The 5th KIM-CSM Symposium

New Metal Materials: Hot stamping, New energy vehicles & Lightweight

China · Hefei
August 21-24, 2024.

Organized by
The Chinese Society for Metals (CSM)
Korea Institute of Metals and Materials (KIM)
Supports by
Korea Institute of Materials Science
Shanghai Mengshan Technology Development Co., Ltd.

The 5th KIM-CSM Symposium

2024 August 23 (Friday), 09:00 ~ 17:00

Title: New Metal Materials: Hot stamping, New energy vehicles & Lightweight

Organizer Person: Hyoung-Wook Kim (Korea Institute of Materials Science, Korea)

Hongzhou Lu (CITIC Metal Co., LTD, China)

Preliminary Schedule*

2024.8.21.(Wednesday) 18:00~20:00: Welcome Dinner

2024.8.22.(Thursday) 09:00~ 17:00: ICHSU 2024 (Parallel Conference)

2024.8.22.(Thursday) 18:00~ 20:00: Gala Dinner (Parallel Conference)

2024.8.23. (Friday) **09:00~ 09:10: Welcome Address (KIM & CSM President)**

2024.8.23. (Friday) **09:10~ 11:50: Morning Session (S1 &S2)**

2024.8.23. (Friday) **12:00~ 14:00: Lunch Break**

2024.8.23. (Friday) **14:00~ 16:40: Afternoon Session (S3 &S4)**

2024.8.23. (Friday) **16:40~ 17:00: Closing Remark**

2024.8.23. (Friday) **18:00~ 20:00: Symposium Dinner**

2024.8.24. (Saturday) Technical Visiting, Closing

2024.8.25. (Sunday) Leave

**Beijing Time*

<Technical program>

(2024. 8. 23(Friday))

Opening Ceremony

09:00 ~ 09:10: Welcome address (CSM President)

Welcome address (KIM President)

Session Title: New materials (Steel) for Lightweight and hot stamping(S1)

Time: 09:10-10:50, Augu.23, Room #: TBD

Session Chair: Hongzhou Lu, CITIC Metal Co., Ltd

09:10-09:30 CSM4. Development and key points of integrated hot forming steel, Ning Tan (Baosteel)

09:30-09:50 KIM2. Investigation of hydrogen-induced fracture behavior and its relation to microstructure evolution in plastically deformed advanced high-strength steel, Hyejin Kim (Hyundai Steel)

09:50-10:10 CSM6. The effect of Nb on the hydrogen embrittlement resistance of 2000MPa press hardened steel, Yan Zhao (Beijing Institute of Technology CIC)

10:30-10:50 KIM5. Fabrication, Microstructure and Mechanical Properties of High Carbon Tool Steels Manufactured by Direct Energy Deposition, Kee-Ahn Lee (Inha University)

10:30-10:50 Coffee Break

Session Title: New materials (Al) for Lightweight and New energy (S2)

Time: 10:50-11:50, Augu.23, Room #: TBD

Session Chair: Hyoung-wook Kim, Korea Institute of Materials Science

10:50-11:10 CSM3. Development and Application of New High-Strength and High-ductility Non-Heat-Treated Al-Mg-Si HPDC Alloy, Liming Peng(Shanghai Jiao Tong University)

11:10-11:30 KIM3. Evolution of Crystallographic Texture in AA6xxx Alloy Subjected to Cryogenic-Temperature Friction Stir Processing: An Experimental and Simulation Study, Shi-Hoon Choi (Sunchon National University)

11:30-11:50 CSM1. The effect of Nb on Harmful Iron Phase Morphology in Recycling Aluminum Alloy, Hongzhou Lu (CITIC Metal Co., Ltd)

12:00 ~ 14:00: Lunch Break

Session Title: New materials (Mg &Al) for Lightweight and New energy (S3)

Time: 14:00-15:20, Augu.23, Room #: TBD

Session Chair: Qian Li, Chongqing University

14:00-14:20 **KIM6. High strength Al alloy sheets for hot forming fabricated by twin roll casting and rolling process**, Hyoung-Wook Kim (Korea Institute of Materials Science)

14:20-14:40 **KIM4. Residual stress prediction and machining path optimization with the extruded aluminum extrusion**, Yong-Nam Kwon (Korea Institute of Materials Science)

14:40-15:00 **CSM2. Atomic-resolution HAADF-STEM study of precipitation in Mg–Gd alloy**, Qian Li (Chongqing University)

15:00-15:20 **KIM7. Current Status of R&D Activities and Magnesium Industry in Korea**, Bong-Sun You (Korea Institute of Materials Science)

15:20-15:40 Coffee Break

Session Title: Hot stamping and Lightweight (S4)

Time: 15:40-16:40, Augu.23, Room #: TBD

Session Chair: Kyungseok Oh, POSCO R&D

15:40-16:00 **CSM5. Resistance-spot Weldability of Al-Si Coated Press Hardening Steels with different coating thicknesses**, Hongliang Yi (Easyforming / Northeastern University)

16:00-16:20 **KIM1. Evaluation of material properties for CAE analysis considering phase transformation in the serial production of hot stamping**, Kyungseok Oh (POSCO R&D)

16:20-16:40 **CSM7. A-pillar tube hot pressing technology and application**, Junping Zhang (China Automotive Engineering Research Institute)

Closing Remark

16:40-17:00 Closing remark and take a group photo

* *Above presentation schedule can be changed in final program*

Participants

CSM

CSM1. Hongzhou Lu, CITIC Metal Co., Ltd, The effect of Nb on Harmful Iron Phase Morphology in recycling Aluminum Alloy

CSM2. Qian Li, Chongqing University, Atomic-resolution HAADF-STEM study of precipitation in Mg–Gd alloy

CSM3. Liming Peng, Shanghai Jiao Tong University, Development and Application of New High-Strength and High-ductility Non-Heat-Treated Al-Mg-Si HPDC Alloy

CSM4. Ning Tan, Baosteel, Development and key points of integrated hot forming steel

CSM5. Hongliang Yi, Easyforming Materials Technology Co., Ltd/ Northeastern University, Resistance-spot Weldability of Al-Si Coated Press Hardening Steels with different coating thicknesses

CSM6. Yan Zhao, Beijing Institute of Technology Chongqing Innovation Center, The effect of Nb on the hydrogen embrittlement resistance of 2000MPa press hardened steel

CSM7. Junping Zhang, China Automotive Engineering Research Institute Co., Ltd, A-pillar tube hot pressing technology and application

KIM

KIM1. Kyungseok Oh, POSCO R&D, Evaluation of material properties for CAE analysis considering phase transformation in the serial production of hot stamping

KIM2. Hyejin Kim, Hyundai Steel, Investigation of hydrogen-induced fracture behavior and its relation to microstructure evolution in plastically deformed advanced high-strength steel

KIM3. Shi-Hoon Choi, Sunchon National University, Evolution of Crystallographic Texture in AA6xxx Alloy Subjected to Cryogenic-Temperature Friction Stir Processing: An Experimental and Simulation Study

KIM4. Yong-Nam Kwon, Korea Institute of Materials Science, Residual stress prediction and machining path optimization with the extruded aluminum extrusion

KIM5. Kee-Ahn Lee, Inha University, Fabrication, Microstructure and Mechanical Properties of High Carbon Tool Steels Manufactured by Direct Energy Deposition

KIM6. Hyoung-Wook Kim, Korea Institute of Materials Science, High strength Al alloy sheets for hot forming fabricated by twin roll casting and rolling process

KIM7. Bong-Sun You, Korea Institute of Materials Science, Current Status of R&D Activities and Magnesium Industry in Korea

* *Above presentation titles can be changed in final program*

CSM1

The effect of Nb on Harmful Iron Phase Morphology in recycling Aluminum Alloy

Hongzhou Lu[1], Zhendong Zhang[2], Wei Wang[2], Bin Hu[3], Qian Li[4], Yisheng Chen[5], Aimin Guo[1], Zuo Xu[2], Wenjun Wang[1]

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Abstract

Aluminum alloy has higher carbon emissions than steel, and recycling aluminum alloy can effectively reduce carbon emissions. The Aluminum casting alloy in conditions of recycling causes its iron content to increase. Increasing iron content in alloy enables the β phase (FeSiAl) to raise and the elongation of alloy to reduce seriously. The effect of Nb on harmful Iron β phase morphology in recycling Aluminum alloy is studied in this work, the results shows that the β phase's size is reduced, and β phase transits to block-like from needle like precipitate phase. The role of niobium on reducing the deleterious effect of iron element and improving the mechanical properties of recycling aluminum casting alloy has been studied, and a Nb-bearing recycling aluminum casting component will be tried. The results will be shown in this report.

Keywords: Recycling; Low Carbon Emissions; Aluminum Casting; Iron; Niobium

Curriculum Vitae

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2004. 7: Bachelor, Dept. of Materials Science & Engineering, Jilin University
2007. 3: Master, Dept. of Materials Science & Engineering, Shanghai Jiaotong University
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PROFESSIONAL EXPERIENCE

2007.3– 2011.8: Director, Materials and Process Department, China Automotive Engineering Research Institute
2010.3– 2011.8: VP, Automotive Lightweight Sub-Center, China Automotive Engineering Research Institute
2011.8 – present: Head of AMT/ Sr. Manager Automotive, CITIC Metal Co., Ltd.

RECENT RELATED PUBLICATIONS

1) Lu H, Hou Z, Ma M, et al. Effect of Fe-Content on the Mechanical Properties of Recycled Al Alloys during Hot Compression[J]. Metals, 2017, 7(7):262.
2) Lu H, Zhang J, Tian N, et al. Recycle-Friendly Aluminum Alloy Sheets for Automotive Applications Based on Hemming[J]. Automotive Innovation, 2018:1-6.
3) Lu Hongzhou. Aluminum Alloy Sheets for Automotive Lightweight: Theory and Technics[M]. Beijing Institute of Technology Press. 2020.1, Beijing, ISBN: 9787568280761
4) Xu Zuo, Liu Xiandong, Lu Hongzhou etc., Lightweight Technology of Automotive Wheel[M]. Chemical Industry Press. 2022, ISBN: 978-7-122-41835-7
5) Ma Mingtu; Mei Huasheng; Lu Hongzhou; Yang Hongya; Wu Emei; Zhou Mingbo; Morphology observation for surface orange peel and fracture in tension sample of aluminum-alloy sheet and characterization of nano hardness, Engineering Sciences , Vol.10 No.6, Dec.2012,p2-6

CSM2

Atomic-resolution HAADF-STEM study of precipitation in Mg–Gd alloy

Qian Li[1], Yu Zhang[2], Qun Luo[3], Houwen Chen[2]

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Abstract

The magnesium-gadolinium (Mg–Gd) system provides an ideal model alloy for precipitation hardening. Evolution of precipitates in a Mg–16.2Gd–0.4Zr (wt.%) alloy during isothermal ageing from 150 °C to 300 °C was systemically studied using high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM). The widely accepted four-stage precipitation sequence of the Mg–Gd(–Zr) alloy system has been accordingly updated to: super-saturated solid solution (S.S.S.S.) → ordered solute clusters → GP zones → β′ → β'_F + tail-like hybrid structures → β_1 → β. In addition to carefully revealing an updated precipitation sequence, new insights into the relationships amongst different precipitate phases were obtained and rationalised. (1) Solute clusters and GP zones form during the early stages of ageing and share the same structural unit; (2) Formation of β′ phase is accomplished via ordered stacking of zigzag GP zones along $\langle 10\bar{1}0\rangle_\alpha$; (3) Coarsening of β′ phase promotes the formation of β'_F phase and tail-like hybrid structures; (4) β'_F phase facilitates the nucleation of β_1 phase; and (5) β_1 and β phases maintain a low-energy Σ9 interface and β_1 phase finally transforms to equilibrium β phase *in situ*. Last, the precipitate strengthening effects of different phases are discussed.

Keywords: Magnesium alloy; Precipitation; Phase transformation; HAADF-STEM.

Curriculum Vitae

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EDUCATION

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PROFESSIONAL EXPERIENCE

2006. 6 –2022. 12: Professor/Doctoral advisor, College of Materials Science and Engineering, Shanghai University
2012. 1 – 2013. 6: Distinguished Visiting Scientist, Oak Ridge National Laboratory
2015. 4 – 2021. 6: Vice president, Materials Genome Institute, Shanghai University
2022. 10 – present: Department Head of Energy Storage Materials, College of Materials Science and Engineering, Chongqing University

RECENT RELATED PUBLICATIONS (5 Representative Publications)

1) Lishun Han, Yiming Guo, Fanghua Ning, Xiaoyu Liu, Jin Yi*, Qun Luo, Baihua Qu, Jili Yue, Yangfan Lu, Qian Li*, Lotus effect inspired hydrophobic strategy for stable Zn metal anodes, Advanced Materials, 36 (2024) 2308086.
2) Qun Luo, Xingrui Li, Qian Li*, Lingyang Yuan, Liming Peng*, Fusheng Pan, Wenjiang Ding, Achieving grain refinement of α-Al and Si modification simultaneously by La-B-Sr addition in Al−10Si alloys, Journal of Materials Science & Technology, 135 (2023) 97-110.
3) Yanlin Guo, Bin Liu, Wei Xie, Qun Luo, Qian Li*, Anti-phase boundary energy of *β* series precipitates in Mg-Y-Nd system, Scripta Materialia, 193 (2021) 127-131.
4) Yang Li, Bin Hu, Bin Liu, Anmin Nie, Qinfen Gu, Jianfeng Wang, Qian Li, Insight into Si poisoning on grain refinement of Al-Si/Al-5Ti-B system, Acta Materialia, 187 (2020) 51-65.
5) Qun Luo, Qinfen Gu*, Bin Liu, Tengfei Zhang, Wenqing Liu, Qian Li*, Achieving superior cycling stability by *in situ* forming NdH_2-Mg-Mg_2Ni nanocomposites, Journal of Materials Chemistry A, 6 (2018) 23103-23908

CSM3

Development and Application of New High-Strength and High-ductility Non-Heat-Treated Al-Mg-Si HPDC Alloy

Prof. Liming PENG

School of Materials Science and Engineering, Shanghai Jiao-Tong University

Abstract:

With increasing demands of weight-saving for auto-bodies, Giga-Casting process based Al alloys has been a mainstream technology in new energy automotive industry, however, the non-heat-treated HPDC Al alloys with high-strength and high-ductility are the cornerstone of this new technology. In this report, a new Al-Mg-Si based NHT HPDC alloy was developed on basis of Al-Mg2Si pseudo-binary hypoeutectic system. By means of orthogonal experiment method, compositional effects of Mg, Si, and Ti addition on the microstructures, tensile properties, and fracture behaviors of the high-pressure die-casting Al-xMg-ySi-zTi alloys have been investigated. Meanwhile, modification method and mechanism of Mg2Si eutectic phase formed during solidification procedure are discussed. The tensile mechanical properties are comprehensively influenced by the amount and morphology of eutectic phase (α-Al + Mg2Si), the average grain size, and the content of Mg dissolved into α-Al matrix. The optimized alloy is about Al-7Mg- 3Si-0.01Ti (wt%), which exhibits tensile yield strength of 219 MPa, ultimate tensile strength of 401 MPa, and elongation of 10.5%. Furthermore, contour maps, showing the relationship among compositions, microstructure characteristics, and the tensile properties are constructed, which provide guidelines for developing high strength and toughness Al–Mg–Si–Ti alloys for high-pressure die-casting. Finally, some typic applications of this new alloy were shown in this report.

Curriculum Vitae

Liming PENG (born in 1972) is currently a Distinguished Professor of School of Mater. Sci. & Eng, and the deputy director of National Engineering Research Center for Light Alloy Net Forming (NERC-LAF), Shanghai Jiaotong University. Prior to his arrival to SJTU as a Postdoc in Material Science and Engineering in 2000, he earned his Bachalor Degree in Material Engineering at SJTU (1994) and Ph.D in Ferrous Metallurgy at Shanghai University, China (2000). He become a faculty of SJTU since 2002 until now. His research interests focus on Magnesium-based and Aluminum-based Materials Science and Engineering, where he systemically investigated the microstructure, mechanical properties, strengthening mechanism of Mg-RE based alloy and developed several high-performance Magnesium alloys. He had successfully undertaken more than 30 national projects, published more than 300 publications and were authorized for 40 invention patents.

Dr. Peng was selected into ″National Ten-thousand Talents Plan-Leading Talent″(2018) and has received a number of awards, including a 12th China Excellent Young Scientist Award, a 2017 Defense Industrial Sci. and Tech. Invention Award (First Prize),a 2013 Shanghai Sci. and Tech. Invention Award (First Prize), a 2010 Shanghai Sci. and Tech. Invention Award (First Prize), a 2007 Shanghai Sci. and Tech. Invention Award (First Prize), a 2003 National Sci. and Tech Progress Award (Sec.Prize) etc.

Dr. Peng nowadays takes as the project chief scientist of National Key Research & Development Program of China (2016 and 2021), which are conduct by the tight collaboration of 13 universities, institutes and industrial companies.

Dr. Peng is a member of several scientific societies, including the Diecasting Committee Chairman of World Foundry Organization (WFO), a member of International Materials Research Society, a member of Chinese Materials Research Society, and a member of TMS Magnesium Technology Committee.

CSM4

Development and key points of integrated hot forming steel

Ning Tan [1], Ping Bao [2], Hao Liu [3], Aihui Luo [4], Xinyan Jin[5]

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Abstract

With the rapid development of new energy vehicles, the demand for integrated hot formed parts is increasing. This article introduces the types, technological advantages and disadvantages, and domestic and international development of hot forming steel, including uncoated and coated steel. A detailed description of the characteristics of aluminum silicon coating hot forming materials, the problems in use and patent issue is mainly introduced.

Keywords: hot formed steel; aluminum silicon coating

Curriculum Vitae

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2006.04-2010.05: PhD, Materials Science and Engineering, Shanghai Jiaotong University

PROFESSIONAL EXPERIENCE

2010.06-2012.05: Postdoctor, Shanghai Jiaotong University-Baosteel Postdoctoral Workstation
2012.06-: Baosteel Central Research Institute

RECENT RELATED PUBLICATIONS

1) Tensile-shear fracture behaviour of resistance spot-welded hot stamping sheet steel with Al－Si coating, SCIENCE AND TECHNOLOGY OF WELDING AND JOINING，2020，25（6）

CSM5

Resistance-spot Weldability of Al-Si Coated Press Hardening Steels with different coating thicknesses

Hongliang Yi[1,2], Zhengxian Li[1,2]

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Abstract

The presence of an aluminum-silicon (Al-Si) coating on the surface of press-hardened steels (PHS) significantly impacts the performance of resistance spot welding (RSW). This study undertakes a comparative analysis of the weldability of PHS with varying coating thicknesses. Our findings reveal that the thickness of the coating does not impede the weldability of the steel. Importantly, the distribution of intermetallic compounds (IMC) within the coating structure exerts a direct influence on the welding characteristics of Al-Si-coated PHS. Attaining Al-Si-coated PHS with exceptional weldability necessitates the implementation of specialized processes. Moreover, this paper advances a welding methodology aimed at augmenting RSW for materials that exhibit poor weldability.

Keywords: Al-Si coating; Resistance spot welding; Intermetallic compounds;

Curriculum Vitae

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EDUCATION

Prof. Yi graduated from Harbin Institute of Technology and attained both of his bachelor and master degree in Materials Science. He earned his doctorate in metal material science in 2010 at the Pohang University of Science and Technology, supervised by Sir H.K.D.H. Bhadeshia.

PROFESSIONAL EXPERIENCE

Hongliang Yi is now a professor of material processing engineering in the Northeastern University of China. His main research interests include phase transformation in steels; strengthening and toughening mechanisms in metals; materials design of press-hardening steels (PHS), cold stamping steels and bearing steels; welding metallurgy of sheet steels. In 2017, Prof. Yi and his partners founded Easyforming at Suzhou Industrial Park in China and served as the chairman and chief scientist, aiming at accelerating the technology development of steels and their industrial application. He proposed the concept of δ-TRIP steel with both low density and superior strength and plasticity. He proposed the nanoprecipitation toughening mechanism in martensite, then developed the world's first PHS with tensile strength exceeding 2000MPa and realized industrial application. He discovered that carbon enrichment at the coating/substrate interface is the main factor for deterioration of the bending fracture strain of Al-Si coated PHS, by thinning the coating and micro-decarburization of the substrate surface to inhibit interfacial carbon enrichment, the bending fracture strain of PHS was improved over 30%. The above process has been applied to industrial production of PHS in five steel mills globally, and their PHS products with improved bending fracture strain have been used in more than 500,000 cars.

RECENT RELATED PUBLICATIONS (5 Representative Publications)

[1] D.P. Yang*, T. Wang, Z.T. Miao, P.J. Du, G.D. Wang, H.L. Yi*. Effect of grain size on the intrinsic mechanical stability of austenite in transformation-induced plasticity steels: The competition between martensite transformation and dislocation slip. Journal of Materials Science & Technology, 2023, 162: 38-43.

[2] J.W. Liang, D.P. Yang*, G.D. Wang, H.L. Yi*. Bending deformation behavior of a 1000 MPa grade dual-phase steel with superior bending toughness. Materials Letters, 2024, 354: 135303.

[3] J.C. Pang, W.F. Yang, G.D. Wang, S.J. Zheng, R.D.K. Misra, H.L. Yi*. Divorced eutectoid transformation in high-Al added steels due to heterogenous nucleation of κ-carbide. Scripta Materialia, 2022, 209: 114395.

[4] P. Chen, X.W. Li, P.F. Wang, G.D. Wang, J.Y. Guo, R.D. Liu, H.L. Yi*. Partitioning-related microstructure evolution and mechanical behavior in a δ-quenching and partitioning steel. Journal of Materials Research and Technology, 2022, 17: 1338-1348.

[5] P. Chen, X. Xu, C. Lin, F.M. Yang, J.C. Pang, X.W. Li, H.L. Yi*. Controlling carbide evolution to improve the ductility in high specific Young's modulus steels. Acta Metallurgica Sinica (English Letters), 2022, 35: 1703-1711.

CSM6

The effect of Nb on the hydrogen embrittlement resistance of 2000MPa press hardened steel

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Abstract

The hydrogen embrittlement (HE) problem of 2000MPa press hardened steel (PHS) has always affected its application on automotive, and microalloyed technology can effectively improve the HE resistance of PHS. This study invented a 2000MPa Nb containing PHS with TS > 1900MPa, YS > 1300MPa, and EL > 5%. It does not break for 300 hours in a 0.2mol/L hydrochloric acid aqueous solution with a strain of 0.2, and its HE resistance far exceeds that of existing industrial boards (broken within 5 hours). And a new experimental method for evaluating HE resistance has been invented, which can concentrate the breaking position at the point of maximum pressure, improving the accuracy and efficiency of the experiment. EBSD analysis shows that the grain size of Nb containing PHS is finer and the dislocation density is lower; Through TEM analysis, the size of nanoscale carbide NbC is 10 nm; In addition, the precipitation amount of nanoscale carbides NbC was tested to be 90%, while VC was only 25%, using the " Electrolytic extraction → ICP-AES" method. Therefore, the reason for the excellent HE resistance is that due to the large amount of NbC precipitation, it can not only act as a strong hydrogen trap to capture more hydrogen, but also reduce the supersaturated carbon content, thereby reducing the dislocation density; And by refining the grain size, grain boundaries are proliferated, and the distribution of stress, dislocations, and hydrogen is more uniform. The results will be shown in this report.

Keywords: Hydrogen embrittlement (HE); Nb-Microalloyed technology; NbC; Hydrogen trap

Curriculum Vitae

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EDUCATION

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2017. 12: Postdoc, Dept. of Materials Department, Imperial College London

PROFESSIONAL EXPERIENCE

2014.3– 2016.6: Engineer, Automotive Lightweight Engineering Technology Research Center, China Automotive Engineering Research Institute
2016.6– 2019.12: Deputy Chief Engineer, Automotive Lightweight Engineering Technology Research Center, China Automotive Engineering Research Institute
2020.1– 2020.5: Deputy Minister, Data Product Department, China Automotive Engineering Research Institute
2020.6 – present: Director, Equipment Lightweight Technology Research Institute ,Beijing Institute of Technology Chongqing Innovation Center

RECENT RELATED PUBLICATIONS

1) Lintao Gui, Yan Zhao, et al. Study on the improving effect of Nb-V microalloying on the hydrogen induced delayed fracture property of 22MnB5 press hardened steel. Materials & Design, 2023, 227:1-14.
2) Yan Zhao, He Binyan, et al. Anti-aging treatment of nuclear power plant steel. Materials Science and Engineering A 2018, 735:73-80.
3) Yan Zhao, Mingtu Ma, et al. A fabrication history based strain-fatigue model for prediction of crack initiation in a radial loading wheel. Fatigue & Fracture of Engineering Materials & Structures. 2017, 40(11): 1882-1892
4) Yan Zhao, Dengfu Chen, et al. A three dimensional cellular automata model for dendrite growth with various crystallographic orientations during solidification. Metallurgic al and Materials Transactions B. 2014, 45(2): 719-725.
5) Yan Zhao, Rongshan Qin et al. A three dimensional cellular automata model for dendrite growth in nonequilibrium solidification of binary alloys. Steel Research International. 2015, 86(12):1-8.
6) Yan Zhan, Dengfu Chen et al. Two-dimensional heat transfer model for secondary cooling of continuously casting beam blanks. Ironmaking & Steelmaking. 2014, 41(5):377-386.
7) Yan Zhao, Rongshan Qin, et al. A three dimensional cellular automata coupled with finite element and thermodynamics debase for alloy solidification. Journal of Crystal Growth. 2013, 377: 72-77.
8) Yan Zhao, Mingtu Ma, et al. The comparative study on dynamic flow behaviors of bulletproof steel using various constitutive models. Advanced Materials Research. 2015, 1063:93-99.
9) Yan Zhao, Mingtu Ma, et al. The Development of Data Processing Software for Dynamic Tension of Materials. Advanced Materials Research. 2015, 127-134.
10) Yan Zhao, Dengfu Chen, et al. A cellular automaton model coupled with finite element method for solidification process of beam blank continuous casting. EPD Congress 2015, p41-47, January 1,2016.

CSM7

A-pillar tube hot pressing technology and application

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Abstract

As one of the most important safety structural components for the vehicle body, the A-pillar is mainly made of metallic sheet through stamping and welding. When the sheet replaced by metallic tube and processed by integrated forming, it can efficiently reduce the quality of the parts, achieve lightweight, and reduce blind spots in the field of vision. The traditional tube forming method has the disadvantages of easy cracking, large spring-back, and high cost. Hot pressing technology is a new type of forming technology that uses the internal pressure provided by filling liquid or gas in the mold as an auxiliary forming force. Through die closing and compression, the tube components are formed into the desired shape and strengthened by quenching in the mold. The compression deformation provided by this process can make the wall thickness of the tube component self uniform, which effectively avoiding the problem of wall thickness thinning and cracking in traditional hydro-forming processes. It is used for the manufacture of A-pillar tube component, with high efficiency and good shape accuracy.

Keywords: A-pillar, tube; hot pressing technology; application

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RECENT RELATED PUBLICATIONS

1) J. P. Zhang, L. F. Song, G. Y. Wang, et al. Performance Evaluation of Hot Pressed Front Bumper[C]. Advanced High Strength Steel and Press Hardening, pp. 712-717 (2016)
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KIM1

Evaluation of material properties for CAE analysis considering phase transformation in the serial production

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Abstract

Computer-aided engineering (CAE) analysis on the hot stamping simulation of press-hardening steel (PHS) needs material cards suitable for commercial software. In general, the material cards consist of elastic properties, thermal properties, phase transformation, yield function, plastic flows and failure limits. Microstructure of 1500MPa PHS at an elevated temperature 930˚C is Austenite, and which transforms into other phases such as Ferrite, Pearlite, Bainite and Martensite during subsequent thermal histories. The phase transformation during hot stamping of 1500MPa PHS is evaluated by continuous cooling transformation (CCT) diagram and time-temperature transformation (TTT). The plastic flow curves for hot stamping CAE should be evaluated at elevated temperatures and various strain rates for each consisting phase, i.e. Austenite, Ferrite, Pearlite, Bainite and Martensite for 1500MPa PHS. Thermal cycle for testing the plastic flow curve at an elevated temperature is divided into three stages: The first step is heating a coupon up to 930˚C and soaking for 75sec for full Austenizing, and the next step forms the individual phases, and the final step is straining the coupon until failure under constant temperature condition. In case of 1500MPa PHS, the thermal cycles for Ferrite, Pearlite and Martensite were modeled based on CCT diagram and those for Bainite are done based on TTT diagram. Test temperatures were determined at three levels from the CCT and TTT diagrams: 700~850˚C for Austenite, 600~750˚C for Ferrite/Pearlite, 400~600˚C for Bainite and 30~400˚C for Martensite. Test strain rates were set to three levels determined between 0.001 and 1/s. Plastic flows of Austenite were derived by directly converting engineering stress-strain curves into true plastic data. On the other hands, uniform deformation range of engineering curves for Ferrite, Pearlite and Bainite were not sufficient to apply direct converting them into true plastic data, therefore, an alternative scaling method was utilized to evaluate those of them. The experimentally obtained data set were finally formatted in accordance with the material card files of commercial software.

Keywords: Safety; Hot press forming; Press-hardening steel; Forming; Simulation

Curriculum Vitae

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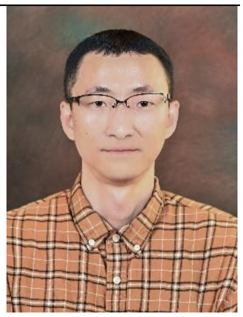

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RECENT RELATED PUBLICATIONS

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KIM2

Investigation of hydrogen-induced fracture behavior and its relation to microstructure evolution in plastically deformed advanced high-strength steel

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Abstract

This study investigates the fracture behavior of plastically deformed quenching and partitioning (Q&P) steel under hydrogen conditions. The experimental results from slow strain rate tensile (SSRT) tests reveal a considerable decrease in elongation with increase of hydrogen traps induced by pre-strains. The effect of prestrain on hydrogen susceptibility is analyzed through fractography and microstructure measurements. The relative reduction of area decreased from 0.389 at 0 % pre-strain to 0.181 at 12 % pre-strain with hydrogen. For hydrogen-free case, fracture surfaces show typical ductile fracture with shallow dimples by micro-void coalescence induced by phase transformation. For hydrogen-charged specimens, the fractography indicates quasicleavage and transgranular fracture at specimen center and brittle-like fracture can be analyzed by the hydrogen-enhanced decohesion. Additionally, the brittle fracture area is enlarged with pre-strain. The mixed fracture between the edge and center of cross-section can be explained using finite element modeling, which calculates the distributions of dislocation density and flux, hydrostatic stress during SSRT at different pre-strains. As an effect of pre-strain in the hydrogen-charged Q&P steel, micro-cracks initiate at transformed martensite with low level of pre-strain, whereas their propagation is blunted at ferrite interface. For specimens with prestrains exceeding 8 %, the cracks initiate predominantly at the martensite, which propagate through deformed ferrite matrix with high dislocations and trapped hydrogens. Our findings shed light on a new metallurgical design for improving the resistance to hydrogen embrittlement in Q&P steel when pre-strain, hydrogen transport, and phase transformation are properly controlled.

Keywords: Hydrogen embrittlement; Quenching and partitioning steel; Pre-strain; Fracture; Plasticity; Finite element modeling

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RECENT RELATED PUBLICATIONS

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KIM3

Evolution of Crystallographic Texture in AA6xxx Alloy Subjected to Cryogenic-Temperature Friction Stir Processing: An Experimental and Simulation Study

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Abstract

In this study, we investigated the crystallographic texture evolution in AA6xxx sheet alloy subjected to friction stir processing (FSP) at both room temperature (RT) and cryogenic temperature (CT). AA6xxx sheet samples underwent FSP with tool rotation speeds ranging from 600 to 1200 RPM and a feed rate of 500 mm/min. Microstructural and microtexture analyses were performed using electron backscatter diffraction (EBSD), scanning electron microscopy (SEM), and high-resolution transmission electron microscopy (HR-TEM) techniques. Initially, the as-received sheet exhibited a coarse grain with a shear-type texture. Following CT-FSP, a homogeneous distribution of grains was observed throughout the stir zone (SZ), thermomechanically affected zone (TMAZ), and intermediate regions between the TMAZ and base metal (BM). In contrast, the RT-FSP sample displayed a heterogeneous grain size distribution. The surface region adjacent to the SZ showed a pronounced Rotated Cube (RCube) component, diminishing in intensity towards the TMAZ and surrounding areas. Notably, texture evolution differed between the retreating side (RS) and advancing side (AS), with Cube and Goss components predominating on the RS and AS, respectively, in CT-FSP. To complement experimental findings, DEFORM™ software was employed to simulate FSP deformation history and assess the temperature's influence on precipitate evolution. Additionally, texture prediction during FSP, incorporating dynamic recrystallization (DRX) in various regions, was analyzed through visco-plastic self-consistent (VPSC) simulations. Advanced image processing, facilitated by an in-house MATLAB™ code, was utilized to analyze precipitate behavior and distribution. Simulation of precipitate dissolution effects on the evolved texture in both RT- and CT-FSP samples was also conducted.

Keywords: Al-alloys, CT-FSP, Crystallographic Texture, Precipitates, DSRX, VPSC.

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RECENT RELATED PUBLICATIONS

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KIM4

RESIDUAL STRESS PREDICTION AND MACHINING PATH OPTIMIZATION WITH THE EXTRUDED ALUMINIUM EXTRUSION

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Abstract

The residual stress in manufacturing of material itself and post-processing to manufacture the aerostructure component has been a crucial issue for the dimensional accuracy of the manufactured aerostructure component. In this research, the application of artificial intelligence has been introduced for the prediction of residual stress and machining path optimization for the 2xxx series aluminium alloy which is used for aerostructure components. The Bulk Residual Stress (BRS) which is induced by quenching after extrusion was predicted by the ANN model with respect to geometry of material and quenching parameters. The Machining-Induced Residual Stress (MIRS) was predicted by the simple regression model with respect to machining parameters. The data set for each residual stress prediction was prepared by using finite element simulation and experimental results where contour and X-Ray Diffraction (XRD) methods were used for the experiment of the residual stress. Both BRS and MIRS were applied into finite element simulation for the distortion prediction of machining without any fracture model to describe element deletion in machining. In the simulation, the BRS was initially mapped into the extruded material with its geometry and quenching condition. Based on the machining parameters such as tool, feed rate, width of cut, and RPM, the MIRS come to be inserted into the integration points of the element which is located machined surface. Then, through the additional simulation time step to satisfy the force equilibrium which is violated by the BRS and MIRS, the machining-induced distortion could be predicted only by the BRS and MIRS whereby it is possible to perform numerically efficient finite element simulation for the prediction of machining-induced distortion. As far as machining path optimization is concerned, since MIRS includes the machining process parameters, XGBoost regression model was adopted because of its feature which combines several decision tree models to give the best prediction and shows excellent prediction for small datasets.

Keywords: Aluminium extrusion, residual stress, tool path, optimization

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1)

KIM5

Fabrication, Microstructure and Mechanical Properties of High Carbon Tool Steels Manufactured by Direct Energy Deposition

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Abstract

Recently, research on tool parts and materials for converting high-strength, lightweight materials into components is actively underway. High carbon tool steels (D2, Caldie etc.) were manufactured by using direct energy deposition (DED) process in this study. Post-heat treatment was applied to the as-built material. The mechanical properties of DED high carbon tool steels were investigated with heat treatment. Samples were fabricated in bulk type with nearly defect free, and columnar dendrite structure was confirmed. Austenite matrix and eutectic structure were observed in the as-built specimen, and martensite matrix and secondary Cr-rich carbide were detected after heat treatment. Ultimate tensile strength was measured to be 1016MPa, and elongation was 2.4% in the case of as-built material (D2). After heat treatment, the maximum tensile strength increased up to 1794MPa and the elongation decreased slightly to 0.8% (D2). The deformation and fracture mechanisms of DED high carbon tool steels were also discussed.

Keywords: High-carbon high-chromium tool steel, Direct energy deposition, Post-heat treatment, Mechanical properties, Microstructure

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RECENT RELATED PUBLICATIONS (5 Representative Publications)

1) Park, G.-W, Song, S.-W., Park, M.-H, Kim, D.-J., Koo, Y.-M., Kim, S.-W., Lee, K.-A., Kim, B.-J., Park, S.-S, Jeon, J.-B., Effect of residual stress on pore formation in multi-materials deposited via directed energy deposition, (2024) Additive Manufacturing, 81, 104016.
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KIM6

High strength Al alloy sheets for hot forming fabricated by twin roll casting and rolling process

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Abstract

Light weighting of vehicles is an important issue to improve energy efficiency. Aluminum alloys have been used for light weight Materials for Car body structure, however, the strength and cost were still consider to accept for the application. Twin roll casting is a cost effective process to make aluminum thin sheets, but it has been applied to manufacture pure aluminum due to many technical issue. Nowadays, several kind of high strength aluminum alloys were fabricated by twin roll casting and rolling process for the purpose of automovile body application. The Al-Mg-(Mn) and Al-Zn-Mg-Cu cast strip showed good workability during hot rolling, so that high strength al alloy sheet with a thickness of 1mm was fabricated successfully by subsequent rolling process without any severe cracks. The annealed Al-(5~7)wt%Mg-(Mn) sheets have high tensile strength and yield strength of about 400 MPa and 180 MPa respectively, and elongation was over 25%. In addition, the sheets with the grain size of below 10um were fabricated by additional rolling and annealing. The tensile strength and elongation of 7075 alloy sheets were 370MPa and 25%, respectively. The yield strength of the sheet increased up to 432MPa after bake hardening treatment. In Several alloy sheets, large elongation over 200% was obtained at relatively high strain rate of 5×10^{-3} s^{-1} at elevated temperature. The high elongation at high temperature were originated from the fully recrystallized and fine grained structure, which grain size was below 10um. Several automobile parts were fabricated successfully by press forming of the alloy sheets at elevated temperature.

Keywords: Al-Zn-Mg-Cu, Twin roll casting, Rolling, Sheet, Hot forming,

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RECENT RELATED PUBLICATIONS

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KIM7

Current Status of R&D Activities and Magnesium Industry in Korea

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Abstract

The efforts are being made to create new markets in areas where magnesium alloys have not been applied until now through the development of new alloys and processes in Korea. We had a notable achievements in fields such as new mobility, IT, and sporting goods through the development of new low density, high formability, and high corrosion resistant alloys. Additionally, in order to evaluate the possibility of a new magnesium smelting plant in Korea, a consortium consisting of several companies began research and development on magnesium smelting-related technologies in new project. In this presentation, we would like to introduce the latest R&D activities and new achievements in the Korean magnesium industry.

Keywords: Magnesium, Light weight, Corrosion resistance, Automobile application

Curriculum Vitae

PERSONAL DATA

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위의 QR 코드를 스캔해서 저를 친구로 추가해 주세요

EDUCATION

Feb. 2001 Ph.D., Materials Science and Engineering, KyungPook National University

Feb. 1991 M.S., Materials Science and Engineering, KyungPook National University

Feb. 1989 B.S., Materials Science and Engineering, KyungPook National University

PROFESSIONAL EXPERIENCE

2022 - Present Editorial Board Member, Journal of Magnesium Alloys (JMA)

1991 - Present Principal Researcher, Korean Institute of Materials Science (KIMS)

2007 - Present Chairman of the Magnesium Division, The Korean Institute of Metals and Materials (KIM)

2010 - 2022 Professor, University of Science & Technology (UST)

2017 - 2008 Visiting Professor, Inje University

1999 Visiting Scientist, MIT (USA)

RECENT RELATED PUBLICATIONS (5 Representative Publications)

- Paper : 150 papers(130>SCI)
- Patent : 14 registered patents on magnesium alloys in foreign countries