Program & Proceedings

AWMFT & APSTP 2023

The 14th Asian Workshop on Micro/Nano Forming Technology & The 4th Asian Pacific Symposium on Technology of Plasticity

May 15-19, 2023

Skybay Hotel Gyeongpo, Gangneung, Republic of Korea

Leading Organization

사단법인 한국소성·가공학회 The Korean Society for Technology of Plasticity and materials processing
KIMS 한국재료연구원 Korea Institute of Materials Science
재료디지털플랫폼연구본부 Materials Digital Platform Division

Co-organization

一般社団法人日本塑性加工学会 The Japan Society for Technology of Plasticity
塑性工程学会 CHINA SOCIETY FOR TECHNOLOGY OF PLASTICITY
台灣塑性加工學會 Taiwan Society for Technology of Plasticity

Main Sponsor

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KIMS Korea Institute of Materials Science Total Solution Center for Metallic Materials
epU Smart Manufacturing Center for Power Units
KIMS Korea Institute of Materials Science Innovative Digital Manufacturing Platform
KIMS Korea Institute of Materials Science Voucher for Metallic Materials
BOK BUGOK STAINLESS CO.,LTD
KOFST Korean Federation of Science & Technology Societies

About Gangneung

Exploring Gangneung

Gangneung is a municipal city in the province of Gangwon-do, on the east coast of South Korea. It has a population of 213,658 (as of 2017). Gangneung is the economic center of the Yeongdong region of Gangwon-do. Gangneung has many tourist attractions, such as Jeongdongjin, a very popular area for watching the sunrise, and Gyeongpo Beach. There is a ROKAF airbase south of downtown Gangneung that formerly doubled as a civil airport. The city hosted all the ice events for the 2018 Winter Olympics.

People exploring the forests and the sea with coffee

There are no boundaries between nature and the city. Gangneung's morning, day and nighttime flow alongside nature. People promenade through the forest trails, filled with the scent of pine, and organize their thoughts in quiet and peace. They dive into the blue waves of the sea in the afternoon, and watch the sun fall beyond the horizon at night and rise again to announce a new day. The people of Gangneung know how to appreciate a good cup of coffee. Gangneung is a place of romance and calm, where you can enjoy nature and coffee.

Local dishes from nature

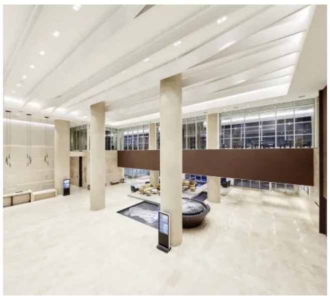
Most of the local dishes of Gangneung are made with seafood, due to its geographic characteristics, and locally grown potatoes and vegetables. The fresh ingredients from the high-altitude regions with clear and cool weather and the clean and blue sea present a unique flavor that the dishes are known for. In Gangneung, you can find a number of special tofu dishes. Soybeans are ground using a millstone and the filtered with a hemp cloth. The filtrate is then boiled in an iron pot to make chodubu or removed of excess moisture to make modubu. There are numerous tofu dishes that are made with these types of tofu, and they are known for being nutritious, tasty and soft.

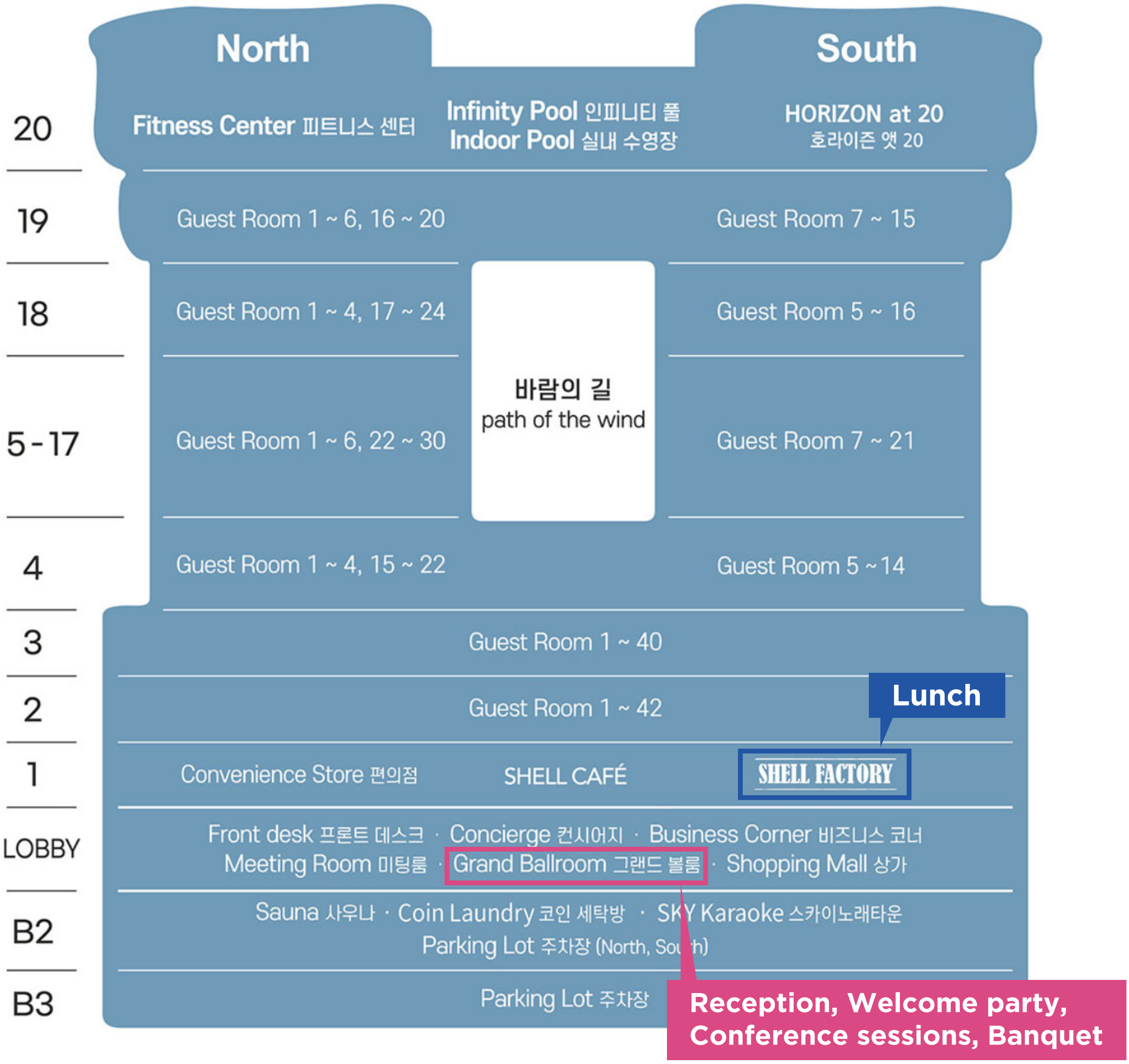
Venue & accomodation

Skybay Hotel Gyeongpo

476, Haean-ro, Gangneung-si, Gangwon-do, Republic of Korea





Train from Seoul to Gangneung

The high-speed train KTX-EUM (max 250 km/h) is available departing from the Seoul train station to the Gangneung train station
It takes around 2 hours from Seoul to Gangneung, and the fare is 27,600 KRW
Please refer to the Korail reservation homepage or mobile app (Korail talk) for the more information

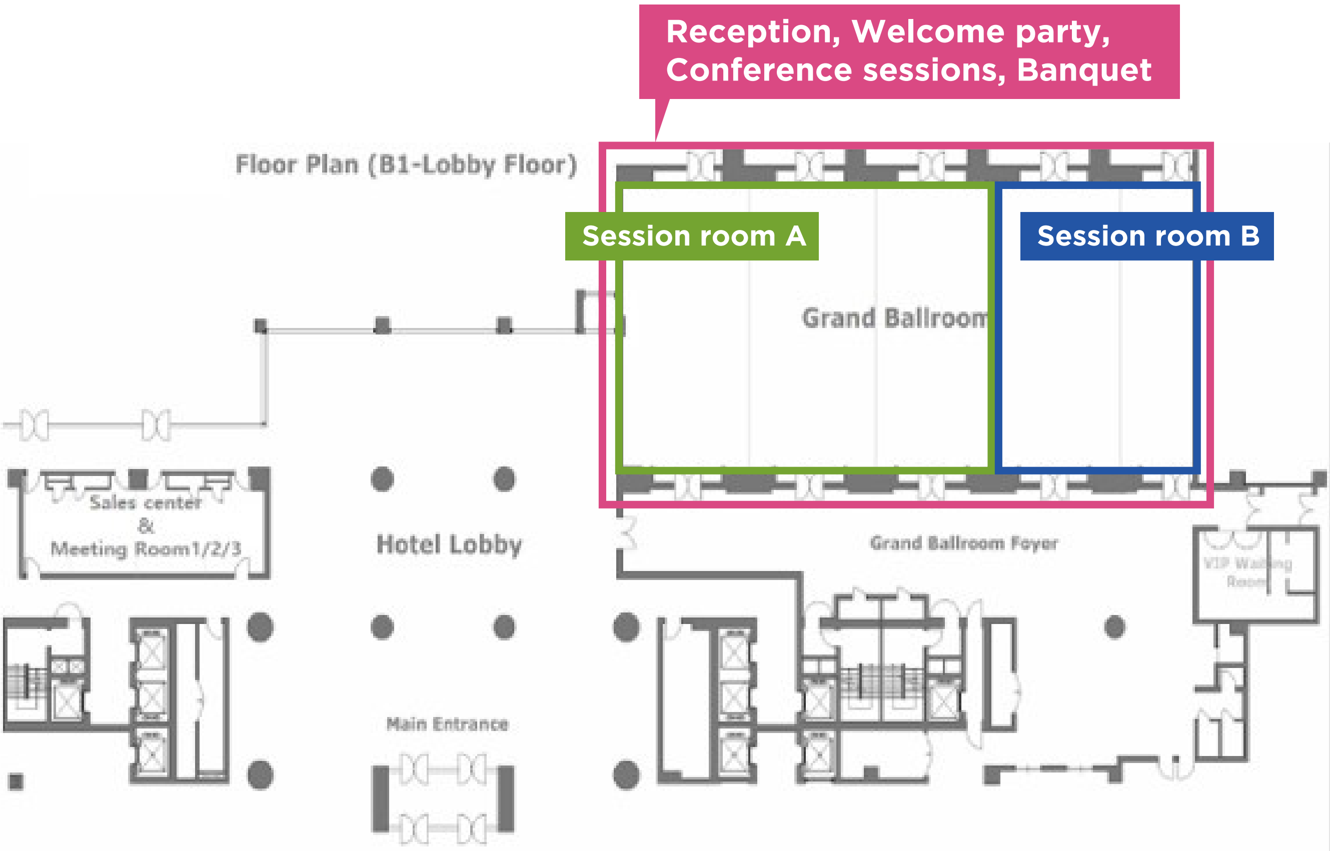
Bus from Incheon Int. airport to Gangneung

Airport bus to Gangneung is also available at both terminals 1 and 2
It takes 4 hours or may longer depending on the traffics, and the fare is 36,000 KRW
For more information, please refer to the Intercity bus reservation homepage

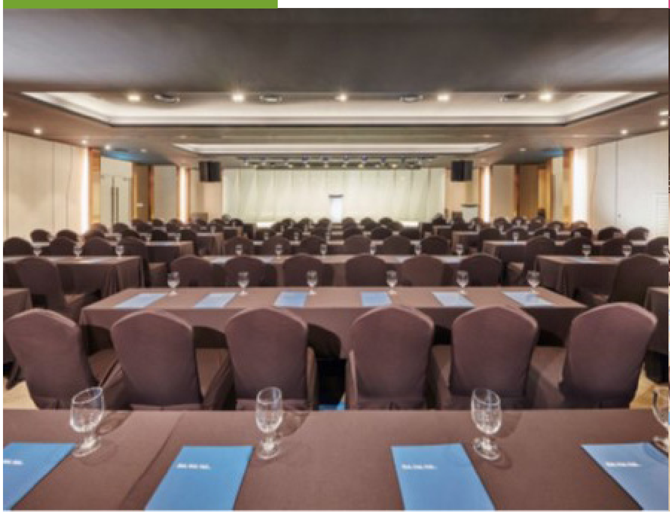
Taxi in Gangneung to the venue

It is recommended to take a taxi from Gangneung train station or bus terminal to the venue
From the Gangneung train station, it takes around 10 min, and the fare is around 7,000 KRW
From the Gangneung bus terminal. it takes around 13 min, and the fare is around 8,000 KRW

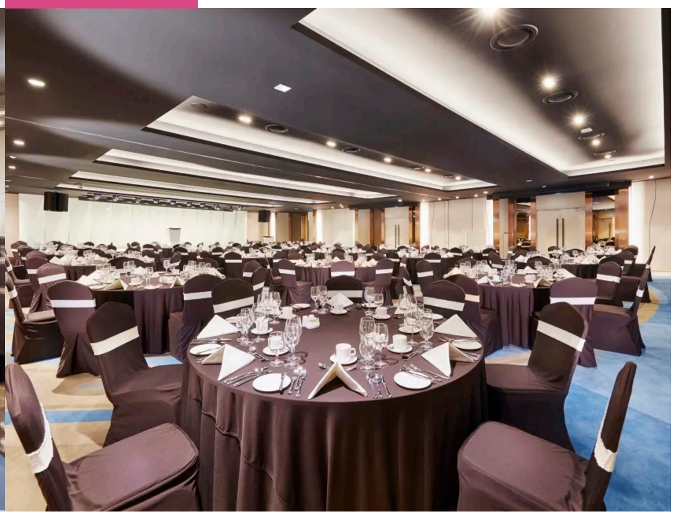
Venue : Grand Ballroom



Session room



Banquet



Contents

AWMFT 2023 & APSTP 2023

The Asian Micro/Nano Forming Technology Workshop (AWMFT) is a part of an exchange program organized by CSTP (China Society for Technology of Plasticity), JSTP (Japan Society for Technology of Plasticity), KSTP (Korean Society for Technology of Plasticity), and TSTP (Taiwanese Society for Technology of Plasticity). The workshop provides a chance for academics, researchers, and engineers to meet and exchange information on all aspects of micro/nano forming technology. The 1st workshop was held in 2007 simultaneously with the 57th Japanese Joint Conference for the Technology of Plasticity in Hokkaido, Japan. It continued in Changsha, China (2nd, 2009), in Jeju, Korea (3rd, 2010), in Toyohashi, Japan (4th, 2011), in Harbin, China (5th, 2012), in Jeju, Korea (6th, 2013), in Taipei, Taiwan (7th, 2014), in Nagano, Japan (8th, 2015), in Jinan, China (9th, 2016), in Pohang, Korea (10th, 2017), in Yunlin, Taiwan (11th, 2018), in Tokyo, Japan (12th, 2019), and in Shanghai, China (13th, 2021). KSTP will organize the 14th workshop in the Gangneung city, famous for coffee, sunrise and sea scenary in South Korea.

The Asian Pacific Symposium on Technology of Plasticity (APSTP) aims to provide an opportunity to discuss and technology of plasticity as well as new technology developments. We assure that you will find your participation a rewarding experience for broadening your academic knowledge and for serving your personal needs.

Technical Areas

The AWMFT aims to provide an opportunity to discuss and exchange ideas on new applications for nano/micro forming as well as new technology developments. We assure that you will find your participation a rewarding experience for broadening your academic knowledge and for serving your personal needs. Several awards are planned for Young Scientists and Graduate Students.

Areas of special interest for discussion include:

- Micro/nano forming processing and application
- Micro/nano scale effect
- Micro/nano forming equipment and simulation
- Measuring and controlling of micro/nano forming
- Preparation, formability, and properties of micro/nano materials
- Nanocrystallization and Nanomechanics

Also for the case of APSTP, areas of special interest for discussion include:

- Processes Forging, Drawing, Roll Forming, Joining by Forming, Rolling, Stamping, Incremental Forming, Rapid prototyping, Extrusion, Hydroforming, Micro Forming, New Processes
- Technology Green Manufacturing, Economy and Ecology Machines, Tools and Dies,
- Tribology Lubricant, Wear Behaviors, Surface Treatments and Coating
- Material Ultra High Strength Steels, Shape Memory Alloys, Lightweight Metals, Biomaterials Material Testing, Material Characterization, Formability, Damage, and Failure Analysis
- Methods Analytical, Numerical, Statistical, Process Control
- Measurement Dimensional Measurement Surface Measurement and Characterization Machine Tool Metrology Modern Optics and Instruments for Precision Measurement in Metal Forming In-Process and On-Line Measurement
- Manufacturing Management Quality and Reliability Quality Engineering Theory and Technology
- Robotics and Automation Mechatronics and Control Machine Vision and Image Processing for Metal Forming Embedded Systems and Applications Technologies for Optical and Photoelectric Devices/Systems Artificial Intelligence for Manufacturing DFX (Design for Assembly, Manufacturing or etc.)
- Smart Manufacturing Technology in Metal Forming
- Industry 4.0 in Metal Forming
- Others

Dear AWMFT & APSTP 2023 participants,

Greetings!

It is our great pleasure to invite you to the AWMFT2023 & APSTP2023 taking place in Gangneung, South Korea.

I would like to first express my sincere gratitude to KSTP and Korea Institute of Materials Science (KIMS) for giving us the opportunity to host this year's workshop & symposium.

Furthermore, I would like to thank China Society for Technology of Plasticity (CSTP), Japan Society for Technology of Plasticity (JSTP), and Taiwan Society for Technology of Plasticity (TSTP) for co-sponsoring the event. I would also like to take this time to acknowledge President Shinichiro Fujikawa of JSTP, President Qingxue Huang of CSTP, and President Jinn-Jong Sheu of TSTP for specially organizing delegations to attend the conference.

This year we have invited experts Prof. Tomomi Shiratori from University of Toyama, Prof. Quang-Cherng Hsu from National Kaohsiung University of Science and Technology, Prof. Shihong Zhang from Institute of Metal Research, Prof. Ming Wang Fu from Hong Kong Polytechnic University, Prof. Nariman Enikeev from Ufa State Aviation Technical University, and Prof. Jae-il Jang from Hanyang University as speakers for the plenary sessions.

I would like to thank our invited speakers who have taken time out of their busy schedule to share their knowledge with presentations on the subject of micro/nano forming and plasticity technologies.

While attending the conference, I hope the participants may enjoy the beautiful city of Gangneung, a coastal city with the scent of pine and coffee permeating throughout. The venue of this conference Skybay Hotel Gyeongpo, is located within a few minutes from the dazzling East Sea and lush pine forests. I hope the participants will get to discuss and exchange various ideas in the beautiful city with diverse cultural heritage and exceptional local cuisine.

I sincerely hope that your time here will be productive and meaningful, and expect many more findings to emerge from the conference.

Thank you for your attendance and we wish you all the best in the future.

Co-Chair - President Heon-Young Kim, KSTP

Leading Organizer

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Korea Institute of Materials Science
- Materials Digital Platform Division

Co-Organizer

China Society for Technology of Plasticity

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Chair of AWMFT & APSTP 2023

Heon Young Kim

Conference Chair

Affiliation: Kangwon National University, South Korea
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Kwang Seok Lee

Conference Chair

Affiliation: Korea Institute of Materials Science, South Korea
Position: Principal Researcher, Head of Department of Materials Processing, Head of Total Solution Center for Metallic Materials
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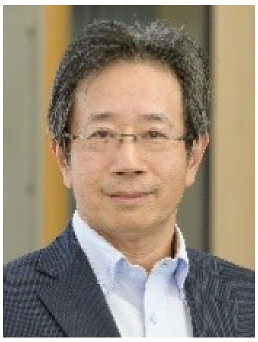
International Steering Committee



Ming Yang

International Steering Committee

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E-mail: yang@tmu.ac.jp

Debin Shan

International Steering Committee

Affiliation: Harbin Institute of Technology, P. R. China
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E-mail: shandb@hit.edu.cn

Hyoung Seop Kim

International Steering Committee

Affiliation: Pohang University of Science and Technology (POSTECH), South Korea
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E-mail: hskim@postech.ac.kr

Yeong-Maw Hwang

International Steering Committee

Affiliation: National Sun Yat-sen University, Taiwan
Position: Distinguished professor, Department of Mechanical and Electro-mechanical Engineering
E-mail: ymhwang@mail.nsysu.edu.tw

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Kazuhiko Kitamura,	Nagoya Institute of Technology (Japan)
Jun Yanagimoto,	University of Tokyo (Japan)
Hiroshi Utsunomiya,	Osaka University (Japan)
Ming Yang,	Tokyo Metropolitan University (Japan)
Tomomi Shiratori,	University of Toyama (Japan)
Zhigang Wang,	Gifu University (Japan)
Ryo Matsumoto,	Osaka University (Japan)
Susumu Takahashi,	Nihon University (Japan)
Toshihiko Kuwabara,	Tokyo University of Agriculture and Technology (Japan)
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Jinn-Jong Sheu,	National Kaohsiung University of Science and Technology (Taiwan)
Kuang-Jau Fann,	National Chung Hsing University (Taiwan)

Presentation Guideline

- Presentation time:
  1. Plenary session (40 mins / Presentation: 35 mins, Q&A :5 mins)
  2. Invited session (30 mins / Presentation: 25 mins, Q&A :5 mins)
  3. Oral session (20 mins / Presentation: 15 mins, Q&A :5 mins)
  4. Graduate Student session (15 mins / Presentation: 12 mins, Q&A :3 mins)
- 1st timer alert: 2 mins remaining
- 2nd timer alert: End of time
- materials: Please bring your PPT material on a USB memory stick
  ; no specific format required
- Please upload your presentation material on the computer in the conference room by 10 mins before the session.
- Please wear your name tag and follow the instructions of the session chair.
- You can ask for help from our staff.
- You have to wear your name tag while attending the Welcome Party / Lunch / Banquet / Half day tour.

May 15th, Mon.	May 16th, Tue.		May 17th, Wed.		May 18th, Thu.
	Session Room A	Session Room B	Session Room A	Session Room B	
pre-registration & welcome party 15:00 – 18:00	Conference registration 8:40 – 09:10		Conference registration 8:40 – 09:10		Excursion & private meetings
	Plenary session #1 09:10 – 10:30		Plenary session #3 09:10 – 10:30		
	Plenary session #2 10:50 – 12:10		Invited session #3 10:50 – 11:50	Invited session #4 10:50 – 11:50	
	Lunch 12:10 – 13:10		Photo time 11:50 – 12:00		May 19th, Fri.
			Lunch 12:00 – 13:10		
	Invited session #1 13:10 – 15:00	Invited session #2 13:10 – 15:00	Grad. student session #1 13:10 – 15:10	Grad. student session #2 13:10 – 15:10	KSTP 2023 spring meeting & private meetings
	Oral session #1 15:20 – 18:00	Oral session #2 15:20 – 18:00	Invited session #5 15:30 – 16:00	Invited session #6 15:30 – 16:00	
			Oral session #3 16:00 – 16:40	Oral session #4 16:00 – 17:00	
			Banquet 18:30 – 20:30		

Program at a Glance

May 16 (Tue.)

Room / Date/time	Session Room A	Session Room B
08:40-09:10	Conference Registration	
	Plenary Session #1 *Session Chair : Ming Yang (Tokyo Metropolitan University, Japan)*	
09:10-09:50	Plenary talk Shi-Hong Zhang (Institute of Metal Research, China)	
09:50-10:30	Plenary talk Nariman Enikeev (Ufa University of Science and Technology, Russia)	
10:30-10:50	Coffee Break #1	
	Plenary Session #2 *Session Chair : Yeong-Maw Hwang (National Sun Yat-sen University, Taiwan)*	
10:50-11:30	Plenary talk Jae-il Jang (Hanyang University, South Korea)	
11:30-12:10	Plenary talk Ming Wang Fu (Hong Kong Polytechnic University, China)	
12:10-13:10	Lunch #1	
	Invited Session #1 *Session Chair : Seong-Hoon Kang (Korea Institute of Materials Science, South Korea)*	***Invited Session #2*** *Session Chair : Jie Xu (Harbin Institute of Technology, China)*
13:10-13:40	Invited talk Kuang-Jau Fann (National Chung Hsing University, Taiwan)	Invited talk Marat Latypov (University of Arizona, USA)
13:40-14:10	Invited talk Wenchen Xu (Harbin Institute of Technology, China)	Invited talk Soo-Young Kim (Yamanaka Eng Co., Ltd., Japan)
14:10-14:35	Invited talk Hyoung Seop Kim (Pohang University of Science and Technology, South Korea)	Invited talk Yeong-Maw Hwang (National Sun Yat-sen University, Taiwan)
14:35-15:00	Invited talk Ming Yang (Tokyo Metropolitan University, Japan)	Invited talk Kwang Seok Lee (Korea Institute of Materials Science, South Korea)
15:00-15:20	Coffee Break #2	
	Oral Session #1 *Session Chair : Kuang-Jau Fann (National Chung Hsing University, Taiwan)*	***Oral Session #2*** *Session Chair : Soo-Young Kim (Yamanaka Eng. Co., Ltd., Japan)*
15:20-15:40	Da Seul Shin (Korea Institute of Materials Science, South Korea)	Tatsuhiko Aizawa (Shibaura Institute of Technology, Japan)
15:40-16:00	Chanyang Kim (Korea Institute of Materials Science, South Korea)	Sehyeok Oh (Korea Institute of Materials Science, South Korea)
16:00-16:20	Hyunsung Choi (Korea Institute of Materials Science, South Korea)	Hoheok Kim (Korea Institute of Materials Science, South Korea)
16:20-16:40	Masaaki Otsu (University of Fukui, Japan)	Christoph Hartmann (Technical University of Munich, Germany)
	Session Chair : Daseul Shin (Korea Institute of Materials Science, South Korea)	*Session Chair : Sehyeok Oh (Korea Institute of Materials Science, South Korea)*
16:40-17:00	Jung Yun Won (Seoul National University, South Korea)	Jaimyun Jung (Korea Institute of Materials Science, South Korea)
17:00-17:20	Majid Mohammad hosseinzadeh (Pusan National University, South Korea)	Zhutian Xu (Shanghai Jiao Tong University, China)
17:20-17:40	Yong Hou (Seoul National University, South Korea)	Lorenz Maier (Technical University of Munich, Germany)
17:40-18:00	Chaogang Ding (Harbin Institute of Technology, China)	Ke Wei (Nanchang Hangkong University, China)

May 17 (Wed.)

Room / Date/time	Session Room A	Session Room B
08:40-09:10	Conference Registration	
	Plenary Session #3 Session Chair : Debin Shan (Harbin Institute of Technology, China)	
09:10-09:50	Plenary talk Tomomi Shiratori (University of Toyama, Japan)	
09:50-10:30	Plenary talk Quang-Cherng Hsu (National Kaohsiung University of Science and Technology, Taiwan)	
10:30-10:50	Coffee Break #3	
	Invited Session #3 Session Chair : Quang-Cherng Hsu (National Kaohsiung University of Science and Technology, Taiwan)	***Invited Session #4*** Session Chair : Tomomi Shiratori (University of Toyama, Japan)
10:50-11:20	Invited talk Tatsuhiko Aizawa (Shibaura Institute of Technology, Japan)	Invited talk Shang-Nan Tsai (National Sun Yat-sen University, Taiwan)
11:20-11:50	Invited talk Seong-Hoon Kang (Korea Institute of Materials Science, South Korea)	Invited talk Linfa Peng (Shanghai Jiao Tong University, China)
11:50-12:00	Photo time	
12:00-13:10	Lunch #2	
	AWMFT & APSTP 2023 Graduate Student Session	
	Graduate student Session #1 Session Chair : Linfa Peng (Shanghai Jiao Tong University, China)	***Graduate student Session #2*** Session Chair : Hyunsung Choi (Korea Institute of Materials Science, South Korea)
13:10-13:25	Mahdi Aghaahmadi (Hanbat National University, South Korea)	Hyogeon Kim (Korea Institute of Materials Science, South Korea)
13:25-13:40	Ji Hoon Kim (Korea Institute of Materials Science, South Korea)	Jhan-Hong Ye (National Kaohsiung University of Science and Technology, Taiwan)
13:40-13:55	Zihan Bai (Beihang University, China)	Seung-Hyeok Shin (Seoul National University of Science and Technology, South Korea)
13:55-14:10	Zidong Yin (Tokyo Metropolitan University, Japan)	Xiaoliang Wang (Harbin Institute of Technology, China)
14:10-14:25	Zhiqin Yang (Harbin Institute of Technology, China)	Ryouma Okada (University of Toyama, Japan)
14:25-14:40	Sang-Gyu Kim (Seoul National University of Science and Technology, South Korea)	Zijian Han (Beihang University, China)
14:40-14:55	Weijun Huang (Nanchang Hangkong University, China)	Takumi Inoue (Tokyo Metropolitan University, Japan)
14:55-15:10	Jin Wook Park (Korea Institute of Materials Science, South Korea)	Yuxi Chen (Harbin Institute of Technology, China)
15:10-15:30	Coffee Break #4	
	Invited Session #5 Session Chair : Marat Latypov (University of Arizona, USA)	***Invited Session #6*** Session Chair : Wenchen Xu (Harbin Institute of Technology, China)
15:30-16:00	Invited talk Namsu Park (Korea Institute of Industrial Technology, South Korea)	Invited talk Jie Xu (Harbin Institute of Technology, China)
	Oral Session #3	***Oral Session #4***
16:00-16:20	Minh Tien Tran (Konkuk University, South Korea)	Yong-Nam Kwon (Korea Institute of Materials Science, South Korea)
16:20-16:40	Young Yun Woo (Korea Institute of Materials Science, South Korea)	Kuang-Jau Fann (National Chung Hsing University, Taiwan)
16:40-17:00		Young-Seok Oh (Korea Institute of Materials Science, South Korea)
18:30-20:30	Banquet	

Plenary Speakers of AWMFT & APSTP 2023

Prof. Shi-Hong Zhang
Institute of Metal Research, China

"Development of CP-FE Methods and Applications in forming of ultra-thin copper sheet and wire products"

Prof. Nariman Enikee
Ufa University of Science and Technology, Russia

"Developing ultrastrong nanostructured austenitic steels by severe plastic deformation"

Prof. Jae-il Jang
Hanyang University, Korea

"Survey of Nanoindentation Studies on Structural Materials: With a focus on high-entropy alloys"

Prof. Ming Wang Fu
Hong Kong Polytechnic University, China

"Size effects (SE) and SE affected process behaviors and performances in multi-scaled materials processing and deformation-based manufacturing"

Prof. Tomomi Shiratori
University of Toyama, Japan

"Punch-Edge Sharpening Effect on Work Hardening and Iron Losses in Shearing Non-Oriented Electrical Steel Sheets"

Prof. Quang-Cherng Hsu
National Kaohsiung University of Science and Technology, Taiwan

"Precision Extrusion of Aluminum Alloy - Current Development and Future Trend"

Invited Speakers of AWMFT & APSTP 2023

Prof. Kuang-Jau Fan

National Chung Hsing University, Taiwan

"Dieless Drawing a Metal Wire to Form its End Geometry"

Prof. Wenchen Xu

Harbin Institute of Technology, China

"Damage evolution and microstructure-property control for spinning forming of hard-to-deform materials"

Prof. Hyoung Seop Kim

Pohang University of Science and Technology, Korea

"Plasticity and Metal Forming of High Entropy Alloys"

Prof. Ming Yang

Tokyo Metropolitan University, Japan

"Effect of Martensitic Phase Transformation and Grain Size on Surface Roughening and Friction Behavior of Austenitic Thin Metal Foils"

Prof. Marat Latypov

University of Arizona, USA

"Machine learning of microstructure-property relationships in structural materials"

Dr. Soo-Young Kim

Yamanaka Eng Co., Ltd., Japan

"Application of SMART Die-set using Sensing and Control Schemes for Cold Forging"

Prof. Yeong-Maw Hwang

National Sun Yat-sen University, Taiwan

"Study of rotating compression forming of composite materials"

Invited Speakers of AWMFT & APSTP 2023

Dr. Kwang Seok Lee

Korea Institute of Materials Science, Korea

"Influence of multi-step drawing process variables on the magnetocaloric effect of gadolinium wire"

Prof. Tatsuhiko Aizawa

Shibaura Institute of Technology, Japan

"Galling Free Fine Blanking of Austenitic Stainless Steel Gears with High Quality"

Dr. Seong-Hoon Kang

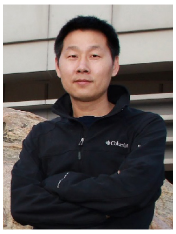
Korea Institute of Materials Science, Korea

"Predicting Dynamic Recrystallization Behavior based on Deep Convolutional Generative Adversarial Network"

Prof. Shang-Nan Tsai

National Sun Yat-sen University, Taiwan

"Mechanical Properties of Sandwich Panels with Corrugated Carbon Fiber Cores"



Prof. Linfa Peng

Shanghai Jiao Tong University, China

"Forming technologies for large-area functional micro/meso structures"

Dr. Namsu Park

Korea Institute of Industrial Technology, Korea

"Incremental Sheet Forming Process: Experiment and FE Simulation"

Prof. Jie Xu

Harbin Institute of Technology, China

"Development of nonconventional energy field assisted microforming"

Plenary Speech I

May 16 (Tue.) 09:10–09:50

Shi-Hong Zhang

Full Professor, PhD

Affiliation: Institute of Metal Research, Chinese Academy of Sciences, China
Position: Leader of Advanced Metal Forming Technology Group
E-mail: shzhang@imr.ac.cn

From 1999 to date Prof. Zhang is a full professor at Institute of Metal Research, Chinese Academy of Sciences (IMR/CAS) in China and the leader of Advanced Metal Forming Technology Group (AMFT), IMR/CAS.

Prof. Zhang has actively participated in the scientific committees of various international conferences and was the chairman of the 13th International Conference on Numerical Methods in Industrial Forming Processes (NUMIFORM 2013), which was held in 2013 at IMR, Shenyang China. He was also the chairman of the IDDRG 2015 which was held in 2015 in Shanghai China. Prof. Zhang is a Member of Steering Committee of IDDRG2016~2023 and Scientific Member of ICTP2008, 2011, 2014, 2017, 2020. In addition, he is Member of Editorial Board of International Journal of Forming Processes, Associate Editor of Manufacturing Reviews, and also Member of Editorial Board of Rare Metals. Prof. Zhang has published more than 250 journal papers (more than 190 articles published in international and Chinese leading SCI journals respectively), 56 conference papers and got around 80 patents.

Prof. Zhang has obtained many prizes and awards for his work, such as the A.M. Strickland Prize, awarded by the Division of Manufacturing Industries of the Institution of Mechanical Engineers for the best paper published in the Proceedings of IMechE as a significant contribution to the field of manufacturing, London,UK, June 15, 2011 and, first Zienkiewicz Honorary Prize awarded by the chairman of NUMIFORM2016 which was held in 2016 at University of Technology of Troyes, France.

Plenary Speech II

May 16 (Tue.) 09:50-10:30

Nariman Enikeev

Affiliation: Ufa University of Science and Technology, Ufa; Saint Petersburg State University, Saint Petersburg, Russia

Position: Leading Researcher, Professor of Material Science and Metal Physics Department

E-mail: nariman.enikeev@gmail.com

Nariman Enikeev works for Ufa University of Science and Technology (Ufa, Russia) and Saint Petersburg State University (Saint Petersburg, Russia) as a full professor of Material Science and Metal Physics Department and a leading researcher of Laboratory of Dynamics and Extreme Characteristics of Promising Nanostructured Materials, respectively. In 2022 he became a director of the Center for Design of Functional Materials of the Bashkir State University (Ufa, Russia). He has got a habilitation (Dr. Sci) degree in mechanics of deformed solids and condensed matter physics on the topic of "Grain boundaries and superstrength of nanostructured materials" in Institute for Problems in Mechanical Engineering of the Russian Academy of Sciences in 2016 (Saint Petersburg, Russia).

Scientific activity of Nariman Enikeev relates to investigation of nanostructured materials produced by severe plastic deformation. His expertise covers theoretical and experimental foundations for understanding the influence of nanoscale features of the mechanical and functional properties of metallic materials. It includes but is not limited to: grain boundary effects, texture, multiscale simulation, x-ray analysis, solute segregation, deformation mechanisms, mechanical performance etc. As a result, Nariman Enikeev published more than 100 papers indexed in Web of Science and Scopus including high-ranked journals with the impact factor up to 33 (Mater. Sci. Eng. R). He is coauthor of 3 monographs, several patents and a certificate of registration of the software package. He has many fruitful collaborations and research stays in various scientific groups in Europe, he has also extensive research experience with Korean research teams visiting Chungnam National University (under APEC fellowship award in Science and Technology supported by KOSEF) and POSTECH (within joint research projects). In 2017-2018 he was invited to develop and read lecture courses in the Normandy University of Rouen (France). He delivered many invited/keynote talks at international conferences including the most recent plenary lecture at the major conference of the SPD community - the 8th International Conference on Nanostructured Materials by Severe Plastic Deformation NanoSPD8 (Feb 26 - Mar 3, 2023, Bangalore, India).

Plenary Speech III

May 16 (Tue.) 10:50-11:30

Jae-il Jang

Affiliation: Div. of Mater. Sci. Eng., Hanyang University, South Korea
Position: Professor
E-mail: jijang@hanyang.ac.kr

Jae-il Jang is a professor of Division of Materials Science and Engineering at Hanyang University, Seoul, Korea. He received a BS, MS, and PhD degree in metallurgical science and engineering from Seoul National University, Seoul, Korea. After studied as a postdoctoral research fellow and then research assistant professor at the University of Tennessee and Oak Ridge National Laboratory, Prof. Jang joined Hanyang University in 2005 as an Assistant Professor and was promoted to full Professor. During 2014-2018, he served as chair of the MSE division.

He has (co-)authored more than 150 peer-reviewed papers in international journals. Now he serves as an editor of the journal Metals and Materials International, an associated editor of the Journal of Pressure Vessel Technology (Transaction of ASME), and a senior editorial board member of the journal Scientific Reports. His research group specializes in analysis of the small-scale deformation and fracture, particularly using instrumented indentation and nanomechanical testing techniques.

Plenary Speech IV

May 16 (Tue.) 11:30–12:10

Mingwang FU

Affiliation: The Hong Kong Polytechnic University, China
Position: Chair Professor of Advanced Manufacturing, Associate Director of the Research Institute for Advanced Manufacturing
E-mail: mmmwfu@polyu.edu.hk

Mingwang FU (M.W. FU) is the Chair Professor of Advanced Manufacturing in the Department of Mechanical Engineering, The Hong Kong Polytechnic University (PolyU). He is the Fellow of Society of Manufacturing Engineers (SME) and Hong Kong Institute of Engineers (HKIE), and Royal Society of Wolfson Visiting Fellow. He is an Associate Director of Research Institute for Advanced Manufacturing in PolyU. From 1987 to 1995, Prof Fu worked as a faculty member in China. Upon completion of his PhD study in the Singapore National University in 1997, he joined the Singapore Institute of Manufacturing Technology as a Senior Research Engineer. In Aug 2006, he joined The Hong Kong PolyU as a faculty member. Professor Fu is quite active in exploring advanced materials processing, multi-scaled manufacturing, metal forming, damage and fracture in manufacturing, structure fatigue in product service, and micro-mechanics in manufacturing. These efforts aim at seeking for an epistemological understanding of the scientific nature behind these disciplines, advancing knowledge in these areas, and successfully addressing a plethora of challenges and bottlenecked issues the explorations face, and eventually developing the state-of-the art manufacturing processes. His researches benefited the development of the technologies in the above-described fields and led to about 300 journal publications, 6 monographs and one volume of the Encyclopedia of Materials: Metals and Alloys published by Springer-Verlag London Ltd, CRC Press, Taylor & Francis Group, and Elsevier. Professor Fu is also sitting in the editorial board or as Associate Editor of a number of prestigious journals, including Int. J. Plast., Int. J. Mach. Tools Manuf., Int. J. Mech. Sci., Mater. Des., Int. J. Damage Mech., Int. J. Adv. Manuf. Technol., Adv. Manuf., etc. He often gives keynote or plenary talk in many international conferences in different countries.

Plenary Speech V

May 17 (Wed.) 09:10–09:50

Tomomi Shiratori

Affiliation: Faculty of engineering, University of Toyama, Japan
Position: Professor, Dr. Engineering
E-mail: shira@eng.u-toyama.ac.jp

Dr. Tomomi Shiratori had been worked in Komatsuseiki Kosakusho Co., Ltd. for 25 years from 1994 to 2019. During this time, he was awarded a doctoral degree in engineering from Tokyo Metropolitan University at 2017. He has served as a professor in the faculty of engineering, University of Toyama since 2019. Dr. Shiratori's main research interests are in the micro manufacturing, micro punching, plasma sputtering, plasma nitriding and carboning, diffusion bonding and advanced tool manufacturing. Dr. Shiratori has published more than 40+ articles on his research areas and 4 books on precision manufacturing in metal forming. Dr. Shiratori has the Technology Development Award from JSTP (Japan Society of Technology of Plasticity) in 2016 and 2023. Currently, Dr. Shiratori serving as a director of JSTP Hokuriku site and is aiming to develop plastic working technology.

Plenary Speech VI

May 17 (Wed.) 09:50-10:30

Quang-Cherng Hsu

Affiliation: National Kaohsiung University of Science and Technology, Taiwan
Position: Professor, Department of Mechanical Engineering
E-mail: hsuqc@nkust.edu.tw

Dr. Quang-Cherng Hsu currently is a professor of Mechanical Engineering, National Kaohsiung University of Science and Technology (NKUST), Taiwan. Prof. Hsu earned his Ph.D. degree in Mechanical Engineering, National Cheng-Kung University in 1981. After two-year service in military, he joined Metal Industry Research and Development Center, a government fund non-profit research organization, in Kaohsiung as a research engineer about two years. Then, he joined the current University.

In 2003~2004, Dr. Hsu visited Ohio State University, U.S.A., as a visiting scholar for one year. During Sept. 12-30, 2016, Prof. Hsu visited Aachen University, German, to study Industry 4.0. From March 3 ~ 26, 2017, Prof. Hsu visited Hung Yen University of Technology and Education, and Hai-Phone University, Viet Nam, and gave intensive speeches. Research interests of Prof. Hsu include Image Processing and Machine Vision, Metal Forming (Forging, Extrusion, Sheet-metal forming), Nano Imprint Lithography Applications, Molecular Dynamics Simulation. Prof. Hsu has published 62 referred journal papers, has obtained 14 invention patents and has attended 28 international conferences among 13 countries to present his research results. Prof. Hsu also likes to organize student's handy-team to attend domestic professional competitions including: Industrial Robot Competition, Computer Aided Measurement and Verification Competition, Mold and Die Industrial Application and Innovation Competition, Image Servo and Precision Measurement Competition, Optical-Electronic Inspection Instrument Competition, and Precision Machinery Competition. In 2021, Prof. was given Outstanding Contribution Award of Taiwan Forging Association. Within these two years, Prof Hsu's group won the first position and the second position of Servo Press Process Design and CAE Simulation Competition which were organized by Taiwan Society of Technology Plasticity.

Invited Speech I

May 16 (Tue.) 13:10-13:40

Kuang-Jau Fann

Affiliation: National Chung Hsing University, Taichung, Taiwan
Position: Associate Professor, Department of Mechanical Engineering
E-mail: kjfann@nchu.edu.tw

Kuang-Jau Fann is a highly accomplished professional with a strong background in engineering and academia. He holds a B.Sc. degree in mechanical engineering from National Cheng Kung University, Tainan, Taiwan, as well as Dipl.-Ing. and Dr.-Ing. degrees from Faculty of Design and Manufacturing, University of Stuttgart, Germany. Currently, he is working at Department of Mechanical Engineering, National Chung Hsing University, where he brings a wealth of experience and expertise to his role.

In addition to his professional endeavors, Kuang-Jau is actively involved in various working activities within associations and societies. He currently serves as a board member in Taiwan Forging Association, and holds the prestigious position of Vice Chair in Taiwan Society for Technology of Plasticity. Notably, he has also played a key role in hosting the first Asia Pacific Symposium for Technology of Plasticity, showcasing his commitment to advancing knowledge and fostering collaboration among professionals.

With his diverse background and extensive experience, Kuang-Jau brings a unique perspective and valuable contributions to the field in technology of plasticity, especially, in metal forming processing. His passion for research, academic excellence, and collaborative networking makes him a valuable asset to the academic community.

Invited Speech II

May 16 (Tue.) 13:40-14:10

Wenchen Xu

Affiliation: Harbin Institute of Technology, P.R. China
Position: Professor, School of Materials Science and Engineering
E-mail: xuwc_76@hit.edu.cn

Wenchen Xu graduated from Harbin Institute of Technology (Harbin, P.R. China), materials science and engineering, specialty in precision forming process and equipment for hard-to-deform materials. At present time he works for the State Key Laboratory of Precision Hot Processing of Metals in Harbin Institute of Technology. Currently he is a principal investigator for General Program of National Natural Science Foundation of China, National Key Research and Development Program of China and Novel Fuel Element Development Program of China Nuclear Power Technology Research Institute.

He received his B.S., M.S. and Ph.D. degree in materials science and engineering from Harbin Institute of Technology in 1999, 2001 and 2005, respectively. Wenchen Xu is a member of Plastic Engineering Branch of the Chinese Society of Mechanical Engineering, the Committee of Aircraft Structural Materials and Application of the Nonferrous Metals Society of China, and the Committee of Materials Science and Engineering of China Ordnance Society.

Invited Speech III

May 16 (Tue.) 13:10–13:40

Marat Latypov

Invited Speaker

Affiliation: University of Arizona, USA
Position: Assistant Professor of Materials Science & Engineering and Applied Math
E-mail: latmarat@arizona.edu

Dr. Marat Latypov is an assistant professor in the Department of Materials Science & Engineering and a faculty member of the Graduate Interdisciplinary Program in Applied Mathematics at the University of Arizona. Dr. Latypov received his Ph.D. from the Department of Materials Science and Engineering at Pohang University of Science and Technology (POSTECH) followed by a postdoc at Georgia Tech/CNRS lab in France and the University of California in Santa Barbara (USA). He spent two years in R&D of an aluminum company as a senior scientist before joining the University of Arizona. Dr. Latypov has a wide range of research interests in the field of materials science including materials informatics, modeling and simulation, mechanics, thermodynamics, alloy design, and process optimization.

Invited Speech IV

May 16 (Tue.) 13:40–14:10

Soo-Young Kim

Affiliation: Yamanaka Eng. Co., Japan
Position: General manager of technical planning
E-mail: sykim@yamanaka-eng.co.jp

Soo-Young Kim graduated received his Ph. D. in Mechanical Engineering from Korea Advanced Institute of Science and Technology (Daejon, South Korea) in 2000. His major research field is the numerical simulation and process design of metal forming processes, the process and tool design for cold forging, and the sensing /data analytic technologies to promote the digital transformation of manufacturing process.

He has been working with Yamanaka Eng. Co., Ltd. from 2002. Currently, He is a general manager of technical planning in Yamanaka Eng. Co. and also acts as a Chief Operating Officer of YG Solutions Co., which is a branch company of Yamanaka Eng. Co. responsible for the advanced R&D tasks. He is a member of JSTP and the assistant section chief of the Research Team for Forging Intellectualization in the Forging Committee of JSTP. Also, he acts as one of co-chairmen in the Tool Life & Tool Quality Subgroup of ICFG. He was awarded the paper award of JSDMT in 2016, and also received the JSTP Academic Award in 2021.

Invited Speech V

May 17 (Wed.) 10:50-11:20

Tatsuhiko Aizawa

Affiliation: SIT (Shibaura Institute of Technology), Japan
Position: Director, Professor at the Surface Engineering Design Laboratory
E-mail: taizawa@ sic.shibaura-it.ac.jp

He received PhD from The University of Tokyo in 1980. He became a research associate, Institute of Aerospace and Aeronautics in 1980, a lecturer in 1985, an associate professor in 1986 and a professor in 1996 till 2004 at the University of Tokyo. After the research professor in the University of Toronto from 2005 to 2008, he has been working as a professor in SIT from 2009 till now. His research interests include the micro-manufacturing, the innovations in manufacturing and materials processing, and, the materials science and engineering.
He has published over 800 papers in Japanese and International Journals and over 90 patents. He has received lots of awards from academic societies including the Distinguished Achievement Award, Japan Institute of Metals, 2011, the Gold Medal, 2017, the Achievement Award, 2019, Japan Society of Technology of Plasticity, respectively, and the best presentation award at the Conference, AWMFT-2021.

Invited Speech VI

May 17 (Wed.) 11:20-11:50

Seong-Hoon Kang

Affiliation: Korea Institute of Materials Science, South Korea
Position: Principal Researcher, Head of Department of Materials AI &Big-Data
E-mail: kangsh@kims.re.kr

Seong-Hoon Kang received his Ph.D. degree in Department of Mechanical Engineering from Korea Advanced Institute of Science and Technology(KAIST) in 2005. He has been a head of department of materials AI & Big-Data at Korea Institute of Materials Science(KIMS) since 2018. His main academic interests are process design, microstructure modeling, FE simulation and AI related with metal forming.
He is members of the Korean Society for Technology of Plasticity(KSTP), the Korean Institute of Metals and Materials(KIM), the Korean Society of Mechanical Engineers(KSME), the Korean Society of Precision Engineering(KSPE), Materials Research Society of Korea(MRS) and the Korean Society of Manufacturing Technology Engineers(KSMTE).

Invited Speech VII

May 17 (Wed.) **10:50–11:20**

Shang-Nan Tsai

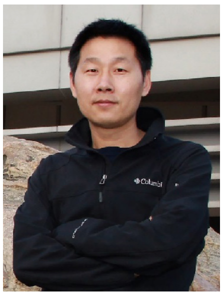
Affiliation: National Sun Yat-sen University, Taiwan
Position: Assistant Professor, Department of Mechanical and Electro-Mechanical Engineering
E-mail: sn.tsai@mail.nsysu.edu.tw

Shang-Nan Tsai graduated from Imperial College London (United Kingdom), in the Department of Mechanical Engineering. His specialties are manufacturing of composite structures, fiber-polymer composites and their mechanics. He now works as an assistant professor in the Department of Mechanical and Electro-Mechanical Engineering, at National Sun Yat-sen University in Taiwan.

Dr. Tsai received his bachelor's degree and master’s degree in the Department of Power Mechanical Engineering from Taiwan National Tsing Hua University in 2010 and 2012. He is a member of the Society of Theoretical and Applied Mechanics (STAM) of Taiwan, and SAMPE Europe.

Invited Speech VIII

May 17 (Wed.) **11:20–11:50**



Linfa Peng

Professor

Affiliation: Shanghai Jiaotong University, Shanghai P.R.China
E-mail: penglinfa@sjtu.edu.cn

Dr. Peng’s is a professor at the Mechanical School of Shanghai Jiao Tong University. He received his B.Eng and M.Eng in Materials Science and Engineering from the Jilin University in Changchun, China and PhD in Mechanical Engineering from the Shanghai Jiao Tong University, China. In 2010, he joined the Mechanical School of Shanghai Jiao Tong University as a faculty member after he finished two-year postdoctoral research work. His research specialties include material processing technology, micro/meso forming, process modeling & optimization.

In 2015, Dr. Peng was supported by National Natural Science Foundation--Outstanding Youth Foundation and also win the first prize of Natural Science Award by the Ministry of Education. In 2016, he was selected as Chang Jiang Youth Scholars by the Ministry of Education of P. R. China

Invited Speech IX

May 17 (Wed.) 15:30-16:00

Namsu Park

Invited Speaker

Affiliation: Korea Institute of Industrial Technology, South Korea
Position: Senior Researcher, Metal Forming R&D Division
E-mail: nspark@kitech.re.kr

Dr. Park is currently affiliated with the Metal Forming R&D Division, Korea Institute of Industrial Technology (KITECH). His areas of expertise include metal forming processes in room and elevated temperatures, forming equipment, formability, and fracture testing/analysis including FE simulations of AHSS automotive structure parts. He received his Ph.D. degree from the Korea Advanced Institute of Science and Technology (KAIST) in 2017. After graduation, he joined the Manufacturing Systems Research Lab. at the General Motors R&D center in Warren, MI as a postdoctoral researcher in 2018, where he conducted research on anisotropy/asymmetry-induced distortional yielding and ductile fracture modeling. During this period, he also participated in a research project by the Auto/Steel Partnership on damage accumulation modeling considering non-linear strain paths. Dr. Park is a member of the International Centre for Innovative Manufacturing (ICIM) led by Prof. Jeongwhan Yoon and is actively involved in global research projects.

Invited Speech X

May 17 (Wed.) 15:30-16:00

Jie Xu

Affiliation: Harbin Institute of Technology
Position: Professor, School of Materials Science and Engineering; Deputy Director, Key Laboratory of Micro-Systems and Micro-Structures Manufacturing of Ministry of Education
E-mail: xjhit@hit.edu.cn

Jie Xu is currently a full professor in materials science and engineering at Harbin Institute of Technology (HIT). His current interests focus on micro/nano-forming of 3D metallic structures in conventional metals and ultrafine-grained metals.
Jie Xu received his B.S., M.S., and Ph.D. degrees in materials science and engineering from Harbin Institute of Technology in 2004, 2006, and 2010, respectively. He is session chair or member of the academic committee of AWMFT, THERMEC, and ICKEM. Jie Xu have authored/co-authored >130 scientific papers that have appeared in peer-reviewed journals concerning materials science and engineering.

Oral Presentation Timetable

May 16 (Tue.)

Plenary Session #1

Session Room A

Session Chair : Ming Yang (Tokyo Metropolitan University, Japan)

09:10-09:50 P. 45

Development of CP-FE Methods and Applications in forming of ultra-thin copper sheet and wire products

Shi-Hong Zhang[1,*], Shuai-Feng Chen[1]
1 Institute of Metal Research, Chinese Academy of Sciences, China
* Corresponding Author / E-mail: shzhang@imr.ac.cn

09:50-10:30 P. 46

Developing ultrastrong nanostructured austenitic steels by severe plastic deformation

Nariman Enikeev[1,*]
1 Ufa University of Science and Technology; Saint Petersburg State University, Russia
* Corresponding Author / E-mail: Nariman.enikeev@gmail.com

Plenary Session #2

Session Room A

Session Chair: Yeong-Maw Hwang (National Sun Yat-sen University, Taiwan)

10:50-11:30 P. 47

Survey of Nanoindentation Studies on Structural Materials : With a focus on high-entropy alloys

Jae-il Jang[1,*], Zhe Gao[1]
1 Hanyang University, South Korea
* Corresponding Author / E-mail: jijang@hanyang.ac.kr

11:30-12:10 P. 48

Size effects (SE) and SE affected process behaviors and performances in multi-scaled materials processing and deformation-based manufacturing

Ming Wang Fu[1,*]
1 The Hong Kong Polytechnic University, Hongkong
* Corresponding Author / E-mail: mmmwfu@polyu.edu.hk

May 16 (Tue.)

Invited Session #1

Session Room A

Session Chair: Seong-Hoon Kang (Korea Institute of Materials Science, South Korea)

13:10-13:40 P. 51

Dieless Drawing a Metal Wire to Form its End Geometry

Kuang-Jau Fann[1,*], He-Yin Hsu[1], Chia-Feng Yu[1]
1 National Chung Hsing University, Taiwan
* Corresponding Author / E-mail: kjfann@nchu.edu.tw

13:40-14:10 P. 52

Damage evolution and microstructure-property control for spinning forming of hard-to-deform materials

Wenchen Xu[1,*]
1 Harbin Institute of Technology, China
* Corresponding Author / E-mail: xuwc_76@hit.edu.cn

14:10-14:35 P. 53

Plasticity and Metal Forming of High Entropy Alloys

Hyoung Seop Kim[1,*]
1 Pohang University of Science and Technology, South Korea
* Corresponding Author / E-mail: hskim@postech.ac.kr

14:35-15:00 P. 54

Effect of Martensitic Phase Transformation and Grain Size on Surface Roughening and Friction Behavior of Austenitic Thin Metal Foils

Ming Yang[1,*], Aziz Abdul[2]
1 Tokyo Metropolitan University, Japan
2 Universitas Sultan Ageng Tirtayasa, Indonesia
* Corresponding Author / E-mail: yang@tmu.ac.jp

May 16 (Tue.)

Invited Session #2

Session Room B

Session Chair: Jie Xu (Harbin Institute of Technology, China)

13:10-13:40 P. 55

Machine learning of microstructure-property relationships in structural materials

Marat Latypov[1,*]
1 University of Arizona, USA
* Corresponding Author / E-mail: latmarat@arizona.edu

13:40-14:10 P. 56

Application of SMART Die-set using Sensing and Control Schemes for Cold Forging

Soo-Young Kim[1,*], Yusuke Ezawa[1], Asuka Sano[1], Takashi Kihara[1]
1 Yamanaka Eng Co., Ltd, Japan
* Corresponding Author / E-mail: sykim@yamanaka-eng.co.jp

14:10-14:35 P. 57

Study of rotating compression forming of composite materials

Yeong-Maw Hwang[1,*], Yun-Hao Tsai[1], Jun-Ru Chen[1]
1 National Sun Yat-sen University, Taiwan
* Corresponding Author / E-mail: ymhwang@mail.nsysu.edu.tw

14:35-15:00 P. 58

Influence of multi-step drawing process variables on the magnetocaloric effect of gadolinium wire

Kwang Seok Lee[1,*], Jeong Hun Kim[2], Da Seul Shin[1], Jun Seok Yoon[1], Jeoung Han Kim[3]
1 Korea Institute of Materials Science, South Korea
2 Hyundai Steel, South Korea
3 Hanbat National University, South Korea
* Corresponding Author / E-mail: ksl1784@kims.re.kr

May 16 (Tue.)

Oral Session #1

Session Room A

Session Chair: Kuang-Jau Fann (National Chung Hsing University, Taiwan)

15:20-15:40 P. 59

Forming technology for La-based magnetocaloric materials

Daseul Shin[1] and Kwang Seok Lee[1,*]
1 Korea Institute of Materials Science, South Korea
* Corresponding Author / E-mail: ksl1784@kims.re.kr

15:40-16:00 P. 60

Identification of the anisotropic constitutive parameters for the Nimonic thin sheets assisted by the virtual fields method

Chanyang Kim[1], Hyuk-Jong Bong[1], Kwang-Seok Lee[1], Jinwoo Lee[2,*]
1 Department of Materials Processing, Korea Institute of Materials Science, South Korea
2 Department of Mechanical Engineering, University of Ulsan, South Korea
* Corresponding Author / E-mail: jinwoolee@ulsan.ac.kr

16:00-16:20 P. 61

AI application to the EV motor component manufacturing

Hyunsung Choi[1,*], Yong-Nam Kwon[1], Donghyuk Cho[2], Piemaan Fazily[2], Jeong Whan Yoon[2], Jaekun Kim[3]
1 Korea Institute of Materials Science, South Korea
2 Korea Advanced Institute of Science and Technology, South Korea
3 LG Electronics, South Korea
* Corresponding Author / E-mail: h.choi@kims.re.kr

16:20-16:40 P. 62

Generation of tool path using neural networks with material properties in incremental forming

Masaaki Otsu[1,*], Yuki Kurita[1]
1 University of Fukui, Japan
* Corresponding Author / E-mail: otsu@u-fukui.ac.jp

May 16 (Tue.)

Oral Session #1

Session Room A

Session Chair: Daseul Shin (Korea Institute of Materials Science, South Korea)

16:40-17:00 P. 63

Evaluation of crushing performance for extruded aluminum alloy tubes based on finite element simulation with ductile fracture

Jung Yun Won[1], Seojun Hong[1], Chanyang Kim[2], Hyungsop Yoon[3], Myoung-Gyu Lee[1,*]
1 Seoul National University, South Korea
2 Korea Institute of Materials Science, South Korea
3 Hyundai Motor Group, South Korea
* Corresponding Author / E-mail: myounglee@snu.ac.kr

17:00-17:20 P. 64

An Experimental and Finite Element Analysis-Based Optimization of a Novel Hydroforming Die for the Producing of Curved Tubes with Non-Uniform Curvature and Unequal Cross-Section

Majid Mohammadhosseinzadeh[1], Hossein Ghorbani-menghari[1], Ji Hoon Kim[1,*]
1 Pusan National University, South Korea
* Corresponding Author / E-mail: kimjh@pusan.ac.kr

17:20-17:40 P. 65

A new anisotropic-asymmetric yield criterion covering wider stress states in sheet metal forming

Yong Hou[1], Junying Min[2], Myoung-Gyu Lee[1,*]
1 Seoul National University, South Korea
2 Tongji University, China
* Corresponding Author / E-mail: myounglee@snu.ac.kr

17:40-18:00 P. 66

Preparation and Properties of Cu/Nb Nanolayered Composites

Chaogang Ding[1], Jie Xu[1,*], Debin Shan[1], Bin Guo[1]
1 Harbin Institute of Technology, China
* Corresponding Author / E-mail: xjhit@hit.edu.cn

May 16 (Tue.)

Oral Session #2

Session Room B

Session Chair: Soo-Young Kim (Yamanaka Eng. Co., Ltd., Japan)

15:20-15:40 P. 67

Acicular Microtexturing onto Copper Sheet for Heat Radiation

Tatsuhiko Aizawa[1,*], Hiroki Nakata[2], Takeshi Nasu[2]
1 Surface Engineering Design Laboratory Shibaura Institute of Technology, Japan
2 Ebinax, Co., Ltd, Japan
* Corresponding Author / E-mail: taizawa@ sic.shibaura-it.ac.jp

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15:40-16:00 P. 68

Deep-learning-based prediction of out-of-plane structural deformation of a deck plate

Sehyeok Oh[1], Hyung Kook Jin[2], Seok Je Joe[2], Hyungson Ki[3,*]
1 Korea Institute of Materials Science, South Korea
2 Korea Shipbuilding & Offshore Engineering, South Korea
3 Ulsan National Institute of Science and Technology, South Korea
* Corresponding Author / E-mail: hski@unist.ac.kr

16:00-16:20 P. 69

Super resolution of three-dimensional microstructural image of a steel using deep learning

Hoheok Kim[1,*], Sehyeok Oh[1], Jaimyun Jung[1], Young-Seok Oh[1], Se-Jong Kim[1], Ho Won Lee[1], Seong-Hoon Kang[1], Junya Inoue[2]
1 Korea Institute of Materials Science, South Korea
2 The University of Tokyo, Japan
* Corresponding Author / E-mail: hoheokkim@kims.re.kr

16:20-16:40 P. 70

Optical flow methods for crack propagation measurement

Christoph Hartmann[1,*]
1 Chair of Metal Forming and Casting, Technical University of Munich, Germany
* Corresponding Author / E-mail: christoph.hartmann@utg.de

May 16 (Tue.)

Oral Session #2

Session Room B

Session Chair: Sehyeok Oh (Korea Institute of Materials Science, South Korea)

16:40-17:00 P. 71

Super-resolving digital microstructure through deep learning for microstructure characterization and micromechanical simulations

Jaimyun Jung[1,*], Juwon Na[2], Hyung Keun Park[2], Jeong Min Park[1], Gyuwon Kim[2], Seungchul Lee[2,*], Hyoung Seop Kim[2,*]
1 Korea Institute of Materials Science, South Korea
2 Pohang University of Science and Technology, South Korea
* Corresponding Author / E-mail: jjm0475@kims.re.kr

17:00-17:20 P. 72

Investigation on the ductility of magnetron sputtered Niobium coatings on SS316L substrate for precoated sheet microforming

Zhutian Xu[1,*], Linfa Peng[1], Chuanzheng Li[1]
1 Shanghai Jiao Tong University, China
* Corresponding Author / E-mail: Zhutianxu@sjtu.edu.cn

17:20-17:40 P. 73

Material card validation setup for the investigation of multi-directional strain hardening behavior for sheet metals

Lorenz Maier[1,*], Wolfram Volk[1], Christoph Hartmann[1]
1 Chair of Metal Forming and Casting, Technical University of Munich, Germany
* Corresponding Author / E-mail: lorenz.maier@utg.de

17:40-18:00 P. 74

Investigation on the maximum elongation of SP700 titanium alloy based on composite superplastic deformation of maximum m value and optimal strain rate

Ke Wei[1,2,*], Gaochao Wang[2], Qianjiang Sun[2], Guoyun He[2], Myoung-Gyu Lee[1,*]
1 Seoul National University, South Korea
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May 17 (Wed.)

Plenary Session #3

Session Room A

Session Chair: Debin Shan (Harbin Institute of Technology, China)

09:10–09:50 P. 77

Punch-Edge Sharpening Effect on Work Hardening and Iron Losses in Shearing Non-Oriented Electrical Steel Sheets

Tomomi Shiratori[1,*], Shunsuke Ohmura[2], Ryouma Okada[2], Yuuya Kozawa[2], Yohei Suzuki[3], Tatsuhiko Aizawa[4]
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09:50–10:30 P. 78

Precision Extrusion of Aluminum Alloy - Current Development and Future Trend

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May 17 (Wed.)

Invited Session #3 Session Room A

Session Chair: Quang-Cherng Hsu (National Kaohsiung University of Science and Technology, Taiwan)

10:50-11:20 P. 79

Galling-Free Fine Blanking of Austenitic Stainless Steel Gears with High Quality

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11:20-11:50 P. 80

Predicting Dynamic Recrystallization Behavior based on Deep Convolutional Generative Adversarial Network

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Invited Session #4 Session Room B

Session Chair: Session Chair : Tomomi Shiratori (University of Toyama, Japan)

10:50-11:20 P. 81

Mechanical Properties of Sandwich Panels with Corrugated Carbon Fiber Cores

Shang-Nan Tsai[1,*], Tsung-Han Hsieh[2], I-Hsin Wang[2], Bo-Wei Guo[2]
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11:20-11:50 P. 82

Forming technologies for large-area functional micro/meso structures

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May 17 (Wed.)

Graduate student Session #1

Session Room A

Session Chair: Linfa Peng (Shanghai Jiao Tong University, China)

13:10–13:25 P. 85

Processing design optimization to produce 75mm thick Ti-6Al-4V alloy plate; correlation of microstructural evolution and mechanical properties

Mahdi Aghaahmadi[1], Hyunseok Lee[2], Mi-Seon Choi[2], Ji Soo Kim[3], Byoung Jun Han[1], Jeoung Han Kim[1,*]
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13:25–13:40 P. 86

Application of acoustic emission signal analysis for monitoring the mechanical behavior of steel bar for cold forging during three-point bending tests

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13:40–13:55 P. 87

Subvoxel-controlled printing of multi-material and multi-structural filaments

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13:55–14:10 P. 88

Evolution of temperature change by impact effect on the surface layer of various materials during ultrasonic micro-forging

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May 17 (Wed.)

Graduate student Session #1

Session Room A

Session Chair: Linfa Peng (Shanghai Jiao Tong University, China)

14:10–14:25 P. 89

Tensile deformation behavior of an equimolar high-entropy alloy subjected to electrically assisted uniaxial tension

Zhiqin Yang[1,2], Sujung Son[2], Jie Xu[1,*], Debin Shan[1], Bin Guo[1], Hyoung Seop Kim[2,*]
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14:25–14:40 P. 90

Effect of Cementite Morphology on Hydrogen Embrittlement of Tempered Martensitic Steels

Sang-Gyu Kim[1], Hee-Chang Shin[1], Hyun-Joo Seo[2], Hwan-Gyo Jung[2], Byoungchul Hwang[1,*]
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14:40–14:55 P. 91

Forming temperature on the influence of 2198 Al-Li alloy sheet forming limit

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14:55–15:10 P. 92

Development of manufacturing process for mass production of stimuli-responsive soft micropillar actuator

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May 17 (Wed.)

Graduate student Session #2

Session Room B

Session Chair: Hyunsung Choi (Korea Institute of Materials Science, South Korea)

13:10-13:25 P. 93

Effect of microstructure and residual stress on mechanical properties of Inconel 718 alloy through ultrasonic nanocrystalline surface modification process

Hyogeon Kim[1], Auezhan Amanov[2], Junggi Kim[3], Eun yoo Yoon[1,*]
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13:25-13:40 P. 94

Heat Generation and Strain Rate Effect on Forming of Low Carbon Boron Steel

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13:40-13:55 P. 95

Microstructure Evolution and Mechanical Properties of Directly Quenched and Intercritical- Annealed Low-Carbon Dual-Phase Steels

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13:55-14:10 P. 96

Fabrication of surface microstructures with three-dimensional multiscale features on aluminum alloy by hot embossing

Xiaoliang Wang[1], Yongda Liu[1], Hongpeng Jiang[1], Jie Xu[1,*], Debin Shan[1], Bin Guo[1]
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May 17 (Wed.)

Graduate student Session #2

Session Room B

Session Chair: Hyunsung Choi (Korea Institute of Materials Science, South Korea)

14:10–14:25	P. 97	**Effects of Nanometric Piercing Tools on Process affected area in Non-oriented Electrical Steel Sheet**

Ryouma Okada[1,*], Yuuya Kozawa[1], Shunsuke Ohmura[1], Tomomi Shiratori[1], Tatsuhiko Aizawa[2]
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14:25–14:40	P. 98	**Effect of forming parameters on mechanical properties of carbon fiber reinforced Inconel 718 composites prepared by spark plasma sintering**

Zijian Han[1], Bao Meng[1,*], Min Wan[1]
1 Beihang University, China
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14:40–14:55	P. 99	**Evaluation of the coefficient of friction during forging process using a CAE-assited sensing system**

Takumi Inoue[1,*], Ming Yang[1], Takunori Kyuno[2], Soo-Young Kim[3]
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14:55–15:10	P. 100	**Mechanical Behavior and Microstructural Evolution of Aluminum Alloy under Ultrasonic Vibration-assisted Micro-tension**

Yuxi Chen[1], Debin Shan[1,*], Jie Xu[1], Bin Guo[1], Chaogang Ding[1]
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May 17 (Wed.)

Invited Session #5

Session Room A

Session Chair: Marat Latypov (University of Arizona, USA)

15:30-16:00 P. 101

Incremental Sheet Forming Process: Experiment and FE Simulation

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Invited Session #6

Session Room B

Session Chair: Wenchen Xu (Harbin Institute of Technology, China)

15:30-16:00 P. 102

Development of nonconventional energy field assisted micro-forming

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Oral Session #3

Session Room A

Session Chair: Marat Latypov (University of Arizona, USA)

16:00-16:20 P. 103

Crystal plasticity modeling of micromechanical properties of constituent phases in 3rd generation complex phase AHSS

Minh Tien Tran[1], Minh Sang Pham[1], Hyunki Kim[2],
Hobyung Chae[3], Wan Chuck Woo[3], Dong-kyu Kim[1,*]
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16:20-16:40 P. 104

Effect of two-step heat treatment on microstructure and mechanical properties of non-heat-treated steel

Young yun Woo[1,*], Young seon Lee[1], Eun yoo Yoon[1], Kyu han Kim[1]
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May 17 (Wed.)

Oral Session #4

Session Room B

Session Chair: Wenchen Xu (Harbin Institute of Technology, China)

16:00-16:20 P. 105

Fatigue life variation of structural part depending on the residual stress level

Yong-Nam Kwon[1,*], Dong Jun Lee[1], Moo Young Seok[1], Hyun Il Park[1], Hyunsung Choi[1]
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16:20-16:40 P. 106

Study on the initial tension of helical tension spring formed by coiling process

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16:40-17:00 P. 107

Densification behavior of Mg+2B powder mixture and its effect on critical current density of superconducting MgB_2 wire

Young-Seok Oh[1], Ho Won Lee[1], Kook-Chae Chung[2], Seong-Hoon Kang[1,*]
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May 16 (Tue.)

Morning Session

Plenary session #1, #2

Development of CP-FE Methods and Applications in forming of ultra-thin copper sheet and wire products

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With the increasing development of miniaturized components in electronic devices, the high-performance ultra-thin cooper sheet and wire are highly demanded. Whereas, the microstructure feature and texture evolution of ultra-thin copper sheet and wire products are difficult to be controlled during their rolling and drawing process with micro-deformation characteristics. Thus, crystal plasticity (CP)- Finite element (FE) coupled simulation method are developed for reasonably adjusting the microstructure feature and texture evolution. Firstly, FE simulation integrated with in-house subroutine code is conducted accurately considering the strain/strain inheritance. It can ensure the precise depiction of deformation history of ultra-thin copper sheet and wire in micrometer scale. Secondly, crystal plasticity method considering the real grain feature (grain morphology and size) and orientation is established. Finally, the CP-FE coupled method is developed with the capacity of considering the micro-scale forming derived grain feature and orientation evolution. With the developed CP-FE method, the effect of external micro-scale loading and interior microstructure feature can be quantitively estimated. Especially, the underlying mechanism for microstructure and texture heterogeneity can be revealed with clarifying the relation among stress state, plastic deformation mode and microstructure and texture evolution.

Key Words: Ultra-thin sheet/wire, Crystal plasticity, Microstructure feature, Texture evolution

Developing ultrastrong nanostructured austenitic steels by severe plastic deformation

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Modern society is in dire need of new materials with superior performance for advanced applications. Steels are among the most important materials for various industries, and there is a global need to further improve their multifunctional properties. For example, austenitic stainless steels are known for their outstanding corrosion resistance, good formability, high durability, and so on. However, the yield strength of these steels is relatively low, which limits their use in many potential applications. Nanostructuring through extremely large straining under high pressures to significantly refine the microstructure of metallic materials in order to obtain ultrafine-grained states attracts much attention of researchers, since it can significantly improve the mechanical and functional properties of existing materials.

This presentation features a review of the broad research activity performed on the microstructure and mechanical behavior of nanostructured austenitic steels, such as corrosion-resistant steels and steels with the effect of twinning induced plasticity (TWIP-steels). Along with the effects of grain structure refinement, a recently discovered phenomenon of redistribution of alloying elements due to severe plastic deformation is discussed. The influence of structural features on the mechanical characteristics of steels and their resistance to external influences, as well as the effect of hardening by annealing and an increase in plasticity in the high-strength state of nanostructured steel due to the plasticity mechanism, which takes into account the interaction of grain-boundary solute segregations and dislocations, is analyzed.

Key Words: nanostructured materials, severe plastic deformation, austenitic steels, mechanical properties

Survey of Nanoindentation Studies on Structural Materials : With a focus on high-entropy alloys

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Over the past 4 decades since it was first introduced in 1980s, nanoindentation technique has been widely used to estimate the various mechanical properties of the small volume in a material at much smaller loads and size scales than conventional (micro-)hardness tests. The technique is now considered not only as a characterizing tool but as a promising technology for better understanding of the mechanisms of small-scale mechanical/physical behavior from materials science viewpoints. In this talk, based on the research of my group and colleagues, I would like to explain how this becoming-somewhat-old technique can be yet very valuable tool for developing novel structural materials. Especially, for a crucial instance, the main focus of this talk is given on the nanoindentation study on high-/medium-entropy alloys, a relatively new member of structural materials family.

Key Words: Nanoindentationm Nano, Nano-/Micro-Mechanics

Size effects (SE) and SE affected process behaviors and performances in multi-scaled materials processing and deformation-based manufacturing

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Size effect (SE) exists in many concerned domains due to the value change of size effect factors. Size effect factors are defined as the influencing parameters of the materials, structures or systems to be concerned whose value change would lead to different SE manifestations. In multi-scaled manufacturing, including macro-, meso- and micro-scaled ones concerned in this talk, SEs occur in these size scales and would induce different process behaviors, phenomena, and performances in different scales. The SEs can further result in the scatters of process behaviors, phenomena, and the quality and property of the fabricated different scaled parts and components. By using multi-scaled materials processing and deformation-based manufacturing as the case study processes, the above-mentioned SEs and their induced manifestations are reviewed and analyzed. The current research status and the future focuses are articulated and discussed. Some critical issues to be addressed and unknowns to be understood are highlighted. The talk aims at presenting a panorama of SEs, their impacts and the bottleneck issues in multi-scaled materials processing and deformation based manufacturing for making multi-scaled parts and components, and how to address them to ensure the efficient realization of multi-scaled materials processing and manufacturing.

Key Words: Size effects, materials processing, metal forming, size effect related process behavior and performance, metal-formed product quality

May 16 (Tue.)

Afternoon Session

Invited session #1, #2

Oral session #1, #2

Dieless Drawing a Metal Wire to Form its End Geometry

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This paper proposes a dieless drawing process to form a reduced geometry on the end of a metal wire, as an alternative to the traditional method of using a die set at room temperature. The cost of the die set and the flash waste material induced in the traditional process will be declined sooner or later because of 2030 emissions reduction or 2050 net zero.

The proposed process utilizes a module that combines heating and cooling to achieve a specific reduced geometry on the end of a wire. To determine the required evolution of the temperature profile for the dieless drawing process, an algorithm based on the slab method for the stress field and the finite difference method for the temperature field has been developed. The algorithm can be carried out on a test bench equipped with a motion control system for the drawing module and for the heating and cooling module.

On the test bench, the cooling water flow rate was experimentally converted from the required evolution of the heat transfer coefficient based on a heat transfer model that uses the finite difference method for the evolution of the temperature profile of the wire, which is heated by induction coils as an energy source with a specific electric power. As a result, the experiment shows that the required evolution of the temperature profile was achieved without any significant difference, and the geometry tolerance of the end shape of the drawn wire also met the current industry standard.

These results could have implications for the metalworking industry by providing a cost-effective and sustainable solution for forming end geometries on metal wires without the need for a die set or significant waste material and the loss of precision and accuracy in the final product.

Key Words: dieless drawing, slab method, heat convection coefficient, induction heating

Damage evolution and microstructure-property control for spinning forming of hard-to-deform materials

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Spinning forming (or flow forming) is an advanced incremental forming process widely used to produce rotationally symmetrical thin-walled components, such as tubular, conical and curvilinear workpieces due to high material utilization and productivity as well as low forming loading and simple tooling. With the increasing demands for high performance, light component weight and reduced ecological impact, particularly in the transportation, aviation and power industries, spinning forming of the hard-to-deform materials possessing high specific strength and low density, such as aluminium alloys, magnesium alloys and titanium alloys, are attracting more and more attention in recent years. However, there are several challenges for spinning forming of those materials, which limits its wide application until now. First, the low room-temperature ductility easily induces cracking during spinning forming. Second, high-temperature spinning triggers complex evolution of microstructure and mechanical property. Third, single-piece or small-batch production is still a bottleneck which needs process innovation to reduce manufacturing cost. To target the above problems, the relative investigations have be conducted to boost the development of the spinning process of hard-to-deform metals. On one hand, the damage evolution and crack mechanism during spinning forming were analyzed based on the FE simulation combined with ductile fracture criteria (DFC), the increasing of tube spinnability using multi-pass spinning was

discussed, and the damage healing using pulse eddy current treatment as well as heat treatment was put forward. On the other hand, the microstructure and texture evolution during hot spinning was investigated, and the novel method for enhancing the mechanical property through tuning texture morphology by cross spinning was proposed. Besides, the spinning process of hard-to-deformation metals using welding tube blank was investigated, and the counter-roller spinning technology of tube workpiece and vessel head was also explored, which provide an effective guidance for flexible manufacture of thin-walled rotary workpieces with low cost.

Key Words: Hard-to-deform materials, Damage evolution, Tube spinnability, Eddy current, Microstructure and texture, Cross spinning, Counter-roller spinning

Plasticity and Metal Forming of High Entropy Alloys

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High-entropy alloys (HEAs), have attracted considerable attention due to their great potential. Many researchers have focused on the phase evolution, alloying effect, mechanical properties, and deformation behavior in various HEAs. However, little attention has been devoted to the investigation of its shape forming and formability. The successful development of HEAs and industrial applications of the new material depends on formability. To investigate sheet formability of HEAs, a circular punch is used to investigate the earing profile and deep drawability. Hole-expansion tests were performed with a scaled-down testing system for estimating stretch-frangibility. The CoCrFeMnNi HEA is successfully drawn to a limit drawing ratio of 2.14 while the planar anisotropy of the drawn cup specimen is negligible. The hole-expansion ratio of the HEA was superior to those of the other alloys, attributed to fewer vulnerable sites for crack initiation and the resulting high crack resistance.

Key Words: High entropy alloy, Metal forming, Sheet formability

Effect of Martensitic Phase Transformation and Grain Size on Surface Roughening and Friction Behavior of Austenitic Thin Metal Foils

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Micro metal forming, particularly for austenitic stainless steel (ASS), is a promising approach in the biomedical, electronic, chemical, electrical power, food, and nuclear industries. In addition, the high demand for microparts has received significant attention in recent decades. However, micro forming of ASS has a number of challenges, such as formability associated with surface roughening in thin metal foils (TMF) and tribological issues. The surface roughening also effects on quality of the products in micro scale. When ASS is subjected to plastic deformation, martensitic phase transformation (MPT) will be induced in most of ASS. Volume fraction of the MPT increases with the increase of plastic deformation. However, it is not clear how the MPT effects on surface roughening and tribological properties during the forming process, and the effect of MPT is not taken into account in any theoretical models for surface roughening in previous studies.

In this study, we attempt to clarify mechanism of surface roughening in ASS and proposing a new model for surface roughening behavior quantitatively and to understand the effect of surface roughening behavior on the tribological properties. The approach of this study is of using uniaxial tensile test of ASS (SUS304) TMF with various grain sizes. The microstructures are investigated using SEM-EBSD analysis. Then, a constitutive model for surface roughening in ASS TMF based on the experimental results is proposed. In addition, a tribological test was performed to evaluate the difference between the foils in coarse and fine grains.

Key Words: Martensitic Phase Transformation, Surface Roughening, Friction

Machine learning of microstructure-property relationships in structural materials

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Microstructure--property relationships are key to effective design of structural materials for advanced applications. Advances in computational methods enabled modeling microstructure-sensitive properties using 3D models (e.g., finite elements) based on microstructure representative volumes. To accelerate these numerical approaches and make them suitable for multiscale modeling, we present methods of machine learning (ML) of microstructure-property relationships based on simulation data. We then address the need in high-resolution 3D microstructure data, which limits wide adoption of both numerical simulations and their surrogate ML models. Specifically, we demonstrate ML strategies that are less demanding in terms of 3D microstructure input. We will first discuss ML approaches to modeling effective properties of two-phase materials directly from 2D microstructure sections. We then present ML models for mechanical properties of polycrystalline materials based on graph representations of their microstructure.

Key Words: microstructure-property relationships, machine learning, mechanics of materials, finite element methods

Application of SMART Die-set using Sensing and Control Schemes for Cold Forging

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To create a smart manufacturing environment, three basic aspects are required: visualization of status, detection of anomalies, and control of the process. The use of sensors to measure state variables such as force, deflection, displacement, and temperature is essential to visuali ze and analyze the process status. The selection of sensor types and their locations should be carefully determined for effectiveness and convenience. The monitoring system and proce ss control scheme should meet the necessary conditions required in a real mass production environment.

This study presents three practical applications of SMART die-sets in cold forging to realize a smart manufacturing environment:

(1) A practical die-set with a built-in edge-monitoring device: An edge-computing monitoring device was implemented inside the die plate, and all connector cables for sensors were connected to the monitoring device through grooves or holes located inside the die-set to prevent any cable-related issues. The example of anomaly detection in cold forging is introduced.
(2) A closed-forging die-set applying an automatic synchronization scheme: The motor-driven synchronizing pin with a variable length was applied to the closed die-set to adjust the timing of synchronization between lower and upper die plates. The control system was developed based on the algorithm using the signal from the bolt-type piezo-load sensor implemented to the synchronizing pin. An automotive part application example explains the effectiveness of the developed scheme.
(3) A die-set with automatic alignment capability: A position adjusting scheme driven by the servo motor system was developed and applied to the die-set. The amount of misalignme nt between upper and lower dies was measured using displacement sensors implemented to upper and lower dies with X and Y directions. A high-performance control system wa s used to achieve in-line process control during a short period of time. The application example shows that the amount of misalignment is reduced within 10 mm.

Key Words: Process Monitoring, In-line Control, Visualization, Mass production

Study of rotating compression forming of composite materials

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Rotating compression forming also called compressive torsion process, where a rotation is imposed to the workpiece simultaneously with the compression action, is an effective method to get severe plastic deformation and decrease the loading force. In this paper, at first the friction coefficient between the die and aluminum powder materials and the plastic flow stress of aluminum alloy Al6061 are obtained using a specially designed friction test method. Then, the finite element analysis is used to investigate the plastic deformation and metal flow of powder embedded composite materials in a closed-die rotating compression forming process. The effects of friction coefficients and rotation speeds on the relative density distributions inside the composite materials are discussed. Finally, experiments of compression forming with three different inner diameters of aluminum powder composite materials are also conducted. The forming loads are compared with the simulation results to validate the finite element modelling of rotating compression forming of powder embedded composite materials.

Key Words: Finite element analysis, Powder embedded composite materials, Rotating Compression, Friction test

Influence of multi-step drawing process variables on the magnetocaloric effect of gadolinium wire

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In accordance with global warming and abnormal climate issues, social demand for heating and cooling devices that are safe, cost-effective, and capable of drastically reducing greenhouse gases at the same time is increasing, and magnetic cooling materials are attracting attention as a technological alternative. While the development of various materials to realize the self-cooling effect at room temperature and the low-field, high-efficiency magnetic properties have been reported in the laboratory. However, research that maximizes the cooling efficiency compared to the input energy by optimally implementing the desired shape in a specific space by combining them still limited. In particular, the method of realizing a high surface area by using a sphere-shaped magnetic cooling material has been mainly used, and research related to plastic processing-based manufacturing of thin or fine wire, which is the basis for low-cost mass production, has not been reported so far. Therefore, in this study, the process of manufacturing gadolinium wires with a minimum diameter less than 1 mm together with in length of several meters was optimized by applying the repeated cold drawing-heat treatment processes. Gd wire with a diameter less than 1 mm was manufactured by applying a cross-section reduction rate of up to 96% from a caliber-rolled Gd rod with a diameter of 4.92 mm, and the magnetocaloric effect was sufficiently restored through heat treatment at 1023 K for 5 hours.

Acknowledgement

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Key Words: Cold rolling, Multi-pass wire drawing, Gadolinium, Magnetocaloric materials

Forming technology for La-based magnetocaloric materials

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La(Fe,Co,Si)$_{13}$ phase is considered as a promising magneto-caloric material for room temperature magnetic refrigeration. Compared with La-Fe-Si alloys of pseudo-ternary system, it is unnecessary to carry out the hydrogeneration process, and consequentially can be prevented from the hydrogen embrittlement. Further, near-net shaping of magnetocaloric materials are consistently required for designing the complex heat exchanger in active magnetic regenerative system. In this study, we design the La-Fe-Co-Si based alloys, and develop the forming technology via forging and rolling process. To solve the difficulty in forming La-based alloys owing to the intrinsic brittleness mode of intermetallic compounds, we proposed a new approach of forming technology by considering the geometrical effect, based on the Weibull probability distribution function. We apply both cold and hot forging/rolling processes, and systematically analyze the underlying deformation mechanism from dual dendrite phases mode (before deformation) to deformation mode (after deformation). In addition, we identify the correlation between microstructural evolution and magnetocaloric properties during forming and the following annealing heat-treatment. The resulting product with our forming technology show high magnetic entropy changes, suggesting the possibility of forming technology for the near-net shaping the magnetocaloric components.

Acknowledgement
This study was supported by the Fundamental Research Program of the Korea Institute of Materials Science [grant number PNK8950]

Key Words: La-Fe-Co-Si alloys, Cold forging, Hot forging, Hot rolling, Magnetocaloric effect, Weibull probability distribution

Identification of the anisotropic constitutive parameters for the Nimonic thin sheets assisted by the virtual fields method

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In this study, plastic anisotropic constitutive parameters of the Nimonic thin sheets were identified using the virtual fields method (VFM), especially in the biaxial-tension states. Many advanced yield criterion such as Yld2000-2D requires uniaxial tensile tests along the different material orientations and equi-biaxial tests for the identification of the constitutive parameters. However equi-biaxial tests such as cruciform tensile tests or hydraulic bulge tests require special test machines, and they may be difficult to perform due to the size restriction in fabricating specimens of those tests. In this study, the VFM, one of the inverse methods based on the principle of virtual work, is applied to overcome the specimen fabrication issue due to the small width of the sheets rather than the direct measurements of the biaxial properties. Uniaxial tensile tests are conducted along the rolling, transverse, and diagonal directions, and notch-tensile tests are conducted to attain the biaxial properties using the VFM. Also, a special type of virtual field is introduced which is generated based on the stress triaxiality calculated in the VFM process to extract biaxial data effectively. Finally, finite element analyses are conducted using the measured anisotropic constitutive parameters and predicted results are compared with experiments.

Key Words: Virtual fields method, Inverse identification, Ni-based superalloys, Anisotropic plastic properties

AI application to the EV motor component manufacturing

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The hairpin is a crucial component of the drive motor of an electric vehicle, consisting of a copper coil and a very thin enamel layer. It is manufactured using successive forming processes due to its complex shape. After the forming processes, springback is inevitably observed, which causes critical issues in fabricating the drive motor. Compensating for springback is a time and cost-inefficient process, and a new process is required for a cost-efficient forming process. In this research, an intelligent forming process has been proposed for springback compensation of hairpin forming by applying Artificial Intelligence to the forming process. The dataset has been constructed using finite element simulation and real manufacturing processes and used for preliminary design and real-time compensation, respectively. The key parameters for the AI are the dimensions of the copper coil, including bobbin information, material property variance in a coil bobbin, punch stroke, and amount of springback. In addition, data has been continuously gathered in real manufacturing, and AI has been newly trained to successfully handle changes in the manufacturing environment. The results show that AI could play a key role in solving the manufacturing issue.

Key Words: Hairpin, Springback compensation, AI(Artificial Intelligence)

Generation of tool path using neural networks with material properties in incremental forming

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Forming accuracy is not so high due to springback in incremental forming. To improve forming accuracy, it is necessary to modify a tool path generated by CAM system with consideration of springback and other factors. However, the strategy of modifying tool path may be very complex. In this study, neural network is used for generation of tool path. 5052 aluminum alloy, 304 stainless steel and low carbon cold rolled sheets were used for specimens. The size of the specimens was 150 mm x 150 mm x 0.5 mm. The sheet was formed into frustum of cone shape with height of 25 - 35 mm, initial diameter of 70 – 90 mm and wall angle of 40 – 50 mm. Formed shapes and ratio of (yield stress) / (Young′s modulus) were used for input data and tool paths were used for output data for neural networks and the neural network was trained. After training, a known shape was input to the neural network and tool path was output. The output tool path was compared with the known tool path for forming the input shape. After that, unknown shape was input and tool path was generated and a sheet was formed with the tool path. The formed shape was compared with the input shape. 5052 aluminum alloy sheet was annealed and measured the proof stress. The ratio of (yield stress) / (Young′s Modulus) of annealed sheet is not trained in neural network. So unknown shape and unknown material property for neural network were input and generated tool path. The annealed sheet is formed with the generated tool path and formed shape was compared with the input shape. As obtained results, foming accuracy by tool path generated from neural network with material property was higher than that by generated tool path without material property. Forming accuracy for all material by tool path generated from neural network was higher than that by the tool path generated from CAM system. Forming accuracy for 5052 aluminum alloy sheets by tool path generated with all material data was higher than that by tool path generated with only 5052 aluminum alloy data. Forming accuracy for annealed 5052 aluminum alloy sheets which was not included in training data by the tool path generated from neural network was higher than that by the tool paths from neural network without material property and CAM system.

Key Words: Incremental Forming, Tool Path, Neural Network, Material Properties

Evaluation of crushing performance for extruded aluminum alloy tubes based on finite element simulation with ductile fracture

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Aluminum alloys as one of the most potential lightweight metals have drawn considerable attention for automotive structure parts as alternative to conventional steels. In this study, the crushing characteristics of hollowed (tubular) aluminum extrusion parts were investigated in the aspect of ductile fracture as one of crashworthiness indicators. The plasticity model and ductile fracture criteria of extruded 6xxx and 7xxx series aluminum alloys were implemented based on a non-quadratic yield function with isotropic hardening and the Hosford-Coulomb criterion, respectively. The latter was identified using the hybrid experiment-numerical method. Finite element analysis of axial crushing test was conducted, and the deformation and fracture behavior were predicted. The simulated results could provide the mechanism of crack formation and its sequence in relation to the stress state. Moreover, the crashworthiness indicator based on energy absorption till the fracture initiation could be newly suggested through the numerical analysis. The study showed that the proposed indicator was linearly related to the deformation energy of individual fracture tests, which simplifies the crush performance evaluation in more practical sense.

Key Words: Crushing, ductile fracture, aluminum alloys, finite element analysis

An Experimental and Finite Element Analysis-Based Optimization of a Novel Hydroforming Die for the Producing of Curved Tubes with Non-Uniform Curvature and Unequal Cross-Section

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Manufacturing non-uniformly bent tubes with sharp corners using conventional hydroforming processes is challenging due to the risk of excessive thinning and fracturing of the tube corners. A common technique to overcome this issue involves increasing the internal pressure to its maximum limit. However, this approach does not guarantee successful results. To address this limitation, the current research proposes a novel hydroforming die to manufacture bent SS-316L tubes with non-uniform curvature and unequal cross-section. The die performs the process in two stages: the primary step of bulging and the shaping step is made possible by utilizing two movable bushes. Finite element simulations were conducted to determine the optimal pressure and axial feed profiles, and the outcomes were confirmed with experimental tests. The proposed die offers a significant advantage, as the movement of the bushes within the die cavity reduces contact between the die and bushes, while facilitating proper axial feeding. This, in turn, produces a tube with a uniform distribution of thickness and utmost filling of corner. In summary, the proposed hydroforming die offers a promising solution to overcome the challenges of manufacturing non-uniformly bent tubes with sharp corners utilizing conventional hydroforming processes.

Key Words: Tube Hydroforming, Finite Element Analysis, Wrinkling

A new anisotropic-asymmetric yield criterion covering wider stress states in sheet metal forming

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The stress state-dependent plastic anisotropy of sheet metals has drawn significant attention. Nevertheless, existing phenomenological plasticity models limitedly capture the distinctive yield strengths under wide range of stress states covering uniaxial tension (UT), equi-biaxial tension (EBT), uniaxial compression (UC), plane strain (PS), and pure shear (SH). This study aims to propose a new anisotropic-asymmetric plasticity model with enhanced flexibility based on the non-associated flow rule. The yield function is formulated based on the additive coupling of two stress potentials: coupling between a new anisotropic pressure-sensitive fourth-order polynomial function, and an isotropic stress invariant-based function. Then, all the anisotropic/asymmetric parameters of the yield function can be analytically identified from 7 yield stresses measured from UT tests along 0°, 45°, and 90° to the rolling direction (RD), UC tests along 0° and 90° to the RD, EBT test, and SH test along 45° to the RD. The additively coupled stress invariant-based term is introduced to adjust the yield stresses under biaxial tension including PS, which leads to an independent description of the yield stresses under SH and PS states. Various automotive sheet metals such as advanced high-strength steels, aluminum alloy, and magnesium alloy with strong asymmetry and anisotropy are investigated to verify the proposed yield criterion. The results demonstrate remarkable flexibility and accuracy of the proposed yield criterion against other existing models. Besides, the advantage of new model is further discussed in terms of the proof of yield surface convexity, identified parameters, and the regulation between anisotropy and isotropy in comparison with existing multiplicative coupling method.

Key Words: Yield criterion, Strength differential effect, Pure shear, Non-associated flow rule

Preparation and Properties of Cu/Nb Nanolayered Composites

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Pure Cu and pure Nb plates were used as raw materials to prepare Cu/Nb multilayer composites through accumulative roll bonding. The causes of material cracking and internal layered structure fracture during accumulative roll bonding and annealing were analyzed. The effects of rolling process parameters on the bonding state and layered structure of materials were studied. By adjusting the ARB parameters, continuous laminated structures of Cu/Nb multilayer composites with layer thicknesses ranging from a micrometer to a few tens of nanometers were successfully prepared. The Vickers hardness of Cu/Nb nanolayered composites after 15 passes of rolling reaches 229 Hv, which is 377.1% and 288.1% higher than that of original pure Cu and pure Nb, respectively. The dislocations interact more frequently with the interface with the decrease of thickness, resulting in a significant increase in the hindrance of dislocations. Therefore, the strength of the Cu/Nb nanolayered composites increases with the decrease of the layer thickness. After processing by ARB through 15 cycles the YS and UTS are about 1.06 GPa and 1.2 GPa, respectively. Meanwhile, The nanolaminated Cu/Nb composites retained superior electrical conductivity. The excellent comprehensive properties of the Cu/Nb multilayer composites indicates that these composites, having alternating heterogeneous lamellar structures, are promising for future energy and power applications.

Key Words: Accumulative roll bonding, Cu/Nb nanolayered composites, strength

Acicular Microtexturing onto Copper Sheet for Heat Radiation

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Cooling process via low temperature heat radiation was highlighted to reduce the temperature of fuel-cell radiators or to transport the heat from hot temperature source to lower one. The micro-/nano-texturing technology provided an efficient method to emit the infrared electromagnetic waves within the selective wave length ranges. Among several micro-/nano-texturing approaches, the acicular micro-/nano-texturing method was proposed for this low temperature heat radiation to cool down the hot spots. In the present study, the electro-chemical processing was utilized to build up the acicular micro-cone cell alignment onto the copper sheet. Its height, root diameter and its distancing pitch were controllable by the total current and the current density in the processing. The geometry and topology of acicular micro-textured copper sheet device was analyzed by SEM (Scanning Electron Microscopy) with aid of image processing. Its emission spectra in the infra-red lengths were measured by the FT-IR (Fourier Transformation Infra-Red) spectroscopy. The correlation between the measured spectra and the micro-cone size distribution proved that IR-emission was controllable by the size effect in this acicular micro-texturing. The heat radiation experiment in vacuum was also performed to investigate the thermal transients on the objective body away from the acicular micro-textured emitter. When the emitter was placed on the hot plate with its holding temperature of 323 K, the measured temperature by the thermography started to increase linearly with time after an incubation period. The maximum temperature increase during 300 s reached to 8K. This proved that the acicular micro-textured device worked as an efficient emitter for heat transportation even in vacuum.

Key Words: Micro-cone cells, Semi-regular alignment, Emission spectroscopy, Heat radiation

Deep-learning-based prediction of out-of-plane structural deformation of a deck plate

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A deep-learning method was introduced to predict three-dimensional structural deformation of a deck plate. In a ship manufacturing process, the deck plate experiences severe loads during the processes of lifting, transportation, turn-over, welding for fitting, pre-erection, and erection, which result in three-dimensional out-of-plane deformation of the deck block. Therefore, it is key to anticipate potential large deformation and minimize it by installing stiffeners. In this study, in lieu of buckling finite element method (FEM) simulation, a generative adversarial network (GAN) combined with convolutional neural network (CNN) deep-learning model was adopted for a high-quality image-to-image translation. The input image contained essential information to predict the mechanical deformation, such as the initial deformation of the deck plate after assembly (*i.e.*, initial deck height), the dimensional information of all the reinforcing structures installed on the deck plate, and the normal reaction force acting along the boundary in the erection stage. The deep-learning model was trained to translate it to a deformation predictive image, that is, final deck height. Three vessel types were considered, and the translation was conducted on a spatially normalized plane. The prediction accuracies were 99.7794% (R-Squared), 99.7685% (structural similarity), and the errors were 0.124 mm (mean absolute error), 0.682% (mean relative error), and 0.077◦ (mean of surface normal vector contained angles).

Key Words: Mechanical deformation, Deck distortion, Image-to-image translation, Deep learning

Super resolution of three-dimensional microstructural image of a steel using deep learning

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A deep learning based method for enhancing the resolution of a 3D image of microstructures of a steel is presented. A high-resolution 3D image of a steel sample is usually obtained by serial sectioning a sample with an focused ion beam (FIB) followed by observation with a scanning electron microscope (SEM). The use of the FIB-SEM system provides a 3D image of the entire sample, however, it lacks resolution in the depth direction. To solve this problem, a deep learning algorithm based on a super resolution generative adversarial network (SRGAN) was applied to increase the resolution in the depth direction. The algorithm learns microstructural features from high-resolution surface images and recovers low-resolution lateral images, resulting in a 3D image with upscaled microstructural information. The results with a low carbon steel sample showed that the deep learning method was able to recover finer details of the microstructure compared to the conventional methods and had the lowest root mean square error (RMSE) among the methods. These results indicate that the deep learning-based method is the most realistic and effective way to recover the resolution of the images obtained from the FIB-SEM system.

Key Words: Deep learning, micsrostructure, steel, super resolution

Optical flow methods for crack propagation measurement

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Optical measurement methods allow for full-field deformation analysis, e.g. in experimental mechanics. For solid materials, the subset-based methods are typically used for surface deformation measurement in engineering applications for simplicity, reliability and flexibility reasons. However, the use of such methods pose significant challenges and even show deficits in the analysis of higher-order gradients and rates (e.g. strain rates, rate of deformation curvatures ...) as well as in the handling of discontinuities (e.g. multi-material testing, cracks, ...). Variational methods, also called optical flow methods, represent a promising alternative. Based on the formulation of the variation functional, (dis-)continuity properties of the full field solution can be included and controlled in sense of a priori information. Such a variational approach is presented to identify crack initiation and measure crack propagation from high-speed camera image sequences. As an illustrative example, the method is used to analyze shear cutting processes.

Key Words: optical measurement, deformation measurement, crack propagation, shear cutting

Super-resolving digital microstructure through deep learning for microstructure characterization and micromechanical simulations

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Accurate high-resolution digital microstructure (DM), or digital representation of microstructure, plays a central role in modern-day materials research that deals with quantitative microstructure characterization and micromechanical behavior analysis through microstructure-based simulations.

Experimental acquisition of DMs with sufficiently high resolution to aptly capture all relevant microstructural features can often be very challenging due to instrumental resolution, technical specifications, and size and distribution of microstructural features. This can be a problem since microstructure characterization and micromechanical behavior analysis through microstructure-based simulations can heavily rely on geometric details of a microstructure. For example, local phase morphology, which may be compromised from insufficient resolution, is a well-known feature that is highly correlated to the damage behavior of some high strength steels. Hence, super-resolving a low-resolution microstructure data can uncover valuable information for understanding microstructure dependent material behavior. In this study, a fast and accurate deep learning-based super-resolution technique that can super-resolve low-resolution microstructure image is presented. The technique is validated using both actual and synthetic microstructure images, and its effectiveness is demonstrated through conventional image similarity measurement, microstructure characterization, and microstructure-based finite element mechanical analysis.

Key Words: Super-resolution, Deep learning, Microstructure characterization, Finite element analysis

Investigation on the ductility of magnetron sputtered Niobium coatings on SS316L substrate for precoated sheet microforming

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Precoating process can substantially improve the manufacturing efficiency of metallic bipolar plates (BPPs) for the mass commercialization of proton exchange membrane fuel cells (PEMFCs). However, the anti-corrosive precoatings are prone to crack during the forming process of pre-coated BPPs, leading to the exposed substrate and deteriorated corrosion resistance. In this work, a formable Niobium (Nb) precoating is developed to sustain large plastic deformation by controlling the film microstructure with unbalanced magnetron sputtering process. With an optimal bias voltage of substrate, the precoatings with compact nanocrystalline microstructure are obtained to sustain a strain of 30% without evident cracks in uniaxial tensile tests, which is a superior ductility compared with previous precoatings. Furthermore, the applicability of precoatings is verified with electrochemical tests. The deformed samples maintain considerable corrosion resistance with the current density of 8E-6 A/cm2 and the contaminated ions dissolution of 0.07 ppm, which is comparable to the performance of traditional formed-then-coated metallic BPPs. Therefore, the mass production of precoated metallic BPPs is enabled with both improved manufacturing efficiency and maintained corrosion resistance after forming process.

Key Words: Microforming, coatings, sheet metal

Material card validation setup for the investigation of multi-directional strain hardening behavior for sheet metals

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The multidirectional deformations that occur in multistage sheet metal forming processes pose a challenge to the modeling of material behavior. This work presents an experimental approach to multidirectional deformation of an aluminum alloy sheet metal. The sheets are submitted to a biaxial pre-strain condition and then further investigated by a material model validation test (MUC-Test). As a reference, the experimental results of the MUC-Test for the aluminum alloy sheet metal without pre-strain are presented. The MUC-Test has already been established as a method for validating material models under proportional loading. By using pre-strained specimens, this method can be extended to nonlinearities in loading. Thus, we show that the MUC-Test is suitable for the representation of multidirectional strain histories and useful for the comprehensive validation of respective material models.

Key Words: Material card validation, material testing, multidirectional deformation, pre-straining

Investigation on the maximum elongation of SP700 titanium alloy based on composite superplastic deformation of maximum m value and optimal strain rate

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SP700 is a new type of α+β titanium alloy with excellent superplasticity and favorable working properties, which has been successful used in automotive, aviation and sport apparatus fields. In this work, a newly developed composite superplastic deformation method which combined with maximum m value and optimal strain rate is introduced. Among, the maximum m value means the maximum strain rate sensitivity, the optimal strain rate includes equivalent strain rate and immediate strain rate. The maximum elongation of SP700 titanium alloy was investigated by this method. Firstly, the maximum m value is automatically detected based on the superplastic tensile control procedure. Then, the deformation speed can be automatically adjusted and changed in the process of superplastic deformation, so as to achieve the best superplastic performance of the SP700 titanium alloy. Subsequently, the optimal constant strain rate was adopted and proceed immediately after the maximum m value method. The results of uniaxial tensile tests show that excellent superplasticity with elongation of more than 3000% can be obtained by using the composite deformation method in the temperature range of 760℃ to 775℃. However, that elongation can only reach 1887% under the constant strain rate of $1.0\times10^{-3}s^{-1}$ and temperature of 760℃. Finally, the maximum elongation of 3346% was achieved at 760℃ under the composite deformation method of maximum m value and immediate strain rate, which created the highest superplasticity index record for titanium alloy.

Key Words: Material card validation, material testing, multidirectional deformation, pre-straining

May 17 (Wed.)

Morning Session

Plenary session #3

Invited session #3, #4

Punch-Edge Sharpening Effect on Work Hardening and Iron Losses in Shearing Non-Oriented Electrical Steel Sheets

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The punching process using a sheet material have been developed to a punch and die. Non-oriented electrical steel sheets and amorphous electrical steel sheets are used for the iron cores of motors, and the specific shape for motor core was manufactured by piercing process. When punching non-oriented electrical steel sheet, Influence of elastic and equivalent strain became main factor to make low iron-loss motor cores. In recent years, the ion-polished tools have been developed to reduce the range of influence of strain during punching process. To using ion-polished tools in punching process of non-oriented electrical steel sheets, it is expected that the tool sharpening works effective when controlling the influence of strain area in inside of punched iron-cores. And expected that decreasing of work hardening area decrease magnetic domain changing and decreasing of iron loss. Furthermore, a Laser processed nanostructure technics has been developed and improve the ejection performance of adhesion on the contact surface between punch and pierced specimens. As a result, tool life became longer than traditional processed tool and processing accuracy was improved. However, there has not been studied for the internal influence of punched hole and iron loss of punched motor cores using non-oriented electrical steel sheets.

In this report, non-oriented electrical steel sheets were punched out to describe the effect of punch edge configuration on the piercing behavior. Three punches were prepared to have the mechanically ground, the ion-polished and the nanostructured surfaces. The work hardening area in the cross-section of hole and the iron loss of pierced specimens were utilized as a measure to evaluate the piercing process using three punches. Finally, we report the effects of state of tool edge on the interior of pierced specimens.

Key Words: Punching, Non-oriented electrical steel sheet, Iron loss

Precision Extrusion of Aluminum Alloy – Current Development and Future Trend

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Aluminum alloys are increasingly used in many industrial fields because of their advantages, namely lightweight, high specific strength, good formability, high thermal conductivity, and corrosion resistant. Extrusion is one of the most efficient methods for producing aluminum profiles, in which extrusion die plays a decisive role in the success of the process and directly affects the extruded product's quality and cost. Nowadays, extrusion profiles are becoming more and more complex, which is a great challenge for die makers and designers. Therefore, to meet the strict requirements from customers, innovative approaches for die design and manufacturing are essential. Aluminum extrusion dies can be divided into three basic types: solid die, semi-hollow die, and hollow die, in which the solid and the semi-hollow dies are used for extruding solid profile products, and hollow die is used for fabricating hollow profile products.

The traditional solution of the extrusion die design is based on the experiences of skillful engineers combined with repeated die tests. In this way, based on the nose geometry of the tested extrudate, an experienced engineer often predicts the possible causes of the die error and then performs a die repair, including die structure modification and/or bearing lengths adjustment. By conducting this modification process several times, a reasonable die structure can be achieved. However, this design process is expensive and time-consuming, especially when designing the die for extrusion of high complex profiles. As a result, the traditional design approach may significantly increase production costs. In recent development of design technology, by using finite element (FE) analysis, a variety of parameters related to the extrusion process such as velocity, temperature, extrusion force, die stress, die deflection, and nose shape of the extrudate can be predicted before the actual fabrication of the die and extrusion production. Therefore, many researchers have studied the effects of die structure on the performance of the extrusion process with FE analysis. Previous studies have shown that the design optimization of the extrusion die is essential for the extrusion of aluminum profiles. One of the most important issues in die design is to ensure a good balance of metal flow in the die. This is because the flow balance directly affects the geometry of the extruded product, as well as the die deformation and the extrusion temperature.

In this speech, the development of several kinds of extrusion profiles including die design, FE analysis, experimental tests will be given including complex thin-walled profile, large-scale heatsink profile, solid heatsink profile with large variable wall thickness, multi-hole profile with large variable wall thickness by guaranteeing flow balance. Then, the solid bonding conditions for hollow extrusion of high strength aluminum alloy will be given including formation ability welding seams and mechanical properties of AA7075 when extrusion hollow square tube and non-symmetric hollow profile. Third, the applying deep convolutional neural network to porthole die design for hollow extrusion including porthole geometry, quantity, arrangement, as well as die bearing design will be given. Finally, the future development trend will be given.

Key Words: Extrusion, Flow balance, Die design, Finite element analysis, Convolutional neural network

Galling-Free Fine Blanking of Austenitic Stainless Steel Gears with High Quality

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Gears were typical elements in mechanics of working machines and systems; e.g., the reducers for robots and electric vehicles. Their market demanded high wear and corrosion resistivity in addition to high strength, stiffness and very low geometric distortion. In particular, small- and medium-sized gears had to be fabricated in mass production to improve the cost-competitiveness. Instead of the conventional gear cutting and adjustment, the fine blanking was highlighted as a gear forming method. Although this fine blanking provided the low carbon steel parts with fully burnished surfaces, it often suffered from severe adhesive wear when fine-blanking the stainless steels. The bare tool steel and high-speed steel punches often suffered from the adhesion of work fragments, resulting in the shortage of punch life. In case of fine blanking under narrow clearance, the punch edges and corners were easily worn out to reduce the dimensional accuracy. In the present study, the fine blanking punch was newly developed to prevent them from the adhesive and abrasive wears even in mass production of AISI304 type austenitic stainless steel gears. The carbon supersaturated high-speed punch was prepared for galling-free fine blanking by using the low temperature plasma carburizing. The punch edges were precisely machined and finished to have a proper edge-profile enough to preserve the tailored punch edge profile all through the punching operations. The fine blanking experiments were performed to describe the punching behavior. Three dimensional profilometer was utilized to measure the punch edge profiles at the specified number of shots. No significant distortion was detected on this edge profile even after fine blanking the AISI304 gears in 50 shots. The pitch, width and circles of the punched-out AISI304 gears with fully burnished surfaces were measured to demonstrate that equivalent gear grade to the cut gears was attained by this fine blanking.

Key Words: Fine blanking, Galling-free, Stainless steel gears, high wear resistance

Predicting Dynamic Recrystallization Behavior based on Deep Convolutional Generative Adversarial Network

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Data-driven methods for predicting and evaluating microstructural characteristics have attracted significant attention owing to recent developments in artificial intelligence (AI). In high-temperature deformation processes, the microstructure changes nonlinearly, according to the causal relationship with the deformation history in the form of time series. This makes it difficult to predict the microstructural evolution using existing AI generative models, in which time-series data are not used as an input. Therefore, herein we proposed a novel method to establish a connection between the time series deformation history and the latent vector of the AI generative model. To this end, the dynamic recrystallization (DRX) fraction and DRX grain size of a microstructure were calculated based on the deformation history, which included the temperature, strain, and strain rate, using the finite element method (FEM) combined with a DRX kinetic model. By applying the calculated DRX fraction and DRX grain size as label data, a conditional deep convolutional generative adversarial network was trained to generate microstructures. It was confirmed that the microstructural evolution due to the deformation history can be realistically reproduced. Furthermore, by comparing the average grain size and grain size distribution of the synthetic and actual microstructures, it was proven that the proposed model can be used to accurately predicts not only the shapes but also the quantitative features of microstructures. The results of this study demonstrate that FEM and AI technologies can be used sequentially to simulate the microstructural evolution as photorealistic images.

Key Words: DRX, DCGAN, TMCP, A230 alloy

Mechanical Properties of Sandwich Panels with Corrugated Carbon Fiber Cores

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Composite sandwich structures are widely used in many areas, such as energy, aerospace, and national defense industries. Sandwich structures are composed of a light core bonded between two strong facesheets. Light materials such as honeycomb panels or foam boards are usually used as the cores, whereas stiff materials such as metal or fiber reinforced polymer (FRP) plates are used as the facesheets. Although sandwich structures using foam cores can be light, they cannot be used to manufacture structures with complicated shapes or highly curved structures since the bending strengths of the cores are weak. This work used carbon fiber reinforced polymers (CFRPs) with different stacking orientations to manufacturing corrugated structures. The corrugated structures were used as the cores of the sandwich structures. Other materials of the cores included paper (PA) honeycomb, aluminum (AL) honeycomb, and polypropylene (PP) honeycomb. The facesheets of the sandwich structures were CFRP plates. Mechanical property tests were conducted on the sandwich structures, including bending tests, face-wise compression tests (FCT), and edgewise compression tests (ECT). Accelerated aging was also applied to the specimens. The results were compared to investigate the effects of different cores on the mechanical properties and the resistance against aging. Finite element simulations were also conducted to model the tests. The simulation results were compared with the test results. The test results indicate that the corrugated CFRP cores with $[0°]_5$ stacking orientation result in the highest flexural stiffness and the ECT strength along the flute direction. In comparison, the corrugated cores with $[90°]_5$ stacking orientation result in the greatest shear rigidity and modulus, FCT modulus and strength, and ECT strength perpendicular to the flute direction. For aging, generally, the mechanical properties of the sandwich structures using the AL honeycomb cores reduce the least. In contrast, the PP cores increase the normal compressive modulus and strength because of the release of residual stress. Since sandwich structures can be subjected to not only the bending load but also loads in other directions, such as longitudinal or face-wise compression, this work aims to investigate the effects of the different cores on the bending, shearing, and compressive properties of the sandwich structures. The resistance against aging is also discussed. The results contribute to the selection of core materials and structures of sandwich structures.

Key Words: Sandwich Structure, Failure analysis, Corrugated Structure, Finite Element Simulation

Forming technologies for large-area functional micro/meso structures

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Large-area micro/meso structures with unique functions are designed to meet different requirements such as mass transfer, heat transfer, hydrophilic/hydrophobic, resistance enhancement/reduction, electromagnetic wave absorption/reflection, which have important applications in new energy, flexible electronics, aerospace and other fields. The accurate yet efficient manufacturing technologies for those micro/meso structures are attracting tremendous attentions in recent years. Among them, micro/meso scale forming processes feature unique advantages such as high repeatability, flexibility, productivity, etc. However, how to innovate the existing forming processes from macro to micro/meso scale in the purpose of meeting the different functional and manufacturable requirements of those micro/meso structures in different scenarios is the key to success. Micro/meso stamping, roll-to-roll imprinting and rapid oscillation imprinting are discussed in detail to highlight the challenges and solutions during the miniaturization of forming processes for the different application conditions such as high power fuel cells for zero-emission vehicles, drag-reducing and anti-icing aircraft skin, optical functional surfaces, as well as medical implants with functional surface microstructures. The mechanisms of various defects and inconsistency during the forming of large-area micro/meso structures in terms of fracture, geometric imperfection, height variation, scratching, etc. are addressed. The optimization methods of those processes are also introduced to achieve the high quality and production rate goals for the precision manufacturing of large-area micro/meso structures in different scenarios.

Key Words: Micro/Meso scale, Large-area, Microstructures, Forming process

May 17 (Wed.)

Afternoon Session

Graduate student session #1, #2

Invited session #5, #6

Oral session #3, #4

Processing design optimization to produce 75mm thick Ti-6Al-4V alloy plate; correlation of microstructural evolution and mechanical properties

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Titanium plates are classified into two fundamental categories: thin plates (less than 4 mm thick) and thick plates (more than 4 mm thick). Thick plates have a structure with high fatigue cracking resistance and can be applied to the manufacturing of major aircraft structures. However, the manufacturing technique of Ti6Al4V thick plate has not been established in Korea, and its production relies on imports from other countries such as USA and Japan. As a result, innovations aimed at reducing or eliminating this reliance are required. In this way, however, there are certain limitations to the production of components because of the heat treatment constraint of such a thick plate. To achieve the requisite mechanical properties, an appropriate heat treatment and processing design are required to eliminate the heterogeneity of microstructure, texture and improve the mechanical properties.

Thus, in order to overcome these challenges and provide theoretical and experimental basis for the subsequent optimization of mechanical properties of Ti6Al4V titanium alloy thick plate, the microstructure, texture and mechanical properties of this alloy with a thickness of 75 mm were investigated in this work. In this way, electron backscatter diffraction (EBSD) and scanning electron microscopy (SEM) were carried out to investigate the microstructural evolutions. In addition, finite-element method (FEM) simulation was also conducted to determine and simulation the effect of rolling parameters such as applied strain on the microstructure.

The microstructural observation showed that, although the material experienced a β-annealing heat treatment above the β transus temperature (1010 °C) for 1 hour after hot rolling at 921 °C, however, the presence of large coarse α grains in microstructure led to a detrimental effect on elongation below 8%, by providing a favorable sites and paths for crack initiation and propagation, respectively. To eliminate this unfavorable morphology of α phase, a solution heat treatment before rolling and a Globularization heat treatment after hot rolling were considered. The microstructure observation after β annealing of optimized procedure showed significant reduction in presence of large coarse α grains which led to increase in elongation to ~ 12%.

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Further discussion on the microstructural evolution and its correlation to FEM and mechanical properties are provided in detail.

Key Words: Ti6Al4V, thick plate, process design, finite element method

Application of acoustic emission signal analysis for monitoring the mechanical behavior of steel bar for cold forging during three-point bending tests

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The study investigated the capability of Acoustic Emission (AE) sensors in detecting plastic deformation and crack propagation in steel bars for cold forging applications. Square bar-type specimens with a V-notch in the center were machined, and AE sensors attached to the specimens made of various cold forging steels. Three-point bending tests were conducted, and AE signals, load-displacement data, and optical images were recorded and synchronized based on the vertical displacement of the loading jig during the bending test. Two clusters of AE hits were detected within the frequency range of 200-600 kHz from the measured AE signals during the experiments. By analyzing the relationship between the load-displacement curve and images around the notch where the clusters of AE hits were observed, it was confirmed that they corresponded to the plastic yield point and the onset of macro cracks, respectively. The experimental results demonstrated that AE technology can be effectively used for monitoring plastic yielding and the onset of cracks in steel material during three-point bending tests, regardless of different materials and notch shapes.

Key Words: Acoustic Emission(AE), Three-Point Bending Test, Crack propagation, Cold forging

Subvoxel-controlled printing of multi-material and multi-structural filaments

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Multi-material voxelized substances are widely used in micro-nano fabrication. Direct ink writing technology can print the most comprehensive range of materials, but it is still challenging to print a variety of heterostructured filaments. Most ink compositions for extrusion printing are static, and few methods are available for dynamically adjusting ink compositions. In this paper, a multi-structured microfluidic printing platform with precise subvoxel control was built by employing a modular combination of microfluidic and direct ink writing techniques. The platform enables subvoxel processing of heterostructured filaments, printing out filaments of various structures and materials. By controlling the drawing and moving of the nozzle of the direct ink writing technology inside the microfluidic flow channel, it is possible to quickly realize switching and printing of various heterogeneous filaments at low cost without changing the equipment and seamlessly change the printing Composition and functional properties of structures. By controlling the specific speed, displacement and moving time of the drawing movement, the same filament can contain segmented structure filaments, layered structure filaments, core-shell structure filaments, and internal broken line structure filaments to adjust the printing Filament structure dynamically. By changing the compatibility between various materials makes printing a droplet dispersion structure possible, and the aqueous droplets are dispersed in the polydimethylsiloxane continuous phase. Therefore, filaments of various structures can be efficiently produced by the integrated platform, which can be applied to manufacture various micro-nano structures, such as innovative triboelectric fibers, artificial muscles, and micro-nano robots.

Key Words: Multi-material, multi-structural, subvoxel-controlled, direct ink writing

Evolution of temperature change by impact effect on the surface layer of various materials during ultrasonic micro-forging

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In the micro forming field, compared with the acoustic softening, the impact effect plays an important role in overcoming the obstacle that size effect results. Surface deformation capacity can be improved by impact effect has been demonstrated since the impact effect created by the vibrated punch can detach from the specimen periodically. Meanwhile, the surface temperature increase is also reported, which means some ultrasonic energy will convert to thermal energy and influence the material surface. However, due to the various physical properties and microstructures, different metal materials will have diverse deformation behavior under impact effect, and the conversion rate of ultrasonic energy to thermal energy on the surface will also change. To further study the mechanism and characteristics of the impact effect, the influence of surface deformation behavior on different metal materials needs to be investigated.

In this studying, a novel ultrasonic-assisted micro-forging test system will be used, which can offer 60kHz frequency and alternative amplitude from 0 to 3.5μm. Pure copper will be processed under an amplitude of 2μm, 3μm, and 3.5μm. For comparison, pure aluminum and titanium will also experiment for the different strain rate dependency and crystal structure. Meanwhile, a technique for directly measuring the surface temperature of the specimen will be proposed. A thermoelectric couple with a diameter of 0.1mm was put into the machined dimple in the specimen surface with depth of 0.2mm and width 1mm. In addition, the whole processing will be monitored by a designed high-sensitivity dynamic force sensing system. It can ensure the frequency is always correct and observe if the impact effect occurs during processing. After the experiment, the temperature change and the conversion rate of ultrasonic energy to thermal energy on the surface of different crystal structure materials will be investigated respectively. And the influence of strain rate increasing by impact effect on surface deformation will be discussed. Finally, to observe the differences in surface deformation behavior influenced by the change of temperature, the topography of every kind of sample surface will be investigated by Atomic Force Microscopy (AFM) and the change of microstructure of processed samples will be carried out by electron backscatter diffraction (EBSD).

Key Words: Surface deformation, Ultrasonic vibration-assisted, Micro-forging, Surface finishing

Tensile deformation behavior of an equimolar high-entropy alloy subjected to electrically assisted uniaxial tension

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Electrically assisted forming has been introduced to various metal forming processes for decades due to the electroplasticity that can reduce the required stress during plastic deformation. However, there is a lack of detailed studies on the electroplasticity of high entropy alloys (HEAs), a new generation of structural materials. In this work, the tensile deformation behavior of an equimolar CoCrFeMnNi HEA subjected to e electrically assisted tension (EAT) was investigated. The results showed that the HEA under EAT had lower flow stress and elongation than that of samples deformed at room temperature. Fracture morphologies under different current densities were analyzed to demonstrate the deformation behavior. Furthermore, electron back-scattered diffraction examinations showed that the geometrically necessary dislocation density in the specimens applied pulse current were all decreased, leading to the reduction in deformation resistance. Deformation-induced twinning over critical stress for twin was found to contribute to the remarkable flow stress, while the current inhibited the formation of nano twining due to the stress reduction. Finally, the relationship between yield strength and current density was determined, and a physical model considering dislocation annihilation and deformation-induced twinning was proposed to describe the tensile deformation behavior of the equimolar HEA. This study demonstrates that pulse current is advantageous to improve the formability of HEAs and provides an experimental basis for forming HEA components.

Key Words: High entropy alloys, electrically-assisted tension, Tensile deformation behavior, Deformation twinning

Effect of Cementite Morphology on Hydrogen Embrittlement of Tempered Martensitic Steels

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The effect of cementite morphology on the tensile property and hydrogen embrittlement resistance of tempered martensitic steels was investigated in this study. Three kinds of tempered martensitic steels with different Si contents were fabricated and tempered at 630°C for 2h. The formation of film-like cementite was suppressed with increasing Si content, resulting in the preferred formation of short rod-like cementite. The tensile and fracture behaviors of tempered martensitic steels with different Si contents were evaluated by using a slow strain-rate tensile test after electrochemical hydrogen charging. Increasing Si content enhanced the hydrogen embrittlement resistance characterized by relative reduction of area. Thermal desorption spectroscopy (TDS), silver decoration and fractography analysis were conducted on the hydrogen pre-charged steel specimens in order to elucidate the beneficial effect of Si addition. The decrease in the fraction of film-like cementite improved the hydrogen embrittlement resistance because the interface between film-like cementite and matrix acts as reversible trapping sites for hydrogen. This was supported by the decrease in the concentration of diffusible hydrogen measured by TDS and silver decoration.

Key Words: Tempered martensite, Cementite, Hydrogen embrittlement

Forming temperature on the influence of 2198 Al-Li alloy sheet forming limit

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As third-generation aluminum-lithium alloys, 2198 aluminum-lithium alloys have received widespread attention from the aerospace industry for their performance advantages. Forming temperature is an important influencing factor for the alloy, and it is crucial to study how temperature affects mechanical properties in the preparation of the alloy as well as its application. We obtained the forming limit diagram (FLD) of 2198 aluminum-lithium alloy sheet in the forming temperature range of 25℃~350℃ by rigid die expansion experiment and AutoGrid grid strain measurement and analysis system, and analyzed the effect of temperature on the change of microstructure morphology of the sheet using Optical microscopy (OM), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and other microscopic means. It is shown that the plastic forming properties of 2198 Al-Li alloy sheets are enhanced with the increase of forming temperature. Our research provides a reference for the preparation and application of high-performance Al-Li alloys, which is important for the research and application of new aerospace material sheets.

Key Words: Forming Limit Diagram (FLD), 2198 Al-Li alloy sheet, Forming temperature

Development of manufacturing process for mass production of stimuli-responsive soft micropillar actuator

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The field of micro/nano-scale components and soft robotics has gained increasing attention in the biomedical industry due to their promising applications. Micropillar actuators are one such technology that shows great potential, but the existing fabrication method using PDMS casting is unsuitable for mass production. In this study, we propose a new manufacturing process for the mass production of micropillar actuators. The first step in this process involved using powder injection molding with mixed magnetic powder and elastomer. we then applied a magnetic field-induced injection molding process and PMMA insert molding system to create the stimuli-responsive micropillar actuator. Additionally, we prepared a permanent metal insert mold for mass production and optimized the demolding process for separating the mold from the micropillar structures. Using this new method, we were able to successfully fabricate micropillar actuators with sizes up to 200μm and aspect ratios of around 10. This manufacturing method offers a new way to produce flexible magnetic micropillar actuators on a mass scale, with high dimensional freedom. These advancements hold great potential for the biomedical industry and could lead to new and innovative medical technologies.

Key Words: Magnetic soft composite, Powder injection molding, Field induced mold, Micropillar actuator

Effect of microstructure and residual stress on mechanical properties of Inconel 718 alloy through ultrasonic nanocrystalline surface modification process

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Inconel 718 alloy is a nickel-based superalloy for gas turbines and aircraft engines due to excellent strength, creep, and fatigue properties at high temperatures and corrosion resistance. The ultrasonic nanocrystalline surface modification process is a physical surface treatment method in which ultrasonic vibrations are applied directly to the surface. Nanocrystalline grains and compressive residual at the surface formed through the ultrasonic nanocrystalline surface modification process improve yield and tensile strength and are particularly effective in suppressing fatigue failure.

In this study, the ultrasonic nanocrystalline surface modification process was applied to Inconel 718 alloy and confirmed the mechanical properties at room temperature, and the microstructure was examined using a scanning electron microscope and electron backscattered diffraction analysis. The ultrasonic nanocrystalline surface modification process was treated at a frequency of 20kHz and an amplitude of 30μm with a force of 60N on the surface of the Inconel 718 tensile test specimen. For the mechanical properties analysis, tensile tests at room temperature were conducted at a strain rate of 10^{-3} s^{-1}, and nanoindentation was used to analyze hardness up to 200μm from the surface.

The effect of the nano-surface layer and the compressive residual stress formed during the ultrasonic nanocrystalline surface modification process on the mechanical properties were obtained from this study.

Key Words: Inconel 718, nanocrystalline surface modification, residual stress, nanoindentation

Heat Generation and Strain Rate Effect on Forming of Low Carbon Boron Steel

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Bolts and nuts (fasteners) have been widely applied in various fields where the multi-stage cold forming process is popular in manufacturing fasteners. In the traditional cold forming process simulation, the temperature and strain rate effects of the material are usually neglected, and only the strain effect of the material is considered. However, the material should still be affected by plastic deformation work, friction effect, and other process conditions during the forming process, which will cause the temperature of the material to rise and further affect the whole process. With the improvement of manufacturing technology, the development of new materials, and the advancement of computer computing capabilities, more characteristics need to be considered, which would make the simulation results closer to the properties of actual materials.

The low carbon boron steel (AISI 10B21) was used as the research material in this study. The initial flow stress of the material at three initial temperatures (30, 100, and 200 °C) and three constant strain rates (0.1, 1.0, and 5.0 s^{-1}) was obtained by conducting Gleeble compression test while monitoring the increase of specimen temperature in the same time. Multiple material models were used for regression of flow stress in order to obtain stress-strain relations with respect to constant temperature and constant strain rate by adjusting the ratio of plastic deformation work to heat, and the model's accuracy was evaluated through model evaluation indicators. Finally, the experimental process was reconstructed by finite element analysis and compared with the experimental results to verify the feasibility of the proposed methodology. The results show that the Average Absolute Relative Error (AARE) are about 0.151% ~ 0.405% for Hoolmon law and 0.348% ~ 1.651% for General flow law.

Key Words: flow stress, Gleeble compression test, low carbon boron steel, temperature effect

Microstructure Evolution and Mechanical Properties of Directly Quenched and Intercritical- Annealed Low-Carbon Dual-Phase Steels

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Dual-phase steels have a composite microstructure in which a hard second phase (martensite) is dispersed in a soft ferrite matrix. When compared to conventional high-strength low alloy steels, the dual-phase steels provide interesting and superior mechanical properties such as excellent ductility, high rate of work hardening, low yield-to-tensile ratio, and continuous yielding behavior. Given that microstructural factors such as grain size, morphology, and volume fraction influence the mechanical properties of dual-phase steels, it is essential to optimize the microstructural factors through an appropriate selection of chemical composition and heat treatment conditions. In this study, low-carbon dual-phase steels with different microstructural factors were fabricated by varying chemical composition and intercritical annealing conditions after direct quenching. Based on the SEM, EBSD, TEM, and Thermo-Calc DICTRA simulation, microstructure evolution during intercritical annealing was studied. Tensile and Charpy V-notch impact tests were also performed at various temperatures in order to examine the correlation between the microstructural factors and the mechanical properties of low-carbon dual-phase steels

Key Words: Dual-phase steel, Intercritical annealing, Microstructure, Mechanical property

Fabrication of surface microstructures with three-dimensional multiscale features on aluminum alloy by hot embossing

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Micro hot embossing is widely used in manufacturing micro-parts and microstructures due to the advantages of high productivity, low cost, near-net-shape, and excellent mechanical properties. Herein, the hot embossing process for surface microstructures with three-dimensional multiscale features in 6063 aluminum alloy is studied. It was found that no matter how to change the embossing load and forming temperature, the two major microforming defects of under-filling and warpage could not be solved simultaneously. Then, a novel exhaust punch is proposed to improve the hot embossing process. The exhaust punch has many exhaust holes, which are assembled by several small punches with structured cavities. And this exhaust punch is easier to process than the integrated punch, and the structured cavities in the exhaust punch are smoother. By using the exhaust punch to carry out the hot embossing experiment, the complete filling of the surface microstructure is achieved, and the problem of warpage of the aluminum alloy sample is also solved. The maximum embossing load of this exhaust process is reduced by 50% compared with the conventional process.

Key Words: Hot embossing, Surface microstructures, Aluminum alloy

Effects of Nanometric Piercing Tools on Process affected area in Non-oriented Electrical Steel Sheet

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In recent years, the demand for motors is expected to expand rapidly as EVs quickly spread in the automotive industry and motors replace engines as the power source. Motors in automobiles and other vehicles use a metal part called an iron core, which is made by shearing and stacking non-oriented electromagnetic steel sheets. During the shearing process, strain accumulates and degrades the iron loss of the electromagnetic steel sheets. In other words, establishing a processing method that does not damage the material functionality can improve the efficiency of motors and reduce power consumption. This paper aims to elucidate the effect on the work hardening area when ion sharpening tools and tools with the nano-metric structure are used along with normal ground tools and to create a new piercing process technology for low iron loss motors.

In this paper, four types of punches were used: a normal punch with only a ground finish, an ion polished punch with a ground finish, a nano-textured punch (texture angle 20° from bottom of punch), and a nano-textured punch (texture angle 90°) with a nano-periodic structure added at different angles after ground finish. The material was to be processed as a 500 μm-thick non-oriented electromagnetic steel plate, and piercing process experiments were performed to punch stroke 30% and 100% of the plate thickness.

After piercing, the sheared surface of the product was observed using a digital microscope. A Vickers hardness tester was used to measure the extent of work hardening in the vicinity of process affected zone. The results were used to create a hardness map.

When the Normal punch was used, process affected zone inside the material was extended in pierced. On the other hand, process affected zone was suppressed by using the Ion polished punch. The secondary burnished surface was appeared in using Normal punch, but efficiency sheared surface was obtained when using an Ion polished punch.

Using the nano-textured punch (texture angle 20°) and the nano-textured punch (texture angle 90°) enabled processing while suppressing the high-hardness area observed near the piercing point. The nano-texture punch (texture angle 90°) minimizes the work hardening area.

It was clarified that the punch tip was sharpened and homogenized and that the nano-texture application enabled processing with less of material functionality. It was also described that the work hardening area differs depending on the angle at nano-textured punch.

Key Words: Punching, Non-oriented electrical steel sheet, Iron loss

Effect of forming parameters on mechanical properties of carbon fiber reinforced Inconel 718 composites prepared by spark plasma sintering

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Carbon fiber reinforced Inconel 718 composites not only have excellent mechanical property at high temperature, but also have the advantages of light weight, easy to prepare, low costing because of the reinforced by carbon fiber. Spark plasma sintering (SPS) has the advantages in prepare metal-matrix composite due to the fast heating rate. In this research, the carbon fiber reinforced Inconel 718 composites were prepared through the SPS experiments under diverse sintering times and temperatures, and the compression tests were performed to explore the effects of the sintering times and temperatures of SPS on the mechanical properties of carbon fiber reinforced Inconel 718 composites. The results indicated that with the increase in sintering time from 5 to 15 minutes, the compressive strength, the yield strength, and the ultimate strain of carbon fiber reinforced Inconel 718 composites decrease under the condition of 900 °C and 950 °C. With the increase in sintering temperature from 900 to 950 °C, the compressive strength, the yield strength, and the ultimate strain of the samples increase. The compressive strength of the samples with sintering time of 5 ,10, and 15 minutes increase by 14.78 %, 11.17 %, and 1.20 %, respectively. Besides, the yield strength increases by 13.42 %, 28.75 %, and 3.18 %, respectively. It is indicated that the effect of temperature in improving mechanical properties of carbon fiber reinforced Inconel 718 composites diminishes gradually. Consequently, this paper makes meaningful contributions on exploring the industrial production and application of carbon fiber reinforced Inconel 718 composites.

Key Words: Spark plasma sintering, fiber reinforced composites; forming parameters, mechanical properties

Evaluation of the coefficient of friction during forging process using a CAE-assited sensing system

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In-process sensing of process conditions in metal forming has been attracting attention. In f orging processing, lubrication plays an important role and its characteristics varied during th e process depending on the process conditions, which greatly effects on product accuracy. Monitoring technology for the dynamic characteristics of lubrication characteristics during for ging process is required.

In this study, a friction evaluation system using a data assimilation method that fuses real-ti me measurement of the pressure using a die-embedded sensor system with CAE is develope d. Multiple pressure sensors are embedded into the die to measure the pressures and its dist ribution in forging process. A process simulation of the forging process is performed using the finite element method. The simulation results are compared with the data measured in-pr ocess. Data assimilation process was adapted to identify factors such as material properties and friction coefficient using the measurement data at initial stage of the process when the lubricant is functioning and the coefficient of friction is approximately constant. The evaluat ion with the data assimilation method was then applied to estimate the variation of friction characteristics in later stage of the process when the lubrication oil film is broken and the coefficient of friction becomes unstable. The system was also applied to evaluate the frictio n characteristics of different lubricants. Experiment of forging an aluminum plate was perfor med for evaluation of the friction characteristics with different lubricants. The results show t hat it was possible to evaluate the friction characteristics of different lubricants and to meas ure the variation of the friction characteristics during the process.

Key Words: Press stamping, Friction, Data identification

Mechanical Behavior and Microstructural Evolution of Aluminum Alloy under Ultrasonic Vibration-assisted Micro-tension

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The fabrication of the microscale products has been the prevailing trend in the processing and production. Owing to the size effect in metallic materials during microforming, traditional process is hardly capable of manufacturing accuracy and reproducibility. Ultrasonic vibration-assisted forming has prominent advantage for reducing deformation resistance and improving the uniformity. Nevertheless, the coupling effect of ultrasonic vibration and size effect on mechanical behavior and microstructural evolution of materials is still unclear. In this paper, ultrasonic vibration-assisted tension experiments were performed on different grain sizes of A5052 aluminum alloy sheets. Full application and local application of ultrasonic vibration-assisted tension were carried out to investigate the effect of coupling ultrasonic vibration and size effect on mechanical characteristic. Meanwhile, we conducted the experiments of ultrasonic vibration-assisted tension followed by EBSD under different grain sizes of sheets. The experiment results indicated that flow stress dramatically reducted under ultrasonic vibration-assisted tension. The ultrasonic softening value increased first and decreases subsequently with the grain size increased. Compared the full application with local application of ultrasonic vibration, the fracture mode gradually develops from microporous aggregation fracture to fatigue fracture. In addition, the increasing proportion of low angle grain boundaries of materials reduced under ultrasonic vibration. The present study provide a reliable investigation for effect of coupling ultrasonic vibration and grain size, and promote the application of ultrasonic vibration in microforming of sheets.

Key Words: ultrasonic vibration, aluminum alloy, microstructural evolution

Incremental Sheet Forming Process: Experiment and FE Simulation

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This talk will review recent developments in the incremental sheet forming process including advanced numerical analysis. An overview of state-of-the-art approaches to successfully handle material deformation during incremental forming will be given, taking into account the effects of 1) anisotropic evolution of yield surface, 2) vacuum-assisted way of forming, and 3) tool path design for 3D profile shaping, which can provide noticeable improvements in dealing with deformation characteristics to ensure geometric accuracy of the target product. This will be followed by a proposed modeling framework for constitutive behavior based on elements of the approaches used in the prediction of yield surface distortion and its evolution with plastic deformation, thereby satisfying industry's need for reliable prediction of metal deformation for the range of forming conditions that occur in incremental manufacturing.

Key Words: Incremental Sheet Forming, Tool Path Generation, Material Characterization, Numerical Analysis

Development of nonconventional energy field assisted micro-forming

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With the further miniaturization of the manufacturing limit, micro-forming just by loading of the tool (force field) becomes more and more difficult and the limit of the forming scale cannot be broken. Therefore, there is an urgent demand to develop new principles, methods and processing technics in micro-forming. Aiming at the fundamental scientific problem of size effects in micro-forming, nontraditional energy fields such as electric field, electromagnetic field and ultrasonic are introduced to micro-forming technology. The new effects of interaction between energy fields and materials will be used to break through the scale limit and expand the range of materials to achieve multi-scale, multi-material and controllable micro-forming. The development of energy field assisted micro-forming technology will significantly promote the evolution and application of micro-forming technology and becomes an important development trend in the field of micro-nano manufacturing technology.

Key Words: micro-forming, size effect, energy field

Crystal plasticity modeling of micromechanical properties of constituent phases in 3rd generation complex phase AHSS

Minh Tien Tran[1], Minh Sang Pham[1], Hyunki Kim[2],
Hobyung Chae[3], Wan Chuck Woo[3], Dong-kyu Kim[1,*]
1 Konkuk University, South Korea
2 Hyundai Motor Company, South Korea
3 Korea Atomic Energy Research Institute, South Korea
*** Corresponding Author / E-mail: dongkyukim@konkuk.ac.kr**

The present study comprehensively investigated micromechanical properties of constituent phases in 3rd generation (GEN) complex phase advanced high strength steel (AHSS) by the hybrid technique using uniaxial tensile test with digital image correlation (DIC), electron backscatter diffraction (EBSD), in-situ neutron diffraction (ND) and crystal plasticity finite element method (CPFEM). It is found that, in addition to the presence of ferrite, martensite and austenite phases, the microstructure of 3rd GEN AHSS is noteworthy with relatively high volume fraction of bainite phase, which can play an important role in the micromechanical deformation of 3rd GEN AHSS. It reveals that the experimental macroscopic responses and lattice strain evolutions of constituent phases measured from in-situ ND are well reproduced by the CPFEM simulations. As a result, the microscopic hardening properties of ferrite, bainite, martensite and austenite phases are successfully determined. Furthermore, the micromechanical simulation using EBSD mapping representative volume element (RVE) discloses a noticeable stress/strain heterogeneities and local hotspot of the ductile fracture initiation. It is found that the pronounced strain localization occurs predominantly at the ferrite/bainite grain boundaries or inside of both ferrite and bainite grains, leading to material failure. These findings advance new insights into the micromechanical properties of 3rd GEN AHSS, particularly regarding the determination of constitutive properties of bainite and its effect on the micromechanical deformation and failure behavior.

Key Words: Complex phase AHSS, Micromechanical properties, In-situ neutron diffraction, Crystal plasticity FEM.

Effect of two-step heat treatment on microstructure and mechanical properties of non-heat-treated steel

Young Yun Woo[1,*], Young seon Lee[1], Eun yoo Yoon[1], Kyu han Kim[1]

1 Korea Institute of Materials Science, South Korea

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The non-heat-treated steel for cold forging has gained attention due to the advantages from eliminating the quenching-tempering heat treatment process. In this study, a Fe-Mn-Si-C-based multi-phase steel, called as Yield-Ratio-Control-Steel (YRCS), was used as a non-heat-treated steel. The effect of a two-step heat treatment on the mechanical properties and microstructure of the YRCS was investigated. Tensile testing was conducted and optical metallography, X-ray diffraction, and image analysis were carried out to investigate the mechanical properties and microstructure. Using the multi-stages cold former, Torx bolt was manufactured from YRCS without heat treatment and compared to those made from SCM435, a quenched and tempered steel typically used for this application. The results showed that the final parts from YRCS satisfied the required hardness of Torx bolts

Key Words: non-heat-treated steel, cold forging, Torx bolt

Fatigue life variation of structural part depending on the residual stress level

Yong-Nam Kwon[1*], Dong Jun Lee[1], Moo Young Seok[1], Hyun Il Park[1], Hyunsung Choi[1]

1 Korea Institute of Materials Science, South Korea

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Residual stress on structural parts is generated during manufacturing processes such as casting, plastic deformation, heat treatment, and machining. The compressive surface stress on the part has been known to give a beneficial effect by delaying a crack initiation. However, the effect of residual stress on crack propagation has been less studied to the author's knowledge.

Various methods have been available to quantify residual stress. Usually, X-ray diffraction, hole drill, and contour methods have been used for the measurement of residual stress. X-ray diffraction or hole-drill method is easy to characterize surface residual stress. To measure internal stress distribution a contour method has been devised and demonstrated.

In this study, the surface of the aircraft part was plastically deformed to change stress distribution. The distribution of stress distributions of aircraft parts was characterized using the X-ray diffraction, hole-drill, and contour method to quantify the amount of plastic deformation. Then, fatigue tests were conducted to find out how the stress distribution on the part influence crack growth. Compressive stress was found to give beneficial effect on the crack propagation.

Key Words: Residual stress, Aircraft part, Fatigue

Study on the initial tension of helical tension spring formed by coiling process

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A tension spring with initial tension is a type of helical spring that has a unique characteristic that other springs do not have. Such a spring is always compressed to its solid height and requires a minimal force as initial tension to extend it. Although it is important in industrial applications such as fixing, measuring, and storing energy, there is still a lack of relevant literature on its manufacturing process. If the relationship between initial tension and process parameters can be determined, it will be beneficial to develop a manufacturing system to meet the demanding requirements of future industrial production. Therefore, this study investigates the process parameters using a coiling machine, which is widely used for manufacturing helical springs, on the geometry of the spring and its initial tension. The metal wire is fed by feed rollers through a mandrel quill and bent into a spiral shape by a tool with an inclined groove when the wire contacts the groove. Before the wire tip moves around the newly fed and bent piece of the wire from the mandrel quill, the wire tip comes to and slides on an inclined plane of the mandrel quill. The wire tip is then shifted in the direction of the spring axis, and then moves to the other side of the mandrel quill when the wire tip leaves the plane, forming the wire as a helically coiled tension spring. The results of the experiment compared with the finite element analysis show that all the process parameters investigated in this study, such as the angle between the mandrel axis and the inclined tool groove, the distance from the mandrel quill exit to the inclined tool, and the lateral displacement of the inclined tool groove, have a significant influence on the geometry and initial tension of the formed helical spring

Key Words: Tension springs, coil forming, initial tension, helical coiled spring, finite element analysis

Densification behavior of Mg+2B powder mixture and its effect on critical current density of superconducting MgB_2 wire

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In this study, the PIT-processed MgB_2 wires with different initial filling densities were fabricated to investigate the densification behavior of Mg+2B powder mixture during multi-pass wire drawing and its effect on critical current properties. It was found that the densification behavior of the powder mixture was divided into two cases depending on the initial filling density. This is due to the different strengths between the sheath materials and the powder mixture. Sudden increases in packing density were observed after a critical level of accumulated strain. The microstructure analysis revealed that sudden changes in area fraction and packing density were because of the accelerated plastic deformation of Mg particles and rearrangement of B aggregates. By correlating the packing density with grain connectivity based on the percolation model, it was found that the packing density strongly affected grain connectivity and critical current properties. The critical current densities increased with increasing level of densification of the Mg+2B powder mixture, whereas the engineering critical current densities increased with increasing initial filling density.

Key Words: Magnesium diboride (MgB_2), multi-pass wire drawing, initial filling density, critical current density

Memorandum

Ministry of Trade, Industry and Energy
KIAT
KIMS Korea Institute of Materials Science

Total Solution Center for Metallic Materials

www.metalsbank.com | testbed.metalsbank.com

Total Solution Center for Metallic Materials

Full cycle supporting infra to promote commercialization of metallic materials through providing materials data, computer simulation and pilot plant scale production

needs
Full cycle supporting
Customer

Metals Bank – Computer Simulation – Test-Bed

Needs – Design — Verification – Application — Commercia-lization

- Materials data
- Market information

- Property data
- Computer simulation

- P/P scale production
- Characterization

- Mass production
- Process Optimizing

Metals Bank

- Construction of Metallic Meterials DB
- International collaboration & networking
- Education for materials specialists nurturing

Computer Simulation

- Support for metallic materials and process design
- Education for computer simulation export of industry

Test-Bed

- Supporting of pilot plant scale equipment
- Technical supporting for process optimizing

To Raise Competitiveness of Metals Industry through Full Cycle Technical Support

Enquiry

- Total Solution Center for Metallic Materials, KIMS
  - TEL : +82-55-280-3273
  - FAX : +82-55-280-3279
- E-mail : mykimsid@kims.re.kr
- Homepage : www.metalsbank.com
  tesbed.metalsbank.com

Smart Manufacturing Center for Power Units(www.epu.re.kr)

Smart Manufacturing Center for Power Units

The definition of industry

What is 'Power units' ?

It means a **power generators** such as turbines, motors, and engines, which are key products that determine the performance and price of the system.

[The goal of promoting high-efficiency power generation systems]

Turbines

Target components/parts

- Gas turbine parts for generators (blades, vanes, and nozzles)
- Aircraft gas turbine (turbine blades, vanes, and blisks)

Target materials

- Superalloys and high-strength alloy steel

Motors

Target components/parts

- High-efficiency high-speed electric motors (permanent magnet and rotor)
- Special motors (conductive materials and stators)

Target materials

- Conductive materials

Engines

Target components/parts

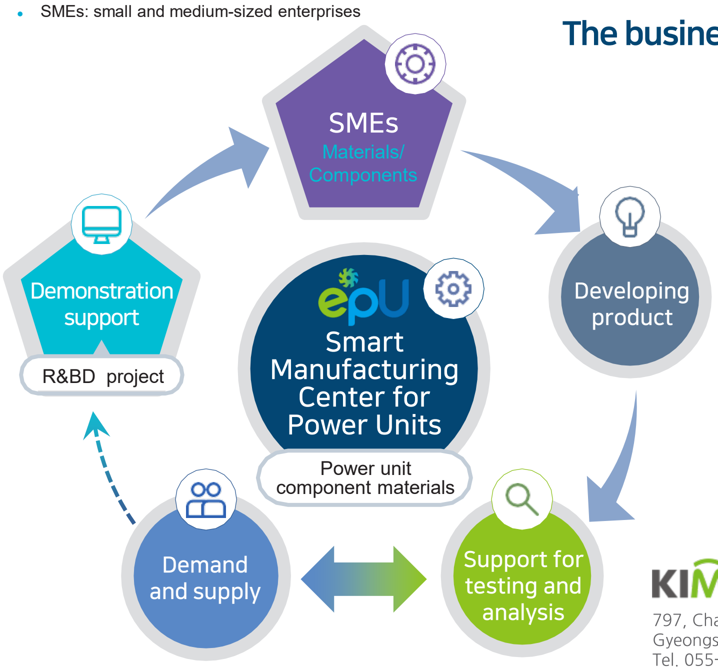
- Engine components (turbochargers and impellers)

Target materials

- Superalloys and wear-resistant high-strength steel

[Developing industrial ecosystem and fostering SMEs]

- SMEs: small and medium-sized enterprises



The business unit fosters SMEs by performing a bridging role

Center	Supporting SMEs through the use of smart manufacturing center for power units
SMEs	Leading the development of materials and components
Consumer	Surveying demand for products under development and acting as an observer

Fostering global SMEs

- Support for sample production, product advancement, and technical guidance
- Marketing/brand development support, exhibition/exhibition support
- Performance dissemination and networking

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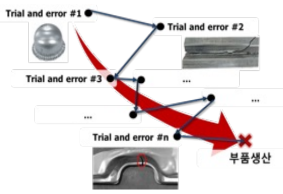
금속소재 제조디지털혁신 플랫폼 구축

Part 1 Simulation Platform

As Is

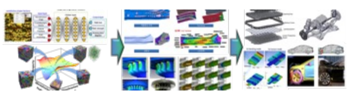


To Be

신규테마

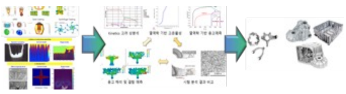
차체 및 구동부품 성형설계 플랫폼

미래차 차체 및 구동부품 제조를 위한 소재물성, 성형품질 및 부품 성능 예측을 가상공간에서 수행하는 설계 플랫폼



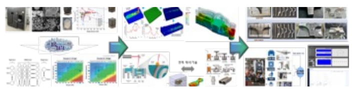
주조부품 공정설계 플랫폼

미래자동차용 경량부품 크기 및 형상 복합도를 고려한 주조 소재 및 공정 해석, 설계 지원 플랫폼



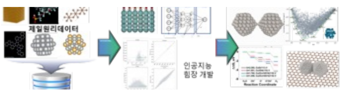
금형 적층제조 공정설계 플랫폼

미래자동차 부품 생산제조용 금형 적층제조 공정설계 및 시뮬레이션, 제조공정 연계해석 및 적층 금형 실증 지원 플랫폼



수소 활용·생산용 촉매 설계 플랫폼

그린수소용 촉매 개발을 위한 인공지능 멀티스케일 모델링 및 해석이 가능한 플랫폼



Education

교육

- 해석 SW(자체개발 및 상용)를 이용한 소재설계 및 공정해석 교육
- 재료공학, 미세조직 분석, 소재의 기계적 특성 등과 같은 이론/실습교육
- 기술동향, 최신기술 소개, 플랫폼 및 SW 활용 사례 관련 세미나

소재 선정-부품설계-공정개발 해석지원 및 컨설팅

해석 지원

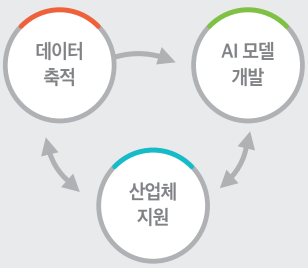
- 소재 선정에서부터 부품·공정 설계까지의 해석에 필요한 SW/HW 인프라 구축 및 지원
- 불필요한 해석과 실험을 최소화를 위한 해석 및 실험 데이터베이스 구축 및 이를 활용한 지원

컨설팅 지원

- 직접적인 해석이 필요 없이 기존 데이터 혹은 전문지식을 기반하여 지원
- 필요에 따라 해석을 도입하여 지원

Part 2 소재데이터 (AI)

소재데이터 통합 플랫폼



Data accumulation
- 소재 데이터 표준화
- 데이터 확장, 특징화, 전처리 모듈 개발
- 데이터 활용

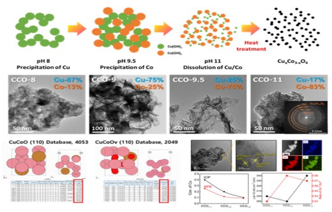
AI model development
- DNN, CNN, GAN, RL, RNN 등
- 소재·공정 데이터 최적화 AI 개발
- GPGPU 기반 병렬화·최적화

Deployment
- 산업현장 맞춤형 솔루션 지원
- 산업체 데이터 수요 발굴, 튜닝 지원
- Feedback 제공, 현장 데이터 축적

그린수소 생산용 촉매 | 가스터빈 부품용 합금소재 | 고탄성 주조용 알루미늄 합금

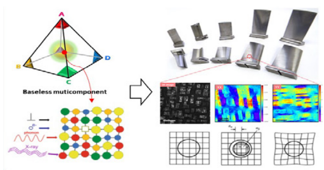
테마 1 그린수소 생산용 촉매

인공지능 멀티스케일 모델링 및 정보기반 회귀 모델로부터 고성능·고내구 연료전지·수전해 촉매 기술 개발



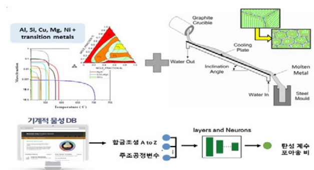
테마 2 가스터빈 부품용 합금소재

고가의 니켈계 초내열 합금 대체용 저가 원소 기반의 고엔트로피 新합금 개발 - 조성·공정 제어 고엔트로피합금 주조재 및 압연재 생산, 실험 빅데이터 기반 저비용 고엔트로피합금 설계 AI 기술개발



테마 3 고탄성 주조용 알루미늄 합금

고탄성 주조용 알루미늄 합금 소재용 중소·중견 기업에 AI 관련 서비스 플랫폼 구축



금속소재 제조디지털혁신 플랫폼 구축 관련 문의

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산업통상자원부 Ministry of Trade, Industry and Energy
beyond leading technology KIAT 한국산업기술진흥원
KIMS 한국재료연구원 Korea Institute of Materials Science

* "금속소재 제조디지털혁신 플랫폼 구축"사업은 산업통상자원부 소재부품산업기술개발기반구축 소재부품기술기반혁신 사업의 일환으로 진행됩니다.

신뢰성기반활용지원사업 (금속분야)

01 사업개요

소재부품장비 글로벌 경쟁력 확보를 위해 중소·중견기업을 대상으로 연구개발기관(서비스 지원기관)의 인프라(인력,장비 등)를 활용하여 신뢰성 및 소재 성능 향상 지원

- **부 처** | 산업통상자원부
- **전 담 기 관** | 한국산업기술진흥원
- **수 행 기 관** | (주관) 한국재료연구원,
  (참여) 포항산업과학연구원,
  오송첨단의료산업진흥재단,
  고등기술연구원
- **사 업 기 간** | 2023년 3월 ~ 2026년 12월

02 지원방법

신뢰성 향상 및 융복합 소재부품장비 및 뿌리기술개발을 필요로 하는 국내 소재부품장비 및 뿌리 기업에게 바우처(온라인 쿠폰)를 발급하여 수행기관에서(서비스 지원기관) 제공하는 서비스 이용 지원

03 지원형태

구분	정기형	수시형
공고시기	연 2회 내외	상시
지원규모	1억원내	3천만원내
선정평가	서면/대면평가	서면평가
지원대상	소재·부품·장비 중소/중견 및 뿌리기업	

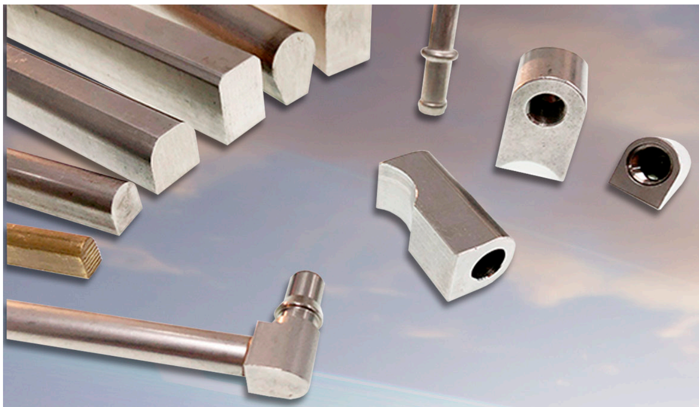
04 지원세부항목

지원세부항목		
신뢰성 향상	신뢰성평가	신뢰성인증 획득 등 기업이 요구하는 제품의 성능, 환경, 수명평가 등 신뢰성향상 지원
	고장분석	고장 재현 시험, 고장원인 분석 등
	가속시험법 등 평가기법 개발	사용조건, 열화메커니즘별 가속수명시험법 및 핵심성능 평가법 개발
	물성·성능평가	테스트베드 및 시뮬레이션 등을 이용하여 물성·성능평가 지원(부품·장비분야)
소재성능 향상	물성정보 등 데이터 및 기술정보 지원	소재 물성정보, 소재 기술정보, 신뢰성 규제/기술/표준/특허 정보 분석 서비스
	성능향상 시뮬레이션 활용 지원	컴퓨터를 활용한 개발소재의 물성 검증 해석
	소재 공정 및 성능개선	개발 소재의 공정/성능 개선 및 생산 지원

05 지원기관 및 서비스 제공 분야

지원기관	구축장비 및 서비스 제공 분야	강점분야	지원항목
한국재료연구원	금속소재종합솔루션센터 구축 - 국내 개발 소재의 사업화 촉진을 위한 상용화 개발 지원 - 금속소재 양산화 검증 장비(압연, 주조, 용해로, 동방가압설비 등) - 금속소재 정보 DB 구축 및 보급, 전산해석 지원, 테스트 베드	범용 금속소재/부품에 대해 대부분 시제품제작 기반으로 구축	- 신뢰성 평가 - 신뢰성비교평가 - 고장분석 - 원인분석 - 테스트베드활용 - 사용환경조건에서의 실증지원 - 소재정보서비스(DB활용) - 시뮬레이션 - 기술개발 연계 시험분석평가 - (해외)인증획득용 시험분석평가 - 가속시험법 등 평가기법 개발 - 융복합 설계 및 신뢰성 설계 - 전문인력 현장 지원
포항산업과학연구원	부품소재 신뢰성평가 기반구축 (기초금속) - 기초금속소재에 대한 시험평가 및 신뢰성평가 장비구축 및 인증지원 - 산업용 금속부품 신뢰성 평가 장비 (피고, 크리프, 부식, 마모 장비 등) - 신뢰성 평가기준 제정 및 인증, 고장분석 지원, 가속수명시험법 개발	철강위주 범용소재에 대한 평가기반 구축	
오송첨단의료산업진흥재단	소재개발을 위한 전주기적 서비스 지원 기반 구축 - 소재개발을 위한 연구기획 단계부터 품목허가, 인증지원까지 전주기적 서비스 지원 - 금속 소재를 기반으로 제작된 시제품의 신뢰성평가 및 인증지원 - 금속/전기전자/화학/전자파분야 등 지원	소재, 부품 및 의료기기 개발을 위한 전주기적 서비스 지원 기반 구축	
고등기술연구원	원천기술부터 실증화기술까지의 토탈솔루션 제공 - 공정해석, 장치 해석, 경제성 평가, 환경성 평가, 신뢰성 평가, 3차원 모델링, 데이터분석 등)의 software와 hardware의 연계를 통해 차별화되고 특화된 기술개발을 지원 - 기능성 부품소재, 고부가소재화 기술, 유가금속 자원순환기술 등을 통해 소재의 고도화 경쟁력 강화를 위한 원천 및 실용화 기술개발을 지원	고기능 소재 제조분야의 산업적 활용 가치 및 에너지 효율 향상 등 기술간 융복합화를 위한 연구 분야 지원	

산업통상자원부 Ministry of Trade, Industry and Energy · beyond leading technology KIAT 한국산업기술진흥원 · KIMS 한국재료연구원 Korea Institute of Materials Science · RIST 재단법인 포항산업과학연구원 Research Institute of Industrial Science & Technology · K BIO HEALTH · IAE 고등기술연구원 Institute for Advanced Engineering



BUGOK

Anniversary

SINCE 1983 40th

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AWARD

2021 Award the Korea Minister of Trade, Industry and Energy prize

2020 Won the Korea Prime Minister prize for Quality Renovation in Korea Chamber of Commerce and Industry's Company Renovation Contest
Won the Korea Institute of Materials Science(KIMS) Special Achievement prize

2019 Won the 'Million-Dollar Export Tower' prize: Korea Prime Minister prize
Won the grand prize of Busan small and medium-sized firms: Busan Mayor prize

2017 Won the merit prize of Busan Metropolitan City's invention contest
: Busan Mayor prize

2016 Won the best prize of Korean National Commissions for Corporate Partnership's mutual growth of corporations contest
Won the best prize of Good pratice about work-learning program contest: Korea Minister of Employment and Labor prize

2015 Won the best prize of Korea Minister of Trade, Industry and Energy for the spreading Clean Manufacturing
Selected as a 'Korea Global IP Star Company'
Won the Outstanding patent: the Best prize/Material component technology development
: Minister prize at the Busan Technopark International Invention & New Technology Fair

PRICM11 The 11th Pacific Rim International Conference on Advanced Materials and Processing

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PRICM11

The 11th Pacific Rim International Conference on Advanced Materials and Processing

November 19-23, 2023 | ICC, Jeju, Korea

Important Dates

- **Abstract Submission :** February 15 ~ May 31, 2023
- **Notification of Abstract Acceptance :** June 30, 2023
- **Early-bird Registration :** April 15 ~ August 15, 2023

Honorary Chair :
Sung-Joon Kim (POSTECH)

Conference Chair :
Prof. Hyoung Seop KIM (POSTECH)

In-Country Technical Representative :
KIM Prof. Hyoung Seop KIM (POSTECH)
CSM Prof. Chengjia Shang (Univ. of Science & Technology Beijing)
JIM Prof. Yoshihito Kawamura (Kumamoto Univ.)
MA Prof. Jian-Feng Nie (Monash Univ.)
TMS Dr. George (Rusty) Gray III (Los Alamos National Lab)

Secretary General :
Prof. Jae Bok Seol (Gyeongsang Nat'l Univ.)

Symposium Topics

Symposium A : Advanced Steels and Properties
Symposium B : Advanced Processing of Materials
Symposium C : Structural Materials for High Temperature
Symposium D : Light Metals and Alloys
Symposium E : Additive Manufacturing
Symposium F : Thin Films and Surface Engineering
Symposium G : Materials for Energy Generation
Symposium H : Electronic and Magnetic Materials
Symposium I : Biomaterials and Soft Materials and their Application
Symposium J : Materials Characterization and in situ/3D/4D Analysis
Symposium K : High-Entropy Materials and Amorphous Materials
Symposium L : Composite, Coating and Hetero-Materials
Symposium M : Nano Materials and Nano Severe Plastic Deformation
Symposium N : Computational Materials and Artificial Intelligence
Symposium O : Materials for Sustainability (Green Steel, Recycling, and Corrosion)

Host : KIM The Korean Institute of Metals and Materials (KIM)
Sponsor : Materials Australia (MA), The Minerals, Metals & Materials Society (TMS) The Japan Institute of Metals and Materials (JIM), The Chinese Society for Metals (CSM)
Pricm11 Secretariat E-mail : info@pricm11.org Tel : +82-2-573-6207 Fax : +82-2-573-6208

GANGNEUNG TOUR

08:30	Sky Bay Pickup
09:00-11:00	Bohemian Coffee Experience
11:30-12:30	Lunch (Chodang Soft Tofu)
12:40-14:00	Ohjukheon/Ohjukheon Hanok Village
14:00	Gangneung Station or Skybay Drop off

Ojukheon Hanok Village exhibits the excellence and simple beauty of the Korean traditional house known as 'hanok'. Based on Ojukheon, the birthplace of Yi I (a Confucian scholar of the Joseon Dynasty), it was built to spread the ideas of Yi I and promote the excellent features of hanok to the world.

Chodang sundubu village's tofu is a soft and light tofu made from ground beans and salt water from the East Sea. The name, Chodang, comes from a famous family, the Chodang Heoyeop. Heoyeop was the father of the poet Heonan-seolheon and the writer/poet Heo Gyun. Where their home once stood, there's now a hanok.

Bohemian Coffee's founder, Korea's first-generation barista, Park Yi-chu, opened his first cafe "International Coffee House Bohemian" in Hyehwa-dong i 1988. In 2004 he opened another branch in Gangneung. There are now two cafes and a flagship roasting factory where you can learn about coffee.

AWMFT & APSTP 2023

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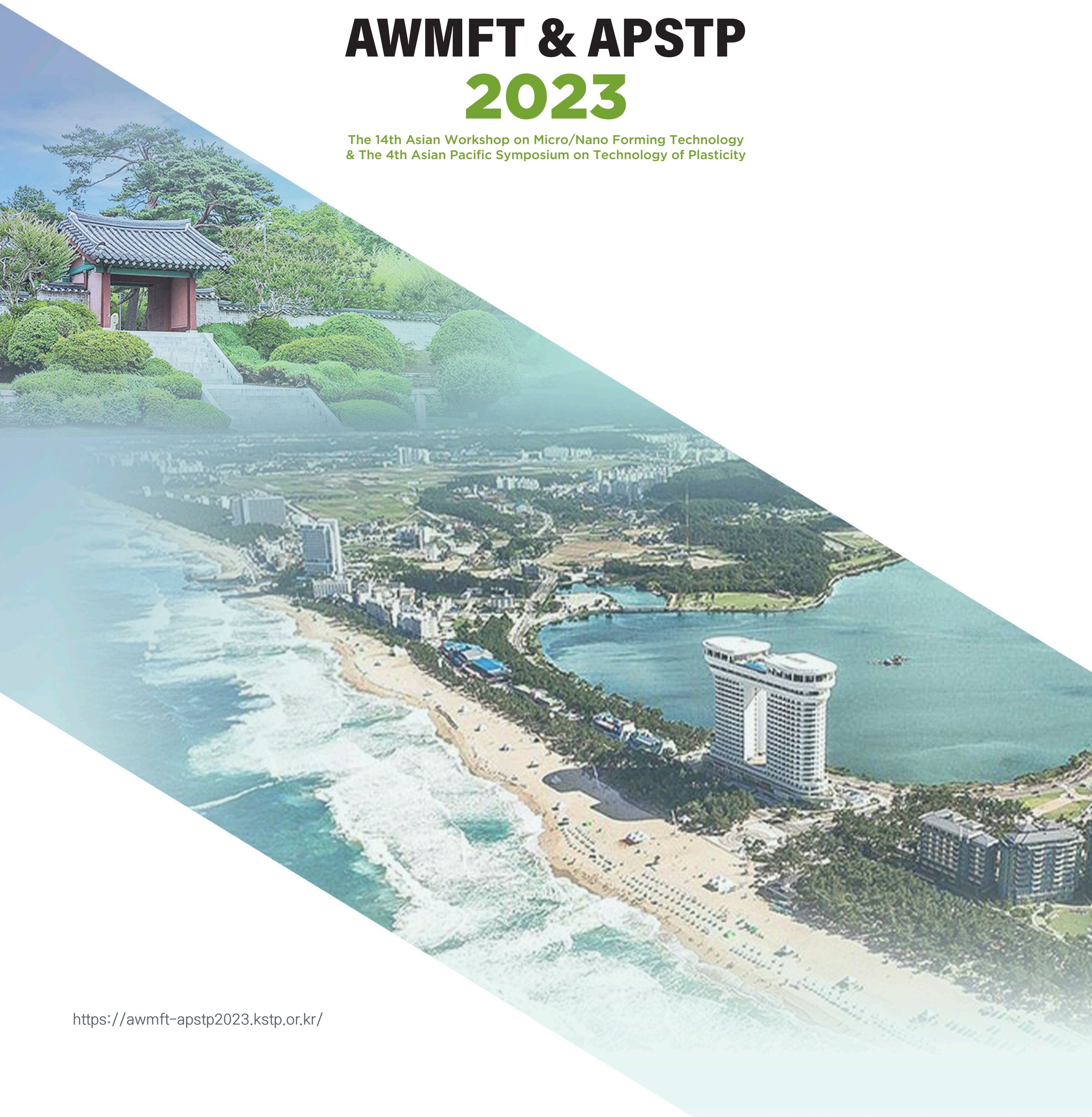
& The 4th Asian Pacific Symposium on Technology of Plasticity



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