuttgart, Germany), S. Baz (German Institutes of Textile and Fiber Research, Germany), P. Middendorf, C. Bonten (University of Stuttgart, Germany), G. T. Gresser (German Institutes of Textile and Fiber Research, Germany)

In the latest research project a three steps process chain has been developed. Aim is reusing carbon fiber material of end-of-life components and manufacturing waste. (Cntd)

Additional Papers:

Bio-Adhesive Coating from Ethylene Propylene Diene Terpolymer (EPDM)/Expanded Organoclay to Polyester Fabric for Multi-Applications
H. Moustafa, S.N. Lawandy, Marwa Rabee, M. Zahran

Bio-Inspired and Bio-Based Composite Structures
Jorg Mussig, David Labonte, Nina Graupner