THE FIRST ASIA PACIFIC SYMPOSIUM ON TECHNOLOGY OF PLASTICITY

PROGRAM INFORMATION
Preface

This special volume includes the papers presented in the First Asia Pacific Symposium on Technology of Plasticity (APSTP 2017) held at National Chung Hsing University, Taichung, Taiwan on November 22-25, 2017. APSTP 2017 features technical and keynote presentations, the most current and relevant trends in academia, industry, and a cultural excursion program. The topics cover metal forming technology, robotics and automation, smart manufacturing technology in metal forming for Industry 4.0, manufacturing management, E-manufacturing and E-business Integration.

There were 87 abstract submissions, among which 53 were invited to submit the full papers. After the Scientific Committee reviewed, 47 papers were accepted to present in the APSTP and included in this special issue. Most of attendees come from China, Japan, Korea, Russia, and Taiwan. In addition, two keynote and four plenary speakers share their excellent research results and technical points of development trend. APSTP offers a great platform for scholars to communicate idea and share experience. Therefore, the attendees request to continue the organizing of APSTP every year.

On behalf of the Organizing Committee, we would like to thank the Ministry of Science and Technology (MOST) in Taiwan for the financial supports and advice. We would like to acknowledge all the authors for their contributions.

Gou-Jen Wang
Editor Dr. Gou-Jen Wang, National Chung Hsing University, Taiwan

Yeong-Maw Hwang
Editor Dr. Yeong-Maw Hwang, National Sun-Yat San University, Taiwan

Kuang-Jau Fann
Editor Dr. Kuang-Jau Fann, National Chung Hsing University, Taiwan

Cho-Pei Jiang
Editor Dr. Cho-Pei Jiang, National Formosa University, Taiwan
Welcome Message from CSTP, JSTP, and KSTP

Dear Chairman Professor Wang, Chairman Professor Hwang, esteemed Colleagues, and Staffs of the Symposium,

On behalf of the China, Japan, and Korea Societies for Technology of Plasticity, it is our honor here to congratulate that Taiwan Society for Technology of Plasticity (TSTP), the newest Society for Technology of Plasticity established in Asia, has taken the incredible first step for our society for Technology of Plasticity Asia-wide. The TSTP actualize the first face-to-face communication and idea-exchanging by holding this fabulous international Symposium for our society in Asia.

Five years have passed since the Taiwan Society for Technology of Plasticity was established in 2012. Professor Hwang humbly mentioned that the Taiwan Society for Technology of Plasticity was established under the encouragement and support of the China Society for Technology of Plasticity, Japan Society for Technology of Plasticity, and Korean Society for Technology of Plasticity. After serving its domestic members and industries for five years, the Taiwan Society for Technology of Plasticity wants to conduct this event to show us their gratitude for the past encouragement and support from these Asian societies.

Thank you, our honorable guests, for your participation. Without your attendance and presentation, this event cannot be so successful. We also show great appreciation to the College of Engineering of National Chung Hsing University here in Taichung for hosting our guests in this great event. Thank you, the staffs, for preparing the program and happenings. Without your hard work, the whole program would not go so smoothly.

Best wishes to the first Asia Pacific Symposium on Technology of Plasticity and the delegates to the symposium.

Thank you and welcome to Taichung.

Debin Shan
Ming Yang
Hyoung Seop Kim
## APSTP 2017

### Agenda

#### Day 1: Wednesday, November 22, 2017

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<td>18:00 – 20:00</td>
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<td>Welcome Reception</td>
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<td>11:10 – 12:00</td>
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<td>12:00 – 13:30</td>
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<td>13:30 – 15:00</td>
<td>Session I – A. Processes</td>
<td>Meeting Room 2</td>
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<tr>
<td>13:30 E1535</td>
<td>Sergei Alexandrov</td>
<td>Meeting Room 3</td>
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### Session I – A. Processes
- **Chairman:** Professor Yasunori Harada, Professor Chang-Cheng Chen
- **Meeting Room 2**
  - 13:30 A1028 Yasunori Harada: Deep drawability of Ti/steel/Ti laminated sheets
  - 13:45 A1048 Sheng-Liang Lin: Geometric Design of Rectangular Cross-sectional Spring

### Session II – E. Methods
- **Chairman:** Professor Sergei Alexandrov, Professor Cho-Pei Jiang

- 13:30 E1573 Sergei Alexandrov: Ideal flow theory of anisotropic materials for design of metal forming processes
- 13:45 E1535 Heng Yang: Characterizing of anisotropy and asymmetry of tubular materials
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>14:00</td>
<td>A1030</td>
<td>Sang Wook Han</td>
<td>Dimensional characteristics of tailor rolled blanks having thickness variations</td>
</tr>
<tr>
<td>14:15</td>
<td>A1052</td>
<td>Chang-Cheng Chen</td>
<td>Numerical Investigation on Micro Cup-Shape Internal Gear in Forging Process</td>
</tr>
<tr>
<td>14:30</td>
<td>A1038</td>
<td>Daokuan Wang</td>
<td>Investigation of a two-step rotary rim-thickening process of disc-like blanks</td>
</tr>
<tr>
<td>14:45</td>
<td>A1046</td>
<td>Ying-Ju Chen</td>
<td>Finite Element Analysis of Rolling Process to Locally Thinning Metal Strips</td>
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<tr>
<td>15:00</td>
<td>I1945</td>
<td>Tsung-Han Huang</td>
<td>Effect of grain size on mini helical gear of pure titanium in hot squeezing deformation process</td>
</tr>
<tr>
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<td>I1945</td>
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</tr>
<tr>
<td>14:00</td>
<td>E1544</td>
<td>Dyi-Cheng Chen</td>
<td>Study of storage shelves deformation using finite element analysis during seismic</td>
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<tr>
<td>14:15</td>
<td>E1567</td>
<td>Chinghua Hung</td>
<td>Design of flexible bulge testing system for evaluating the influence of size effect on thin metal sheets</td>
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<tr>
<td>14:30</td>
<td>J2027</td>
<td>Abdelrahman Farghali</td>
<td>Plasma printing of micro-punch assembly for micro-embossing of aluminum sheets</td>
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<tr>
<td>14:45</td>
<td>E1521</td>
<td>Shusuke Sato</td>
<td>Prediction of shear length in blanking process by numerical analysis</td>
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<tr>
<td>15:00</td>
<td>C1361</td>
<td>Hironori Kan</td>
<td>The effect of geometrical parameters of micro-textured DLC coatings on tribological properties under dry sliding friction</td>
</tr>
<tr>
<td>14:00</td>
<td>E1572</td>
<td>Lihui Lang</td>
<td>Influence of the friction factor on the temperature field in upsetting of a perfectly plastic strip under plane strain conditions</td>
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<tr>
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<td>F1641</td>
<td>Ganfeng Xiao</td>
<td>Research on the dimensional accuracy measurement method of cylindrical spun parts based on machine vision</td>
</tr>
<tr>
<td>15:45</td>
<td>E1520</td>
<td>Akinori Yamanaka</td>
<td>Estimation of hardening parameters for numerical biaxial tensile test by machine learning</td>
</tr>
<tr>
<td>16:00</td>
<td>E1522</td>
<td>Onoshima Shin</td>
<td>Comparing two selection laws of active slip systems in finite element polycrystalline model for numerical material testing</td>
</tr>
<tr>
<td>16:15</td>
<td>E1562</td>
<td>Ryota Ogura</td>
<td>Application of hard coating films to microforming die surface for resistance heating</td>
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<tr>
<td>16:30</td>
<td>E1574</td>
<td>Mengqi Wang</td>
<td>Impact loads on the occupant under the protection of an inversion tube energy absorber during a helicopter crash</td>
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**Session III – A. Processes**  
Chairman: Professor Yixi Zhao  
Professor Quang-Cherng Hsu

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<td>A1025</td>
<td>Yixi Zhao</td>
<td>Study the influence of geometric parameters on springback in T-section aluminum alloy window trim strip sheets forming</td>
</tr>
<tr>
<td>15:45</td>
<td>A1016</td>
<td>Zhe Wang</td>
<td>Grain size effect on optimum clearance determination in blanking non-oriented electrical steel sheet</td>
</tr>
<tr>
<td>16:00</td>
<td>A1031</td>
<td>Il Yeong Oh</td>
<td>Process analysis of fabricating elbow tubes by mandrel bending process</td>
</tr>
<tr>
<td>16:15</td>
<td>A1011</td>
<td>Quang-Cherng Hsu</td>
<td>Study on thickness distribution and spring back phenomena of sheet-bulk forming for aluminum alloy</td>
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<td>A1026</td>
<td>Hiroshi Morita</td>
<td>Dry progressive stamping of copper-alloy snaps by the plasma nitrided punches</td>
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<td>A1070</td>
<td>Junfun Wu</td>
<td>Surface morphology and bending deformation of 2024-T3 thin sheets with laser peen forming</td>
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**Session IV – E. Methods**  
Chairman: Professor Lihui Lang  
Professor Akinori Yamanaka

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15:00 – 15:30  
Break  

Foyer  

15:30 – 17:00  

Session III – A. Processes  
Chairman: Professor Yixi Zhao  
Professor Quang-Cherng Hsu  

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<tr>
<td>08:30</td>
<td>A1071 Tsung-Chia Chen</td>
<td>08:30 D1434 Tetsuo Oya</td>
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<td></td>
<td>Experimental and numerical analysis of titanium</td>
<td>Tensile and compression analyses to investigate the</td>
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<td></td>
<td>alloy microtube tube-end nosing forming</td>
<td>mesoscale mechanical characteristics influential for</td>
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<td>press formability of CFRP sheets</td>
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<td>08:45</td>
<td>A1060 Jun Hu</td>
<td>08:45 D1439 Peng Zhou</td>
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<td>Influence of dimensional size effect on material</td>
<td>The texture evolution of 2024 aluminum alloy sheet</td>
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<td>characteristics in ultrasonic-assisted micro</td>
<td>under different stress states</td>
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<td>compression</td>
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<td>09:00</td>
<td>A1032 Tae Woo Hwang</td>
<td>09:00 D1440 Chi Zhou</td>
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<td></td>
<td>Mechanical and microstructural evolutions of the</td>
<td>Effect of strain path change on the forming limit</td>
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<td>laser deposited titanium layers under various</td>
<td>of TRIP steel</td>
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<td>shielding atmospheres</td>
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<td>09:15</td>
<td>A1017 Junsong Jin</td>
<td>09:15 D1469 Satoshi Mitsui</td>
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<td>Rim thickening of a disk-like part using spinning</td>
<td>Warm bulge forming of small diameter A1100</td>
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<tr>
<td>09:30</td>
<td>A1050 Bo-Hao Peng</td>
<td>aluminum tube</td>
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<tr>
<td></td>
<td>Study on single point incremental forming an</td>
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<td></td>
<td>AA1060 sheet</td>
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<td>09:45</td>
<td>A1065 Shusaku Furusawa</td>
<td>09:30 B1149 Sergey Surudin</td>
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<td></td>
<td>Development of multi-pass laser dieless drawing</td>
<td>Hot deformation behavior of Al-Cu-Li-Mg-Zn-Zr-Sc</td>
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<td>system for fabrication of microtube</td>
<td>alloy in as-cast and hot-rolled condition</td>
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<td>10:00 – 10:30</td>
<td>Break</td>
<td>09:45 D1447 Yu-Mi Choi</td>
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<tr>
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<td>Mechanical properties of aluminum alloy 7075</td>
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<td>sheet under different heat treatments</td>
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<td>10:00 D1453 Jie Xu</td>
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<td>Size effect on softening behavior during</td>
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<td>electrically-assisted micro-tension in AZ31</td>
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<tr>
<td>10:30 – 12:00</td>
<td><strong>Meeting Room 2</strong></td>
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<tr>
<td>10:30</td>
<td>A1037 Qinxiang Xia</td>
<td>10:30 A1018 Ji He</td>
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<td></td>
<td>Research on single-pass deep drawing spinning</td>
<td>Optimizing design of the cutting tool in cutting of</td>
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<td>formability of cup-shaped parts</td>
<td>ultra-high strength steel beam part</td>
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<td>10:45</td>
<td>A1013 Hao-Cheng Yu</td>
<td>10:45 I1959 Tung-Sheng Yang</td>
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<tr>
<td></td>
<td>Finite Element simulation of rotating compression</td>
<td>Application of FEM and abductive network to</td>
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<td>forming</td>
<td>determine forging force and billet dimensions of</td>
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<tr>
<td>11:00</td>
<td>A1024 Young Yun Woo</td>
<td>near net-shape helical bevel gear forging</td>
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<td></td>
<td>The effect of flange length on the distribution</td>
<td>11:00 B1156 Quanda Zhang</td>
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<td></td>
<td>of longitudinal strain during the flexible roll</td>
<td>The numerical simulation and experiment</td>
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<td>forming process</td>
<td>verification of the large aluminum alloy covering</td>
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<td>part of car using sequential coupling technology</td>
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<tr>
<td>Time</td>
<td>Session</td>
<td>Description</td>
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<tr>
<td>11:15</td>
<td><strong>A1066 Gow-Yi Tzou</strong></td>
<td>Optimization research on forming parameters of drawing wire rod with rotating die under coulomb friction</td>
</tr>
<tr>
<td>11:30</td>
<td><strong>A1042 Junhao Zhang</strong></td>
<td>Influence of laser shot peening parameters on the surface hardness and roughness of 7075 aluminum alloy</td>
</tr>
<tr>
<td>11:45</td>
<td><strong>A1058 Veeramanikandan Rajagopal</strong></td>
<td>Effect of different processes on hydrogen storage properties of AZ magnesium alloy</td>
</tr>
<tr>
<td>11:15</td>
<td><strong>K2175 Pei-Hsing Huang</strong></td>
<td>Molecular dynamics simulations of crater formation induced by laser ablation on the surface of α-Fe substrate</td>
</tr>
<tr>
<td>11:30</td>
<td><strong>K2119 Chen-Yu Lee</strong></td>
<td>The study of residual stress and stress corrosion by surface plastic working in austenitic stainless steel weld</td>
</tr>
<tr>
<td>11:45</td>
<td><strong>K2164 Hejie Li</strong></td>
<td>Development on the technologies and applications of the equal channel angular pressing</td>
</tr>
<tr>
<td>12:00</td>
<td><strong>B1112 Hanlin Peng</strong></td>
<td>The investigations of several lapping methods to improving surface integrity for the wirecutted surfaces of finebanking tools</td>
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<td>13:30</td>
<td><strong>Committee Meeting</strong></td>
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<tr>
<td>14:00</td>
<td><strong>Keynote Speech I</strong></td>
<td>Title: Effect of Deep Cryogenic Treatment and Alternating Temperature Treatment on the Microstructure and Properties of Mg-Li Alloy</td>
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<td>Speaker: Professor Yingying Zong</td>
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<td>Chairman: Professor Gow-Yi Tzou</td>
<td></td>
</tr>
<tr>
<td>14:30</td>
<td><strong>Keynote Speech II</strong></td>
<td>Title: Scientific Work in the Field of Reducer Rolling</td>
</tr>
<tr>
<td></td>
<td>Speaker: Mr. Hermann Eratz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chairman: Professor Kuang-Jau Fann</td>
<td></td>
</tr>
<tr>
<td>15:00</td>
<td><strong>Break</strong></td>
<td></td>
</tr>
<tr>
<td>15:30</td>
<td><strong>Plenary Speech III</strong></td>
<td>Title: Severe plastic Deformation for Multiscale Gradient Architectured Materials</td>
</tr>
<tr>
<td></td>
<td>Speaker: Professor Hyoung Seop Kim</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chairman: Professor Yeong-Maw Hwang</td>
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</tr>
<tr>
<td>16:20</td>
<td><strong>Plenary Speech IV</strong></td>
<td>Title: Electro-Magnetic Forming Technologies</td>
</tr>
<tr>
<td></td>
<td>Speaker: Professor Yaroslav Erisov</td>
<td></td>
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<tr>
<td></td>
<td>Chairman: Professor Cho-Pei Jiang</td>
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</tr>
<tr>
<td>17:10</td>
<td><strong>Group Photo</strong></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Event</td>
<td>Location</td>
</tr>
<tr>
<td>-------------</td>
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<td>--------------------------------------------</td>
</tr>
<tr>
<td>18:00 – 20:00</td>
<td>Banquet &amp; Ceremony</td>
<td>New Palace International 2F Elisabeth</td>
</tr>
<tr>
<td>07:00 – 12:00</td>
<td>Registration</td>
<td>Foyer</td>
</tr>
<tr>
<td>07:30 – 12:00</td>
<td>Tour &amp; Communication</td>
<td>Gaomei Wetland Preservation Area</td>
</tr>
</tbody>
</table>

**Day 4: Saturday, November 25, 2017**

📍 NCHU Library 1F
ORGANIZER

National Chung Hsing University (NCHU), Taiwan
China Society for Technology of Plasticity (CSTP)
Taiwan Society for Technology of Plasticity (TSTP)
Korean Society for Technology of Plasticity (KSTP)
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• Chien-Hung Liu (Taiwan)
• Ming-Chyuan Lu (Taiwan)
• Hsi-Fu Shih (Taiwan)
• Chia-Che Wu (Taiwan)
• Tian-Yau Wu (Taiwan)

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• Yin-Yu Chang (Taiwan)
• Chang-Cheng Chen (Taiwan)
• Dyi-Cheng Chen (Taiwan)
• Fuh-Kuo Chen (Taiwan)
• Tsung-Chia Chen (Taiwan)
• Kuang-Jau Fann (Taiwan)
• Huey-Lin Ho (Taiwan)
• Shao-Yi Hsia (Taiwan)
• Su-Hai Hsiang (Taiwan)
• Quang-Cherng Hsu (Taiwan)
• Ray-Quan Hsu (Taiwan)
• You-Min Huang (Taiwan)
• Chinghua Hung (Taiwan)
• Yeong-Maw Hwang (Taiwan)
• Cho-Pei Jiang (Taiwan)
- Yung-Chou Kao (Taiwan)
- Chin-Tarn Kwan (Taiwan)
- Rong-Shean Lee (Taiwan)
- Woei-Shyan Lee (Taiwan)
- Daw-Kwei Leu (Taiwan)
- Bo-Cun Lin (Taiwan)
- Heng-Sheng Lin (Taiwan)
- Shen-Yung Lin (Taiwan)
- Sheng-Li Lin (Taiwan)
- Chun-Ho Liu (Taiwan)
- Jinn-Jong Sheu (Taiwan)
- Chung-Yu Tsai (Taiwan)
- Gow-Yi Tzou (Taiwan)
- Tung-Shang Yang (Taiwan)
- Wei-Ching Yeh (Taiwan)
Virtual Metrology (VM) is a method to conjecture manufacturing quality of a process tool based on data sensed from the process tool and without physical metrology operations. In other words, VM can convert sampling inspection with metrology delay into real-time and on-line total inspection. This talk will first introduce the theories and functions of the Automatic Virtual Metrology (AVM) system and then demonstrate how to apply AVM to high-tech (semiconductor, TFT-LCD, etc.) and traditional machine-tool (automobile wheel machining, airplane engine casing, etc.) industries.

The current Industry 4.0 platform can only keep the faith of achieving the nearly Zero-Defects state without realizing this goal. In other words, Industry 4.0 only emphasizes “Enhancing Productivity” but not “Improving Quality”. The key reason for this inability is the lack of an affordable online and real-time total inspection system. The Zero-Defects state can be achieved by adopting the AVM system due to its capability of providing all products total inspection data. As the AVM system is integrated with the Industry 4.0 platform, the goal of Zero-Defects can be accomplished, which is defined as “Industry 4.1.”

This talk then focuses on how to utilize Internet of Things (IoT), Big Data Analysis, Cloud Manufacturing (CM), and Cyber Physical Systems (CPS) along with the AVM technology to develop an Advanced Manufacturing Cloud of Things (AMCoT) that construct a smart manufacturing platform for achieving the goals of Industry 4.1.

**Experience**

- 2009-Present: Chair Professor of National Cheng Kung University (NCKU)
- 2008-Present: Director of e-Manufacturing Research Center, NCKU
- 2006-2009: Convener & Director of Automation Engineering Program, National Science Council
- 2003-2009: Distinguished Professor of Institute of Manufacturing Engineering, NCKU
- 1998-2001: Director of Institute of Manufacturing Engineering, NCKU
- 1990-1995: Director of Project Office of Electronics Systems Division, Chung-Shan Institute of Science and Technology (CSIST)
• 1994-1995: Senior Scientist of Electronics Systems Division, CSIST

Main Research Activities

• e-Manufacturing (Industry 4.0)
• Semiconductor Manufacturing Automation
• Virtual Metrology
• Predictive Maintenance
• Intelligent Machinery
• Intelligent Manufacturing Systems
Manufacturers and industrial organizations around the world start to invest in Internet of Things (IoT) programs and initiatives to help accelerate the era of IT-oriented smart manufacturing in the last few years. They have started to look at what is possible in the age of Industry 4.0 by embracing the Internet of Things and smart manufacturing. Manufacturers in the metal forming industry are also paying attentions on the smart manufacturing. An innovation has been occurring by changing metal forming processes from analog to digital by utilizing servo press system and IT technology to process big data from the digital system for improving worth of the mass production manufacturing technology. The difficulty in the metal forming for matching to the IoT is of complicated material deformation behaviors and visualization of the behavior in the dies or molds. It is important to enhance research and development of process monitoring using die-embedded sensors and CAE technologies for the visualization of deformation of materials in the dies. In this study, the author will review some novel applications of servo press as a digital manufacturing system to improve formability and accuracy of the product, and its development to the smart manufacturing system with the IoT.

**Experience**

- 2006-Present: Professor, Graduate School of System Design, Tokyo Metropolitan University, Japan
- 1998-2006: Associate Professor of Mechanical Engineering, Tokyo Metropolitan University, Japan
- 1991-1998: Research Associate of Mechanical Engineering, Tokyo Metropolitan University, Japan
- 1990-1991: Researcher, Research and Development Laboratory, AMADA Co., Japan

**Main Research Activities**

- Fabrication of Micro Devices with Semiconductors, Polymers and Metals
- Application of Mems to Chemical and Biological Analysis
- Development of Intelligent Micro Instruments
- Application of Bio-Mems for Health Monitoring and Infectious Diseases Detection
- Micro Metal Forming
- Precision Process of Sheet Metal
- Micro Die Fabrication
- Characterization of Thin Metal Films
Because of the special structure of Mg-Li alloy, it has the characteristics of low density, high specific strength, high specific stiffness, high elastic modulus and good seismic performance. Research on two-phase Mg-Li alloy has gradually increased due to its high strength and elongation in recent years. The workpiece in the space is exposed to sustained low temperature, which is lower than the liquid nitrogen temperature, while the cryogenic treatment is also a way to improve the microstructure and properties of the alloy. Moreover, during the flight of satellite around the earth, the workpiece is exposed to high and low temperature alternating cycle. In the space high temperature can reach 127°C and low temperature is below the liquid nitrogen temperature. Nowadays, the research of the effects of deep cryogenic treatment and the alternating temperature treatment on the microstructure and properties of Mg-Li alloy has not been reported.

In this paper, Mg-Li alloy sheet in cold rolling state of different orientations are analyzed, which consists of 5 phases, α-Mg, β-Li, AlLi, MgLiZn and Mg₂Si. Though there is no difference in the composition of the three directions, the phase distribution is slightly different. The grains in ND are equiaxed with grain size of about 100μm, the grains in TD and RD are long strip with length of about 100μm. α phase and AlLi in TD and RD are distributed in a certain direction, resulting in fiber texture. AlLi is mainly distributed along the phase boundary of α phase and inside the β phase. There exists massive block and short rod Mg₂Si.

The samples were placed in liquid nitrogen for 5 days, 10 days, 15 days and 20 days to investigate the influence of deep cryogenic treatment on the microstructure and properties of the alloy. The results show that after the deep cryogenic treatment the alloy does not change in the composition, has slight change in the grain size, has obvious increase in the volume fraction of the dispersed second phase. Thus the strength does not change, the elongation is slightly increased, the fracture mechanism before and after the treatment is microporous aggregation type.

As the high temperature in the space is up to 127°C and the low temperature is lower than the liquid nitrogen temperature, the alternating temperature used in this paper is low temperature of -196°C, high temperature of 127°C with the maximum cycle of 100 times. The experimental results show that the phase composition does not change much after alternation treatment, but grains are obviously refined, and the grain orientation is not obvious. RD, TD and ND directions all have equiaxed grains with a size of about 30μm. The α-Mg in TD and RD directions exhibits spheroidization and the microstructure
becomes uniform and stable. After alternating temperature treatment, the second phase is dissolved in the β-Li matrix, which reduces the second phase strengthening effect and improves the solid solution strengthening effect. There still exists much the second phase at low cycle times, which interacts with the dislocation, strengthens the metal and reduces the elongation. At high cycle times, the second phase almost entirely dissolves into the matrix, resulting in pure β-Li of body-centered cubic structure. After high alternating cycles, the strength is slightly reduced, but the elongation is significantly improved.

The influence mechanisms of the deep cryogenic treatment and the alternating temperature treatment on the microstructure and properties of Mg-Li alloy are analyzed.

**Experience**

- 2014-present: Professor, School of Materials Science & Engineering Harbin Institute of Technology, China
- 2010-2014: Associate Professor, School of Materials Science & Engineering Harbin Institute of Technology, China
- 2007-2010: Lecturer, School of Materials Science & Engineering Harbin Institute of Technology, China

**Main Research Activities**

- Hydrogen Induced Plasticity of Titanium Alloys
- Plastic Deformation of Metals
- Investigation on Microstructure Evolution and Mechanical Properties
- Sheet Metal Forming
Reducer Rolling often is used as preform operation in hot forging of large production volumes. The process provides a mass distribution of the material prior to the main forging operation. Thereby material and energy can be saved, press forces and die wear are reduced. The process is fast and works from small to very large forging parts, like front axle beams or crankshafts. Because it is a rough process of limited precision, it is normally not used for near net shape forging.

The session will explain the general procedure of Reducer Rolling, how the process works, the benefits of the process, its limitations, rules and introduce some rolling defects.

Although the process is very old, the amount of scientific papers in the literature, in machine manuals and in commonly available guidelines is limited and fragmentary. Some of the algorithms and guidelines have been developed by machine manufacturers, but furthermore some publications are very old and based on randomly tested real projects. That is, the experimental results could only be upgraded, as a side effect of industrial service projects.

At this time no Computer Aided Design tools or Metal flow Simulation Software (FEM) was in the world. Today we have advanced design tools for Reducer Rolling (VeraCAD) and highly developed Simulation Software for verifying the process stability.

This gives us the option to restart the scientific work of analysing the reducer roll process and to find rules for calibration sequences, reduction rates, spreading of cross-section or filling rates. Only if this knowledge is available, it will be possible to avoid rolling defects during the design stage. If the tool design is improper, the tools must be modified during try-out of the rolling dies. This mostly is though, time-killing and costly.

Surely the tool design can be tested by Finite Element Simulation, but running a simulation requires plenty of time and interpreting the results needs some expert knowledge and good experience.

The visions is, not only to abbreviate the loop of Tool Design, Simulation, Optimisation until a stable process and faultless roller product is reached, but rather to completely avoid this loop.

The basic idea is, to do the FEM-Simulation work in advance before the user will do. That is a number of 10,000 or more simulation jobs, have been performed in advance. Within these jobs the major parameters that have an effect to the reducer roll process are identified and analysed. The results of this huge number of simulations will form the “Reducer Roll Database”. Later during interactive tool construction, the software will check the database for similarity of the current case with any pre-calculated case. It will identify a pre-calculated case by a set of normalised parameters or perform an interpolation between cases. By incorporating the pre-simulated design parameters into the current project, a high accurate rolling process can be expected. Furthermore the access to a database needs zero time, instead of FEM-Simulation time. Therefore the design process becomes interactive.

Parts of the new database already exists and are integrated in VeraCAD Software. This work was done with diploma workers in Germany and also from Taiwan.
This paper will introduce some of the results and outline the basic strategy. The project is supported by German Industry, machine manufactures and a specialist for FEM-Simulation software.

Experience

- 1994-present: Owner, ERATZ Engineering, Germany
- 1989-1994: CEO, DGN GmbH, Germany
- 1979-1989: Project engineer, MEC GmbH, Germany
The excellent properties and potentials of nano and ultrafine grained (UFG) materials are the driving force of active research for practical applications, and they provide scientific meaning in understanding the underlying physics of grain refinement in materials. As a result, the interest and effort of many researchers in materials science and engineering have been focused on the microstructure and mechanical properties of nano/UFG materials. In this presentation, shock consolidation of ultrafine copper powders at room temperature for bulk nano/ultrafine structured materials is achieved in a gas gun system. The shock-consolidated bulk specimens were highly densified over 98% of relative density with uniform spatial distributions of high hardness. However, insufficient consolidation due to the tensile stress wave induced by the interactions between shock waves in the powders and due to the ultrafine particles requiring high pressure for good bonding has resulted in several defects in the consolidated specimens. The mechanical properties of the shock-consolidated copper are evaluated in terms of hardness, static tensile and compressive strengths, and dynamic compressive strength. The stress states in the powders during the shock consolidation process are systematically analyzed using the finite element method associated with the dynamic densification model (P-α model). A modified design of dies produces the successful results that swelling was prohibited by changing the shock propagation characteristics.

Experience

- 2008–present: Professor, Dept. of Materials Science and Engineering, Pohang University of Science and Technology, Korea
- 2005-2007: Visiting Associate Professor, Department of Materials Science and Engineering, University of Pennsylvania, USA
- 1995-2008: Professor, Department of Metallurgical Engineering, Chungnam National University (CNU), Korea
- 1994-1995: Senior Researcher, Institute for Advanced Engineering (IAE), Korea

Main Research Activities

- Intelligent Design of Mechanical Properties & Processing for Structural Metallic Materials Based on Microstructure & Mechanisms
- Development of Image Processing-Based 3-Dimensional Technique
- Simulation Analysis of Advanced Materials and Processing
- Modeling and Finite Element Simulations of Metallic Materials Based on Microstructures and Deformation Mechanisms
- Nano/Porous/Hybrid Mater
Electro-magnetic forming (EMF) is a powerful tool for forming flat and hollow blanks to complex parts as well as joining parts together. EMF is characterized by high precision proportionality of energy, locality of load application, absence of the contact between the tool and the blank, simplicity of incorporating into technological lines and ecological safety. The major advantage of EMF is that it increases the formability of materials. Moreover, EMF influences also on such properties as residual stresses, impact toughness, durability, etc. Thus, EMF is profusely different from other high-speed and conventional processing techniques.

The principle of the method implies that the capacitor bank discharges into the inductor, which acts as a tool. Magnetic field appearing about the inductor delivers pulse pressure to a metal blank, which is located adjacent to the inductor. The forward conversion of electrical energy stored in the capacitor bank to work of plastic deformation occurs. In this case loading of the blank is contactless, not impairing the blank surface. The duration of the electro-magnetic action to a blank is from 100 to 300 microseconds, the loading velocity is from 10 to 100 m/sec.

Due to its versatility and relative simplicity, EMF is widely applied in industry, especially, in aerospace, and finds new and new applications. This method is used for forming a wide range of materials. Materials with high electric conductivity like aluminum and copper alloys, low-carbon steels, etc. are processed well by EMF; alloyed steels and titanium alloys with medium or low electric conductivity are processed satisfactory. Nonmetallic and composites materials are processed by EMF with the use of additional technological methods.

**Experience**

- 2014-present: Associate Professor, Metal Forming Department, Samara University, Russia
- 2014-present: Senior Engineer, Scientific Laboratory of Plastic Deformation of Special Materials, Samara University, Russia
- 2010-2014: Assistant Lecturer, Metal Forming Department, Samara University, Russia
- 2009-2014: Engineer, Metal Forming Department, Samara University, Russia
VENUE

National Chung Hsing University (NCHU), Taichung, Taiwan

MAP to NCHU

Map of NCHU Campus
Day 1: Wednesday, November 22, 2017

1. NCHU International Agriculture Center 1F

Day 2: Thursday, November 23, 2017

2. NCHU Library 6F

Day 3: Friday, November 24, 2017

2. NCHU Library 6F

Day 4: Saturday, November 25, 2017

2. NCHU Library 1F

Map of NCHU Library 6F
TRANSPORTATION

1. FROM TAOYUAN AIRPORT

A. By Taiwan High Speed Rail (THSR)
   
   Taoyuan Airport 7 → Shuttle Bus or Taoyuan Airport MRT (~ 30 min, TWD 30) → THSR Taoyuan Station → Taichung (~ 50 min; Standard Class: TWD 540; Business Class: TWD 905) → Railway Trains (TRA) → Taichung Railway Station → City Buses (Routes 33, 35, 50, 73) → NCHU

B. By Bus
   
   Bus stations (Kuo-Kuang or U-BUS) at Taoyuan Airport → Taichung Railway Station (~ 2 hr 20 min, TWD 280) → City Buses (Routes 33, 35, 50, 73) → NCHU
   
   Tickets sold at bus counters:
   
   Terminal 1 bus pickup point: Bus pickup zone at B1 Arrivals.
   Terminal 2 bus pickup point: Bus pickup zone at the northeast arcade of the 1st floor Arrivals lobby.

C. By Taxi

2. FROM TAICHUNG AIRPORT

A. By Bus
   
   Taichung Airport → City Buses (Routes 9, 302) → Taichung Railway Station → City Buses (Routes 33, 35, 50, 73) → NCHU

B. By Taxi
3. FROM KAOHSIUNG AIRPORT

A. By Taiwan High Speed Rail (THSR)

Kaohsiung Airport → KRTC Metro (R4) → THSR Zuoying Station (R16) → Taichung (~ 1 hr; Standard Class: TWD 790; Business Class: TWD 1,250) → Railway Trains (TRA) → Taichung Railway Station → City Buses (Routes 33, 35, 50, 73) → NCHU

B. By Railway Trains (TRA)

Kaohsiung Airport → KRTC Metro (R4) → Railway Trains (TRA) Kaohsiung Main Station (R11) → Taichung Railway Station (~ 2 hr 50 min, TWD 469) → City Buses (Routes 33, 35, 50, 73) → NCHU

C. By Bus

Kaohsiung Airport → KRTC Metro (R4) → Kaohsiung Railway Main Station (R11) → Inter-City Bus stations (Kuo-Kuang or U-BUS) → Taichung Railway Station (~ 3 hr 10 min, TWD 330) → City Buses (Routes 33, 35, 50, 73) → NCHU

D. By Taxi

COMPLIMENTARY SHUTTLE BUS

(NCHU ↔ PARK CITY HOTEL)

Day 1: Wednesday, November 22, 2017
☆ 18:00 Park City Hotels Central Taichung (to NCHU International Agriculture Center)
☆ 20:15 NCHU International Agriculture Center (to Park City Hotels Central Taichung)

Day 2: Thursday, November 23, 2017
☆ 09:30 Park City Hotels Central Taichung (to NCHU Library)
☆ 17:15 NCHU Library (to Park City Hotels Central Taichung)
Day 3: Friday, November 24, 2017
   ✪ 08:00 Park City Hotels Central Taichung (to NCHU Library)
   ✪ 17:30 NCHU Library (to New Palace International)
   ✪ 20:15 New Palace International (to Park City Hotels Central Taichung and NCHU Library)

Day 4: Saturday, November 25, 2017
   ✪ 07:00 NCHU Library (to Park City Hotels Central Taichung)
   ✪ 07:30 Park City Hotels Central Taichung (to Gaomei Wetland Preservation Area)
   ✪ 10:30 Gaomei Wetland Preservation Area (to Park City Hotels Central Taichung and NCHU Library)
## Schedule at a Glance

### Wednesday, November 22

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>18:00~20:00</td>
<td>Registration</td>
</tr>
<tr>
<td>18:30~20:00</td>
<td>Welcome Reception</td>
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### Thursday, November 23

<table>
<thead>
<tr>
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<th>Event</th>
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<tbody>
<tr>
<td>09:00~16:00</td>
<td>Registration</td>
</tr>
<tr>
<td>10:00~10:20</td>
<td>Opening Ceremony</td>
</tr>
<tr>
<td>10:20~11:10</td>
<td>Plenary Speech I</td>
</tr>
<tr>
<td>11:10~12:00</td>
<td>Plenary Speech II</td>
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<tr>
<td>12:00~13:30</td>
<td>Break</td>
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<tr>
<td>13:30~15:00</td>
<td>Session I-II</td>
</tr>
<tr>
<td>15:00~15:30</td>
<td>Break</td>
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<tr>
<td>15:30~17:00</td>
<td>Session III-IV</td>
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### Friday, November 24

<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>08:00~16:00</td>
<td>Registration</td>
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<tr>
<td>08:30-10:00</td>
<td>Session V-VI</td>
</tr>
<tr>
<td>10:00~10:30</td>
<td>Break</td>
</tr>
<tr>
<td>10:30~12:00</td>
<td>Session VII-VIII</td>
</tr>
<tr>
<td>12:00-13:30</td>
<td>Break</td>
</tr>
<tr>
<td>13:30-14:00</td>
<td>Committee Meeting</td>
</tr>
<tr>
<td>14:00-14:30</td>
<td>Keynote Speech I</td>
</tr>
<tr>
<td>14:30-15:00</td>
<td>Keynote Speech II</td>
</tr>
<tr>
<td>15:00-15:30</td>
<td>Break</td>
</tr>
<tr>
<td>15:30-16:20</td>
<td>Plenary Speech III</td>
</tr>
<tr>
<td>16:20-17:10</td>
<td>Plenary Speech IV</td>
</tr>
<tr>
<td>17:10-17:30</td>
<td>Group Photo</td>
</tr>
<tr>
<td>18:00-20:00</td>
<td>Banquet &amp; Ceremony</td>
</tr>
</tbody>
</table>

### Saturday, November 25

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>07:00~12:00</td>
<td>Registration</td>
</tr>
<tr>
<td>07:30~12:00</td>
<td>Tour &amp; Communication</td>
</tr>
</tbody>
</table>

- **Time for each presentation** (Including the question-and-answer period)
  - Plenary/Keynote Speech: 50/30 minutes
  - Presentation: 15 minutes
### Session I - A. Processes

**Meeting Room 2**

**Chairman:** Professor Yasunori Harada  
Professor Chang-Cheng Chen

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Presenters</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:30-13:45</td>
<td>Deep Drawability of Ti/Steel/Ti Laminated Sheets</td>
<td>Yasunori Harada, Hiroto Ono, Yuki Nishikubo</td>
</tr>
<tr>
<td>13:45-14:00</td>
<td>Geometric Design of Rectangular Cross-sectional Springs</td>
<td>Y.M. Hwang, D. S. Lin, S.L. Lin</td>
</tr>
<tr>
<td>14:00-14:15</td>
<td>Dimensional Characteristics of Tailor Rolled Blanks having Thickness Variations both in Longitudinal and Width Directions</td>
<td>Sang Wook Han, Hee Seok Jung, Young Yun Woo, Young Hoon Moon</td>
</tr>
<tr>
<td>14:15-14:30</td>
<td>Numerical Investigation on Micro Cup-Shape Internal Gear in Forging Process</td>
<td>Chang-Cheng Chen, Cho-Pei Jiang, Bo-Shen Che</td>
</tr>
<tr>
<td>14:45-15:00</td>
<td>Finite Element Analysis of Rolling Process to Locally Thinning Metal Strips</td>
<td>Kuang-Jau Fann, Che-Yi Lin, Ying-Ju Chen</td>
</tr>
<tr>
<td>15:00-15:15</td>
<td>Effect of Grain Size on Mini Helical Gear of Pure Titanium in Hot Squeezing Deformation Process</td>
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Professor Cho-Pei Jiang

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Dyi-Cheng Chen, Tsung-Ying Kuo

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Shusuke Sato, Masaki Omiya

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Professor Quang-Cherng Hsu

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**Chairman:** Professor Lihui Lang  
**Professor:** Akinori Yamanaka

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**Chairman:** Professor Yaroslav Erisov  
Professor Junsong Jin

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**Chairman:** Professor Tetsuo Oya  
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**Chairman:** Professor Ji He  
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[K2175] Molecular dynamics simulations of crater formation induced by laser ablation on the surface of α-Fe substrate ........................................................................ 57
Study on Thickness Distribution and Spring Back Phenomena of Sheet-Bulk Forming for Aluminum Alloy

Jhan-Hong Ye\textsuperscript{1,a} and Quang-Cherng Hsu\textsuperscript{2,b,*}

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Keywords: aluminum, sheet bulk metal forming, thickness distribution, spring back phenomena

Abstract. With the improvement of process technology, Aluminum alloy is widely used in many industries. The function of aluminum alloy product gradually change to functional integration of product from a single function. It is important to study the formability and spring back phenomena of thick aluminum alloy sheet. In this study, we used Deform 3D and Simufact.forming to simulate the sheet-bulk forming for thick aluminum alloy sheet. Mesh convergence analysis was conducted to find the optimal element size. Thickness distribution and spring back phenomena of the rectangular blank with round corners feature at process one was also investigated. Simulation results were compared to scanning file based on spring back phenomena. The results are as follows: the optimal element size is 2 mm in the mesh convergence analysis. Compared to tetrahedral elements, solid-shell elements are suitable for analyzing sheet bulk metal forming process. Cross section near binder area of the x-axis and near quarter of keyboard of the y-axis area it has minimum spring back phenomena.
Finite Element Simulation of Rotating Compression Forming

Y.M. Hwang \textsuperscript{1,a}, K.S. Jhuang \textsuperscript{1,b} and H.C. Yu \textsuperscript{1,c,*}

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Keywords: Rotary Compression Forming, Finite Element Simulation, Magnesium Alloy

Main idea

In this study, finite element analyses of Rotating Compression Forming (RCF) of magnesium alloy AZ31 with 20mm in diameter are carried out. A commercial software DEFORM-3D is used to simulate the plastic deformation behavior of magnesium alloy during rotating compression forming processes. Various forming parameters in the FE simulation to obtain different effective strain distributions. By comparing simulation results with the obtained grain size distributions from experiments, the magnesium alloy forming parameters to effective strain and grain size gradient properties is obtained.

Features

Experimental specimen is cylinder, the diameter $d_0 = 20$ mm, height $h_0 = 20$ mm, the end of the column is fixed, the other planes are free. The specimen is installed on the machine. Rotating Compression Forming machine can control the parameters of pressure, temperature, speed, number of rotations, machine is provided by the hydraulic equipment to the bottom die pressure, the specimens will be brought into contact with the top die, and the 2 HP motor rotates the top die, the specimen occured shear force inside. Define the pressure 60 MPa, speed 10 rpm, 10 of rotation number and the temperature 320°C for the basis of forming parameters, and change one parameter at a time. After the specimen was formed, the plane of the specimen was observed by the metallographic observation, then according to ASTM E112 specification in the Heyn average particle size determination method calculated grain size $d_g$.

Results

The grain size decreases with the increase of the effective strain, but in the same conditions only compare the different rotate speeds of the case, faster speeds have smaller effective strain with smaller grains. It is known from the metallographic observation that the average grain size is reduced due to the occurrence of dynamic recrystallization at the grain boundary. As the rotate revolution increases, the effective strain and grain size along the height position will approach the linear distribution. Forming temperature of 280°C is no effective strain produced, with the experimental results, almost no effect on the specimen. All of the grain size at different temperatures is kept smaller with the increase in the effective strain.

Conclusions

The peak value of grain sizes and effective strain will occurred between the center and the age of the cross section. When the rotate speed reaches 30rpm, dynamic recrystallization makes the grains size close to 5μm. Larger effective strain gradients generated with compression pressure of 62 MPa and rotation number of 30 revolutions at the radius of 4 mm.
Grain Size Effect on Optimum Clearance Determination in Blanking Non-oriented Electrical Steel Sheet

Zhe Wang¹,², Ronggao Cui¹,², Xinke Wang¹,², Ji He¹,², Shuhui Li¹,² *

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¹ State Key Laboratory of Mechanical System and Vibration, Shanghai Jiao Tong University, Shanghai 200240, China
² Shanghai Key Laboratory of Digital Manufacture for Thin-walled Structures, Shanghai Jiao Tong University, Shanghai 200240, China

Keywords: Grain size effect, Optimum blanking clearance, Blanked edge quality, Non-oriented electrical steel.

Main idea
The increasing energy and environment crisis has promoted the great development of new energy vehicle. In motor manufacturing, how to study the blanking process with consideration of grain size effect is of great importance to reduce the magnetic properties deterioration of non-oriented electrical steel.

Features
This paper aims to systemically investigate the influence of blanking clearance and grain size on blanked edge quality. This research would provide an in-depth understanding and guidance for optimum blanking clearance determination influenced by size effect.

Results
Blanked edge morphology is determined by not only the punch-die clearance, but also the grain size. The morphology results show that the optimum clearance with best edge quality for each grain size level is quite similar. It suggested that for coarse-grained sheets, grain size becomes an important factor in blanking process which is often ignored in macro blanking process.

The linear variation of the ratio (optimum clearance/gain size) with \(D^{1/2}\) is found to demonstrate the significant grain size effect on the blanking process and optimum clearance determination. The linear function can be good guidance for the optimum clearance determination inblanking coarser-grained non-oriented electrical steel sheet for reducing the deterioration of magnetic properties.

Conclusions
It can be concluded that the punch-die clearance integrated with grain size directly determines theblanked edge quality. An approximate linear function of the ratio (optimum clearance/gain size) with \(D^{1/2}\) is found to demonstrate the grain size dependence on optimum clearance, which provides guidance for optimum clearance determination inblanking coarser-grained non-oriented electrical steel sheet.
Study on multi-step spinning process for disk-like part with thickened rim

Jin Junsong¹, a *, Su Xuedong¹, b, Wang Xinyun¹, c and Deng Lei¹, d

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Keywords: Multi-step Spinning; Rim Thickening; Finite Element Simulation; Parameter Design

Main idea

Disk-like parts with thickened rims are typical light-weight designed sheet parts. However, it is unable to form this kind of parts by using combined sheet forging processes, because the material is difficult to flow inside the blank. Due to its nonuniform thickness distribution, the part is conventionally manufactured by welding several parts with different thicknesses together or machining a thick workpiece. Hence, there are too many working procedures, resulting in high energy consumption, low production efficiency, and poor economy. Furthermore, these manufacturing processes always result in poor part properties, such as the reduced material strength. Therefore, a multi-step sheet blank rotary forging process which is similar to a rotary beading is proposed to form this kind of parts.

Features

The characteristic of this process is that the rim of the rotating round workpiece is compressed by an outer grooved roller in the radial direction and thickened incrementally. In this process, if the process parameters are not reasonable, the rim is easy to buckle and curl as the rim is compressed radially.

Results

The forming process of steps 1, 2 and 3 can be divided into three stages. The forming process of steps 4 and 5 is divided into two stages. There are two kinds of defects in the forming process: folding and pit. Folding is likely to happen in step 1 when r is larger than 2.8 mm, and pit mainly appears on the upper side of the thickened rim in step 2 when r is larger than 3.4 mm and α is smaller than 4°.

Conclusions

A disc-like part with thickened rim can be well formed by a multi-step spinning process. A large bottom radius of roller groove can lead to a folding in step 1; An over-small angle α in step 2 results in a pit defect.
Optimizing design of the cutting tool in cutting of ultra-high strength steel beam part

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¹dliang123@sjtu.edu.cn, ²li_cong@sjtu.edu.cn, ³lishuhui@sjtu.edu.cn

Shanghai Key Laboratory of Digital Manufacture for Thin-walled Structures, Shanghai Jiao Tong University, Shanghai 200240, China

Keywords: Optimizing design; Ultra-High Strength Steel; tool wear; The Modified Mohr-Coulomb fracture model.

Main idea

The fracture locus of 1180MS was obtained by experimental method. Based on the simulation, the local load situation of wear serious areas of the cutting tool is studied and the wear reason is explained. Optimizing design scheme for the tool profile is proposed to improve the tool wear. The optimized cutting tool is adopted in the actual industrial production and the wear life cycle is improved up to 14000 times cutting frequency compared with 4000 times cutting frequency for the original tool.

Features

In this research, the cutting process of a martensitic Ultra-High Strength Steel (UHSS) beam is investigated by using finite element method. The Modified Mohr-Coulomb fracture criterion (MMC) is employed in numerical simulation to calculate the ductile fracture during the process evolution. Tensile specimens are designed to obtain various stress states in tension. Equivalent fracture strains are measured with Digital Image Correlation (DIC) equipment to constitute the fracture locus. Based on the simulation, the local load situation of wear serious areas of the cutting tool is studied and the wear reason is explained. Optimizing design scheme for the tool profile is proposed to improve the tool wear. The optimized cutting tool is adopted in the actual industrial production and the wear life cycle is improved up to 14000 times cutting frequency compared with 4000 times cutting frequency for the original tool. The practice results demonstrate that the optimizing design scheme for the tool profile is very successfully.

Results

There are two seriously worn regions for the cutting tool in actual production. Region 1 and 2 are the cutting edges which take part in cutting the vertical edge and the knee point of the curve on the bottom of the beam respectively. It is found that the equivalent stress is relatively high in region 1 and the time with high stress level is long because that the vertical edge is almost parallel to the cutting direction. It is found that the cutting edge of the tool experienced a very large impact force during the cutting process in region 2. The maximum load is up to almost 8000 MPa. This excessive load leads to the chipping of the cutting tool in this region.

The blade angle of region 1 is optimized to 30° and the cutting order of the bottom is optimized to from left to right. It is found that the load in region 1 of the cutting tool is improved effectively and the equivalent stress of the elements in region 2 is reduced significantly. The simulation results demonstrate that the optimization is effective.

The optimized tool is manufactured and applied to the production line of the beam part. The cutting edge of region 1 has experienced light wear after 4000 times cutting. However, the burr height of the parts meet the requirement until 14000 times cutting. Meanwhile, the cutting edge of region 2 keeps in good condition after 15000 times cutting. These results demonstrate that the optimized tool has a much better performance than the original tool, whose wear life cycle is only 4000 times cutting frequency.
Conclusions

In this research, the cutting process of a martensitic Ultra-High Strength Steel (UHSS) beam is investigated by using finite element method. Through the study of the local loading history, the reason of the serious wear of the cutting tool is analyzed. The actual production test proved that this proposed optimized tool life increases to 14,000 times. The main conclusions of this paper include:

1. The reason for the serious wear of area 1 is that the equivalent stress is relatively high in this region and the time with high stress level is long because that the vertical edge is almost parallel to the cutting direction. Appropriate increase in the area of the blade angle can effectively improve its wear situation.

2. The reason for the serious wear of area 2 is that the cutting edge of the tool experienced a very large impact force during the cutting process. Changing the cutting order of the material at the bottom of the beam component can significantly reduce the loading of this region and improve its chipping.
The effect of flange length on the distribution of longitudinal strain during the flexible roll forming process

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**Keywords:** flexible roll forming, longitudinal strain, flange length, longitudinal bow, FEM simulation.

**Abstract.** Flexible roll forming is an advanced sheet metal forming process which allows the production of variable cross-section profiles. In flexible roll forming process, nonuniform transversal distribution of the longitudinal strain can cause the longitudinal bow, which is deviation in height of the web over the length of the profile. To investigate the effect of flange length on the transversal distribution of the longitudinal strain, FEM simulations are conducted with different flange length for three blank shapes; trapezoid, convex and concave. The result shows that the longitudinal strain and longitudinal bow decrease with increasing flange length for a trapezoid and a concave blank. For a convex blank, the longitudinal strain and longitudinal bow increase with increasing flange length. To validate FEM simulation result, numerically obtained longitudinal strain has been compared with experimental results.
Study the influence of geometric parameters on springback in T-section aluminum alloy window trim strip sheets forming

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Keywords: flanging forming, window trim strip, geometric parameters, springback

Main idea
Aluminum alloy window trim strips on the external decoration of the car played a significant role. Beautiful aluminum alloy window trim strips make cars more attractive to consumers. The blank of T-section aluminum alloy window trim strip is flanged to form window trim strip. As cosmetic parts, its springback should be controlled well.

Features
In the flanging forming process, although the main forming portion is the flanging part, geometric accuracy of the support part and the stiffeners part of the T-section are also influenced. For these two parts, the support part is constrained by the flanging part and the stiffeners part, the springback is very small. So, we focused on studying the springback of the flanging part and the stiffeners part. In this paper, the influence of the window trim strip geometric parameters on forming springback was studied. Some finite element models of the process were built with the Dynaform software. The simulation results were verified experimentally.

Results
The results show that the value of springback increases with the increase of ratio of H/W when ratio of H/W is between 0.1 and 0.6. When ratio of H/W is between 0.6 and 1, the value of springback fluctuates with the increase of ratio of H/W. When W value is 15mm and ratio of H/W is less than 0.5, the springback values are mostly less than ±0.5 mm in key sections, which is acceptable.

Conclusions
Although the stiffeners part of T-section aluminum alloy extrusion profile blank does not participate in the forming process, it is influenced by the forming of the flanging part. And the deformation of the stiffeners part has an influence on the springback of the flanging part, which affects the assembly accuracy.

The ratio H/W of T-section aluminum alloy extrusion profile blank should be a good index to evaluate the flanging quality.

When ratio of H/W increases from 0.1 to 0.6, the springback increases with the increase of ratio of H/W. When ratio of H/W increases from 0.6 to 1, the springback fluctuates with the increase of ratio of H/W. Combined with simulation and experimental verification, when W value is 15mm and ratio of H/W is less than 0.5, the springback values are basically controlled within ±0.5 mm in key sections, which meets the process requirements.
Dry progressive stamping of copper-alloy snaps by the plasma nitrided punches

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Keywords: Dry progressive stamping, Copper-alloy sheet, American snaps, Plasma nitriding, Hardness control, Homogeneous nitriding

Abstract. The dry progressive stamping was strongly required to make mass production of clothing parts and beverage cans. The duplex coating was one of the most reliable means to protect the dies and punches from wear and friction and to prolong their life time. In this coating, the die and punch was first surface-treated to have sufficient hardness in compatible to the hard ceramic coatings. In the present study, the low temperature plasma nitriding at 673 K was employed to harden the six kinds of punches and dies for progressive stamping of copper alloyed fucks. The micro-structure and nitrogen mapping were investigated by SEM with EDS to demonstrate that the hardening took place by nitrogen super saturation into SKD11 matrix without nitride precipitations. These nitrogen super-saturated punches and dies were fix into the progressive die set for dry stamping. No significant wear of tools as well as reduction of stamping loads even after a million shots proved that the low temperature plasma nitriding should be suitable to make hardening of dry stamping die substrates even without use of hard ceramic coatings.
Deep Drawability of Ti/Steel/Ti Laminated Sheets

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Keywords: Sheet Forming, Deep Drawing, Formability, Titanium, Cladding

Main idea

In consideration of corrosion resistance, the composite material which laminated the different sheets of materials is used widely. Cladding is one of the most popular composite materials; it is the bonding together of dissimilar metals. In the case of clad steel plate, it is a composite steel plate made by bonding stainless steel plate. In general, clad plates are manufactured a rolling process. On the other hand, the authors propose the new processing technique of the clad cup by deep drawing processing. In the present study, the steel sheet and titanium sheets are not bonded or pressure-pressed but they are simply stacked. Cladding is achieved by deep drawing two or three metals through a die.

Features

Long titanium clad cups were formed by multistage cold deep drawing using oxidatively-treated titanium sheets for preventing seizing. In general, the pure titanium has enough ductility for cold forming unlike titanium alloys. Furthermore, the normal anisotropy of the titanium sheets having the hexagonal close-packed crystal structure is considerably high, about 5 of the r-value, and thus this is favorable to the sheet metal forming. However, in forming operations of pure titanium sheets, seizure and galling tend to occur due to high reactivity with other materials. In the present study, for the prevention, pure titanium blank was treated by oxide coating. By oxide coating, the titanium sheet has sufficient ability in preventing the seizure in multistage deep drawing.

Results

The three-layer laminated sheet of Ti/Steel/Ti was deep-drawn. The use of the oxidatively-treated titanium sheets was effective in preventing the seizure. The clad cups until 6th stage were formed by multistage deep drawing. The cross section of the around corner on the bottom of the drawn cup was observed. There is no indication of damage on the three-layer of the sheets. Long clad cups were successfully formed in multistage deep drawing process.

Conclusions

The formability of pure titanium clad sheet by multistage deep drawing was investigated to enhance corrosion resistance of steel cup. Since pure titanium has excellent corrosion resistance, the use of the pure titanium sheet is very effective as the anticorrosion coating for steel. The oxidatively-treated titanium sheets are applied to prevent the seizure in a multi-stage deep drawing process. The clad cups until 6th stage were formed by multistage deep drawing. It was found that the drawn cups of the three-layer laminated sheet were successfully formed.
Dimensional Characteristics of Tailor Rolled Blanks having Thickness Variations both in Longitudinal and Width Directions

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\textbf{Keywords:} Tailor rolled blanks (TRB); Rolling process; FM simulation; Bowing

\textbf{Abstract.} Tailored blanks with different blank thicknesses are semi-finished parts that can be used to produce stamping parts having a real tailor-made solution. This study investigates a manufacturing process that can produce a tailored rolled blanks (TRB) having variable thickness variations both in longitudinal and width directions. The process was experimentally and numerically investigated using three types of the conventional blank and blanks having circular and square holes. To characterize the process, the deformation behaviors of blanks were intensively analyzed. In order to understand the effect of the blank shape on the manufacturing TRB, the strain behaviors was compared by numerical simulation. The results show that the hollow blanks have good formability in the manufacturing of TRB having variable thickness variations both in longitudinal and width directions compared with the conventional blank.
Process Analysis of Fabricating Elbow Tubes by Mandrel Bending Process

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Keywords: Push-bending, SUS 304L, Finite Element Analysis, Elbow Tube, Shape parameter

Abstract. The process of tube bending involves using mechanical force to push stock material pipe or tubing against a die, forcing the pipe or tube to conform to the shape of the die. For some tube bending processing, a mandrel is placed inside the tube to prevent collapsing. In this study, the elbow bending process using mandrel has been investigated to fabricate precise elbow-shaped tubes. To fabricate tube having target shape within the dimensional tolerance, the process analysis has been performed at various processing parameters such as tube dimensions, tilting angles, curved cutting surface and the radius of curvature. To estimate the dimensional accuracies of formed tubes, the standard deviations of dimensional errors between target and formed tubes have been used as a quantitative index. Results show that the elbow tube having larger radius of curvature shows higher dimensional accuracy due to the relatively uniform strain distribution. And the convex cutting surface is desirable to increase contacts between the punch and the tube ends during the bending process.
Mechanical and Microstructural Evolutions of the Laser Deposited Titanium Layers under Various Shielding Atmospheres

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\textbf{Keywords:} Direct laser melting, Shielding gas, Hardness, Surface roughness

\textbf{Abstract.} Direct laser melting process is a kind of prototyping process whereby a 3-D part is built layer-wise by melting the metal powder with laser scanning. The properties of laser melted layer are found to be strongly dependent upon the types of shielding gas used. In this study, the effects of shielding gases on the mechanical and microstructural properties of the deposited titanium layers have been investigated. The laser remelting process has also been implemented at various shielding atmospheres to investigate the changes in surface roughness and hardness of deposited layers. The characterization of laser processing parameters, such as laser power, scan rate, gas flow rate, powder layer thickness, beam spot size and hatch distance, is proved to be useful in controlling the mechanical and microstructural properties of the deposited layer.
Research on single pass deep drawing spinning formability of cup-shaped parts

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Keywords: Cup-shaped parts, Single pass deep drawing spinning, Formability, Limit deep drawing spinning coefficient, DP600 high-strength steel plate

Main idea
Fracture or wrinkling occurs easily during the deep drawing spinning (DDS) process. Currently, no literature was reported about the DDS formability of high-strength steel. The evaluation index of DDS formability was put forward, and the influences of blank thickness, roller feed rate and roller fillet radius on the single pass DDS formability of DP600 high-strength steel were analysed theoretically and experimentally, which provided guidance for evaluating the forming limit of the DDS and planning the technical process of DDS reasonably.

Features
Due to the similarity of the stress and strain state between deep drawing spinning and deep drawing stamping, the coefficient $m (m = d/D_0$, where $d$ is the internal diameter of spun parts, $D_0$ is the blank diameter) was put forward as the evaluation index of DDS formability, and the minimum coefficient without the occurrences of wrinkle and fracture during the single pass DDS process was defined as the limit DDS coefficient $m_{\text{lim}}$.

Results
For the same metal material, $m_{\text{lim}}$ decreases with the increasing of blank thickness $t_0$; fracture occurs easily when roller feed rate $f$ is small, excessively large or excessively small $f$ is not beneficial for the single pass DDS process; wrinkling occurs easily when roller fillet radius $r_\rho$ is small and $m_{\text{lim}}$ decreases with the increasing of $r_\rho$; $r_\rho$ should be larger than 5$t_0$ during the single pass DDS process, and the large $r_\rho$ should be selected when $m$ is small.

Conclusions
(1) The proposed DDS coefficient $m = d/D_0$ can be used to evaluate the formability of single pass DDS process reasonably, and the proposed limit DDS coefficient $m_{\text{lim}}$ can be used to construct the spinning processing window of single pass DDS process effectively.

(2) Wrinkling is the main failure form during the single pass DDS of DP600, which occurs mainly in the region of small $m$ and large $f$; the formability of the single pass DDS improves with the increasing of $t_0$.

(3) The influences of $f$ and $r_\rho$ on the forming limit for single pass DDS both can be divided into three regions: "fracture region", "wrinkling region" and "success region".

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Investigation of a two-step rotary rim-thickening process of disc-like blanks

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Keywords: spinning, rim-thickening, sheet metal, forming limit diagram

Main idea

A two-step rotary rim-thickening process of disc-like blanks was investigated by FE simulation and spinning experiments. The preforming shape of cross section for first step was designed as trapezium before forming rectangular-shape rim in the second step. The spinning experiments were carried out to verify the validity of numerical simulation.

Features

A two-step spinning process for rim-thickening was proposed and the profile parameters of roller were designed for forming without defects and instability. The processing map for first step was established by FE simulation to show the effects of each parameters. Besides, it’s beneficial for design of parameters at second step.

Results

The main factors influencing the blank forming in the first step were groove bottom height $h_1$ and the inclination angle $\alpha$ of the roller. With the increase of $h_1$ and $\alpha$ of the roller in FE simulation, the workpiece will be more prone to lose stability and cause defects. The forming limit diagram was obtained in first step, including stable forming zone, unstable forming zone and failed forming zone. Considering the stability and efficiency of thickening, four groups of $h_1$ and $\alpha$ were selected for the second step simulation. Four groups of parameters could achieve biggest bottom height of groove ($h_1$) stably with corresponding incline angle ($\alpha$). Smaller free length and larger $\alpha$ could avoid occurrence of distortion before billet contacted upper and lower surface of groove. Maximum rim thickness ($h_2$) after second-step forming was 9 mm, obtained by trial and error in FE simulations.

Conclusions

The forming limit diagram of first step considering $h_1$ and $\alpha$ was obtained by FE simulation. Three forming zone are divided, including stable forming zone, unstable forming zone and failed forming zone. Smaller $h_1$ and $\alpha$ made billet thickening stably, but it decreased the efficiency of thickening. The simulation results of black lines Fig. 4(a) were considered as proper initial workpieces for second step simulation. Excepting having smallest free length in corresponding $\alpha$, the black dashed line could also be successfully conducted by experiments. The maximum thickness obtained by FE simulations was 9 mm, which was verified by experiments.
Influence of laser shot peening parameters on the surface hardness and roughness of 7075 aluminum alloy

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Keywords: Laser shot peening, 7075 aluminum alloy, Parameters of laser shot peening, Surface hardness, Surface roughness

Main idea
The laser shot peening has the widely application prospect in aircraft structural parts repairing. The corrosion resistance and fatigue life of the 7075 aluminum alloy improves effectively after laser shot peening. The surface hardness and surface roughness are the common characterization parameters to evaluate the laser shot peening strengthening. The influence of laser shot peening parameters on the surface hardness and surface roughness has guiding significance for laser shot peening process. In this paper, the variation law of surface hardness and surface roughness in the peening area of 7075 aluminum alloy were obtained based on the experiment research.

Features
Taking the 7075 aluminum alloy polished plane specimens as the research object. The laser shot peening experiments were carried out under different laser energy, impact times and overlap ratio of impact crater. The corresponding data of surface hardness and surface roughness in the peening area were obtained by means of microhardness tester and roughness measuring instrument.

Results
The results show that the surface hardness improves effectively after laser shot peening, and the maximum hardness is 205.4HV, which is improved by 19.49% compared with the original hardness. Besides, the surface roughness of the rough specimen decreases; whereas, those of the smooth specimen increases after laser shot peening.

Conclusions
The surface hardness and the surface roughness of smooth specimen increases with the increasing of the laser energy, impact times and overlap ratio; while the surface roughness of rough specimen decreases with the increasing of the laser energy, impact times and overlap ratio. However, both the surface hardness and surface roughness tend to be saturated when the impact times exceeds 3 times or the overlap ratio exceeds 50%. Therefore, in the case of keeping economic efficiency, a good repairing effect can be obtained with 3 impact times and 50% overlap ratio for the 7075 aluminum alloy specimen.

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Finite Element Analysis of Rolling Process to Locally Thin Metal Strips

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Keywords: Non-Symmetrical Rolling, Metal Profile, Roll Forming, Finite Element Analysis

Main idea
Two kinds of roll configuration are used in this study, namely symmetrical and non-symmetrical. The symmetrical rolling process has the same diameter for the upper and the lower roll, while the non-symmetrical rolling process has different diameter in both rolls. As the process parameters, the roll speed ratio between the upper and the lower roll is used for the symmetrical rolling process, while the distance between the axis of the upper and lower roll is used for the non-symmetrical rolling process.

Features
If using the roll forming process to locally bend the metal sheet as a serial process, it can not only reduce the forming load, but also have less requirement of rolling equipment and rolls. Furthermore, a lightweight design is nowadays more and more asked for the structures to echo the contemporary tendency of reducing carbon emissions and waste as well as enhancing energy efficiency. If a new lightweight design of structures with local thinning can be used the roll forming production, that will make metal profiles more market competitiveness. Therefore, this study is aimed to use a Finite Element Analysis of the rolling process preparing the metal strips with local thinning for the subsequent roll forming process to form a lightweight metal profile.

Results
In this study, the commercial Finite Element software DEFORM is used to investigate the rolling process preparing the metal strips with local thinning feature for the subsequent roll forming process. Two kinds of roll configuration are used in this study: the symmetrical rolling process has the same diameter for the upper and the lower roll, while the non-symmetrical rolling process has different diameter in both rolls. The roll speed ratio between the upper and the lower roll as well as the roll diameter are used for the symmetrical rolling process as the process parameters, while the distance between the axis of the upper and lower roll as well as the diameter ratio of the upper and the lower roll are used for the non-symmetrical rolling process. As a result, the rolled thinning feature having a centrally convex bottom, a flaring sidewalls, and a raising at the opening accompanied with depression on the further side can be observed in either symmetrical or non-symmetrical rolling process. Furthermore, the thickness of the rolled thinning feature is not thinned enough as required.

Conclusions
In general, increasing the roll diameter or keeping the speed of the two rolls as the same can have a better thinning result for the symmetric rolling. In the non-symmetric rolling, increasing the roll diameter can improve the thickness, but no significant effect can be found by changing the roll diameter ratio.
**Geometric Design of Rectangular Cross-sectional Springs**

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**Keywords:** Spring, Cross-sectional shape design, Finite element simulations

**Main idea**

In this study, a finite element analysis software DEFORM is used to simulate the torsion of bars and compression of springs with different cross-sectional shape, and find the preferred cross-sectional shape design by evaluating cross-sectional area, load, and maximum shear stress. The goal of design is obtaining uniform stress distribution with a larger spring constant and lighter weight.

**Features**

The material of the bar is TS1800 SAE9254 and the cross-section of aspect ratio (w / h) is 1.5. From literature it is known that when the rectangular section bar is twisted, the shear stress at the four corners is zero, so elliptical corners can decrease the volume and increase the stiffness with the same volume. Five levels for the long side of the elliptical corner are set as 1 to 5 mm, and 3 levels are set for the short side. Five levels for the long side of the elliptical corner are set as 1 to 5 mm, and 3 levels are set for the short side. Torsion of the rectangular section bars under 15 kinds of geometric designs are simulated to find the preferred cross-sectional shape design by evaluating the cross-sectional area, load, and the maximum shear stress.

**Results**

In the finite element analysis is used to analyze the geometric design of the rectangular cross-section spring, simulate the rectangular bar to twist and observe the stress distribution, and simulate the compression of the coil spring, and judge the better rectangular cross-section design by means of area, load and maximum shear stress, this design criteria can be achieved to improve the spring stress distribution, to maintain the spring stiffness and lightweight target.

**Conclusions**

In the simulation of rectangular bars with different rounded corners, the fillet size is a=1, b=1 has the maximum resistance torque capacity under the same area; rounded size a=2, b=1 in the same area. There is a minimum maximum shear stress, shear stress distribution can be more uniform when subjected to the same torque. Choose the rounded size a=2, b=1 for spring compression simulation. The rectangular cross section of rounded size a=2 and b=1 is established as a spring model. Compression simulation is carried out. The cross-section design is divided into three types: the inner and outer fillet are the same; the outer fillet is larger than the inside; The angular size is greater than the outside. Oval cross-section in addition to the required load per unit area is slightly less than the reference standard, the other two are better than the reference benchmark. In the load comparison per unit area, the results of the same inner and outer fillet dimensions are higher than the reference. The value of the fillet is ai=2, bi=1, ai=1, ao=0.5 is the highest in the comparison of the load divided by the maximum shear stress, 10.4% higher than the reference value; the maximum shear stress per unit area, there is a lower value, lower than the baseline value of 7.34%.
Study on Single Point Incremental Forming an AA1060 Sheet

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Keywords: Single point incremental forming, Metal sheet forming, Aluminum

Main idea
This study attempted to use the single point incremental forming process to form an AA1060 sheet into a pyramid shape with a platform at its center. Experiments were conducted to mainly focus on the influence of two different process parameters, the diameter of forming tool and the vertical step size between consecutive contours, on the thickness and the roughness of the part.

Features
Beside the formability of the sheet metal, the obtained surface roughness, which might cause poor surface quality, and thickness, which might cause rupture, are the other factors to determine the quality of the formed part by the incremental forming. This study is thus aimed to investigate the influence of two different process parameter, the diameter of forming tool and the vertical step size between consecutive contours, on the thickness and the roughness of the part, so that the quality of products might be improved.

Results
In this study, an aluminum A1060 sheet with a thickness of 1 mm was used to investigate the influence of the diameter of the forming tool and the vertical step size on the forming force of a single point incremental sheet forming a pyramid with an inclination of 60°. The diameter of the forming tool is set as 6 mm, 8 mm, and 10 mm, while the vertical step size is set as 1 mm, 0.7 mm, and 0.5 mm.

The forming force in Z-axis with the forming tool of 6 mm in comparison to that with 8 mm. It can be seen that the process time with smaller forming tool is longer, because each side of a layer to travel for the forming tool of 6 mm is 2 mm longer than that of 8 mm. Furthermore, the forming force is smaller with smaller forming tool. It can be attributed to that the smaller the forming tool, the smaller the contact area between tool and sheet and the smaller the forming force.

With a smaller vertical step size like 0.7 mm for a single point incremental sheet forming with the forming tool of 8 mm, the process time is longer than that with a larger vertical step size as 1 mm, because the total number of the forming layers for this process is larger than that with a larger vertical step size. It can be found that not only the maximum pulsed forming force but also the later stabilized forming force in Z-axis on each forming layer are reduced with a smaller vertical step size.

Conclusions
As a result, after a little bit rising in forming the first layers, the forming force in Z-axis will be stabilized to a constant value. At the beginning of forming each layer, a pulse is shown in the forming force in Z-axis. The average pulsed forming force in Z-axis decreases as the diameter of the forming tool decreases and as the vertical step size decreases. The forming forces in X- and Y-axis have similar amplitudes and evolutions but a phase shift between them.
Numerical Investigation on Micro Cup-Shape Internal Gear in Forging Process

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Keywords: gear, cup-shape internal gear, forging process, finite element method

Abstract. The gear drive systems are closely related to the consumer electronics, factory automation industry, toys technology, medical equipment, electric hand tools, home appliances, and the automotive industry. In the past, the gear elements of gear transmission system were mostly produced by milling, but after the gears are miniaturized, the fabricating process of the relative milling tools would face a difficult situation. If the manufacturing process is changed by forging, the productions of micro-gear transmission system components will not only be a higher precision, the production speed may be many times higher than that of the milling process; it has an excellent benefit with great competitive advantage. In this paper, the finite element method was used to simulate and analyze the formability of micro cup-shape internal gear in forging process. Analysis of the forging process of micro cup-shape internal gear was carried by Deform-3D software. The results of the simulation, the loading process, the flow field of the material filling into the mold cavity can be observed during the forging process, and the accompanying stress and strain fields were also available. All findings can effectively be provided to the manufacturing procedure for the development of micro cup-shape internal gears.
Effect of different processes on hydrogen storage properties of AZ magnesium alloy

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Keywords: Hydrogen storage, Equal channel angular pressing (ECAP), High energy ball milling (HEBM), AZ magnesium alloy.

Main idea

Hydrogen has been widely recognized as an alternate energy carrier for future. In the recent years, magnesium and its alloys has been attracted the researcher due to its potential hydrogen storage properties. However, thermodynamic stability and poor absorption and desorption kinetics need to be overcome. Hydrogen storage performance of magnesium and its alloys could be improved through different process and preparation method.

Features

The aim of this work to reduce the thermodynamic stability, and increase the kinetics by using the severe plastic deformation method. The equal channel angular pressing (ECAP), and the high energy ball milling (HEBM) process are used to develop the kinetics by refining the grain structure and by increase the surface area of materials. Effect of different type of AZ magnesium alloys also discussed.

Results

The results show that the crystal size of AZ magnesium alloy has been decreased by both ECAP and HEBM processes. It was also revealed that AZ31 magnesium alloy processed by ECAP route Bc with 8 passes has faster absorption and desorption rate than AZ31 magnesium alloy processed by HEBM ball material ratio 30:1 with 300rpm. The capacity of two samples by ECAP and HEBM are 7.0 and 6.8 wt%. The AZ91 magnesium alloy processed by HEBM ball material ratio 30:1 with 300rpm has faster hydrogen absorption and desorption rate than that of AZ91 magnesium alloy processed by ECAP route Bc with 8 passes at 375°c. The capacity of two samples by ECAP and HEBM, both are 6.7 wt%. The hydrogen storage powder has been activated at 375 °C, in a fixed volume with the H2 pressure of 35atm, the maximum hydrogen absorption reached in 1 hour. The materials desorbed hydrogen in 8 minutes when the pressures 8 atm at the temperature of 375 °C.

Conclusions

After ECAP process, the grain refinement can be observed which AZ31 grain refinement effect is better. Addition of Al content in Mg based hydrogen storage material decrease the thermodynamic stability of hydride and increases the grain boundary that helps hydrogen diffusion. Both ECAP and HEBM process can improve AZ31 and AZ91 hydrogen kinetic properties.
Investigation on dynamic impact effect of ultrasonic-assisted compression test

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Keywords: Ultrasonic vibration, Aluminum, Compression test, Impact effect, Micro forming

Main idea
Ultrasonic-assisted metal forming have been studied numerously in conventional macro scale. However, ultrasonic dynamic impact effect, occurring in micro scale, has never been studied thoroughly, which makes the characteristics of material deformation more unpredictable in ultrasonic-assisted micro forming.

Features
The purpose of this study is to confirm the critical condition for occurrence of ultrasonic dynamic impact effect and to investigate the dimensional height dependency of ultrasonic dynamic impact effect on material deformation. In this paper, commercially pure aluminum 1100 with varying height (φ2×2mm, φ2×1.5mm, φ2×1mm) were selected for conventional static (without ultrasonic vibration) and ultrasonic-assisted compression tests. Ultrasonic-induced stress reduction was evaluated and the contour shape of deformed specimens was compared to investigate the ultrasonic dynamic impact effect on material deformation.

Results
The results showed that, as dimensional height of specimen decreased, ultrasonic vibration can reduce forming stress more effectively. In addition, by SEM analysis an anti-barreling shape and a significant contact surface area expansion were observed near contact surfaces in every specimen compressed with ultrasonic-assistance.

Conclusions
1. The critical condition for occurrence of ultrasonic dynamic impact effect is confirmed to be $2\lambda E/H > \sigma_{0.2}$, and ultrasonic impact is more effective on specimens with smaller dimensional height for stress reduction, showing the promising prospect in micro forming.
2. By SEM analysis, an anti-barreling shape and a significant contact surface area expansion were observed near contact surfaces in every specimen compressed with ultrasonic-assistance, indicating that additional plastic deformation can be produced by ultrasonic dynamic impact effect. The amount of additional plastic deformation increases as the dimensional height of specimens decreases.
3. In order to quantify the ultrasonic dynamic impact effect in different dimensional height, an ultrasonic dynamic impact factor $y$ is proposed, which can be estimated by an exponential type trend line as $y = 2.42e^{-1.48x}$ for different dimensional specimen height $x$. 
Development of multi-pass laser dieless drawing system for Fabrication of Microtube

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Keywords: Multi-pass dieless drawing, Laser, Microtube, Surface profile smoothing

Main idea

Dieless drawing is a unique deformation process without the need for conventional dies. A tube is locally heated by laser, and both tube ends move at different speeds. When the drawing speed $V_1$ is larger than the feeding speed $V_2$, the tube is pulled. Since the heated part of the tube has low flow stress, necking occurs only in this region. Necking is diffused out by the continuous relative motion of the heated position, achieving a large reduction in tube size in a single pass drawing.

Features

In this study, a multi-pass laser dieless drawing process was performed to fabricate finer microtubes for titanium alloy tube, which is known as a medical material. To develop this system, the surface profile smoothing process was integrated after each passes to increase the drawing limit.

Results

The β titanium alloy used in this experiment was Ti-15V-3Cr-3Sn-3Al with 500µm in outer diameter and 130µm in thickness. Drawing process was carried out at 800°C and the feeding speed $V_2$ was 0.1 mm·s⁻¹. Each reduction ratio were $\Delta r_1=\Delta r_2=40\%$, $\Delta r_3=37.5\%$, $\Delta r_4=30\%$, and the total number of pass was four, achieving micro tube with outer diameter of 200µm. The tube surface was polished by emery papers to make the profile smooth after each pass. To evaluate the effects of surface smoothing, drawing limit and distribution of outer diameter are measured.

Without the surface smoothing process, the variation of outer diameter accumulates as the number of pass increase, and then the tube failed during the 3rd pass. On the other hand, it is suppressed with the surface smoothing and the micro tube with outer diameter 180µm was obtained after 4th pass drawing. The total reduction in area increases from $r_{total}=64\%$ to $r_{total}=84.3\%$. Since the limit increases 20.3%, the effectiveness of surface smoothing process was verified.

Conclusions

In this study, a multi-pass laser dieless drawing process was performed to fabricate finer microtubes for β titanium alloy. And also the surface profile smoothing process was integrated in the system to enhance the drawing limit. As a result, it is found that the surface smoothing suppresses the variation of outer diameter and increases drawing limit of 20.3%, then micro tube with outer diameter of 180µm was obtained. Consequently, the effectiveness of the laser multi-pass dieless drawing system with the surface smoothing process was verified for fabrication of β titanium microtube.
Drawing Force Optimization Research on Forming Parameters of Drawing Wire Rod with Rotating Die under Coulomb Friction

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Keywords: Optimization, Forming Parameters, Drawing Force, Rotating Die, Coulomb Friction

Main idea
Cold metal drawing is a manufacturing process which is widely used in Taiwan. With the purpose of producing quality product economically, proper process design has been an area of interest to related industries. The main purposes of process design are to study the mechanical properties of the tool and product, reduce the energy required for the process and extend the tool life. Since the computer is playing an important role in this decade, the process design can be done with the aid of computer software. In this study, an optimization research based on the drawing force is done on the forming parameters of metal rod drawing through a rotating die under Coulomb friction.

Features
This study is conducted through FEM simulation software by using DEFORM 3D combining with Taguchi method. The metal rod and rotating die are constructed in SolidWorks and imported into DEFORM 3D for carrying out FEM simulations. The forming parameters included in this study are half die angle ($\alpha$), frictional coefficient ($\mu$), die fillet (R, mm) and rotating angular speed ($\omega$). With aid of L9$(3^4)$ Table (Taguchi method), nine experiments with different combination of parameters are carried out and the results are recorded. The signal-to-noise (S/N) ratio for each experiment is calculated and the influence rank of the forming parameters is obtained. The optimal parameters’ combination is obtained and the corresponding FEM simulation is carried out. The results are recorded and compared.

Results
Apart from drawing force, the effective stress, effective strain, and velocity field are recorded. According to the results, the optimal parameters’ combination is obtained to be A1B1C3D2 ($\alpha$=10º, $\mu$=0.05, R=7 mm, $\omega$=4.5 rad/s). The first experiment has the smaller drawing force and largest S/N ratio which is the best result of the nine experiments while the ninth experiment has the largest drawing force and smallest S/N ratio which is the worst result. The drawing force is improved from the best and the worst results by 3.81 % and 34.4 % respectively. The effective stress is improved within the range of 4.66 % to 16.35 % whereas the effective strain is improved within the range of 11.55 % to 37.22 %. The velocity field of the optimized result is overall higher than the best and the worst results. The frictional coefficient has the highest influence on the drawing force obtained following by half die angle, die fillet and angular velocity.

Conclusions
In this study, the aims of minimizing the drawing force and obtaining the optimal parameters’ combination are achieved. The influence rank of drawing parameters is also obtained.
Surface morphology and bending deformation of 2024-T3 thin sheets with laser peen forming

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Keywords: Laser peen forming, 2024-T3 thin sheets, Bending deformation, Surface morphology

Main idea
Laser peen forming is a pure mechanical forming method through accumulated plastic strain induced by laser shock processing. Experimental investigation has been carried out to understand the effect of laser process parameters such as laser energy and boundary condition on surface morphology and bending deformation of 2024-T3 thin sheets with different thicknesses.

Features
This paper aims to address the relation between laser process parameters, different thin sheets thicknesses, different boundary conditions and surface morphology and bending deformation of thin sheets, which would provide the fundamental process experiment reference for laser peen forming of large-scale thin sheets.

Results
Research results are as follows: 1. Surface morphology. No bulge at the topmost surface is generated on aluminum foil. Bulge height at the bottom surface increases with the decrease of thin sheet thickness. 2. Different sheet thicknesses. Arc heights at the topmost surface after LPF with laser energy of 20 J are -0.816 mm for 1 mm thickness, 0.138 mm for 2 mm thickness and 0.206 mm for 3 mm thickness, respectively. Arc heights at the topmost surface are 0.13 mm for 25 J and 2 mm thickness, 0.221 mm for 25 J and 3 mm thickness, 0.136 mm for 30 J and 2 mm thickness, 0.239 mm for 30 J and 3 mm thickness, respectively. 3. Different laser energies. Curvature radii (R) gradually decrease with the increase of laser energy and are about 800 mm for 20 J, 690 mm for 25 J and 645 mm for 30 J, respectively. 4. Bending deformation types. Different bending deformation types after LPF are convex deformation, flat, concave deformation and laser deep drawing with the decrease of sheet thicknesses.

Conclusions
Aluminum foil at the bottom surface absorbs laser shock wave and bulge increases with the decrease of sheet thickness. No heel block decreases the arc height of thin sheets compared with heel block. Concave deformation transforms into convex deformation with the increase of thin sheet thickness. Sheet thicknesses of remain flat are about 1 mm ~ 2 mm for 20 J, 25 J and 30 J. Curvature radii decrease with the increase of laser energy. It is found that convex deformation, flat, concave deformation and laser deep drawing for thin sheets with different thicknesses.
Experimental and Numerical Analysis of Titanium Alloy Microtube Tube-end Nosing Forming

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Keywords: Microtube, Titanium Alloy, Finite Element, Elasto-plastic, Tube-end Nosing.

Main idea
This study is mainly based on five sets of mold cone angle and friction coefficient of micro-tube tube end necking forming analysis, and the tool cone angle of 60° experimental verification is carried out to analyze the titanium alloy (Grade 1) micro-tube for different mold cone angle and the different friction coefficient caused by the difference between the shrinkage forming. In this paper, Prandtl-Reuss’s plastic flow rule, combined with finite element deformation theory and updated Lagrangian formulation (ULF) concept, establish an incremental elasto-plastic finite element analysis program for simulating the miniature tube end necking. The forming process also uses the generalized rmin algorithm to deal with elasto-plastic state and contact problems. From the simulation data of necking process, deformation history, punch load and punch stroke, stress and strain distribution is obtained. The analysis results show that by increasing the mold cone angle and friction coefficient, the thickness tends to be thicker in the certain area.

Features
Sheet metal needs to be developed a new material model in the micro-stamping process, as the material exists in size effect for micro-forming that traditional material model is not suitable for micro-forming. For this reason, merely the relation formula of thickness and material stress-strain is modified in this study.

Results
The figure of geometric deformation of the five stages of microtube tube-end nosing forming were clearly displays that the microtube end, with the punch stamping, contacts the coning angle of die to generate the deformed nosing. All contact interfaces are accurately calculated the results with rmin rule. The stroke setting could avoid tube end fracture caused by long stroke. It therefore shows the maximum stroke which the tube could bear before fracture caused by different coning angles of die and reduces the costs for forming time and labor.

Conclusions
Following conclusions about the microtube tube-end nosing forming with the finite element simulation are summarized. (1) The finite element analysis could accurately analyze the complete deformation process of the microtube tube-end nosing forming. (2) In changing the tool cone angle and friction coefficient, the punch load increases with the increase of the tool cone angle and the friction coefficient. (3) In changing the tool cone angle and friction coefficient, the thinnest thickness with the tool cone angle and friction coefficient increases the trend. (4) In the microtube tube-end nosing simulation, the thinnest thickness of the material after unloading and springback.
Micro-Drawing of Circular Cups with Thin Stainless Steel Sheets

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Keywords: 304 stainless steel, micro-drawing, multi-stage, size effect, grain size, finite element analysis

Abstract. With the ongoing development of product process, there is a growing demand on micro products. Though the macro-drawing process has been well-developed, the design concepts may not be directly applicable to the micro-drawing due to the size effect occurred in the micro-forming processes. In the present study, experiments were conducted first to establish the stress-strain curves, r-values and work hardening exponents of 304 stainless steel sheets with different grain sizes. The experiment results reveal that the stress-strain and r-value become smaller and the work hardening exponent increases for larger grain sizes. The difference between stress-strain curves in various directions of 0°, 45° and 90°, respectively, is significant when the grain size increases. The stamping of a vibration motor shell of cell phone, which bears a circular cylindrical shape, was also examined in the present study. The finite element simulations were performed to evaluate the formability of the multi-stage drawing process with initial die design. The forming characteristics were identified and an optimum die design was then developed with the use of the finite element analysis. The stamping process with multi-stage tooling design based on the finite element analysis was implemented and the actual stamping experiments were conducted to verify finite element analysis. The experimental results confirm the validity of the modified tooling design and the efficiency of the finite element analysis.
Evolution of white layer during wire-cutting and comparison of several methods to improve surface integrity for fineblanking tools

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Keywords: Wire electrical discharge machining; manual polishing; towed polishing; Electrolytic polishing; White layer; High speed steel.

Abstract. Powder metallurgical high speed steel (such as S390) has superior mechanical properties and been used as fineblanking tools. The electrical discharge machining has been widely used for cutting fine blanking tools which are made of especially hard tool steels. Whereas, its thermal nature causes great concerns regarding surface integrity, which matters a lot to tool life. In the present study, the evolution of surface integrity of the S390 with multi-cutting is comprehensively compared. The result shows that the surface roughness, white layer thickness and surface residual stress decrease with the increase of cutting pass. Additionally, the effectiveness to remove white layer on HSS S390 by manual and towed polishing and electrolytic polishing are compared. At last, a device of abrasive water jet polishing is designated to remove the white layer resulted from wire-cutting.
Hot Deformation Behavior of Al-Cu-Li-Mg-Zn-Zr-Sc Alloy in As-Cast and Hot-Rolled Condition

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**Keywords:** Aluminum-Lithium Alloy, Deformation, Temperature, Strain Rate, Cast, Hot Rolled.

**Main idea**

It is well-known that the cast and deformed structure have fundamental differences, affecting the manufacturing processes, the analysis of the published literature sources has shown that there are no works reflecting the influence of the initial state of the material on the deformation behavior of aluminum-lithium alloys. Therefore, the purpose of this work is to study the hot deformation behavior of Al-Cu-Li-Mg-Zn-Zr-Sc alloy in as-cast and hot-rolled condition.

**Features**

To evaluate the influence of the initial structure, the temperature and strain rate on the deformation behavior of the aluminum-lithium alloy V-1461 (2.8% Cu, 1.7% Li, 0.5% Zn, 0.09% Zr, 0.06% Sc), hot compression tests have been performed. The ranges of strain rates 0.1-60 s⁻¹ and temperatures 400-460°C at testing were selected in such way as to cover all the forming processes used in the manufacture of semi-finished products from the aluminum-lithium alloy V-1461.

**Results**

For both cast and rolled samples, at a constant strain rate flow stresses drop with increasing test temperature. An increase in the strain rate at a constant temperature is accompanied by an increase in stresses. It should be noted that the flow stresses of the rolled samples exceed the analogous stresses of cast specimens under the other equal conditions.

For both cast and rolled samples, the flow stresses at small strains increase rapidly, reaching a maximum value. Then for the majority of the conditions under consideration a slight drop in stresses occurs up to a certain steady value, which is being maintained throughout the process. This means that the softening rate is equal to the strain hardening rate. An exception is the deformation with a strain rate of 60 s⁻¹, at which, upon reaching peak stresses, a gradual decrease in the flow stresses occurs with an increase in the upsetting ratio. Thus, the rate of softening exceeds the rate of strain hardening, which is probably due to the processes of dynamic recovery and dynamic recrystallization. In some cases, especially at elevated temperatures, the flow stresses increase with increasing of strain ratio, which can be explained by the strain age-hardening of the alloy.

**Conclusions**

Physical simulation of hot deformation of the cast and rolled semi-finished products from aluminum-lithium alloy V-1461 allowed establishing the features and mechanisms of deformation behavior in the temperature range of 400-460°C and strain rates of 1-60 s⁻¹. The constants of the rheological model of hot deformation, including the Zener-Hollomon parameter and the hyperbolic sine law are determined. Overall, the parameters of the rheological model are weakly dependent on the initial state of the material, and therefore when modeling any hot deformation process one can use the same parameters regardless of the structure of the material being processed.
The numerical simulation and experiment verification of the large aluminum alloy covering part of car using sequential coupling technology

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**Keywords:** Aluminum alloy, Coupling forming

**Main idea**

Based on the large aluminum alloy covering part of car with characteristics such as complex shape and structure and the requirements of surface quality, in this paper, the covering part is formed by use of the combination of liquid medium forming with high pressure and local shaping with rigid mold which is also named as sequential coupling forming technology.

**Features**

It was analyzed from the aspect of the numerical simulation and experimental verification respectively. Firstly, the numerical simulation of the liquid medium forming with high pressure of the part was carried out using the special sheet forming software DYNAFORM, according to the results of numerical simulation, the key parameter such as loading path of liquid chamber pressure was optimized and the hydraulic test was carried out according to the optimal results. Then, in order to fully form the small features in the part which are difficult to form, reduce the equipment tonnage, and the dimensional accuracy of parts which have been formed were not affected, the method using a rigid mold to shape the local parts in the part was adopted.

**Results**

When the hydraulic test was carried out, the parts with good surface quality were obtained. Then, the final part with good quality was obtained according to the experiment of the local shaping with rigid mold. Taking the final part as the study object, the experimental values and numerical simulation values of the wall thickness along the typical paths were measured and compared respectively. According to the comparison results of the wall thickness, the numerical simulation values have a good agreement with the experimental results.

**Conclusions**

The sequential coupling forming technology using the combination of liquid medium forming with high pressure and local shaping with rigid mold is verified feasible.
The effect of geometrical parameters of micro-textured DLC coatings on tribological properties under dry sliding friction

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Keywords: Tribology, Surface texturing, Diamond Like Carbon, Wear, Picosecond Pulsed Laser

Main idea
Under dry sliding conditions the plowing of hard asperities often causes increased friction as well as abrasive wear. Surface texturing is besides coating applications an approach to enhance the tribological performance in dry forming operations. In the presented work, the tribological properties of micro-textured metallic masks are applied during the ionized physical vapor deposition (I-PVD) to fabricate the textured DLC films

Features
This study aims to investigate the influence of texturing parameters such as structure size, interspace and total DLC-coverage on the tribological performance under dry sliding conditions. In a first step a picosecond laser (pulse duration < 10ps) was used to fabricate metallic masks from 10 μm stainless foils. Using a percussion drilling strategy circular holes with diameters between 10 and 100 μm and hole-to-hole distances of 40 and 130 μm were realized over the entire mask area (8 mm x 8 mm). In a second step the negatives of the masks were coated as textured DLC-films. These were evaluated by ball-on-desk sliding friction test under dry condition. In addition, scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) were used to assure a metallographic investigation of wear debris after the sliding tests.

Results
The comparison of the tribological performance of the different DLC textures showed the influence of both structure diameter and interspace. At a constant interspace distance of 30 μm it was found that T-DLC with structure diameters of 50 and 100 μm result in low and stable coefficients of friction, while T-DLC with diameter of 10 μm was characterized by high and unstable coefficient of friction. The SEM analysis indicated that with structure size of 10 μm the DLC was worn out after sliding tests and thereby tungsten elements from WC-Co were detected under this condition. In addition, the variation of the interspace distance between 15, 30 and 50 μm for a constant structure size of 50 μm has shown that the friction coefficient decreases and becomes more stable when decreasing the interspace and thereby increasing the DLC coverage at the surface of the tungsten workpiece.

Conclusions
The ball-on-disk type friction test was carried out to evaluate the tribological properties of T-DLC. It was found that smaller texture diameter can help ejecting wear debris from contact area. Moreover, the texture interspace should be kept small to prevent the stress concentration, since this becomes more dominant when the diameter decreases. Thus, a suitable texture design should consider the DLC coverage depending on the contact state between tools and work materials.
Tensile and compression analyses to investigate the mesoscale mechanical characteristics influential for press formability of CFRP sheets

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Keywords: CFRP, press formability, fiber kinking, GTN mode

Abstract. Carbon fiber reinforced plastic (CFRP) is applied in various fields such as automobile and aerospace industry due to high specific strength and rigidity than metals. However, since its ductility is poor, there are problems that it is difficult to perform press forming and the production cost increases. In recent years, studies on improving the ductility of CFRP for realizing press forming are gradually increasing.

Experiments to obtain the mechanical properties of CFRP are costly and time consuming. Although there are several test standards in the compression test for CFRP, none of them evaluates mesoscale compression characteristics, and it is difficult to capture the deformation of internal fibers and resins when the sheet is subjected to forming. Therefore, establishing an analytical model that expresses the deformation of CFRP by evaluating mesoscale mechanical characteristics would be important to meet the increasing demand for the press forming of CFRP sheets.

In this research, by modeling and analyzing CFRP sheets in microscale, the influence of the interaction between resin and fiber within a CFRP during plastic deformation was evaluated. The carbon fiber was modeled to observe its kink behavior based on an orthotropic elastic material model. The epoxy resin was regarded as a ductile material and a Gurson-Tvergaard-Needleman (GTN) model was applied, which represent a viscoelastic plastic material considering damage by void generation, growth and coalescence. Simulations were performed by changing the GTN parameters, and this paper explains the influence of each parameter on formability based on the analysis result.
Microstructure and Texture Evolution of 2024 Aluminum Alloy Sheet under Different Loading Conditions

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\textbf{Keywords:} 2024 aluminum; tension and compression; ODFs; texture

\textbf{Main idea}

To meet the increasing requirement of greater load bearing capacity and longer service time, plastic forming processes with advantages in obtaining excellent mechanical performances have been widely used in the part manufacturing. Hot stamping is one of the plastic forming process. A hot stamped sheet has obvious layered characteristic that the inner layer is under compressive stress while the external side under tensile stress. The main purpose of this manuscript is to study the influences of tension and compression on the mechanisms of recrystallization and texture evolution of 2024 aluminum alloy, aiming to understand the microstructure evolution mechanism during stamping.

\textbf{Features}

Study the influences of tension and compression on the mechanisms of recrystallization and texture evolution of 2024 aluminum alloy.

\textbf{Results}

DRX process occurs during compression deformation and the boundaries of original grains are directly elongated during tensile deformation. The increase of strain rate or decrease of temperature leads to the increase of LABs and slows down the weakening process of {011} <100> Goss texture during tension.

\textbf{Conclusions}

1. The HABs of original grains are directly elongated until abruption during tensile deformation. DRX process occurs during compression.
2. The increase of strain rate or decrease of temperature leads to the increase of the frequency of LABs. The frequency of LABs during compression is higher than that during tension. at 573 K.
3. The frequency of LABs is significantly larger than those at other temperatures during tension for the reduction of dislocation migration.
4. The increase of deformation temperature or the decrease of strain rate slows down the weakening process of {011} <100> Goss texture during tension. But it produces a quasi-random texture during compression.
Effect of strain path change on formability of TRIP steels

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\textbf{Keywords:} Sheet metal forming; TRIP steel; Formability; Strain path change

\textbf{Main idea}
Sheet materials often experience complex strain path changes in sheet metal forming applications. TRIP steels have complex multi-phase microstructures and the retained austenitic phase will transform into martensite phase when subjected to mechanical loading. The effect of strain path change on the formability is much more complex for TRIP steels than materials with stable composition. In this paper, monotonic uniaxial tension tests and two-step tension tests were carried out to investigate influence of strain path change on the formability of TRIP steel.

\textbf{Features}
Two kinds of cold-rolled TRIP steels with 590Mpa and 780Mpa grade were investigated in this study. Monotonic uniaxial tension tests and two-step tension tests were conduct for both TRIP steels. Two-step uniaxial tension test is consisted of two tensile tests. In the first step, a big specimen was loaded to 3\% engineering strain along RD. Then small sub specimens oriented with RD in every 15\(^\circ\) from 0\(^\circ\) to 90\(^\circ\) were cut from the pre-strained big specimen by using wire-EDM.

The displacement field of specimen was measured in every 3 seconds by digital image correlation (DIC) system. Two types of region of interest (ROI) were used for each test. The first type of the ROI covers a 6mm\times14mm area in the center of specimen. It was used to measure the engineering strain in traditional gauge section. The second type of ROI, which consist of two 6mm\times6mm zones, was used to measure the strain rate in the uniform deforming zone and the necked zone after when the localized necking happens.

\textbf{Results and Discussions}
\textbf{Engineering stress-engineering strain curves.} The engineering stress-engineering strain curves of monotonic tests for TRIP 590 are plotted in Fig.1. When the angle between the two loading directions was increased from 0\(^\circ\) to 90\(^\circ\), the subsequent hardening behavior in second loading was transited from cross-loading type to Bauschinger type. The total elongation was increased when the two loading directions are close to each other and then it was decreased with the increase of angle. When the angle further increased to 90\(^\circ\), the total elongation was increased again. It is believed that pre-strain will promote martensitic transformation and leads to increased re-yielding stress and total elongation. With the increase of loading angle, martensite transformation becomes more difficult and the total elongation is decreased. When it comes to orthogonal loading cases, \(\theta = 90^\circ\), the martensite transformation is greatly suppressed. The mechanism of dislocation movement play a more important role in the plastic defamation and the Bauschinger type transient becomes more apparent. It promotes homogeneous uniform deformation and the total elongation is increased.
Total elongation and development of defects. The strain rate in the zone of necked band $\dot{\varepsilon}_n$ and the strain rate in the zone of uniform deformation $\dot{\varepsilon}_u$ were calculated based on the measured displacements using DIC method. The ratio $\dot{\varepsilon}_n/\dot{\varepsilon}_u$ is used to indicate the development of defects. The $\dot{\varepsilon}_n/\dot{\varepsilon}_u=1.3$ is taken as the criteria for the onset of localized necking. Total elongations of TRIP 590 and TRIP 780 specimens measured in monotonic tensile tests and two-step tensile tests are summarized in Fig. 2. It shows that the total elongations in different directions are almost same for monotonic loading, which means the in-plane anisotropy has no significant influence on the total elongation for proportional loading. The difference of total elongations and localized necking strains between monotonic loading and two step loading are plotted in Fig. 2 using respectively triangle and circle symbols. The similar tendency of them suggests that the effect of strain path change on total elongation strongly relates with the development of defects in the imperfect zone of sheet metal.

Conclusions

From the experimental investigation of the effect of strain path change on formability of TRIP steel, the following conclusions are drawn:

(1) In-plane anisotropy has no significant influence on the formability of TRIP steel for
(2) Formability of TRIP steel was influenced by the strain path change. The total elongation of TRIP steel is slightly increased if the loading directions of two tension steps are close to each other. When the angle between loading direction is increased from 0° to 90°, the total elongation was firstly decreased and then increased again when the angle is close to 90°.

(3) TRIP steel exhibited various hardening behavior upon reloading in different direction, including cross-hardening and transient softening. The work-hardening behavior after the pre-strain plays an important role in the path dependent behavior of forming limits.

(4) Effect of strain path change on total elongation strongly relates with the development of defects in the imperfect zone of sheet metal.
Mechanical properties of AA 7075 sheet under W-temper heat treatment

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Keywords: AA7075, mechanical properties, anisotropy, heat treatment, W-temper

Main idea
As the weight reduction of vehicle becomes an important issue in automotive industries, lightweight and high strength materials have received a great attention as a future material solution. This study investigates the mechanical properties of an aluminum alloy 7075 sheet, which exhibits superior strength but has not been successfully used for conventional cold forming in automotive applications. A prior heat treatment followed by quenching, namely W-temper, has been suggested as an alternative to conventional cold/warm forming technology. The objective of this study is to experimentally measure the anisotropic mechanical properties of the AA7075 under the W-temper condition, which will be compared with those with as-received T6 condition.

Features
In this work, the forming process following solution heat treatment and water quenching, so called W-temper, is optimized for the AA7075 sheet. For predicting the formability more accurately, plastic anisotropy and flow stress are comparatively analyzed with those of as-received sheet. Mechanical properties include the yield stress and Lankford coefficient for different loading directions: the rolling (RD), diagonal (DD) and transverse directions (TD).

Results
The optimum heat treatment conditions for W-temper was iteratively determined considering the temperature and time for solution heat treatment as well as the time duration for tensile loading after quenching. The anisotropy in flow stresses for T6 and W-temper condition was both marginal, while pronounced anisotropy in R-value was observed. The W-temper condition represented much lower stress and enhanced elongation till fracture than T6 condition. The elongation after W-temper is almost 150 % larger than T6 condition. Based on the measured mechanical properties, the anisotropic yield function and hardening model could be identified for future forming simulations.

Conclusions
The stress-strain curve of AA7075 sheet in W-temper condition showed lower flow stress and longer elongation than those of T6 condition, which may improve the formability with lower forming force. Since the AA7075 sheet exhibited strong anisotropy in terms of the Lankford coefficient and prolonged uniform elongation compared to the as-received T6 condition, accurate constitutive modeling considering the anisotropy in both yield function and hardening model should be carefully investigated for enhancing prediction capability of forming and springback simulations.

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Size effect on softening behavior during electrically-assisted micro-tension in AZ31 magnesium alloy

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Abstract. Various electrically-assisted plastic forming technologies have been developed for difficult-to-form materials such as magnesium alloys and titanium alloys in recent years. However, very few studies have been conducted on EA micro-forming, especially determining the size effect on electrically-induced softening behavior. In this study, the effects of grain size and specimen size on the electrically-induced softening behavior were investigated using uniaxial micro-tension tests at various current densities. It was found that the electrically-induced softening parameter followed an inverse-S-shaped function of current density. A relatively lower current density would be sufficient for larger sample sizes and smaller grain sizes to achieve a higher softening effect, indicating that grain number may be an important factor influencing electrically-induced softening. These size effects on electrically-induced softening were used to modify a semi-empirical softening function of current density, which could effectively predict the electrically-induced softening behaviors of five metals. The current density threshold in EA tension was defined and formulated based on the semi-empirical softening function, which nonlinearly increased with grain size, but decreased with specimen size and electrical resistivity.
Warm bulge forming of small diameter A1100 aluminum tube

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Keywords: Warm bulge forming, Small diameter tube, A1100 aluminum, Forming conditions

Main idea
In recent years, small diameter aluminum tubes have been widely utilized for digital devices and so forth. For miniaturization of the size of these instruments, micro tubular components are required. However, the small diameter tube loses its conventional characteristics due to the size effect. In this paper, the formability of small diameter A1100 aluminum tubes were investigated using warm bulge forming to improve the formability of the material.

Features
The warm bulge forming system (max. temperature: 600°C, max. internal pressure: 70MPa) has been developed for the small diameter A1100 aluminum tubes. The sizes of aluminum tubes were 2.0 mm outer diameter, 0.2 mm wall thickness and 69.0 mm length. In this study, through investigation of temperature conditions and internal pressure loading ratio, the optimum forming conditions has been clarified.

Results
1. Fracture pressures in warm bulge forming
The fracture experiments regarding warm bulge forming were carried out on two different temperatures (room temperature RT and 200°C) and three different internal pressure loading rates (0.1MPa/s, 0.25MPa/s and 1.0MPa/s). The fracture pressure at 200°C was approximately 56% lower than the one at RT. It was confirmed that the strength of the A1100 aluminum tubes had decreased as the forming temperature was increased from RT to 200°C.

2. Relationship between forming temperatures and tube expansion rates
The internal pressure in warm bulge forming is loaded until the limit before the small diameter A1100 aluminum tube fractures. The tubes did not expand at RT, whereas the tube expansion at 200°C was confirmed on all internal pressure loading rate conditions. From these results, the formability of the small diameter A1100 aluminum tubes has been improved by warm bulge forming.

Conclusions
The warm bulge forming of the small diameter A1100 aluminum tubes has been done. From these results, it has shown that the formability of the tubes can be improved through use of the warm bulge forming system. Furthermore, it might be effective to apply the axial feeding at the same time as the loading internal pressure to prevent the wall thickness reduction and to expect the large expansion.
Numerical Biaxial Tensile and Tension-Compression Tests of Aluminum Alloy Sheet using Crystal Plasticity Finite Element Method

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Keywords: Multi-axial stress test, Numerical material test, Crystal plasticity

Main idea
Calibration of material models which can accurately describe plastic deformation behavior under multi-axial stress state is a key for improving accuracy of sheet metal forming simulation based on finite element method (FEM). Therefore, Kuwabara et al. have developed multi-axial material testing machines and procedures, e.g., the biaxial tensile testing method using a cruciform specimen, and calibrated various material models and their parameters. However, in order to calibrate the materials models, one has to perform the multi-axial stress tests several times. On the other hand, we have proposed a numerical multi-axial material testing methodology based on the crystal plasticity finite element method (CPFEM). The main idea of this study is to apply the numerical multi-axial material testing method to predict the multi-axial stress-strain (SS) curves of a 5000-series aluminum alloy and to conduct the experimental validation of the simulation results.

Features
We have predicted the SS curves of the 5000-series aluminum alloy sheet under not only biaxial tensile stress states, but also in-plane tension compression stress states using CPFEM based on the mathematical homogenization theory.

Results
In order to perform the numerical material tests of the 5000-series aluminum alloy sheet using CPFEM, the crystal orientation data measured by EBSD was used as input data. The parameters of the CP constitutive equations were identified on the basis of the uniaxial SS curve for rolling direction of the sheet. The SS curves calculated were compared with those measured by the biaxial tensile tests with a cruciform specimen and the in-plane tension compression tests using a comb-shaped die.

Conclusions
The SS curves of the 5000-series aluminum alloy sheet under the biaxial tension and the in-plane tension-compression stress states predicted by the numerical multi-axial material tests showed a good agreement with the experimentally measured ones.
Prediction of shear length in blanking process by numerical analysis

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Keywords: blanking process, plane strain, FEM, ductile fracture criterion, shear length

Main idea
Blanking process has high productivity compared with other cutting processes. However, the blanking process is the process that leads to fracture and there has been a growing interest in elucidation of fracture phenomenon or the determination of the optimal process condition by numerical method such as the finite element method (FEM). In the previous studies, blanking process analyses of round blanking process which were modeled as 2D axisymmetric problem have been carried out and the cutting surface that coincided well with the experimental result was obtained. However, the blanking shape was not taken into consideration and they were not considering whether it can be applied to complicated shape expected to be applied in the future. In this study, blanking process analysis of quadrilateral blanking process was carried out and the applicability to the prediction of shear length of various ductile fracture criteria was examined by comparing numerical results with experimental results based on shear length.

Features
The blanking process analysis of quadrilateral blanking process was modeled as 2D plane strain problem. The prediction of shear length was carried out based on the fracture value along the cutting surface after blanking simulation without deleting elements. The shear length of prediction was compared with the shear length of experiments and the applicability of Cockcroft and Latham, Ayada, Brozzo ductile fracture criterion to the prediction of shear length was examined.

Results
It was found that the shear length was predicted with about less than 10 % regardless of the ductile fracture criteria and there was little difference in the applicability of Cockcroft and Latham, Ayada, Brozzo ductile fracture criterion to prediction of shear length. Therefore, it is concluded that the prediction of shear length can be possible with almost the same accuracy under the current condition whichever criterion is used.

Conclusions
In this study, blanking process analysis of quadrilateral blanking process was modeled as 2D plane strain problem and the applicability of various ductile fracture criteria was examined by comparing numerical results with experimental results based on the length of shear surface. As a result, it can be possible to predict the shear length about less than 10 % and there was little difference in the applicability of Cockcroft and Latham, Ayada, Brozzo ductile fracture criterion to the prediction of shear length under the current conditions.
Comparing Two Selection Laws of Active Slip Systems in Finite Element Polycrystalline Model for Numerical Material Testing

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Keywords: Numerical Material Testing, Finite Element Method, Slip Systems, Multiscale Model

Abstract. To meet the demand for high accuracy in metal forming simulation including difficult problems such as anisotropy, many material models have been developed. Since the recent material models usually possess many parameters and require cumbersome experiments, a reliable numerical material testing would be helpful to reduce the number of experiments. Therefore, we have engaged in development of a numerical material testing based on the finite element polycrystalline model in which the successive integration method is used for modeling slip systems. However, implementation based on the strain-rate dependent model, which is considered as the mainstream of such model, has not been rigorously considered in our research. In this study, two polycrystalline models were compared to establish better microstructural modeling for constructing a scheme of numerical material testing to predict material behavior that is not obtained by experiments.

Numerical rolling, uniaxial tensile tests were conducted on aluminum alloy sheet with the strain-rate dependent model and the successive integration method. The crystal orientation calculated by the successive integration method exhibited close agreement with the experimental value of the rolled aluminum alloy sheet. On the other hand, the calculated crystal orientation by the strain-rate dependent model exhibited less close agreement with the experimental value of the same material than the successive integration method. To ascertain the characteristics of each model in terms of slip deformation quantitatively, the other tensile tests were conducted to calculate Lankford values caused by crystal orientation. Lankford values, calculated by the successive integration method, exhibited better agreement with experimental values than the strain-rate dependent model. These comparisons indicate that the successive integration method represented slip deformation more physically valid than the strain-rate dependent model and resulted in better calculation.
Characterizing of anisotropy and asymmetry of tubular materials

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Keywords: Tubular materials, anisotropy and asymmetry, characterizing method, Knoop microhardness, VPSC, loading conditions

Main idea

Titanium tubular materials with high strength, long-lifetime and light weight has attracted wide attention in many industries such as aerospace, energy and chemistry. While, titanium tubular materials are subjected to complex multiple thermal-mechanical processing, and generally present pronounced anisotropy and asymmetry behaviors, which greatly affects the formability and the performance of the tubular materials. Thus, how to accurately and comprehensively characterize the mechanical properties is the most vital issue and precondition for innovative design of the fabricating and forming of the tubular materials and components. However, the hollow structure of tubular materials, especially thin-walled geometry, makes the testing and characterizing of the mechanical properties a challenging issue. The paper focuses on the testing and characterizing method for determining anisotropic and asymmetrical behaviors of tubular materials.

Features

The paper proposed a general testing and characterizing framework to determine anisotropic and asymmetrical mechanical properties for tubular materials. In the framework, Knoop microhardness is first employed to qualitatively identify anisotropy and asymmetry of titanium tubes. The basic tension and compression properties along axial direction are determined by mean of uniaxial tensile and compressive tests. Combined with uniaxial tension and compression tests, the viscoplastic self-consistent crystal plasticity (VPSC) is calibrated to complement the deformation behaviors along other different loading directions. Taking Ti-3Al-2.5V titanium tube and commercial pure titanium (CP-Ti) tube as the case materials, the application of the above framework for the mandrel bending demonstrates the feasibility of the proposed methodology.

Results

The Knoop hardness values show an obvious difference under different test directions. Based on the obtained mechanical properties, for the mandrel bending of Ti-3Al-2.5V titanium tube, the simulated wall thickening and thinning degree well agree with the experimental ones. And for CP-Ti tube bending, the location of the simulated wrinkle waves is close to the experimental result, and the wrinkle waves quantity is the same for both simulation and experiment.

Conclusions

The proposed framework is reliable and effective for determining anisotropic and asymmetrical mechanical properties of tubular materials. Knoop microhardness test is a simple and effective method to preliminarily estimate the overall anisotropy and asymmetry of tubular material. Combined with tension and compression tests, viscoplastic self-consistent crystal plasticity (VPSC) as a virtual approach can accurately calculate the properties of tubular materials along different loading directions.
Study of Storage Shelves Deformation Using Finite Element Analysis during Seismic

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Keywords: Finite element analysis, Storage shelves, Seismic

Main idea
In recent years the government strongly promoted industry 4.0. Domestic enterprises highly developed of wisdom manufactured. Therefore, in the warehouse, the automatic storage system has gradually been taken seriously. The focus of this study is on the deformation of the shelves during the earthquake. First, this study used Inventor graphics software to model the shelf, the model into the Workbench for meshing and conditional constraints, then the completion of the model into ANSYS waiting for the solution. In earthquake conditions, in this study a scale 6-level seismic data is taken from the network PEER seismic database system. Using the ANSeismic program developed in Matlab, the seismic data downloaded from the network is transformed into ANSYS readable seismic code.

Features
This study is based on the market commonly used iron plate cold bay assembly rack to model, Inventor 3D graphics software built the model. The shelves can put a total of 60 boxes, each box the highest load 50kg. In this study, the full storage rate of 80% of the load conditions. In the condition set, the shelf material is set to iron, Density of 7.9g / cm³, Elasticity coefficient is E = 211GPa, Poisson's ratio of 0.3, and the Y-axis vertical contact with the ground bottom of the shelf area as a fixed end.

Results
The study found the shelves in the X axis 1.09 seconds when the earthquake simulation deformation diagram, observation of this paper can be found, the deformation of the shelf increases with height, deformation also gradually increased. In the top of the head and tail position of the maximum deformation is 0.302E-04 mm. The minimum amount of deformation at the bottom is zero. Moreover, it found the shelves in the X axis 1.09 seconds when the seismic simulation of the strain diagram. Observation of this paper can be found, the shelf strain are concentrated in the column, and the greater the bottom of the larger strain, the maximum value of 0.431E-05, beam at the junction with the column at a higher strain value of 0.959E-06. The minimum value of the overall shelf strain is 0.172E-08.

Conclusions
The simulation results can be obtained by importing the seismic code into ANSYS and model simulation. In this study, we observed and analyzed the simulation results, through the shelf stress, strain and deformation to analyze the situation of the shelves, and improved the shelf structure.
Analysis of Dieless Drawing to Form the End of Metal Wires under Proportional Shape Evolution with Slab Method

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Keywords: Dieless drawing, metal wire end forming, slab method, temperature distribution, proportional deformation.

Main idea

This study is to set a goal to create a model solving the temperature distribution and its evolution for the process of dieless drawing metal wire parts by using slab method and postulating that the wire end suffers a proportional deformation.

Features

In which the final fracture surface in the middle after drawing is described as the symmetrical plane, a slab method based on literature is established for the dieless drawing process to form the end geometry of a metal wire as a one-dimensional axisymmetric model. The model has the following assumptions: a) During the deformation, each slab element keeps its disc-shape and has a uniform deformation. b) The elastic deformation and the radial and the circumferential stress of each slab element are ignored. c) Each element is in plastic loading state without an elastic unloading condition.

Results

In order to expand the application of dieless drawing method to general metal wire products, this study attempts to develop an analytical model to calculate the temperature distribution evolution for dieless drawing a metal wire to form its end geometry by using slab method along with the assumption of proportional shape evolution during the drawing process.

For given drawing speed and the constitutive characteristics of the wire, which was SUS304 stainless used in this study as a case calculation with a diameter of 5 mm, the method proposed by this study is feasible. Furthermore, for a given final shape of the metal wire end, a variety of temperature distribution evolution can be provided by this method along with different temperature boundary condition settings. The higher the boundary temperature, the higher the temperature distribution, but the lower the drawing force needed. Moreover, at the beginning of the drawing process, the highest temperature appears on the symmetry plane, so that it can neck there first and form the end geometry of the wire. And the temperature distribution evolution obtained in this study is feasible and practicable, because the range of temperature to raise or to drop can be easily to be achieved even within very short time interval

Conclusions

The method proposed by this study is feasible. In addition, for a given final shape of the metal wire end, there are many possibilities to get different temperature distribution and its evolution by setting different temperature boundary condition. The higher the boundary temperature set, the higher the temperature distribution, but the lower the drawing force needed.
Application of hard coating films to microforming die surface for resistance heating

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Keywords: Micro-forming, Resistance heating, Joule heating, Surface modification,

Main idea

The demand for micro metallic components has rapidly increased within the trend of miniaturization of medical products and so on. In previous research, H.Tanabe et al. developed resistance heating (RH) system for metallic foils and applied to micro-forming process. RH system could improve the material formability and accuracy of products. However, to apply the system to real manufacturing process, controllability of temperature distribution in work materials is one of the important issues. In particular, temperature distribution is dependent on the positioning of the electrode and shape of workpieces. In addition, depending on the variety of the electrical resistivity in work materials, there are materials which are difficult to apply the RH system. Thus, a novel RH method independent from the resistivity of work materials and work geometry is required.

Features

In this study, a novel heating system controlling the electrical resistance of die surface by surface modification process was proposed. By current flowing to work materials through the die, surface layer which has higher electrical resistivity can heat up the work material under lower current density compared with the conventional RH processes. Since the heating source will be at the die surface, this method can achieve the heating of work materials independent from its resistivity and its geometry. To investigate the applicability of this proposed method, the surface coating with AlCrSiN films of thickness 0.5, 1.0, 4.0 μm were deposited on upper die and bottom die for compression tests and forging tests. Pure titanium, pure copper, and stainless steel (JIS:SUS304 UFGSS) rods ∅ 1 mm × 2 mm were prepared for compression tests and SUS304 UFGSS of thickness 0.2 mm was prepared for forging tests. Diameter of upper die for compression test is 10 mm and that for forging test is 1 mm. The range of flow current density which was defined as the current intensity divided by the initial cross-sectional area was 0-64 A/mm².

Results

As results, higher temperature of work materials was obtained for the die coated AlCrSiN films than that without surface treatment. In particular for the Ti rod under 64 A/mm², there was a temperature difference of 400 °C between the die with and without surface treatment. Forming load also decreased by increasing the temperature of work materials by using the surface treated dies. As for the forging tests, depth of forged parts increased by the proposed method.

Conclusions

In this study, applicability of the proposed method in micro-forming was demonstrated. In the future, applicability of other deposited films will be investigated.
Influence of the Friction Factor on the Temperature Field in Upsetting of a Perfectly Plastic Strip under Plane Strain Conditions

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Keywords: Temperature. Friction factor. Continued compression. Fine grain layer

Main idea

Temperature has a great effect of the evolution of material properties. In particular, a narrow fine grain layer is often generated in the vicinity of frictional interfaces in metal forming processes. In order to develop a method for an accurate prediction of material properties in this layer, it is necessary to have a method for an accurate prediction of the temperature field near such interfaces. This paper presents a theoretical investigation into the effect of the friction factor on heat generation in the continued quasi-static plane strain compression of a thin metal strip between two rigid, parallel dies. The solution is given in Lagrangian coordinates. In this case, the original initial/boundary value problem reduces to the standard second initial/boundary value problem for the nonhomogeneous heat conduction equation. Therefore, the Green’s function is available in the literature and the through thickness distribution of temperature can be found with a high accuracy, including a narrow layer near the friction surface.

Features

The solution is singular if the friction factor is equal to 1. In particular, the plastic work rate approaches infinity in the vicinity of such friction surfaces. Since the plastic work rate is involved in the heat conduction equations, this greatly adds to the difficulties of solutions of this equation. In particular, commercial finite element packages are not capable of solving such boundary value problems.

Results

The through thickness distribution of temperature in continued compression of rigid perfectly plastic strip between two rough, parallel plates has been found with a high accuracy using the Green function available in the literature.

Conclusions

The method proposed for finding the through thickness distribution of temperature in continued compression of rigid perfectly plastic strip between two rough, parallel plates is efficient for a class of boundary value problems. The method can be extended to other constitutive equations.
Ideal Flow Theory of Pressure-Dependent Materials for Design of Metal Forming Processes

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\textbf{Keywords:} Extrusion, ideal flow, design, pressure-dependency.

\textbf{Abstract.} The ideal flow theory for pressure-dependent materials is used to calculate an ideal die for plane strain extrusion/drawing. In particular, the double slip and rotation and double shearing model are adopted. Comparison with the available ideal flow solution for pressure – independent material is made. It is shown that the die for pressure-dependent material is shorter than that for pressure-independent material. Moreover, the angle of internal friction has an effect of the distribution of contact pressure.
Design of Flexible Bulge Testing System for Evaluating the Influence of Size Effect on Thin Metal Sheets

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\textbf{Keywords:} Formability; Finite Element Method; Sheet forming; Stress-strain curve, Size effect, Stainless steel.

\textbf{Abstract.} Formability in sheet forming processes are usually analyzed by standardized tests, which often requires different test equipment associated with high initial investment cost. The present study purposes a flexible test tooling system for hydraulic bulge test apparatus that allows to evaluate the impact of size effect on the formability of thin metallic sheets. Finite Element Method was used for concept and design of the tooling system and experimental tests were carried out with thin sheets of SUS316L stainless steel to assess the overall performance of the tooling system.
Impact loads on the occupant under the protection of an inversion tube energy absorber during a helicopter crash

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Keywords: impact loads; inversion tube; energy absorber; helicopter crash; injury condition; numerical simulation

Main idea

During a helicopter crash, the head, neck and spine are the most vulnerable parts of the occupant, so that an energy absorber is needed to dissipate the kinetic energy of the occupant and the seat to minimize the impact loads. In this paper, an inversion tube was adopted as an energy-absorbing device. The occupant injury conditions were evaluated by a numerical simulation. The result indicates that the impact loads on occupant’s head, neck and spine are below the regulated thresholds under the protection of the energy absorber when the helicopter crash at a speed of 12.81 m/s in vertical direction. As a consequence, the design of the occupant protection system has been proven reliable.

Features

The objective of this paper is to investigate the impact loads on the occupants’ head, neck, and spine under the protection of an inversion tube energy absorber during a helicopter crash landing. In this research, an inversion tube was adopted as the energy-absorbing device, for it offers a significant advantage over other energy absorbers with respect to its light weight, small volume, stable deformation force and high efficiency of energy absorption. The occupant injury condition was evaluated by a numerical simulation conducted by an explicit code, MSC.Dytran, associated with articulated total body (ATB) program.

Results

The occupant responses, HIC value, neck load, and spine load are investigated to evaluate occupant injury condition in this research. The result indicates that there is no large movement on the body except hands under the constraint of belts, the hands move largely so that they are easy to collide with the helicopter equipments and get fractured. Besides, the maximum HIC value is 325, below the HIC threshold of 1000. Moreover, the maximum load on the neck and spine are 909N and 4855N respectively, which are under the human physical tolerances.

Conclusions

On the basis of the results of the numerical simulation, the inversion tube and the belt design are reasonable, for that the HIC value, impact loads on the neck, the spine and belt loads are all less than the regulated thresholds under the protection of the shock-mitigation system.
Research on the dimensional accuracy measurement method of cylindrical spun parts based on machine vision

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Keywords: Dimensional accuracy, Measurement method, Cylindrical spun parts, Machine vision, Power spinning

Main idea
Dimensional accuracy of the spun parts is usually obtained by manual measurement. However, the artificial deviation is existed and the efficiency is low. A new method of measuring the dimensional accuracy of the cylindrical spun parts based on machine vision is proposed. The image acquisition system of machine vision is built up. The methods of image processing and contour extraction of cylindrical spun parts are studied. The straightness and ovality of the cylindrical spun parts are obtained by the proposed new method. The dimensional accuracy measurement method based on machine vision can realize the online measurement, which lay the foundation for the intelligent development of spinning technology.

Features
Taking the cylindrical parts obtained by power spinning as the research object. The image acquisition system of machine vision including light source, CCD camera, computer and image processing software was built up to obtain the cylindrical spun parts image. The ideal binary image was obtained by grayscale transformation, median filtering and threshold processing. Different edge detection methods were comparative studied. The contour line of the spun parts was obtained by writing the contour search program and least squares fitting. The cross section center of the spun parts was obtained by least squares fitting, and then the contour points were converted to polar coordinates.

Results
The boundary contour of the cylindrical spun parts extracted by Canny edge detector is better than Sobel and Prewitt edge detector. The straightness and ovality can be automatically calculated through writing program.

Conclusions
(1) The Dimensional accuracy of the cylindrical spun parts can be quickly obtained by the proposed measurement method based on machine vision.
(2) The relative errors of the straightness and ovality between the machine vision and the manual measurement are less than 10%.

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Effect of grain size on mini helical gear of pure titanium in hot squeezing deformation process

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Keyword: Grain size, Titanium, Filling rate, Mini spur gear, Hot squeezing

Abstract. The aim of this research is to investigate the effect of grain size on the mechanical properties of titanium alloy and deformability of mini-helical gear in hot squeezing forming process. A helical gear die with 0.4 modulus and sixteen of right hand tooth is made by electric discharge machining. The thickness of helical gear die is 2mm. The specimen is grade 2 titanium alloy with a diameter of 5 mm and annealed to varying temperatures in a rang of 500 °C to 900 °C. The annealed specimen is carried out the tensile test to obtain the mechanical properties associated with initial grain size. Experimental results show that the α-phase and β-phase microstructure begins to form in the annealed temperature of 700 °C and 900 °C, respectively. Annealing temperature of 700 °C produces the smallest grain size of 36.48 µm, detotes as batch_4, but tensile test reveals it has the largest elongation. The specimen of batch_4 is inserted in the die, raised the temperature to 400 °C by a high frequency heating device and squeezed by a 10 ton hydraulic press machine. The maximum press load in the effective stroke is about 4.9 ton resulting in 98% filling rate. The profile of formed mini-helical gear is measured and shows that maximum error is 30 µm.
Application of FEM and Abductive Network to Determine Forging Force and Billet Dimensions of Near Net-Shape Helical Bevel Gear Forging

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Keywords: Helical bevel gear, Near net-shape forging, Finite element analysis, Abductive network

Abstract. In this paper, the use of the finite element method in conjunction with abductive network is presented to predict the maximum forging force and the volume of billet during near net-shape helical bevel gear forging. The maximum forging load and volume of billet are influenced by the process parameters such as modules, number of teeth, and die temperature. A finite element method is used to investigate the forging of helical bevel gear. In order to verify the prediction of FEM simulation for forging load, the experimental data are compared with the results of current simulation. A finite element analysis is also utilized to investigate the process parameters on forging load and volume of billet. Additionally, the abductive network was applied to synthesize the data sets obtained from the numerical simulation. The prediction models are then established for the maximum forging force and volume of billet of near net-shape helical bevel gear forging under a suitable range of process parameters. After the predictions of the maximum forging force and the volume of billet, the optimum of the power of forging machine and the dimensions of billet are determined.
Plasma printing of micro-punch assembly for micro-embossing of aluminum sheets

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Keywords: Plasma printing; Multi DLC-punch assembly; Plasma oxidation; Micro-cavity textures; Micro-embossing; Aluminum sheets; Heat transfer

Abstract. This paper concerned with micro-embossing of micro-cavities and micro-grooves into aluminum sheets by CNC-stamping with use of the arrayed DLC multi-punches. Both SKD11 and AISI420 steel die substrates were prepared and DLC-coated with the thickness of 10 to 15 µm. This DLC coating worked as a punch material. The two dimensional micro-patterns were printed onto this DLC film by maskless lithography. The unprinted DLC films were removed by the plasma oxidation to leave the three dimensional DLC-punch array on the steel substrate. This micro-pillared and micro-grooved DLC-punches were placed into the cassette die set for micro-embossing process by using the table-top CNC stamper. The micro-circular patterns transformed to the micro-pillars in the DLC punch by the plasma oxidation. Through the CNC-micro-embossing, this micro-texture further transferred to micro-cavities in the aluminum sheet. The dimensional accuracy of embossed micro-textures by stamping was measured by SEM and three dimensional profilometer with comparison to the tailored micro-pattern and the DLC-punch array configuration.
The Study of Residual Stress and Stress Corrosion by Surface Plastic Working in Austenitic Stainless Steel Weld

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Keywords: AISI 304 Stainless Steel, Shot Peening, Laser Shock Peening, Residual Stress

Main idea
After welding, AISI 304 stainless steel weld commonly resulting in uneven temperature distribution and coagulation shrinkage process, which lead to very high residual stress into weld. The residual stress should be reduced to overcome the welding defects and corrosion. Therefore, this study mainly discusses the change of weld surface and sub-surface residual stress affect layer but also analyzing the corrosion resistance by different surface plastic working.

Features
Cosα method was used to measure the residual stress in this study, which calculation principle was collected the diffraction signal at 360° to form the debye ring. The diffraction of lattice plane that satisfy the Bragg’s law will have a diffraction cone and projecting onto the plane to become the Debye-Scherrer ring then obtain residual stress from the change in lattice plane.

Results
1. The residual stress of weld and base material surface can be homogenized by grinding and shot peening. As for laser shock peening, the total lattice compression is the largest and the highest compressive stress is available. 2. The sub-surface residual stress distribution after different treatment show the maximum compressive stress are all not on surface. Such the distribution is mainly due to the dominant role of Hertz stress in the surface treatment, which make the maximum shear stress occur in sub-surface layer and leading to the maximum plastic deformation. Furthermore, the highest tensile stress can be found at sub-surface which were occurred to achieve a balance with the high compressive stress of weld surface. 3. The corrosion currents obtained by the potentiostat of non-machined, grinding, shot peening and laser shock peening are 99.46 μA, 94.01 μA, 74.90 μA and 42.07 μA respectively. Weld by laser shock peening has the lowest corrosion current means the better resistance to corrosion. 4. Debye ring signal is more complete with the higher residual stress, and the profile feature is gradually converted to single lattice so as the higher residual stress. 5. Morphology of welds show that the black part of initial two types of microstructure tends to be small and dispersed as the higher residual stress, and the results of morphology coincide with the analysis of the debye ring. The more uniform the distribution of microstructure, the more complete the debye ring signal.

Conclusions
Laser shock peening can produce the largest residual stress (-504MPa) on weld surface in three kinds of surface treatment and the sub-surface has the deepest influence layer (240microns). Which also has the best corrosion resistance. The signal of debye ring become more complete and the profile feature is gradually converted to single lattice as the higher residual stress occur.
Development on the Technologies and Applications of the Equal Channel Angular Pressing

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Keywords: SPD, ECAP, Applications, Ultra-Fine Grain material, Bio-properties, Future prospect

Main idea
This review analysed the influence of important parameters in ECAP, the development of the ECAP technologies, related simulations, and current application of ECAP products. Special attention is given on the current problems and inefficiency of current typical ECAP processing technologies. Further prospects are pointed out.

Features
Main parameters in ECAP process are analysed: Materials for specimen, die and punch, lubricant, common ECAP deformation routes. Current ECAP technologies are compared and analysed. Novel ECAP developments are also mentioned. Problems existing in current ECAP technologies are listed and discussed. Different simulations of ECAP are also compared.

Results
Based on the analysis of current existing problems in ECAP technologies, future directions are proposed as: various and extensive materials, reduction in the material waste, fabrication of bulk billets and semi-products with a homogenous UFG structure and superior properties, raising the efficiency of the ECAP processing technique, small scale products, potential application for other industries.

Conclusions
Due to the low productivity, manual operation, very limited dimensions, high material waste, application in a few range of metals and alloys, ECAP processed products are still far away from the practical applications. In the near future, research on ECAP techniques will mainly focus on the optimization and improvement of current ECAP techniques, development of new ECAP approaches, better understanding of bio-properties of ECAP products, extensive applications of ECAP products.

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Molecular dynamics simulations of crater formation induced by laser ablation on the surface of α-Fe substrate

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Keywords: Molecular dynamics, laser ablation, crater formation

Main idea
We employed molecular dynamics (MD) simulations to investigate ablation induced by the application of pulsed laser irradiation to a thin α-Fe substrate. We observed several mechanisms underlying the removal of material, including ultrafast melting, cluster ejection, and thermal vaporization. We also examined the effects of laser fluence on the resulting surface morphology as well as the amount of material ablated and deposited around the craters. The MD simulations provide microscopic insights for a better understanding of the crater formation induced by laser ablation, and the results presented in this paper can be further enhanced to predict the quality of laser ablation on the surface of α-Fe substrate.

Features
MD simulation was used to investigate the ablation of a thin α-Fe substrate. Laser energy applied to the substrate decayed exponentially in the direction of incident light in accordance with the Beer-Lambert law. The energy of the photons was transformed into kinetic energy (in the irradiated atoms) within a characteristic time ($\tau_{eq}$) [8]. Time $\tau_{eq}$ corresponds to the relaxation time between electrons and the lattice, which typically takes between hundreds of femtoseconds to several tens of picoseconds for metals, depending on the properties of the target [1,10,11]. Here, we adopted a typical relaxation time of $\tau_{eq} \sim 10$ ps. The laser energy deposited to depth $z$ within the substrate is expressed using the equation of $S(z)$ by $S(z) = I_0 (1 - R) D_p \exp(-z/D_p)$, where $I_0$ is the intensity of the laser radiation, $R$ denotes the reflectivity of the substrate, and $D_p$ is the optical penetration depth.

Results
During the laser heating process, the surface and the interior of the target underwent rapid heating and swelling, which caused the eruption of melted as well as semi-melted material from the top and bottom surfaces. Laser energy of 900 mJ/cm² was sufficient to penetrate the substrate and form micropores, whereas laser energy of 300 mJ/cm² was insufficient to penetrate the substrate and merely formed a small pit. Melted material that did not undergo complete desorption or lift-off from the substrate surface (i.e., residual slag or residue) created a crater-like structure, which severely reduced the quality of the surface (Fig. 1).
Fig. 1 (a)-(d) Transient states of α-Fe crystal irradiated at a laser energy of 900 mJ/cm$^2$ for $t = 10$ ps, 15 ps, 20 ps, and 50 ps.

As shown in Fig. 2(a), the application of a laser with energy of $E \leq 600$ mJ/cm$^2$ resulted in a larger number of atoms being ablated from the top surface ($N_a$). At this energy level, deformations also formed on the bottom surface, due to stress induced by the thermal shock wave. Nonetheless, the fact that the laser did not penetrate the target meant that almost no atoms were ablated from the bottom surface, as shown in Fig. 2(b). In contrast, higher energy levels enabled the laser to penetrate the substrate, which resulted in the formation of micropores (Fig. 1). In these cases, the number of atoms passing through the bottom surface exceeded the number of atoms ablated from the top surface. Nonetheless, a portion of the metal slag lacked the ejection or lift-off power required to overcome the attraction of the metal bonds. These atoms did not undergo complete desorption or lift-off from the target surface in the final stage, such that $N_a$ ultimately decreased. These atoms eventually accumulated on the top and bottom surfaces of the target to form uneven craters and bumps.

Fig. 2 Number of melted atoms that underwent desorption from (a) top surface and (b) bottom surface of substrate during laser heating.

Conclusions

In this study, EAM molecular dynamics was used to simulate the laser ablation of α-Fe surfaces in order to elucidate the mechanisms underlying the formation of craters. Our results could be used to guide the design of process parameters with the objective of improving the quality of laser ablation and laser-cutting surfaces.