WAM 2024

İstanbul GEDİK University

2. International Hybrid Conference and Exhibition

ADVANCES IN WELDING AND METAL ADDITIVE MANUFACTURING TECHNOLOGIES

CONFERENCE PROGRAM AND BOOK OF ABSTRACTS

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21-22 November 2024
Istanbul Marriott Hotel Asia

Conference Chair
Prof. Dr. Mustafa KOÇAK
Vice Chair
Prof. Dr. Savaş DİLİBAL

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WAM2024—ADVANCES IN WELDING AND METAL ADDITIVE MANUFACTURING TECHNOLOGIES

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Editors
Prof. Dr. Mustafa Koçak — Prof. Dr. Savaş Dilibal

Conference Program and Book of Abstracts

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PREFACE

This second International Hybrid Conference on the "Advances in **W**elding and Metal **A**dditive **M**anufacturing Technologies - **WAM**" has been organized to establish an international platform for experts to present and discuss the latest developments in welding and metal additive manufacturing (AM) technologies. This conference primarily aims to bring together leading scientists and engineers specializing in the most current topics within the welding and AM/Wire Arc Additive Manufacturing (WAAM) areas.

It is widely recognized that a deep understanding of arc welding science and technology forms the foundation of the continually evolving metallic AM/WAAM technologies. Hence WAM 2023 and this WAM 2024 conference were designed to cover both areas to keep the interrelationship of both technologies and experts particularly in the metal AM/WAAM topics.

We are pleased to report that this goal has been successfully achieved, and our call were well-responded by the national and international experts and WAM 2024 is able to present recent views and R&D results of the experts from 22 countries.

WAM 2024 Conference is hosting two Keynote Lectures and 38 Invited Speakers in the fields of welding and AM / WAAM Technologies covering lightweight and high strength Materials for the application areas from aerospace, defense to major structural engineering applications.

Needless to mention that all developments are covering recent studies in the fields of robotic technologies, software developments, arc and solid-state welding technologies with innovative material applications.

We, İstanbul Gedik University, with the strong support of the 61 years old Gedik Welding industry, are welcoming all delegates to historical city of İstanbul for the 21-22 November 2024.

We sincerely thank all speakers, both in person and online, for their work and effort for the success of the WAM 2024 Conference.

We extend our heartfelt gratitude to Ms. Hülya Gedik of Gedik Welding and Prof. Dr. Ahmet Kesik, Rector of İstanbul Gedik University, for their invaluable support in organizing this conference. We also sincerely thank conference secretary Dr. Doruk Gürkan and team members, Serhat Yakar, Dr. Ali Koruk, and all advisory board members for their unwavering support and tireless efforts.

21 November 2024, İstanbul, Türkiye

Prof. Dr. Mustafa Koçak, Chair WAM 2024

Prof. Dr. Savaş Dilibal, Vice-Chair WAM 2024

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LIST OF PRESENTATIONS

21 November 2024

Hall A - Opening Session

8.00 – 8.30	Registration
8.30 – 9.00	**Opening Session and Welcome** Hülya Gedik, Chair of the Board of the Trustees, İstanbul Gedik University Prof. Dr. Ahmet Kesik, Rector of İstanbul Gedik University Prof. Dr. Mustafa Koçak, Chair WAM 2023 International Conference
9.00 – 9.30	**Keynote Lecture** **Wire + Arc Additive Manufacture (WAAM) Qualification – The Last Remaining Challenge for Widespread Industrial Applications?** Stewart Williams, Cranfield University, UK (INVITED LECTURE)
9.30 – 10.00	**Solid-State Joining of Additive Manufactured Metals for Lightweight Applications** Sergio Amancio, Graz University of Technology, Austria IIW 2024 Halil Kaya Gedik Award Winner (INVITED LECTURE)
10.00 – 10.30	**COFFEE BREAK and POSTER SESSION**

SESSION A1

Hall A - Advances in AM&WAAM Technologies - I

Chair: Prof. Dr. Mustafa Koçak, İstanbul Gedik University, TÜRKİYE

10.30 – 11.00	**Towards a Digital Twin for Laser Metal Deposition** Peter Mayr and Stephan Hartmann, Technical University of Munich, Germany (INVITED LECTURE)
11.00 – 11.30	**Fitness-for-Purpose Based Acceptance Criteria for Distributed Discontinuities in Metallic AM Components** Pingsha Dong, University of Michigan, USA (INVITED LECTURE)
11.30 – 12.00	**Increasing LPBF Machines Availability By Using Machine Tool Design Principles** Hashan Wijesundara, DMG MORI, Germany
12.00 – 12.30	**Challenges in Welding of Additively Manufactured (WAAM and PBF LB) Aluminum Alloy Components** Rafael Nunes, K. Faes, W. Verlinde, W. D. Waele, M. Lezaack, A. Simar, Belgian Welding Institute, Belgium (INVITED LECTURE)
12.30 – 13.00	**Recent Developments on Aerospace Applications of DED Technologies** Remzi Ecmel Ece, Turkish Aerospace Industries, Türkiye (INVITED LECTURE)
13.00 – 14.00	**LUNCH BREAK and POSTER SESSION**

SESSION A2
Hall A - Design and Applications of AM&WAAM Technologies - I
Chair: Prof. Dr. Savaş Dilibal, İstanbul Gedik University, TÜRKİYE

14.00 – 14.30	**Titanium Titans – The Remarkable World of Aircraft Manufacturing and the WAAM Evolution** Sebastian Recke, GEFERTECH GmbH, Germany (INVITED LECTURE)
14.30 – 15.00	**Mechanical Properties of Wire Plus Arc Additive Manufactured Steel, Stainless Steel and Nickel-Based Superalloys and Potential Challenges in Defect Assessment** Yin Jin Janin, The Welding Institute (TWI), UK (INVITED LECTURE)
15.00 – 15.30	**WAAM of Multi-Material and Functionally Graded Structures and in-Situ Alloy Development Using Multi-Wire Mixing** Jialuo Ding, WAAM3D, UK
15.30 – 16.00	**Effect of Cooling Cycles on Microstructure Formation in Wire Arc Additive Manufacturing** Ozan Can Ozaner, R. Talemi, T. Tjahjowidodo, A. Sharma, Katholieke Universiteit Leuven, Belgium (INVITED LECTURE)
16.00 – 16.30	**COFFEE BREAK and POSTER SESSION**

SESSION A3
Hall A - Design and Applications of AM&WAAM Technologies - II
Chair: Dr. Remzi Ecmel Ece, TAI, Ankara, TÜRKİYE

16.30 – 17.00	**Improving Printability of Large Directed Energy Deposition Components** Alejandro Lázaro, Carretero, F., Olivieri, G. , Escobar, E. , Ramos, A., Robinson,C., MELTIO, Spain (INVITED LECTURE) **(ONLINE)**
17.00 – 17.30	**Keynote Lecture (ONLINE)** **Materials Design and Additive Manufacturing of Metal Matrix Composites** Ju Li, Massachusetts Institute of Technology, USA (INVITED LECTURE)
17.30 – 18.00	**A Multi-Laser Approach for In-Situ Thermo-Mechanical Treatment of Metals and Alloys** Huang Sheng, Massachusetts Institute of Technology, USA (INVITED LECTURE)
18.00 – 18.30	**Design and Applications on SLM-based Additive Manufacturing of Shape Memory Alloys (ONLINE)** Mohammad Elahinia, University of Toledo, USA (INVITED LECTURE)

SESSION B1
Hall B - Advances in Welding Technologies
Chair: Prof. Dr. Güney Güven Yapıcı, Özyeğin University, TÜRKİYE

10.30 – 11.00	**Factors Affecting Arc Stability in Tandem Pulsed GMA Welding Process** Tomoyuki Ueyama, OTC Daihen, Japan (INVITED LECTURE)
11.00 – 11.30	**Innovative Control of Robots for Manual Welding Application** Shahram Sheikhi, Hamburg Technology University, Germany (INVITED LECTURE)
11.30 – 12.00	**Potentials of Handheld Laser Beam Welding** Simon Jahn, IFW Jena, Germany (INVITED LECTURE)
12.00 – 12.30	**Innovative Welding Technologies for Enhancing Liquid Propulsion Systems** Murat Yücel, ROKETSAN, Türkiye (INVITED LECTURE)
12.30 – 13.00	**Tailoring Laser Properties for Efficient Laser-Based Manufacturing** Danijela Rostohar, Coventry University, UK (INVITED LECTURE)
13.00 – 14.00	**LUNCH BREAK and POSTER SESSION**

SESSION B2
HALL B – Testing and Characterization - I
Chair: Assoc. Prof. Ulaş Yaman, METU, TÜRKİYE

14.00 – 14.30	**Fracture Toughness Characterization of Welds by Using Mini-CT Specimens: FRACTESUS Project Findings** Sergio Cicero González, University of Cantabria, Spain (INVITED LECTURE)
14.30 – 15.00	**Severe Plastic Deformation for Post-Processing of Additive-Manufactured Alloys** Güney Güven Yapıcı, Özyeğin University, Türkiye (INVITED LECTURE)
15.00 – 15.30	**Insights into Grain Structure Formation During Friction Stir Welding/Processing of Metals and Alloys** Akbar Heidarzadeh, M. Javidani, Rasoul Khajeh, Azarbaijan Shahid Madani University, Iran (INVITED LECTURE)
15.30 – 16.00	**Sandwich Welding Design: Improving Ballistic Resistance of High Hardness Armor Steels** Ceren Çelik, Uğur Gürol, İstanbul Gedik University, Türkiye
16.00 – 16.30	**COFFEE BREAK and POSTER SESSION**

SESSION B3
HALL B – Testing and Characterization - II
Chair: Dr. Ali İhsan Koruk, BOSAL Energy, Belgium

16.30 – 17.00	**Defense Industry Additive Manufacturing Roadmap** Deniz Demirci, Secretariat of Defense Industries, Advanced Materials and Energy Program Manager, Türkiye (INVITED LECTURE)
17.00 – 17.30	**Recent Advances in the Manufacturing of Magnesium Components Using Directed Energy Deposition Techniques** Gürel Çam, A. Günen, Iskenderun Technical University, Türkiye (INVITED LECTURE)
17.30 – 18.00	**Impact of Volumetric Energy Density on Mechanical Properties of Magnesium Alloy via Selective Laser Melting (ONLINE)** Dhanesh G. Mohan, University of Sunderland, UK (INVITED LECTURE)
18.00 – 18.30	**Advanced In Situ Deformation Monitoring in Wire Arc Additive Manufacturing via Digital Image Correlation (ONLINE)** Amir Kordijazi, A. Lanba, University of Southern Maine, USA Savaş Dilibal, Doruk Gürkan, İstanbul Gedik University

22 November 2024

SESSION A4

Hall A - Advances in AM&WAAM Technologies - II

Chair: Ozan Can Ozaner, KU Leuven, Belgium

8.30 – 9.00	**Impact and Potential of In-Situ Monitoring on the Development of Metal Laser Powder Bed Fusion (L-PBF) Technologies** Aydın Yağmur, EOS GmbH, Additive Mind, Germany (INVITED LECTURE)
9.00 – 9.30	**A New Method to Control Thermal Behavior of WAAM: Active Heating via Infrared Technology (ONLINE)** Oğuzhan Yılmaz, Gazi University, Türkiye (INVITED LECTURE)
9.30 – 10.00	**Utilization of Additive Manufacturing Methods in the Energy and Emission Sectors** Ali İhsan Koruk, BOSAL Energy, Belgium (INVITED LECTURE)
10.00 – 10.30	**Additive Manufacturing and Biomedical Applications** Binnur Sagbas, Yıldız Technical University, Türkiye (INVITED LECTURE)
10.30 – 11.00	**COFFEE BREAK and POSTER SESSION**

SESSION A5

HALL A – Additive Manufacturing Applications - I

Chair: Assoc. Prof. Binnur Sagbas, Yıldız Technical University, Türkiye

11.00 – 11.30	**Purge Gas for Welding of Stainless-Steel Pipes: Must or Luxury** Emel Taban, Kocaeli University, Türkiye (INVITED LECTURE)
11.30 – 12.00	**Additive Manufacturing Designers: A Comparison Between IAMQS Professional Profiles and Relevant ISO Standards** Pedro Catarino, EWF, Portugal (INVITED LECTURE)
12.00 – 12.30	**Overview of Laser Shock Peening Processing for Improvements of Metal Additive Manufactured Part at HiLASE Centre** Sanin Zulic, Hilase Center, Czechia
12.30 – 13.00	**High-Speed Laser-Directed Energy Deposition of Ti/Al Multi-Material Component (ONLINE)** Dongsheng Wu, H. Komen, M. Tanaka, Osaka University, Japan J. Sun, Z. Li, Shanghai Jiao Tong University, China
13.00 – 14.00	**LUNCH BREAK and POSTER SESSION**

SESSION A6
HALL A – Additive Manufacturing Applications-II
Chair: Yin Jin Janin, TWI, UK

14.00 – 14.30	**Understanding the Thermally Induced Martensitic Transformation in Nitinol Manufactured via Electron Beam Powder Bed Fusion** Tymur Sabirov, A. Lanba, University of Maine, USA S. Dilibal, G. Peduk, İstanbul Gedik University Türkiye
14.30 – 15.00	**Material Selection & Development, and Metal Additive Manufacturing Process for AR/MR/VR Products** Ustun Duman, Meta Platforms, California, USA (INVITED LECTURE)
15.00 – 15.30	**Metal Additive Manufacturing and its Unique Corrosion Mechanisms (ONLINE)** Iris De Graeve, Vrije Universiteit Brussel, Belgium (INVITED LECTURE)
15.30 – 16.00	**Determination Of Solid Particle Erosion Wear Behavior of Aircraft Turbine Blades Specific to Additive Manufacturing Orientation Effects** Mehmet Esat Aydın, M. Demirci, M. Bağcı, Konya Technical University, Türkiye
16.00 – 16.30	**COFFEE BREAK and POSTER SESSION**

SESSION A7
HALL A – Additive Manufacturing Software and Applications
Chair: Assoc. Prof. Atilla Savaş, Piri Reis University, Türkiye

16.30 – 17.00	**Digitized Quality Inspection in Welding Production Role and Significance of the Software for the Development of Additive Manufacturing Technology** Zuheir Barsoum, KTH Royal Institute of Technology, Sweden (INVITED LECTURE)
17.00 – 17.30	**The Significant Role of Software Development for the Additive Manufacturing Technology** Jonas Zielinski, Moduleworks GmBh, Germany (INVITED LECTURE)
17.30 – 18.00	**Non-Destructive Evaluation Approaches for Wire Arc Additive Manufacturing** Ulaş Yaman, METU, Türkiye (INVITED LECTURE)
18.00 – 18.30	**Investigating Slag Accumulation in Wire Arc Additive Manufacturing of High Strength Low Alloy Steel** Malan Jayawickrama, Mattias Igestrand, Nicolas Coniglio, Paul Kah University West, Sweden Arts Et Métiers Institute of Technology, France

SESSION B4

HALL B – Properties of Welding and AM Parts - I

Chair: Prof. Dr. Zuheir Barsoum, KTH Sweden

8.30 – 9.00	**Local Approach for Fracture Assessment of Components with Heterogeneity of Mechanical Properties (ONLINE)** Mitsuru Ohata, Osaka University, Japan (INVITED LECTURE)
9.00 – 9.30	**Engineering Assessment Procedure of the Local Thin Areas (LTA) in Welded Pipelines** Fikri Başar Yalçıner, NMDC Group, Abu Dhabi Mustafa Koçak, İstanbul Gedik University, Türkiye
9.30 – 10.00	**Breaking the Boundaries of Additive Manufacturing: Additive Friction Stir Deposition** Evren Yasa, University of Sheffield, UK (INVITED LECTURE)
10.00 – 10.30	**The Influence of Heat Input and Cooling Time on the Residual Stress During Wire Arc Additive Manufacturing** Atilla Savaş, Piri Reis University, Türkiye
10.30 – 11.00	**COFFEE BREAK and POSTER SESSION**

SESSION B5

HALL B – Properties of Welding and AM Parts - II

Chair: Prof. Dr. Gürel Çam, İskenderun University, TÜRKİYE

11.00 – 11.30	**Application of Resistance Spot Welding in Cold-Formed Steel Structures** Viorel Ungureanu, Ioan Both, J. Hulka, A. Popescu, S. Saraolu, A. A. Cristian, Politehnica University Timisoara, Romania
11.30 – 12.00	**Effect of Filler Metals on Strength and Toughness of High Hardness Armor Steel** Recep Murat Kurt, Uğur Gürol, Mustafa Koçak, İstanbul Gedik University, Türkiye and VESUVIUS, Türkiye, M. Tümer, Kocaeli University, Türkiye
12.00 – 12.30	**Potential of Process Gases for the WAAM to Increase Quality and Productivity** Çerkez Kaya, Air Liquide Deutschland GmbH, Germany
12.30 – 13.00	**Advanced Process Modeling and Simulation of Multi-Material Directed Energy Deposition** Emre Osmanoglu and Peter Mayr, Technical University of Munich, Germany
13.00 – 14.00	**LUNCH BREAK and POSTER SESSION**

SESSION B6

HALL B – Additive Manufacturing - I

Chair: Akbar Heidarzadeh, Azarbaijan Shahid Madani University, Iran

14.00 – 14.30	**Design for Material Properties of Additively Manufactured Metals Using Topology Optimization** Can Ayas, Delft University of Technology, The Netherlands (INVITED LECTURE)
14.30 – 15.00	**Development Of Fast-Paced Modular Microsatellite Production By Additive Manufacturing** Sertaç Altınok, Turkish Aerospace Ind. Company, Türkiye (INVITED LECTURE)
15.00 – 15.30	**Enhancing Material Performance: Evaluating Shot Peening and Laser Peening Processes for Industrial Applications** (INVITED LECTURE) (ONLINE) Simge Gençalp, Manisa Celal Bayar University, Türkiye
15.30 – 16.00	**Metallic Additive Manufacturing: Opportunities and Challenges for Passive Microwave Components in Telecommunications and Defense** Bülent Alıcıoğlu, Asartech ARGE Tasarım Mühendislik, Türkiye
16.00 – 16.30	**COFFEE BREAK and POSTER SESSION**

SESSION B7

HALL B – Additive Manufacturing - II

Chair: Dr. Sertaç Altınok, Turkish Aerospace Ind. Company, Türkiye

16.30 – 17.00	**Enhancing Texture in High Entropy Alloys with Nb: In-Situ Synthesis and Microstructural Insights via Laser Powder Bed Fusion** Isaque A. B. Moura, G. G. Ribamar, J. Shen, W. Zhang, T. S. Nunes, F. Zhang, J. P. Oliveira, Universidade NOVA de Lisboa, Portugal
17.00 – 17.30	**Welding and Characterization of P355GH Steel Used in Pressure Vessels** Ismail Oguzhan Ayhan, Hakan Ateş, Gazi University, Ankara, Türkiye
17.30 – 18.00	**A Method for Detecting Bead Geometry of Thin-Wall Structural Aviation Components in Wire Arc Additive Manufacturing (ONLINE)** Rostislav Palivoda, Transport and Telecommunication Institute, Latvia
18.00 – 18.30	**Thermal Modeling of Tungsten Inert Gas Wire Arc Additive Manufacturing of Ti-6Al-4V Alloy** Mustafa Çağrı Özkader, Öncü Akyildiz and Cengiz Baykasoğlu, Hitit University, Ankara, TÜRKİYE

POSTER PRESENTATIONS

Crack Growth Resistance Research on Selective Laser Melting Manufactured Ti-6Al-4V Components: Effects of Post Heat Treatment and Build Orientation
Yun Hu, M. Ling, K. Nikbin, J. Xi, Nanchang University, China

Defect Assessment for Welded Structures using BS 7910 /FITNET and API 579 Procedures: Practical Examples
Fikri Başar Yalçıner and Mustafa Koçak, NMDC Group, Abu Dhabi and İstanbul Gedik University, Türkiye

Development of a 4-Axis CNC Rotary Friction Welding Machine
Sinan Dizge, Dizge Mekatronik, Türkiye

Investigating Topology Optimization and Additive Manufacturing Processes of Engine Bracket
Kazım Özek, BMC POWER Engine and Control Technologies, Türkiye
Binnur Sagbas, Yıldız Technical University, Türkiye

Investigation on the Similar and Dissimilar Weld Joints Between WAAM Parts and Rolled Steel Plate using SG3 Solid Wire
Hüseyin Yavaş, Nur İsmet, Rabia Yağmur Aksoy, Abdullah Baran Aytekin, Serhat Yakar, Mustafa Koçak, İstanbul Gedik University and Gedik Welding, İstanbul,Türkiye

Investigation on the Similar and Dissimilar Weld Joints Between WAAM Parts and Rolled Steel Plate using Elcor M70 Metal Cored Wire
Nur İsmet, Rabia Yağmur Aksoy, Hüseyin Yavaş, Abdullah Baran Aytekin, Serhat Yakar, Mustafa Koçak, İstanbul Gedik University and Gedik Welding, Türkiye

Investigation on the Similar and Dissimilar Weld Joints Between WAAM Parts and Armor Steel Plate using Elcor ER110 Metal Cored Wire
Fatih Kaymak, Ozan Çoban, Uğur Gürol, Mustafa Koçak, İstanbul Gedik University, Türkiye

Investigation on the Similar and Dissimilar Weld Joints Between WAAM Parts and Rolled High Strength Steel Plate using Elcor ER110 Metal Cored Wire
Rabia Yağmur Aksoy, Nur İsmet, Hüseyin Yavaş, Abdullah Baran Aytekin, Serhat Yakar, Mustafa Koçak, İstanbul Gedik University and Gedik Welding, Türkiye

Investigation on the Similar and Dissimilar Weld Joints Between WAAM Parts and Rolled Stainless Steel Plate using SS308 Wire
Abdullah Baran Aytekin, Nur İsmet, Hüseyin Yavaş, Rabia Yağmur Aksoy, Serhat Yakar, Mustafa Koçak, İstanbul Gedik University and Gedik Welding, Türkiye

Mechanical and Microstructural Homogeneity of Printed ER70 S-1 Cylindrical Components Using CMT-Powered WAAM
Yusuf O. Busari, A. J. Farounbi, S. N. M. Ghazali, Y. HP Manurung, Y. L. Shuaib-Babata, K. S. Ajao, M. F. Mat, I. H. Kobe, M. Leitner, University of Ilorin, Nigeria

Microstructural And Mechanical Characterizations of In718 Nickel-Based Superalloy Fabricated via Laser-Based Additive Manufacturing
Hassan Ghorbani, University of Tehran, Iran

POSTER PRESENTATIONS (cont.)

Microstructure, Mechanical properties, and High-Temperature Oxidation Performance of Wire Arc Additively Manufactured Inconel 625 Alloy

Abolfazl Safarzadeh, M. Sharifitabar, M. S. Afarani, S. Khorshahian, University of Sistan and Baluchestan, Iran
N. K. Jain, P. Kumar, Partogaran Sanat Khayyam Welding Research Company, Iran

Welding and Characterization of Armor Steels

Müesser Göçmen, Ceren Çelik, Ozan Çoban, Uğur Gürol, Mustafa Koçak, İstanbul Gedik University, Türkiye

ABSTRACTS

KEYNOTE LECTURE

Wire + Arc Additive Manufacture (WAAM) Qualification – The Last Remaining Challenge for Widespread Industrial Applications?

Prof. Dr. Stewart Williams
Cranfield University, UK

ABSTRACT-1

Since the early 2000's Cranfield University has been researching and developing WAAM technology and applications with a multi-disciplinary approach and a wide range of industry partners and applications. Throughout this time many challenges have been faced to develop and mature the technology to a level that it can used for critical structural engineering applications. Using the example of Ti6Al4V for airframe and space applications the techniques and solutions developed to overcome these challenges will be highlighted. Despite this the widespread adoption of WAAM still remains elusive. The last and perhaps biggest remaining challenge is that of qualification. The current approach is inflexible, slow and costly. A physics-based qualification approach is being developed which would be process, system and part geometry independent, leading to much greater flexibility and reduced cost and time. Progress towards this and the challenges involved will be presented.

Keywords: WAAM; Ti6Al4V; Structural engineering; Physics-based qualification.

BIOGRAPHY

Professor Williams has been researching into material processing for manufacturing applications for more than 30 years. Initially through an SME supplying laser systems, then for nearly 20 years at BAE Systems and for the last 15 years at Cranfield University where he is Director of the Welding and Additive Manufacturing Centre. His main research activities are large-scale wire based direct energy deposition additive manufacture and laser processing. He is director of the WAAMMat industrial collaboration program, which has been maturing WAAM technology for 12 years. He is Technical Director and Co-Founder of WAAM3D, a company set up to commercialize and supply WAAM technology to industry.

Solid-State Joining of Additive Manufactured Metals for Lightweight Applications

Sergio Amancio

Graz University of Technology, Institute of Materials Science, Joining and Forming, Graz 8010, Austria

ABSTRACT-2

The aerospace industry is experiencing a significant and growing demand for lightweight components, and metal additive manufacturing technologies are playing an increasingly important role in meeting this need. These technologies enable the production of lightweight, topology-optimized components. Such components must be incorporated into the wrought alloy airframe structure using either reopenable or permanent joining methods. Refill Friction Stir Spot Welding (RFSSW) is emerging as a promising technique for permanent joining because it is a solid-state process that does not add weight to the welded structure. RFSSW is an effective method for welding various aluminum alloys, including both similar and dissimilar joints commonly used in the aerospace and automotive industries. Therefore, RFSSW is a potential alternative to conventional mechanical fastening methods that have long been the standard in aircraft structural design. This invited lecture will present a comparative analysis of RFSSW single-lap joints versus traditional mechanically fastened joints. The analysis will focus on the microstructure, quasi-static mechanical strength, and fatigue life of similar and dissimilar single-lap joints made from Laser Powder Bed Fusion Printed (L-PBF) AlSi10Mg and rolled AA7075-T6 aluminum alloys. The study will also investigate the fracture and crack propagation mechanisms of these joints, highlighting the key differences between the two joining technologies.

Keywords: Aerospace; Metal additive manufacturing; Lightweight components; RFSSW; Aluminum alloys; Mechanical fastening; Single-lap joints; L-PBF; AA7075-T6.

BIOGRAPHY

Prof. Dr. Sergio T. Amancio-Filho is a full professor for aviation materials and manufacturing techniques at Graz University of Technology - TU Graz (Austria). In addition, Sergio Amancio is an adjunct professor in the Welding Engineering Program at Ohio State University (USA) since 2020. He was also a visiting professor in joining technology and additive manufacturing at Peter the Great St. Petersburg Polytechnic University, (Russia) from 2020 to 2021. Prof. Amancio has been working on the correlation between processing parameters, microstructure and material properties of joining and additive manufacturing techniques. Before joining TU Graz, he was a Helmholtz-Young Investigator Group Leader at Helmholtz-Zentrum Geesthacht (Germany) and Assistant Professor (Juniorprofessor) for Joining Technology at Hamburg University of Technology - TU Hamburg (Germany). Sergio Amancio has been awarded 36 patents, co-authored more than 320 technical publications and co-edited 3 technical books. During his academic career, he has advised and supported the careers of several young professionals, with 80 PhD, MSc and BSc theses completed under his supervision by September 2024. He has received national and international awards, including the 'Georg Sachs Prize 2013' and the 'DGM Prize 2022' of the German Society for Materials Science (DGM), as well as the 'Granjon Prize 2009', the 'Yoshiaki Arata Prize 2023' and the 'Halil Kaya Gedik Prize 2024' of the International Institute of Welding. Since 2009, Prof. Amancio has served as an expert and delegate member of various IIW Commissions and is currently the Chair of IIW Commission XVI - Polymer Joining and Adhesive Technology.

Towards a Digital Twin for Laser Metal Deposition

P. Mayr[1], S. Hartmann[1,2]
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ABSTRACT-3
Additive Manufacturing (AM) enables the production of functional and complex parts in a resource-efficient way, only applying the material to the desired location. Especially Laser-based-Directed Energy Deposition (DED-LB) enables an excellent trade-off between production time and part complexity. However, this metal AM technology is currently lacking in process stability. To overcome this, various industrial and academic efforts are focusing on investigating the application of digital process representations, often referred to as Digital Twins (DT), to improve the stability of DED-LB. This contribution presents a complete framework for a digital twin of the DED-LB process consisting of three major pillars. At first, a modular digitization framework for DED-LB is presented that utilizes an edge-cloud computing methodology to fuse data streams from multiple sensors monitoring the laser-induced melt pool during production. The second pillar incorporates a thermal simulation model to predict the essential melt pool characteristics before the actual printing process. As third, a physics-informed neural network approach is applied to substantially reduce the computational time and efforts of the simulation's melt pool predictions. In summary, the presentation showcases a path towards data-based process control of an industrial-grade laser-based manufacturing system by utilizing digitization, physics -based simulation, and artificial intelligence.

Keywords: Additive Manufacturing; Laser-based Directed Energy Deposition; Digital Twins; Process stability; Modular digitization; Thermal simulation; Physics-informed neural network.

BIOGRAPHY

The research of Prof. Mayr's group focuses on the investigation of structure-process-property relationships for advanced manufacturing of challenging metallic materials and material combinations. Peter Mayr holds a diploma (Dipl.-Ing.) in Mechanical Engineering and a doctorate in Technical Sciences (Dr. techn.) of Graz University of Technology in Austria. He spent one year as a visiting scientist at the Department of Materials Science and Engineering of the Massachusetts Institute of Technology (MIT). In 2011, he was promoted to full professor of Welding Engineering at Chemnitz University of Technology. In September 2019, Prof. Mayr founded the Chair of Materials Engineering of Additive Manufacturing at the Technical University of Munich. His current research focuses on the development of novel feedstock for metal additive manufacturing and the development of structure-process-property relationships for various material systems and additive and welding processes.

Fitness-for-Purpose Based Acceptance Criteria for Distributed Discontinuities in Metallic AM Components

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ABSTRACT-4

Most of the existing manufacturing quality acceptance criteria stipulated in various Codes and Standards or recommended practices are empirical in nature. These workmanship-based criteria have been shown adequate historically for quality control purposes in construction of metallic structures. However, as additive manufacturing (AM) is being rapidly adopted for cost-effectively fabricating critical metallic parts for safety-critical components subjected to fatigue loading, one of the major challenges has been on how to address structural significance of spatially distributed geometric discontinuities. In this talk, some of the recent developments in fracture mechanics based discontinuity acceptance criteria will be first highlighted. Interestingly, there exists a great deal of similarity between AM and welded components as far fatigue behaviors are concerned. Such an important observations will then be substantiated through synthesis of a number of detailed studies on AM parts made of stainless steel, Inconel 718, Ti64, and aluminum alloys through different AM processes and post-AM processing techniques. Finally, the resulting key findings on fitness-for-purpose based discontinuity acceptance criteria will demonstrated on a few selected engineering components, including their NDT-based implementation in practice.

Keywords: Fitness-for-Purpose, Acceptance Criteria, Distributed Discontinuities, Fatigue Loading, Alloys

BIOGRAPHY

Dr. Dong's teaching and research interests include advanced design and analysis methodologies for engineering structures with an emphasis on welded structures and novel computational modeling techniques for manufacturing processes. He has developed numerous unique computational procedures that have been adopted by major manufacturing industries and National/International Codes & Standards. These include the mesh-insensitive structural stress method for fatigue design and life evaluation of welded structures adopted by 2007 ASME Div 2 International Code, the Joint 2007 ASME FFS-1/API 579 RP-1 Fitness for Service Code. Dr. Dong has published about 200 papers in peer-reviewed archive journals and major conference proceedings, giving over two dozens of Plenary/Keynote Lectures at major international conferences.

Design for Material Properties of Additively Manufactured Metals Using Topology Optimization

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ABSTRACT-5

The main advantage of additive manufacturing (AM) technologies is that geometrically complex shapes can be realized, which is not feasible with conventional manufacturing technologies such as milling and casting. Topology Optimization (TO) is often used in conjunction with AM to exploit this form freedom. TO is a computational design tool through which the optimal geometric layout of a part is obtained to enhance part-specific performance. The designs obtained by TO tend to be geometrically complex and thus can often only be realized by AM. Large-scale parts with dimensions of a few meters can be manufactured by Directed Energy Deposition (DED) processes such as Wire and Arc Additive Manufacturing (WAAM) and similar to any metal AM processes, the deposited material is subjected to a series of heating and cooling cycles. The locally occurring temperature extremes and cooling rates determine solid-state phase fractions, material microstructure, texture, and ultimately the local material properties. As the shape of a part determines the local thermal history during AM, this offers an opportunity to influence these material properties through design. In this paper, we present a way to obtain desired properties by controlling the local thermal history. This is achieved through topology optimization of the printed part while considering its entire transient thermal history. As an example of this approach, this work focuses on high strength low alloy steels, where resulting phase fractions significantly influence mechanical properties such as yield strength and ductility. These solid-state phase fractions depend on cooling rates in a particular critical temperature range. The phase composition and hence the local yield strength in target regions can be controlled by constraining the cooling time in this range. Numerical examples illustrate the capability of the proposed approach in adapting part designs to achieve various desired material properties.

Keywords: Additive manufacturing; Topology optimization; Directed Energy Deposition; WAAM; Thermal history; High strength low alloy steels.

BIOGRAPHY

Can Ayas is an Associate Professor at the Delft University of Technology in the Precision and Microsystems department. He has attained a PhD. degree from the Applied Physics Department of the University of Groningen in 2010 and subsequently joined the Eindhoven University of Technology as a post-doc researcher. Successively, he worked at the University of Cambridge as a post-doctoral research associate before joining TU Delft in 2014. His research interest is concentrated on developing computational tools in the field of mechanics of materials and structural design, such as additive manufacturing process, topology optimization for additive manufacturing, plasticity at small scales, hydrogen embrittlement and design of lattice materials.

Challenges in Welding of Additively Manufactured (WAAM and PBF LB) Aluminum Alloy Components

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ABSTRACT-6

Additive manufacturing (AM) technology has been developing steadily in the last few decades to overcome challenges, and operational and financial disadvantages related to conventional manufacturing processes. The Wire Arc Additive Manufacturing (WAAM or DED-Arc) and Laser Powder Bed Fusion (PBF-LB) technologies appear as very promising processes for manufacturing large and highly complex metallic components, respectively. However, even with the several advantages of AM technology, it's not realistic to imagine a final complex product produced entirely without conventional manufacturing processes. In this way, the ability to join conventionally to additively manufactured components or parts represents a crucial step toward the future of both technologies. Although there is an increasing interest in AM technology, there is still a significant lack of information related to the joining between conventionally to additively manufactured components. The current work proposes an assessment of the weldability of AM (in this case, WAAM and PBF-LB) Al alloys by fusion and solid-state welding processes. The work describes in depth the challenges to be overcome, as well as guidelines for the welding community on how to achieve the highest quality possible in the joining of AM Al-alloys.

Keywords: Additive Manufacturing; WAAM; PBF-LB; Conventional manufacturing; Weldability; Al alloys; Fusion welding; Solid-state welding.

BIOGRAPHY

Rafael Nunes holds a Bachelor's degree in Materials Engineering and a Master's degree in Mechanical Engineering from the Federal University of Santa Catarina (UFSC) in Brazil. Currently, he is pursuing a double PhD in Electromechanical Engineering at Ghent University (UGent) and in Engineering Sciences and Technology at Université Catholique de Louvain (UCLouvain) in Belgium, both focused on Wire Arc Additive Manufacturing (WAAM) and weldability of WAAM and PBF-LB additively manufactured components. As a Project Engineer at the Belgium Welding Institute, Rafael Nunes is the responsible for the R&D activities related to WAAM and brings over 12 years of experience in welding processes, metallurgy, physics, and automation. With a strong passion for arc, solid-state, and laser welding technologies, he has led numerous projects in collaboration with international companies and research institutes, focusing on the development and evaluation of joining, coating, and additive manufacturing processes.

Recent Developments on Aerospace Applications of DED Technologies

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ABSTRACT-7

The importance of Additive Manufacturing technology has gradually increased for the aerospace industry in the last decades. The specific applications for each of the sub-branches of this technology have been developed and continue to grow. The development of these technologies, especially in the aerospace sector, where international regulations and rules are strict, has led to developments that will have a multiplier effect in other sectors. These improvements include development of materials, machines and processes. From this perspective, DED technology is among the promising technologies. Many application examples have been developed because it is a fast and effective technology that allows the use of different materials. Since DED Additive Manufacturing technology is based on welding technology well known by the industry, many subsystems can be easily adapted. With the support of developments in machine technologies (robotic applications, automation technologies, etc.), high value-added products can be produced. In aircraft technologies, technology is widely used in direct Near Net shape aircraft parts and mold production.

Keywords: Additive Manufacturing; Aerospace; DED technology; Materials; Machine technologies; Robotic applications; Near Net shape; Mold production.

BIOGRAPHY

Remzi Ecmel ECE was graduated as Mechanical Engineer in 2008 from the engineering faculty of Niğde Ömer Halisdemir University. He started working as a research engineer in the Turkish Aerospace between 2008 and 2010 within the scope of a project. Between 2010-2017, He worked as a Tool Design Engineer at Turkish Aerospace. His Master thesis which is about hot forming of sheet metal titanium aircraft parts was awarded the "Most Successful Thesis and Foundation" in the “4th Akın Çakmakçı University-Industry Cooperation Awards” in 2012. He also worked as chief R&D engineer between 2017-2022. His PhD study was about " Effects of Post Processes on Additively Manufactured AlSi10Mg Parts" completed at Gazi University Mechanical Engineering Department. He has several funded international/national projects. Within the scope of those projects, he published articles in national and international conferences and journals (30+) related on his expertise especially, additive manufacturing, metal forming and forming analysis/testing methods of aerospace materials. He has 12 patented and awarded mechanical designs. Currently he dedicated himself to improve the company’s additive manufacturing capabilities and works as the Manager at Additive Manufacturing Division at Turkish Aerospace Ind. Company.

Design and Applications on SLM-Based Additive Manufacturing of Shape Memory Alloys

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ABSTRACT-8

This presentation explores the recent advancements in additive manufacturing of NiTi, a shape memory alloy with unique properties. Laser powder bed fusion (LPBF) has been the primary focus, with research optimizing process parameters like laser power and scanning speed to achieve dense parts with desired microstructures and mechanical behavior. The influence of build orientation and scanning strategy on texture and residual stress is also discussed. Additionally, emerging techniques such as direct energy deposition and binder jetting offer alternative approaches to NiTi fabrication, with ongoing research focusing on parameter optimization and post-processing to achieve high-quality parts.

Keywords: Additive manufacturing; NiTi; Shape memory alloy; Laser powder bed fusion; Process parameters; Build orientation; Direct energy deposition; Binder jetting.

BIOGRAPHY

Dr. Elahinia is a University Distinguished Professor of Engineering and Interim Dean of Chair Engineering at The University of Toledo. He obtained his doctorate in Mechanical Engineering from Virginia Polytechnic Institute and State University in August 2004. Following his graduation, he joined the faculty of the Mechanical, Industrial, and Manufacturing Engineering (MIME) Department, where he currently served as the department head and director of the Institute for Applied Engineering Research from 2018-2024.

Over the course of his career, Dr. Elahinia has made significant contributions to the field of advanced manufacturing, with a focus on the modeling, control, and design of smart and active materials. His research particularly emphasizes additive manufacturing of functional materials, such as shape memory alloys, for aerospace and biomedical applications. Dr. Elahinia has successfully secured over $26 million in external grants and has served as the advisor for over 100 graduate students, postdocs, and visiting scholars, twelve of whom have gone on to become professors at other universities.

His research findings have been widely disseminated through his numerous publications, which have been cited more than 12,000 times. In addition to his research achievements, Dr. Elahinia has been actively involved in professional societies. In 2004, he was elected as a member of the ASME/SPIE Adaptive Structures and Material Systems Branch under the Aerospace Division. He has held several elected positions within the branch, including the chair. The branch boasts a membership of over 1500 professionals. Dr. Elahinia is a Fellow of ASME and a Fellow of SPIE and serves as an associate editor for esteemed journals in his research area, including Intelligent Material Systems and Structures, as well as the Journal of Shock and Vibration.

Mechanical Properties Of Wire Plus Arc Additive Manufactured Steel, Stainless Steel and Nickel-Based Superalloys and Potential Challenges in Defect Assessment

Yin Jin Janin
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ABSTRACT-9

Different approaches to build methodology and their effects on the mechanical properties including yield and tensile strength, impact, fracture toughness, and anisotropy were examined and interactions and co-relations identified. The technology has been demonstrated to be capable of producing structures with acceptable properties, but they remained direction-dependent (i.e. anisotropic). The potential challenges associated with defect assessment of AM materials were discussed with considerations given to the guidance described in handbook procedures eg BS 7910.

Keywords: Methodology; Mechanical properties; Yield strength; Tensile strength; Impact; Fracture toughness; Anisotropy; Defect assessment; AM materials; BS 7910.

BIOGRAPHY

Yin Jin Janin is a highly experienced structural integrity engineer with a thorough knowledge of ECA and experience in fracture toughness testing. Employed by TWI since July 2012, her job scope spans across testing, defect assessment, technical peer review as well as design-by-analysis. She has an active track record in fracture testing and engineering consultancy. She is currently leading structural integrity assessment activities at TWI. Since 2016, she has been actively involved in the revision of British defect assessment procedure BS 7910. She is a member of the main committee and various working groups of BS 7910. Along with the chair of UK Fracture Toughness Testing Committee, she represents UK BSI on ISO committees. Yin Jin is also the UK delegate for IIW Commission X and theme lead for Codes and Standards of FESI.

Titanium Titans – The Remarkable World of Aircraft Manufacturing and the WAAM Evolution

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ABSTRACT-10

Titanium is one of the metals that makes the aerospace industry soar—strong, lightweight, and resistant to corrosion. But here's the catch: the traditional process of turning titanium into essential aircraft parts is anything but efficient. In fact, it's downright wasteful, with up to 95% of the material ending up as scrap. Add to that the enormous energy consumption and high costs, and you're left with a manufacturing process that seems stuck in the past. So, what's the answer? Could Wire Arc Additive Manufacturing (WAAM) be the game-changer we've been waiting for? In this session, we'll explore how WAAM is poised to evolutionize drastically the production of titanium parts. We'll dive into real-world examples and discuss why the big aircraft manufacturer are rethinking currently how to produce titanium components. Curious about how this could impact your business or your research efforts? Come find out why WAAM might just be one important piece for the future of aerospace manufacturing.

Keywords: Titanium; Aerospace; WAAM; Manufacturing efficiency; Scrap reduction; Energy consumption; Cost; Aircraft parts.

BIOGRAPHY

Sebastian is a Production Engineer with a passion for turning big ideas into tangible results through Wire Arc Additive Manufacturing (WAAM). With a Diplom-Ingenieur from the University of Bremen, Sebastian has spent years honing his skills in 3D printing, from early projects in Stereolithography to advancing LBPF technology for dental restorations at Begomedical. Since 2018 uptil now, at Gefertec, Sebastian is at the forefront of WAAM technology, helping businesses unlock new possibilities in manufacturing. As a Senior Key Account Manager and Authorized Representative, he combines deep technical expertise with a knack for making this promising technology accessible and actionable.

Sebastian knows that WAAM isn't just another 3D-printing tool—it's a game changer for modern manufacturing of big metal parts.

Effect of Cooling Cycles on Microstructure Formation in Wire and Arc Additive Manufacturing

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ABSTRACT-11

Wire and Arc Additive Manufacturing (WAAM) is distinguished by its high production rate capacity and flexibility. However, it is important to note that, due to its working principle, deposition results in anisotropic microstructure distribution throughout the workpiece. This phenomenon is often undesirable in many industries where the as-built use of additive parts is required or where heat treatment operations are not feasible. Therefore, an in-depth investigation of the factors that cause anisotropy is warranted. The study focused on the influence of workpiece location and cooling cycles on microstructural formation. Hardness measurements were evaluated to relate its distribution along the building direction and cooling cycles. The analysis aimed to elucidate the interaction between cooling cycles and ferrite formations near the substrate, in the middle of the part, and at the top, and related this to hardness distribution. In conclusion, this study offers insights into the intricate dynamics of WAAM and highlights the crucial role of cooling cycles in microstructural formation.

Keywords: WAAM; Anisotropy; Microstructure; Cooling cycles; Hardness distribution; Ferrite formations.

BIOGRAPHY

Ozan Can Ozaner graduated from TOBB University of Economics and Technology (TOBB ETU, Türkiye) with a degree in Mechanical Engineering. After graduation, he began his career as a mechanical engineer at TUSAS Engine Industries, Inc. (TEI, Türkiye). Over five years at TEI, he specialized in the machinability and assessment of structural and surface integrity of additively manufactured aerospace components. Ozaner completed his master's thesis at Gazi University, graduating as the top student in his department. In 2022, he completed his career at TEI as a lead mechanical design engineer. He continued collaborating on various research projects with the Fraunhofer Institute for Machine Tools and Forming Technology while working as a researcher at Chemnitz University of Technology (Germany). In the same year, he joined KU Leuven as a research associate; he specialized in the production methodology and machinability of bimetallic components produced by Directed Energy Deposition (DED) systems. He has been involved in significant projects related to Wire Arc Additive Manufacturing (WAAM) process optimization and the mechanical properties of components. Ozaner also embarked on a PhD program at the same institute in 2023. His doctoral research focuses on structural and surface integrity assessment of multi-material components produced via WAAM. With an extensive portfolio of publications and contributions to various projects, Ozaner is currently actively involved in the "Sustainable Materials Processing and Recycling" and "Structural Composites and Alloys, Integrity and Nondestructive Testing" departments at KU Leuven.

Improving Printability of Large Directed Energy Deposition Components

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ABSTRACT-12

Directed energy deposition (DED), an additive manufacturing (AM) technology, is known for its varied usages that enable manufacturing and the repair of metal components using powder or wire material. While other technologies, such as powder bed fusion, limit the size of the printing components to the machine build envelopes, AM-DED with wire as feedstock material offer larger build envelopes, high deposition rates, greater cost benefits, and increased manufacturing freedom due to the multiple deposition axes. AM-DED is used today across multiple industries, including mass manufacturing, maintenance, and industrial applications. But despite these advantages, distortions and residual stresses can potentially be observed in printed components if the energy applied per unit of material is not meticulously designed through different manufacturing parameters. Especially when manufacturing large metal components that can take days or weeks to complete, it is essential to control the process before manufacturing to predict and avoid manufacturing defects. In this presentation, we delve into Meltio's advanced AM-DED Wire technologies and their integration with Ansys simulation tools to predict and mitigate deformations in a titanium roll hoop Formula 1 component. The study combines simulation predictions with optic and scanning electron metallography to evaluate the microstructural effects of different manufacturing parameters. Through this case study, we highlight the importance of optimizing parameters in DED processes for achieving desired outcomes and maintaining component integrity. The findings and insights gained from this research contribute to advancing the understanding and application of AM-DED technology in industrial settings, particularly in the motor racing industry.

Keywords: Additive manufacturing, Directed Energy Deposition, Overheating, Warping, FE simulation, Metallography, Formula 1, Motor racing.

BIOGRAPHY

Alejandro is the Manager of the Materials department at Meltio, responsible for printing process, materials characterization, and troubleshooting in manufacturing. He holds a strong academic background in materials engineering, having studied at both the Polytechnic University of Madrid and Beihang University in Beijing.

KEYNOTE LECTURE

Materials Design and Additive Manufacturing of Metal Matrix Composites

Prof. Dr. Ju Li
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ABSTRACT-13

We explore the design principles behind additive manufacturing of metallic matrix composites (MMC) [Additive Manufacturing 67 (2023) 103478; Composites Part B 268 (2024) 111052], which presents a simple and effective method for strengthening high-temperature materials by ceramic nano dispersions that could be used in the increasingly harsh environments in energy and propulsion applications. In particular, I will take structural materials for fusion energy application as an example [Acta Materialia 266 (2024) 119654; Adv. Sci. 9 (2022) 2203555]. We also illustrate progress in autonomous experiments assisted by large language models ["Machine learning in nuclear materials research," Current Opinion in Solid State and Materials Science 26 (2022) 100975; CRESt – Copilot for Real-world Experimental Scientist, chemrxiv-2023-tnz1x].

Keywords: Additive manufacturing; Metallic matrix composites; Ceramic nanodispersions; Fusion energy; Machine learning.

BIOGRAPHY

Ju Li has held faculty positions at the Ohio State University, the University of Pennsylvania, and is presently a chaired professor at MIT. His group (http://Li.mit.edu) investigates the mechanical, belectrochemical and transport behaviors of materials as well as novel means of energy storage and conversion. Ju is a recipient of the 2005 Presidential Early Career Award for Scientists and Engineers, the 2006 Materials Research Society Outstanding Young Investigator Award, and the TR35 award from Technological Review. He was elected Fellow of the American Physical Society in 2014, a Fellow of the Materials Research Society in 2017 and a Fellow of AAAS in 2020. Li is the chief organizer of MIT A+B Applied Energy Symposia that aim to develop solutions to global climate change challenges with “A-Action before 2040” and “B-Beyond 2040” technologies.

A Multi-Laser Approach for In-Situ Thermo - Mechanical Treatment of Metals and Alloys

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ABSTRACT-14

Laser Powder Bed Fusion (LPBF) has advanced significantly in recent decades, but it remains limited in the variety of microstructures it can produce. To address this limitation, we have implemented a multi-laser system, with each laser inducing different thermo/mechanical effects on the material to achieve spatial microstructure control. This system will be showcased at the conference, where we will also discuss the microstructures achievable through this approach.

Keywords: LPBF; Multi-laser system; Microstructure control; Thermo/mechanical effects; Spatial microstructures.

BIOGRAPHY

Huang obtained his Ph.D. from Nanyang Technological University (Singapore), where his thesis introduced a novel laser scanning strategy to address the porosity-segregation trade-off commonly associated with in-situ alloying. Throughout his Ph.D. and subsequent postdoctoral research, Huang established several lab testing capabilities, including fracture and fatigue testing, stress corrosion cracking, and X-ray computational tomography. He expanded his research to encompass a wide array of materials, including steels, aluminum alloys, high entropy alloys, and metal matrix composites. He is currently a postdoctoral associate in the Tasan Group within the Department of Materials Science and Engineering at the Massachusetts Institute of Technology, where he is developing a multi-laser setup. His scholarly contributions have been published in journals such as Acta Materialia, Nature Communications, and Progress in Materials Science.

WAAM of Multi-Material and Functionally Graded Structures and In-Situ Alloy Development Using Multi-Wire Mixing

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ABSTRACT-15

The plasma transferred arc (PTA) WAAM process is inherently suitable for making new alloy compositions and producing mixed material or functionally graded structures. This is because multiple wires can easily be incorporated and high-quality feedstock materials are available in a wide range of compositions. In addition, it is a clean process does not suffer from elemental loss and has 100% material utilisation so that precise control of the material addition rate is obtained. In this talk we will demonstrate the capability of the PTA process for producing mixed material structures in Copa and invar, functionally graded structures in pinball and steel and can be used for mixing compositionally variable alloys. A CNC based system for multi-materials was developed for specifically these applications and features precise material input control, a wide range of process monitoring tools and a sealed for environmental control.

Keywords: Plasma transferred arc; WAAM; Alloy compositions; Mixed materials; Functionally graded structures; CNC system; Material control

Factors Affecting Arc Stability in Tandem Pulsed GMA Welding Process

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ABSTRACT-16

In the tandem pulsed gas metal arc welding, the occurrence of arc interruption by the electromagnetic interaction between the two adjacent arcs becomes a problem. In order to clarify this problem, effects of inter-wire distance and Ar-CO_2 gas mixture ratio on an abnormal arc voltage and arc interruption are investigated. The abnormal arc voltage and the arc interruption frequently occur with pulse peak currents are supplied alternately to two wires. In addition, both phenomena occur in trailing arc which is located on molten pool at base current duration remarkably. There is most number of abnormal arc voltage and arc interruption times in trailing when the inter-wire distance is 10 mm because a deflected length of trailing arc by the electromagnetic interaction becomes the longest. Moreover, the CO_2 mixture ratio in shielded gas affects the occurrence of abnormal arc voltage and arc interruption. The abnormal arc voltage and arc interruption do not occur when CO_2 gas mixture ratio is equal to or less than 5%. However, number of abnormal arc voltage and arc interruption time increase rapidly with increasing CO_2 gas mixture ratio when CO_2 gas mixture ratio is over 10%.

Keywords: Tandem pulsed GMAW; Arc interruption; Electromagnetic interaction; Inter-wire distance; Ar-CO_2 ratio; Abnormal voltage; Trailing arc; CO_2 ratio.

BIOGRAPHY

After graduating from Graduate School of Welding Engineering, Osaka University in 1987, Dr. Ueyama jointed DAIHEN Corporation and started his career in the R&D division, engaging in research on arc welding process with digital and inverter control technology. These results have been adopted at various welding field and contribute to the advance of manufacturing in the world. In 2006, he received PhD (Engineering) from Osaka University. Currently, he is a senior executive officer of DAIHEN Corporation, and he is managing group companies as the head of European operations. In addition, Dr. Ueyama is also a visiting professor at the Joining and Welding Research Institute, Osaka University, and serves as an IIW Board Director from 2023.

Innovative Control of Robots for Manual Welding Application

Sharam Sheikhi
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ABSTRACT-17

In the field of welding technology, despite digitalization and automation, many tasks are still carried out manually. The potential for accidents is particularly high when working in confined spaces, such as in boiler making or shipbuilding. For reasons of occupational safety, the welders must be replaced at intervals of two to four hours, depending on the severity of the workload. Therefore, to carry out a welding activity in working environments that are dangerous for people, at least a team with at least two welders is required.

To ensure the quality of work, the required welders must have the same qualifications and manual skills for each shift. In addition, the quality of the work depends on the length of time the welder is employed until he is replaced. As part of the Meritec project, a system was implemented that reduces the workload and risk to staff through the cooperative use of humans and robots and at the same time increases the competitiveness of businesses. The system is a mobile unit developed at HAW-Hamburg as part of a project funded by the IFB Bank Hamburg from April 2019 to December 2021, which makes it possible to produce weld seams remotely via a computer terminal. The unit consists of a number of sensors and computers. These are connected to each other and to an industrial robot via network interfaces. Using various controls, it is possible to remotely control the industrial robot in real time. No computers or programming knowledge from operating staff is required to produce welds with the robot.

Keywords: Welding technology; Digitalization; Automation; Occupational safety; Meritec project; Human -robot collaboration; Mobile welding unit; Industrial robot; Remote control.

BIOGRAPHY

Shahram Sheikhi is a distinguished professor in the field of material sciences and welding at HAW Hamburg, where he has been serving since October 2014. He is also the head of the Joining Laboratories and the Transfer Center FTZ3i at the Institut für Werkstoffkunde und Schweißtechnik. Dr. Sheikhi began his academic journey at BUGH University Wuppertal, where he earned his graduate degree (Dipl.-Ing.) in 1998, focusing on optical stress analysis. He later obtained his doctorate (Dr.-Ing.) from Duisburg-Essen University in 2006, specializing in welding and forming.

Before joining HAW Hamburg, Dr. Sheikhi accumulated extensive industry experience, notably at MAN Diesel und Turbo SE, where he served as the Head of the Technology Department, overseeing key areas such as welding, material testing, quality assurance, and development. His career also includes significant roles at SLV-Duisburg, Steel Institute VDEH, GKSS-Research Centre Geesthacht, and Kosching-Consulting. Throughout his career, Dr. Sheikhi has made substantial contributions to the fields of material science, joining technology, and additive manufacturing.

Potentials of Handheld Laser Beam Welding

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ABSTRACT-18

Since 2023 at the latest, handheld laser beam welding systems have become of interest to many companies. This is mainly due to two factors. Firstly, the costs for such a system have fallen significantly in recent years. Secondly, there is economic pressure in the manufacture of welded products, also due to the shortage of skilled workers. The presentation addresses various aspects of handheld laser beam welding, in particular the current state of the art and the application potentials.
The higher throughput, less straightening work due to the lower heat input, and the use of less experienced personnel has to be mentioned here. However, welders still need to be qualified, also to deal with the dangers of laser radiation. In addition to welding, many systems for handheld laser beam welding also have a cleaning function, as described. The risks to be considered here are considerably greater, since on the one hand, a touchdown or contact control is often omitted and on the other hand, the beam is conditioned for a larger working distance.
Application requirements must be taken into account during the design for handheld laser welding ("zero gap"). This continues during edge preparation. Handheld laser welding is a supplement to welding processes, although arc processes still have their place, for example with small, complex geometries or in terms of accessibility. However, if longer seams, for example 1.5 m long, have to be welded and these are prepared accordingly, then handheld laser welding is currently the norm, especially with regard to welding speed when welding by hand.

Keywords: Handheld laser welding, application, laser safety

BIOGRAPHY

After studying mechanical engineering, Simon finished his PhD. thesis in 2007 (about additive manufacturing by diffusion bonding) and held various positions at Ilmenau University of Technology) as well as Technical University of Berlin. He joined ifw Jena in 2010 and is head of the institute since 2016. Beside others, projects about influence of gases in PBF, arc and laser welding or heat treatment were carried out (e.g. duplex steels, Ti- and Al alloys). Simon is convenor of ISO/TC 261/JWG 10 - Additive manufacturing in aerospace applications as well as for the national DIN Metal-AM committee, member of different steering committees (ISO, DIN, VDI, DVS, etc.) and supports the International Institute of Welding in different commissions, e.g. Brazing and Diffusion Bonding or as German delegate for AM.

.Innovative Welding Technologies for Enhancing Liquid Propulsion Systems

Murat Yücel
Roketsan, Ankara, Türkiye

ABSTRACT-19

In aerospace engineering, the efficiency and reliability of liquid propulsion systems are critical to mission success. This presentation provides an in-depth look at the role of cutting-edge welding technologies in the design and optimization of these systems. We will explore various welding techniques such as MIG, TIG, plasma, and electron beam welding, focusing on their applications in fabricating key components including fuel tanks, pressurization tanks, and feed lines.

The discussion will cover recent advancements and their practical applications, highlighting how these technologies have overcome challenges related to material compatibility, joint strength, and performance under demanding conditions. Additionally, the presentation will address the integration of Wire Arc Additive Manufacturing (WAAM) in producing combustion chambers, pressure tanks and load bearing rods showcasing its impact on improving manufacturing processes.

Attendees will gain:

An understanding of the latest welding and production technologies and their relevance to aerospace propulsion.

Insights into optimizing weld quality and reliability in high-stress applications.

Strategies for addressing common challenges in welding components for liquid propulsion systems.

This presentation aims to equip professionals with the knowledge to leverage advanced welding techniques, enhancing the performance and reliability of liquid propulsion systems.

Keywords: Aerospace engineering; Liquid propulsion; MIG welding; TIG welding; Plasma welding; Electron beam welding; WAAM; Combustion chambers; Fuel tanks.

BIOGRAPHY

My career began at Roketsan A.Ş., where I played a crucial role in developing and implementing complex manufacturing processes. Notable projects include the Turkish National Main Battle Tank Composite Armor Production and the establishment of the Türkiye Ballistic Protection Center. I was also responsible for the welded fabrication of all metal structures, including fuel tanks, tank bodies, pressurization tanks, and fuel and pressure feed lines, within liquid propulsion systems for the Micro Satellite Launch System project. Additionally, I have been involved in Wire Arc Additive Manufacturing (WAAM) production trials for combustion chambers, pressure tanks and load bearing rods, exploring innovative manufacturing techniques to enhance component performance.

Tailoring Laser Properties for Efficient Laser-Based Manufacturing

Danijela Rostohar
Institute for Advance Manufacturing, Coventry University, UK

ABSTRACT-20

The recent development of novel laser systems allows for the adjustment of several parameters, ranging from wavelength and average power to temporal and spatial energy distribution. This session will examine issues related to the reliable and efficient laser welding of dissimilar materials for the battery sector, as well as the additive manufacturing of complicated multi-material assemblies. The ability for controlling mechanical and electrical characteristics of welds using temporal and spatial energy distribution will be demonstrated. Finally, developments on the creation of a novel multi-wavelength additive manufacturing technology will be discussed.

Keywords: Laser welding; Dissimilar materials; Battery sector; Multi-material assemblies; Multi-wavelength additive manufacturing.

BIOGRAPHY

Dr. Danijela Rostohar is an accomplished and results-driven professional with expertise in strategic laser processes development and project leadership. She is an Associate Professor in Laser Processing at the Centre for Manufacturing and Materials at Coventry University. Her research focuses on increasing our understanding of laser-material interactions and optimizing laser processing and joining for industrial applications.

Fracture Toughness Characterization of Welds by Using Mini-CT Specimens: FRACTESUS Project Findings

Sergio Cicero
LADICIM, University of Cantabria, Spain

ABSTRACT-21

This work provides an overview of mini-C(T) specimen technology, which may be used to characterize the fracture behavior of steels by using miniaturized 0.16T (4 mm thick) CT specimens. Thus, mini-C(T) specimens are significantly smaller than conventional fracture specimens and allow testing a large number of specimens with limited material. The approach has been systematically validated in a number of steels, mainly (but not only) nuclear grades in both irradiated and non-irradiated conditions and covering both base materials and welds. On this last case, mini-C(T) approach is of particular importance, as it allows the local fracture toughness of the weld bead to be specifically characterized. The research shown here summarizes the results obtained within the European project FRACTESUS, which lasted from 2020 to 2024, and gathers the main conclusions obtained during these four years of intense research.

Keywords: Mini-C(T) specimens; Fracture behavior; Steels; Nuclear grades; Irradiated conditions; Welds; FRACTESUS project.

BIOGRAPHY

Sergio Cicero is Full Professor of Materials Science and Metallurgical Engineering at the UC. He has published more than 250 documents in journals and conference proceedings, and presented more than 90 works at national and international conferences. He is associate editor of the J. of Mech. Behav. Mater. (De Gruyter) and Alex. Eng. J. (Elsevier), member of the editorial board of Mater. Des. Process. Commun. (Wiley), Int. J. Struct. Integr. (Emerald), Front. Mater. (Frontiers) and Metals (MDPI). Concerning research projects, he has participated as Principal Researcher in a number of initiatives, including 4 international projects undertaken within the European 7th Framework Programme (HIPERCUT) and Horizon2020 (INCEFA-PLUS, INCEFA-SCALE, FRACTESUS). These initiatives have been accompanied by a strong national and international presence, being, among others, Vice-President of the Spanish Society of Structural Integrity (SEIE-GEF) and Vicechair of ASME Spain Section.

Severe Plastic Deformation for PostProcessing of Additive-Manufactured Alloys

Güney Güven Yapıcı
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Center for Additive Manufacturing Alloys (KİMTAL), Özyeğin University, Türkiye

ABSTRACT-22

The constant need for high performance engineering components supports the efforts for expanding the design envelopes through the realization of complex shapes and geometries by additive manufacturing. Although additive manufacturing can accurately provide the topology, mechanical behavior is inherently limited by the material properties and how the material is built. Therefore, improvement of additive manufactured components from a mechanical behavior perspective has several technological implications. Severe plastic deformation (SPD) has long been utilized to achieve extraordinary physical and mechanical properties in a variety of material systems. In this work, cases on the utilization of SPD technologies as post-AM processing tools for mechanical response enhancement is provided by highlighting the recent efforts in various alloys. As such, this study demonstrates the potential of SPD for obtaining unprecedented properties in additive-manufactured alloys, whereby optimum selection of post -AM processing parameters and workpiece geometry are crucial.

Keywords: Additive manufacturing; Complex geometries; Mechanical behavior; Severe plastic deformation (SPD); Post-processing; Alloy enhancement.

BIOGRAPHY

Following graduate studies at Texas A&M University, Prof. Yapıcı held engineering-management positions in various corporations in USA. Following his return to Türkiye, he participated in the establishment of the Mechanical Engineering Department at Özyeğin University, where he holds the Department Head position and directs the Center for Additive Manufacturing Alloys (KİMTAL). His research interests lie in the area of processing-microstructure-property relationships of structural and smart materials through advanced experimental characterizations coupled with computational modeling of the material behavior at micro and nano scale. He has extensive experience in the areas of mechanical behavior, advanced manufacturing and thermo-mechanical processing of novel alloys. He has published in various high impact journals and directed externally funded projects supported by Tübitak, European Research Executive Agency and Science Academy of Türkiye.

Insights into Grain Structure Formation During Friction Stir Welding/Processing of Metals and Alloys

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ABSTRACT-23

There is increasing interest in friction stir welding/processing (FSW/P) of metals and alloys due to its ability to address several challenges associated with conventional fusion welding techniques. These challenges include significant distortions, solidification cracking, macro and micro segregations, dendritic structures, gas and shrinkage porosities, solid inclusions, color changes, the formation of brittle intermetallics in dissimilar materials, a broad heat-affected zone (HAZ), high energy consumption, and environmental pollution. In contrast, FSW/P not only mitigates these issues but also promotes grain refinement through various deformation and restoration mechanisms driven by the combined effects of strain and heat. As a result, there is a strong impetus across multiple industrial sectors to replace traditional fusion processes with FSW/P, given its substantial potential. Understanding the microstructural aspects of FSW/P in metals and alloys is therefore crucial for comprehending the fundamental processes, material behavior, and the resultant properties. This presentation will discuss recent research that has significantly advanced our understanding of microstructural evolution, with a particular focus on grain structure formation during FSW/P.

Keywords: Friction stir welding; Friction stir processing; Microstructure; Grain structure.

BIOGRAPHY

Akbar Heidarzadeh is currently an associate professor at the Faculty of Engineering, Department of Materials Engineering, Azarbaijan Shahid Madani University, Tabriz, Iran. He earned a BSc degree in Materials Science in autumn 2007. He obtained his MSc degree in Advanced Engineering Materials in the autumn of 2010. He received his Ph.D. degree in Materials Science, working on the FSW of copper-based alloys, in Feb. 2016. Akbar's PhD studies resulted in more than 25 papers in the field of microstructural evolution during FSW/FSP. His achievements in the field of FSW and Additive Manufacturing (AM) have been appreciated by the society and he received several awards and research grants. He is currently the author of more than 100 papers (Google Scholar (2024), h -index= 35), 5 book chapters, and more than 35 communications to national and international conferences.

Sandwich Welding Design: Improving Ballistic Resistance of High Hardness Armor Steels

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[3]İstanbul Vesuvius Refrekter A.Ş., FOSECO Foundry Division, Türkiye (Current Affiliation)

ABSTRACT-24

The study aims to investigate the effect of sandwich joint design on the microstructure, mechanical, and ballistic properties of welded high-hardness armor steel plates. The locally produced, 15 mm thick Protection 500 armor steel plates were welded in two different configurations: (1) using 100% austenitic stainless steel welding wire (ASS, GEKA ELOX SG 307), and (2) a sandwich design that used hard-facing welding wire (GEKATEC HARDCOR 600 G) between the soft austenitic stainless layers. The welding process was carried out using robotic gas metal arc welding to provide constant heat input and eliminate human-related error during the welding operations.

The welded joints were evaluated in detail through non-destructive (visual, liquid penetrant, and radiographic), destructive (hardness, tensile, Charpy impact, and ballistic), and metallographic (optical and scanning electron microscopy) testing. The results revealed that the joints welded with 100% austenitic wire demonstrated higher yield strength, tensile strength, and impact energy due to their more homogenized structure. However, ballistic results showed that the projectile fully penetrated the austenitic joint's weld region while only partially deforming the sandwich joint, thereby enhancing ballistic protection in the weld region with the hard-facing welding wire. Furthermore, neither design demonstrated complete penetration in the HAZ region, which is typically considered a weak point in armor steel joints because of softening, indicating the effectiveness of the selected welding method and parameters.

These findings demonstrate that the sandwich welding method, especially when using low heat input in robotic welding, significantly improves ballistic resistance without sacrificing toughness values, offering valuable insights for defense-related applications.

Keywords: Armor Steel, Robotic Gas Metal Arc Welding, Sandwich Joint, Mechanical Properties, Microstructural Characterization, Ballistic Test

Acknowledgments: This study has been supported by the Scientific and Technological Research Council of Türkiye (TUBITAK) with project number 5210029.

Defense Industry Additive Manufacturing Roadmap

Deniz Demirci
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ABSTRACT-25

As the Presidency of Defense Industries, we closely follow additive manufacturing technology, which is rapidly developing and seen as one of the most important groundbreaking technologies of the future. We aim to maximize the benefits provided by this technology, such as agility, production of complex geometries, and mobility, in the qualified production, which is the cornerstone of our defense industry.

From powder bed production methods to directed energy deposition, and from polymers to superalloys, this technology encompasses many aspects that need to be developed and worked on, both in terms of production and materials. We are conducting meetings with all stakeholders in the sector, from universities to SMEs and foundation companies, to assess the current state of this technology in our country, identify areas where we have advanced experience and skills, and determine the gaps we need to work on. We are also preparing the roadmap for this technology.

Following the publication of the Additive Manufacturing Technologies Roadmap in 2020, we plan to update this document next year with the participation of all stakeholders through our activities, aiming to create a guide for all funding organizations and companies operating in our country.

Keywords: Additive manufacturing; Defense industry; Powder bed production; Directed energy deposition; Polymers; Superalloys; Roadmap.

BIOGRAPHY

Deniz DEMİRCİ, Advanced Materials and Energy Projects Manager at the Presidency of Defense Industries, holds a Bachelor's and Master's degree in Civil Engineering from Middle East Technical University (METU), a Master's degree in Business Administration from Ankara University, and a Master's degree in Engineering and Technology Innovation Management from Carnegie Mellon University in the USA. Since 1999, I have been involved in numerous projects at the Presidency of Defense Industries and have represented my organization in national and international working groups. I have been serving in my current position since 2017. In my role, I oversee projects related to metallic, ceramic, and composite materials, as well as additive manufacturing, casting, forging technologies, and innovative materials (nanomaterials, graphene) and hydrogen energy technologies.

Recent Advances in the Manufacturing of Magnesium Components Using Directed Energy Deposition Techniques

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ABSTRACT-26

The rising demand for lightweight materials in industries such as medical, automotive, and aerospace has driven research into Mg-alloys due to their high strength-to-weight ratio. However, their low formability at room temperature, caused by limited slip systems, hinders their widespread use, especially for intricate components. Traditional manufacturing methods increase production costs and cycle times for complex Mg-alloy parts, making it difficult to meet high property specifications. This has spurred significant research into additive manufacturing (AM) of Mg-alloy products.
Additive manufacturing (AM) has revolutionized the production of Mg-alloys parts, though its high chemical reactivity and oxidization rate pose challenges. Despite some manufacturing defects like inhomogeneous microstructure, porosity, and high surface roughness, metal additive manufacturing (MAM) produces Mg alloy parts with superior properties compared to cast parts, though not as strong as wrought parts. This makes MAM a promising technique for Mg alloys. Techniques like selective laser melting (SLM) using powder are particularly difficult due to the high surface energy of Mg powder. Conversely, laser-based directed energy deposition (DED) systems with wire feedstock can produce precise and smooth components if well-controlled. Similarly, electron beam wire-based DED systems benefit from vacuum chambers, yielding strong components with enhanced mechanical properties. However, both systems are costly and therefore they are particularly selected for parts with complex details or requiring precise dimensional tolerances in advanced engineering applications where the production expense is justified, such as in the aerospace industry. In contrast, wire arc directed energy deposition (WA-DED) process, also known as wire arc additive manufacturing (WAAM) method, is cost-effective and environmentally friendly, and offers high production rates and can economically produce large parts (>10 kg) compared to subtractive processes. However, WAAM with layer heights of 1-2 mm typically results in a rougher surface finish, i.e., surface roughness (Ra) around 200 microns. Furthermore, issues such as magnesium's high reactivity and vulnerability to oxidation pose distinct obstacles.
This review examines the progress, challenges, and future prospects of using DED technology for Mg-alloys. It discusses common defects like inhomogeneous microstructures and porosity in DED-manufactured Mg-alloy components, and explores measures to prevent these issues.

Keywords: Additive manufacturing, Direct energy deposition processes, Wire arc additive manufacturing, 3-D printing, Mg alloys

BIOGRAPHY

Gürel Çam is currently a full professor at the Department of Mechanical Engineering of Iskenderun Technical University, İskenderun-Hatay, Türkiye. He earned his Ph.D. degree in Materials Science from the Imperial College of Science, Technology, and Medicine, University of London, U.K., in 1990. He also worked at Helmholtz-Zentrum Geesthacht (Research Center), Institute of Materials Research, Germany for four years between 1994 and 1998. He has authored or co-authored 107 journal articles, 91 proceeding papers (12 of them are keynote presentations - invited lectures), and one international book chapter. His publications have been cited more than 8000 times in Google Scholar, h-index = 47 (5843 citations in Scopus; h-index: 42, and 5293 citations in WOS; h-index: 40). He is the writer of a book entitled 'Science and Technology of Welding' (in Turkish). His research interests include metal additive manufacturing, particularly wire arc additive manufacturing (WAAM), welding technologies including friction stir welding, diffusion bonding, electron beam welding, laser beam welding, and characterization of welded joints. He is a member of AWS (American Welding Society), USA, and DVS (Deutsche Verband für Schweisstechnik), Germany. He is also a member of the General Board, Institute of Turkish Welding Technologies, İstanbul, Türkiye, since January 2009, and MUDEK Programme Evaluator, Türkiye (Mechanical Engineering and Metallurgy-Materials Engineering) since May 2018.

Impact of Volumetric Energy Density on Mechanical Properties of Magnesium Alloy via Selective Laser Melting

Dhanesh G. Mohan
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ABSTRACT-27

The emergence of pores during the Laser Powder Bed Fusion (LPBF) process significantly diminishes mechanical properties, often leading to reduced performance and structural integrity of the fabricated components. Consequently, pore elimination is crucial for ensuring the quality and productivity of manufactured parts. This study aims to assess the influence of key parameters—including laser power (ranging from 200 W to 400 W), layer thickness (20 μm to 50 μm), exposure time (50 μs to 200 μs), hatch distance (0.1 mm to 0.2 mm), and volumetric energy density (VED) (50 J/mm^3 to 100 J/mm^3)—on the microstructure and tensile properties of AlSi10Mg specimens produced by LPBF, both in their as-built state and after solution heat treatment. Volumetric Energy Density (VED) is frequently used to optimize LPBF process parameters, as it provides a comprehensive evaluation of all four primary factors. This article specifically investigates the effect of VED on the microstructural features and tensile characteristics of printed parts. Results indicate that a high VED of 78.13 J/mm^3 reduces porosity and defects, thereby enhancing the tensile properties of the specimens. For instance, the ultimate tensile strength (UTS) and yield strength (YS) improved by approximately 15% and 10%, respectively, compared to specimens with lower VED. For specimens subjected to solution heat treatment, it is recommended to reduce the laser power to 350 W, achieving a VED of 60.76 J/mm^3. This adjustment resulted in specimens with a UTS of 320 MPa and YS of 200 MPa, which are significant improvements over untreated specimens. The study's findings suggest that optimizing LPBF parameters, particularly VED, can lead to substantial improvements in the tensile properties of AlSi10Mg parts, offering new insights for advancing additive manufacturing techniques.

Keywords: Laser Powder Bed Fusion; Pores; Mechanical properties; AlSi10Mg; Volumetric Energy Density; Tensile properties; Process parameters.

BIOGRAPHY

Dr. Dhanesh G. Mohan is a Fellow of the Institute of Materials, Minerals and Mining (FIMMM), a licensed Professional Engineer (P.E.), and a Chartered Engineer (C.Eng.) with over a decade of academic experience. He is a Senior Lecturer in the Faculty of Technology at the University of Sunderland, UK, where he leads research on AI-driven Net-Zero Manufacturing, focusing on novel alloy design, additive manufacturing, and hybrid welding techniques. Dr. Mohan serves as Associate Editor for the Journal of Process Mechanical Engineering (Sage Publishing), the International Journal on Interactive Design and Manufacturing (Springer), and Welding International (Taylor and Francis). He is also an Academic Editor for Advances In Materials Science and Engineering and Advances In Polymer Technology (Wiley) and an editorial board member for the Journal of Adhesion Science and Technology (Taylor and Francis). His research focuses on big-area additive manufacturing and hybrid friction stir welding methods, including laser-assisted FSW, ultrasonic vibration-assisted FSW, and induction-assisted FSW and FSP. Dr. Mohan investigates the mechanical, metallurgical, corrosive, and microstructural properties of dissimilar metals and alloys, such as steels, magnesium alloys, aluminum alloys, and high entropy alloys.

Advanced In-Situ Deformation Monitoring in Wire Arc Additive Manufacturing via Digital Image Correlation

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ABSTRACT-28

As wire arc additive manufacturing (WAAM) continues to evolve as an advanced production method in industry, new tools for in-situ processing monitoring need to be developed. In this study, we developed a digital image correlation (DIC) system to monitor the full-field deformation during the WAAM process. DIC is an optical non-contact technique that provides full-field displacement and strain information, enabling comprehensive analysis of material behavior. The system was applied to the production of a single-wall sample of AISI316L stainless steel using a gas metal arc welding-based robotic WAAM process. We propose conducting DIC on deposited material after each layer of material is deposited. Eventually, the goal is to use these deformation measurements to inform the deposition of the subsequent layer in a fully automated closed-loop process. The results which are received from the case study demonstrate that DIC is a feasible and effective approach for in situ monitoring of full-field deformations in arc-based directed energy deposition processes. Additionally, this capability has the potential to provide in-situ quality assurance in wire arc additive manufacturing process. In the future work, we will focus on integrating DIC with machine learning algorithms to enable predictive analytics and process control for developing WAAM-based industrial components. This integration is expected to enhance the precision, quality, and efficiency of the WAAM process.

Keywords: Additive manufacturing, WAAM, Digital image correlation, Stainless steel

Impact and Potential of In-Situ Monitoring on the Development of Metal Laser Powder Bed Fusion (L-PBF) Technologies

Aydın Yağmur
Additive Minds / EOS, Munich, Germany

ABSTRACT-29

In this session the latest advancements in Laser Powder Bed Fusion (LPBF) technology, with a special focus on In-Situ Monitoring Systems, will be covered. LPBF has revolutionized the manufacturing industry, offering unparalleled precision and efficiency in producing complex geometries. However, ensuring quality and consistency in the additive manufacturing process remains a challenge. In-Situ Monitoring Systems have emerged as a crucial tool for real-time monitoring and control, offering a deeper understanding of the process dynamics and enabling instant feedback-control for process regulation. The principles behind In-Situ Monitoring Systems, their application on EOS L-PBF systems, and their impact on enhancing process stability, part quality, and overall productivity is discussed. From optical tomography to melt pool monitoring, we will uncover the diverse array of sensing techniques employed in these systems and their role in mitigating defects and ensuring part integrity and economic feasibility.

Keywords: LPBF; In-Situ Monitoring; EOS systems; Process stability; Melt pool monitoring; Optical tomography; Defect mitigation.

BIOGRAPHY

Aydın's passion is exploring the mechanisms of laser-material interaction, inspired by his B.Sc. studies in metallurgical engineering at METU in Ankara and his M.Sc. in materials science at the University of Stuttgart. Following a previous six-year career specializing in conventional manufacturing processes and materials, he joined the Additive Minds team in September 2017, where he supports customers in various questions, such as evaluating the machine capability of EOS metal machines and implementing EOSTATE monitoring solutions. He conducts customer-specified projects that enable him to utilize his expertise to understand the effects of DMLS process parameters on part properties. This helps him to develop optimum solutions of an appropriate quality and cost for industrial AM.

A New Method to Control Thermal Behavior of WAAM: Active Heating via Infrared Technology

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ABSTRACT-30

Control of residual stresses and distortions in parts produced using Wire Arc Additive Manufacturing (WAAM) method is one of the main concerns in the part production. Due to high heat input during the melting process in WAAM, the parts are subjected to thermal shocks, which can lead to various issues such as distortions, residual stresses, surface morphology defects, and irregular macro and microstructures. This research proposes and applies the use of external heaters in WAAM production as an innovative approach aimed at improving the quality of the produced parts by controlling thermal behavior more effectively. In this context, experimental studies were conducted to evaluate the effects of external heaters on part quality. Sample geometries were fabricated using ER70S-6 welding wire, and conventional WAAM and externally heated WAAM methods were compared. In parallel, numerical simulations were performed to provide reference data for the experimental studies. The results showed that the parts produced with externally heated WAAM exhibited more regular geometries, refined internal structures, and more stable mechanical properties. Optical and SEM images revealed that the externally heated WAAM method reduced the formation of acicular and polygonal ferrite structures and inhibited bainite formation. Additionally, a decrease in defects such as pores, lack of fusion, and interlayer discontinuities was observed. In the conventional WAAM process, the variation in microhardness was around 30%, while this variation decreased to 12% in the externally heated WAAM process. The results indicate that the use of external heaters enhances microstructural homogeneity, resulting in a more consistent hardness distribution within the material. Furthermore, the samples produced with external heaters exhibited approximately 17% higher tensile strength compared to standard WAAM samples. The use of external heaters also resulted in a significant reduction in residual stress measurements, and the alignment of the produced parts with CAD data improved by an average of 20%. These findings highlight the effectiveness of external heaters in controlling thermal behavior in WAAM processes, thereby improving material quality and mechanical performance.

Key Words: Additive manufacturing, wire arc additive manufacturing, residual stress, distortion

BIOGRAPHY

Prof. Oguzhan Yılmaz received his Ph.D. Degree in 2006 from the School of Mechanical, Materials and Manufacturing Engineering and Operation Management of The University of Nottingham, UK. He involved many Rolls-Royce plc and EPSRC funded research projects as a post graduate researcher and post-doc researcher in Nottingham University Rolls-Royce University Technology Centre (UTC). He also supervised national funded academic and industrial research projects in Türkiye and EU. He is the head of Advanced Manufacturing Technologies Research Group (AMTRG) in Gazi University Mechanical Engineering Department. His research interests are additive manufacturing, WAAM, advanced manufacturing processes and repair technologies.

Prof. Yilmaz is currently having different roles as,

- CEO of MetalWorm Additive Manufacturing Technologies Inc.
- President of Turkish Additive Manufacturing Association (TAMA)
- Organizing Committee member of International Additive Manufacturing Conference AMC 2019, 2021, 2022, 2024
- Editor-in-Chief of The journal of the faculty of engineering and architecture of Gazi University (SCI-E indexed).

Utilization of Additive Manufacturing Methods in the Energy and Emission Sectors

Ali İhsan Koruk
BOSAL Energy, Belgium

ABSTRACT-31

The design and manufacturing of exhaust systems and energy components, such as heat exchangers, require the use of multiple materials, which presents several challenges. This presentation will showcase different additive manufacturing techniques applied to specific examples of exhaust components and high-temperature-resistant stainless steel heat exchangers.

Keywords: Additive manufacturing; Exhaust systems; Heat exchangers; High-temperature stainless steel.

BIOGRAPHY

Dr. Ali Ihsan Koruk is an expert in materials science, specializing in welding, stainless steels, superalloys, and various metallurgical processes. His research interests include the microstructure and mechanical behavior of materials, thermodynamics, composite materials, laser welding, and additive manufacturing. Dr. Koruk has collaborated with academic and research institutions internationally. He is currently a process development engineer at Bosal Emission Control Systems in Belgium, focusing on welding and joining exhaust systems, high-temperature heat exchangers, towbars, air tanks, and fuel tank components.

Additive Manufacturing and Biomedical Applications

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ABSTRACT-32

Additive manufacturing, or 3D printing, is transforming the biomedical field with its ability to create highly customized, complex structures tailored to individual patient needs in various biomedical applications such as orthopedics, dental, tissue engineering, artificial organs etc. In orthopedics it enables the production of patient-specific implants and prosthetics, such as hip and knee replacements, which offer better fit and functionality compared to traditional methods. In the dental industry, 3D printing is used to fabricate precise dental implants, crowns, and bridges, enhancing both the accuracy and efficiency of dental procedures. Tissue engineering has also greatly benefited from additive manufacturing, as it allows for the creation of scaffolds that mimic the extracellular matrix, supporting cell growth and tissue regeneration. This technology can print with biocompatible materials and living cells, opening the door to innovations like the creation of skin, cartilage, and even more complex organs for transplantation. Different additive manufacturing (AM) methods are utilized in various biomedical applications, each chosen for its specific capabilities and material compatibilities. Stereolithography (SLA), which uses a laser to cure liquid resin into solid structures, is popular in dental applications for creating highly detailed crowns, bridges, and surgical guides due to its high resolution and accuracy. Laser Powder Bed Fusion (LPBF), which fuse powdered materials with a laser, are often used in orthopedic applications to produce strong, durable implants such as titanium bone plates and joint replacements. These methods are ideal for creating porous structures that mimic natural bone, facilitating better integration with the body. Fused Deposition Modelling (FDM), which extrudes thermoplastic filaments layer by layer, is commonly employed in producing customized prosthetics and anatomical models due to its cost-effectiveness and the availability of biocompatible materials. Direct Ink Writing (DIW) and Bioprinting are used in tissue engineering and living cell applications, where cells and biomaterials are precisely deposited to create scaffolds that support tissue growth or even direct printing of tissue constructs, such as skin grafts or cartilage. These methods are crucial for advancing regenerative medicine and developing personalized, patient-specific treatments. Material Jetting (MJ), is another additive manufacturing method that has significant applications in the biomedical field with its ability to produce high-resolution, multi-material, and multi-color prints. In material jetting, droplets of photopolymer material are deposited layer by layer and cured using ultraviolet (UV) light, allowing for the creation of detailed and complex structures. This method is particularly useful for creating realistic anatomical models for surgical planning and training. The versatility of additive manufacturing in combining different materials and biological components makes it a critical tool in advancing personalized biomedical applications and regenerative therapies.

Keywords: Additive manufacturing; Biomedical applications; Orthopedics; Dental; Tissue engineering; SLA; LPBF; FDM; DIW; Bioprinting; Material Jetting.

BIOGRAPHY

Assoc.Prof. Dr. Binnur Sagbas is a Mechanical Engineer and a faculty member of Yildiz Technical University Mechanical Engineering Department in İstanbul, Türkiye. Her research interests are manufacturing technologies, additive manufacturing, manufacturing metrology, surface post processing, coatings and tribology. She is the head of the Surface Technologies Laboratory and the coordinator of the YTU-Additive Manufacturing Research group which has 4 PhD, 15 MSc. and 5 BSc. students. She conducted more than 20 scientific projects and has more than 30 scientific papers, 8 book chapters and more than 50 proceedings about additive manufacturing, surface modification, tribology and metrology. She is the editorial board member of Advanced Manufacturing Research and International Journal of 3D Printing Technologies and Digital Industry. She is the board member of Turkish Additive Manufacturing Association and vice dean of the YTU Mechanical Engineering Faculty.

Purge Gas for Welding of Stainless Steel Pipes: Must or Luxury

Emel Taban
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ABSTRACT-33

The oil and gas plants must select the most cost-effective and reliable materials due to their diverse applications and conditions. Much oil and gas technology is mature practice. In large part, the stainless steels are employed in plant and associated equipment where the corrosion resistance of plain carbon- or low-alloy steels is inadequate. The austenitic and duplex grades find applications where their excellent elevated-temperature or cryogenic mechanical properties are of advantage. For the high-quality stainless steel pipe welds required for power plants, petrochemical facilities, pharmaceutical, brewery, and food-processing factories, the gas tungsten arc welding (GTAW) process is preferred. Weld root quality of stainless steel pipe and tubes can be ensured by removing the air from the fusion zone using an inert purging gas. Unsatisfactory purging results in formation of ferrochromium layers of colored oxide films commonly referred to as “heat tints.” Oxygen contamination in stainless steel welding causes dross or “sugaring,” referred to in the industry as an oxide layer on the root surface of the weld bead. This is a rough, pitted, and porous layer that can trap organic matter that may lead to contamination, weakened mechanical properties, and compromised in-service corrosion resistance of the weldments. In particular, pitting in weld heat-affected zone (HAZ) has often been reported for standard austenitic stainless steels such as EN 1.4301/1.4401 (AISI 304/316). In practice, the high-temperature oxides formed during welding are removed by pickling using a bath or paste followed by repassivation. This is considered the best method to restore the pitting corrosion resistance of an already oxidized weld. However, postweld cleaning using mechanical or chemical procedures is often complex or too expensive It is therefore essential to use a proper purging technique to shield the root side of the joint from atmospheric contamination. Common root shielding (purging) gases are argon (Ar), nitrogen (N_2), and nitrogen mixed with hydrogen (H_2, typically 10%). Other gases such as helium (He), Ar/He, and H_2 mixtures are also used. Hydrogen provides a reducing atmosphere that counteracts oxide formation more effectively than Ar, but is generally only recommended for austenitic stainless steels. For N_2 alloyed austenitic grades or superduplex stainless steels, it is often recommended to use N_2-containing mixes to counteract losses of N_2 from the weld pool. Variation in purge gas quality may arise during welding and it may be desirable to apply continuous gas monitoring, in particular to control O_2 and moisture content. There is inadequate published literature about the effects of purging gases on the microstructural, corrosion, and mechanical properties of austenitic and duplex stainless steel that is applicable to the oil and gas industry and refinery applications where severe corrosion conditions are common. Thus, the aim of this speech is to show the effects of purging gases on the properties of the GTA welded joints of various stainless steel pipes used in refinery applications.

Keywords: Oil and gas; Stainless steel; GTAW; Purging gases; Weld quality; Corrosion resistance; Austenitic; Duplex steels.

BIOGRAPHY

Prof. Dr. Emel TABAN, born in 1980, received her BS, MSc and PhD in Mechanical Engineering in 2002, 2004 and 2007 respectively. Her academic career gets started in Kocaeli University as Research Assistant at the Department of Mechanical Engineering of Kocaeli University in 2002. She has been guest researcher and exchange PhD student at the University of Ghent and Belgian Welding Institute. She conducted her postdoctoral studies as a Guest Professor at the Welding Engineering Department of the Ohio State University (OSU) and Edison Welding Institute (EWI). She successfully conducted and completed research projects on aluminum to steel welding as principal investigator in cooperation with OSU and EWI.

She has been working as Full Professor in Department of Mechanical Eng. of Kocaeli University since 2018 and she is currently the Vice Director of the Welding Research Center. She has over 120 publications and books on welding technologies, weldability and welding metallurgy of stainless steels, high alloyed steels and aluminum alloys using conventional and advanced welding processes. She has over 2000 citations to date and an h-index of 22 as a researcher. She has served as a member of several organizations such as International Institute of Welding, Turkish Academy of Welding, Turkish Standardization Institute, panelist and reviewer of several Industrial Research projects and R&D Centers in Türkiye, American Society of Metals, American Welding Society, German Welding Society, Scientific Committee Member of several Welding and Materials Congress and Symposiums. She has given keynote speeches for many international respected organizations related to welding and materials science.

Prof. Dr. Emel Taban is the recipient of McKay-Helm award from American Welding Society for the best contribution to the advancement of knowledge of stainless steel welding, involving the use, development and testing of these materials.

In December 2020, October 2021 and October 2022, she has been listed among the World's top 2% Scientists in a global list compiled by prestigious Stanford University. And in March and May 2021, she has been listed among Türkiye's top 1% Scientists.

In December 2021, she has been listed as the author of most cited 6th scientific paper in Europe and most cited 28th paper in the World by AD Scientific Rankings. In December 2021, she has been listed within top 1% scientists in Türkiye by AD Scientific Rankings

In February 2022 and February 2023, she has been listed in World Scientists List by AD Scientific Rankings. She has been serving as Executive Board Meeting Member of Manufacturing Section at the Scientific Research Council of Türkiye since 2024. She is also recipient of Prof. Dr. Baki Komsuoglu Science and Technology award, various awards from Research Council of Türkiye. She is awarded over 10 times by Kocaeli University due to Excellence in research and academic activities.

Additive Manufacturing Designers: A Comparison Between IAMQS Professional Profiles and Relevant ISO Standards

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ABSTRACT-34

There is a significant demand for AM designers in the current market. The AM industry is experiencing rapid growth due to its ability to produce complex geometries, reduce lead times, and customize products. As a result, there is a growing need for professionals who can design parts specifically for AM processes. Among several, some factors contributing to the high demand for AM designers are: industry expansion, with Industries such as aerospace, automotive, medical, and consumer goods increasingly adopting AM for prototyping, production, and tooling; design complexity: since AM enables the creation of intricate and lightweight designs that were previously difficult or impossible to manufacture using traditional methods; customization: as AM allows for mass customization, which requires designers to create tailored products for individual customers; and material innovation: as the development of new materials compatible with AM processes is expanding the range of applications and increasing the demand for skilled designers. Effective AM designers should possess a unique blend of technological, creative, and problem-solving skills. They must understand AM processes, materials, and design principles, while also being proficient in CAD software and simulation tools. Creativity, problem-solving, and collaboration are essential for successful AM designers to perform their jobs. Professionals can pursue a course under the IAMQS to be qualified as AM Designers. Qualification and Certification can further enhance the proficiency and credibility of professionals. There are specific standards to qualify personnel in the field of additive manufacturing (AM) design, which were developed to ensure that designers have the necessary knowledge, skills, and experience to create high-quality AM parts. While there is no single, universally accepted standard, there are several on-going developments to validate the qualifications of AM designers. This paper will conduct a comparative analysis of the IAMQS and ISO standards for AM designer qualification, specifically focusing on ISO/ASTM 52937. The primary objective is to determine whether the IAMQS guidelines comprehensively cover the requirements outlined in ISO/ASTM 52937, ensuring that AM designers who meet IAMQS qualification are also qualified according to ISO standards. By identifying any gaps or discrepancies, the paper will provide valuable insights for further alignment between the two.

Keywords: Designers, DED, PFL-LB, skills, qualification, standards

BIOGRAPHY

Pedro Catarino is an International Welding Engineer and Manager of the International Additive Manufacturing Qualification System (IAMQS), with significant expertise in additive manufacturing (AM) standardization activities. He actively participates in ISO/TC 261 and CEN/TC 438 and serves as the convener of ISO/TC 261/JG 74, leading initiatives on Personnel Qualification standards.

Overview of Laser Shock Peening Processing for Improvements of Metal Additive Manufactured Part at Hilase Centre

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ABSTRACT-35

To use metal additive manufacturing (3D printing) for the applications requiring high quality, it is usually necessary to perform post processing treatment after the 3D printing. We will present work at HiLASE Centre on this topic for the last several years. Changes in mechanical properties of various metallic alloys treated with LSP after the 3D printing will be shown.

Keywords: Metal additive manufacturing; 3D printing; Post-processing; HiLASE Centre; Mechanical properties; Metallic alloys; LSP.

High-Speed Laser-Directed Energy Deposition of Ti/Al Multi-Material Component

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ABSTRACT-36

A crack-free titanium/aluminum (Ti/Al) multi-material component (MMC) was fabricated by a high-speed laser-directed energy deposition process, in which the Ti and intermetallic compound (IMC) coatings improved the microhardness, electrochemical corrosion and wear performances, and the bottom Al alloy substrate reduced the material cost. The element content and microstructure were investigated by electron-probe microanalyzer (EPMA), electron backscatter diffraction (EBSD), and transmission electron microscopy (TEM). The free energies of Ti-Al IMCs were calculated by a first-principles model. The element flow mechanism and formation mechanism of the dominant α2-Ti_3Al IMC were elucidated. The low Al content, low free energy of α2-Ti_3Al phase and high cooling rate caused the dominant α2-Ti_3Al formation in the IMC coating. The study would provide the basis for manufacturing crack-free, anti-corrosion and wear-resistant synergistic reinforced coatings.

Keywords: High-speed laser-directed energy deposition, synergistic reinforcing coatings, Ti_3Al phase, intermetallic compound

Understanding the Thermally-Induced Martensitic Transformation in Nitinol Manufactured via Electron Beam Powder Bed Fusion

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ABSTRACT-37

Nitinol (NiTi) is well-known for its exceptional functional properties, including the shape memory effect and superelasticity, which result from martensitic phase transformations within the alloy. Despite these remarkable characteristics, the practical applications of NiTi SMA have been limited due to its poor machinability which make it unsuitable for traditional subtractive manufacturing techniques. However, additive manufacturing offers a novel solution to this challenge, potentially broadening the scope of Nitinol's use across various applications. In this study, we present nitinol produced via electron beam power bed fusion (EB-PBF) that displays the reversible thermally induced martensitic transformation. This transformation has been characterized through differential scanning calorimetry. Furthermore, a phenomenological understanding of the phase transformation has been added by quantifying the elastic strain and irreversible energies during cyclic stabilization.

Keywords: Additive manufacturing, EBM, DSC, Shape Memory Alloy

Material Selection & Development, and Metal Additive Manufacturing Process for AR/MR/VR Products

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ABSTRACT-38

Material selection & development is key for Electronics Industry (especially consumer electronics) to deliver the best customer experience and achieve competitive advantage in the market. In last 20 years with the ultra fast developing electronics, the need for better and specific materials has been increased. Highly competitive market conditions causing the companies to compete for development and production of electronic devices that delivers better and better performance that consumers appreciate year over year. Due to this high demand and "fast pace" development needs, material Design and manufacturing methods also need to be delivered in shorter lead times, better mechanical and chemical performance. AR (Augmented Reality) / MR (Mixed Reality) / VR (Virtual Reality) aims to deliver best user experience by working on durable, lighter weight, and special design materials and thus the methods of producing them. The transition from traditional manufacturing methods to additive manufacturing is reshaping the production of various products. "Speed to Market" is very important, thus prototyping lead times need to be as short as possible. This brings the need of using 3D printing of plastics, metals, etc. which also shortens and allows faster "Prototype to Product" implementations. In this study, I will provide a comprehensive overview of the development of these products/parts through additive manufacturing technologies, starting with the critical aspect of material selection & development, and its impact on performance and functionality.

Keywords: Metals, Alloy Development, Electronics, 3D printing, Lightweight materials, Material qualification

BIOGRAPHY

Dr. Duman is currently working at Meta under Reality Labs (Hardware) pillar in Materials Innovation Technology team. He is specialized in Metal materials development & selection (Al, Ti, SS, NiTi, Ni, MMC, clad alloys, etc.), and material manufacturing (sheet, cast, wire&bar, 3D print, etc.), material supplier qualification for electronics products. Ustun Duman had his Bachelors, Masters and first round of Ph.D. at Yildiz Technical University, İstanbul, Türkiye (Laser Welding, Dissimilar Metals Welding, Bio-Materials). Then moved to US where he completed his Ph.D. (Welding, Modeling) in Metallurgical and Material Science Eng. at Colorado School of Mines (Supervisor: Prof. Dr. Patricio Mendez). He also has a Lean Manager degree from The Ohio State University, and also he is a certified Lean 6 Sigma Master Black Belt (Accenture). After his graduate work, he worked in manufacturing industry at Caterpillar R&D (intern), Novelis (formerly known ALCAN), Kaiser Aluminum. In last decade, he continued his career by switching to Electronics industry (Consumer and Semi-Conductor) at Apple, LAM Research, Applied Materials and Meta.

Metal Additive Manufacturing and Its Unique Corrosion Mechanisms

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ABSTRACT-39

Various additive manufacturing (AM) methods of metals exist and they all have one thing in common: the creation of unique and much finer microstructures, very different than the ones we know from conventional metal production by casting, rolling or extrusion. Typically in the AM technology the metals are either from an alloy powder or wire rapidly molten and solidified, resulting mostly in non-equilibrium microstructures. These unique microstructures present us with unique challenges in terms of corrosion, showing mechanisms also far from the conventional ones. In the current presentation several case studies will be discussed including examples on stainless steel 316L produced by powder-based methods (Laser Powder-Bed Fusion LPBF versus Direct Energy Deposition DED), on Wire Arc Additive Manufactured steel (WAAM), on LPBF aluminum alloys and titanium alloys. Inherent features of the AM will be indicated as corrosion triggers.

BIOGRAPHY

Prof. Dr. Iris De Graeve is head of the Department of Chemistry and Materials at the Vrije Universiteit Brussel. In the Research Group of Sustainable Materials Engineering, lab unit Electrochemical and Surface Engineering, she is mainly active on surface properties and engineering of metals, including additive manufactured alloys, recycled metals etc. She focusses on surface characterization and surface treatments to create corrosion resistance and other functional properties. She studies the mechanisms and the performance. In this field, she has both fundamental and industrial research projects. The research on additive manufacturing originates from an industrial collaboration for aerospace applications.

Determination of Solid Particle Erosion Wear Behavior of Aircraft Turbine Blades Specific to Additive Manufacturing Orientation Effects

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ABSTRACT-40

In many areas of the industry, especially in the aviation sector, mechanical components have to work under harsh environmental conditions. In addition to being exposed to extreme environmental conditions due to the environment in which they operate, the basic components of aircraft have to take into account many engineering details such as high strength expectations, speed and impact problems under the influence of hard particles. In addition, the geometries of parts in aircraft can be quite complex and detailed shapes. For this reason, it makes sense to utilize different manufacturing processes to create the final shapes of the components. In this study, a research was carried out to determine the solid particle erosion wear behavior of In718 test specimens representing the material properties of jet engine turbine blades in aircraft by alternative manufacturing methods and to interpret the results obtained by performing experiments. In718 alloys with horizontal (0°), vertical (90°) and angular (45°) orientation were produced by selective laser melting, a layered powder-based additive manufacturing method, and test specimens were produced by casting, a conventional method. These specimens were subjected to solid particle erosion tests using three different sizes (500 g, 1000 g and 1500 g) of Al_2O_3 abrasive particles at 30° impact angle. Surface topography and macroscope images were used to interpret the results of the surface differences obtained at the end of the experiments. Consequently, the layer orientation in additive manufacturing and the additive manufacturing method were compared with parts produced by a conventional method in terms of erosion rate. In addition, it was concluded whether the surface damage that occurs in erosive wear depending on the impact angle has a ductile, semi-ductile or brittle character.

Keywords: Additive manufacturing, Selective laser melting, Solid particle erosion wear, Inconel 718 alloy

Digitized Quality Inspection in Welding Production

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ABSTRACT-41

A comprehensive overview of weld quality control and assurance for welded structures, focusing on preventing failures due to fatigue loading is provided. It highlights the drawbacks and limitations of current quality control systems and discusses the international weld quality standards and guidelines used in modern welding production. Additionally, a new online method for quality control and assurance of welded structures is introduced. This method aims to enable complete, online evaluation of large quantities of welds in an accurate and repeatable manner. The information gathered will not only determine weld quality levels concerning fatigue strength but also improve process control, welding power sources, and robot control systems. A key aspect of this new approach is the integration of digital visual inspection technology, specifically the Winteria system. This system captures high-resolution images of welds and uses sophisticated algorithms to detect defects, inconsistencies, and other quality issues that may not be visible through traditional inspection methods. Winteria's digital inspection capabilities allow for a more thorough and consistent assessment of weld quality, contributing to better overall quality control. The incorporation of advanced digital visual inspection technology and laser scanning serves as a modern tool for automated, unbiased geometrical weld quality assurance in a production environment. Today, this integrated system, Winteria, is commercialized and successfully implemented at several manufacturing sites.

Keywords: Welding, Digitalization, Quality Assurance, Fatigue and Fracture, Inspection, Digitalization.

BIOGRAPHY

Dr. Zuheir Barsoum is a Professor of Lightweight Structures at the Department of Engineering Mechanics, KTH Royal Institute of Technology in Stockholm, Sweden. He holds an annual endowment through SSAB (Swedish Steel Company). His research interests include the fatigue and fracture of engineering materials and structures, structural integrity, joining and welding of lightweight metals, and computational weld mechanics. He currently supervises five PhD students and has authored or coauthored over 200 articles in international journals and conferences. Professor Barsoum plays an active role in the International Institute of Welding (IIW). He has also authored and co-authored books on IIW design recommendations. He has received international awards through IIW, including the Granjon Award in 2010 and the Gedik Award in 2020, for his contributions to the fields of design and structural integrity. In addition to his academic achievements, Professor Barsoum has been active in commercializing research. He is a co-founder of Winteria® (www.winteria.se), a company that develops and sells digitized systems for quality assurance in welding and other manufacturing processes.

The Significant Role of Software Development for the Additive Manufacturing Technology

Jonas Zielinski
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ABSTRACT-42

With the idea of Additive manufacturing a dream was born: to build any complex geometry from scratch. The reality differs drastically from this utopian idea: additive manufacturing is a complex to control process which physical effects spans several orders of magnitude and influence the final part quality. Simple manufacturing strategies lead to mediocre part quality. The key are process, geometry and material adapted strategies that lead to a first-time-right build-up of any geometry.

The significant role of for AM developed software is examined and how it can help enable the dream of first-time-right builds. The focus is on toolpath generation and the optimization of the virtual process chain for AM. General challenges in toolpath planning for AM are presented; primitive approaches are compared to special AM-adapted algorithms that harvest the full capability of modern multi-axis AM machines. Examples of successful implementations and practical demonstrations as well as current and newly arising challenges are given. In the outlook the future of the AM, specifically in the software domain, is discussed.

BIOGRAPHY

Dr. Jonas Zielinski is a distinguished physicist specializing in laser additive manufacturing and material processing. Dr. Zielinski holds a Master of Science in Physics (2013) and a Bachelor of Science in Physics (2011), both from RWTH Aachen University. From March 2018 to February 2023, Dr. Zielinski held the position of Project Leader at the Digital Additive Production (DAP) group at RWTH Aachen University, where he spearheaded research on microstructure and process simulation during rapid solidification in additive manufacturing. Currently serving as a Research Program Manager at ModuleWorks GmbH in Aachen, Germany since March 2023, Dr. Zielinski leads innovative research programs that focus on the development of cutting-edge manufacturing technologies.

Non-Destructive Evaluation Approaches for Wire Arc Additive Manufacturing

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ABSTRACT-43

Wire Arc Additive Manufacturing (WAAM) has emerged as a promising technique in the field of metal additive manufacturing, offering significant advantages in terms of material efficiency, cost, and scalability. However, ensuring the integrity and reliability of components produced by WAAM remains a critical challenge, particularly in safety-critical industries such as aerospace, automotive, and energy. Non-Destructive Evaluation (NDE) plays a pivotal role in this context, enabling the detection of defects and irregularities without compromising the component's usability.

This talk will provide an overview of the current NDE techniques applicable to WAAM, highlighting their capabilities and limitations. It will cover conventional methods such as ultrasonic testing, radiography, and visual inspection, as well as advanced approaches like thermography, eddy current testing, and X-ray computed tomography (CT). Additionally, the talk will address the challenges unique to WAAM, including the detection of porosity, cracks, and microstructural inconsistencies, and will discuss the ongoing research aimed at enhancing the effectiveness of NDE in this domain.

By exploring case studies and recent developments, the presentation will offer insights into how NDE can be integrated into the WAAM process to ensure high-quality production, paving the way for broader industrial adoption. The talk will conclude with a discussion on future trends and the potential for real-time monitoring and in-situ evaluation techniques, which could revolutionize quality assurance in WAAM.

Keywords: Wire Arc Additive Manufacturing (WAAM); Non-Destructive Evaluation (NDE); Ultrasonic testing; Radiography; Visual inspection; Thermography; Eddy current testing; X-ray CT; Defect detection; Porosity; Cracks; Microstructural inconsistencies.

BIOGRAPHY

Assoc. Prof. Ulaş Yaman has been a faculty member in the Department of Mechanical Engineering at Middle East Technical University (METU) since February 2016. He earned his Bachelor's, Master's, and Ph.D. degrees from the same department, successfully completing a minor in Mechatronics during his undergraduate studies. From 2014 to 2015, he conducted postdoctoral research as a visiting scholar in the Department of Computer Science at Purdue University. Currently, he also serves as the Director of the Welding Technology and Non-Destructive Testing Center at METU.

Assoc. Prof. Yaman's research interests include additive manufacturing, CAD/CAM architectures, and computational geometry for design and manufacturing. He has published extensively in these areas and has received two best paper awards at international conferences.

Investigating Slag Accumulation in Wire Arc Additive Manufacturing of High Strength Low Alloy Steel

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ABSTRACT-44

Some industrial components made from High Strength Low Alloy (HSLA) steels are produced using the Wire Arc Additive Manufacturing (WAAM) technology because of the achievable complex geometries. Nonetheless, these materials produce during the manufacturing process surface oxides known as silicon islands due to the presence of alloying elements like Si, Mn, Al, and Ti. The accumulation of these oxides across layers leads to defects such as oxide entrapment, dimensional accuracy induced by arc instability, and manufacturing delay caused by interlayer grinding for oxide removal. The present study focuses on HSLA steels deposited with WAAM technology. It investigates the effect on silicon islands of heat input, CO_2 content in the Ar-CO_2 shielding gas, and additional trailing shield protecting from the atmospheric environment. A three factor – two level experimental design was applied on samples composed of sixteen beads deposited as superposed four layers of four beads. The oxides were characterized by image processing at different stages of the deposition to quantify their amount and distribution. A mathematical regression law indicated a minimization of the oxide amount with smaller heat input, smaller CO_2 content in the shielding gas and the use of the trailing shield. The variability of these parameters from the first to the fourth layer is quantified. The results also show that slag accumulation increases when more layers are added. The observations are discussed in light of the physics controlling the oxide formation.

Keywords: Wire arc additive manufacturing, WAAM, High strength low alloy steel, Slag, Silicon islands

Local Approach for Fracture Assessment of Components with Heterogeneity of Mechanical Properties

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ABSTRACT-45

WAAM (wire-arc additive manufacturing) components have great potential for application in structural components. In order to properly assess the safety of WAAM components against brittle fracture, it is necessary to take into account not only the plastic constraint caused by different crack sizes and loading modes, but also the local heterogeneity in strength and toughness within the WAAM components. This lecture firstly introduces a local approach based on the Beremin model of brittle fracture, which has been widely demonstrated to be applied to assess the effect of plastic restraint on the fracture performance of structural components. And examples of the successful application of this model for evaluation of fracture performance of welded joints that has heterogeneity in strength and toughness in welds are also introduced. Finally, a new local approach to predict the fracture toughness of each heat affected zone itself with different microstructures that can be generated by WAAM process is presented. This new local approach can be advanced to evaluate fracture resistance of the WAAM components with high accuracy and high reliability.

Keywords: WAAM; Brittle fracture; Beremin model; Plastic restraint; Fracture toughness; Heat affected zone; Structural components.

BIOGRAPHY

Professor Mitsuru Ohata, born on October 22, 1970, is a distinguished expert in materials and manufacturing science at Osaka University, where he currently serves as a Professor in the Graduate School of Engineering. He completed his B.Eng., M.Eng., and Dr. Engs. at Osaka University, specializing in Welding & Production Engineering. Starting his academic career as an Assistant Professor in 1997, he later became an Associate Professor in 2004 and was promoted to full Professor in 2016. His research, enriched by international experience in Slovenia and Germany, has significantly advanced the fields of welding and manufacturing processes.

Engineering Assessment Procedure of the Local Thin Areas (LTA) in Welded Pipelines

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ABSTRACT-46

Additive Manufacturing (AM) of metal pipes offers significant advantages in customization and material efficiency. However, the development of local thinned areas (LTAs) due to manufacturing defects, corrosion, or wear poses challenges to structural integrity. This study presents a comprehensive methodology for assessing LTAs in AM metal pipes, integrating material properties, finite element analysis, and state of the art industry standards. The process begins with visual inspection and non-destructive testing (NDT) techniques like ultrasonic testing identify and map LTAs.

A detailed 3D finite element model incorporating the geometrical and material properties of the pipe with LTAs mapped is developed. The FE model simulates various loading conditions to evaluate stress distribution and potential failure locations and burst pressures. The properties of LTAs, including shape, size, location, and depth, are discussed to understand their impact on pipe structural integrity.

This methodology adheres to the most common defect assessment standards such as BS7910 and API 579-1/ASME FFS-1 to ensure reliability and safety. This comprehensive approach provides a robust assessment LTAs in AM metal pipes, enhancing their safety and durability in various applications.

Keywords: AM metal pipes; Local thinned areas (LTAs); Defects; Finite element analysis (FEA); Non-destructive testing (NDT); Ultrasonic testing; BS7910; API 579-1.

Breaking the Boundaries of Additive Manufacturing: Additive Friction Stir Deposition

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ABSTRACT-47

Additive Friction Stir Deposition (AFSD), combining friction stir welding concept with material feeding, is an emerging Additive Manufacturing (AM) technology for large-scale component manufacturing with good mechanical properties. The fact that the AFSD process is carried out under ambient atmosphere for most of the materials eliminates the need for a protective/inert gas chamber and simplifies the upscaling of the build volume. Moreover, being a solid-state process, the temperatures do not exceed the melting temperature of the material, and this makes it possible to use reactive materials such as Mg alloys or high-strength Al alloys which are difficult to melt or weld by conventional process routes due to their susceptibility to cracking. This talk will introduce this promising AM technology by exploring the advantages and limitations of AFSD for industrial applications in aerospace and defense sectors.

Keywords: Additive Friction Stir Deposition; Additive Manufacturing; Large-scale components; Solid-state process; Aerospace; Defense.

BIOGRAPHY

Dr. Evren Yasa leads the Additive Manufacturing group and activities at the Advanced Manufacturing Research Centre (AMRC), University of Sheffield, UK. She graduated with a BS in mechanical engineering from İstanbul Technical University (Türkiye) and has actively been working in additive manufacturing since 2005 when she started her PhD studies at the Catholic University of Leuven, Belgium. Her Ph.D. thesis, “Combined Process of Selective Laser Melting and Selective Laser Erosion/Laser Re-melting,” was awarded the Emerald Outstanding Doctoral Research Award. After a short period of postdoctoral study, Dr. Yasa worked as a senior engineer at TUSAS Engine Industries, a General Electric joint-venture company specializing in manufacturing aero-engine parts, where she led additive manufacturing projects/activities. Later, she returned to academia as an assistant professor for 5 years. Moreover, she has been working as an independent expert in laser-based manufacturing on behalf of the European Commission. In 2022, she joined AMRC, working closely with the industry to enhance the adoption of additive manufacturing technologies for real-world problems by merging novel research and goal-focused additive manufacturing usability.

The Influence of Heat Input and Cooling Time on the Residual Stress During Wire Arc Additive Manufacturing

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ABSTRACT-48

A GMAW (Gas Metal Arc Welding) based WAAM (Wire Arc Additive Manufacturing) process was modeled using commercial Abaqus Software. The model was validated according to an experiment from the literature. Heat input and the cooling time values have been changed to analyze their effect on the residual stresses. The effect of the increase in heat input was not that significant, whereas the cooling time had a very high impact on the residual stress distribution. The unclamping effect was also analyzed, and the residual stress in all directions was relaxed after unclamping.

Keywords: Wire Arc Additive Manufacturing, Gas Metal Arc Welding, Residual Stress

Application of Resistance Spot Welding in Cold-Formed Steel Structures

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ABSTRACT-49

Welding technologies are constantly evolving, and their applicability is expanding considering also the construction domain. Steel structures benefit from the advances in welding technologies due to the use of thin gauge steel sheets, which can now be connected at high quality and automatically. The resistance of the connection between the thin steel sheets is crucial for the durability and safety of a structure made of built-up thin-walled cold-formed steel elements. Generally, self-drilling screws or bolts are used to connect thin-walled elements, but the amount of time and manpower required for a large number of connections demands an improved solution. Due to its high productivity, low cost, and increased work efficiency, resistance spot welding can instantly join two or more steel sheets, and it is widely used in the automotive industry and recently in the manufacturing of thin-walled cold-formed steel constructions.

The paper presents the results of research carried out in the Department of Steel Structures and Structural Mechanics, from the Politehnica University Timisoara, which focused on the possibility of creating built-up cold-formed steel beams made of corrugated galvanised steel sheets by using resistance spot welding. Resistance spot welding technologies were developed and tested, together with mechanical testing of the welded joints, which were performed in our laboratories. The results obtained and presented confirm the good quality of the welded joints and, as a result, the good capability of this technology to be used in production to replace the old type of beams.

It is also well known that due to the elevated temperature that occurs during the welding process, followed by rapid cooling, defects such as cracking, porosity, lack of fusion, and an increased amount of brittle phases affect the welding quality. Therefore, the influence of the resistance spot welding process parameters established by an automatic sequence on the nugget geometry, microstructure, and mechanical properties was investigated. The phase transformations that took place during the heating-cooling cycle were analyzed in detail through metallographic studies. The results showed that the microstructure of the weld nuggets was similar, characterized by columnar grains elongated in the direction of heat evacuation. Nevertheless, there were differences in terms of phase dispersion, defects and mechanical properties that have been linked to the resistance spot welding process parameters.

Keywords: cold-formed steel members; resistance spot welding; experimental tests; galvanized steel, microstructure; mechanical properties

Effect of Filler Metals on Strength and Toughness of High Hardness Armor Steel

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ABSTRACT-50

Two different filler metals were used in the process of joining 15 mm thick military martensitic steel plates using gas metal arc welding. The ferritic (high strength steel - ER 110) and duplex (stainless steel – ER 2209) filler metals, having different chemical compositions from the base material, caused significant changes in the microstructures of the weld metal, seriously affecting the performance of the weld in terms of strength and impact toughness. The weld metal produced with ER 110 exhibited fine acicular ferrite and bainite, which maintained acceptable levels of impact toughness while providing high strength. On the other hand, the weld using ER 2209 filler wire, although showing good results in impact toughness, could not match the strength values provided by ER 110. The dilution resulted in a change in the chemical composition of the weld metal, which disturbed the ferrite-austenite phase balance. The altered chemical composition changed the Creq/Nieq ratio, leading to an expansion of austenite regions, particularly in the root and middle areas.

Keywords: Strength, toughness, microstructure, chemical composition, duplex stainless steel, armor steel

Acknowledgments: This study has been supported by the Scientific and Technological Research Council of Türkiye (TUBITAK) with project number 5210029.

Potential of Process gases for the WAAM to Increase Quality and Productivity

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ABSTRACT-51

In the WAAM process (wire arc additive manufacturing), the entire molten pool volume consists of filler metal. This means that 100% of the filler material, the welding wire, is converted into a component, and the weld seam accounts for 100% of the component mass. Up to now, the gas mixtures optimized and known for joint welding with high active gas contents such as Ar +18 % CO_2, Ar + 8 % CO_2 or Ar + 2 % CO_2 have been used for the WAAM process. However, the requirements differ diametrically from joint welding to WAAM. In summary, the WAAM process requires a liquid melt that preferably has a lower degree of mixing <5%. This means that the melting of the previously welded layer must be minimal in order to form a stable molten pool that minimizes the risk of running or deformation of the component. The material transition, i.e. the droplet detachment from wire in the build-up area should be stable and repeatable. This enables a component buildup close to the final contour. This minimizes the necessary effort for mechanical processing. Since layer upon layer is welded, the surface of each layer should also be as clean as possible (free of spatter and silicate) in order to achieve optimum weld and joint stability in each layer. In order to prevent excessive losses of alloying elements during welding, burning loss should be kept as low as possible. Another challenge with WAAM is maintaining the intermediate layer temperature during layer build-up. Depending on the material, process interruptions (cooling breaks) are often necessary to create a homogeneous microstructure. The presentation shows new developments around the potential of customized process gases to increase quality and productivity through protective gas concepts and the use of cryogenic gases for temperature control in WAAM processes.

Keywords: WAAM; Filler metal; Gas mixtures; Melt stability; Droplet detachment; Surface cleanliness; Alloying loss; Temperature control; Cryogenic gases.

Advanced Process Modeling and Simulation of Multi-Material Directed Energy Deposition

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ABSTRACT-52

As technological demands grow, particularly in aerospace and marine industries, materials must withstand increasingly harsh environments or higher external loads. Metal additive manufacturing (AM), specifically directed energy deposition (DED), offers a promising solution by enabling simultaneous multi -material deposition, facilitating in-situ alloying and the creation of functionally graded materials (FGMs). These materials provide tailored properties within a single component, leading to enhanced performance under demanding conditions. In the European Union project DISCO2030, we are advancing the development of metallic multi-material structures for aerospace and marine engines using additive manufacturing. A key aspect of our work is the development of an enhanced simulation method to predict temperature fields and distortions in the DED process. This coupled thermo-mechanical simulation approach reduces the need for costly trial runs by accurately modelling FGMs during the manufacturing process. Using Simufact Welding software, we have created and assigned specific material compositions to build FGM structures. As part of the calibration process, we successfully simulated the deposition of CuCrZr on a CuCrZr substrate. Additionally, DED manufacturing simulations for two FGMs—CuCrZr-IN718 and CuCrZr-316L—are conducted to predict temperature fields and possible problems with distortions. Moving forward, we will further validate these simulations with additional temperature and distortion measurements and scale up the models for industrial applications.

Development Of Fast-Paced Modular Microsatellite Production By Additive Manufacturing

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ABSTRACT-53

The rapid advancements in rocket technology have significantly reduced launch costs, transforming satellite design from large, multi-purpose structures weighing tons to compact, single-purpose platforms weighing only a few kilograms. This shift has enabled highly specialized satellite designs requiring custom structural components. In this context, the laser powder bed fusion (L-PBF) process offers great potential for manufacturing satellite structural panels. A lattice-based panel, developed with 0.5 mm and 1 mm sheet and strut thicknesses, has been successfully qualified within manufacturing constraints. Repeated use of this developed panel allows for the rapid production of scalable microsatellite platforms, minimizing engineering design time while ensuring structural integrity for space applications.

Keywords: Rocket technology; Microsatellites; L-PBF; Structural panels; Lattice design; Space applications; Manufacturing constraints.

BIOGRAPHY

Sertaç Altınok holds a B.Sc., M.Sc., and Ph.D. in Metallurgical and Materials Engineering from Middle East Technical University (METU) and is an international welding engineer approved by IIW. During his Master's studies, he developed a novel process for the continuous production of nano-sized boron carbide particles through thermal plasma synthesis. Alongside his academic research, Sertaç began his industrial career at Turkish Aerospace, where he contributed to the Joint Strike Fighter (JSF) program for F-35 aircraft, focusing on metallic materials, such as aluminum and titanium, as well as polymer-based composites.

In the R&D department of Turkish Aerospace, his dual expertise in academia and industry led him to pioneer a process for the thermal plasma production of micron-sized powder feedstock for additive manufacturing, particularly focused on the recycling of titanium Grade 5 alloy chips. He also spearheaded the development and qualification of AlSi10Mg satellite brackets produced via laser powder bed fusion (L-PBF) for space applications.

Sertaç completed his Ph.D. with a focus on the development of high-entropy alloys via additive manufacturing, employing both L-PBF and arc-directed energy deposition (arc-DED) processes. Since 2022, he has served as the Chief Engineer of Advanced Manufacturing Technologies at Turkish Aerospace, leading a team of highly skilled engineers with backgrounds in various disciplines. His team is dedicated to adopting and advancing emerging manufacturing technologies for aerospace structures.

Under his leadership, the team has secured grants for 11 major projects, including 5 funded by the European Commission. Sertaç holds 6 national and 5 internationally protected patents, and his innovative work has been recognized with multiple awards, including the prestigious Grand Prix from the International Federation of Inventors' Associations (IFIA).

Enhancing Material Performance: Evaluating Shot Peening and Laser Peening Processes for Industrial Applications

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ABSTRACT-54

In modern industrial applications, the demand for materials with superior performance is ever-increasing, pushing the boundaries of surface treatment processes. Among these, shot peening and laser peening can be used as critical techniques for enhancing material properties, particularly in casting, welding, and additive manufacturing processes.

Shot peening has proven to be highly effective in enhancing the surface hardness and microstructure of aluminum-silicon (Al-Si) cast alloys. Notably, in the hypoeutectic A356 alloy, shot peening facilitates a finer, denser distribution of silicon particles while refining grain morphology at the surface. This transformation leads to improved wear resistance, making the alloy more durable in high-stress environments. Additionally, shot peening mitigates the impact of surface defects in steel materials, enhancing their defect tolerance and shifting crack initiation to subsurface layers. This effect significantly bolsters fatigue resistance, extending the operational lifespan of these materials under cyclic loading.

Moving beyond traditional alloys, shot peening has also demonstrated its value in austenitic stainless steel, providing comparable benefits to those observed in laser peening. While both techniques improve surface hardness and introduce beneficial compressive residual stresses, laser peening offers more precise, localized application, particularly advantageous in stress-critical areas like weld seams. Recent studies highlight laser peening's superior effectiveness in reducing stress corrosion cracking in welded austenitic stainless steel, especially when applied without a coating—underscoring its potential as a future-focused solution in industries where reliability under extreme conditions is paramount.

In the realm of additive manufacturing, particularly with selective laser melting (SLM) of Ti6Al4V alloys, the microstructural modifications induced by both conventional and severe shot peening have garnered significant attention. These treatments have not only refined the material's grain structure and increased dislocation density but also improved its fatigue strength and extended its lifecycle—further solidifying peening processes as essential in optimizing the performance of advanced, additively manufactured components.

In summary, shot peening and laser peening represent powerful methods for enhancing the performance of various materials across industries. Whether improving the wear resistance of cast alloys, preventing stress corrosion in welded components, or enhancing the fatigue life of additively manufactured parts, these processes hold immense potential for achieving the high standards required in modern industrial applications.

Keywords: Shot peening, laser peening, casting, welding, SLM, fatigue, micro-hardness, microstructure

BIOGRAPHY

Dr. Simge (Gençalp) İrizalp is an Associate Professor of Mechanical Engineering at Manisa Celal Bayar University, specializing in advanced manufacturing processes and surface engineering. With a Ph.D. in Mechanical Engineering from Manisa Celal Bayar University, Dr. Doe's research focuses on improving the mechanical and metallurgical properties of metals and alloys through innovative techniques such as laser peening, shot peening, semi solid forming, laser welding and additive manufacturing. Dr. (Gençalp) İrizalp has authored over 30 peer-reviewed articles in leading journals, including Optics and Laser Technology and materials and manufacturing processes, and her work has been cited more than 350 times. She has received grants from both industry and government agencies to explore applications of surface treatments in automotive and aerospace sectors. Dr. (Gençalp) İrizalp is also an invited speaker at international conferences, regularly presenting her findings on optimizing material performance for industrial applications. In addition to her research, Dr. (Gençalp) İrizalp is passionate about mentoring the next generation of engineers. She has supervised graduate students, several of whom have gone on to pursue academic careers or advanced research positions in industry.

Metallic Additive Manufacturing: Opportunities and Challenges for Passive Microwave Components in Telecommunications and Defense

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ABSTRACT-55

This paper examines the use of metallic additive manufacturing (AM) for the production of passive microwave components, which are vital in telecommunications and defense systems. The ability of AM to create complex, lightweight, and precise structures offers significant advantages, including improved performance, reduced production times, and enhanced design flexibility. However, challenges such as material limitations, surface finish requirements, and stringent regulatory standards must be addressed. This paper delves into these opportunities and challenges, providing insights into the future of metallic AM in the fabrication of passive microwave components.

Keywords: Metallic additive manufacturing (AM); Passive microwave components; Telecommunications; Defense systems; Complex structures; Lightweight; Performance; Production times; Design flexibility; Material limitations; Surface finish; Regulatory standards.

Enhancing Texture in High Entropy Alloys with Nb: In-Situ Synthesis and Microstructural Insights via Laser Powder Bed Fusion

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ABSTRACT-56

High entropy alloys (HEAs) are a versatile class of materials renowned for their superior mechanical properties, making them suitable for a wide range of applications. Literature indicates that Nb alloying can significantly refine the grain structure and enhance the corrosion resistance of various alloys. However, the impact of Nb on phase transformation and stabilization in HEAs is not fully understood. This study aims to investigate the synthesis and microstructural evolution of a Fe49.5Mn30Co10Cr10C0.5 (at.%) interstitial solute-strengthened base HEA with 0.3 and 0.6 at.% Nb additions, fabricated using the LPBF additive manufacturing process. To analyze the microstructure developed after alloy production, EBSD was employed. Additionally, synchrotron X-ray diffraction (SXRD) experiments were conducted in situ during the laser-melting process. These analyses aimed to elucidate the effects of Nb additions on the texture and phase composition of the alloys. The results demonstrated that Nb addition led to an increase in the lattice parameter for both alloys. Specifically, higher Nb additions resulted in a notable decrease in the {111}γ peak intensity. During solidification, the crystal orientation underwent a significant transformation, with the disappearance of the distinctive {220}γ and {311}γ peaks and the emergence of the {222}γ and {400}γ peaks. The absence of the {400}γ peak with 0.3 wt.% Nb suggests a complex interaction between composition and structural changes. Furthermore, the variation in Nb content influenced the appearance of the {400}γ peak over a broader measurement spectrum. The addition of 0.3 wt.% Nb was also associated with increased micro residual stress, providing deeper insights into the material's behavior under different conditions. These findings highlight the role of Nb in promoting texture changes within HEAs, contributing to the understanding of phase transformations and stabilization in these advanced materials.

Keywords: Laser powder bed fusion, High entropy alloys, Additive manufacturing, SXRD, EBSD

Welding and Characterization of P355GH Steel Used in Pressure Vessels

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ABSTRACT-57

This essay explores the critical role of welding techniques and the characterization process in enhancing the integrity and performance of pressure vessels constructed with P355GH steel. An overview of the significance of pressure vessels in various industries has been given briefly, and the properties of P355GH steel have been given, emphasizing its suitability for high-pressure applications. It then examines different welding methods commonly employed in joining P355GH components, assessing their advantages, limitations, and impact on material properties. Furthermore, the characterization of welded joints through non-destructive and destructive testing methods is discussed, highlighting the importance of ensuring structural integrity and compliance with regulatory standards. Through a comprehensive analysis of welding procedures and characterization techniques, this essay aims to provide insights into optimizing the fabrication process and ensuring the reliability of P355GH pressure vessels in demanding operational environments.

Keywords: Pressure vessel, Welding Characterization, P355GH, Destructive Testing, Non-Destructive Testing

A Method for Detecting Bead Geometry of Thin-Wall Structural Aviation Components in Wire Arc Additive Manufacturing (WAAM)

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ABSTRACT-58

Wire Arc Additive Manufacturing (WAAM) has seen rapid development in recent years due to its numerous advantages, such as high productivity, lower costs, sufficient quality compared to other AM and conventional manufacturing methods. It is particularly valued in the aerospace industry for its efficiency in fabricating large, thin-walled parts. WAAM is a method for producing metal components layer-by-layer, where the bead's height and width must fit within model dimensions. Deviations in height can introduce greater total height errors, while deviations in width can result in extra waste during post-processing or defects in the wall thickness, potentially compromising the entire part production. Therefore, measuring bead dimensions is an important step during WAAM production. This study proposes a method for detecting bead geometry profiles using data obtained from a laser scanner. The proposed method identifies the bead profile in raw data by employing a modified DBSCAN algorithm and approximates the profile to an elliptic shape. To accurately calculate the deposited material volume, the intersecting surfaces of the ellipses must be excluded. Evaluated parameters of the bead allows it to determine the bead's height and width.

Keywords: Wire Arc Additive Manufacturing (WAAM), shape recognition, laser scanning, DBSCAN algorithm, ellipse approximation, grid sampling for complex shapes area calculation.

Thermal Modeling of Tungsten Inert Gas Wire Arc Additive Manufacturing of Ti-6Al-4V Alloy

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ABSTRACT-59

Thermal gradients in Wire Arc Additive Manufacturing (WAAM), leading to microstructural changes, distortions, and residual stresses, can substantially affect the final properties of the components. Therefore, understanding the thermal phenomena during the WAAM process is extremely important for optimizing the production parameters and providing the desired material properties to the final product. However, accurate measurement of temperature during the manufacturing process is often difficult. At this point, numerical simulation methods provide a good alternative to estimate the thermal history during production. In this study a thermal finite element model (FEM) is developed and experimentally validated to calculate the thermal history of Ti-6Al-4V parts produced by tungsten inert gas (TIG) WAAM. In the simulations, heat transfer through conduction, convection, and radiation is considered, and a modified Goldak heat source model is used to define the moving TIG welding heat source. The FEM model is developed within the ABAQUS finite element program using Python macros and FORTRAN user subroutines. The simulated temperature profiles are validated experimentally by comparing the temperatures measured from 2 different thermocouple points on the substrate of a single bead single line wall sample produced by a laboratory-scale TIG-WAAM device. The simulation results demonstrated that the proposed model is capable of predicting the thermal history of Ti-6Al-4V during TIG - WAAM processes.

Keywords: Wire arc additive manufacturing, finite element modelling, thermal history prediction, heat source model

Acknowledgments: This study was supported by Scientific and Technological Research Council of Türkiye (TUBITAK) under the Grant Number 122M355. The authors thank to TUBITAK for their supports.

Investigating Topology Optimization and Additive Manufacturing Processes of Engine Bracket

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ABSTRACT-60

Additive manufacturing (AM) is a transformative technology that provides opportunity to build complex geometries layer by layer directly from digital models, enabling unprecedented design freedom and customization. Combined with topology optimization, a computational method used to determine the best material distribution within a given design space for optimal performance, this synergy opens new possibilities in engineering and manufacturing. This study focused on the development of production processes of a topology optimized functional part. Tensioner bracket of a 4-cylinder in-line diesel internal combustion engine which is manufactured conventionally by casting method with GJL-300 cast iron material was topologically optimized and manufacturability of this geometry by laser powder bed fusion technique with 17-4PH stainless steel was investigated. Structural finite element analysis, fatigue analysis and modal analysis studies were carried out for the optimized tensioner bracket. The results were compared with conventional manufacturing methods in terms of material usage, mechanical strength, production time, cost and weight of the part. The results revealed that, topology optimization and AM were promising technologies to develop an equivalent part with lighter, more cost-effective, reduced production time, and maintains its functionality.

Keywords: Additive Manufacturing, Topology Optimization, Weight Reduction, Laser Powder Bed Fusion

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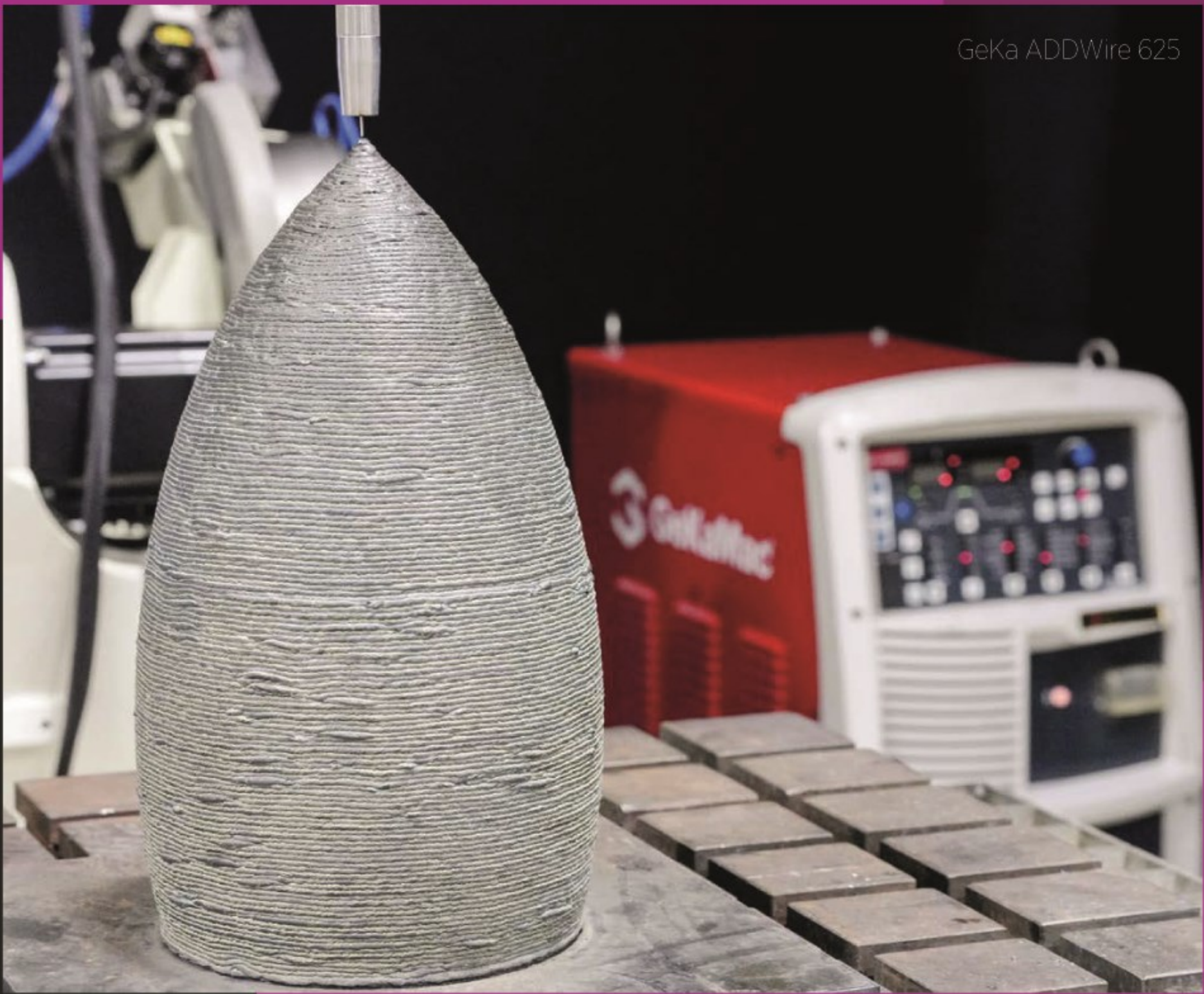

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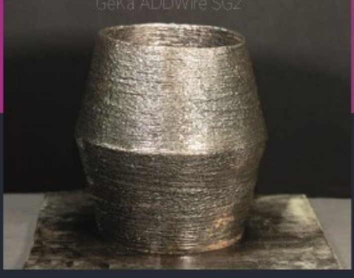

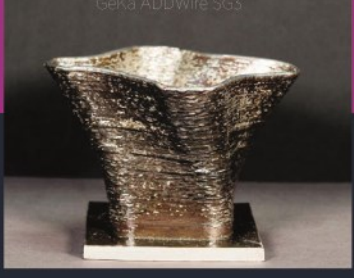

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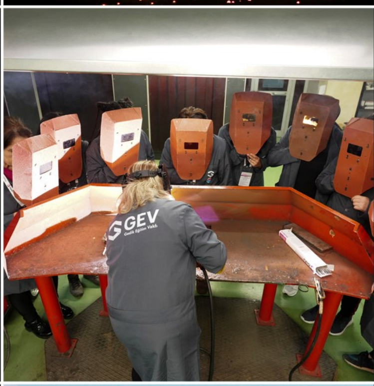

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