

# **52nd CIRP Conference on Manufacturing Systems 2019**

Procedia CIRP Volume 81

Ljubljana, Slovenia  
12 – 14 June 2019

Part 1 of 2

**Editors:**

**Peter Butala  
Edvard Govekar  
Rok Vrabcic**

ISBN: 978-1-7138-0095-8

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2019) The Authors. Published by Elsevier Ltd.  
Creative Commons Attribution 3.0 International License.  
License details: <http://creativecommons.org/licenses/by-nc-nd/3.0/>.

No changes have been made to the content of these proceedings. There may be changes to pagination, and minor adjustments for aesthetics.

Printed with permission by Curran Associates, Inc. (2020)

For permission requests, please contact the publisher:

Elsevier B.V.  
Radarweg 29  
Amsterdam 1043 NX  
The Netherlands

Phone: +31 20 485 3911  
Fax: +31 20 485 2457

<http://www.elsevierpublishingsolutions.com/contact.asp>

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## PART 1

<b>MANUFACTURING ANALYTICS FOR PROBLEM-SOLVING PROCESSES IN PRODUCTION</b> .....	1
<i>Maximilian Meister, Julia Beßle, Amir Cviko, Tobias Böing, Joachim Metternich</i>	
<b>ENGINEERING EDUCATION IN CHANGEABLE AND RECONFIGURABLE MANUFACTURING: USING PROBLEM-BASED LEARNING IN A LEARNING FACTORY ENVIRONMENT</b> .....	7
<i>Ann-Louise Andersen, Thomas D. Brunoe, Kjeld Nielsen</i>	
<b>MODELING VARIABILITY AND PERSISTING CONFIGURATIONS IN OPC UA</b> .....	13
<i>Bernhard Wally, Christian Huemer, Alexandra Mazak, Manuel Wimmer, Radek Šindelár</i>	
<b>EVALUATING THE USE OF ADDITIVE MANUFACTURING IN INDUSTRY APPLICATIONS</b> .....	19
<i>Matthias Schneck, Matthias Gollnau, Max Lutter-Günther, Benjamin Haller, Gunther Reinhart</i>	
<b>RFID DATA DRIVEN PERFORMANCE EVALUATION IN PRODUCTION SYSTEMS</b> .....	24
<i>Ray Y. Zhong</i>	
<b>DEVELOPMENT OF A SIMULATION TOOL FOR PREDICTING ENERGY CONSUMPTION OF SELECTIVE LASER MELTING BY USING MATLAB/SIMULINK</b> .....	28
<i>Li Yi, Bahram Ravani, Jan C. Aurich</i>	
<b>DEVELOPMENT OF A FRAMEWORK FOR THE FLEXIBILITY ASSESSMENT OF AUTOMOTIVE PRODUCTION CONCEPTS</b> .....	34
<i>Achim Kampker, Georg Bergweiler, Ansgar Hollah, Philipp Bickendorf, Felix Hoffmann</i>	
<b>NUMERICAL PREDICTION OF 3D PRINTED SPECIMENS BASED ON A STRENGTHENING METHOD OF FRACTURE TOUGHNESS</b> .....	40
<i>Marouene Zouaoui, Carl Labergere, Julien Gardan, Ali Makke, Pascal Lafon</i>	
<b>DESIGN AND TESTING OF THE DIFFERENT INTERFACES IN A 3D PRINTED WELDING JIG</b> .....	45
<i>Achim Kampker, Georg Bergweiler, Ansgar Hollah, Kolja Lichtenthäler, Sebastian Leimbrink</i>	
<b>COORDINATION-BASED REACTIVE RESOURCE-CONSTRAINED PROJECT SCHEDULING</b> .....	51
<i>Byung Jun Joo, Tay Jin Chua, Tian Xiang Cai, Ping Chong Chua</i>	
<b>FROM 3D PRODUCT DATA TO HYBRID ASSEMBLY WORKPLACE GENERATION USING THE AUTOMATIONML EXCHANGE FILE FORMAT</b> .....	57
<i>Manuel Fechter, Alexander Neb</i>	
<b>ENABLING BIDIRECTIONAL REAL TIME INTERACTION BETWEEN BIOLOGICAL AND TECHNICAL SYSTEMS: STRUCTURAL BASICS OF A CONTROL ORIENTED MODELING OF BIOLOGY-TECHNOLOGY-INTERFACES</b> .....	63
<i>Robert Miehe, Evelyn Fischer, Dirk Berndt, Andreas Herzog, Michael Schenk</i>	
<b>PREDICTIVE CONTROL OF A SYNCHRONIZED INDIVIDUAL PRODUCTION</b> .....	69
<i>T. Heutmann, R. H. Schmitt</i>	
<b>A MULTIVARIATE KPI-BASED METHOD FOR QUALITY ASSURANCE IN LITHIUM-ION- BATTERY PRODUCTION</b> .....	75
<i>Thomas Kornas, Edgar Knak, Rüdiger Daub, Ulrich Bühner, Christoph Herrmann</i>	
<b>SITUATIONAL TASK CHANGE OF LIGHTWEIGHT ROBOTS IN HYBRID ASSEMBLY SYSTEMS</b> .....	81
<i>Matthias Linsinger, Jannis Stecken, Jürgen Kutschinski, Bernd Kuhlenkötter</i>	
<b>ENHANCED CLASSIFICATION OF EVENTS FOR MANUFACTURING COMPANIES IN SUPPLY NETWORKS</b> .....	87
<i>Dennis Bauer, Thomas Bauernhansl, Alexander Sauer</i>	
<b>A PARTICIPATORY PROGRAMMING MODEL FOR DEMOCRATIZING COBOT TECHNOLOGY IN PUBLIC AND INDUSTRIAL FABLABS</b> .....	93
<i>Tudor B. Ionescu, Sebastian Schlund</i>	
<b>INFLUENCE OF PROCESSING PARAMETERS ON CHARACTERISTICS OF LASER-INDUCED PERIODIC SURFACE STRUCTURES ON STEEL AND TITANIUM</b> .....	99
<i>Matej Senegacnik, Matej Hocevar, Peter Gregorcic</i>	
<b>CLASSIFICATION METHOD FOR AN AUTOMATED LINKING OF MODELS IN THE CO- SIMULATION OF PRODUCTION SYSTEMS</b> .....	104
<i>Jannis Stecken, Kay Lenkenhoff, Bernd Kuhlenkötter</i>	
<b>APPLICATION OF FEATURE SELECTION METHODS FOR DEFINING CRITICAL PARAMETERS IN THERMOPLASTICS INJECTION MOLDING</b> .....	110
<i>Olga Ogorodnyk, Ole Vidar Lyngstad, Mats Larsen, Kristian Martinsen</i>	

<b>IDENTIFICATION OF INTERACTIONS BETWEEN DIGITAL TECHNOLOGIES IN MANUFACTURING SYSTEMS .....</b>	<b>115</b>
<i>Carina Siedler, Pascal Langlotz, Jan C. Aurich</i>	
<b>A SURVEY ON AUTOMATIC MODEL GENERATION FOR MATERIAL FLOW SIMULATION IN DISCRETE MANUFACTURING .....</b>	<b>121</b>
<i>Heiner Reinhardt, Marek Weber, Matthias Putz</i>	
<b>MULTI-OBJECTIVE TESTING OF DIFFERENT BRASS ALLOY COMPONENTS FOR DFM .....</b>	<b>127</b>
<i>Sampsa V. A. Laakso, Jakob Johansson, Daniel Johansson, Fredrik Schultheiss, Jan-Eric Ståhl</i>	
<b>RECONFIGURATION OF PRODUCTION SYSTEMS USING OPTIMIZATION AND MATERIAL FLOW SIMULATION .....</b>	<b>133</b>
<i>Georg Hoellthaler, Martin Schreiber, Kilian Vernickel, Johannes Be Isa, Stefan Braunreuther</i>	
<b>COMBINING CHANNEL THEORY AND SEMANTIC WEB TECHNOLOGY TO BUILD UP A PRODUCTION CAPABILITY MATCHING FRAMEWORK .....</b>	<b>139</b>
<i>Andreas Bildstein, Junkang Feng, Thomas Bauernhansl</i>	
<b>A FRAMEWORK TO PREDICT ENERGY RELATED KEY PERFORMANCE INDICATORS OF MANUFACTURING SYSTEMS AT EARLY DESIGN PHASE .....</b>	<b>145</b>
<i>F. Assad, B. Alkan, M. K. Chinnathai, M. H. Ahmad, R. Harrison</i>	
<b>EXPLORING APPLICATION FIELDS OF ADDITIVE MANUFACTURING ALONG THE PRODUCT LIFE CYCLE .....</b>	<b>151</b>
<i>Kathrin Pfähler, Dominik Morar, Hans-Georg Kemper</i>	
<b>TASK BALANCING BETWEEN HUMAN AND ROBOT IN MID-HEAVY ASSEMBLY TASKS .....</b>	<b>157</b>
<i>Morteza Dianatfar, Jyrki Latokartano, Minna Lanz</i>	
<b>HOW TO IMPROVE WORKER'S WELL-BEING AND COMPANY PERFORMANCE: A METHOD TO IDENTIFY EFFECTIVE CORRECTIVE ACTIONS .....</b>	<b>162</b>
<i>Martina Scafà, Alessandra Papetti, Agnese Brunzini, Michele Germani</i>	
<b>AN ANALYSIS OF PREMIUM PAYMENTS AS A MECHANISM FOR SECURING PREFERENTIAL SERVICE IN CLOUD MANUFACTURING .....</b>	<b>168</b>
<i>Andrew Ma, Aydın Nassehi, Chris Snider</i>	
<b>UPGRADING AND ENSURING A FULLY-AUTOMATED ASSEMBLY PROCESS USING TOLERANCE MANAGEMENT METHODS .....</b>	<b>174</b>
<i>Rainer Müller, Matthias Vette-Steinkamp, Matthias Scholer, Leonie Schirmer, Anne Blum</i>	
<b>A FRAMEWORK FOR PLANNING LOGISTICAL ALTERNATIVES IN VALUE STREAM DESIGN .....</b>	<b>180</b>
<i>Joscha Kaiser, Christian Urnauer, Joachim Metternich</i>	
<b>A DESIGN OF AN AUTOMATED COMPACT POSITIONING SYSTEM FOR WORKPIECE POSITIONING IN MACHINE TOOL WORKSPACE .....</b>	<b>186</b>
<i>Tomasz Bartkowiak, Marcin Kaczmarek, Adam Myszkowski, Marcin Pelic</i>	
<b>CHARACTERIZATION OF AUTONOMOUS PRODUCTION BY A STAGE MODEL .....</b>	<b>192</b>
<i>Dennis Bauer, Simon Schumacher, Alexander Gust, Joachim Seidelmann, Thomas Bauernhansl</i>	
<b>DETERMINATION OF THE ABSTRACTION LEVEL IN PRODUCTION NETWORK MODELS .....</b>	<b>198</b>
<i>Martin Benfer, Moritz Ziegler, Andreas Gützlaff, Bastian Fränken, Günther Schuh</i>	
<b>SIMULATION BASED PRODUCTION SUPPORT SYSTEM IN THE FIELD OF STEEL CONSTRUCTION FOR LARGE OFFSHORE STRUCTURES .....</b>	<b>204</b>
<i>Benjamin Illgen, Jan Sender, Wilko Flügge</i>	
<b>STABILIZATION OF REMOVAL RATE IN SMALL TOOL POLISHING OF GLASS LENSES .....</b>	<b>210</b>
<i>Urara Satake, Toshiyuki Enomoto, Teppei Miyagawa, Takuya Ohsumi, Katsuhiko Funabashi</i>	
<b>INTEGRATION OF CONDITION BASED MAINTENANCE ORDERS INTO THE DECISION-MAKING OF AUTONOMOUS CONTROL METHODS .....</b>	<b>216</b>
<i>Fabian Foerster, Daniel Mueller, David Scholz, Alexander Michalik, Lorenz Kiebler</i>	
<b>TOWARD DATA-DRIVEN PRODUCTION SIMULATION MODELING: DISPATCHING RULE IDENTIFICATION BY MACHINE LEARNING TECHNIQUES .....</b>	<b>222</b>
<i>Satoshi Nagahara, Timothy A. Sprock, Moneer M. Helu</i>	
<b>INTRODUCING A METHODOLOGY FOR SMARTIFICATION OF PRODUCTS IN MANUFACTURING INDUSTRY .....</b>	<b>228</b>
<i>Günther Schuh, Violetta Zeller, Jan Hicking, Anne Bernardy</i>	
<b>DESIGN, IMPLEMENTATION AND EVALUATION OF REINFORCEMENT LEARNING FOR AN ADAPTIVE ORDER DISPATCHING IN JOB SHOP MANUFACTURING SYSTEMS .....</b>	<b>234</b>
<i>Andreas Kuhnle, Louis Schäfer, Nicole Stricker, Gisela Lanza</i>	
<b>REVIEWING DIGITAL MANUFACTURING CONCEPT IN THE INDUSTRY 4.0 PARADIGM .....</b>	<b>240</b>
<i>Elias Hans Dener Ribeiro Da Silva, Ana Carolina Shinohara, Edson Pinheiro De Lima, Jannis Angelis, Carla Gonçalves Machado</i>	

<b>KNOWLEDGE ACQUISITION IN PRODUCT PLANNING OF FRUGAL MANUFACTURING SYSTEMS FOR EMERGING MARKETS</b> .....	246
<i>Uwe Schleinkofer, Daniel Moz, Thomas Bauernhansl, Alexander Lang</i>	
<b>REAL-TIME ENVIRONMENTAL ANALYSIS FOR INDUSTRIAL VEHICLES BASED ON SYNTHETIC SENSOR DATA AND DEEP LEARNING</b> .....	252
<i>Axel Börold, Michael Freitag</i>	
<b>DEVELOPMENT OF A METHOD TO INCREASE FLEXIBILITY AND CHANGEABILITY OF SUPPLY CONTRACTS IN THE AUTOMOTIVE INDUSTRY</b> .....	258
<i>Jens Niemann, Stephan Seisenberger, Andreas Schlegel, Matthias Putz</i>	
<b>CYBER-PHYSICAL SYSTEMS AS PART OF FRUGAL MANUFACTURING SYSTEMS</b> .....	264
<i>Uwe Schleinkofer, Kevin Klöpfer, Marco Schneider, Thomas Bauernhansl</i>	
<b>ACOUSTIC EMISSION-BASED CHARACTERIZATION OF FOCAL POSITION DURING ULTRA-SHORT PULSE LASER ABLATION</b> .....	270
<i>Andreas Kacaras, Matthias Bächle, Markus Schwabe, Frederik Zanger, Volker Schulze</i>	
<b>APPROACH TO GENERATE OPTIMIZED ASSEMBLY SEQUENCES FROM SENSOR DATA</b> .....	276
<i>Susann Kärcher, Thomas Bauernhansl</i>	
<b>A METHOD TO EVALUATE INTERFACE COMPATIBILITY DURING PRODUCTION SYSTEM DESIGN AND RECONFIGURATION</b> .....	282
<i>Niko Siltala, Eeva Järvenpää, Minna Lanz</i>	
<b>WEB-BASED SOLUTION TO AUTOMATE CAPABILITY MATCHMAKING FOR RAPID SYSTEM DESIGN AND RECONFIGURATION</b> .....	288
<i>Anant Mital, Niko Siltala, Eeva Järvenpää, Minna Lanz</i>	
<b>COMPARISON OF SIMULATION-BASED AND OPTIMIZATION-BASED ENERGY FLEXIBLE PRODUCTION PLANNING</b> .....	294
<i>Lukas Bank, Martin Rösch, Eric Unterberger, Stefan Roth, Johannes Schilp</i>	
<b>A CYBER-PHYSICAL FAILURE MANAGEMENT SYSTEM FOR SMART FACTORIES</b> .....	300
<i>Matthias Schneider, Dominik Lucke, Thomas Adolf</i>	
<b>MODEL BASED DESIGN APPLIED TO CERAMIC BALLS GRINDING</b> .....	306
<i>M. P. G. Pedroso, C. A. Fortulan</i>	
<b>MULTI-PROTOCOL DATA AGGREGATION AND ACQUISITION FOR DISTRIBUTED CONTROL SYSTEMS</b> .....	310
<i>David Albert Breunig, Matthias Schneider</i>	
<b>DETERMINING STABLE EQUILIBRIA OF SPATIAL OBJECTS AND VALIDATING THE RESULTS WITH DROP SIMULATION</b> .....	316
<i>Márk Fekula, Gergely Horváth</i>	
<b>USABILITY OF INFORMATION SYSTEMS TO SUPPORT DECISION MAKING IN THE ORDER MANAGEMENT PROCESS</b> .....	322
<i>Martin Kunath, Herwig Winkler</i>	
<b>SAFEGUARDING OF AN AUTOMATED ASSEMBLY PROCESS USING A BALANCED DECOUPLING UNIT AND THE HRC SWITCHING MODE</b> .....	328
<i>Thomas Koch, Bahman Soltani</i>	
<b>A SIMULATION FRAMEWORK TO ANALYZE INFORMATION FLOWS IN A SMART FACTORY WITH FOCUS ON RUN-TIME ADAPTABILITY OF MACHINE TOOLS</b> .....	334
<i>H. Komoto, S. Kondoh, Y. Furukawa, H. Sawada</i>	
<b>SURVEY OF CONFIGURATION DESIGN APPROACHES: A FOCUS ON DESIGN OF COMPLEX INDUSTRIAL MANUFACTURING SYSTEMS</b> .....	340
<i>Fan Liu, Ye Zhang, Chen Zheng, Xiansheng Qin, Benoît Eynard</i>	
<b>AN APPLICATION OF 3D MODEL RECONSTRUCTION AND AUGMENTED REALITY FOR REAL-TIME MONITORING OF ADDITIVE MANUFACTURING</b> .....	346
<i>Ammar Malik, Hugo Lhachemi, Joern Ploennigs, Amadou Ba, Robert Shorten</i>	
<b>SOFTWARE MODEL REQUIREMENTS APPLIED TO A CYBER-PHYSICAL MODULAR ROBOT IN A PRODUCTION ENVIRONMENT</b> .....	352
<i>Liliana Zarco, Jörg Siegert, Thomas Bauernhansl</i>	
<b>INVESTIGATION OF FLM MATERIALS FOR APPLICATION IN HIGH-TEMPERATURE AND HIGH-VIBRATION AUTOMOTIVE ENVIRONMENTS</b> .....	358
<i>Achim Kampker, Johannes B. Triebs, Peter Ayvaz, Dennis Ilic</i>	
<b>AN ADAPTIVE FRAMEWORK FOR AUGMENTED REALITY INSTRUCTIONS CONSIDERING WORKFORCE SKILL</b> .....	363
<i>Dimitris Mourtzis, Fotini Xanthi, Vasilios Zogopoulos</i>	
<b>DATA ANALYTICS FOR MANUFACTURING SYSTEMS – A DATA-DRIVEN APPROACH FOR PROCESS OPTIMIZATION</b> .....	369
<i>Florian Ungermann, Andreas Kuhnle, Nicole Stricker, Gisela Lanza</i>	

<b>DIRECT MACHINING OF SELECTIVE LASER MELTED COMPONENTS WITH OPTIMIZED SUPPORT STRUCTURES</b> .....	375
<i>Christian Höller, Thomas Hinterbuchner, Philipp Schwemberger, Philipp Zopf, Franz Haas</i>	
<b>ANALYSIS OF CHIP SHAPE DISTRIBUTION USING IMAGE PROCESSING TECHNOLOGY TO ESTIMATE WEARING CONDITION OF GEAR GRINDING WHEEL</b> .....	381
<i>Hiroyuki Karasawa, Takehito Yoshida, Rui Fukui, Toru Kizaki, Shin'Ichi Warisawa</i>	
<b>OVERVIEW OF THE STATE OF THE ART IN THE PRODUCTION PROCESS OF AUTOMOTIVE WIRE HARNESSSES, CURRENT RESEARCH AND FUTURE TRENDS</b> .....	387
<i>Jerome Trommnau, Jens Kühnle, Jörg Siegert, Robert Inderka, Thomas Bauernhansl</i>	
<b>CYBER-PHYSICAL PRODUCTION SYSTEM FINGERPRINTING</b> .....	393
<i>Daniel Stock, Daniel Schel</i>	
<b>CHALLENGES IN DEVELOPING MODULAR SERVICES IN MANUFACTURING COMPANIES: A MULTIPLE CASE STUDY IN DANISH MANUFACTURING INDUSTRY</b> .....	399
<i>Maria Støettrup Schioenning Larsen, Ann-Louise Andersen, Kjeld Nielsen, Thomas Ditlev Brunoe</i>	
<b>STABILITY ANALYSIS ON RESOURCE MATCHING IN CROWDSOURCED MANUFACTURING</b> .....	405
<i>Takafumi Chida, Toshiya Kaihara, Nobutada Fujii, Daisuke Kokuryo</i>	
<b>EVALUATION OF INVESTMENTS IN THE DIGITALIZATION OF A PRODUCTION</b> .....	411
<i>Robert Joppen, Andre Lipsmeier, Christian Tewes, Arno Kühn, Roman Dumitrescu</i>	
<b>METHODOLOGY FOR ENABLING DIGITAL TWIN USING ADVANCED PHYSICS-BASED MODELLING IN PREDICTIVE MAINTENANCE</b> .....	417
<i>P. Aivaliotis, K. Georgoulas, Z. Arkouli, S. Makris</i>	
<b>MACHINE LEARNING-BASED ICING PREDICTION ON WIND TURBINES</b> .....	423
<i>Markus Kreutz, Abderrahim Ait-Alla, Kamaloddin Varasteh, Stephan Oelker, Klaus-Dieter Thoben</i>	
<b>A MACHINE LEARNING BASED ENERGY EFFICIENT TRAJECTORY PLANNING APPROACH FOR INDUSTRIAL ROBOTS</b> .....	429
<i>Shubin Yin, Wei Ji, Lihui Wang</i>	
<b>DEVELOPMENT OF A DECISION LOGIC FOR THE SELECTION OF A FLEXIBLE ROBOTIC SYSTEM FOR THE AUTOMATED MANUFACTURING IN TOOLING</b> .....	435
<i>Marcel Wilms, Thomas Bergs, Kristian Arntz, Lars Johannsen, Simon Strassburg</i>	
<b>BENEFIT EVALUATION OF DIGITAL ASSISTANCE SYSTEMS FOR ASSEMBLY WORKSTATIONS</b> .....	441
<i>Thimo Keller, Christian Bayer, Phillip Bausch, Joachim Metternich</i>	
<b>AUTOMOBILE MAINTENANCE PREDICTION USING DEEP LEARNING WITH GIS DATA</b> .....	447
<i>Chong Chen, Ying Liu, Xianfang Sun, Carla Di Cairano-Gilfedder, Scott Titmus</i>	
<b>CHARACTERIZING STRIP SNAP IN COLD ROLLING PROCESS USING ADVANCED DATA ANALYTICS</b> .....	453
<i>Zheyuan Chen, Ying Liu, Agustin Valera-Medina, Fiona Robinson</i>	
<b>INFLUENCE OF WALL THICKNESS ON THE HARDNESS OF ALSI10MG ALLOY PARTS MANUFACTURED BY SELECTIVE LASER MELTING</b> .....	459
<i>Arfan Majeed, Altaf Ahmed, Bufan Liu, Shan Ren, Jiahao Yang</i>	
<b>ADDITIVELY MANUFACTURED MILLING TOOL WITH FOCUSED CUTTING FLUID SUPPLY</b> .....	464
<i>T. Lakner, T. Bergs, B. Döbbeler</i>	
<b>PERIPHERY EVALUATION FOR INTERLINKED MANUFACTURING SYSTEMS IN INDUSTRIAL TOOLING</b> .....	470
<i>Marcel Prümmer, Thomas Bergs, Kristian Arntz, Christian Lürken</i>	
<b>RPM-SYNCHRONOUS GRINDING - INVESTIGATION AND COMPARISON OF SURFACE TOPOGRAPHY OF SYNCHRO-FINISH MANUFACTURED WORKPIECES</b> .....	476
<i>Thomas Spenger, Franz Haas, Ulrike Cihak-Bayr, Stefan J. Eder, Michael Schneider</i>	
<b>ADDITIVE MANUFACTURING FROM THE SUSTAINABILITY PERSPECTIVE: PROPOSAL FOR A SELF-ASSESSMENT TOOL</b> .....	482
<i>Carla Gonçalves Machado, Mélanie Despeisse, Mats Winroth, Elias Hans Dener Ribeiro Da Silva</i>	
<b>KINEMATICS ANALYSIS AND SELF - COLLISION DETECTION OF TRUSS TYPE MULTI-ROBOT COOPERATIVE WELDING PLATFORM</b> .....	488
<i>Ziting Hou, Shumei Ma, Qingfei Zeng, Aiping Li</i>	
<b>VALIDATION OF A PHYSICS ENGINE FOR THE SIMULATION OF MATERIAL FLOWS IN CYBER-PHYSICAL PRODUCTION SYSTEMS</b> .....	494
<i>Moritz Glatt, Daniel Kull, Bahram Ravani, Jan C. Aurich</i>	
<b>TRACING THE INTERRELATIONSHIP BETWEEN KEY PERFORMANCE INDICATORS AND PRODUCTION COST USING BAYESIAN NETWORKS</b> .....	500
<i>Suraj Panicker, Hari P. N. Nagarajan, Hossein Mokhtarian, Azarakhsh Hamedi, Kari Koskinen</i>	

<b>LASER POWDER BED FUSION OF A MAGNESIUM-SIC METAL MATRIX COMPOSITE</b> .....	506
<i>Wessel W. Wits, Marc De Smit, Kamaal Al-Hamdani, Adam T. Clare</i>	
<b>VISUALIZATION SUPPORT FOR DESIGN OF MANUFACTURING SYSTEMS AND PROTOTYPES – LESSONS LEARNED FROM TWO CASE STUDIES</b> .....	512
<i>Lars Andre Langøyli Giske, Tommy Benjaminsen, Ola Jon Mork, Trond Løydal</i>	
<b>FRAMEWORK FOR ROBUST DESIGN AND RELIABILITY METHODS TO DEVELOP FRUGAL MANUFACTURING SYSTEMS</b> .....	518
<i>Uwe Schleinkofer, Martin Dazer, Kevin Lucan, Oliver Mannuß, Thomas Bauernhansl</i>	
<b>EFFECT OF DWELL TIME AND PRESS SPEED ON THE FORMING QUALITY OF THE PRESS FORMED WOOD PLASTIC COMPOSITE PRODUCT</b> .....	524
<i>Amir Toghyani, Sami Matthews, Juha Varis</i>	
<b>AUTOMATION DECISIONS IN FLOW-LINE ASSEMBLY SYSTEMS BASED ON A COST-BENEFIT ANALYSIS</b> .....	529
<i>Peter Burggräf, Johannes Wagner, Matthias Dannapfel, Sarah Fluchs, Benjamin Koke</i>	
<b>INTEGRATION OF ENGINEERING AND MANUFACTURING CHANGE MANAGEMENT: INFRASTRUCTURE AND SCENARIOS FOR TEACHING AND DEMONSTRATION</b> .....	535
<i>Eldar Shakirov, Felix J. Brandl, Harald Bauer, Niklas Kattner, Ighor Uzhinsky</i>	
<b>PLATFORM-BASED SERVICE COMPOSITION FOR MANUFACTURING: A CONCEPTUALIZATION</b> .....	541
<i>Jonathan Fuchs, Sascha Julian Oks, Jörg Franke</i>	
<b>ON AN EVOLUTIONARY INFORMATION SYSTEM FOR PERSONALIZED SUPPORT TO PLANT OPERATORS</b> .....	547
<i>Nikolaos Nikolakis, Ioannis Stathakis, Sotirios Makris</i>	
<b>THE IMPACT OF DIGITAL TECHNOLOGIES ON OPERATIONAL CAUSES OF THE BULLWHIP EFFECT – A LITERATURE REVIEW</b> .....	552
<i>Marc Wiedenmann, Andreas Größler</i>	
<b>STUDY ON AGVS BATTERY CHARGING STRATEGY FOR IMPROVING UTILIZATION</b> .....	558
<i>Xiangnan Zhan, Liyun Xu, Jian Zhang, Aiping Li</i>	
<b>DATA DRIVEN SMART CUSTOMIZATION</b> .....	564
<i>Cheng Zhang, Daindi Chen, Fei Tao, Ang Liu</i>	
<b>A SENSOR REDUCED MACHINE LEARNING APPROACH FOR CONDITION-BASED ENERGY MONITORING FOR MACHINE TOOLS</b> .....	570
<i>Johannes Sossenheimer, Jessica Walther, Jan Fleddermann, Eberhard Abele</i>	
<b>AN AUTOMATED PACKAGING PLANNING APPROACH USING MACHINE LEARNING</b> .....	576
<i>Dino Knoll, Daniel Neumeier, Marco Prüglmeier, Gunther Reinhart</i>	
<b>OH, NO – NOT ANOTHER POLICY! OH, YES - AN OT-POLICY!</b> .....	582
<i>John Lindström, Petra Viklund, Fredrik Tideman, Berndt Hällgren, Jonny Elvelin</i>	
<b>COMBINING SIMULATION AND AUGMENTED REALITY METHODS FOR ENHANCED WORKER ASSISTANCE IN MANUAL ASSEMBLY</b> .....	588
<i>Eva Lampen, Jonas Teuber, Felix Gaisbauer, Thomas Bär, Sven Wachsmuth</i>	
<b>A ROBUST OPTIMIZATION APPROACH FOR UNEQUAL-AREA DYNAMIC FACILITY LAYOUT WITH DEMAND UNCERTAINTY</b> .....	594
<i>Xi Xiao, Yaoguang Hu, Weidong Wang, Weibo Ren</i>	
<b>A HUMAN-IN-THE-LOOP CYBER-PHYSICAL SYSTEM FOR COLLABORATIVE ASSEMBLY IN SMART MANUFACTURING</b> .....	600
<i>Manuel A. Ruiz Garcia, Rafael Rojas, Luca Gualtieri, Erwin Rauch, Dominik Matt</i>	
<b>IMPLEMENTATION OF THE MIALINX USER INTERFACE FOR FUTURE MANUFACTURING ENVIRONMENTS</b> .....	606
<i>Dominik Lucke, Frank Steimle, Emir Cuk, Michael Luckert, Daniel Schel</i>	
<b>A SUITABILITY ANALYSIS METHOD FOR ADDITIVE MANUFACTURING TECHNOLOGIES IN SMALL AND MEDIUM-SIZED COMPANIES</b> .....	612
<i>Julian Ilg, Albrecht Oehler, Dominik Lucke</i>	
<b>IT-BASED ARCHITECTURE FOR POWER MARKET ORIENTED OPTIMIZATION AT MULTIPLE LEVELS IN PRODUCTION PROCESSES</b> .....	618
<i>Philipp Seitz, Eberhard Abele, Lukas Bank, Thomas Bauernhansl, Thomas Weber</i>	
<b>ENABLERS AND INHIBITORS OF INDUSTRY 4.0: RESULTS FROM A SURVEY OF INDUSTRIAL COMPANIES IN NORWAY</b> .....	624
<i>Maria Flavia Mogos, Ragnhild J. Eleftheriadis, Odd Myklebust</i>	
<b>AUTOMATIC ESTIMATE OF OEE CONSIDERING UNCERTAINTY</b> .....	630
<i>Zhang Heng, Li Aiping, Xu Liyun, Giovanni Moroni</i>	
<b>AUTOMATIZED SETUP OF PROCESS MONITORING IN CYBER-PHYSICAL SYSTEMS</b> .....	636
<i>Clemens Gonnermann, Gunther Reinhart</i>	

<b>IMPROVING MANUFACTURING PRODUCTIVITY BY COMBINING COGNITIVE ENGINEERING AND LEAN-SIX SIGMA METHODS.</b> .....	641
<i>Frank Gleeson, Paul Coughlan, Lizbeth Goodman, Anthony Newell, Vincent Hargaden</i>	
<b>INTEGRATIVE SIMULATION OF INFORMATION FLOWS IN MANUFACTURING SYSTEMS</b> .....	647
<i>Sebastian Thiede, Filz Marc-André, Bastian Thiede, Niels L. Martin, Christoph Herrmann</i>	
<b>CHARACTERISTICS OF A CIRCULAR ECONOMY FRAMEWORK TO SUPPORT STRATEGIC RENEWAL IN MANUFACTURING FIRMS</b> .....	653
<i>Nillo Halonen, Matti Majuri, Minna Lanz</i>	
<b>HUMAN CENTERED LEAN AUTOMATION IN ASSEMBLY</b> .....	659
<i>Ali Ahmad Malik, Arne Bilberg</i>	
<b>COLLABORATIVE ROBOTS IN ASSEMBLY: A PRACTICAL APPROACH FOR TASKS DISTRIBUTION</b> .....	665
<i>Ali Ahmad Malik, Arne Bilberg</i>	
<b>EVOLUTIONARY ALGORITHMS IN ADDITIVE MANUFACTURING SYSTEMS: DISCUSSION OF FUTURE PROSPECTS</b> .....	671
<i>Torbjørn Schjelderup Leirmo, Kristian Martinsen</i>	
<b>MIXING, CONVEYING AND INJECTION MOLDING HYBRID SYSTEM FOR CONDUCTIVE POLYMER COMPOSITES</b> .....	677
<i>Daniël Serban, Giuseppe Lamanna, Constantin Gheorghe Opran</i>	
<b>TOWARDS ENERGY FLEXIBLE AND ENERGY SELF-SUFFICIENT MANUFACTURING SYSTEMS</b> .....	683
<i>Christine Schulze, Stefan Blume, Lukas Siemon, Christoph Herrmann, Sebastian Thiede</i>	
<b>CLOSED LOOP CYCLE TIME FEEDBACK TO OPTIMIZE HIGH-MIX / LOW-VOLUME PRODUCTION PLANNING</b> .....	689
<i>M. Messner, F. Pauker, G. Mauthner, T. Frühwirth, J. Mangler</i>	
<b>AUTOMATIC TIME SERIES SEGMENTATION AS THE BASIS FOR UNSUPERVISED, NON-INTRUSIVE LOAD MONITORING OF MACHINE TOOLS</b> .....	695
<i>J-P. Seevers, J. Johst, T. Weiß, H. Meschede, J. Hesselbach</i>	
<b>MACHINE LEARNING TECHNOLOGIES FOR ORDER FLOWTIME ESTIMATION IN MANUFACTURING SYSTEMS</b> .....	701
<i>Rory Murphy, Anthony Newell, Vincent Hargaden, Nikolaos Papakostas</i>	
<b>REDISTRIBUTED MANUFACTURING OF SPARE PARTS: AN AGENT-BASED MODELLING APPROACH</b> .....	707
<i>Yousef Haddad, Konstantinos Salonitis, Christos Emmanouilidis</i>	
<b>HIERARCHICAL MOTION CONTROL FOR REAL TIME SIMULATION OF INDUSTRIAL ROBOTS</b> .....	713
<i>Tadele Belay Tuli, Martin Manns</i>	
<b>REAL-TIME ASSET TRACKING; A STARTING POINT FOR DIGITAL TWIN IMPLEMENTATION IN MANUFACTURING</b> .....	719
<i>Kousay Samir, Antonio Maffei, Mauro A. Onori</i>	

## PART 2

<b>MODELLING AND ASSESSING LINE-LESS MOBILE ASSEMBLY SYSTEMS</b> .....	724
<i>Guido Hüttemann, Armin F. Buckhorst, Robert H. Schmitt</i>	
<b>GENERIC AUTOMATION TASK DESCRIPTION FOR FLEXIBLE ASSEMBLY SYSTEMS</b> .....	730
<i>Rainer Müller, Matthias Scholer, Martin Karkowski</i>	
<b>GRADUAL TOOL-BASED OPTIMIZATION OF ENGINEERING PROCESSES AIMING AT A KNOWLEDGE-BASED CONFIGURATION OF ROBOT-BASED AUTOMATION SOLUTIONS</b> .....	736
<i>Eike Schäffer, Andreas Mayr, Tobias Huber, Tobias Höflinger, Jörg Franke</i>	
<b>ERGONOMICS SIMULATION IN AIRCRAFT MANUFACTURING – METHODS AND POTENTIALS</b> .....	742
<i>Florian Beuß, Jan Sender, Wilko Flügge</i>	
<b>VISION-BASED MELT POOL MONITORING SYSTEM SETUP FOR ADDITIVE MANUFACTURING</b> .....	747
<i>Ambra Vandone, Stefano Baraldo, Anna Valente, Federico Mazzucato</i>	
<b>DERIVING ESSENTIAL COMPONENTS OF LEAN AND INDUSTRY 4.0 ASSESSMENT MODEL FOR MANUFACTURING SMES</b> .....	753
<i>Sri Kolla, Meysam Minufekr, Peter Plapper</i>	
<b>KEY PERFORMANCE INDICATORS IN THE PRODUCTION OF THE FUTURE</b> .....	759
<i>Robert Joppen, Sebastian Von Enzberg, Jan Gundlach, Arno Kühn, Roman Dumitrescu</i>	



<b>CHARACTERIZATION OF THE IMPACT OF DIGITALIZATION ON THE ADOPTION OF SUSTAINABLE BUSINESS MODELS IN MANUFACTURING .....</b>	<b>765</b>
<i>Antonio Maffei, Sten Grahn, Cali Nuur</i>	
<b>A VISUAL INSPECTION SYSTEM FOR KTL COATINGS.....</b>	<b>771</b>
<i>Drago Bracun, Igor Lekše</i>	
<b>ENERGY FLEXIBLE MANAGEMENT OF INDUSTRIAL TECHNICAL BUILDING SERVICES: A SYNERGETIC DATA-DRIVEN AND SIMULATION APPROACH FOR COOLING TOWERS .....</b>	<b>775</b>
<i>Christine Schulze, Martin Plank, Johannes Linzbach, Christoph Herrmann, Sebastian Thiede</i>	
<b>APPLICABILITY EVALUATION OF KINECT FOR EAWS ERGONOMIC ASSESSMENTS .....</b>	<b>781</b>
<i>Michael Otto, Eva Lampen, Felix Auris, Felix Gaisbauer, Enrico Rukzio</i>	
<b>A VIRTUAL REALITY ASSEMBLY ASSESSMENT BENCHMARK FOR MEASURING VR PERFORMANCE &amp; LIMITATIONS .....</b>	<b>785</b>
<i>Michael Otto, Eva Lampen, Philipp Agethen, Mareike Langohr, Enrico Rukzio</i>	
<b>TRANSPARENCY IN THE DESIGN-ACCOMPANYING PRODUCTION ON SHIPYARDS.....</b>	<b>791</b>
<i>Konrad Jagusch, Jan Sender, Wilko Flügge</i>	
<b>EMPOWERING ASSEMBLY WORKERS WITH COGNITIVE DISABILITIES BY WORKING WITH COLLABORATIVE ROBOTS: A STUDY TO CAPTURE DESIGN REQUIREMENTS .....</b>	<b>797</b>
<i>Johan Kildal, Miguel Martín, Ibon Ipiña, Iñaki Maurtua</i>	
<b>DEVELOPING AN AUGMENTED REALITY BASED TRAINING DEMONSTRATOR FOR MANUFACTURING CHERRY PICKERS .....</b>	<b>803</b>
<i>Francesca Ferrati, John Ahmet Erkoyuncu, Samuel Court</i>	
<b>DATA MINING FOR FAULT DIAGNOSTICS: A CASE FOR PLASTIC INJECTION MOLDING .....</b>	<b>809</b>
<i>DominiK Kozjek, Rok Vrabic, David Kralj, Peter Butala, Nada Lavrac</i>	
<b>REVIEW ON MACHINE DESIGNS OF MATERIAL EXTRUSION BASED ADDITIVE MANUFACTURING (AM) SYSTEMS - STATUS-QUO AND POTENTIAL ANALYSIS FOR FUTURE AM SYSTEMS.....</b>	<b>815</b>
<i>Achim Kampker, Johannes Triebs, Sebastian Kawollek, Peter Ayzaz, Steffen Hohenstein</i>	
<b>COMPENSATION OF PART DISTORTION IN PROCESS DESIGN FOR RE-CONTOURING PROCESSES.....</b>	<b>820</b>
<i>Volker Böß, Felix Rust, Marc-André Dittrich, Berend Denkena</i>	
<b>DISTRIBUTED LOGISTICS PLATFORM BASED ON BLOCKCHAIN AND IOT .....</b>	<b>826</b>
<i>Nejc Rožman, Rok Vrabic, Marko Corn, Tomaž Požrl, Janez Diaci</i>	
<b>DISPLAYING PRODUCT MANUFACTURING INFORMATION IN AUGMENTED REALITY FOR INSPECTION .....</b>	<b>832</b>
<i>Uroš Urbas, Rok Vrabic, Nikola Vukašinovic</i>	
<b>PROCEDURE TO SUSTAIN COMPETITIVE ADVANTAGE IN AN ERA OF CHANGING DOMINANT DESIGN .....</b>	<b>838</b>
<i>Sebastian Rauch</i>	
<b>EVALUATION OF LOCALIZATION SYSTEMS FOR CNC MACHINING OF LARGE FRPC PARTS.....</b>	<b>844</b>
<i>Luka Selak, Drago Bracun</i>	
<b>AN ONTOLOGY FOR SUPPORTING DIGITAL MANUFACTURABILITY ANALYSIS .....</b>	<b>850</b>
<i>Ji Han, Dirk Schaefer</i>	
<b>REVIEW ON APPROACHES TO GENERATE ASSEMBLY SEQUENCES BY EXTRACTION OF ASSEMBLY FEATURES FROM 3D MODELS .....</b>	<b>856</b>
<i>Alexander Neb</i>	
<b>BUILDING OF INTERNET OF THINGS MODEL FOR CYBER-PHYSICAL MANUFACTURING METROLOGY MODEL (CPM3).....</b>	<b>862</b>
<i>Vidosav Majstorovic, Srdjan Živkovic, Dragan Djurdjanovic, Ramin Sabbagh, Nemanja Gligorijevic</i>	
<b>FRAMEWORK FOR THE USAGE OF DATA FROM REAL-TIME INDOOR LOCALIZATION SYSTEMS TO DERIVE INPUTS FOR MANUFACTURING SIMULATION.....</b>	<b>868</b>
<i>Carina Mieth, Anne Meyer, Michael Henke</i>	
<b>DATA MINING DEFINITIONS AND APPLICATIONS FOR THE MANAGEMENT OF PRODUCTION COMPLEXITY .....</b>	<b>874</b>
<i>Günther Schuh, Gunther Reinhart, Jan-Philipp Prote, Frederick Sauer mann, Dino Knoll</i>	
<b>TOWARDS INTELLIGENT AND SUSTAINABLE PRODUCTION SYSTEMS WITH A ZERO-DEFECT MANUFACTURING APPROACH IN AN INDUSTRY4.0 CONTEXT .....</b>	<b>880</b>
<i>John Lindström, Erik Lejon, Petter Kyösti, Massimo Mecella, Bengt Gunnarsson</i>	
<b>INVESTIGATING THE THERMAL PROPERTIES OF CARBON STEEL STKM13A FOR THE WELDING ASSEMBLY OF RAIL CAR SUSPENSION SYSTEM.....</b>	<b>886</b>
<i>I. A. Daniyan, K. Mpoju, A. O. Adeodu</i>	

<b>A HYBRID FRAMEWORK FOR INDUSTRIAL DATA STORAGE AND EXPLOITATION</b> .....	892
<i>K. Grevenitis, F. Psarommatas, A. Reina, W. Xu, D. Kiritis</i>	
<b>VISUALISATION OF THE DIGITAL TWIN DATA IN MANUFACTURING BY USING AUGMENTED REALITY</b> .....	898
<i>Zexuan Zhu, Chao Liu, Xun Xu</i>	
<b>INFLUENCE OF RAKE FACE TEXTURING ON MACHINING PERFORMANCE OF CARBIDE TOOLS</b> .....	904
<i>Damir Grguraš, Franci Pušavec</i>	
<b>DEVELOPMENT OF A NEW MECHANIC SAFETY COUPLING FOR HUMAN ROBOT COLLABORATION USING MAGNETORHEOLOGICAL FLUIDS</b> .....	908
<i>Arik Lämmle</i>	
<b>THE IMPACT OF SERVICITIZATION AND DIGITAL TRANSFORMATION - A CONCEPTUAL EXTENSION OF THE IPOO-FRAMEWORK</b> .....	914
<i>Philipp Humbeck, Kathrin Pfähler, Marc Wiedenmann, Georg Herzwurm</i>	
<b>MODELLING OF ABRASIVE WATER JET CUTTING WITH CONTROLLED DEPTH FOR NEAR-NET-SHAPE FABRICATION</b> .....	920
<i>Eckart Uhlmann, Constantin Männel</i>	
<b>APPROACH TO INCREASE WORKER ACCEPTANCE OF COGNITIVE ASSISTANCE SYSTEMS IN MANUAL ASSEMBLY</b> .....	926
<i>Robin Sochor, Lorenz Kraus, Lukas Merkel, Stefan Braunreuther, Gunther Reinhart</i>	
<b>VIRTUALIZATION OF A SUPPLY CHAIN FROM THE MANUFACTURING ENTERPRISE VIEW USING E-CATALOGUES</b> .....	932
<i>Michiko Matsuda, Tatsushi Nishi, Mao Hasegawa, Sota Matsumoto</i>	
<b>AN INDUSTRY-ORIENTED APPROACH FOR MACHINE CONDITION-BASED PRODUCTION SCHEDULING</b> .....	938
<i>Mathias Karner, Robert Glawar, Wilfried Sihn, Kurt Matyas</i>	
<b>POTENTIAL BENEFITS AND CHALLENGES OF CHANGEABLE MANUFACTURING IN THE PROCESS INDUSTRY</b> .....	944
<i>Rasmus Andersen, Ann-Louise Andersen, Maria S. S. Larsen, Thomas D. Brunoe, Kjeld Nielsen</i>	
<b>BLOCK-BASED ANALYTICAL HIERARCHY PROCESS APPLIED FOR THE EVALUATION OF CONSTRUCTION SECTOR ADDITIVE MANUFACTURING</b> .....	950
<i>Panagis Foteinopoulos, Alexios Papacharalampopoulos, Panagiotis Stavropoulos</i>	
<b>PROBABILISTIC MODELLING OF DEFECTS IN ADDITIVE MANUFACTURING: A CASE STUDY IN POWDER BED FUSION TECHNOLOGY</b> .....	956
<i>Hossein Mokhtarian, Azarakhsh Hamed, Hari P. N. Nagarajan, Suraj Panicker, Karl Haapala</i>	
<b>A FRAMEWORK FOR PILOT LINE SCALE-UP USING DIGITAL MANUFACTURING</b> .....	962
<i>Malarvizhi Kaniappan Chinnathai, Zeinab Al-Mowafy, Bugra Alkan, Daniel Vera, Robert Harrison</i>	
<b>FREE-FORM SURFACE ANALYSIS AND LINKING STRATEGIES FOR HIGH REGISTRATION ACCURACY IN QUALITY ASSURANCE APPLICATIONS</b> .....	968
<i>Philipp Bauer, Alejandro Magaña Flores, Gunther Reinhart</i>	
<b>IMPACT OF RISK ATTITUDES ON THE CONCURRENT DESIGN OF SUPPLY CHAINS AND PRODUCT ARCHITECTURES</b> .....	974
<i>Jessica Olivares Aguila, Waguih Elmaraghy, Hoda Elmaraghy</i>	
<b>KNOWLEDGE-BASED PROCESS PLANNING FOR ECONOMICAL RE-SCHEDULING IN PRODUCTION CONTROL</b> .....	980
<i>Berend Denkena, Marc-André Dittrich, Siebo Claas Stamm, Vannila Prasanthan</i>	
<b>BROWNFIELD DEVELOPMENT OF PLATFORMS FOR CHANGEABLE MANUFACTURING</b> .....	986
<i>Daniel G. H. Sorensen, Thomas Ditlev Brunoe, Kjeld Nielsen</i>	
<b>DESIGN CONCEPTS FOR THE INTEGRATION OF ELECTRONIC COMPONENTS INTO METAL LASER-BASED POWDER BED FUSION PARTS</b> .....	992
<i>Maximilian Binder, Ludwig Kirchbichler, Christian Seidel, Christine Anstaett, Gunther Reinhart</i>	
<b>EXTENDING THE AUTOMATION PYRAMID FOR INDUSTRIAL DEMAND RESPONSE</b> .....	998
<i>Marc-Fabian Körner, Dennis Bauer, Robert Keller, Martin Rösch, Gunther Reinhart</i>	
<b>ANALYZING DIFFERENT MATERIAL SUPPLY STRATEGIES IN MATRIX-STRUCTURED MANUFACTURING SYSTEMS</b> .....	1004
<i>Marc-André Filz, Johann Gerberding, Christoph Herrmann, Sebastian Thiede</i>	
<b>INVESTIGATION AND ANALYSIS OF ACCUMULATORS FOR THE USE OF ELECTROCHEMICAL STORAGE IN HYBRID SHUNTING LOCOMOTIVES</b> .....	1010
<i>Martin Richter, Amirhossein Sarram, Christian Kaucher, Herwig Winkler</i>	
<b>DESIGN OF NETWORKED MANUFACTURING SYSTEMS FOR INDUSTRY 4.0</b> .....	1016
<i>Jelena Milisavljevic-Syed, Janet K. Allen, Sesh Commuri, Farrokh Mistree</i>	

<b>APPROACH FOR EXTENDING EVALUATION CRITERIA FOR SCALABLE AND MODULAR INDUSTRIAL ROBOTS.....</b>	1022
<i>Thomas Rossmeissl, Erwin Groß, Liliana Zarco, Thilo Schlegel, Thomas Bauernhansl</i>	
<b>BURNISHING OF PRISMATIC WORKPIECES ON THREE-AXIS MACHINE ENABLED BY CLOSED LOOP FORCE CONTROL.....</b>	1028
<i>Marco Posdlich, Chris Schöberlein, Johannes Quellmaltz, Matthias Putz</i>	
<b>KINEMATICS ANALYSIS AND TRAJECTORY PLANNING OF COLLABORATIVE WELDING ROBOT WITH MULTIPLE MANIPULATORS.....</b>	1034
<i>Xuemei Liu, Chengrong Qiu, Qingfei Zeng, Aiping Li</i>	
<b>INTEGRATED OPTIMIZATION OF MIXED-MODEL ASSEMBLY LINE BALANCING AND BUFFER ALLOCATION BASED ON OPERATION TIME COMPLEXITY.....</b>	1040
<i>Xuemei Liu, Mingliang Lei, Qingfei Zeng, Aiping Li</i>	
<b>MTO/MTS POLICY OPTIMIZATION FOR SHEET METAL PLATE PARTS IN AN ATO ENVIRONMENT.....</b>	1046
<i>M. Bortolini, M. Faccio, M. Gamberi, F. Pilati</i>	
<b>ACTIVE LEARNING FOR ACCURATE SETTLEMENT PREDICTION USING NUMERICAL SIMULATIONS IN MECHANIZED TUNNELING.....</b>	1052
<i>Amal Saadallah, Alexey Egorov, Ba-Trung Cao, Steffen Freitag, Günther Meschke</i>	
<b>RESEARCH ON HYBRID-LOAD AGV DISPATCHING PROBLEM FOR MIXED-MODEL AUTOMOBILE ASSEMBLY LINE.....</b>	1059
<i>Lixiang Zhang, Yaoguang Hu, Yu Guan</i>	
<b>PRODUCT AND PROCESS VARIETY MANAGEMENT: CASE STUDY IN THE FOOD INDUSTRY.....</b>	1065
<i>Sofie Bech, Thomas Ditlev Brunoe, Kjeld Nielsen, Ann-Louise Andersen</i>	
<b>A BETTER UNDERSTANDING OF CRYOGENIC MACHINING USING CFD AND FEM SIMULATION.....</b>	1071
<i>Charlie Salame, Roland Bejjani, Prakash Marimuthu</i>	
<b>NEW PRODUCT SIMILARITY INDEX DEVELOPMENT WITH APPLICATION TO AN ASSEMBLY SYSTEM TYPOLOGY SELECTION.....</b>	1077
<i>Paul Stief, Jean-Yves Dantan, Alain Etienne, Ali Siadat, Guillaume Burgat</i>	
<b>AN INTEGRATED REVERSE ENGINEERING AND FAILURE ANALYSIS APPROACH FOR RECOVERY OF MECHANICAL SHAFTS.....</b>	1083
<i>Bernd Engel, Sara Salman Hassan Al-Maeni</i>	
<b>BIG DATA DRIVEN SUPPLY CHAIN MANAGEMENT.....</b>	1089
<i>Qi Li, Ang Liu</i>	
<b>IDENTIFYING THE POTENTIAL OF EDGE COMPUTING IN FACTORIES THROUGH MIXED REALITY.....</b>	1095
<i>Jakob Zietsch, Lennart Büth, Max Juraschek, Nils Weinert, Christoph Herrmann</i>	
<b>COMPARING ACQUISITION AND OPERATION LIFE CYCLE COSTS OF POWDER METALLURGY AND CONVENTIONAL WROUGHT STEEL GEAR MANUFACTURING TECHNIQUES.....</b>	1101
<i>Babak Kianian</i>	
<b>A DECISION SUPPORT METHOD FOR EVALUATION AND PROCESS SELECTION OF ADDITIVE MANUFACTURING.....</b>	1107
<i>Harry Bikas, Sotiris Koutsoukos, Panagiotis Stavropoulos</i>	
<b>INDUSTRY 4.0 READINESS IN MANUFACTURING COMPANIES: CHALLENGES AND ENABLERS TOWARDS INCREASED DIGITALIZATION.....</b>	1113
<i>Carla Gonçalves Machado, Mats Winroth, Dan Carlsson, Peter Almström, Malin Hallin</i>	
<b>STRUCTURAL DEVELOPMENT AND EVALUATION OF PROFITABLE INDUSTRIAL USE CASES BASED ON INNOVATIVE TECHNOLOGIES LIKE 5G.....</b>	1119
<i>Volker Stich, Anne Bernardy, Vasco Seelmann, Jan Hicking</i>	
<b>VIRTUAL COMMISSIONING – SCIENTIFIC REVIEW AND EXPLORATORY USE CASES IN ADVANCED PRODUCTION SYSTEMS.....</b>	1125
<i>Tobias Lechler, Eva Fischer, Maximilian Metzner, Andreas Mayr, Jörg Franke</i>	
<b>END MILLING OF INCONEL 718 USING SOLID SI3N4 CERAMIC CUTTING TOOLS.....</b>	1131
<i>Daniel Finkeldei, Marcus Sexauer, Friedrich Bleicher</i>	
<b>REDUCING MEAN TARDINESS IN A FLEXIBLE JOB SHOP CONTAINING AGVS WITH OPTIMIZED COMBINATIONS OF SEQUENCING AND ROUTING RULES.....</b>	1136
<i>Jens Heger, Thomas Voss</i>	
<b>DEFINING SECTOR-SPECIFIC GUIDING PRINCIPLES FOR INITIATING SUSTAINABILITY WITHIN COMPANIES.....</b>	1142
<i>Lara Waltersmann, Steffen Kiemel, Yvonne Amann, Alexander Sauer</i>	

<b>SUSTAINABILITY – RECOMMENDATIONS FOR AN ELECTRIC VEHICLE</b>	
<b>MANUFACTURING IN SUB-SAHARAN AFRICA .....</b>	<b>1148</b>
<i>Matthias Brönnner, Marie-Sophie Hagenauer, Markus Lienkamp</i>	
<b>AUTOMATED STATISTICAL EVALUATION OF ENERGY DATA IN THE AUTOMOTIVE</b>	
<b>PRODUCTION.....</b>	<b>1154</b>
<i>Ingo Labbus, Hanno Teiwes, Marc-André Filz, Christoph Herrmann, Sebastian Thiede</i>	
<b>DYNAMIC PRODUCTION CONTROL FOR FLEXIBILITY IN CYBER-PHYSICAL</b>	
<b>PRODUCTION SYSTEMS USING AN AUTONOMOUS TRANSPORT SYSTEM.....</b>	<b>1160</b>
<i>Michaela Krü, Sebastian Hörbrand, Johannes Schilp</i>	
<b>AUTOMATIC OPTICAL SURFACE INSPECTION OF WIND TURBINE ROTOR BLADES</b>	
<b>USING CONVOLUTIONAL NEURAL NETWORKS.....</b>	<b>1166</b>
<i>Dimitri Denhof, Benjamin Staar, Michael Lütjen, Michael Freitag</i>	
<b>EVALUATION OF THE INFLUENCE OF DIFFERENT INNER CORES ON THE DYNAMIC</b>	
<b>BEHAVIOR OF BORING BARS .....</b>	<b>1171</b>
<i>B. Thorenz, M. Friedrich, H.-H. Westermann, F. Döpfer</i>	
<b>ACTIVITY RECOGNITION IN MANUAL MANUFACTURING: DETECTING SCREWING</b>	
<b>PROCESSES FROM SENSOR DATA .....</b>	<b>1177</b>
<i>Lisa C. Günther, Susann Kärcher, Thomas Bauernhansl</i>	
<b>FORECASTING CHANGES IN MATERIAL FLOW NETWORKS WITH STOCHASTIC BLOCK</b>	
<b>MODELS.....</b>	<b>1183</b>
<i>Thorben Funke, Till Becker</i>	
<b>REMOTE-LASER WELDING SYSTEM WITH IN-LINE ADAPTIVE 3D SEAM TRACKING AND</b>	
<b>POWER CONTROL .....</b>	<b>1189</b>
<i>Matjaž Kos, Erih Arko, Hubert Kosler, Matija Jezeršek</i>	
<b>APPROACH FOR A PRODUCTION PLANNING AND CONTROL SYSTEM IN VALUE-ADDING</b>	
<b>NETWORKS.....</b>	<b>1195</b>
<i>Alexander Zipfel, Stefan Braunreuther, Gunther Reinhart</i>	
<b>A NOVEL OPTIMIZATION METHOD FOR MODULAR FACILITIES LAYOUT PROBLEM</b>	
<b>CONSIDERING FLEXIBLE PROCESSES.....</b>	<b>1201</b>
<i>Weibo Ren, Jingqian Wen, Yu Guan, Yaoguang Hu</i>	
<b>JOINT OPTIMIZATION OF DYNAMIC FACILITY LAYOUT AND PRODUCTION PLANNING</b>	
<b>BASED ON PETRI NET.....</b>	<b>1207</b>
<i>Weidong Wang, Yaoguang Hu, Xi Xiao, Yu Guan</i>	
<b>EXPLORING PROCESS VARIANCE IN ASSEMBLY PLANNING WITH NON-FIXED</b>	
<b>SIMULATION PARAMETERS .....</b>	<b>1213</b>
<i>Felix Auris, Felix Gaisbauer, Thomas Bär</i>	
<b>COST DRIVEN GREEN KAIZEN IN PHARMACEUTICAL PRODUCTION – CREATING</b>	
<b>POSITIVE ENGAGEMENT FOR ENVIRONMENTAL IMPROVEMENTS.....</b>	<b>1219</b>
<i>Monica Bellgran, Martin Kurdve, Rodan Hanna</i>	
<b>CHARACTERIZATION AND MECHANICAL PROPERTIES OF AS-BUILT SLM TI-6AL-4V</b>	
<b>SUBJECTED TO SURFACE MECHANICAL POST-TREATMENT .....</b>	<b>1225</b>
<i>Y. Eyzat, M. Chemkhi, Q. Portella, J. Gardan, D. Retraint</i>	
<b>MODELLING AND SIMULATION BASED SURFACE CHARACTERIZATION OF REVERSE-</b>	
<b>µEDM FABRICATED MICRO PIN-FINS .....</b>	<b>1230</b>
<i>Hreetabh Kishore, Rahul Nadda, Chandrakant K Nirala, Anupam Agrawal</i>	
<b>HANDLING CELL COMPONENTS IN THE PRODUCTION OF MULTI-LAYERED LARGE</b>	
<b>FORMAT ALL-SOLID-STATE BATTERIES WITH LITHIUM ANODE .....</b>	<b>1236</b>
<i>Fabian Konwitschny, Joscha Schnell, Gunther Reinhart</i>	
<b>ENABLING KNOWLEDGE TRANSFER THROUGH ANALYTICS IN INDUSTRIAL SOCIAL</b>	
<b>NETWORKS.....</b>	<b>1242</b>
<i>Dimitris Mourtzis, Fotini Xanthi, Konstantinos Chariatidis, Vasilios Zogopoulos</i>	
<b>CHOOSING EFFICIENT META-HEURISTICS TO SOLVE THE ASSEMBLY LINE BALANCING</b>	
<b>PROBLEM: A LANDSCAPE ANALYSIS APPROACH .....</b>	<b>1248</b>
<i>Amir Nourmohammadi, Masood Fathi, Amos H. C. Ng</i>	
<b>REAL-TIME ASSISTANCE TO MANUAL ASSEMBLY THROUGH DEPTH CAMERA AND</b>	
<b>VISUAL FEEDBACK .....</b>	<b>1254</b>
<i>Maurizio Faccio, Emilio Ferrari, Francesco G. Galizia, Mauro Gamberi, Francesco Pilati</i>	
<b>APPROACH FOR THE OBSERVATION OF SURFACE CONDITIONS IN-PROCESS BY SOFT</b>	
<b>SENSORS DURING CRYOGENIC HARD TURNING .....</b>	<b>1260</b>
<i>Julian Uebel, Felix Ströer, Stephan Basten, Werner Ankener, Tilmann Beck</i>	

<b>A SIMULTANEOUS OPTIMIZATION FRAMEWORK FOR PRODUCT FAMILY CONFIGURATION AND SUPPLY CHAIN PLANNING .....</b>	<b>1266</b>
<i>Tatsushi Nishi, Takuya Tsuboi, Michiko Matsuda</i>	
<b>PREDICTION OF WELD INTERFACE DEPTH AND WIDTH AT OPTIMUM LASER WELDING TEMPERATURE FOR POLYPROPYLENE.....</b>	<b>1272</b>
<i>N. Kumar, R. Sherlock, D. Tormey</i>	
<b>PRODUCTION ASPECT OF DIRECT DRIVE IN-WHEEL MOTORS.....</b>	<b>1278</b>
<i>Matej Bicek, Tomaž Pepelnjak, Franci Pušavec</i>	
<b>DEVELOPMENT OF A SOCIOTECHNICAL PLANNING SYSTEM FOR HUMAN-ROBOT INTERACTION IN ASSEMBLY SYSTEMS FOCUSING ON SMALL AND MEDIUM-SIZED ENTERPRISES .....</b>	<b>1284</b>
<i>Vanessa Weßkamp, Tatjana Seckelmann, André Barthelme, Marcus Kaiser, Jochen Deuse</i>	
<b>DIGITAL TWIN DRIVEN GREEN MATERIAL OPTIMAL-SELECTION TOWARDS SUSTAINABLE MANUFACTURING .....</b>	<b>1290</b>
<i>Feng Xiang, Zhi Zhang, Ying Zuo, Fei Tao</i>	
<b>COLLABORATIVE VIRTUAL REALITY DECISION TOOL FOR PLANNING INDUSTRIAL SHOP FLOOR LAYOUTS .....</b>	<b>1295</b>
<i>Vincent Havard, Anirudh Trigunayat, Killian Richard, David Baudry</i>	
<b>HYBRID MODELING OF THERMO-ELASTIC BEHAVIOR OF A THREE-AXIS MACHINING CENTER USING INTEGRAL DEFORMATION SENSORS .....</b>	<b>1301</b>
<i>Christian Brecher, Tae Hun Lee, Filippos Tzanetos, Daniel Zontar</i>	
<b>THE EFFECT OF THE DEFORMATION RATE ON THE WALL THICKNESS OF 1.5LT PET BOTTLE DURING ISBM (INJECTION STRETCH BLOW MOLDING) PROCESS.....</b>	<b>1307</b>
<i>A. Lontos, A. Gregoriou</i>	
<b>METROLOGICAL PRODUCTION CONTROL FOR ULTRA-FLEXIBLE FACTORIES .....</b>	<b>1313</b>
<i>Thilo Schlegel, Jörg Siegert, Thomas Bauernhansl</i>	
<b>A VARIABLE FREQUENCY SAMPLING METHOD FOR SUDDEN SMALL-VOLUME DATA AND CONVENTIONAL LARGE-VOLUME DATA .....</b>	<b>1319</b>
<i>Jiangfeng Cheng, Xiaofu Zou, Ying Zuo, Ang Liu, Fei Tao</i>	
<b>ADVANCES IN ENERGY-RELATED PLANT SIMULATION BY CONSIDERING LOAD AND TEMPERATURE PROFILES IN DISCRETE EVENT SIMULATION .....</b>	<b>1325</b>
<i>Andreas Mayr, Tobias Lechler, Toni Donhauser, Maximilian Metzner, Jörg Franke</i>	
<b>MODULAR SMART CONTROLLER FOR INDUSTRY 4.0 FUNCTIONS IN MACHINE TOOLS .....</b>	<b>1331</b>
<i>David Barton, Philipp Gönnheimer, Florian Schade, Christopher Ehrmann, Jürgen Fleischer</i>	
<b>THE EFFECT OF OPERATIONAL POLICIES ON PRODUCTION SYSTEMS ROBUSTNESS: AN AEROSPACE CASE STUDY.....</b>	<b>1337</b>
<i>Emanuele Pagone, Konstantinos Efthymiou, Brandon Mahoney, Konstantinos Salonitis</i>	
<b>PERFORMANCE EVALUATION OF STOCHASTIC FORWARD AND REVERSE SUPPLY NETWORKS.....</b>	<b>1342</b>
<i>Mohammadtaghi Falsafi, Rosanna Fornasiero, Walter Terkaj</i>	
<b>ASSISTED SETUP OF FORMING PROCESSES: ARCHITECTURE FOR THE INTEGRATION OF NON-ADJUSTABLE DISTURBANCES .....</b>	<b>1348</b>
<i>Manuel Gräler, Astrid Wallow, Christian Henke, Ansgar Trächtler</i>	
<b>THE CARBON FOOTPRINT OF MANUFACTURING DIGITALIZATION: CRITICAL LITERATURE REVIEW AND FUTURE RESEARCH AGENDA.....</b>	<b>1354</b>
<i>John Patsavellas, Konstantinos Salonitis</i>	
<b>A DESCRIPTIVE FRAMEWORK TO CHARACTERIZE THE MANUFACTURING DOMAIN IN THE CONTEXT OF BUSINESS MODELS .....</b>	<b>1360</b>
<i>Eleonora Boffa, Antonio Maffei</i>	
<b>MAPPING AND DESIGN OF INFORMATION PROCESSING FOR MACHINING OF INDIVIDUALIZED COMPONENTS.....</b>	<b>1366</b>
<i>Carsten Schaede, Lukas Hartmann, Joachim Mettermich</i>	
<b>DEALING WITH DISRUPTIONS IN LOW-VOLUME MANUFACTURING: A CONSTRAINT PROGRAMMING APPROACH .....</b>	<b>1372</b>
<i>Olga Battaia, Lorenzo Sanmartin, Cédric Pralet</i>	
<b>EFFECT OF EXTRUSION TEMPERATURE ON PRINTABLE THRESHOLD OVERHANG IN ADDITIVE MANUFACTURING .....</b>	<b>1376</b>
<i>Jingchao Jiang, Xun Xu, Jonathan Stringer</i>	
<b>DESIGN OF A SALES AND OPERATIONS PLANNING (S&amp;OP) PROCESS – CASE STUDY .....</b>	<b>1382</b>
<i>Paulo Ávila, Daniela Lima, Dália Moreira, António Pires, João Bastos</i>	
<b>DIGITAL TWIN FOR MACHINING TOOL CONDITION PREDICTION .....</b>	<b>1388</b>
<i>Qianzhe Qiao, Jinjiang Wang, Lunkuan Ye, Robert X. Gao</i>	

<b>THE DEGREE OF MASS PERSONALISATION UNDER INDUSTRY 4.0</b> .....	1394
<i>Shohin Aheleroff, Ross Philip, Ray Y. Zhong, Xun Xu</i>	
<b>POTENTIAL-BASED TECHNOLOGY PLANNING FOR PRODUCTION COMPANIES</b> .....	1400
<i>Andreas Hofer, Joscha Schnell, Benedict Beck, Gunther Reinhart</i>	
<b>RECONFIGURABLE ASSEMBLY STATION: A CONSUMER GOODS INDUSTRY PARADIGM</b> .....	1406
<i>Panagiotis Karagiannis, Stereos Alexandros Matthaïakis, Dionisis Andronas, Konstantinos Filis, Sotiris Makris</i>	
<b>INCREASE IN TOOL LIFE FOR END MILLING TITANIUM ALLOYS USING TOOLS WITH MULTILAYER COMPOSITE NANOSTRUCTURED MODIFIED COATINGS</b> .....	1412
<i>Alexey Vereschaka, Vladimir Gurin, Maksim Oganyan, Gaik Oganyan, Alexander Shein</i>	
<b>SMART MAINTENANCE – DYNAMIC MODEL-BASED INSTRUCTIONS FOR SERVICE OPERATIONS</b> .....	1417
<i>Eckart Uhlmann, David Franke, Eckhard Hohwieler</i>	
<b>CHANGEABLE MANUFACTURING SYSTEMS SUPPORTING CIRCULAR SUPPLY CHAINS</b> .....	1423
<i>Thomas D. Brunoe, Ann-Louise Andersen, Kjeld Nielsen</i>	
<b>ENABLING HUMAN ROBOT INTERACTION IN FLEXIBLE ROBOTIC ASSEMBLY LINES: AN AUGMENTED REALITY BASED SOFTWARE SUITE</b> .....	1429
<i>Niki Kousi, Christos Stoubos, Christos Gkournelos, George Michalos, Sotiris Makris</i>	
<b>OPTIMAL REDESIGN OF CELLULAR FLEXIBLE AND RECONFIGURABLE MANUFACTURING SYSTEMS</b> .....	1435
<i>Marco Bortolini, Emilio Ferrari, Francesco Gabriele Galizia, Cristina Mora, Francesco Pilati</i>	
<b>BUSINESS MODEL FOR INTEGRATING ENERGY EFFICIENCY PERFORMANCE IN MANUFACTURING INDUSTRIES: RAILCAR CASE STUDY</b> .....	1441
<i>Gabisile Buyiswa Gamede, Khumbulani Mpofu, Olukorede Tijani Adenuga</i>	
<b>A METHOD FOR LEAN ENERGY ASSESSMENT OF MANUFACTURING SYSTEMS</b> .....	1447
<i>Giulia Di Domizio, Roberto Menghi, Alessandra Papetti, Michele Germani, Marco Marconi</i>	
<b>Author Index</b>	