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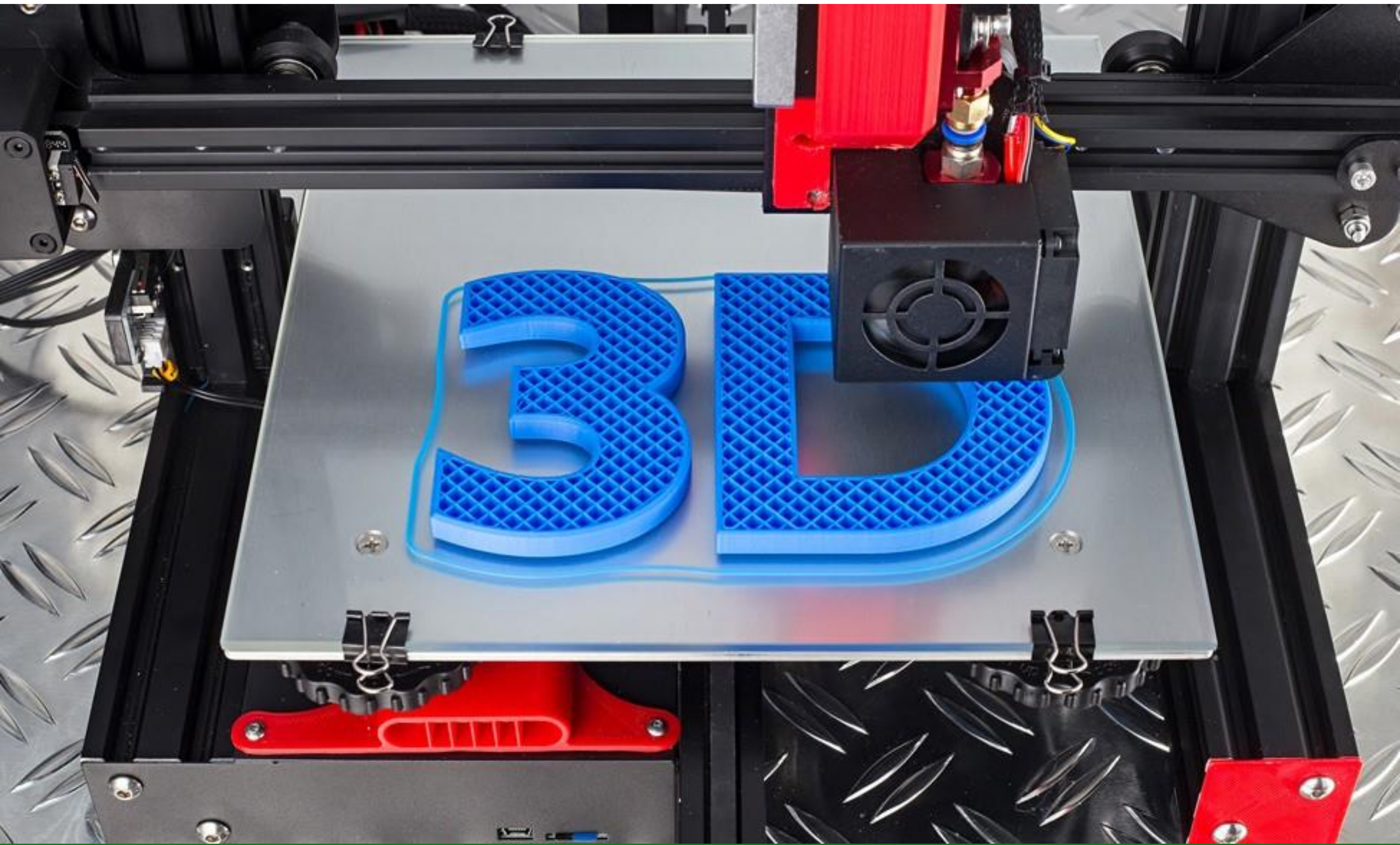
Abstract Book

3DPAM2022

Global Conference on 3D Printing and Additive Manufacturing

November 10-11, 2022 | Valencia, Spain



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FOREWORD

Dear Colleagues,

It is our pleasure to invite all scientists, academicians, young researchers, business delegates and students from all over the world to attend the Global Conference on 3D Printing and Additive Manufacturing will be held in Valencia, Spain during November 10-11, 2022.

3DPAM2022 shares an insight into the recent research and cutting edge technologies, which gains immense interest with the colossal and exuberant presence of young and brilliant researchers, business, delegates and talented student communities.

3DPAM2022 goal is to bring together, a multi-disciplinary group of scientists and engineers from all over the world to present and exchange break-through ideas relating to the Semiconductors, Optoelectronics and Nanostructures. It promotes top level research and to globalize the quality research in general, thus makes discussions, presentations more internationally competitive and focusing attention on the recent outstanding achievements in the field of Additive Manufacturing, 3D Printing and Nanotechnology.

We're looking forward to an excellent meeting with scientists from different countries around the world and sharing new and exciting results in Additive Manufacturing, 3D Printing and Nanotechnology.

Organizing Committee:

Nima Shamsaei	Auburn University, USA
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Rossi Setchi	Cardiff University, United Kingdom
Evangelos Kordatos	Sheffield Hallam University, United Kingdom

Plenary Forum

Introducing 4D Printing: Control of Implant Shape From Outside of the Body

Thomas J. Webster

UFPI, Federal University of Piaui, Brazil, websterthomas02@gmail.com

Abstract

A switched-inductor quasi-Z-source inverter topology (SL-QZSI) with high boost voltage was 3D printing has already revolutionized numerous fields, including medicine. The promise of reduced manufacturing costs and synthesis of tailored structures with enhanced properties has propelled 3D printing into a premiere technology. This presentation will introduce 4D printing as the next generation 3D printing technology. 4D printing refers to 3D printing of structures whose shape and geometry can be controlled from a distance, on-demand. 4D printing can be accomplished by incorporating nanoparticles that generate heat under near infrared to change molecular orientation of 3D printed materials. 4D printing has found numerous medical applications in improving tissue growth on-demand, controlled drug delivery, straightening the spine of scoliosis patients, opening and closing of sphincters, delivery of stem cells, and so much more. This invited presentation will cover the latest advancements in 4D printing for medicine.

Keywords: Biomaterials, 4D printing, Nano materials, Tissue growth

Biography

Thomas J. Webster's (H index: 111; Google Scholar) degrees are in chemical engineering from the University of Pittsburgh (B.S., 1995; USA) and in biomedical engineering from RPI (Ph.D., 2000; USA). He has served as a professor at Purdue (2000-2005), Brown (2005-2012), and Northeastern (2012-2021; serving as Chemical Engineering Department Chair from 2012 - 2019) Universities and has formed over a dozen companies who have numerous FDA approved medical products currently improving human health. Dr. Webster has numerous awards including: 2020, World Top 2% Scientist by Citations (PLOS); 2020, SCOPUS Highly Cited Research (Top 1% Materials Science and Mixed Fields); 2021, Clarivate Top 0.1% Most Influential Researchers (Pharmacology and Toxicology); and is a fellow of over 8 societies.

Powder for Metal Additive Manufacturing: Production, Reuse and Degradation and its Effect on Material Properties

Eduard Hryha

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Abstract

A switched-inductor quasi-Z-source inverter topology (SL-QZSI) with high boost voltage was The metal powder is the feedstock material for most of the metal additive manufacturing (AM) technologies, including powder bed fusion – laser beam (PBF-LB), powder bed fusion – electron beam (PBF-EB), binder jetting (BJT) and powder blown directed energy deposition (DED). Even though the same alloys systems are used for these technologies, they have different requirements to the powder feedstock when it comes to its physical and chemical characteristics and utilize different size fractions of the metal powder. In addition, this metal powder is exposed to the very different conditions during the AM manufacturing cycle in case of different AM technologies. Hence, changes in powder properties during manufacturing cycle and its impact on the final component properties differ significantly.

Metal powder used for additive manufacturing is characterized by large surface area of the powder that leads to high surface reactivity. This, in combination with the alloy composition, will determine powder sensitivity to the powder manufacturing method, handling and AM processing. Powder surface chemistry is initially determined by powder manufacturing method and alloy composition. This initial chemical composition is, however, not stable, and progressively changes with time in dependence on powder handling and processing by metal additive manufacturing. These changes in powder surface chemistry during powder reuse have a strong impact on powder quality and process ability by specific AM technologies. This talk summarizes recent experimental observations and thermodynamic simulations of the changes in powder surface chemistry during the whole life-cycle of metal powder: from its manufacturing through powder handling and AM processing by variety of powder-based metal AM technologies. Generic model of the powder degradation in dependence on initial powder properties and alloy composition when processed by different AM processes is elaborated. Effect of the reused powder on the defect formation during AM processing and its impact on material properties is discussed.

Keywords: metal additive manufacturing, powder for AM, powder manufacturing, surface chemistry of powder, powder degradation, powder reuse

Biography

Eduard Hryha is Professor in Powder Metallurgy and Metal Additive Manufacturing at the Department of Industrial and Materials Science, Chalmers University of Technology, Sweden. He is also director of the Competence Centre for Metal Additive Manufacturing – Metal (CAM2: https://www.chalmers.se/en/centres/cam2) that involves more than 30 national and international research and industrial partners focusing on powder-based metal additive manufacturing (AM). He received his MSc in Applied Physics from Uzhorod National University, Ukraine, in 2003 and PhD in Materials Science from IMR SAS in Slovakia in 2008.

Laser Powder Bed Fusion of Metals and Alloys: The Zero-Defect Objective

Roland E. Loge

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Abstract

Laser Powder Bed Fusion (LPBF, also known as SLM, Selective Laser Melting) is a well-known Additive Manufacturing technology, among the most studied in literature for metals and alloys. A number of drawbacks however still limit its range of applications, among which: (i) the stochastic nature of some of the defects, reducing the reproducibility of parts quality; (ii) the difficulty in adapting laser processing parameters when changing the shape or size of the part; (iii) the often narrow safe processing window, which makes it difficult to optimize both defect content and microstructures.

To solve some of these issues, we present a strategy combining multi scale numerical modelling of the process, monitoring methods, and operando experiments to follow defects formation and microstructure changes during LPBF. While the modelling approach allows defining optimal time-dependent laser parameters, monitoring methods can both help calibrating the models and detect the formation of defects or undesired microstructures. Remedies can then be devised, using additional in situ laser treatments. These treatments are by nature local, and may promote defect healing, microstructure changes, and/or release of residual stresses.

Examples of the above strategy are presented on cracking phenomena in a Ni-based super alloy, regime instability induced porosity formation, grain structure changes in 316L stainless steel, phase transformations in Ti-6Al-4V, and crystallization in a metallic glass.

Biography

Roland Logé is an associate professor at EPFL (Switzerland), with a primary affiliation to the Materials Institute, and a secondary affiliation to the Electrical and Micro engineering Institute. He is the head of the Laboratory of Thermo mechanical Metallurgy, and active in the field of processing of metals and alloys in the solid state, focusing on the ability to tailor microstructures, and the associated material properties. Phenomena of interest include recrystallization, precipitation, grain growth, textures and grain boundary engineering, phase transformations, internal stresses and cracking phenomena, with applications to bulk metal forming and additive manufacturing, and have led to more than 140 academic papers.

Prof. Logé received in 2008, with Yvan Chastel, the ALCAN award from the French Academy of Sciences; in 2019, the Materials Science best teacher award from EPFL; and in 2021, the THERMEC Distinguished Award. He has been a member of the Editorial Board of Metals, of the Scientific Advisory Board of the SEAM laboratory of Excellence (France), of the Swiss Spallation Neutron Source Scientific Committee (PSI, Switzerland), of the THERMEC International Advisory Committee, of the CNRS National committee, of SF2M and TMS.

Fatigue of Additively Manufactured Lattice Materials: A Design and Manufacturing Challenge

Matteo Benedetti

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Abstract

Additive manufacturing of industrially-relevant high-performance parts and products is today a reality, especially for metal additive manufacturing technologies. The design complexity that is now possible makes it particularly useful to improve product performance in a variety of applications. Metal additive manufacturing is especially well matured and is being used for production of end-use mission-critical parts. The next level of this development includes the use of intentionally designed porous metals - architected cellular or lattice structures. Cellular structures can be designed or tailored for specific mechanical or other performance characteristics and have numerous advantages due to their large surface area, low mass, regular repeated structure and open interconnected pore spaces. This is considered particularly useful for medical implants and for lightweight automotive and aerospace components, which are the main industry drivers at present. The huge potential of these porous architected cellular materials manufactured by additive manufacturing is currently limited by concerns over their structural integrity. This is a valid concern, when considering the complexity of the manufacturing process, and the only recent maturation of metal additive manufacturing technologies. Many potential manufacturing errors can occur, which have so far resulted in a widely disparate set of results in the literature for these types of structures, with especially poor fatigue properties often found. These have improved over the years, matching the maturation and improvement of the metal additive manufacturing processes. As the causes of errors and effects of these on mechanical properties are now better understood, many of the underlying issues can be removed or mitigated. This makes additively manufactured cellular structures a highly valid option for disruptive new and improved industrial products. The present plenary lecture will discuss the progress to date in the improvement of the fatigue performance of cellular structures manufactured by additive manufacturing, especially metal-based, providing insights and a glimpse to the future for fatigue-tolerant additively manufactured architected cellular materials.

Biography

Matteo Benedetti is an associate professor in Machine Design at the University of Trento, where he has been since 2007.In 2004 he got his PhD in Materials Engineering from the University of Trento. In 2003-2004 he was a visiting researcher at the Technical University Hamburg-Harburg (Germany). His research interests include (a) characterization and modelling of the mechanical behavior of materials under static and cyclic loadings, (b) manufacturing-related fatigue issues in 3D printed cellular lattice materials, (c) measurement and modelling of residual stress fields and their incorporation into fatigue design, (c) structural integrity of machine elements and structural details. He co-authored more than 90 journal papers and 120 conference articles. He gave some invited seminars and plenary lectures. He served as the chairman of the Technical Division “Residual Stresses” of the Society for Experimental Mechanics (USA). He currently serves as Associate Editor for the journals "Material Design & Processing Communication" and "Additive Manufacturing Letters"

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Multi-scale Multi-physics Modeling of 3D Additive Printing of Metal Products

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Abstract

Additive Manufacturing (AM) of metal products is the Selective Laser Melting (SLM) of metal powders to form the products in one process. It has advantages of combining parts, making products with internal structures, and creating prototypes quickly, etc. The Multi-scale modeling covering laser trace, layer forming, and full product construction has been established at CMU. From the multi-scale multi-physics modeling, the melt-pool characteristics, the process map, the thermal history during the production, the residual stress, the distortion, and the material properties in the product are predictable. The predictive capability of the modeling has been validated on various test cases of Ti64 in our lab. In a recent modeling competition sponsored by DARPA, thorough verifications on an Inconel 718 part has been compared with a set of detailed experimental data of Penn State University. Good agreement is achieved, and our team has won the 1st prize.

Biography

Thomas J. Webster's (H index: 111; Google Scholar) degrees are in chemical engineering Professor Yao received his Ph.D. from U.C. Berkeley in 1974. He worked at Argonne National Lab for 3 years before joined Carnegie Mellon University in 1977. He also served as the Pao Yu Kang Chaired professor at the Zhe Jiang University in China since 2010 for twice of three-year terms. Prof. Yao has conducted research of multi-phase systems over 30 years. He performed research on boiling, spray, and cooling of electronics. Recently he has focused on MEMS micro thermal systems and modeling of additive manufacturing of metal products. Dr. Yao is a LIFE FELLOW of the ASME and served as the chairman of Fire and Combustion Committee and the Long-Range Planning Committee previously. He has organized various national and international conferences. He also served twice as the interim Head of the Mechanical Engineering Dept. at CMU.

3D Printing of Porous Materials for Application in High Temperature Fuel Cells

Tomasz Wejrzanowski

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Abstract

Open porous materials combine both structural and functional properties in various applications. This can be especially seen in materials for catalysis, where mechanical strength, transport of reagents and surface reactivity are optimized by the design of the microstructure and chemical composition.
Present studies are focused on high temperature fuel cells, in particular Molten Carbonate Fuel Cells (MCFC), which operate at temperatures above 600°C. This means they have to exhibit a high tolerance to the fuel type and impurities as well as being low-cost (Noble metal free) catalyst materials.
The comprehensive design of high temperature fuel cell materials encompasses the optimization of both: chemical composition and microstructure. The chemical composition influences corrosion resistance and catalytic activity of the surface, whereas the microstructure is crucial when the transport and interaction/exchange of gas molecules, electrons and ions are considered.
Recent progress in additive manufacturing and especially in 3D printing allows for the direct design of the internal structure of porous materials at the macro-micro scale. Further modification at nanoscale by thermal or/and chemical treatment allows for the fabrication of a hierarchical microstructure. The recent results of material fabrication and characterization by means of 3D printing techniques are presented and discussed.
Within these studies a deeper insight into the understanding of the influence of porosity, pore size distribution, specific surface area and other microstructure parameters on the performance of fuel cells is arrived at by the complementary application of advanced experimental techniques and numerical simulations.

Biography

Tomasz Wejrzanowski graduated in materials engineering (2000) and received the Ph.D. degree in technical sciences in the discipline Materials Engineering (2006) at the Faculty of Materials Science and Engineering of Warsaw University of Technology in Poland. He completed several international scientific stays, including to Concordia University in Canada, National Cheng Kung University in Taiwan, Ulm University in Germany or the Cape Peninsula University of Technology in South Africa. Tomasz Wejrzanowski is currently the Professor at the WUT and also the Vice Dean for Research at the Faculty. Total number of Professor's publications is above 100, has several invited and keynote talks at prestigious international conferences, obtained many awards for scientific achievements. At this stage of His research career already established active cooperation with renowned international partners. Professor's scientific activity concerns the design aspects of modern engineering materials. His interests include computer modeling, 3D printing, fuel cells, porous materials, batteries.

Numerical Simulation of Additive Manufacturing Processes: Industrial Technologies and Numerical Analyses

Michele Chiumenti

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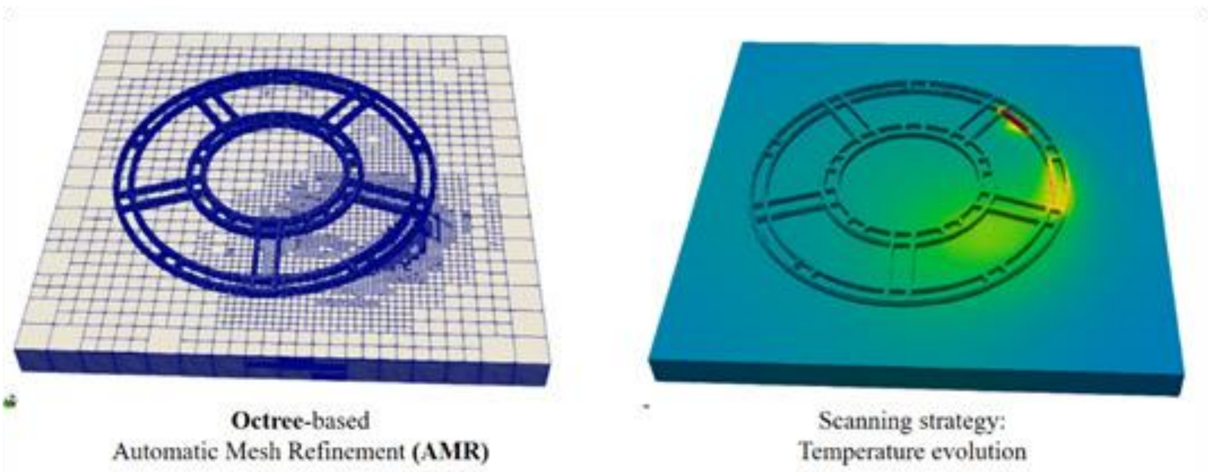
Abstract

In this work the current developments on the numerical simulation of different AM processes are presented. A fully coupled thermo-mechanical framework has been tailored to the analysis of several 3D-printing processes ranging from metals (DED, WAAM) or polymers extrusion (FFF) to technologies for civil and architectural applications (D-Shape and Contour Crafting). The accurate definition of the material deposition is addressed, taking into account actual movement of the power/feeding source along the scanning path as defined for the machine. The result is a high-fidelity simulation of the AM process leading to an accurate layer-by-layer building sequence. An advanced high-performance parallel software platform has been enhanced to include the FE activation technique used to follow the growth of the computational domain according to the fabrication process. The mesh adaptively strategy makes use of Cartesian grids together with octree-type local refinements and global coarsening to keep controlled the total number of elements within the computational domain. The thermo-viscoelastic-viscoplastic constitutive model introduced is calibrated and the numerical results are validated through an extensive experimental campaign carried out taking advantage of the partnership with Arcelor Mittal and several research centers such as: Northwestern Polytechnical University (Xi'an, China), Monash and RMIT Universities (Melbourne, Australia), IK4-Lortek, Leitat, Eurecat (Spain), among others.



Biography

Prof. Dr. Michele Chiumenti Education: Civil Engineer and MCs in Structural Analysis (Politécnico di Milano,1994), Ingeniero de Caminos, Canales y Puertos (Universitat Politècnica de Catalunya - UPC, 2004), Ph.D. degree as Dr. Ingeniero de Caminos, Canales y Puertos (UPC, 1999)Position: Professor of Continuum Mechanics and Structural Analysis (Dep. of Civil and Environmental Engineering – DECA, UPC, since 2004), Full Research Professor (Industrial Manufacturing group) at the International Center for Numerical Methods in Engineering – CIMNE, Research activity: 110 research papers in JCR scientific journals (h-index=31, Scopus 2022). He was participated in 100 national and international research conferences. Keynote in several international congresses: COBIM (2003), COUPLED (2009, 2021) and NUMIFORM (2013), Sim-AM (2017), AM-Bench (2018), FSWP (2019), CASICAM (2021).

Awards and fellowships:

- Chairman of the COMPLAS Conference series.
- Member of the Spanish Society for Numerical Methods in Engineering (SEMNI). Project leader of several financed European and Spanish research projects
- Fellowship from the State Administration of Foreign Experts Affairs of China through the High-end Experts Recruitment Program.

Research interests:

- Finite element technology for highly non-linear analysis including the incompressible limit, strain-localization and tensile cracking.
- Non-linear constitutive modelling for coupled thermo-mechanical problems including phase-change.
- Numerical simulation of metal forming processes for the manufacturing industry such as metal casting for foundry processes, EB welding, Additive Manufacturing (AM) by metal deposition and Frictional Stir Welding (FSW).

AM Challenge: Make it fly!

Marta García Cosio (CiTD)*, Lidia Hernández (CITD), Montserrat Esteban (AIRBUS), Fernando Lasagni (CATEC), Antonio Periñán (CATEC), PhilippeCorberand (AIRBUS), Johannes Gumpinger(ESA)

*Director, CiTD Engineering & Technologies, Spain, marta.garcia-cosio@citd.eu

Abstract

Additive manufacturing technologies are living in a never ending hype or they are just becoming a reality? Additive manufacturing technologies have shown themselves as a revolution in the manufacturing arena, mainly in sectors such as space, where the mass and performance optimization are always more than welcome.
CiTD has focused its effort in make it fly! New technologies have a painful entry barrier in the regulated sectors due to the risk associated to it. CiTD has become an enabler of the technology in the aerospace sector thanks to the deep knowledge in these sectors.
This is a question that can be answered thanks to the GSTP "Novel structural components for launchers/satellites applications using additive manufacturing technologies". Within the scope of this GSTP, all the Material & Processes, requirements and mission aspects are addressed and 11 secondary structure brackets of JUICE mission are being designed, manufactured and tested in order to reach Jupiter in 2029.
JUICE AM brackets are being manufactured in Scalmalloy® and all the end to end process from design and manufacturing to qualification has been validated by both Airbus and ESA, addressing not only mechanical requirements but also thermal, assembly and integration ones. The way the requirements are covered and understood for these brackets is a team work between all the parties, demanding flexibility and novel solutions for issues that arise with the technology and unique geometries of these brackets.
Within the life cycle of AM products, the stage of requirements gathering is key for the success of the design as every single requirement has impact not only in the design but also in several processes involved (stand-off and heaters gluing, harness routing…). The requirements statement also takes into account an ad-hoc safety factors and margin policy to account for uncertainties of the design process. The process validation covers the bracket building in the Additive manufacturing machine with the powder control, samples, process parameters and building inspection procedures but also associated processes such as sandblasting, aging, polish…
Scalmalloy® has been selected as preferred material in order to obtain good mechanical properties at a contained cost and risk (avoiding HIP) and due to its thermal properties: thermal compliance together with mechanical requirements is a challenge in a mission where thermal couplings are part of the design optimization and sometimes drives the mass of the bracket, more than the mechanical performance. Other requirements such as shielding that were considered at the very end of the design process ended out in shielding plates to be attached to the AM brackets.

As a result of the program and ESA efforts 11Scalmalloy® brackets have been designed tested and qualified and are about to be assembled in JUICE SSTS. The mean mass reduction is around 50% (8 kg) fulfilling all the requirements from the performance and process point of view.

May 2023 will be the first time 11 scalmalloy brackets will be launched in the same mission.

Biography

Marta G. Cosio studied MS Mechanical Engineering by the Universidad Politecnica of Madrid with double degree in the Politecnico di Torino. Marta has dedicated her career to the aeronautical and space sectors working with companies such as Airbus, European Space Agency or Eviation, always pushing new technologies. Today Marta is the director of CiTD Engineering & Technologies, an innovative SME pushing for additive manufacturing technology in aerospace sector, CITD has already Titaniym and Aluminum flight hardware in satellites such as Cheops and JUICE.

Keynote Forum

Challenges in the Aerospace Application of Additive Manufacturing

Dario Gonzalez Fernandez

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Abstract

Additive manufacturing has been rapidly introduced in the industrial, dental, medical, and automotive sectors; however, it is more difficult for these technologies to succeed in the aeronautical sectors, since the risk of failure involves human lives. In the case of parts for satellites, although the weight saving that accompanies additive manufacturing is very important, however, these parts cannot be replaced and must ensure their correct operation for years in extreme conditions of temperature and radiation. At Indaero we collaborate with companies in the aerospace sector to apply controls in the verification processes to ensure that they comply with the standards created by important companies such as Boeing and Airbus and to guarantee the service life of the product, which will be subjected to stress, vibrations, high temperature and fire ranges. The enormous number of additive manufacturing technologies, the multitude of materials and manufacturing strategies make additive manufacturing a great unknown for the engineers who must design the equipment and therefore the fear of incorporating this technology is high. At INDAERO GRUPO EMERGY we have successfully manufactured a multitude of 3D printed parts and have met technical challenges such as precision, limited dimensions, design problems, post-processing and qualification.

Biography

Dario Gonzalez Fernandez studied Industrial Technical Engineering at the University of Seville and did business internships in the AIRBUS Tablada Plant Engineering department. In 2004 he was selected for the 50K program of San Telmo Business School and in 2006 he completed the Master of Aeronautical Management at the School of Industrial Organization. In 2002 he co-founded the company INDAERO GRUPO EMERGY dedicated to the manufacture of machined parts and the design of equipment for aircraft. In 2014 he acquired his first additive manufacturing equipment and the company has developed projects with this technology for important companies in the sector such as AIRBUS, ACITURRI, SENER Aerospace, ITP, and AERONNOVA. In the space sector, the company delivers more than 800 pieces per year for different satellite constellations and in 2021 the first structure of the NEPTUNE satellite manufactured in ULTEM by 3D printing was launched. INDAERO GRUPO EMERGY has research agreements with different Technological Centers and Universities and carries out Innovation projects related to digital manufacturing and aerospace engineering.

Prediction of Metal Additive Manufacturing based on Non-iterative Computations

Steven Y. Liang

Morris M. Bryan, Jr. Professor in Mechanical Engineering for Advanced Manufacturing

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Abstract

Recognized as a milestone technology, additive manufacturing (AM) has promised unparalleled part complexity and small-batch cost effectiveness. However the control of AM throughput and build quality has been challenged by the deficiency in process mechanics understanding to support systematic prediction, monitoring, and optimization. a fair amount of experimental observations and numerical FEM studies have been pursued and documented, but they unfortunately suffer from the need of trial-and-errors and the lack of knowledge extendibility. Aiming at a scientific scope and engineering applicability way beyond experimentation and FEM, physics-based analytical modeling flanked on computational mechanics of materials is developed at Georgia Tech and presented herein to quantify the thermodynamics, heat-transfer, and materials thermos-physical behaviors in powder bed and powder feed metal AM. Closed-form solutions have been established for temperature distributions. Subsequently the corresponding thermal stresses, residual stresses, microstructure, build distortion, and mechanical properties are expressed as explicit and algebraic functions of process parameters and powder properties, factoring in the effects of scan strategy, and powder packing. Bounded-medium solutions have been established by folding boundary thermal balance conditions into the traditional semi-infinite medium solutions to compute material responses near build edges without iterations. Extensive experimental validations are also presented. The solutions deliver more penetrating physics of the metal AM process, showing much higher accuracy, and costing less than 1% time of commercial FEM's, thus promising effective prediction and optimization for first-and-every-print-correct AM.

Biography

Steven Y. Liang holds a Ph.D.in Mechanical Engineering from the University of California at Berkeley and MS from Michigan State University, USA. He is currently Morris M. Bryan, Jr. Professor for Advanced Manufacturing at Georgia Institute of Technology. Served as Georgia Tech's founding Director of Precision Machining Research Consortium and Director of Manufacturing Education Program, President of Walsin Lihwa Corporation (publicly traded with $6+ billion revenue), President of North American Manufacturing Research Institution (NAMRI), Chair of Manufacturing Engineering Division of American Society of Mechanical Engineers(MED/ASME). He is serving as Technical Editor of Int'l Journal of Precision Engineering and Manufacturing (Springer) and Editor-in-Chief of Journal of Manufacturing and Materials Processing (MDPI). Technical interests lie in precision engineering, extreme manufacturing, and technology innovation. Supervised over 80 Post-Doctoral studies, Ph.D.dissertations, and M.S. theses and published over 700 archival scientific articles and5 books. He has been invited to deliver more than 70 keynote speeches and seminars in over 20 countries. Recognized by Robert B. Douglas Outstanding Young Manufacturing Engineer Award of Society of Manufacturing Engineers (SME), Ralph R. Teetor Education Award of the Society of Automotive Engineers (SAE), Black all Machine Tool and Gage Award of ASME, Milton

C. Shaw Manufacturing Research Medal of ASME, and others. He is a fellow of ASME, SME, and Academy of Engineering and Technology (AET).

Morphology Mapping – A New Approach to 3-DPrinting with Polymers

Geoffrey R. Mitchell

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Abstract

Morphology mapping is an emerging concept associated with the 3D printing of polymers. In this presentation, the concept is introduced and the technology required for its implementation is described. Although it may be possible to extend this concept to other materials, in this work it restricted to semi-crystalline and liquid crystalline polymers. In this type of material, the properties of the printed part are defined by both the chemistry of the material and by the morphology present in the final part. In all polymer processing the nature of the processing has a profound impact on the morphology generated in the part and this is greatly influenced by the parameters of the processing technology, whether it is injection moulding, fiber spinning or 3D printing. We have recently shown that we can control the morphology which develops during 3D printing using the standard process control parameters [1, 2] through the use of in-situ time-resolved small-angle X-ray Scattering. The morphology and structure of the polymer is an important component in determining the properties of the part as in any polymer processing technology and we have shown that 3D provides a technology which can be used to deposit material exhibiting different morphologies in different parts of the product. We are now exploring how this new approach may be exploited in novel designs. We have identified that it may provide a route to enhancing the properties of recycled plastics to fabricate higher value products. In this presentation we focus on the impact of 3D printing processes on the morphology and properties of polymers, in particular semi-crystalline polymers. We show how we can manufacture objects with structure and properties which vary throughout the object. We use in-situ x-ray scattering techniques to evaluate the polymer morphology on multiple length scales. We identify the process parameters that can be varied continuously during printing to influence the morphology.We explore some case studies to illustrate the design possibilities.

This work is supported by the Fundação para a Ciência e Tecnologia (FCT) through the Project references:MIT-EXPL/TDI/0044/2021,UID/Multi/04044/2013;PAMI-ROTEIRO/0328/2013 (Nº 022158), Add. Additive - add additive manufacturing to Portuguese industry POCI-01-0247-FEDER-024533 and UC4EP PTDC/CTM-POL/7133/2014). These experiments were performed at NCD-SWEET beamline at ALBA Synchrotron with the collaboration of ALBA staff.

[1] da Silva, D.P.; Pinheiro, J.; Abdulghani, S.; Kamma Lorger, C.; Martinez, J.C.; Solano, E.; Mateus, A.; Pascoal-Faria, P.; Mitchell, G.R. Changing the Paradigm-Controlling Polymer Morphology during 3D Printing Defines Properties. Polymers 2022, 14, 1638. https://doi.org/10.3390/polym14091638

[2] Silva, D.; Pinheiro, J.; Abdulghani, S.; Kamma-Lorger, C.S.; Solano, E.; Martinez, J.C.; Pascoal-Faria, P.; Mateus, A.; Mitchell, G.R. Controlling Morphological Development during Additive Manufacturing: A Route to the Mapping of Properties. Mater.Proc. 2022, 8,116. https://doi.org/10.3390/materproc2022008116.

Biography

Geoffrey Mitchell is Professor and Vice-Director of the Centre for Rapid and Sustainable Product Development at the Polytechnic of Leiria in Portugal. He is Adjunct Professor at the Sri Jayachamarajendra College of Engineering, Department of Polymer Science and Engineering in Mysore India and Visiting Medical Physicist Oxford University Hospitals NHS Foundation Trust, Oxford UK. Geoffrey Mitchell carried out his doctoral work at the University of Cambridge in the UK and subsequently held a post-doctoral fellowship at Cambridge and a JSPS Fellowship at Hokkaido University in Japan. Prior to his current position he was Professor of Polymer Physics at the University of Reading, UK and from 2005 the founding Director of the Centre for Advanced Microscopy at Reading. His research work bridges physics, biology, chemistry and technology and he is passionate about the opportunities afforded by Additive Manufacturing. He is a Fellow of the Institute of Physics and the Royal Society of Chemistry as well as the Royal Society for the Encouragement of Arts, Manufactures and Commerce and a Member of the Institute for Physics and Engineering of Medicine.

Global Conference on 3D Printing and Additive Manufacturing

November 10-11, 2022 | Valencia, Spain

Computed Tomography Imaging of Internal Pores inLaser Powder Bed Fusion of Nickel-Based Alloys Using Synchrotron Radiation

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Abstract

Nickel-based alloys are being used in the aerospace and automotive industries for their good mechanical and magnetic properties at elevated temperatures. Inconel 625 offers high strength and corrosion resistance, while Fe50Ni is a soft magnetic alloy that has very high magnetic permeabilities. Invar 36 has been used in applications that require low coefficient of thermal expansion. The nickel (Ni) content in Inconel 625, Fe50Ni, and Invar 36 are approximately 55-60%, 48-50%, and 35.5-36.5%, respectively. Laser powder bed fusion (LPBF) of nickel-based alloys offers a high degree of design freedom for aerospace and automotive applications. In this work, samples were produced from three nickel-based alloys at various sets of laser process parameters using an EOSINT M280 machine. Synchrotron X-ray tomography was utilized for imaging the LPBF parts at the Canadian Light Source (CLS). Internal pores were quantified and classified into pores located inside the melt tracks and pores located at the edges of the test parts using MIPAR Image Analysis software. The influence of laser process parameters on the total volume of internal pores was investigated. In addition, the effect of nickel content on the volume of pores was studied. It was found that the amount of porosity in nickel-based alloys that are processed at the same laser process parameters is affected by the nickel content, presence of other alloying elements, and melting temperature of the material.

Biography

Dr. Mostafa Yakout is an Assistant Professor in the Department of Mechanical Engineering at the University of Alberta, specialized in the area of Advanced Manufacturing and Design. His research interests include Additive Manufacturing of Metals, In-situ Monitoring and Control for Additive Manufacturing, Multiphysics Modelling of Manufacturing Processes, Hybrid Additive Manufacturing, and Design for Additive Manufacturing. He is registered as a Professional Engineer in Ontario, and he is an Adjunct Research Professor at Western University. Dr. Yakout

received his PhD in Mechanical Engineering from McMaster University in 2019. He also holds a B.Sc. (2010) and M.Sc. (2013) degrees in Production Engineering from Alexandria University. His scholar record includes over 24 archival papers and contribution to 3 books. He is a voting member of the American Society for Testing and Materials (ASTM): Committee F42 on Additive Manufacturing; Committee D20 on Plastics; and Committee A01 on Steel, Stainless Steel and Related Alloys. He is also a member of the Canadian Society for Mechanical Engineering (CSME), Ontario Society of Professional Engineers (OSPE), American Society of Mechanical Engineers (ASME), and American Society for Metals (ASM International).

Assessment of Experimental and Finite Element Simulation Residual Stresses In an Additively Manufacturing Austenitic Steel, And Evaluation of Heat Treatment's Effect on Stress Relief and theMicrostructure

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Abstract

Laser powder bed fusion (LPBF) is a method for selectively or partly melting a bed of powdered material using a laser, where each subsequent layer of molten or partly melted material is bonded to the previous layer [1, 2]. The rapid cooling rates inherent to this process result in large stress gradients, which can have a significant effect on the performance during service of metallic components, reducing fatigue lifetime or provoking sudden localized failures. Thermal treatments applied after the build but before the components are removed from the build plate usually release these residual stresses (RS). As a result, estimating the RS and their distribution has become critical for maximizing the viability of manufacturing parameters. 316L austenitic stainless steel is a well-known and characterized steel in Additive Manufacturing (AM) that is industrially relevant. Because this material is stable against micro structural changes in temperature and segregation, it is a good choice for this study.

Two arch-shape samples with a hollow region have been manufactured to measure the RS in as- built and heat treated (HT) conditions. This HT was developed for stress relief on this steel based on micro structural and experimental analysis i.e., tensile and distortion tests. The microstructure of both samples was characterized by means of different techniques (i.e., LOM, FEG-SEM, EBSD, XRD, and hardness maps) and the RS were measured with non-destructive depth- resolved synchrotron X-ray diffraction experiments. RS measurements are compared to computer-based simulations using two different models with a different degree of simplification: one purely mechanical and thermo mechanical the other. The novelty of this research is the combined evaluation of these three fields i.e., microstructure, experimental RS and calculated RS, all in all evaluated in an end use geometry.

This work is being developed in the frame of the EU Horizon 2020 EASI-Stress project under grant agreement No 953219.

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Biography

Manuel Sánchez-Poncela is Scientist researcher and Project Manager at the Department of Additive Manufacturing at Arcelor Mittal Global Research and Development, where he has been since February 2018. Since then, he has been involved in different R&D projects related to Additive Manufacturing, both private and public funded (regional, national, and European calls) and has been granted with some patents in the field.
His background is industrial engineer by the Polytechnic Schools of Gijón (ES) and Grenoble INP (FR), with a further specialization in material science by LMU and TUM universities (Munich, GR). Before joining Arcelor Mittal, he worked at CEA Cadarache: studying the relaxation cracking with numerical simulation of austenitic steel welding and FRM II as data analyst of residual stresses in welding.

3D and 4D Printing of Multifunctional Composite Materials

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Abstract

Additive Manufacturing (AM) technologies have attracted the interest from both scientific community and industry in recent years due to the advantages that these technologies present with regard to the traditional manufacturing ones. However, there is a lack of available materials for AM processes at present times, being the availability of commercial smart and/or multifunctional materials almost nonexistent. In this context, the development of multifunctional polymer matrix composite materials for AM technologies is still a challenge of great interest in the industry 4.0 framework.

This work focuses on the development of smart materials for AM processes, based on multifunctional thermo set matrix nanocomposites filled with carbon nanostructures, as carbon nanotubes (CNTs) and graphene nanoplatelets (GNP). In this sense, multifunctional materials were developed for two different AM technologies: Direct Write (DW) and Digital Light Processing (DLP).Regarding DW technology, suitable for high viscosity inks, was used for successfully developing 3D-printed circuits with structural health monitoring (SHM) and Joule heating capabilities, enabling their use for self-post-curing or anti-icing and de-icing purposes. On the other hand, Digital Light Processing technology was used for successfully developing complex geometry nanocomposites with SHM and Joule heating capabilities for shape memory purposes. In this regard, the thermally induced shape memory capability was studied as a function of the heating method: conventional oven, infrared lamp and Joule heating.

Biography

Monica Campo Gomez is Professor of the Department of Materials Science and Engineering in Rey Juan Carlos University, where he has been since 2001.She is graduated in Chemistry (Complutense University, 2001) and in 2005 she got her PhD in Materials Science and Engineering (Rey Juan Carlos University). She co-authored more than 50 research journal papers and more than 65 conference articles (H index of 19). The main lines of research are focused on epoxy matrix composites with carbon nano fillers (carbon nanotubes and graphene) for obtained nanocomposites and multiscalar materials. The last lines of research are the process of epoxy coatings with carbon nanostructures (graphene and nanotubes) with high wear resistance and anti-icing and de-icing properties for application in parts of wind turbines, airplanes or aircraft composites and the processing of nanocomposites by additive manufacturing or 3D printing by Direct Write and DLP process.

Surviving Disruption in Additive Manufacturing – Demystifying the AM Technology Question

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Abstract

Growth in AM creates two fold disruptive dynamics: (1) AM disrupts the way we produce - new applications emerge in all industry segments; (2) the AM ecosystem itself is under disruption along the value chain. In this context, many technologies are evolving, but only a few are proven at industrial scale with a high level of automation and reproducibility. All current printing technologies will improve in certain aspects – none will be best for all applications. This assessmentis backed by a global user survey in which we investigated the usage of AM technologies and their main limitations today and tomorrow across various industries. The number of AM technologies has strongly increased in recent years. Choosing the right technology became a challenge for many users. This presentation will investigate the AM technology landscape and analyse the current strengths and future potential of major technologies. It will present a multi dimensional assessment that includes technical and financial criteria. It will comprise of long-standing technologies like material extrusion or laser sintering but also newer technologies such as high-speed sintering and metal binder jetting. The choice of the best technology depends strongly on the selected application. This talk will thus explore a selection frame work to identify the best technology for any given use case.

Biography

Wilderich is a Partner& Associate Director at the Boston Consulting Group. He is a core member of BCG's Innovation Center for Operations and very active in BCG's Healthcare, Consumer Products and Industrial Goods practices. His focus at BCG is on advanced manufacturing topics such as additive manufacturing/3D printing, digitalization and the Factory of the Future/ Industry 4.0 as well as on manufacturing strategy and network optimization.He joined BCG in 2006 after graduating in from Darmstadt University of Technology with a masters degree in industrial/mechanical engineering. He holds a PhD in engineering from Technical University of Berlin.

Research interest: Additive Manufacturing, Industry 4.0, Digitalization of Operations.

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Towards the Evolution and Qualification of PBF-LBApplications for the Aerospace Industry

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Abstract

A switched-inductor quasi-Z-source inverter topology (SL-QZSI) with high boost voltage was Additive Manufacturing (AM) technologies have shown to be capable of producing aerospace hardware for functional and structural applications, tackling different materials and methods which have been used for critical and non-critical parts. This is clearly pushed by the outstanding benefits that can be achieved due to the increased functionality of the developed parts as well as the capability of reducing lead-time and mass. The last is of particular interest in the space industry, where the cost for delivering 1Kg of payload range from about 10-20k€. Powder Bed Fusion Laser-Based (PBF-LB) is largely the most AM process applied in the aerospace industry due to (i) the acquired knowledge for processing different metal alloys, together with the required thermal treatments and definition of allowable values for each material and condition; (ii) the maturity of the technology, which has evolved for producing more robust manufacturing systems, capable of obtaining repetitive mechanical/microstructural/etc. characteristics in the different alloy systems; (iii) the development of post-processing strategies such surface finishing treatments, I/F machining methods, etc., and (iv) the implementation of inspection methods like computed tomography depending on the part criticality. Thanks to that, there is available today standards like the ESA (European Space Agency) ECSS-Q-ST-70-80C, and many other being in production from ISO and ASTM, although the main aerospace OEMs have defined and established internal procedures, methods and allowable values for part qualification/certification.
This work covers relevant aspects for the development of metallic aerospace hardware using PBF-LB process in AlSi10Mg, Al-Mg-Sc and Ti6Al4V alloys, for different missions and aircrafts. This paper covers the industrialization aspects of several applications developed for space missions like the QUANTUM and PROBA3 satellites, and in particular for the development of primary and secondary structural parts in aircraft platforms within the Clean Sky 2 programme, like the RACER rotorcraft. Different production steps are addressed, starting from the design, followed by fabrication, post- processes and finalizing by the description of inspection methods, and with a timeline perspective, as well as qualification/certification aspects.

Biography

Fernando Lasagni: MSc. in Chemical Engineering at Comahue National University (Argentina) in 2003 and Ph.D. holder on composite materials and light alloys from the Vienna University of Technology in 2006 (laureate with honors'). There, he was involved in several research programs in collaboration with industrial partners in the field of light metals and MMCs. He was laureate in 2007 with the Fritz-Grasenick Prize of the Austrian Society of Electron Microscopy and with 2 cover pages of the prestigious Journal of Advanced Engineering Materials (2006 and 2008) for his contributions in the field of FIB tomography. During 2008 he was involved in the development of porous materials for heat pipes at Iber Espacio S.A. (Madrid, Spain). Currently he is Chief Technical Officer (CTO) Materials & Processes at CATEC as well as honorary Professor at the Seville University. His main activities are related with managing and coordination of aerospace research projects in the field of additive manufacturing, automation & robotics, advanced NDT methods & systems and structural testing, within the national and international community, in conjunction with the main actors of the aerospace community. He has also a long trajectory in Structural Health Monitoring demonstrated along different projects and the coordination of 2 PhD theses. Mr. Lasagni has a scientific record of more than 220 contributions in peer-reviewed journals, conference proceedings and participations, 3 patents and 4 intellectual property registers. He acted as Spanish representative during the Additive Manufacturing harmonization meetings at the European Space Agency in 2014 and co-representative 2017. Lasagni coordinates as well the additive manufacturing group of the Spanish Platform for Aerospace (PAE). He has been also awarded with the Georg Sachs prize of the German Society of Materials (DGM) for his contributions in the industrialization of Additive Manufacturing for aerospace (2018); and recently (2019) with the "Domingo Faustino Sarmiento Award" of the Argentinean senate for his contributions in applied research and engineering. Lasagni owns a relevant experience in AM technologies for the development of applications in the aerospace field, including space missions like CHEOPS, PROBA3, QUANTUM, JUICE Jupiter Icy moons Explorer, Mars Sample Return, etc., and aircrafts like the AIRBUS A320neo, A400M, C295 and the Clean Sk2 aircraft demonstrator and RACER helicopter.

The Effect of Fiber Orientation and Infill Pattern on Tensile Strength of Additively Manufactured CompositeMaterial

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Abstract

Additive Manufacturing (AM), also known as 3D Printing has been there for more than two decades and has recently gained importance for manufacturing functional products. AM has excellent developments in recent days with a huge number of applications in industry, automotive, aerospace, medical, architecture, food, fashion, etc. Composite materials are widely used in structures with weight as a critical factor especially in aerospace industry. In recent periods, AM has gained lot of importance in fabricating composite material. Fused Deposition Modelling (FDM) is one of the promising AM technology used for the fabrication of complex geometry product using continuous fiber reinforced composite material. There is lot of research on effect of fiber orientation on tensile strength of composite materials made using conventional manufacturing processes. It will be interesting and significant to study the effect of fiber orientation and infill pattern (honeycomb, triangular & rectangular) on tensile strength of additively manufactured continuous fiber reinforced polymer composite. Now-a-days, continuous fiber reinforced thermoplastic composite materials are becoming more important in industrial applications due to inherit advantages such as excellent mechanical performance, recycling and potential lightweight structures. In present study, carbon was used as continuous fiber reinforced material which has high tensile resistance. The FDM based 3D printer named Mark forged Mark Two was used to fabricate the test specimen. This work aims to investigate and find out the best combination of fiber orientation and infill pattern that has better tensile strength for additively manufactured polymer composite. Further, microstructural analysis was conducted to investigate the fracture mechanism, morphology, and printing quality of the test specimens.

Keywords: additive manufacturing, 3D printing, composite material, Kevlar fiber, impact testing

Biography

Mahesh Naik is a Ph.D. Scholar in Mechanical Engineering at Defence Institute of Advanced Technology, Pune, and Maharashtra. He has completed B.E in Mechanical Engineering from Sanjivani College of Engineering, Kopargaon, Maharashtra, India (2015) and M.Tech in Manufacturing Engineering from Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat (2017). His Ph.D. research area is Additive Manufacturing of polymer composite for Aerospace applications. He has worked for one year as Assistant Professor at Sandip Institute of Management and Technology, Nashik. Additive manufacturing, optimization of process parameters, mechanical and material characterization of fiber-reinforced polymer composite, and metal additive manufacturing are his research area of interest. He has published more than 15 research papers in National & International Conferences and Journals. He has been granted the International Travel Grant by DST, Govt. of India and CSIR-HRDG, Govt. of India.

Invited Forum

A Full Modelling Approach for the Electron Beam Powder Bed Fusion Process

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Abstract

Modelling and simulation are today recognised asessential tools for helping the process development and provide furtherunderstandings that are often difficult to findusing real-world experiments. Especially in the field of additive manufacturing, the complexity involved in the process requires a description in length and time scales of many orders of magnitude. Each modelling scale represents a selected portion of the process and these models are extremely powerfulwithin the boundary of conditions in which each model has been developed. This work presents a picture of a modelling approach, in the case of the electron beam powder bed fusion (EB-PBF) process, which spansa wide range of length and time scales necessary to address the multi-physics of the process (EB-PBF).

Biography

Dr. Eng. Manuela Galati is an Assistant professor in Technologies and manufacturing systems at the department of Management and Production Engineering, Politecnico di Torino, Italy. She is also senior researcher at the Integrated Additive Manufacturing (AM) Center at Politecnico di Torino, Italy (iam.polito.it). She received her MSc in mechanical Engineering in 2013 and PhD in Management, Production and Design in 2017. Her research spans from product quality measurements to process modelling and process performance analysis via statistical instruments, process optimisation for new materials and part quality, and process qualification, includingnew methodologies and tools for design for AM. A specific attention is devoted to electron beam powder bed fusion (EB-PBF) processes. She is author and coauthor of more than 40 papers on international journals and conference proceedings. He is co-author of an Italian and international patent in the field of Additive Manufacturing. She is also author of the chapter “Electron Beam Melting Process: A General Overview” included in the book “Handbook in Additive Manufacturing and Surface Treatment” - Elsevier Inc., published in May 2021. In 2020, she was awarded with the Medal "Leonardo Da Vinci" for the best original scientific or artistic paper in the category of young researchers.

Modular Bioinks for Bioprinting Heterogenous 3D Living Constructs

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Abstract

Bioprinting is assuming a central position in tissue engineering and regenerative medicine, enabling the fabrication of biologically functional 3D constructs and in vitro tissue models. In recent years, a great interest has been focused on the design of bioinks capable of recapitulating key features of native extracellular matrix (ECM). Inspired by the composition, properties and functions of ECM, several strategies have been proposed to design ECM-mimetic bioinks with tunable and controllable characteristics. This talk will discuss recent advances in the rational design of bioinks for 3D bioprinting, focusing on the regulatory role of material cues on cell behavior and biological function of bio printed constructs.

Biography

Rúben Pereira is an Assistant Professor at Instituto de Ciências Biomédicas Abel Salazar (ICBAS, University of Porto) and Assistant Researcher at the Biofabrication Group (i3S, Instituto de Investigação e Inovaçãoem Saúde). He holds a PhD in Biomedical Sciences with specialization in 3D bioprinting and has been collaborating with the pharmaceutical industry in the design of biomaterials for skin repair. He has also been involved in research projects in the fields of bioengineering, 3D bioprinting and tissue engineering. His research interests focus on the development of dynamic hydrogels for the bioprinting of biomimetic cell microenvironments for tissue engineering and regenerative medicine applications.

Predicting Part Properties in the Material Extrusion Process by Modeling and Simulating the Thermal HistoryField

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Abstract

The use of Additive Manufacturing within industries such as automotive and aerospace has lately extended beyond the use of prototyping. The transition towards direct manufacturing of parts using high-performance semi-crystalline polymers requires machine and parameter settings to be critically selected. As of today, no link exists between the print process parameters and its corresponding mechanical properties. In order to compete with conventional manufacturing methods such as metallic milling, it is necessary to manufacture strong and lightweight components that have guaranteed homogeneous material properties, are independent of part complexity and size, and do not require any form of expensive post-processing such as annealing.

In this study, the thermal history of the Material Extrusion process is simulated using Abaqus 2020 based on a non-isothermal crystallization and autohesion model and the application of user-specified material models. By smartly adapting the key process parameters, this additional step in the end-to-end process allows to select the most feasible key process parameters resulting in the highest degree of crystallinity and interface strength. The experimental set-up consists of Luvocom 3F PEEK 9581NT filament with an Intamsys Funmat Pro 610HT printing platform. Tensile specimens according to ISO527 and fracture toughness specimens according to ISO13586 were printed and used as input for user-specified material models.

By simulating the manufacturing process, it was found that material cooling rates had the biggest influence on the formation of crystalline regions as well as interface strength. This is mainly determined by the temperature of the substrate during deposition of the current layer and was efficiently adapted by changing the build space and platform temperature. For specimens printed at a build environment temperature of 100°C and 250°C, the out-of-plane tensile strength changed from 69MPa to 95MPa, which indicates the need for selecting the proper process settings for complex components based on simulation.

Biography

Jorne Driezen is a PhD student at the Faserinstitut Bremen e. V. (University Bremen, Germany) and works in combination as a scientific researcher at CTC GmbH (an Airbus Company), located in State Germany. He obtained his master degree at the Delft University of Technology in the Netherlands at the faculty of Aerospace Engineering. Since 2019 he is working within the Additive Manufacturing environment and focuses on the introduction of novel high performance thermoplastic and composite materials in the aviation industry.

His scientific interest includes modelling material behavior, process simulation and certainly experimental lab work of several manufacturing processes in particular for continuous fiber Additive Manufacturing

Development of 3D-Printed Tool for Cardiovascular Surgery

Giacomo Talevi

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Abstract

The medical industry, already one of the largest users of additive manufacturing (AM),is one of the industries where the twin advantages of complex part design freedom and personalization, offered by AM, can really be exploited. It is also the industry where some of the most cutting edge and groundbreaking uses of additive manufacturing are taking place and being researched. Brugada syndrome was recently identified in 1992. Its global prevalence varies from 5-20/10,000 subjects worldwide with a higher incidence in men and accounts for up to 20% of sudden deaths in patients with apparently normal hearts. Recent studies prove that it is Brugada Syndrome, rather than long QT syndrome, the most common cause of sudden cardiac death. The realization of patient-specific tools realized through the 3D printing process, could implement a well-established procedure for the treatment of this syndrome. The surgical tool is designed to protect the non-pathogenic parts of the heart during the ablation procedure.

Biography

Dr. Giacomo Talevi is a Ph.D. student in Medicine focused on the application of additive manufacturing in cardiology at the Universitair Ziekenhuis Brussel. He achieved his Bachelor's degree in Biomedical Engineering at the Università Politecnica delle Marche. He obtained his master's degree in Biomedical Civil Engineering specialized in Biomechanics and Instrumentation at the Université libre de Bruxelles. Co-author of three scientific articles, one of which is about the 3D Printed Surgical Guide for Coronary Artery Bypass Graft. Founder of a start-up that offers precision agriculture facilities among which customizable Io T services are made by the 3D printing process.

Nickel Based Composite Materials for 3D Printing of Porous Structures

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Abstract

Porous materials are extremely important functional materials with a number of potential applications, such as catalysis, electro catalysis and fuel cells. The key aspects that should be taken into consideration when designing a new material are the proper material composition, its microstructure, as well as the final properties. From the point of view of above mentioned applications, the material should be characterized by high open porosity. Appropriate micro and macro porosity enables the optimal flow of liquid and gaseous reagents through the material, ensuring high efficiency of the processes carried out (e.g. methanation).

Catalysis is an area where two additive manufacturing methods, i.e. DIW (Direct Ink Writing) and FDM (Fused Deposition Modeling), are of great interest especially in the case of open porous catalysts and their supports. The literature reports focus mainly on ceramic materials, hence the possibility of printing nickel or hybrid (nickel-ceramic) materials, especially with high open porosity and controlled micro structure is a unique approach.

The presentation focuses on some of the research conducted on the porous materials prepared via two 3D printing techniques: FDM and DIW. In the first one polymer based nickel composite filaments were prepared and used for printing. In the DIW method ceramic based pastes with nickel powder were applied. The structures after printing were thermally treated in order to remove organic molecules and partially sinter the powder particles. The results of material fabrication and characterization are presented and discussed in details.

Biography

Ewelina Mackiewicz graduated in chemistry (2013) and received the Ph.D. degree in natural sciences in the discipline Chemical Sciences (2020) at the Faculty of Chemistry of the University of Lodz in Poland. She completed several international scientific stays and internships, including to the University of Cadiz in Spain and CEITEC, Brno University of Technology in Czech Republic. Dr. Ewelina Mackiewicz is currently employed as the postdocs at the Faculty of Materials Science and Engineering of Warsaw University of Technology. Her scientific achievements include 7 publications, two national patents related to the subject of materials science, many awards for scientific achievements, and numerous national and international conference presentations. Her scientific interests include fabrication and characterization of different functional materials, including porous materials, 3D printing, catalysis, chemical modification of materials.

Laser Powder Bed Fusion of High Stiffness Titanium based Metal Matrix Composite for Space Applications

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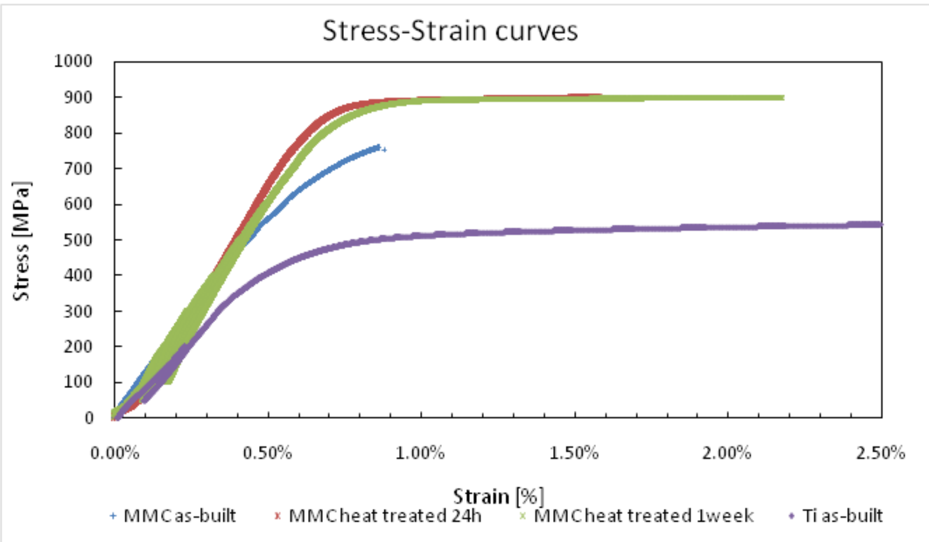
Abstract

Space applications require reliable components as light as possible. In the last years, the use of additive manufacturing in the space industry has grown drastically as it allows to produce more complex parts with minimum machining. It led to a reduction of the number of components and allowed the use of tools such as topology optimization to reduce the weight of the parts. However, even by combining Additive Manufacturing and Topology Optimization, lightweigthing is still limited by the ratio of mechanical properties to the density of the selected material. One way to change this ratio is to produce Metal Matrix Composites (MMCs). MMCs are composed of a continuous metallic matrix reinforcement by a second phase, generally ceramics. The reinforcement typically takes most of the load leading to increased mechanical properties.

In the present work, we focus on a Laser Powder Bed Fusion (LPBF) processas a way to produce Metal Matrix Composites (MMCs). Although very promising, the AM process of MMCs is highly challenging due to the need for homogeneous powder mixes, a reduced process window, a more complex metallurgical system and increased post-process internal thermal stress. The focus of this presentation is on Titanium reinforced by Titanium Carbide and how to address the aforementioned challenges.MMCs were produced over a wide range of processing parameter and their microstructure and mechanical properties were characterized. We show the processing route to obtain fully dense Ti-TiC MMC with more than 30% stiffness and strength improvement while having more than 3% elongation.



Biography

Gaetan Bernard is a PhD student at CSEM research center in Neuchâtel, Switzerland. He studied Material Science at Swiss Federal Institute of Technology in Lausanne, Switzerland and worked in GF Machining Solutions as a Research Engineer on Laser Texturing before starting his PhD Laser Powder Bed Fusion of Metal Matrix Composite for Space Applications at CSEM. His work focuses on the development of high specific stiffness Titanium based Metal Matrix Composites produced by Laser Powder Bed Fusion.

Virtual Presentations

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November 10-11, 2022 | Valencia, Spain

BIM-driven Computational Design for Robotic 3D Concrete Printing: A Design-To-Manufacturing Approach

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Abstract

As the Architecture, Engineering, and Construction (AEC) industry's digitization accelerates, digital technologies and their relation to design and construction are reaching a new level of complexity. Data integration is becoming the quest of ad hoc digital tools, and workflow automation is gaining momentum. These global developments are forcing the built environment to implement drastic changes in how construction projects are designed and produced. In this context, Building Information Modeling (BIM) gained momentum in design practices through its ability to frame construction workflows in a digital environment. On the other hand, interest in Robotic Manufacturing (RM) for industrialized production has significantly increased thanks to the opportunities it offers to improve productivity. However, the joint use of BIM and RM in construction has not yet been sufficiently studied in the scientific literature. Moreover, each system is characterized by its software and proprietary file formats, implying a lack of technological interoperability between the BIM-RM dyad.

This presentation discusses the operationalization of robotics in construction through 3D Concrete Printing (3DCP). Specifically, it clarifies the technological integration of BIM and RM tools to operationalize industrial robots in construction systems. The literature review initially found that such integration is achievable through Computational Design (CD) tools. It also found that Off-Site Construction (OSC) is a suitable system for this technological integration. These findings were studied through the Design Science Research (DSR) methodology, which demonstrated the technological interoperability of the BIM-CD-RM triad in OSC systems. This technological convergence led to the Design-to-Manufacturing (DtM) framework, which was validated by a board of 16 evaluators.

Biography

Walid ANANE is currently a member of the GRIDD research support team and a teaching assistant at École de Technologie Supérieure (ÉTS).His current research interests include BIM, Computational Design, Robotic Manufacturing, and Off-Site Construction.

Multi-Scale Finite Element Simulation of Laser Powder-Bed Fusion Additive Manufacturing Process

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Abstract

Laser Powder-bed fusion (LPBF) is an additive manufacturing process that produces complex geometries for structural components. Through LPBF, successive powder layers are selectively melted by a laser beam to fabricate a part directly from a three-dimensional model. There are however certain technical barriers and challenges associated with the production of metallic components. As a result of the thermal cycles associated with LPBF process, parts manufactured using this method tend to exhibit high residual stresses and distortions. For investigating the influence of various processing parameters on part quality and optimizing those parameters, a numerical model to predict residual stresses and distortions would be highly beneficial. Additionally, the use of a reliable numerical model can reduce the need for numerous tests, cut-ups, and manufacturing iterations generally associated with the development of optimized process parameters and part design. In this study, a high fidelity finite element (FE) model has been developed to numerically simulate the LPBF process in order to predict the induced residual stresses and distortions. Results from the preliminary analyses indicate that the model results have good agreement with experimental data and previous predictions from FE, in addition to resulting in significant reductions in computational time.

Biography

Dr. Marjan Molavi-Zarandi is a Research Officer in the Automotive and Surface Transportation Centre at the National Research Council of Canada (NRC) located in Montreal, Canada. After completing her Ph.D. studies in Mechanical Engineering at McGill University, she worked as a Postdoctoral Fellow in the Advanced Structure Core Engineering Department at Bombardier Aerospace focusing on design and topology optimization for laser powder bed fusion (LPBF) additive manufacturing. In 2015, she joined Siemens Canada as a Postdoctoral Fellow to expand her expertise in advanced manufacturing by the development of a high fidelity finite element model to simulate the LPBF process with applications in gas turbine components. Since joining the Numerical Modelling and Simulation team at NRC in 2016, Marjan has been pursuing her R&D activities by engaging in several collaborative research projects in numerical modelling for fluid and structural mechanics, heat transfer, multi-physics topology optimization, composite forming and additive manufacturing processes.

Substrate Stereolithography of Fine Ceramic Additive Manufacturing

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Abstract

In stereo lithographic additive manufacturing (STL-AM), 2-D cross sections were created through photo polymerization by UV laser drawing on spread resin paste including nanoparticles, and 3-D models were sterically printed by layer lamination. The lithography system has been developed to obtain bulky ceramic components with functional geometries. An automatic collimeter was newly equipped with the laser scanner to adjust the beam diameter. Fine or coarse beams could realize high resolution or wide area drawings, respectively. As the row material of the 3-D printing, nanometer sized metal and ceramic particles were dispersed into acrylic liquid resins at about 60 % in volume fraction. These materials were mixed and deformed to obtain thixotropic slurry. The resin paste was spread on a glass substrate with 50 μm in layer thickness by a mechanically moved knife edge. An ultraviolet laser beam of 355 nm in wavelength was adjusted to 50 μm in variable diameter and scanned on the spread resin surface. Irradiation power was automatically changed for an adequate solidification depth for layer bonding. The composite precursors including nanoparticles were dewaxed and sintered in the air atmosphere. In recent investigations, ultraviolet laser lithographic additive manufacturing (UVL-AM) was newly developed as a direct forming process of fine metal or ceramic components. As an additive manufacturing technique, 2-D cross sections were created through dewaxing and sintering by UV laser drawing, and 3-D components were sterically printed by layer laminations with interlayer joining. Through computer-aided smart manufacturing, design, and evaluation (Smart MADE), practical material components were fabricated to modulate energy and material transfers in potential fields between human societies and natural environments as active contributions to Sustainable Development Goals (SDGs).

Biography

Soshu Kirihara is a doctor of engineering and a professor of Joining and Welding Research Institute (JWRI), Osaka University, Japan. In his main investigation “Materials Tectonics as Sustainable Geoengineering” for environmental modifications and resource circulations, multi-dimensional structures were successfully fabricated to modulate energy and materials flows effectively. Ceramic and metal components were fabricated directly by smart additive manufacturing, design and evaluation (Smart MADE) using high power ultraviolet laser lithography. Original stereolithography systems were developed and new start-up company “SK-Fine” was established through academic-industrial collaboration.

Poster Presentations

3D Printing of High Temperature Fuel Cell's Components

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Abstract

High-temperature fuel cells are electrochemical devices which convert fuels, e.g. hydrogen or methanol, into electricity above 500℃. They are extensively investigated as a promising green energy conversion technology. Among others, there are two popular types of this technology: molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC). Both consist of three basic elements: anode, cathode and electrolyte. Each element should have appropriate properties that connect with chemical and microstructural optimization. Critical parameters are open porosity, average pore size and specific surface, which directly influence densities of (electrode–electrolyte-pore) triple phase boundaries (TPBs) and enhance fuel cell performance. These parameters depend mainly on the chosen manufacturing methods. One of the new methods used in fuel cells is 3D printing.

Compared with conventional fuel cells manufacturing methods such as tape casting, sintering or screen printing, the 3D printing technology makes personalized design cheaper and less time-consuming. This allows optimizing the device to a specific application. Additionally, it allows overcoming technological limitations such as fuel cell dimensions, different sintering temperatures of particular elements, creating a very thin, continuous layer and hierarchical porous structure.

Within these studies, the possibility of using 3D printing technology to manufacture composite elements of high-temperature fuel cells is addressed.

Biography

Gabriela Komorowska is a PhD student at the Faculty of Materials Science and Engineering of Warsaw University of Technology in Poland. Her research covers the area of high-temperature fuel cells. Her interests include fuel cells, ceramics and manufacturing methods of porous materials..

Composite Filaments for 3D Printing of Highly Porous Materials

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Abstract

3D printing of porous materials enables for the design of the microstructure with respect to medium flow and free surface area reactions, which are of key importance for catalysis. Various 3D printing techniques can be applied to achieve special pore architecture. Within these studies the porous materials are fabricated by Fused Deposition Modeling (FDM) 3D printing basing on thermoplastic matrix reinforced by metallic and/or ceramic particles, which after firing form a three-dimensional porous structure.

The high volume fraction of metal and/or ceramic additives in the composite material may cause some significant changes, for instance in the extrusion properties of thermoplastics. Adding metal and, if a necessary, ceramic powder modifies the extrusion temperature of the filament and the quality of its surface, causing difficulties in maintaining the proper filament's diameter.

The abovementioned cases leads to considering modification of composite materials as a successful way to improve feedstock materials properties. Additives improve the extrusion properties of composites based on the thermoplastic matrix but also cause changes in parameters in the extrusion process.

Different additive manufacturing technologies have benefits and draw backs considering material type, design versatility, resolution and costs. Features of each 3D printing technology should be taken into consideration before choosing the appropriate method for a specific application.

Employing composite filaments for 3D printed elements creates a possibility of obtaining skeletal catalysts. After the firing process, such structures containing non-noble metals can create a hierarchical porous material with a high surface area, which may improve catalytic activity.

Biography

Remigiusz Nowacki graduated in materials engineering (2018). He worked for three and a half years in the defense industry company and since 2021has been a PhD student in the Faculty of Materials Science and Engineering of Warsaw University of Technology. MSc. Eng. Remigiusz Nowacki started working in a field related to 3D printing in a start-up company in 2017 before graduating from his studies. While working in the defense industry and in his subsequent PhD studies, Remigiusz Nowacki developed his own start-up company called Cbox in the Ed tech industry. His scope of work during PhD includes 3D printing, feedstock materials preparation (including modification) and characterization. Remigiusz Nowacki also actively participates in the life of the University, including the Committee on Education.

Global Conference on 3D Printing and Additive Manufacturing

November 10-11, 2022 | Valencia, Spain

3D Printing Technology for Marine Propeller Prototypes

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Abstract

Additive Manufacturing (AM), which leads to gaining a final form of the objects by creating objects layer-by-layer, is currently the fastest developing manufacturing method. AM is showing its advantages there, where a need for the production of products of non-standard shape and specific properties occurs. The Wire Arc Additive Manufacturing (WAAM) uses, for the 3D printing, the MIG/MAG welding process which uses an electric arc that is created between consumable electrode and workpiece. Taking account of both the installation costs and input materials costs, WAAM represents the technology with the lowest investment needs, in comparison to other additive technologies, especially those using metal powders. Moreover, this technology allows rapid manufacturing of elements of complicated shapes, without porosity, so WAAM is mostly used in the case of prototyping and medium-, large-scale production. WAAM requires using adequate printing parameters, which are dependent on the used feedstock, shape and size of the final object, and also its final work conditions. Occurring heat cycles during the 3D printing process can be used for creating product functional properties. Phase transformations and precipitation processes which are controlled by, among others thermal processes occurring during WAAM, provide the possibilities of gaining final products revealed high mechanical properties.

The main objective of the work was to print a prototype of a marine propeller using the 3D Metal Printing process (3DMP® process – belongs to WAAM group technologies) based on the material technological concept developed in the frame of a project: "3DMPWire. Material-efficient Cu wire-based 3D printing technology". Feedstock materials in the form of 1.0 mm

wires, were used for the propeller prototype manufacturing. Based on the preliminary research, optimization of 3D printing technological parameters of a propeller demo suited for this type of object was carried out. The prototypes of a marine propeller were printed by means of the 3DMP® process. The printed elements were subjected to a quality check and tests. The X-Ray and Ultrasonic techniques have been used to investigate defects and porosities of the propeller.

Keywords: WAAM; marine propeller; additive manufacturing; CuAl alloys

Biography

Joanna Kulasa, PhD Eng. Joanna Kulasa has a PhD degree in technical sciences in the field of Metallurgy from the Silesian University of Technology. Director of the Centre for Advanced Material Technologies in Łukasiewicz Research Network - Institute of Non-Ferrous Metals, Gliwice, Poland.

Her scientific and research work focuses on the development of, among others: modern manufacturing technologies, including additive manufacturing technologies (WAAM), non-ferrous metals alloys and composites (high-temperature pressure infiltration, stir casting, and powder metallurgy), plastic working and heat treatment of non-ferrous metals and their alloys, material testing (advanced methods of structure examination, tribological tests). J. Kulasa has gained experience as a manager and co-author of projects co-financed from structural and European funds, the winner of 12 distinctions and awards. Author and co-author of more than 63 research and development works and more than 50 national and international scientific publications, mainly in the field of foundry, additive manufacturing, non-ferrous metals processing, composite materials, and tribological properties of these materials. She is Co-creator of patents and patent applications, as well as industrial implementations. She was responsible for projects management in international and national R&D projects.

WAAM Parameters Optimization for Non-Commercial CuAl-Based Alloys

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Abstract

The use of Additive Manufacturing - AM has so far been limited to quick prototyping, and research, although the development of available techniques for producing objects from digital models, and thus the possibility of creating new or improved products, has led to a rapid increase in interest in these technologies from the point of view of mass production. Wire Arc Additive Manufacturing (WAAM), due to the high speed of manufacturing objects with complex shapes and the low price of the input material, has a significant potential for use in mass production. Moreover, the WAAM is considered an alternative, competitive, and more environmentally friendly to presently used conventional metal processing technologies. The WAAM technology uses the MIG/MAG welding process for printing, which is welding with an electric arc generated between the consumable electrode and the material being welded. The consumable electrode in this case is a continuously fed wire. The arc and molten metal pool are protected by a stream of shielding gas.

The main objective of the work was to optimize the printing parameters of the WAAM to print the test objects. Optimization of the WAAM parameters was carried out with the use of both commercial wires, as well as the non-commercial wires. The parameters optimization was carried out on the arc403 3D Printer by Gefertec. The protection gas was a mixture of helium and argon. The optimization of parameters was carried out during the printing of objects in the form of blocks and consisted of the assessment of the stability of subsequent layers of the material deposition, including the stability of the electric arc burning, the number of splashings, and the assessment of the geometric correctness of the produced test objects. The scope of optimization included the analysis of the content of individual gases of the helium-argon mixture and the selection of an appropriate synergic line (current-voltage characteristics) of welding adapted to Cu-based materials and the determination of the WAAM parameters. The microstructure analyses of the printed blocks were carried out using Light and Scanning Electron Microscopy.

Keywords: 3D printing; WAAM; CuAl alloys; additive manufacturing

Biography

Aleksander Kowalski, PhD Eng. Graduated in material processes technologies from the Silesian University of Technology in Gliwice in 2010. PhD Eng. degree in the field of material engineering received in 2016 at the Institute of Engineering Materials and Biomaterials of the Silesian University of Technology. The PhD thesis “The influence of structure on mechanical properties and corrosion resistance of Al-Zn-Mg alloys in seawater” was honoured by the Scientific Council of the Faculty of Mechanical Engineering, the Silesian University of Technology. Since 2018 he has worked as an assistant professor at the Metal Processing Department of the Łukasiewicz Research Network – Institute of Non-Ferrous Metals in Gliwice. Main scientific and research activities focus on: wire-feed additive manufacturing (3D Printing); the development and manufacturing of non-ferrous metals and their alloys as well as their thermo-mechanical treatment, study of structure development, mechanical, fatigue, and tribological properties; metal matrix composites manufactured by means of liquid phase methods. An author and co-author of research and development works, national and international scientific publications mainly in the field of processing of non-ferrous metals.

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