MANUFACTURING SCIENCE AND ENGINEERING 1997

VOLUME 2

- Predictable Modeling in Metal Cutting as Means of Bridging Gap Between Theory and Practice
- Advances in Cutting Tools and Work Holding Technology for Machine Tools
- Machine Tools

presented at
THE 1997 ASME INTERNATIONAL MECHANICAL ENGINEERING CONGRESS AND EXPOSITION
NOVEMBER 16–21, 1997
DALLAS, TEXAS

sponsored by
THE MANUFACTURING ENGINEERING DIVISION, ASME

do-sponsed by
THE DYNAMIC SYSTEMS AND CONTROL DIVISION, ASME
THE ELECTRICAL AND ELECTRONIC PACKAGING DIVISION, ASME

principal editor
GLORIA J. WIENS
UNIVERSITY OF FLORIDA

contributing editors
Y. ALTINTAS
R. J. FURNESS
W. J. ENDRES
V. CHANDRASEKHARAN
G. J. WIENS
F. A. REED
C.-P. YEH
S. LIU
A. J. RAFANELLI
C. SAHAY
K. SUBRAMANIAN
E. KANNATEY-ASIBU, JR.
V. P. ASTAKHOV
P. SUBRAMANY
S. MELKOTE
S. M. ATHAVALE
B. ZHANG
J. D. DRESCHER
G. RIZZONI
D. AGONAHER

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
United Engineering Center / 345 East 47th Street / New York, N.Y. 10017
# CONTENTS

**PREDICTIVE MODELING IN METAL CUTTING AS MEANS OF BRIDGING GAP BETWEEN THEORY AND PRACTICE**

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towards Predictive Modeling and Optimization of Machining Operations</td>
<td>3</td>
</tr>
<tr>
<td>I. S. Jawahir, A. K. Balaji, R. Stevenson, and C. A. van Luttervelt</td>
<td>3</td>
</tr>
<tr>
<td>Effect of Process Parameters on Chip Morphology When Machining Hardened Steel</td>
<td>13</td>
</tr>
<tr>
<td>Hossam A. Kishawy and Mohamed A. Elbestawi</td>
<td>13</td>
</tr>
<tr>
<td>Chip Formation When Hard Turning Steel</td>
<td>21</td>
</tr>
<tr>
<td>Amitabh Vyas and Milton C. Shaw</td>
<td>21</td>
</tr>
<tr>
<td>Numerical and Experimental Analysis of Orthogonal Metal Cutting</td>
<td>29</td>
</tr>
<tr>
<td>Vahid Kalhori, Mikael Lundblad, and Lars-Erik Lindgren</td>
<td>29</td>
</tr>
<tr>
<td>A Slip-Line Field for Ploughing During Orthogonal Cutting</td>
<td>37</td>
</tr>
<tr>
<td>Daniel J. Waldorf, Richard E. DeVor, and Shiv G. Kapoor</td>
<td>37</td>
</tr>
<tr>
<td>Direct Observations of the Chip-Tool Interface in Machining</td>
<td>45</td>
</tr>
<tr>
<td>V. Madhavan, S. Chandrasekar, and T. N. Farris</td>
<td>45</td>
</tr>
<tr>
<td>The Bending Moment as the Cause of Chip Formation</td>
<td>53</td>
</tr>
<tr>
<td>Viktor P. Astakhov, Stanislav V. Shvets, and M. O. M. Osman</td>
<td>53</td>
</tr>
<tr>
<td>A Continuum Mechanics Model to Predict Shear Angle and Cutting Forces in Orthogonal Cutting</td>
<td>61</td>
</tr>
<tr>
<td>Y. Zheng, J. W. Sutherland, and W. W. Olson</td>
<td>61</td>
</tr>
<tr>
<td>Dynamic Indentation Hardness of Metals and Its Implications to High Speed Machining</td>
<td>69</td>
</tr>
<tr>
<td>Ghatu Subhash, Brian J. Koeppel, Abhijit Chandra, and Yonggang Y. Huang</td>
<td>69</td>
</tr>
<tr>
<td>White Layers and Thermal Modeling of Hard Turned Surfaces</td>
<td>75</td>
</tr>
<tr>
<td>Y. Kevin Chou and Chris J. Evans</td>
<td>75</td>
</tr>
<tr>
<td>Role of Unloading in Machining of Brittle Materials</td>
<td>83</td>
</tr>
<tr>
<td>A. Chandra, K. Wang, Y. Huang, and G. Subhash</td>
<td>83</td>
</tr>
<tr>
<td>Material Constitutive Modeling Under High Strain Rates and Temperatures Through Orthogonal Machining Tests</td>
<td>91</td>
</tr>
<tr>
<td>Shuting Lei, Yung C. Shin, and Frank P. Incropera</td>
<td>91</td>
</tr>
<tr>
<td>Some Observations on the Uniqueness of Machining</td>
<td>99</td>
</tr>
<tr>
<td>V. Madhavan and S. Chandrasekar</td>
<td>99</td>
</tr>
<tr>
<td>A Study of Wave-Removing Cutting Process Using a Model of Shear Zone With Parallel Boundaries</td>
<td>111</td>
</tr>
<tr>
<td>M. T. Hayajneh, M. O. M. Osman, and V. N. Latinovic</td>
<td>111</td>
</tr>
<tr>
<td>An Experimental Investigation on Application of Basic Orthogonal Cutting Model to Ultra-Precision Diamond Cutting</td>
<td>119</td>
</tr>
<tr>
<td>Koichi Okuda, Motoyoshi Hasegawa, and Toshimichi Moriwaki</td>
<td>119</td>
</tr>
<tr>
<td>Closing the Gap Between CAD/CAM and Machining Process Simulation: A Generic Solution</td>
<td>127</td>
</tr>
<tr>
<td>Hazim A. El-Mounayri, Behnam M. Imani, Mohamed A. Elbestawi, and Allan D. Spence</td>
<td>127</td>
</tr>
<tr>
<td>An Improved Analytical Modeling of Force System in Ball-End Milling</td>
<td>135</td>
</tr>
<tr>
<td>Ismail Lazoglu and Steven Y. Liang</td>
<td>135</td>
</tr>
</tbody>
</table>
Mechanistic Force Models for Chip Control Tools
Rixin Zhu, Shounak M. Athavale, Shiv G. Kapoor, and Richard E. DeVor ............................................................... 269

Engaged Cutting Edge Effects on Tool-Wear and Tool-Life in Turning Operations Using Grooved Cutting Tools
P. X. Li, D. Stein, R. Ghosh, and I. S. Jawahir ........................................................................................................ 277

Influence of the Clamping Mechanism on Tool Failure During Dry High Speed Machining
Tahany I. El-Wardany and Mohamed A. Elbestawi .............................................................................................. 285

A Study on the Dynamics of Toolholders
Joseph Jouraij, Ruxu Du, and Juhchin A. Yang ........................................................................................................ 297

Formation and Breaking of Side-Curl Dominated Short-Spiral Chips
Zhenjia Li, Guimin Qu, Yihong Xu, and Yiming (Kevin) Rong ........................................................................... 305

Correlation of Measured Shoe Forces and Surface Quality in Centerless Grinding
Richard W. Monahan and D. Michael McFarland ................................................................................................. 313

MACHINE TOOLS
Introduction
Bi Zhang and Joseph D. Drescher .............................................................................................................................. 321

Design of a High Speed Milling Machine for Aluminum Aircraft Parts
Jiri Tlusty, Scott Smith, Sinan J. Badrawy, David A. Smith, and Andrew P. Smith .................................................. 323

Tool Path Generation Using C-Space for 5-Axis Machining
Koichi Morishige, Yoshimi Takeuchi, and Kiwamu Kase .................................................................................... 333

Performance Analysis of Parallel Manipulator Architectures for CNC Machining Applications
Jin Wook Kim, Changbeom Park, Jongwon Kim, and F. C. Park ........................................................................... 341

Analysis of Tapered Roller Bearing Stiffness
Timothy Rowell and Yung C. Shin ........................................................................................................................... 349

Improving Gear Profile With an Electroplated CBN Wheel for High Accuracy Gear Profile Grinding and the Development of a Truing Machine for High Accuracy Wheel Grinding
Ryuzo Masaki, Hiroshi Nagata, and Jiro Hisada .................................................................................................... 359

Nonlinearity in a Single Nut, Preloaded, Precision Ball Screw
James F. Cuttino, Thomas A. Dow, and Byron F. Knight ......................................................................................... 367

Investigation of a Special 6-6 Parallel Platform for Contour Milling
Waheed A. Abbasi, Shannon C. Ridgeway, Phillip D. Adsit, Carl D. Crane, and Joseph Duffy .................................. 373

Chatter Suppression via an Oscillating Cutter
Fulun Yang, Bi Zhang, and Junyi Yu .......................................................................................................................... 381

Simulation and Measurement of Chatter in Diamond Turning
David S. Yantek, Eric R. Marsh, Matthew A. Davies, and David E. Gilsinn ............................................................. 389

Delayed Resonance Yields a New Perspective on Regenerative Machine Tool Chatter
Nejat Olgac and Martin Hosek ................................................................................................................................. 395

Stability Analysis in Face Milling Operations: Part 1 — Theory of Stability Lobe Prediction
Steve A. Jensen and Yung C. Shin ............................................................................................................................ 403

Stability Analysis in Face Milling Operations: Part 2 — Experimental Validation and Influencing Factors
Steve A. Jensen and Yung C. Shin ............................................................................................................................ 411
Analytical Expression of the Damping Characteristics of Air-Lubricated Slideways for Machine Tools
Shigeo Kato.............................................................................................................. 419
Theoretical Examination of a New Calibration Method for Multi-Axis Machines
Y. Wang, K. S. Moon, and J. W. Sutherland.............................................................. 427
Forward and Inverse Kinematic Solutions of a New Three Dimensional Metrology Frame
Dale E. Schinstock and James F. Cuttino................................................................. 435
Autonomous Calibration of Hexapod Machine Tools
Hanqi Zhuang, Lixin Liu, and Oren Masory............................................................. 443
High-Speed Scanning of Piezo-Probes for Nano-Fabrication
Donald Croft, David McAllister, and Santosh Devasia............................................. 451

Author Index.............................................................................................................. 459