

# **39th North American Manufacturing Research Conference 2011**

**Transactions of the North American Manufacturing Research  
Institution of SME Volume 39, 2011**

**Corvallis, Oregon, USA  
13-17 June 2011**

**ISBN: 978-1-61839-057-8  
ISSN: 2161-220X**

**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© (2011) by the Society of Manufacturing Engineers  
All rights reserved.

Printed by Curran Associates, Inc. (2011)

For permission requests, please contact the Society of Manufacturing Engineers  
at the address below.

Society of Manufacturing Engineers  
One SME Drive  
Dearborn, Michigan 48128

Phone: 800-733-4763 or 313-425-3000  
Fax: 313-425-3400

[www.sme.org](http://www.sme.org)

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

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2634  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## FORMING 1

<b>Theoretical and Experimental Investigation of the Springback Characteristics of Metal Foam</b> .....	1
<i>Steven Schmid, Paul Nebosky, Miguel-Angel Selles</i>	
<b>Prediction and Analysis of Fracture in Single Point Incremental Forming Using a Damage Based Material Model</b> .....	11
<i>Rajiv Malhotra, Liang Xue, Jian Cao, Ted Belytschko, K. Scott Smith, John Ziegert</i>	
<b>Experimental Investigation of Key Assumptions in Analytical Failure Criteria for Sheet Metal Forming</b> .....	21
<i>Tugce Kasikci, Joseph F. Wilson, Brad L. Kinsey</i>	

## FORMING 2

<b>Optimization of Parameters in Roll Forming Process of Aluminum Automotive Component by Neural Network and Genetic Algorithm</b> .....	31
<i>Hong-Seok Park, Tran Viet Anh</i>	
<b>Optimal Load Path Input in Tube Hydroforming Machines</b> .....	40
<i>Gracious Ngaile, Grant Welch</i>	

## MICRO-BIO FABRICATION

<b>Automated Micro-Transfer Printing With Cantilevered Stamps</b> .....	50
<i>Numair Ahmed, Placid Ferreira, Andrew Carlson, John A. Rogers</i>	
<b>Alginate Microsphere Fabrication Using Bipolar Wave-Based Drop-on-Demand Jetting</b> .....	60
<i>C. Leigh Herran, Yong Huang</i>	
<b>A High-Resolution Electrohydrodynamic Jet Printing System</b> .....	69
<i>P. G. Graf, E. Sutanto, K. L. Barton, A. G. Alleyne, J. A. Rogers, P. M. Ferreira</i>	

## MANUFACTURING SYSTEM 1

<b>Automatic Generation of Assembly System Configuration With Equipment Selection for Automotive Battery Manufacturing</b> .....	78
<i>Sha Li, Hui Wang, S. Jack Hu, Yhu-Tin Lin, Jeffrey A. Abell</i>	
<b>An Evolutionary Operation Sequence Optimization Tool for Robotic Spot Welding Based on Collision-Free Path Planner in Virtual Manufacturing</b> .....	88
<i>Mohammad Givehchi, Amos Ng, Lihui Wang</i>	
<b>A Web-Based Framework for Semantic Supplier Discovery for Discrete Part Manufacturing</b> .....	99
<i>Farhad Ameri, Christian McArthur, Bahram Asiabanpour, Mohammad Hayasi</i>	

## MANUFACTURING SYSTEMS 2

<b>Compensability of Errors in Product Quality in Multistage Manufacturing Processes</b> .....	108
<i>Yibo Jiao, Dragan Djurdjanovic</i>	
<b>Segmentation and Segment Dynamics of a Serial Manufacturing System</b> .....	118
<i>Saumil Ambani, Lin Li, Jun Ni</i>	

## ADDITIVE AND POLYMER MANUFACTURING

<b>Additive Manufacturing Based on Optimized Mask Video Projection for Improved Accuracy and Resolution</b> .....	125
<i>Yong Chen, Chi Zhou</i>	

<b>Optimal Part Orientation in Rapid Manufacturing Process for Achieving Geometric Tolerances</b> .....	135
<i>Ratnadeep Paul, Sam Anand</i>	
<b>Modeling of a Subcritical CO<sub>2</sub> Microcellular Foam Extrusion Process</b> .....	145
<i>Yongha Kim, Wei Li</i>	

### **SUSTAINABLE MANUFACTURING 1**

<b>An Ontology-Based Approach to Develop Sustainable Manufacturing Metrics for Supply Chain Evaluation</b> .....	152
<i>Fazleena Badurdeen, Chris Stovall, I. S. Jawahir, Thomas J. Goldsby, Mohannad Shuaib, Haritha Metta</i>	
<b>Greenhouse Gas Emission Mitigation of Global Automotive Manufacturing Through Clean Energy Supply</b> .....	162
<i>Huajun Cao, Qiang Zhai, Xiang Zhao, Chris Yuan</i>	
<b>Environmental Impact and Cost Assessment of Product Service Systems Using IDEF0 Modeling</b> .....	172
<i>Hao Zhang, Karl R. Haapala, Mary E. Vanlue, Kenneth H. Funk II</i>	

### **SUSTAINABLE MANUFACTURING 2**

<b>A New Approach to Scheduling in Manufacturing for Power Consumption and Carbon Footprint Reduction</b> .....	182
<i>Kan Fang, Nelson Uhan, John W. Sutherland, Fu Zhao</i>	
<b>Feature Level Energy Assessments for Discrete Part Manufacturing</b> .....	190
<i>Amit Deshpande, John Snyder, Dan Scherrer</i>	
<b>Software-Based Tool Path Evaluation for Environmental Sustainability</b> .....	198
<i>Daeyoung Kong, Seungchoun Choi, Yusuke Yasui, Sushrut Pavanaskar, David Dornfeld, Paul Wright</i>	

### **MACHINING 1**

<b>Statistically Based Process Optimization for Improved Surface Quality in Micro-End Milling of Ti-6Al-4V Titanium Alloy</b> .....	207
<i>Thanongsak Thepsonthi, Tugrul Ozel</i>	
<b>A Solid Modeler Based Simulation of Chip Load in Broaching Operation</b> .....	217
<i>H. A. Kishawy, A. Hosseini, H. El-Mounayri</i>	
<b>Efficient Machining of Hardened AISI 52100 Steel Using a Laser-Based Hybrid Process</b> .....	224
<i>Satyanarayanan Raghavan, Fukuo Hashimoto, Shreyes Melkote</i>	

### **MACHINING 2**

<b>Model for the Indentation Force in Metal Cutting</b> .....	233
<i>Amit A. Deshpande, Vis Madhavan, Amir H. Adibi-Sedeh</i>	
<b>Orthogonal Machining of Single-Crystal and Coarse-Grained Aluminum</b> .....	243
<i>Nithyanand Kota, O. Burak Ozdoganlar</i>	
<b>Tool Temperatures in Orthogonal Cutting of Alloyed Titanium</b> .....	253
<i>Robert W. Ivester</i>	

### **MACHINING 3**

<b>Fixture Shape Rigidity Evaluation by an Integrated Machining &amp; Vibration Analysis</b> .....	260
<i>Yajun Fan, Richard K. Huff</i>	
<b>Influence of Size Effect and Radial Runouts on the End Milling of a Nickel-Based Superalloy</b> .....	268
<i>Manuel Estrems, Horacio T. Sanchez, Thomas Kurfess, Cristina Bunget, Andrew Henderson, Boyce J. Richardson</i>	
<b>The Effect of Machining Variables on the Machinability of Turning/Boring Compacted Graphite Iron</b> .....	277
<i>John S. Agapiou</i>	

## **MACHINING 4**

<b>Aero-Lap Polishing of Poly Crystalline Diamond Inserts Using Multicon Media</b> .....	287
<i>K. Ramesh, Serdar Ozbayraktar, Habib Saridikme</i>	
<b>Micro-Scratch Testing and Simulations for Adhesion Characterizations of Diamond-Coated Tools</b> .....	295
<i>Ping Lu, Xingcheng Xiao, Michael Lukitsch, Kevin Chou</i>	
<b>Evaluation of Tool-Grade Ceramics for Use as Precision Cutting Tools</b> .....	305
<i>K. Prashanth Anandan, O. Burak Ozdoganlar</i>	

## **MICRO/NANO MACHINING 1**

<b>Influence of Cutting Edge Roughness on Brittle Cracking in the Milling Process on Soda Lime Glass</b> .....	312
<i>Takenori Ono</i>	
<b>Experimental Study of the Effect of Tool Orientation on Surface Quality in Five-Axis Micro-Milling of Brass Using Ball-End Mills</b> .....	320
<i>M. Javad Barakchi Fard, Evgueni V. Bordatchev</i>	
<b>Micro Dimple Milling on Cylinder Surfaces</b> .....	326
<i>Takashi Matsumura, Satoru Takahashi</i>	

## **MICRO/NANO MACHINING 2**

<b>Modeling and Interpretation of Fiber Orientation-Based Failure Mechanisms in Machining of Carbon Fiber-Reinforced Polymer Composites</b> .....	332
<i>Kevin A. Calzada, Shiv G. Kapoor, Richard E. Devor, Johnson Samuel, Anil K. Srivastava</i>	
<b>Experimental Investigation of the Machinability of Polystyrene Reinforced With Single-Walled Carbon Nanotubes</b> .....	342
<i>C. S. Goo, L. H. Huynh, C. Papadopoulos, M. B. G. Jun, S. S. Park</i>	
<b>AFM Probe Based Nano Mechanical Scratching of Glass</b> .....	350
<i>M. G. Mostofa, C. Park, S. S. Park</i>	

## **NONTRADITIONAL MACHINING**

<b>Study of Coated Microtools in Electrochemical Machining (ECM)</b> .....	358
<i>A. K. Swain, M. M. Sundaram, K. P. Rajurkar</i>	
<b>Experimental Study on Cutting Temperature in Rotary Ultrasonic Machining</b> .....	369
<i>W. L. Cong, Q. Feng, Z. J. Pei, T. W. Deines, C. Treadwell</i>	
<b>Application of Chemical Transformation Induced Fracture for Cutting of Superhard Materials</b> .....	377
<i>Dinesh Kalyanasundaram, Pal Molian, Pranav Shrotriya</i>	

## **MACHINING AND GRINDING TRIBOLOGY**

<b>CFD Investigation of the Impact of the Fluid Properties and Delivery Conditions on Flow and Heat Transfer in Grinding</b> .....	385
<i>Stefan Mihic, Sorin Cioc, Ioan Marinescu, Michael Weismiller</i>	
<b>Effects of Tool Micro-Geometry and Coatings in Turning of Ti-6Al-4V Titanium Alloy</b> .....	395
<i>Mohammad Sima, Durul Ulutan, Tugrul Ozel</i>	
<b>Study of Specific Energy and Friction Coefficient in Minimum Quantity Lubrication Grinding Using Oil-Based Nanolubricants</b> .....	403
<i>Parash Kalita, Ajay P. Malshe, S. Arun Kumar, V. G. Yoganath, T. Gurumurthy</i>	

## **METROLOGY 1**

<b>Effect of Shape Change of the Elastic Model of the Flexible Sensor for Three-Axis Load Measurement of Normal Load and Shearing Load</b> .....	412
<i>Kang Ning Tan, Noboru Nakayama, Masato Kobayashi, Sung-Moo Song, Hiroyuku Takeishi, Hiroaki Fukui, Takuya Suzuki</i>	
<b>Probing System for Measurement of Micro-Scale Components</b> .....	422
<i>Chan-Seo Goo, Martin B. G. Jun, Akinori Saito</i>	

<b>On-Machine Monitoring of Tool Wear With Touch Probes</b> .....	430
<i>Andrew J. Henderson, Cristina J. Bunget, Thomas R. Kurfess</i>	

## **METROLOGY 2**

<b>Comparison of Process Capability Index and Uncertainty Calculations When Using Conventional and Coordinate Metrology Tools</b> .....	438
<i>Mohamed A. Gadalla, Mirosław Popielarczyk</i>	
<b>Evaluation of Optical Fiber Positioning Using Silicon V-Grooves</b> .....	447
<i>Matthew Rueff, Tony Schmitz, Benjamin Griffin, David Mills, Mark Sheplak</i>	

## **MANUFACTURING UNCERTAINTY**

<b>The Effect of Cutting Force Model Coefficient Variability on Process Planning in Milling</b> .....	456
<i>Firat Eren, Robert B. Jerard, Barry K. Fussell</i>	
<b>Tool Life Prediction Using Bayesian Updating</b> .....	466
<i>Jaydeep M. Karandikar, Tony L. Schmitz, Ali E. Abbas</i>	
<b>Model-Augmented Methods for Estimation of Contact Pressure Distribution</b> .....	476
<i>Sripati Sah, Robert X. Gao, Timothy Kurp</i>	

## **JOINING 1**

<b>Laser Welding of Nonwoven Polyglycolic Acid (PGA) Scaffold</b> .....	486
<i>Sambit Rout, Shuting Lei</i>	
<b>An Investigation of Hydroxide Catalysis Bonding Strength</b> .....	493
<i>Hyo Soo Kim, Tony L. Schmitz</i>	
<b>Cooling Rate Limitations in the Diffusion Bonding of Microchannel Arrays</b> .....	500
<i>Brian K. Paul, Gopi K. Lingam</i>	

## **JOINING 2**

<b>The Bauschinger Effect for Cold Finished Mild Steel After Friction Stir Processing</b> .....	509
<i>Brennan S. Domec, William J. Emblom, Theodore A. Kozman, Jim Lee</i>	
<b>Mechanical and Microstructural Properties Prediction by Artificial Neural Networks in FSW Processes of Dual Phase Titanium Alloys</b> .....	517
<i>Gianluca Buffa, Livan Fratini, Fabrizio Micari</i>	

## **LASER PROCESSING**

<b>Effect of Processing Medium and Condition on Absorption Enhancement of Femtosecond Laser Treated a-Si:H Thin Film</b> .....	526
<i>Hongliang Wang, Panjawat Kongsuwan, Gen Satoh, Y. Lawrence Yao</i>	
<b>Strength and Microstructure of Laser Fusion Welded Ti-SS Dissimilar Material Pair</b> .....	536
<i>Gen Satoh, Y. Lawrence Yao, Caian Qiu</i>	
<b>Modeling of Transport Phenomena and Thermal Stress in Spot Laser Keyhole Welding</b> .....	546
<i>Jun Zhou, Amir Khalilollahi, Hai-Lung Tsai</i>	

## **RESIDUAL STRESS IN MANUFACTURING**

<b>Modeling of Autofrettage-Induced Deformations When Manufacturing High Pressure Parts</b> .....	553
<i>Dirk Baehre, Horst Bruennet</i>	
<b>Modeling Residual Stresses Induced by Hole Punching 6013 Aluminum Alloy Side Rails</b> .....	561
<i>Daniel C. Mashack, Jeremy L. Rickli, Jaime A. Camelio, Tory P. Smith, Sean Fleming</i>	

## **DESIGN FOR MANUFACTURING**

<b>Prediction of Porosity in Casting Junctions Using a Mathematical Model Developed Through Design of Experiments</b> .....	571
<i>Elsayed Orady, Abhay Mane, James Knight, Mahmoud Awad</i>	
<b>Design for Manufacture of Bipolar Plates for a PEMFC: A Numerical Study</b> .....	581
<i>Jaikp Mallory, Tequila A. L. Harris, Albert Brown</i>	
<b>System for Computer Aided Cavity Layout Design for Diecasting Dies</b> .....	591
<i>J. Madan, V. Kumar</i>	
<b>Author Index</b>	