EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

ABSTRACTS BOOK

CONSOLIDATION TECHNOLOGIES

EPMA
european powder metallurgy association

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

AM BEAM BASED TECHNOLOGIES

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C01
ID : 6269857

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Prof Dr Afonso Conrado Ramos Moreira (Department of Materials Engineering DEMa), Brazil)

Co-author(s) : Mr Mattos Felype N. (Department of Materials Engineering (DEMa), Brazil); Prof Dr Figueiredo Roberto Braga (Universidade Federal de Minas Gerais (UFMG), Brazil); Prof Dr Caram Rubens (State University of Campinas (Dema|FEM|Unicamp), Brazil); Prof Dr Afonso Conrado Ramos Moreira (Universidade Federal de São Carlos (UFSCar), Brazil)

Title : Selective Laser Melting And High Pressure Torsion Of Beta Ti Micrometric Powders For Implant Applications

Keyword(s) :
Selective Laser Melting, High Pressure Torsion, Elastic Modulus, Beta Ti Alloys, Atomized Powders, Implant Applications

Abstract :
ß Ti alloys are acclaimed for biomedical applications due to their mechanical properties, good biocompatibility and corrosion resistance. For orthopedic applications, there is a considerable difference between elastic modulus of Ti and a+ß alloys, from E = 100 to 110 GPa, and that of human bone (E = 30 GPa). In this context, the selective laser melting (SLM) of ß Ti-15Nb (wt%) appears, since it shows lower Young modulus. Another route is the HPT of ß alloy Ti-42Nb (wt%) atomized powder in order to obtain near net shape nanocrystalline structure. Characterization of SLM of Ti-15Nb and HPT of Ti-42Nb alloys was done by optical microscopy, XRD, SEM and TEM coupled to ASTAR technique. Elastic modulus via impulse excitation were evaluated for SLM of Ti-15Nb alloy with a´+ ß microstructure and for HPT of stable ß Ti-42Nb, showed, respectively, elastic modulus of around 60 and 62 GPa for biomedical applications.

Innovative Aspect(s) :
The LPBF process successfully obtained in-situ alloying of Ti-15Nb from pure powders. Martensitic alda' and beta phases were found by XRD, SEM, and TEM analysis, depicting a homogenous and dense Ti-15Nb alloy manufactured using high energy density, exhibiting fractions of porous and unmelted Nb particles below 0.5 %. Vickers hardness measurements show low dispersion and consistent values with a martensitic a' phase of about 318 HV, corroborating with microstructural characterization. A low Young's modulus of about 64 GPa was found for denser sample and these findings highlight a promisor in-situ laser alloying of Ti-15Nb for biomedical applications. HPT at 6 GPa of stable β Ti-42Nb after 10 turns with nanocrystalline grain size of ~50 nm showed compression stremght of 1400 MPa, Vickers microhardness of 300 HV and elastic modulus of E= 62 GPa suitable for biomedical applications.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C02
ID : 6275270

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Johannsen Jan (Fraunhofer Research Institution for Additive Manufacturing Technologies IAPT, Germany)

Co-author(s) : Mr Abraham Sachin (Fraunhofer Research Institution for Additive Manufacturing Technologies IAPT, Germany); Mr Matthes Sebastian (Günter-Köhler-Institut für Fügetechnik und Werkstoffprüfung GmbH, Germany); Mr Maximilian Streinz (Günter-Köhler-Institut für Fügetechnik und Werkstoffprüfung GmbH, Germany)

Title : Influence Of Powder Moisture On The Quality In Laser Beam Powder Bed Fusion (PBF-LB|M)

Keyword(s) :
AlSi10Mg, Powder Moisture, PBF-LB|M, Quality, Humidity

Abstract :
The impact of powder moisture on the quality of additively manufactured parts through laser beam powder bed fusion (PBF-LB|M) is investigated in this study. Pre-alloyed AlSi10Mg powder was artificial moistened by aging it in a climate chamber under regulated conditions of relative humidity and temperature. Various powder batches, ranging from 85 ppm to 1767 ppm water content, were prepared and processed by PBF-LB|M using diverse sets of process parameters. The printed specimens were examined for relative density, mechanical properties, hydrogen and oxygen content.The findings demonstrate a correlation between the moisture content in the powder and both mechanical properties and H- and O-content. Notably, a decline in the quality of printed AlSi10Mg specimens is observed when the moisture content exceeds 189 ppm water content in the powder. This study sheds light on the criticality of moisture in powder, providing valuable insights for ensuring the production of high-quality additively manufactured components.

Innovative Aspect(s) :
The industrial and scientific community has noticed a negativ behaivour of moistured metal powder onto the mechanical properties of parts additivley manufactured with laaser beam powder bed fusion. However, a comprehensive study of the impact of moistured powder onto the quality of printed parts and the effect on the PBF-LB|M process was missing. This study for the first time used controlled moistened powder to analyze the effect and mechanisms on the part properties. With the measurements of the resulting H- and O-content in the printed parts the mechanism of the reduction of mechanical properties can be reconized. The results highlight the importance of the quality control of the moisture in AM-metal powders and will help the AM community to ensure high-quality AM parts.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C03
ID : 6276978

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Memu Firat (TOBB University of Economics and Technology, Turkey)

Co-author(s) : Prof Dr Durlu Nuri (TOBB University of Economics and Technology, Turkey)

Title : Size-Dependent Microstructure Of Electron Beam Melted Ti-6Al-4V Alloy

Keyword(s) :
Electron Beam Melting, Ti-6Al-4V, X-ray Diffraction, Microstructure, Size Effect, Mechanical Properties

Abstract :
The Powder Bed Fusion (PBF) techniques allow for the production of complex-shaped components, yet geometric variations lead to varying mechanical properties within the fabricated structures. Despite employing the same manufacturing process, specimens of different sizes exhibit distinct microstructures. This study compares the microstructures of Electron Beam Melted (EBM) Ti-6Al-4V samples with build diameters of 6, 7.5, and 15 mm by examining alpha (a) phase thickness, dislocation densities, and hardness. Lattice parameters of phases and dislocation densities in the specimens are compared through X-ray diffraction (XRD) analysis. Notably, the study finds that a phase thickness increases with an increase in build diameter. The results demonstrate that size-induced differences in microstructure led to variations in mechanical properties. This highlights the crucial need to consider size effects in the design and assessment of complex PBF-fabricated structures.

Innovative Aspect(s) :
Witness samples are frequently used in various studies and manufacturing procedures to assess the final mechanical characteristics of a part produced through Powder Bed Fusion techniques. However, this practice increases the unnecessary use of alloy powder, resulting in adverse effects on the environment, cost, and time. Alternatively, without the requirement for destructive mechanical tests, the regional mechanical properties can be predicted by analyzing the traces of geometric differences in the final microstructure. The study examines the thickness of alpha phase, dislocation densities, and hardness to reveal the complexities of size-related impacts of Electron Beam Melted Ti-6Al-4V samples. The detailed examination of X-ray diffraction (XRD) helps in understanding the variations in lattice parameters and dislocation densities that are dependent on size. The study's novelty is found in its investigation of how these features directly impact the mechanical properties, highlighting the essential need to take into account the effects of size.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C04
ID : 6278214

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Salam Shahzad (Sumitomo Heavy Industreis ltd., Japan)

Co-author(s) : Dr Mitama Ichiro (Sumitomo Heavy Industreis ltd., Japan); Mr Sakata Takuma (Sumitomo Heavy Industreis ltd., Japan)

Title : Influence Of Powder Characteristics On Mechanical Behavior Of Additively Manufactured Alloys

Keyword(s) :
Additive Manufacturing, Mechanical Properties, Powder Characterisitics

Abstract :
Powder quality is a critical processing parameter in powder-based metal additive manufacturing that can affect both the processability and mechanical properties of the manufactured parts. While commercially available powders come in various shapes, sizes, and distributions, it is essential to understand the impact of these powder characteristics on the finished product. This study investigates the correlation between powder characteristics and stress-rupture behavior of IN718 alloy. Test samples were fabricated using laser powder bed fusion (L-PBF) with powders of varying characteristics. The results indicate that the samples fabricated with powder of optimal characteristics contained fewer microstructural defects resulting in a significant 13-fold improvement in rupture-life. The aim of this article is to discuss these powder effects and provide a basis for producing final components with consistent mechanical properties.

Innovative Aspect(s) :
Powder effects on high-temperature mechanical properties of additive manufactured alloys are reported.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C05
ID : 6278649

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Miss Lupi Giorgia (Politecnico di Milano, Italy)

Co-author(s) : Miss Ceroni Marta (Politecnico di Torino, Italy); Prof Actis Grande Marco (Politecnico di Torino, Italy); Prof Casati Riccardo (Politecnico di Milano, Italy)

Title : Powder Functionalization Of Pure Cu With Ag For Improved PBF-LB|M Processability

Keyword(s) :
Coated Metal Powders, Powder Functionalization, PBF-LB|M, Copper, Silver

Abstract :
The PBF-LB processability of pure Cu pose significant challenges due to the high laser-reflectivity and thermal-conductivity of this metal. Near-IR lasers are widely considered not suitable for processing Cu, unless high power is employed, limiting the accessibility to Cu. In this work, we investigate a disruptive approach to improve Cu processability by using a low-power (200W) near-IR PBF-LB|M system, which is based on the Ag-coating of Cu particles that were heat-treated at 500°C|600°C to promote diffusion at the coating interface. Pure Cu and coated powder were processed by PBF-LB|M to produce bulk samples. Microstructure analysis was performed by SEM, EDX, and XRD. It was observed that the Ag layer has a positive effect on the laser processability of Cu. Almost fully dense materials (>98%) were achieved due to the formation of a Cu-Ag eutectic network able to heal pores and defects during solidification.

Innovative Aspect(s) :
The near-IR PBF-LB at low power is difficult due to the high reflectivity and thermal conductivity of Cu. Manufacturing of fully dense Cu parts with conventional PBF-LB systems is challenging.Cu powder particles were coated with a thin layer of Ag to improve their PBF-LB processability. The functionalization of Cu powder with Ag is a novel approach, highly scalable, that has never been studied so far.This work sheds light on the ability of Ag layer to heal pores and defects during solidification of Cu.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C06
ID : 6281101

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Thangamani Geethapriyan (Politecnico di Torino, Italy)

Co-author(s) : Mr Vanzetti Matteo (Politecnico di Torino, Italy); Mr Felicioni Stefano (Politecnico di Torino, Italy); Dr Padovano Elisa (Politecnico di Torino, Italy); Prof Bondioli Federica (Politecnico di Torino, Italy)

Title : Microhardness And Microstructural Evolution Of Additive Manufactured GRCop-42 By Electron Beam Powder Bed Fusion

Keyword(s) :
Additive Manufacturing, Electron beam Powder Bed Fusion (EB-PBF), GRCop-42, Microhardness, Microstructure

Abstract :
GRCop-42 samples were additively manufactured by varying the electron beam powder bed fusion (EB-PBF) process parameters in a volumetric energy density (VED) range from 112.9 – 213.3 J|mm3: laser scan speed was varied from 450–850 mm|s, while voltage, power, line-offst and layer thickness were fixed parameters, to study their influence on the density, melt pool structure, and microstructure. Under the optimal conditions, the microhardness of the GRCop-42 samples achieved the highest value of 112.4 ± 5.8 HV. In addition, the microstructural evolution as a function of VED variation on additive manufactured GRCop-42 samples was examined using scaining electron microscopy (SEM) and X-ray Diffraction. From the microstructure observation, Cr2Nb precipitates, formed in the alloy during the printing process, reinforce the Cu matrix by preventing dislocation motion and impeding grain development.

Innovative Aspect(s) :
This study demonstrates the use of innovation in GRCop-42 sample additive manufacturing by carefully examining the parameters of the electron beam powder bed fusion (EB-PBF) method. Interestingly, the study maintains other parameters constant and systematically modifies the laser scan speed within a given range, providing a detailed analysis of its effects on density, melt pool structure, and microstructure. This comprehensive approach adds greatly to developing additive manufacturing methods and understanding material behavior, marking a remarkable step forward in the area. These GRCop alloys with exceptional oxidation resistance were created specifically for regeneratively-cooled combustion chambers and nozzles in severe situations. Consequently, the creation of GRCop-42 for use with combustion devices for liquid rocket engines.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C07
ID : 6281567

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Riabov Dmitri (Höganäs AB, Sweden)

Co-author(s) : Dr Frisk Karin (Innomat AB, Sweden); Prof Dr Bengtsson Sven (Höganäs AB and Chalmers University of Technology, Sweden)

Title : Novel Co-free Precipitation Strengthened Tool Steel For Additive Manufacturing - Properties And Microstructure

Keyword(s) :
LB-PBF, Tool Steel, Cobalt, Precipitation, Mechanical, Powder, Microscopy, Xrd, Processing

Abstract :
This work presents the alloy TS-CF1, a new cobalt-free stainless maraging steel designed specifically for laser-based powder bed fusion using a computer-based alloy design approach. The aim was to create a material that easily printable, while performing similarly to the common maraging variant 18Ni-300. After exploring various compositions, we settled on Fe-13.2Cr-9.1Ni-1.1Al-0.6Mo-0.5Nb-0.23Ti-0.5Mn-0.5Si (wt.%). This composition exhibited excellent printability at 40, and 80 µm layer thicknesses with minimal porosity. The precipitation response was assessed by aging at 500 °C, in both as-printed and solutioned conditions. A balanced set of properties was reached after aging between 3 and 6 hours, reaching 50 HRC. Different conditions were microstructurally characterized using EBSD and XRD, showing a mostly martensitic structure with some retained austenite. The tensile strength was between 1560 and 1700 MPa, where higher strength was reached by performing a solutioning heat-treatment. Long-term high temperature exposure tests showed good resilience against precipitate coarsening.

Innovative Aspect(s) :
The innovation is that it is a Co-free stainless, printable, age-hardenable alloy that was developed using the CALPHAD methodology. The alloy reaches relatively high hardness of 50 HRC and retains it after pro-longed exposure to higher temperatures, which is otherwise difficult to accomplish using carbon alloyed steels without cracks or defects. Effects of microstructural constituents on mechanical performance are explored and elucidated.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C08
ID : 6281597

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ms Larsson Anna (Höganäs AB, Sweden)

Co-author(s) : Mr Oshchepkov Denis (Höganäs AB, Sweden); Mr Gårdstam Johannes (Quintus Technologies AB, Sweden); Mr Shipley James (Quintus Technologies AB, Sweden)

Title : Experience In AM & HIP Of Ni-based Superalloys

Keyword(s) :
Additive Manufacturing, PBF-LB, Nickel Base Superalloys, Hot Isostatic Pressing

Abstract :
Industrial sectors such as aerospace, industrial gas turbines are transforming by using powder bed fusion – laser beam (PBF-LB) process for making critical parts in nickel base super alloys. The performance requirements on these parts are very strict and process defects must be minimized and under control. All process steps must be optimized in order to reach the required quality goals. In this study the properties of additively manufactured nickel base super alloys are examined. The influence of print process, as well as post processes like heat treatment and hot isostatic pressing and the combination of the last two on the mechanical properties and on the microstructure was examined. Tensile tests, Impact test and Hardness were evaluated, and the microstructures were examined in light optical microscope and in SEM.

Innovative Aspect(s) :
Increase robustness and reliability of additive manufactured components by postprocessing.Combination of postprocessing operations (HIP + Heat treatmet) for increased productivity.Optimise the microstructure for desired mechanical properties.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C09
ID : 6281702

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Guimarães Bruno (Palbit S.A., Portugal)

Co-author(s) : Dr Fernandes Cristina (Palbit S.A., Portugal); Mr Figueiredo Daniel (Palbit S.A., Portugal); Prof Dr Miranda Georgina (CICECO - Aveiro Institute of Materials, Portugal); Prof Dr Silva Filipe (CMEMS - University of Minho, Portugal)

Title : WC-Co Smart Cutting Tools With 3D Printed Embedded Thermocouples For Real Time Cutting Temperature Measurement

Keyword(s) :
WC-Co Smart Cutting Tools, Additive Manufacturing, Multi-Material Laser Powder Bed Fusion, 3D Printed Embedded Thermocouples, Cutting Temperature Measurement

Abstract :
In the scope of Industry 5.0 applied to the cutting tools industry, the advent of smart cutting tools consisting in the integration of sensors in cutting tools to monitor, and thus help control and adjust in real time different aspects of a machining process, arises as a unique opportunity to achieve unprecedent levels of operational efficiency and productivity. Therefore, this work focuses on the incorporation of temperature sensors in WC-Co cutting tools for measuring cutting temperature, through the fabrication of 3D printed K-type embedded thermocouples by multi-material laser powder bed fusion. The thermocouples powder composition was prepared through high-energy ball milling and properly characterized to guarantee the characteristics for laser powder bed fusion. Validation in an industrial environment during turning of different alloys revealed that the developed 3D printed embedded thermocouples can measure precisely and accurately cutting temperature in real time, as well as withstand the demanding turning process.

Innovative Aspect(s) :
To the authors best knowledge, the present study is the first reporting the fabrication of 3D printed embedded thermocouples by additive manufacturing technologies for cutting temperature measurement during machining applications. Moreover, a multi-material laser powder bed fusion approach was employed for the fabrication of the embedded thermocouples, which allied to the high fabrication freedom of this technology, allows the development of smart cutting tools with an extraordinary level of functionality, adaptability and tailorability.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C10
ID : 6281718

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ing Svanberg Arvid (Rise research institutes of Sweden, Sweden)

Co-author(s) : Ing Larson Anna (Höganäs, Sweden); Dr Ing Hosseini Seyed Behnam (RISE research institutes of Sweden, Swaziland); Ing Habelmann Fenja (University of Rostock, Germany, Germany); Dr Ing Khademzadeh Saeed (RISE research institutes of Sweden, Sweden)

Title : Exploring Enhanced Productivity In Laser Powder Bed Fusion Of Inconel 718: Analyzing Microstructure, Support-Free Printing, Surface Integrity, And Spatter Formation

Keyword(s) :
Powder Bed Fusion Laser Beam, Inconel 718, Productivity, Process Development

Abstract :
While laser powder bed fusion (PBF-LB) technology holds significant promise for integration into industrial manufacturing workflows, it still faces challenges related to low production rates. The adjustment of process parameters, such as the utilization of heightened values for layer thicknesses and scanning speeds, proves effective and cost-efficient in enhancing productivity in the LPBF process. However, ensuring the retention of appropriate properties poses challenges that necessitate further studies. Another obstacle arises from the elevated level of spatters due to the intensified energy density required for increased layer thicknesses. This study delves into the feasibility of this approach in enhancing productivity in PBF-LB for Inconel 718 components, encompassing inclined features. The investigation includes various aspects such as relative density, surface roughness, microstructure, spatter formation, and mechanical properties. Optimal process parameters have been determined for different layer thicknesses, extending up to 120 µm, with corresponding adjustments tailored for downfacing surfaces.

Innovative Aspect(s) :
Including challenging features, such as down-facing surfaces, in the test geometries to replicate real-world situations in productivity analysis; Analyzing spatter formation, a crucial factor in scaling up production from test geometries to actual components.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C11
ID : 6281394

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Montero-Sistiaga Maria L. (NLR- Royal Netherlands Aerospace Centre, Netherlands)

Co-author(s) : Mr Osinga Timo (NLR- Royal Netherlands Aerospace Centre, Netherlands); Mr Haagsma Ralph (NLR- Royal Netherlands Aerospace Centre, Netherlands); Dr Bottazzi Olmo (Mokveld Valves B.V., Netherlands); Ing Esveldt Vincent (Mokveld Valves B.V., Netherlands); Ing Bautmans Ludo (Oerlikon Metco AM powders, Belgium); Ing Hamer Wouter (Shell Global Solutions International B.V., Netherlands); Ing de Smit Marc (NLR- Royal Netherlands Aerospace Centre, Netherlands)

Title : Hybrid And Multimaterial Production Of A Check Valve Combining Laser Powder Bed Fusion And Directed Energy Deposition Technologies

Keyword(s) :
Directed Energy Deposition, Laser Powder Bed Fusion, Muti-material, Hybrid Manufacturing

Abstract :
Extensive research is currently done on microstructure and mechanical property characterisation of metal additive manufacturing technologies. However, there remains a limited focus on the combination of these technologies. This study addresses this gap by combining laser powder bed fusion (LPBF) and directed energy deposition (DED) technologies to produce a check valve. The interior of a valve requires high corrosion resistance which can be obtained using In718, while the exterior benefits from intermediate mechanical properties, specifically using 316L. From the consolidation side, LPBF allows the production of small complex features and DED offers a higher production rate and the possibility of tailoring compositions and mechanical properties.The interface quality and microstructure of different multi-material combinations were studied in this work. Tensile properties were investigated of hybrid multi-material parts to select the best combination. In addition, the production route for producing a multi-material check valve combining LPBF and DED was developed.

Innovative Aspect(s) :
Different multi-material interfaces are produced between 316L and In718. Besides muti-material interfaces, LPBF and DED technologies are combined to increase the production flexibility of AM. The production route for producing hybrid and multi-material check valve is described.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C12
ID : 6281572

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mrs Guillon Maxence (école des Mines de Saint Etienne, France)

Co-author(s) : Mr Desrayaud Christophe (école des Mines de Saint Etienne, France); Mr Boulnat Xavier (Mateis, France); Mr Elguedj Thomas (Lamcos, France); Mrs Lambert Pauline (école des Mines de Saint Etienne, France)

Title : Characterization Of Keyhole Regime For Laser Powder Bed Fusion: From Single Track Formation To Multi Layers Volume, The Change In Laser And Matter Interaction

Keyword(s) :
Additive Manufacturing, Laser, Focal Shift, Process Windows, 316l

Abstract :
Laser Powder bed Fusion is a strong process enabling the on-demand production of components with complex geometry and high added value. Despite its strengths, there are still significant challenges to fully understanding the interaction between laser and powder.The interaction between laser and material differs significantly between single tracks and multiple tracks. In a single track, the laser only interacts with the powder. In contrast, for multiple tracks, the laser interacts also with the previously laid tracks. This underscores the inadequacy of characterizing only a single track for a comprehensive understanding of the interactions between laser and powder. Moreover, previous analyses show a focal shift that cannot be neglected on the machine used. Hence, this works aims at characterizing the melt pool during the formation of a single and multiple tracks with 316L powder material. The consequence of the focal shift is observed and measured.

Innovative Aspect(s) :
In this paper, the innovative aspect is the characterization of laser spot due to focus beam profiler and the effect of laser focal shift on final characteristic of the final bulk material. A thorough study of the laser used for this study revealed a significant focal shift. Because of the heating of the elements in the optical path, the laser focal point tends to shift and reduce the focal distance during sintering of the powder layer. Indeed, the beam size and its energy distribution evolve quickly as a function of time. For a fixed working distance, the state of the laser beam is very different. This results in an important during the process and therefore influences the formation and integrity of the single tracks.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C13
ID : 6281977

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Kaserer Lukas (University of Innsbruck, Austria)

Co-author(s) : Dr Braun Jakob (University of Innsbruck, Austria); Dr Mayr-Schmoelzer Bernhard (Plansee SE, Austria); Dr Distl Benedikt (Plansee SE, Austria); Dr Schafbauer Wolfgang (Plansee SE, Austria); Prof Dr Leichtfried Gerhard (University of Innsbruck, Austria)

Title : Alloying Concepts For Grain Refinement And Grain Boundary Engineering In Powder Bed Fusion-Laser Beam Of Tungsten

Keyword(s) :
Tungsten, Powder Bed Fusion-Laser Beam, Alloying Strategy

Abstract :
The Powder Bed Fusion - Laser Beam (PBF-LB) technology enables the production of complex-shaped components that surpass the limitations of other manufacturing methods. PBF-LB is, therefore, ideally suited for producing functionally optimized components in novel high-tech applications, especially for high-performance materials such as tungsten (W).The disadvantage of PBF-LB-manufactured W components is that they show a coarse-grained, columnar microstructure which is prone to cracking, preventing them from competing with conventional powder metallurgical components. To suppress the formation of such an unfavorable microstructure, it is necessary to adapt the material to the unique solidification conditions of the PBF-LB process.In the present work, different alloying concepts are investigated, firstly to induce grain refinement and thus suppress the formation of a coarse-grained microstructure and secondly to purify the grain boundaries from impurities and thus prevent the formation of cracks. Both the theoretical foundation and experimental results are shown.

Innovative Aspect(s) :
Presentation of different alloying strategies to counteract the main defect-initiating mechanisms in PBF-LB of W Discussion on the mechanism of grain refinement Discussion on the mechanism for the purification of grain boundaries

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C14
ID : 6282019

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Karimi Paria (OptiFab Technologies, Canada)

Co-author(s) : Mrs Karimi Paria (Opti-Fab Technologies, Canada); Dr Sadeghi Esmaeil (OptiFab Technologies, Canada)

Title : Application-Driven Intelligent Scan Patterns In Additive Manufacturing

Keyword(s) :
Additive Manufacturing, Powder Bed Fusion, Toolpath, Scan Patterns, Magnets

Abstract :
This study concentrates on leveraging a distinctive feature of the 3D printing technology known as toolpaths to produce magnets essential for applications in electrical machines, notably motors and generators. Delving into the powder bed fusion branch of 3D printing processes, the focus extends to two primary magnet categories: NdFeB (integral for rotor applications in energy conversion and electronic devices) and FeSi (deployed in both rotor and stator cores). Employing artificial intelligence-based scan patterns for each layer, the study aims to optimize thermal and stress distribution through laser powder bed fusion (LPBF) technologies. The investigation meticulously elucidates the microstructure evolution and phase selection, highlighting the significance of solidification parameters influenced by scan patterns. Despite yielding identical relative densities, different scan patterns engender varying structural features, thereby impacting magnetic properties. Applying a targeted scan pattern mitigates losses, yielding superior magnetic properties compared to conventional methods and laser powder bed fusion (LPBF).

Innovative Aspect(s) :
OptiFab is showcasing an AI-powered platform that generates scan patterns and optimizes each individual layer in order to minimize the part deformation and decrease dependence on design-oriented aspects throughout the process.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C15
ID : 6281988

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mrs Leclercq Aurore (École de Technologie Supérieure de Montréal, Canada)

Co-author(s) : Prof Brailovski Vladimir (École de Technologie Supérieure de Montréal, Canada)

Title : Effects Of Laser Powder Bed Fusion And HIP Conditions On The Physical And Mechanical Properties Of Pure Molybdenum Parts At Room And Elevated Temperatures

Keyword(s) :
Molybdenum, Laser powder bed fusion, HIP, Modeling, Numerical predictions, Mechanical testing, Crack-free specimens, Geometric analysis

Abstract :
Molybdenum belongs to the refractory metals group and is one of the target materials for laser powder bed fusion additive manufacturing. To correlate the physical and mechanical properties of parts printed using molybdenum powders, a comprehensive design-of-experiment protocol was built using a numerical model of the melt pool generated in a semi-infinite volume by a moving gaussian heat source. Specimens were printed, post-treated (HIP) and characterized at room and elevated temperatures in terms of their density, structure and compression behavior. The HIP treatment enabled to increase the printed density by up to 10% and resulted in the material density of 93%, an ultimate compression stress of 510 MPa (250 MPa at 800°C) and a maximum compression strain of 11% (17% at 800°C). Finally, the optimized printing and post-treatment conditions were used to successfully print selected geometric features.

Innovative Aspect(s) :
Molybdenum is a material of interest for high temperature applications due to its special properties, such as its high melting point and low coefficient of thermal expansion. However, shaping molybdenum parts using conventional processes is difficult and expensive, which limits their use in high temperature applications. This study aims to expand the range of geometries achievable with this material, while limiting the cost of its shaping, by using the laser powder bed fusion process. This study contributes to a better understanding of the effects of powder granulometry, LPBF and hot isostatic pressing conditions on the specimen properties at room and elevated temperatures, and also to produce samples without cracks and parts with complex geometries, including narrow channels and other design features. Using a numerical model developed in the framework of this work allowed the process optimization with a significant reduction of costs associated with implementation of new LPBF-ready materials.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C16
ID : 6282485

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Ing Deirmina Faraz (sandvik, Sweden)

Co-author(s) : Dr Ing Bettini Eleonora (sandvik, Sweden); Dr Ing amir sasan (Prom, Italy); Dr Hann Jonathan (Bergische Universität Wuppertal, Germany); Dr Ing Zhao Zhao (Trento university, Italy); Dr Ing dossin Sylvain (Hydro Norsk, Belgium); Prof Dr Röttger Arne (Bergische Universität Wuppertal, Germany); Prof Dr Pellizzari Massimo (Trento University, Italy)

Title : Laser Powder Bed Fusion And Directed Energy Deposition Of A Novel Hot Work Tool Steel : A Comparative Study

Keyword(s) :
Hot Work Tool Steel, Additive Manufacturing, L-PBF, L-DED

Abstract :
To address the challenges in processing of medium-carbon hot work tool steels by laser based additive manufacturing (AM), a recently developed hot work tool steel with improved processability was processed by both laser powder bed fusion (L-PBF) and laser directed energy deposition (L-DED). Microstructure and phases in as built (AB) and quenched (Q) states were compared for both processing routes. Hardness, impact toughness, tempering- and thermomechanical softening resistance, and nitriding response, after direct double tempering from AB condition (ABT) and quenching and tempering (QT) were measured and assessed. Properties were then compared with those of AM-, as well as wrought- AISI H13 hot work tool steel. The results suggest the new steel exhibits comparable mechanical and thermomechanical properties to H13. Finally, practical case studies of repair of tools in H13, using the new tool steel (L-DED), and production of relatively large molds with complex geometries (L-PBF) was demonstrated.

Innovative Aspect(s) :
The research aims at developing leaner tool steels with improved processabilty by Laser based additive manufacturing methods.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C17
ID : 6281362

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mrs Scheck Marie Luise (Institute for Applied Powder Metallurgy and Ceramics at RWTH Aachen e.V., Germany)

Co-author(s) : Mr Santos Batista Rui Joao (Fraunhofer Institute for Laser Technology ILT, Germany); Dr Ing Herzog Simone (Institute for Materials Applications in Mechanical Engineering at RWTH Aachen University, Germany); Dr Ing Kaletsch Anke (Institute for Applied Powder Metallurgy and Ceramics at RWTH Aachen e.V., Germany); Prof Häfner Constantin (Fraunhofer Institute for Laser Technology ILT, Germany); Prof Dr Broeckmann Christoph (Institute for Materials Applications in Mechanical Engineering at RWTH Aachen University, Germany)

Title : Effect Of Substrate Plate Heating On Retained Austenite Content And Cracking Susceptibility Of A Carbide-rich Tool Steel

Keyword(s) :
Laser-based Powder Bed Fusion, Retained Austenite, Carbides, Tool Steel, Substrate Plate Heating, Cracks

Abstract :
Processing carbide-rich tool steels with laser-based powder bed fusion is challenging as cracks occur frequently. Substrate plate preheating is commonly applied to improve the processability as the temperature gradients are lowered and stresses reduced. The modified temperature gradients alter the microstructure formation of the alloy. In this study, a carbide-rich tool steel was processed at RT, 500°C and 800°C substrate plate preheating which lead to different precipitated carbide and retained austenite contents. The high substrate plate heating of 800°C significantly reduced cracking of the alloy and a fully martensitic microstructure was obtained. In the samples built at RT or 500°C, the lower diffusion hinders carbide precipitation and thus leads to austenite stabilization. These specimens show cracks despite their higher retained austenite contents. Here, the retained austenite has a high hardness, and therefore it is assumed that it is distorted, brittle and thus cannot prevent crack growth within the specimens.

Innovative Aspect(s) :
Retained austenite is often referred to as beneficial for processing alloys that are prone to cracking. This study shows that in this case the retained austenite is not able to compensate the stresses within the alloy and that it is more advantageous to achieve a martensitic microstructure during cooling after the process than by trying to improve processability via a high retained austenite content.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C18
ID : 6277112

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ing Felicioni Stefano (Politecnico di Torino, Italy)

Co-author(s) : Dr Vanzetti Matteo (Politecnico di Torino, Italy); Prof Padovano Elisa (Politecnico di Torino, Italy); Prof Bondioli Federica (Politecnico di Torino, Italy)

Title : Advanced Analysis Of Cu-Cr-Zr Alloy Obtained By Electron-Beam Powder Bed Fusion: Microstructural Insights And Precipitation Behaviour

Keyword(s) :
Additive Manufacturing, Electron beam Powder Bed Fusion (EB-PBF), CuCrZr,C18150, Precipitation Behaviour, Microstructure, TEM, SEM

Abstract :
A comprehensive characterization of microstructure and mechanical properties of CuCrZr alloy processed by electron beam powder bed fusion (EB-PBF) was conducted to explore the impact the thermal history of the material has on printed part properties. In fact, this technology requires a careful control of the thermal evolution underwent by the material during the manufacturing process because it significantly affects the crystallographic texture and the grain morphology. Nearly fully dense samples with a relative density up to 99.77±0.04% was successfully obtained. The as-built samples exhibit an anisotropic trend for the horizontal and vertical planes, which is independent of energetic input and specimen defects. Huge microstructural transformation coincides with the precipitation and segregation of specific chromium-rich species, driven by the elevated thermal conditions during the deposition. To identify and quantify the precipitations within the microstructure, scanning and transmission electron microscopy, along with X-ray diffraction were used.

Innovative Aspect(s) :
The present investigation offers novel insights into the feasibility of processing the system without relying on the essential post-processing heat treatment typically associated with this material. This alloy, specifically engineered for utilisation in high-temperature environments, confronts the inherent challenge of precipitation clustering. The complexities of high-temperature processing simulate the operational conditions of the component. Therefore, an in-depth understanding of the precipitation mechanism not only serves as a valuable guide for anticipating potential issues, but also provides essential information for predicting the material's behaviour under operational conditions.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C19
ID : 6281376

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Miss Sajjadivand Shahrzad (University College Dublin, Ireland)

Co-author(s) : Dr Celikin Mert (University College Dublin, Ireland); Mr Hartnett Mark (Irish Manufacturing Research, Ireland)

Title : Understanding The Differences In Microstructural Evolution Between Additively Manufactured And Conventional 18Ni(300) Maraging Steel Upon Post-Processing Heat Treatment

Keyword(s) :
18Ni (300) Maraging Steel, Laser powder Bed Fusion (L-PBF), Heat Treatment, Microstructure, Mechanical Property

Abstract :
This study aims to optimise post-processing heat treatment methodology of 18Ni(300) Maraging steel manufactured via Laser Powder Bed Fusion (L-PBF). This is achieved by understanding the effect of post-processing heat treatment on the microstructural evolution and mechanical behaviour of LPBF 18Ni(300) Maraging steel in comparison to conventionally manufactured 18Ni(300) Maraging steel. In-depth materials characterisation was carried out using X-ray diffraction (XRD), optical and scanning electron microscopy (OM| SEM), and transmission electron microscopy (TEM). Resultant changes in mechanical properties determined via compression and hardness testing were linked with precipitation kinetics (formation, size, and distribution of secondary phases), process-induced porosity and micro-strain levels. Based on conventionally produced 18Ni(300) steel as a control and baseline, a novel heat treatment methodology has been developed for AM maraging steels.

Innovative Aspect(s) :
18Ni(300) maraging steels belong to an exclusive class of ultra-high-strength low-carbon steels. Because of their high strength, toughness, and weldability, they are widely used in tool|die industry. Using L-PBF instead of conventional processes for producing maraging steel components has become more important due to its ability to produce complex and precise geometries in one step and reduce production costs, waste material, and time. Currently, there are several studies on L-PBF 18Ni(300) maraging steel focused on improving mechanical properties to be in similar levels to conventional ones by optimizing the post-processing heat treatment. There is a optimised post-processing heat treatment for conventionally produced maraging steels however according to recent studies there is considerable scattering in published data concerning the post-processing heat treatment recommended for L-PBF 18Ni maraging steel due to the variation in processing conditions. Therefore, developing a novel heat treatment methodology for L-PBF 18Ni(300) maraging steel is crucial.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C20
ID : 6281349

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ing Hajeck Tobias (Institute for Materials Applications in Mechanical Engineering (IWM), Germany)

Co-author(s) : Ing Weiß Christian (Fraunhofer Institute for Laser Technology ILT, Germany); Prof Dr Broeckmann Christoph (Institute for Materials Applications in Mechanical Engineering (IWM), Germany); Prof Häfner Constantin (Fraunhofer Institute for Laser Technology ILT, Germany)

Title : Influences Of Process Parameters On Failure Mechanisms Of Additively Manufactured 16MnCr5 Under Cyclical Loading

Keyword(s) :
Fatigue Strength, Laser Powder Bed Fusion, Internal Defects, Process Parameters

Abstract :
The mechanical properties, especially the strength of a component under cyclic loading, depend on factors such as the chosen material, component geometry and manufacturing history. In Laser Powder Bed Fusion (LPBF), metal powder is deposited and selectively melted using focused laser radiation. The properties of additively manufactured components exhibit a strong dependence on process-related conditions, such as component position and orientation within the build space, or the chosen process parameters. In particular, the density, type and distribution of defects show a significant variability depending on parameter selection, which in turn has a notable impact on the mechanical properties of the components. Present work focuses on fatigue strength, as many mechanical components undergo cyclic stress, which is particularly sensitive to internal defects. Especially the position on the build platform shows a significant impact on the mechanical properties.

Innovative Aspect(s) :
Additively manufactured components, unlike conventionally produced ones, offer several advantages such as increased geometric freedom and reduced material consumption. However, to fully harness these benefits, it is important to understand the failure mechanisms inherent in this relatively novel manufacturing technology. This knowledge is essential for designing and calculating components for use under cyclic loading. This study elucidates the failure mechanisms of components produced using this additive manufacturing technology, aiming to ensure their future designs are robust and secure.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C21
ID : 6281479

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Ing Kirchner Alexander (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Co-author(s) : Dr Ing Gaitzsch Uwe (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Dr Dorow-Gerspach Daniel (Forschungszentrum Jülich GmbH, Germany); Dr Distl Benedikt (Plansee SE, Austria); Dr Ing Franke-Jurisch Marie (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Dr Zhòng Chóngliàng (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Prof Dr Weißgärber Thomas (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Title : Electron Beam Powder Bed Fusion Of Refractory Metals

Keyword(s) :
Powder Bed Fusion, Electron Beam Melting, Refractory, High-Temperature Materials

Abstract :
For refractory metals additive manufacturing of near-net shape parts represents an attractive opportunity, in particular for complex geometries. The combination of high melting point, thermal conductivity and brittleness represents a challenge for fusion processes. Electron beam powder bed fusion (PBF-EB) facilitates preheat temperatures above 1000°C and vacuum processing with negligible oxygen contamination.Elemental tungsten and molybdenum were PBF-EB processed to high density from spherical and non-spherical powders. The resulting microstructure is characterized by large grains elongated in build direction and texture. Accordingly, the potential for the mechanical strength of defect-free PBF-EB refractory metals corresponds to conventionally fabricated material in recrystallized condition. The cracking behavior of tungsten tiles under extreme thermal shock was analyzed. Generated test geometries include thin-walled components and lattice structures.The Mo9Si8B alloy required 1100°C preheat temperature for crack-free processing. The microstructure is fine-grained with coarsening in the lower part. Bending strength exceeds 1200 MPa at 1000°C.

Innovative Aspect(s) :
The developed PBF-EB process resulted in crack-free refractory metal and alloys with low porosity. For tungsten and molybdenum, the possible resolution for thin-walled structures was tested. In the Mo9Si8B alloy a complex microstructure and an exceptional high temperature strength were found.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C22
ID : 6282865

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Tobar Maria Jose (Universidade Da Coruña, Spain)

Co-author(s) : Dr Amado Jose Manuel (Universidade Da Coruña, Spain); Dr Luaces Alan (Universidade Da Coruña, Spain); Dr Yañez Armando (Universidade Da Coruña, Spain)

Title : Characterization Of Compositionaly Graded A316L|Inconel 625 Profiles Manufactured By Laser Direct Energy Deposition Using Different Powder Morphologies

Keyword(s) :
AM, Laser DED, Inconel 625, 316L, Functionally Graded Material, Multimaterial

Abstract :
Multimaterial additive manufacturing allows to obtain near-net-shape components with local customized properties. Combining different alloys, significant increased life service, functionality and cost savings are to be expected if mechanical, thermal, electric|magnetic properties can be tailored to specific demands. The laser DED technology provides with a natural environment for multi-material manufacturing with steels and high performance alloys. They can be mixed along the process with custom mixing ratios, although this is usually performed by developing compositionally graded interfaces between different materials. As when processing single alloys, laser DED deposits often suffer from known detrimental features as porosity, micro-segregation, cracks and|or directional grain growth. In this work this features will be examined in compositional graded A316L|Inconel 625 laser DED samples manufactured with powders from different providers. It will be analysed whether the morphology or minor elemental composition of the powders might influence the microstructure and mechanical characteristics of the deposited material.

Innovative Aspect(s) :
Features as the porosity, micro-segregation and directional grain growth of the metallic deposits obtained will be compared.But AM offers a unique feature: which is the capability of producing multi-material parts. This means that the final AM product would not only be a near-net-shape component but also had local customized properties, adapted to specific needs. The ability to readily combine metallic| metal-ceramic|ceramic materials in a single piece will deploy all its benefits when applied to high demanding industries. Significant increased life service and functionality is to be expected in components if mechanical, thermal, electric|magnetic properties can easily be tailored to specific demands. Obvious examples could be the combination of hard ceramics for thermal and wear resistance with structural metals easily machined. Or high performance and expensive alloys combined with cheaper support materials.The laser DED technology provides with a natural enviroment for multi-material manufacturing with high performance alloys.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C23
ID : 6283117

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Zissel Kai (Linde GmbH, Germany)

Co-author(s) : Mr Forêt Pierre (Linde GmbH, Germany); Prof Dr Hryha Eduard (Chalmers University of Technology, Sweden)

Title : Study On Deoxidation Of Binder Jetted 17-4 PH Stainless Steel In Hydrogen Atmosphere

Keyword(s) :
Binder Jetting, Debinding, Deoxidation, Residual Carbon, 17-4 PH, Sintering, Hydrogen, Dilatometry

Abstract :
The final dimensions and material properties of metal components manufactured via Binder Jetting (BJT) depend on sintering densification, which requires precise control of the shrinkage to reach required tolerances. Sintering studies are typically limited to parameters such as heating rate, sintering temperature and dwell time. Processing atmospheres, especially during the debinding stage are, however, often not considered despite their significant impact on binder decomposition and powder oxidation. Maximizing binder removal and lowering powder oxidation at the same time by lowering the oxygen content during debinding is crucial to enhance sintering densification and material properties of stainless steels. The impact of processing atmosphere during debinding of 17-4 PH stainless steel green parts was studied in Ar, Ar + 1 vol.% O2 and N2 + 20 vol.% O2 through sintering in a dilatometer under pure hydrogen atmosphere. The results were correlated with the resulting microstructure and material properties.

Innovative Aspect(s) :
Decreasing oxygen content during debinding to improve sintering densificationDeoxidation during debinding and sinteringStudy on densification behavior via dilatometry in pure hydrogenCorrelation between debinding atmosphere, binder residuals and material propertiesFocus on underexplored aspect of debinding atmospheres for Binder Jetting.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C24
ID : 6283184

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Tobar Maria Jose (Universidade Da Coruña, Spain)

Co-author(s) : Dr Amado Jose Manuel (Universidade Da Coruña, Spain); Ing Luaces Alan (Universidade Da Coruña, Spain); Dipl-Ing García Garazi (Universidade Da Coruña, Spain); Dipl-Ing Aourdou Ali (Universidade Da Coruña, Spain); Dr Yañez Armando (Universidade Da Coruña, Spain)

Title : Laser-DED Of WC-Ni Composites: Functionally Graded Deposition And Tribological Performance

Keyword(s) :
AM, Laser DED, Tungsten Carbide, Metal Matrix Composite, Functionally Graded Material, Multimaterial

Abstract :
This study examines the laser deposition process for functionally graded WC-Ni metal matrix composites, employing in-flight powder mixing to concurrently incorporate tungsten carbide (WC) and a nickel-based alloy. The research systematically assesses how variations in WC percentage and deposition strategy impact the resulting microstructure and mechanical properties of the fabricated composites.

Innovative Aspect(s) :
The present study focuses on the laser deposition of functionally graded WC-Ni metal matrix composites, employing advanced Additive Manufacturing (AM) Laser-DED technology. Noteworthy innovations include the exploration of multimaterial capabilities, allowing the simultaneous integration of tungsten carbide (WC) and a nickel-based alloy. The introduction of in-flight powder mixing enhances homogeneity, contributing to improved integrity and performance. Graded deposition strategies, featuring variations in WC percentage, offer controlled transitions in material properties, presenting opportunities for tailored mechanical and tribological characteristics. Beyond the fabrication process, the study emphasizes practical applications, particularly in wear and tribocorrosion resistance. Overall, these innovations advance material design possibilities and hold promise for diverse applications requiring specialized metal matrix composites.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C25
ID : 6283203

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ing Maffia Simone (Ponticon GmbH, Germany)

Co-author(s) : Dr Stittgen Tobias (Ponticon GmbH, Germany)

Title : Investigating The Application Of 3D-EHLA For Microstructure Control In Large-Scale Additive Manufacturing

Keyword(s) :
Laser Metal Deposition, Directed Energy Deposition, Extreme High-Speed Laser Metal Deposition, LMD, DED, EHLA, Microstructure Tailoring

Abstract :
Conventional powder Laser Metal Deposition (LMD) has revolutionized Additive Manufacturing (AM) by enabling the fabrication of large, support-free geometries and minimizing material waste through targeted deposition. Despite these advantages, conventional LMD faces challenges in microstructure control, primarily due to high heat inputs, limiting fine adjustments and compromising material integrity. In this work, the transformative potential of Ponticon's 3D Extreme High-Speed Laser Metal Deposition (EHLA) for large-scale applications is investigated, highlighting its capabilities in both deposition performance and microstructural control. 3D EHLA's high feed rates, reaching up to 200 m|min, not only significantly enhance deposition performance but also enable precise control over microstructures, thanks to a two-order-of-magnitude increase in cooling rates. As a result, tailored microstructures enables local modification of mechanical properties through process parameter adoption. This innovation addresses the limitations of conventional LMD, providing a viable solution for high-end large-scale AM components.

Innovative Aspect(s) :
This study explores Ponticon's 3D-EHLA for large-scale AM. 3D EHLA's high feed rates revolutionize microstructure control. This innovation enables precise adjustments in mechanical properties via localized modifications, addressing challenges encountered in conventional Laser Metal Deposition, in which the microstructure is hindered the high heat inputs and relatively slow cooling rates. The research introduces a groundbreaking solution for optimizing material integrity in high-end large-scale AM components by exploiting the full potential of 3D-EHLA technology.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C26
ID : 6282627

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Ms Mkhaliphi Thuli (Stellenbosch University, South Africa)

Co-author(s) :

Title : Suitable Laser Scanning Strategy For Producing Ti-4.7Mo-4.5Fe Alloy Using Laser Powder Bed Fusion

Keyword(s) :
Laser Powder Bed Fusion, Selective Laser Melting, Scanning Strategy, Ti-4.7Mo-4.5Fe, Mechanical Properties, In-Situ Alloying, Low-Cost Titanium Alloys

Abstract :
In laser powder bed fusion, the quality and material properties of the built part depend on process parameters such as the employed laser scanning strategy. For this study, the investigation focused on determining the optimal laser scanning strategy for producing Ti-4.7Mo-4.5Fe alloy using laser powder bed fusion. Cylindrical and tensile testing samples were printed with three scan patterns: a line scanning strategy with a 67° rotation, a chessboard pattern, and a cross-striped scanning strategy with a 45° rotation. The initial results indicated that the different scanning strategies produced samples with a relative density >99% and hardness ranging between 380 and 420 HV. The samples produced using the chessboard pattern demonstrated the highest porosity and lowest hardness. The microstructure of the samples was investigated using a scanning electron microscope, an X-ray diffractometer and a micro-diffraction instrument. The ultimate strength, % elongation and Young's modulus were also determined for the samples.

Innovative Aspect(s) :
The paper will provide insight into the optimum parameters to produce the novel Ti-4.7Mo-4.5Fe alloy using laser powder bed fusion, as research regarding additive manufacturing of this alloy is still in its infancy. Most published research regarding this alloy is related to conventional processing methods.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C27
ID : 6283756

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Nagaram Anok Babu (Chalmers University of Technology, Sweden)

Co-author(s) : Mr Mahoney Phillip (GE Additive (ARCAM EBM), Sweden); Mr Algardh Joakim (GE Additive (ARCAM EBM), Sweden); Prof Nyborg Lars (Chalmers University of Technology, Sweden); Prof Hryha Eduard (Chalmers University of Technology, Sweden)

Title : Effect Of Microstructure On Thermal And Electrical Conductivity Of Pure Copper Produced Via Powder Bed Fusion-electron Beam (PBF-EB)

Keyword(s) :
Additive Manufacturing (AM), Powder Bed Fusion-Electron Beam (PBF-EB), Pure Copper, Point Melt, Thermal And Electrical Conductivity

Abstract :
The outstanding thermal and electrical conductivity characteristics of pure copper renders it a highly desirable material for diverse applications such as electronics, heat exchangers and electric motor components. The capability of fabricating intricate geometries using additive manufacturing (AM) technology, makes it a well-suited for heat exchangers. Powder bed fusion-electron beam (PBF-EB) exhibits relatively low reflectivity for pure copper compared to powder bed fusion-laser beam (PBF-LB). In this work the influence of microstructure, and component density on thermal and electrical conductivity of pure copper are investigated. Copper samples were fabricated using virgin and recycled powders with different processing parameters and printing strategies, namely hatch and point melt. Results indicates that employing point melt yields a relative density of about 99.9%, while achieving twice the productivity compared to hatch melt. Deviations in the conductivity properties observed using specific geometry samples highlights the influence of measurement directions, emphasizing the crucial role of microstructure.

Innovative Aspect(s) :
This paper focusses mainly on the specific printing strategy, namely point melt. It involves selectively melting specifiic spots within a powder bed using an electron beam, allowing for the fabrication of intricate and complex geometries with foremost details. The precision of point melt contributes to efficiency and productivity in the manufacturing process. Furthermore, point melt results in improved microstructure and better mechanical properties, thus enhancing the thermal and electrical conductivity of pure copper.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C28
ID : 6282705

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Dr Ing Heikkilä Irma (Swerim AB, Sweden)

Co-author(s) : Mr Gustavsson Oliwer (Swerim AB, Sweden); Dr Ing Blackwell Cameron (MTC Ltd., United Kingdom); Dr Ing Chroztek-Mroz Aneta (MTC Ltd., United Kingdom); Dr Ing Meisnar Martina (ESA, United Kingdom); Dr Ing Pambaguian Laurent (ESA, United Kingdom); Dipl-Ing Karlsson Oskar (Swerim AB, Sweden); Dr Ing Heikkilä Irma (Swerim AB, Sweden)

Title : Evaluation Of The Mechanical Strength Of AlSi10Mg Manufactured By Laser Powder Bed Fusion - The Impact Of The Laser Contour Strategy

Keyword(s) :
Contour, AlSi10Mg, L-PBF, Mechanical Strength, Design Of Parts

Abstract :
The mechanical strength of laser power bed fusion (L-PBF) of AlSi10Mg is correlated to a fine hierarchical microstructure formed during the repeated layer-by-layer melting guided by a digital model. The microstructure of the surface area of the L-PBF parts is often different to that of the bulk material as specific laser contouring strategies are applied at the surface areas. However, the evaluation of the mechanical strength is frequently made on machined tensile specimens where the microstructure of the surface area is removed. In this investigation two different AlSi10Mg powders are processed by two bureaus, each having different contouring strategies. Mechanical testing is conducted with machined and contoured specimens. The microstructure and fracture surfaces of four materials is studied. The results show that the mechanical strength of the contoured specimens is slightly lower than the one of the machined specimens and has a correlation to the microstructure at the contour areas.

Innovative Aspect(s) :
The necessity of designing L-PBF parts taking into consideration the most realistic material data i.e. including the potential adverse impact of a contour.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C29
ID : 6282622

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Kindermann Philipp (Fraunhofer Institute for Casting, Composite and Processing Technology IGCV, Germany)

Co-author(s) : Mr Wunderer Martin (Fraunhofer Institute for Casting, Germany); Mr Strasser Maximilian (Fraunhofer Institute for Casting, Germany); Ms Lehmann Maja (Fraunhofer Institute for Casting, Germany); Mr Ünsal Ismail (Fraunhofer Institute for Casting, Germany); Dr Schlick Georg (Fraunhofer Institute for Casting, Germany); Prof Dr Seidel Christian (Fraunhofer Institute for Casting, Germany)

Title : Key Factors Influencing The Gas And Nozzle Outlet Temperature In Cold Spray

Keyword(s) :
Cold Spray, Additive Manufacturing

Abstract :
Cold spray is an innovative process with high potential for the additive manufacturing of metallic materials. It has several unique characteristics—most notably, the process does not require any melting or fusion of the processed materials and the substrate. The powder is accelerated by a gas flow and forms dense layers on impact due to the high kinetic energy. The chamber temperature is the most known parameter in cold spray alongside the pressure of the process gas. The set chamber temperature has a crucial effect on the gas flow and thus the build quality. However, in addition to the chamber temperature, other parameters, such as the nozzle material and the powder gas flow rate, also influence the gas flow. The cause-effect relationships are not yet fully understood. This paper describes and examines the key factors associated with the temperature during cold spray in more detail.

Innovative Aspect(s) :
This paper deals with fundamental topics of cold spray, which have not yet been sufficiently addressed, for example, the relationship between the nozzle-material and the temperature of the exiting gas stream. However, this relationship is essential for the cold spraying process: the higher the gas stream temperature, the higher the achievable gas and particle velocity. This means that high-strength materials in particular, such as Inconel alloys, where modern cold spray plant technology is already at its limit, may only become processable with this knowledge. Furthermore, the influences of other parameters that have received almost no attention in the literature, such as the gas flow rate of the powder feeders, are examined in more detail on the basis of experiments. Therefore, this paper provides a deeper understanding of the interrelationships between the lesser known parameters of cold spray, and thus contributes to the further improvement of this process.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C30
ID : 6282740

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Großwendt Felix (Ruhr-Universität Bochum, Germany)

Co-author(s) : Mr Hantke Nick (Ruhr-Universität Bochum, Germany); Prof Dr Sehrt Jan (Ruhr-Universität Bochum, Germany); Prof Dr Weber Sebastian (Ruhr-Universität Bochum, Germany); Dr Ing Lentz Jonathan (Ruhr-Universität Bochum, Germany)

Title : Increasing Chemical Homogeneity In In-situ Alloying In Laser Powder Bed Fusion Of Metals By Targeted Raw Material Selection

Keyword(s) :
Laser Powder Bed Fusion, Powder Mixing, In-Situ Alloying, Chemical Homogeneity

Abstract :
Many commercial alloys suffer from defect formation like cracking during laser powder bed fusion owing to high cooling rates. To provide a variety of starting materials adapted to laser powder bed fusion and specific applications, mixing powders, known as in-situ alloying, using a modular powder design set is a promising approach. Unfortunately, in-situ alloying promotes chemically inhomogeneous components. In this work, different powder mixtures were analyzed and processed to obtain a carbon steel of a specified composition. The samples were characterized microstructurally applying several methods and compared to a pre-alloyed reference. The chemical homogeneity is statistically assessed employing fast first-order variograms. The composition of the individual raw materials was found to be critical for homogenization within the melt pool. Large scale homogenization is also affected by the amount of raw material added. Almost complete in-situ homogenization has been achieved in laser powder bed fusion by careful selection of raw materials.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C31
ID : 6282914

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Beam Based Technologies

Author : Mr Koob Jonas (Institute for Materials Applications in Mechanical Engineering, RWTH Aachen University, Germany)

Co-author(s) : Mr Mirz Markus (Institute for Materials Applications in Mechanical Engineering, RWTH Aachen University, Germany); Ms Scheck Marie Luise (Institute for Applied Powder Metallurgy and Ceramics at RWTH Aachen e. V., Germany); Dr Ing Kaletsch Anke (Institute for Materials Applications in Mechanical Engineering, RWTH Aachen University, Germany); Prof Dr Broeckmann Christoph (Institute for Materials Applications in Mechanical Engineering, RWTH Aachen University, Germany)

Title : Influence Of The Process Atmosphere On The Microstructure And Impact Toughness Of PBF-LB|-EB AISI 318LN Duplex Stainless Steel

Keyword(s) :
Laser-Based Powder Bed Fusion, Electron-Beam Powder Bed Fusion, Duplex Stainless Steel, Toughness, Mechanical Properties

Abstract :
Duplex stainless steels (DSSs) exhibit excellent mechanical properties due to their austenitic-ferritic microstructure, which, for example, leads to higher impact toughness compared to fully ferritic steels. The phase equilibrium is dependent on solidification conditions and chemical composition, with elemental nitrogen stabilizing the austenitic phase. To better understand the influence of process gases during processing by laser-based powder bed fusion (PBF-LB) on microstructure and mechanical properties, in this study, DSS AISI 318LN was processed with PBF-LB with different shielding atmospheres (argon and nitrogen) and subsequently, some of the samples were hot-isostatically post-densified before final heat treatment. The impact toughness of the different conditions was tested and complemented by microstructural- and fractographic analyses. To completely exclude the influence of process gases, samples were also built up by electron-beam powder bed fusion (PBF-EB) under vacuum as a reference and subjected to the same post-processing strategies for comparison with the samples produced by PBF-LB.

Innovative Aspect(s) :
PBF-LB is a well-established manufacturing process for stainless steels with the most commonly employed types being austenitic or martensitic grades. However, the influence of PBF-LB-process characteristics on the microstructure and mechanical properties of duplex stainless steels has rarely been investigated. This study expands the knowledge by investigating process-gas-induced differences in DSS manufactured under argon and nitrogen protective atmosphere.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

AM SINTER BASED TECHNOLOGIES

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C32
ID : 6233737

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ing Reineke Lea (Fraunhofer IFAM, Germany)

Co-author(s) : Dr Hein Sebastian Boris (Fraunhofer IFAM, Germany); Mrs Schlegel Regina (Fraunhofer IFAM, Germany)

Title : Influence Of Binder Characteristics On Binder Saturation And Wetting Behavior In Metal Binder Jetting

Keyword(s) :
Metal Binder Jetting, Powder-Binder-Interaction, Wetting Behavior, Binder Characteristics, Binder Saturation

Abstract :
Metal Binder Jetting (MBJ) has an increasing attention in Additive Manufacturing because of its serial production potential. The aim of this work is to get a better understanding of the powder-binder-interaction for better process control and consequently a reduction in the number of iteration stages in material-specific process development, which saves costs, effort as well as material resources and printing capacity. Depending on the binder characteristics the equilibrium saturation and wetting behavior changes. A better understanding of binder viscosity and surface tension on the powder-binder-interaction will improve the part quality. A suitable parameterization of the MBJ printing processes for specific powder-binder combinations, based on the binder and powder characteristics as well as the powder-binder interaction will improve the part density, accuracy and surface quality.

Innovative Aspect(s) :
The innovation of this work is the analysis of binder saturation and wetting behavior depending on the binder charactertics.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024 CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C33
ID : 6275809

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Prof Dr Kate Kunal (University of Louisville, USA)

Co-author(s) : Dr Ajjarapu Pavan Kumar (University of Louisville, USA); Prof Dr Bhatia Bikram (University of Louisville, USA); Mr Izquierdo Julio (University of Louisville, USA); Prof Dr Malhotra Rajiv (Rutgers, USA); Mr Khanjar Saleh (University of Louisville, USA); Prof Dr Roussel Tommy (University of Louisville, USA)

Title : Material Extrusion Additive Manufacturing (MEX-AM) Of Copper Heat Sinks: Process Development, Product Design, And Process Optimization

Keyword(s) :
3D-Printing Copper, Heat Sinks, Lattice-Structure, Sintering, Hot Isostatic Pressing

Abstract :
Copper heat sinks (electronic applications) typically manufactured using conventional techniques tend to have simple fin|pin structures due to limitations in processing capabilities. To transform these traditional designs, intricate lattice structures of high surface area were 3D-printed and sintered via Material Extrusion Additive Manufacturing (MEX-AM). Copper powder-filled filaments (> 90wt.%) were developed and 3D-printed via MEX-AM. Three types of structures – planar, strut and surface lattices were 3D-printed to facilitate efficient heat-transfer pathways within the heat sinks. Subsequent post-processing steps, including polymer removal, sintering, and hot-isostatic-pressing (HIP), were performed to achieve 98% dense and 100% IACS copper parts. Finite element analysis (FEA) was conducted to assess the heat transfer efficiency of the designs, and heat transfer experiments were performed using a custom setup to validate the simulation results. The investigation combines experimental analysis and simulations to gain insights into the structure-material property relationships and optimize the thermal performance of the printed.

Innovative Aspect(s) :
This talk elucidates the advancements and challenges in 3D-printing, sintering, and HIPing of copper parts fabricated via MEX-AM. This study is at the forefront of presenting superior mechanical and electrical attributes through copper 3D printing, offering a pathway for both 3D printing and HIPing as a viable strategy for crafting high-performance copper components for applications in electronics, aerospace, and automotive sectors. Feedstocks and filaments with 61vol.% solids loading of copper were compounded and extruded to 3D print and sinter test coupons and heat sinks. Incorporating pre-sintering holds in a reducing atmosphere alongside HIP resulted in remarkable mechanical and electrical properties. Sintering yielded 93% density, while HIP yielded 98% density relative to pure copper. HIPed parts exhibited improved mechanical (190 MPa UTS, 32% elongation at failure) and electrical (100% IACS) characteristics. Finally, the talk culminates with understanding the effect of change in infill density leading to part warpage and defects.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C34
ID : 6276985

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Mr Malti Abolfazl (The University of Melbourne, Australia)

Co-author(s) : Dr Brandl Christian (The University of Melbourne, Australia); Dr Molla Tesfaye (The University of Melbourne, Australia)

Title : Role Of Process Parameters On The Effective Properties Of The Print-bed During Binder Jet Additive Manufacturing: A DEM-based Study

Keyword(s) :
Powder Spreading, Discrete Element Method, Binder Jet Printing, Additive Manufacturing

Abstract :
Analysis of the powder spreading process in additive manufacturing (AM) is often based on formation of a single layer of powders on a smooth substrate. While this approach is valid for powder-bed fusion AM techniques, it can oversimplify the printing process in binder jet (BJ-AM), where parts are built through multi-layer spreading of powders with liquid binder added in between. This study analyses the printing process based on multi-layer spreading of powders during BJ-AM process by using DEM simulation. The influence of printing parameters including layer thickness, roller velocity and substrate surface roughness on the bulk properties of the print-bed (e.g., density, structural homogeneity, and surface quality) are investigated. The study shows convergence of the relative density of the print-bed towards an asymptotic limit, while structural homogeneity and surface roughness vary significantly with process parameters. A process map is suggested showing parameter insensitive window for optimal powder spreading.

Innovative Aspect(s) :
The current work focuses on the advancement of multi-layer powder spreading in the binder jet printing process. In addition to the horizontal structural homogeneity, the vertical structural homogeneity as a considerable feature in multi-layered samples is investigated.The study can extend our understanding of the various mechanisms involved in multi-layer powder spreading and enable optimizing the process for BJ-AM to achieve print-beds with improved density, structural homogeneity, and surface quality.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C35
ID : 6278376

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dipl-Ing Vogel Lucas (MetShape GmbH, Germany)

Co-author(s) : Dr Khan Qaiser Ali (MetShape GmbH, Germany); Dr Ing Baum Andreas (MetShape GmbH, Germany); Prof Dr Burkhardt Carlo (University Pforzheim, Germany)

Title : Characterisation Of Microstructure And Mechanical Properties Of 17-4PH Parts Produced With The Lithography-based Metal Manufacturing Technology

Keyword(s) :
LMM, Lithography-based Metal Manufacturing, MetShape, 17-4PH, Mechanical Properties

Abstract :
The lithography-based metal manufacturing (LMM) process is a novel additive manufacturing technique that enables the sinter-based manufacturing of metal parts with high dimensional precision and exceptional surface quality o effectively apply this technology, comprehending the relationship between mechanical properties and printing orientation is imperative. Given the relative novelty of this technology, our study seeks to explore the influence of manufacturing orientation on both the mechanical properties and shrinkage behaviour of stainless steel 17-4PH. In most additive manufacturing technologies typical variations in mechanical properties is observed in every axis, our investigation focuses on assessing the tensile properties of the material in all orientations. Tensile bars are fabricated accordingly and evaluated in terms of density and dimensions as both green and sintered components. Subsequent to the sintering process, an in-depth analysis of mechanical properties and microstructure is conducted to elucidate the inherent correlations between the technology and material.

Innovative Aspect(s) :
This study aims to contribute valuable insights into the optimization and application of Lithography-based Metal Manufacturing (LMM) for stainless steel 17-4PH in diverse manufacturing scenarios. The research focuses on the critical aspect of manufacturing orientation and its impact on mechanical properties and densification behaviour. Also, it demonstrates the first analysis of the microstructure of 17-4PH Parts manufactured with the LMM technology. Thereby the study offers insights on both the porosity and phase distribution in the material´s evolution during the manufacturing process.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C36
ID : 6278445

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Mr Eckel Julius (Fraunhofer IFAM Bremen, Germany)

Co-author(s) : Ms Schlegel Regina (Fraunhofer IFAM Bremen, Germany); Ms Reineke Lea (Fraunhofer IFAM Bremen, Germany); Dr Hein Sebastian Boris (Fraunhofer IFAM Bremen, Germany)

Title : Comparative Study Of Water-Atomized And Gas-Atomized Powders For Metal Binder Jetting: Pre-Tests And Feasibility Analysis

Keyword(s) :
Metal Binder Jetting, Water Atomized Powder, Gas Atomized Powder, Wahburn Method, Initial Wetting, Cost Effectiveness

Abstract :
This study compares water-atomized powders and gas-atomized powders in Metal Binder Jetting (MBJ) while also exploring the potential use of water-atomized powders, which are more cost-effective. Previous research has already investigated this topic to some extent. However, this study shifts the focus towards pre-tests, where the properties of the powders, including binder saturation (using the Washburn method) and initial wetting, are examined to determine their suitability for binder jetting. Additionally, the study aims to generate further knowledge regarding the potential viability of water-atomized powders for MBJ. Through a combination of pre-tests and actual printing, the selected powders are evaluated to provide insights into the feasibility and optimization of the MBJ process.

Innovative Aspect(s) :
The innovative aspect of this paper lies in the potential of the pre-tests to provide a new approach for making the comparison between water-atomized and gas-atomized powders in Metal Binder Jetting (MBJ) more meaningful. Overall, this study contributes to the field by providing a comprehensive analysis, exploring cost-effective powders, and offering insights for improving the Metal Binder Jetting process.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C37
ID : 6280667

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Muñoz Moreno Rocio (HP, Spain)

Co-author(s) : Ms Marin Camara Ariadna (HP, Spain); Dr Pérez Prado Maria Teresa (IMDEA Materials Institute, Spain); Dr Bafaluy Sergi (IMDEA Materials Institute, Spain); Dr Sket Federico (IMDEA Materials Institute, Spain)

Title : 3D Metal Binder Jetting Green Parts Microstructure Metrics For Sintered Parts Macroproperties Prediction

Keyword(s) :
Additive Manufacturing Sinter Based Technologies, Metal Binder Jetting , Green Parts Properties, Microstructures Metrics

Abstract :
3D Metal Jet is currently disrupting manufacturing and accelerating mass production of 3D-printed parts. Metal Jet excellent balance between part quality and productivity rates are founded on powerful R&D investigations and metrics development on support to applications for user cases. In this study, it will be explained the technical physics description of the binder jet fundamentals empowered by key advantage assets founded in the latex binders and printheads. Powder properties, green and sintered microstructures, together with final parts performance derived from their macroproperties will be evaluated. In particular, focus will be devoted to describe novel green parts microstructure metrics obtained by scanning electron microscope (SEM) and X-ray computed tomography (XCT), as binder and porosity local fractions, together with possible period or amplitudes patterns. The use of these metrics in support to printmode development and materials integration, as a predictive and more sustainable method will be discussed.

Innovative Aspect(s) :
Novel metrics of Metal Binder Jetting green parts to predict sintered parts performance; New Methodologies more sustainable to develop materials and processes development by minimizing iterations and resources consumption; Investigations driven by novel 3D Metal Binder Jetting applications user cases

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C38
ID : 6280682

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ing Garcia Grau Marc (HP, Spain)

Co-author(s) : Ing González Daniel (HP, Spain); Ing Jiménez Xavier (HP, Spain); Ing Barreda David (HP, Spain); Ing Puigardeu Sergi (HP, Spain); Ing Sole Macia (HP, Spain); Mr Sala Casanovas Marti (HP, Spain)

Title : 3D Metal Binder Jetting Powder Consumption Reduction

Keyword(s) :
Additive Manufacturing Sinter Based Technologies, Metal Binder Jetting , Powder Consumption Reduction , Closed-loopPrintmodes, Computer Vision System

Abstract :
3D Metal Jet is currently disrupting manufacturing and accelerating mass production of 3D-printed parts. Metal Jet excellent balance between part quality and productivity rates are also complemented with sustainable efforts of minimizing the used resources. In this case, powder consumption reduction has been confirmed by the development of a novel functionality that enables the minimum powder use for certain job heights. Utilizing a cutting-edge closed-loop algorithm in conjunction with a computer vision system within the printer chamber not only significantly reduces the amount of powder required for constructing base layers in a job but also facilitates the extraction of essential powder metrics. This print mode that minimizes powder loading is of great value when powder production constraints, powder elevated costs and, overall, it is highlighted thanks to the ensurance of efficient sustainable processes.

Innovative Aspect(s) :
New printing functionalities enabling minimum powder consumption and metrics identification, Efficient and sustainable closed-loop printmodes supported by computer vision system, Optimal printing resources use for quality, robustnes and throughput purposes

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C39
ID : 6281550

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Fregeac Arnaud (NORIMAT, France)

Co-author(s) : Dr Epherre Romain (NORIMAT, France); Dr Ing Larignon Céline (NORIMAT, France); Dr Mackie Jennifer (NORIMAT, France); Ing Beynet Yannick (NORIMAT, France)

Title : FAST|SPS: New Industrial Post-process For Full Densification Of 3D Complex Shape From AM Sinter Based Technologies

Keyword(s) :
Sinter Based Additive Manufacturing, Binder Jet, FAST|SPS

Abstract :
The FAST|SPS process is recognized as an R&D method capable of producing high-performance parts from a wide range of materials. In recent years, significant progress has been made in overcoming the two main constraints of the technology: production capacity and geometric limitations, thanks to important advances in research and technology.This conference will focus on the progress made in the production of dense 3D complex shapes using FAST|SPS. An innovative and versatile approach, combining additive manufacturing (SBAM mostly binder jetting) and FAST|SPS, will be presented, along with original use cases involving various ceramic and metallic materials designed for applications in the aerospace, space, or defense sectors. Numerical tools to define the green part, chemical analisys and mechanical properties of the 3D parts will also be presented.

Innovative Aspect(s) :
Norimat has made an important industrial breakthrough by developing a unique and easy process which enables the consolidation of 3D green parts frome SBAM processes by FAST|SPS. It allows to fully densify (porosity <1%) green parts made from SBAM just after printing in only one step and less than 1h of thermal treatment. The debinding of the green parts made of AM has been optimized and is in situ realize in the FAST|SPS process. That's allowed to limit the thermal treatment time and to enhance the quality of the part in terms of chemistry and deformation. Moreover, the first FAST|SPS software suite dedicated to the FAST|SPS process has been developed to help the users with all aspects of SPS, from R&D (Digital Twin) to production monitoring (Statistical Process Control). Numerical simulation has ensured that thermal gradients during sintering of 3D parts are kept to a minimum.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C40
ID : 6280993

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ms Azadi Chegeni Ava (University College Dublin, Ireland)

Co-author(s) : Dr O'Cearbhaill Eoin (University College Dublin, Ireland); Dr Celikin Mert (University College Dublin, Ireland)

Title : Sintering Of Novel Bioresorbable Mg-Sr-Ca Alloys For Biomedical Applications

Keyword(s) :
Low Temperature Additive Manufacturing, Sinterability, Bioresorbable Magnesium Alloys, Powder Metallurgy, Mg Alloy Development

Abstract :
Magnesium (Mg) alloys have been receiving increased attention as an emerging class of biomedical metallic materials due to their outstanding combination of biocompatibility and bioresorbability. The customisation of biomedical Mg-based alloys via additive manufacturing (AM) technologies has remarkably enabled patient-specific designs over a short period of time. However, the low sinterability of Mg-based alloys is a key issue limiting the efficiency of post-processing required for the low temperature AM techniques (i.e., extrusion-based techniques). Hence, the aim of this work is to fundamentally evaluate the sinterability of the thermodynamically designed Mg-Sr-Ca based alloys processed by powder metallurgical routes in terms of porosity level and|or wettability of the target alloys. Differential scanning calorimetry (DSC) was used to select the sintering parameters. Materials characterisation was employed (Scanning Electron Microscopy (SEM|EDS) and X-ray Computed Tomography) to determine the porosity level and the effects of powder size|morphology on sinterability.

Innovative Aspect(s) :
Intrinsic properties of magnesium (Mg), such as high oxygen affinity, low ignition temperature and high vapor pressures, lead to safety concerns as well as lower mechanical performance when high temperature AM techniques (i.e., selective laser melting) are used. The use of low temperature AM techniques are more compatible with the aforementioned Mg inherent challenges. However, poor sinterability of Mg alloys is the main issue related to the low temperature AM techniques. Based on the literature, there are limited Mg-based alloys (mainly commercial series) for biomedical applications.Therefore, Mg alloy development by thermodynamic calculations and the choice of proper alloying additions are the first innovation in this work. Also, liquid phase sintering (LPS) was employed in this project to improve Mg sinterability. A dedicated powder (as the starting material for the sintering)preparation process was used, and the fundamental investigations of liquid-solid interactions during LPS was studied proving the novelty of this work.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C41
ID : 6281562

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Prof Biasetto Lisa (University of Padova, Italy)

Co-author(s) : Ing Gastaldi Vanessa (University of Padova, Italy); Prof Bolzon Gabriella (Politecnico di Milano, Italy); Prof Bellucci Devis (University of Modena and Reggio Emilia, Italy); Prof Cannillo Valeria (University of Modena and Reggio Emilia, Italy)

Title : Material Extrusion Of Multi-material Components: Comparison Between Direct Ink Writing And Fused Deposition Modelling Technologies

Keyword(s) :
Direct Ink Writing, Fused Deposition Modelling, Core-shell Structures

Abstract :
The use of 3D printing for fabricating multi-material structures presents a formidable task laden with multifaceted prospects. The challenge lies in the combination of materials (metallic alloys and ceramics) which engenders intricacies in managing processing parameters, spanning the gamut from the initial printing phase to subsequent post-processing stages. Conversely, this challenge is concomitant with a profusion of opportunities, as the coupling of distinct metallics and ceramics offers the potential to conjoin both structural and functional attributes within a singular component.The present study will focus on the production of metal-ceramic (316L-Al2O3 and 316L-CaTiSiO5) components by mean of two different technologies: direct ink writing of core-shell structures and extrusion of pellets by fused deposition modelling. Microstructural characteristics and mechanical properties of the two different technologies will be analyzed and compared.

Innovative Aspect(s) :
Multi-materials 3D printing represents the next step toward the production of components capable of showing multi-functional properties. Co-extrusion of metallic and ceramic inks by DIW so as FDM of modified pellets by multi-extrusion systems are two innovative technologies that are here analyzed showing the potentials for scalability of the process.Inks and pellet engineering for 3D printing intricated shapes so as their consolidation by de-binding and sintering step without cracks is the most significant result of the proposed work. Practical examples will be presented, underscoring the tangible real-world implications and innovative potential of this technology within the field of advanced manufacturing.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C42
ID : 6281677

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Mr Cogotti Andrea (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Co-author(s) : Dr Hein Sebastian Boris (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Ms Reineke Lea (1Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Title : Monitoring Of Powder Bed Temperature And Its Influence On Properties In Metal Binder Jetting

Keyword(s) :
Metal Binder Jetting, Temperature Measurement, In-Situ Measurement, Powder Bed Temperature

Abstract :
The focus on Metal Binder Jetting is increasing due to its potential for serial production. To control the printing process, in situ measurements are becoming essential. These measurements are commonly used in laser-based additive manufacturing processes. The objective of this study is to utilise a thermal camera during a Metal Binder Jetting process to determine the temperature distribution of the powder bed and its correlation with the properties of green parts. The temperature development was determined for each printed part, and a correlation with the final properties was established. To ensure homogeneity of properties and to achieve repeatable improvements in process control, it was suggested to standardize this measurement process.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C43
ID : 6281810

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dipl-Ing Abel Johannes (Fraunhofer IKTS Winterbergstraße 28, 01277 Dresden, Germany)

Co-author(s) : Dr Ing Scheithauer Uwe (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany); Dr Matthey Björn (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany); Dipl-Ing Kunze Steffen (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany); Dipl-Ing Müller-Köhn Axel (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany); Dipl-Ing Pötschke Johannes (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany); Dr Moritz Tassilo (Fraunhofer IKTS Winterbergstraße 28, 1277 Dresden, Germany)

Title : Thermoplastic Additive Manufacturing Of Very And Super Hard Ceramics By Means Of Fused Filament Fabrication

Keyword(s) :
Additive Manufacturing, Ceramics, Diamond, Fused Filament Fabrication, AM, FFF, Boron Carbide

Abstract :
The near net shaping of super hard ceramic materials such as WC-Co, RBB4C or diamond|SiC becomes particular interest when it comes to high performance applications. Additive Manufacturing (AM) plays a special role when complex shapes which can be manufactured with a low loss of material in low or medium quantities are needed. A very promising AM method to utilize a very broad material variety and particle size is CerAM FFF, which uses cost-effective equipment. On the other hand, machining and structuring of very hard materials is often costly which justifies AM additionally. For the precision machining of diamond composites for example water guided laser cutting can be applied which reduces the processing time and costs dramatically. The presentation gives an overview about current works and results in terms filament and component manufacturing as well as first results of water guided laser cutting of very and super hard ceramic materials.

Innovative Aspect(s) :
AM of complex super hard ceramic materials using cost effective FFF; Precision machining of super hard ceramic materials by water guided laser cutting

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C44
ID : 6281341

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Etiemble Aurélien (ECAM Lasalle, France)

Co-author(s) : Dr Simon Sandra (ECAM Lasalle, France); Dr Rigollet Claire (ECAM Lasalle, France)

Title : Influence Of Feedstock Formulation On Steel Processability By Extrusion Based Additive Manufacturing

Keyword(s) :
Formulation, Steel, Extrusion-based AM, Printing, Debinding, Sintering

Abstract :
Material extrusion additive manufacturing (EAM) offers a versatile range of applications for various metallic materials. In indirect processes, a mixture of metal powder and a polymer binder is extruded and deposited to shape the layers of the part, analogous to traditional polymer 3D printing. Subsequently, debinding and sintering steps are indispensable to achieve the final metallic component. Each of these stages may induce impurities and defects, significantly impacting geometric tolerances and mechanical properties. These defects such as warpage, shrinkage, porosity, residual carbon, and undesired phases result from complex mechanisms, due to insufficient or heterogeneous loading of feedstock, thermomechanical distortion during printing, partial debinding and inefficient sintering. This presentation will delve into these challenges, mechanisms, and EAM optimization strategies in the case of stainless and tool steels. The influence of feedstock formulation and associated process parameters on defects, microstructure, and resulting mechanical properties will be discussed.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C45
ID : 6281354

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Etiemble Aurélien (ECAM Lasalle, France)

Co-author(s) : Dr Simon Sandra (ECAM Lasalle, France); Dr Faye Romain (Nanoe, France); Dr Boulnat Xavier (MATEIS, INSA-Lyon, France); Dr Maire Eric (MATEIS, INSA-Lyon, France); Ing Lacorne Jordan (Nanoe, France)

Title : Insight Into Sintering Mechanism And Optimization Of Fused Filament Fabrication Of H13 Tool Steel

Keyword(s) :
Extrusion-based AM, Debinding, Sintering, H13 Work Tool Steel, Mechanical Characterization

Abstract :
In sinter-based additive manufacturing, such as metallic fused filament fabrication (mFFF), the sintering mechanism must be carefully understood and controlled to end up with the expected density, microstructure and mechanical behaviour. In the case of mFFF H13 tool steel, the considerations especially include carbon content, due to binder residue, porosity and pore size, associated with the densification step, as well as martensitic and carbide formations. This work will discuss the influence of sintering parameters (temperature, ramp rate and atmosphere) on its mechanism, based on in situ shrinkage measurements and the characterization of green, brown and sinter parts. The outcome on the final composition, microstructure and hardness will be highlighted.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C46
ID : 6281371

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Harakály György (Incus GmbH, Austria)

Co-author(s) : Dr Cano Cano Santiago (Incus GmbH, Austria); Dipl-Ing Bosters Johannes (Incus GmbH, Austria); Dipl-Ing Sperling Clemens (Incus GmbH, Austria); Ms Mödder Denise (Incus GmbH, Austria); Dr Stögerer Johannes (Incus GmbH, Austria)

Title : Effect Of The Powder Size Distribution On The Lithography-based Metal Manufacturing Process

Keyword(s) :
Lithography, Powder Selection, Additive Manufacturing, Stainless Steel, Surface Analysis

Abstract :
Lithography-based Metal Manufacturing (LMM) is an additive manufacturing (AM) technology that delivers components with high feature resolution and surface quality. By utilizing common Metal Injection Molding grade powders (d90 <25 µm) in the process, a surface roughness of Ra < 2 µm can be achieved, with stable geometric features down to 100 µm. Although these as-printed component parameters surpass those of other metal AM technologies, some applications demand lower surface roughness.To enhance part quality, one approach is the introduction metal powders with smaller size distribution. This not only improves the surface roughness, but also augment the sintering process by facilitating better powder packing. In pursuit of this objective, steel alloys of 316L and 17-4PH with varying size distribution have been analysed, with a specific focus on their processability in the LMM technology and their effectiveness in raising the quality of the components.

Innovative Aspect(s) :
LMM has the potential to produce currently unattainable designs for various applications. This work explores the opportunities to further improve the quality of the produced part. This opens the possibilities to design higher performance components for various applications, especially geometries difficult to polish efficiently.More specifically, this study explores the powder – resin interactions, from the standpoint of the physical characteristic of the metal powder, which is not a deeply explored field. By exhibiting this initial work, we show the powder metallurgy community a starting point for future work in sinter-based AM about powder selection, physical interaction of chemicals and powders and the effects of the physical form of the powder on sintered parts.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C47
ID : 6281459

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dipl-Ing Teuber Robert (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Co-author(s) : Dipl-Ing Herzer Niklas (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Prof Dr Weißgärber Thomas (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM; TUD Dresden University of Technology, Germany); Dr Ing Dollmeier Klaus (Georgsmarienhütte Holding GmbH, Germany)

Title : Additive Manufacturing Of Components From Pressure-embroidered Stainless Steel Using The MoldJet Process

Keyword(s) :
Additive Manufacturing, Moldjet, Sinter-Based, Nitrogen Alloyed Steel

Abstract :
This study deals with the processing of a developed nitrogen alloyed steel, containing additionally chromium, manganese and molybdenum (X13CrMnMoN18-14-3), using additive manufacturing. Applying the MoldJet process, the powder is first processed into a metal powder paste used for the printing of components. The MoldJet process is a novel, sinter-based additive manufacturing process, which enables the production of a wide range of geometries without the need of support structures. The high productivity of up to 1600 $cm^3|h$ also enables series production of components. The material can be used for components submitted to elevated stress levels, exhibiting at the same time a high degree of biocompatibility and enhanced corrosion resistance. The study will examine the powder itself, the processing into a paste and the mechanical properties after additive manufacturing. The aim is to show how an increase in performance can be achieved in combination with the use of the MoldJet process.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C48
ID : 6283049

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Ing Friso Andrea (Legor Group S.p.A., Italy)

Co-author(s) : Dr Ing Lago Mattia (Legor Group S.p.A., Italy); Dr Ing Friso Andrea (Legor Group S.p.A., Italy)

Title : Binder Jetting Additive Manufacturing For Fashion And Jewellery Items Production

Keyword(s) :
Binder Jetting Technology, Additive Manufacturing, Sintering, MIM, Investment Casting, PANACEA, AISI 316L, 17-4PH, Steel, Silver 925, Platinum 950, Fashion Production, Decorative, Surface Quality

Abstract :
The presentation is focused on introducing Binder Jet technology in its applications for jewellery and fashion items making, showing results from two years of use of 3D binder jet printers at our laboratories in Bressanvido, Italy. Despite being well known in other industries, binder jetting additive manufacturing is still not used in the jewellery sector; after a presentation of the technique and its possibilities, our practical experiences over two years of testing and production will be shared. Materials worked in our project span from steels suitable for fashion and watchmaking industry, to precious metals alloys (Silver 925 and Platinum 950). The experience so far proves Binder Jetting to be a realistic player in the world of jewelry production by additive manufacturing, although still undergoing a learning curve.

Innovative Aspect(s) :
Discussion of a new technology, Binder Jetting, that is still not well known in different manufacturing sectors; Offers the results in terms of quality and feasibility of alloys that have never printed with Binder Jetting, such as Silver 925, Platinum 950 and PANACEA steel, and on which there is little or no literature available.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C49
ID : 6283017

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Ing Studnitzky Thomas (Fraunhofer IFAM, Germany)

Co-author(s) : Prof Dr Weißgärber Thomas (Fraunhofer IFAM, Germany); Dr Ing Reuter Kay (Fraunhofer IFAM, Germany); Dr Zhong Chongliang (Fraunhofer IFAM, Germany); Prof Dr Höft Michael (Kiel University, Germany); Dipl-Ing Boe Patrick (Kiel University, Germany)

Title : Multi-material Printing Tungsten-copper For Future 5G And 6G High-frequency Applications

Keyword(s) :
High Requency Application, Sinter-Based Addtive Manufacturing, Screen Printing, Tungsten, Copper

Abstract :
Rectangular waveguides are widely used in communications satellites due to its low insertion loss and high power-handling. Additionally, near field communication in the upcoming 5G and 6G mobile communication standards are in this frequency range. As high quantities and tight tolerances are required for future applications, only a few manufacturing technologies come into consideration. In this work, the mass productive and cost-effective 3D screen printing was successfully used for this pupose. To achieve the goals, both a master alloy route tungsten-copper and a printing of tungsten with subsequent copper infiltration were investigated. Structures sizes of 300 µm with deviation of less than 10 µm with a surface roughness von 2 µm were successfully printed and sintered. The manufactured waveguides were characterised metallographically, tested for their function and compared with the design simulation. The specifications were well achieved, proving that 3D screen printing is an important candidate for digital communication technology.

Innovative Aspect(s) :
Conventionally manufactured (i.e. milled) components are manufactured successively one after the other. Additionally, depending on the center frequency, the milling machine is required to have very small tolerances for the realization of low-loss and well-matched filter responses. Mass-production of these components is therefore cost- and time-intensive. Furthermore, a lot of material is removed during milling, which is critical from an environmental point of view. The number of possible other both cheap and productive technologies is also limited. Screen-printed waveguide devices reveal the advantage to be suitable for mass-production, which also offers the possibility of cost-reduction. The tight tolerances of just a few µm pose a particular challenge for sinter-based additive processes, which could be successfully met here with a multi-material tungsten-copper approach. This approach is therefore a door opener for corresponding high-frequency applications that were previously closed to additive manufacturing.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C50
ID : 6283206

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ing Azurmendi Naiara (Tecnalia, Spain)

Co-author(s) : Dr Agote Iñigo (Tecnalia, Spain); Ing Gómez Xabier (Tecnalia, Spain); Dr Lores Asier (Tecnalia R&D, Spain)

Title : Study Of The Feasibility Of Processing P91 Steel Alloy Via Binder Jetting For Energy Sector Applications

Keyword(s) :
Binder Jetting, P91, Microstructure, Fusion Energy

Abstract :
In response to the recent demand for innovation in new sustainable energy sources, nuclear fusion emerges as a highly relevant and significant process. Given the international effort invested in manufacturing functional reactors, Additive Manufacturing (AM) stands out as a technology that can contribute to meeting the challenges and objectives of applications requiring advanced designs. This study explores the manufacturability of P91 alloy using Binder Jetting (BJ) for high-pressure applications, including those within prospective fusion reactor systems. Following the optimization of the AM process, subsequent adjustments in sintering, Hot Isostatic Pressing (HIP), and various required heat treatments have resulted in excellent material quality in terms of microstructure. Therefore, this study validates the successful use of BJ technology for employing P91 alloy.

Innovative Aspect(s) :
This study presents, for the first time in the literature to the best knowledge of the authors, the exploration of the P91 alloy through Binder Jetting, yielding excellent microstructural results. Validating this alloy for this manufacturing technology opens numerous possibilities for future applications across various sectors and industries, particularly in the development of components for the future energy landscape. This contribution aligns with ambitious decarbonization goals and environmental improvement efforts.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C51
ID : 6283231

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Dr Lores Asier (Tecnalia, Spain)

Co-author(s) : Ing Agote Iñigo (Tecnalia, Spain); Ing Gómez Xabier (Tecnalia, Spain); Ing Andrés Unai (MIM-Tech Alfa S.L., Spain)

Title : Exploring The Impact Of Cost-Effective Surface Treatments On The Roughness, Geometry, And Dimensional Stability Of FFF Sintered Parts

Keyword(s) :
FFF, 17-4PH, Surface Rougness, Post-processing, SBAM

Abstract :
Many requirements and applications in various industrial sectors demand high-quality finishes on parts. These finishes, whether due to tolerances or surface quality, are often challenging to achieve through additive manufacturing technologies, necessitating additional post-processing. This study aims to investigate the effect of specific surface treatments on parts produced through Sintering Based Additive Manufacturing (SBAM), such as Fused Filament Fabrication (FFF). With the premise of employing affordable post-processing methods that can potentially maintain competitive prices for the parts, the study analyzes the post-processing techniques of shot blasting and vibratory polishing on parts with different geometries. Additionally, the study examines the effect of surface treatments on part walls manufactured at various angles. The results obtained demonstrate significant improvements in surface roughness, although there is potential for them to modify the geometry and round the edges of the parts.

Innovative Aspect(s) :
The innovative aspect of this study focuses on correlating the effect of different surface post-processing techniques with both the achieved surface improvement and the adverse effects such as rounding of edges or geometric and dimensional modifications experienced by the parts. By varying processing parameters or the type of shot material, for example, we can observe and quantify the dimensional, roghnes and geometrical effects on the parts. The main goal, with all this, is twofold: on one hand, to select optimal conditions|processes for specific application requirements, and on the other hand, to be able to adapt or redesign the parts to compensate for the adverse effects of the treatment. In conclusion, this work aims to shed some light on the effect of post-processing on parts produced through SBAM.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C52
ID : 6283366

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Mr Aguilar-García José Luis (Carlos III University, Spain)

Co-author(s) : Mr Martínez Rodríguez Dayron (Carlos III University, Spain); Prof Dr Jimenez-Morales Antonia (Carlos III University, Spain); Prof Dr Ruiz-Navas Elisa M. (Carlos III University, Spain)

Title : Comparing Of Metal Injection Moulding And Composite Extrusion Modelling For Two Aluminium Alloys

Keyword(s) :
Aluminium Alloy, Metal Injection Moulding (MIM), Composite Extrusion Modeling (CEM), Sustainable Feedstock, Pellet

Abstract :
This work studies the processing of two industrial aluminium alloys, Al2024 and Scalmalloy, obtained by Metal Injection Moulding (MIM) and a novel additive manufacturing technology, Composite Extrusion Modelling (CEM), from sustainable feedstocks in pellets shape. For this purpose, both aluminium alloy powders were combined with water-soluble polymer, polyethylene-glycol (PEG), and low-CO2 emitting polymer, cellulose acetate butyrate (CAB). By means of the rheological characterisation of the feedstock and the subsequent microstructural characterisation and evaluation of the mechanical properties of the parts obtained, a comparison has been made between two different aluminium alloy powders consolidated by MIM and CEM, validating the processability of parts of these alloys using an innovative 3D printing technology. Compared to the injection moulding process, this technology offers advantages such as freedom in the shape of the parts obtained, and it also offers cost savings as it is a cost-effective process without the need for mass production.

Innovative Aspect(s) :
The processability of parts of two aluminium alloys using an innovative 3D printing technology by extrusion with feedstock in pellet form.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C53
ID : 6283714

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Prof Dr Kate Kunal (University of Louisville, USA)

Co-author(s) : Mr Zhang Sihan (University of Louisville, USA); Miss Ndiaye Fatou (University of Louisville, USA)

Title : Material Extrusion Additive Manufacturing (MEX-AM) Of Aluminium: Process Development And Process Optimization

Keyword(s) :
3D-Printing Aluminum, Paste Dispensing, Alloying, Debinding, Sintering, Recycling

Abstract :
This research studies Material Extrusion Additive Manufacturing (MEX-AM) for manufacturing 3D structures of aluminum and its alloy. Aluminum or aluminum 6061 powder was mixed with polymer binders to form a paste with up to 80 wt.% solids loading. The paste was pneumatically extruded at around 10 psi to fabricate green parts. Dried green parts were subjected to thermal debinding and sintering in nitrogen atmosphere. Sintered parts yielded over 95% sintered density with over 90% ultimate tensile strength of annealed aluminum 6061. To promote sintering performance of pure aluminum, magnesium and magnesium acetate were added as alloying agent and the effects were investigated. The main objective is to develop a customer-friendly MEX-AM process to fabricate components from a common lightweight metal. The focus lies on lowering requirements of tooling, space, and energy without sacrificing performance, which caters for space manufacturing.

Innovative Aspect(s) :
This talk elucidates the development of a novel approach to additive manufacturing of aluminum and its alloy by combining paste dispensing with thermal debinding and sintering. This study brings a customer-friendly way to 3D print metal with relatively lower requirement on tooling, space, and energy. As aluminum and its alloy are widely used in structural and packaging materials in space missions. The raw material in this study could come from aluminum recycling, therefore convert waste to useful structures in space missions. Paste feedstock with up to 80 wt.% solids loading could be extruded at around 10 psi pneumatic pressure to fabricate 3D structures. Sintered density could exceed 95% of wrought aluminum 6061 and the ultimate tensile strength could reach over 90% of annealed aluminum 6061. The effect of adding alloying agent to pure aluminum for promoting sintering performance was also evaluated.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C54
ID : 6282804

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ing Sandoval Neyder A. (Universidad Carlos III de Madrid, Spain)

Co-author(s) : Dr Murillo Edwin A. (Universidad Francisco de Paula Santander, Colombia); Dr Tsipas Sophia A. (Universidad Carlos III de Madrid, Spain)

Title : Evaluation Of Biopolymers To Produce Metal Or Metal-ceramic Feedstocks For Eco-sustainable Composite Extrusion Modelling

Keyword(s) :
Composite Extrusion Modelling, Biopolymer, Feedstocks, Environmental

Abstract :
Sinter-based additive manufacturing of metallic materials offers advantages in terms of design and efficiency but poses environmental concerns due to the use of chemicals and the generation of pollutant gases during the elimination of binders which are harmful to the environment. To improve this problem, the study of biopolymeric binders derived from renewable sources is proposed. This work explores composite extrusion modelling of metallic or metal-ceramic alloys. using biopolymers to produce environmentally friendly feedstocks. Comprehensive evaluation of biopolymer blends based on poly lactic acid and polyvinyl alcohol were carried out for their use as binders. A study of critical solidity loads, microstructural and rheological characterisation, densification, homogenisation, and thermogravimetric studies was performed. The deposition parameters of the material to produce parts were also optimised.

Innovative Aspect(s) :
Innovates by addressing environmental issues inherent in current AM sinter- based methods, proposing the use of biopolymer binders to mitigate chemical use and pollutant gas generation; Conducts thorough characterization of biopolymer blends for their use a binder in composite extrusion modelling.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C55
ID : 6281742

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Mr Wu Jianzhang (Delft University of Technology, Netherlands)

Co-author(s) : Mr Wu Jianzhang (Delft University of Technology, Netherlands)

Title : The Study Of Sintering Of Binder Jet 316L Stainless Steel

Keyword(s) :
Binder Jetting, 316L Stainless Steel, Sintering Process, Mechanical Properties, Microstructure

Abstract :
Notably, bidner jet technology enables swift prototyping of materials, attracting considerable interest in industrial applications. While 316L stainless steel is extensively utilized for its superior processability and mechanical attributes, its conventional production processes are typically intricate and exhibit low material efficiency. BJ thus emerges as a viable method for the expedited fabrication of 316L stainless steel parts. However, challenges persist with BJ-produced 316L components, particularly concerning porosity and mechanical performance, which often necessitate further post-processing treatments like sintering to improve the quality of the final product.This study seeks to enhance the density and mechanical characteristics of 316L stainless steel components fabricated using BJ technology by investigating the microstructure and mechanical performance of BJ 316L stainless steel components.

Innovative Aspect(s) :
This project primarily focuses on enhancing the density and mechanical properties of 316L stainless steel components through Binder Jetting (BJ) technology. A comprehensive study of the entire BJ process applied to 316L stainless steel materials is conducted, with particular attention to optimizing the sintering parameters for 316L stainless steel.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C56
ID : 6283238

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** AM Sinter Based Technologies

Author : Ms Gastaldi Vanessa (University of Padova, Italy)

Co-author(s) : Prof Biasetto Lisa (University of Padova, Italy); Prof Dr Bolzon Gabriella (Politecnico di Milano, Italy); Prof Bellucci Devis (University of Modena and Reggio Emilia, Italy); Prof Cannillo Valeria (University of Modena and Reggio Emilia, Italy)

Title : Direct Ink Writing Of 316L-sphene Core-shell Structures

Keyword(s) :
Direct Ink Writing, Core-shell Structures, 316L, Sphene

Abstract :
Direct Ink Writing allows to produce structures characterized by a personalized geometry, using different types of materials and keeping the costs low. Thanks to the versatility of this technology, it's also possible to increase the complexity of the obtainable structures by combining different materials, using multi-extruder printers or coaxial nozzles. One of the main advantages is to give the components hybrid and unique properties, tunable in accordance to the specific application.In this study the main focus is the production of core-shell metal-ceramic structures (316L-CaTiSiO5) with suitable mechanical, microstructural and functional properties for bone tissue regeneration. The effect of the sintering process on materials shrinkage, metal-ceramic interface and in particular on mechanical properties of the final components will be discussed.

Innovative Aspect(s) :
The production of multi-material components allows a flexible control over the final construct's properties: metal-ceramic match could lead to components with improved mechanical characteristics, compared with total ceramic objects, and keeping also functional properties related to the bio-ceramic contribution.The production of structures for bone tissue regeneration requires suitable properties for the interaction with the human body, such as bioactivity and biocompatibility, but the intrinsic fragility of ceramic materials could be limiting because of the mechanical stresses related to the type of application. The use of a coaxial printing nozzle enables to increase the performance of the components thanks to the presence of a metallic core, keeping the functional bio-ceramic properties required for a successful permanence inside a biological environment.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

COMPACTION AND SINTERING

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C57
ID : 6278273

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Compaction and Sintering

Author : Ing Valsecchi Giorgio (TAV VACUUM FURNACES, Italy)

Co-author(s) : Ing Valsecchi Giorgio (TAV VACUUM FURNACES, Italy)

Title : Sintering Atmospheres For The Vacuum Sintering Of 316L Stainless Steel

Keyword(s) :
Sintering, Sintering Furnaces, Metal Injection Molding, Metal Binder Jetting, Sinter-Based Additive Manufacturing

Abstract :
Sintered stainless-steel components are widely adopted in the automotive, biomedical, electronics and fashion industries. For complex shaped sintered stainless-steel parts, metal injection molding (MIM) has been the primary production technology for decades but, in past few years, sinter-based additive manufacturing (SBAM) has grown significantly in popularity.Both metal injection molded and additively manufactured stainless-steel parts are often sintered on vacuum furnaces to prevent oxidation, contamination and obtain high densities with bright surfaces. In that case, a partial pressure of inert or reactive gas is commonly adopted to suppress evaporation of volatile alloying elements (i.e. chromium and nickel) and to help remove binder residuals. During sintering, the gaseous atmosphere interacts with the steel influencing its final mechanical and corrosion properties.In this experiment, the effects of sintering on vacuum furnaces with different atmospheres (argon or hydrogen) on 316L parts manufactured through MIM and metal binder jetting SBAM were investigated.

Innovative Aspect(s) :
The use of different sintering atmosphere is affecting the density and other relevant properties of sintered stainless-steel. In particular, hydrogen is often regarded as the best solution to sinter low carbon stainless steels. There are, however, several factor that should be kept into consideration while comparing hydrogen to argon and nitrogen, such as the higher cost, the requirement for additional safety measures and, consequently, the increased complexity of furnaces designed for hydrogen operation. The aim of this experimentation is to investigate how the choice of different atmospheres impacts on the properties of sintered stainless steel parts produced using Metal Injection Molding and Metal Binder Jetting and, finally, provide an overall comparison between the different options.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C58
ID : 6281370

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Compaction and Sintering

Author : Dr Ing Raveu Gaelle (Framatome, France)

Co-author(s) : Dr Ing Bischoff Jérémy (Framatome, France); Ing Kandeepan Keerthanan (Framatome, France); Ing Collin de l'hortet Adrien (Framatome, France); Ing Namy Patrick (Simtec, France); Ing Bruyère Vincent (Simtec, France)

Title : Modelling Of The Fuel Sintering Process

Keyword(s) :
Sintering, Modelling, Parametric Studies

Abstract :
Framatome manufacturing plants use walking-beam furnaces to sinter large productions of fuel pellets. The sintering process of different products in the same equipment is complex with sublimation and reduction reactions involved, but also densification and grain-growth. Hence, Framatome started to model it with several benefits: - Increase reaction knowledge- Perform parametric studies without using the production equipment- Increase performance by process optimisation- Compare the different equipment within Framatome and use the best developments - Create teaching tools through theoretical description of the process and its key influencing parameters.The modelling is a step-by-step approach: first the geometry, gas flows and temperature were established, then adding more detailed pieces. Validation of the model is then done with experimental data from production campaigns. Afterwards, parametric sensitivity calculations can be performed to evaluate the influence of different parameters such as gas mixture, temperatures and therefore optimize the sintering.

Innovative Aspect(s) :
Use modelling to perform parametric testing, better knowledge of the equipment, improve product quality.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C59
ID : 6281603

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** Compaction and Sintering

Author : Mr Chaaban Khalil (ICB, UMR 6303 CNRS|Université de Bourgogne, France)

Co-author(s) : Dr Ariane Mostapha (SINTERMAT SAS, France); Dr Szczepan Victor (Safran Tech, France); Dr Chateau-Cornu Jean-Philippe (ICB, UMR 633 CNRS|Université de Bourgogne, France)

Title : Material Approach And Modelling Of The Thermo-electro-mechanical Sintering Process For The Dimension Control Of Complex Shape Parts

Keyword(s) :
Modelling, Densification, Complex Shape, Spark Plasma Sintering

Abstract :
Spark plasma sintering (SPS) technology is used to sinter, in a very short time, a large range of materials. One of the challenges of using this process is to control the final dimension of complex shape parts. In order to predict the compaction of the powder during a SPS cycle, we develop numerical models which take into account several physical laws involved during the sintering such as granular rearrangement and creep behavior at high temperatures (viscoplasticity). In this study, the code is fitted on an experimental densification curve of a nickel-based superalloy and implemented via the Abaqus® software in a thermal-electrical-mechanical model of the SPS process. A comparison of the numerical outputs with the experimental data shows a good agreement. The results demonstrate the capability to simulate accurately the sintering of powder with a limited number of experimental adjusted parameters compared to literature and to decrease significantly simulation run-time.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C60
ID : 6275377

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** Compaction and Sintering

Author : Ing Rosenblad Louise (KTH, Sweden)

Co-author(s) : Prof Larsson Per-Lennart (KTH, Sweden); Dr Staf Hjalmar (Sandvik, Sweden); Dr Larsson Henrik (KTH, Sweden)

Title : Robustness Analysis Of A Constitutive Model For Cemented Carbide Sintering

Keyword(s) :
Constitutive Modelling, Sintering, Cemented Carbide, Dilatometer Experiment

Abstract :
By performing a dilatometer experiment, the measured shrinkage can be used to determine the adjustable parameters in a constitutive model for sintering. While the dilatometer machine is excellent at collecting data, its conditions differ from those in an industrial sintering oven. Therefore, the constitutive model must be robust. Different sintering time cycles have been used to optimize the adjustable parameters in the model. The initial density has also been investigated to better understand the sintering process. This is important since the relative density in the green body after compaction may vary. Before the particles start to sinter, during the debinding process, densification can be detected, which is dependent on the initial density. The constitutive model for sintering was improved to include this phenomenon by adding particle rearrangement based on the theoretical packing of spheres.

Innovative Aspect(s) :
A better understanding of how and when shrinkage occurs during sintering of cemented carbide will lead to a shorter and better product development stage. The results are used for a specific constitutive model, but the experimental method can be used as guidelines to other models as well.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

FIELD ASSISTED SINTERING TECHNOLOGIES

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C61
ID : 6202215

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Ing Karpowicz Damian (GeniCore Sp. z o.o., Poland)

Co-author(s) :

Title : Hybrid Field Assisted Sintering As An Semi-automated Process For Cost-effective Production Of High Quality Big Volume Samples

Keyword(s) :
Fast Hybrid SPS Sintering

Abstract :
Field assisted sintering called also spark plasma sintering allow to produce exceptional quality materials which found a niche in applications where the quality is a most important factor or making the product with different method is impossible. GeniCore would like to present a new type of HYBRID FAST system which combines FAST type DC power supply with induction heating provided by AC power supply where novelty is oriented on assuring the extraordinary heating rates even for very big samples volume. Such a solution guarantees that FAST technology main advantage which is limiting the grain grow will affect the sample quality which has been challenging in previous solution.

Innovative Aspect(s) :
The presentation will refer to the applications where previously FAST method was inefficient or impossible to imply due to expected product volume. This can refer to the military, aerospace and energy applications. The second novelty is related with eddy current impact on the sintering with FAST technology for big volumes where using a different frequencies can generate a various results and when used properly lead to great energy savings or enhancing the material quality.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C62
ID : 6268565

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Ing Karpowicz Damian (GeniCore Sp. z o.o., Poland)

Co-author(s) :

Title : Upgraded Field Assisted Sintering Technology Latest Devices And Applications

Keyword(s) :
Spark Plasma Sintering, SPS, FAST, Field Assisted Sintering Technology, U-FAST, Upgraded Field Assisted Sintering Technology, Latest SPS Device, Latest SPS Applications

Abstract :
Field assisted sintering technology become a good alternative for most demanding applications. During the presentation most recent examples of materials made with FAST and PPC technology will be presented and solutions which allows to compete with other technologies when it comes for cost-effectiveness which in most cases is the biggest disadvantage for FAST|SPS technology. Presentation includes descriptions of solutions like graphite mold multi-hole design, near-net shaping, functionally graded materials. The current market expectations related with FAST technology will be shown on real examples.During the presentation also the new types of SPS devices will be presented to prove SPS techology can be used in bigger volume production.

Innovative Aspect(s) :
The article focuses on device technologies that affect the ability to not only achieve new types of results when it comes to sintering materials, but also enable the transition from research and development to the industrial world. New materials and increased material quality are key to scientific progress, and this article will show the tools that help create them.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C63
ID : 6276973

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dr Fregeac Arnaud (NORIMAT, France)

Co-author(s) : Dr Epherre Romain (NORIMAT, France); Dr Mackie Jennifer (NORIMAT, France); Ing Beynet Yannick (NORIMAT, France); Dr Ing Larignon Céline (NORIMAT, France)

Title : FAST|SPS: Industrial Post-process For Full Densification Of 3D Complex Shape From Additive Manufacturing

Keyword(s) :
FAST|SPS, Complexe Shape, Additive Manufacturing, High Mechanical Performance

Abstract :
The FAST|SPS process is recognized as an R&D method capable of producing high-performance parts from a wide range of materials. In recent years, significant progress has been made in overcoming the two main constraints of the technology: production capacity and geometric limitations, thanks to important advances in research and technology.This conference will focus on the progress made in the production of dense 3D complex shapes using FAST|SPS. An innovative and versatile approach, combining additive manufacturing and FAST|SPS, will be presented, along with original use cases involving various ceramic and metallic materials designed for applications in the aerospace, space, or defense sectors. Numerical tools to define the green part, chemical analisys and mechanical properties of the 3D parts will also be presented.

Innovative Aspect(s) :
Norimat made an important industrial breakthrough by developing a unique and easy process which enables the consolidation of 3D complex shapes by SPS. It allows to fully densify (porosity <1%) green parts made from additive manufacturing just after printing in only one step and less than 1h of thermal treatment. The debinding of the green parts made of AM has been optimized and is in situ realize in the FAST|SPS process. That's allowed to limit the thermal treatment time and to enhance the quality of the part in terms of chemistry and deformation. Moreover, the first FAST|SPS software suite dedicated to the FAST|SPS process has been developed to help the users with all aspects of SPS, from R&D (Digital Twin) to production monitoring (Statistical Process Control). Numerical simulation has ensured that thermal gradients during sintering of 3D parts are kept to a minimum.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C64
ID : 6278593

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Mr Weber Gerhard (Dr. Fritsch Group, Germany)

Co-author(s) :

Title : Sintering Of Ceramic Material On FAST|SPS-machines

Keyword(s) :
FAST|SPS-Sintering of ceramics, Graded Ceramics, Mould Set-up

Abstract :
The FAST-SPS-sintering of metallic materials is state of the art since a long time. One huge application there is the diamond tool industry. Recently, there were numerous approaches to sinter ceramic materials also with this technology to benefit of the many advantages of the FAST-SPS. However, the sintering of ceramics is much more challenging. The lack of electrical conductibility, the brittleness of the material and the reaction with the mould material is making fast results difficult.This paper will address several materials like B4C, Al2O3, ZrO2 TiB2 and some more. Furthermore, it will look into different Applications like Defense Industry, Sputter Targets, Jewelry and Electronic Industry.Also, the paper will have a look at graduated materials and heterogenic materials, e.g. bonding of ceramic powders onto metallic surfaces.

Innovative Aspect(s) :
FAST|SPS-sintering of ceramic materials Graded ceramic materials Metallic-ceramic-bonding by FAST|SPS

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024 CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C65
ID : 6279398

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dipl-Ing Thamm Merlin (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Co-author(s) : Dr Ing Lindemann-Geipel Inge (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany); Dipl-Ing Höhnel Christoph (TUD Dresden University of Technology, Germany); Mr Wang Shufan (Institute of Applied Powder Metallurgy and Ceramics at RWTH, Germany); Mr Deng Yuanbin (Institute of Applied Powder Metallurgy and Ceramics at RWTH, Germany); Prof Dr Broeckmann Christoph (Institute of Applied Powder Metallurgy and Ceramics at RWTH, Germany); Dipl-Ing Wentzlik Thomas (Magnetec GmbH, Germany); Mr Trupp Tobias (Magnetec GmbH, Germany); Prof Dr Weißgärber Thomas (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Germany)

Title : Analysis Of A Powder Metallurgical Production Route For Nanocrystalline Soft Magnetic Components

Keyword(s) :
Powder Compaction, FAST|SPS, Soft Magnetic Materials, Nanocrystalline

Abstract :
The prominent nanocrystalline alloy Fe73.6Si15.5B6.9Cu1.0Nb3.0 (at.%) is characterized by superior soft magnetic properties such as extremely low magnetic losses. The ribbons produced by melt spinning are conventionally difficult to process and thus are only wounded into toroidal cores. To avoid damage of the brittle nanocrystalline ribbons, a protective housing is needed, which limits the operating temperature of the wounded toroids to about 200 °C. In the publicly funded NanoKompakt project, both issues are addressed by manufacturing nanocrystalline components via a powder metallurgical process route using FAST|SPS to compact powder into discs, toroids and E-cores. Achieving a homogeneous temperature distribution during the FAST|SPS process is a great challenge due to the low conductance of the powder and a narrow temperature range for compaction. Therefore, simulation of the temperature distribution during FAST|SPS is needed. Both, process parameters, e.g. pressure and temperature, and material properties of powder and tooling are taken into account.

Innovative Aspect(s) :
The article describes a new fabrication process for processing nanocrystalline soft magnets using FAST|SPS. Large powder flakes are used to achieve significantly higher permeabilities (up to 20,000) than is usual with powder cores. These powders only apply a low transverse pressure to the pressing tool, so that it can be designed with very thin walls. This improves the temperature distribution during compaction with FAST|SPS.The temperature range during compaction to achieve excellent soft magnetic properties is very small, so the temperature distribution in the pressing tool is simulated based on the thermal and electrical properties of the used materials. Based on the simulation, new pressing tools are designed to produce larger and complex shaped components.The process has also already been applied to new types of nanocrystalline soft magnetic alloys with high power density. These require a high heating rate during crystallisation in order to prevent grain growth.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C66
ID : 6280921

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Ing Sauceda Martínez Sergio (Universidad de Concepción, Chile)

Co-author(s) : Dr Ing Arévalo Mora Cristina (Escuela Politécnica Superior, Universidad de Sevilla, Spain); Dr Ing Lascano Farak Sheila (Universidad Técnica Federico Santa María, Chile); Dr Montealegre Melendez Isabel (Escuela Politécnica Superior, Universidad de Sevilla, Spain); Dr Perez Soriano Eva Maria (Escuela Politécnica Superior, Universidad de Sevilla, Spain); Ing Pedrosa Fernández Pablo (Escuela Politécnica Superior, Universidad de Sevilla, Spain); Ing Machuca Lorca Ayelén (Universidad Técnica Federico Santa María, Chile); Ing Chávez Vásconez Ricardo (Universidad Técnica Federico Santa María, Chile); Ing Oropesa Márquez Yovany (Universidad de Concepción, Chile); Dr Ing Araya Rivera Nicolás Ignacio (Universidad de Concepción, Chile)

Title : A Comparison Between Spark Plasma Sintering (SPS) And Rapid Sinter Pressing (RSP) For Sintering Of W-Cu Composites At Low Temperature

Keyword(s) :
Metallic Composites, W-Cu, Field Assisted Sintering Technology|Spark Plasma Sintering, Rapid Sinter Pressing

Abstract :
Applications demanding exceptional electrical and thermal conductivity under extreme conditions, such as high-power contacts or nuclear fusion reactors, frequently rely on W-Cu composites. Powder metallurgy serves to create this type of material with distinct melting points; however, there is a discussion in the literature about the most suitable powder metallurgy techniques. Spark Plasma Sintering (SPS) and Rapid Sintering Process (RSP) propose the creation of materials within minutes and at lower temperatures on an industrial scale. This study undertakes a comparative analysis of two different sintering techniques at 600°C, while varying the pressure and sintering time for W-Cu samples containing 25% and 75%wt of W. The findings showed that the materials' density, hardness, and electrical conductivity are significantly affected by the applied pressure during sintering, particularly in the case of the SPS technique. Furthermore, in SPS and RSP, with even minor increments in sintering time results in improved properties.

Innovative Aspect(s) :
This paper compares two non-traditional sintering methods for manufacturing metallic compounds, intending to select the most suitable for industrial scaling and studying the benefits of the sintering principles of each technique on their microstructure and final properties in W-Cu composites.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C67
ID : 6280685

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Prof Dr Bram Martin (Forschungszentrum Jülich, Germany)

Co-author(s) : Dipl-Ing Keszler Monica (Forschungszentrum Jülich, Germany); Dipl-Ing Großwendt Felix (Ruhr-Universität Bochum, Germany); Dipl-Ing Assmann Anna-Caroline (RWTH Aachen University, Germany); Prof Dr Guillon Olivier (Forschungszentrum Jülich, Germany); Prof Dr Weber Sebastian (Ruhr-Universität Bochum, Germany)

Title : Application Of Field Assisted Sintering For The Recycling Of Steel Swarf

Keyword(s) :
Field Assisted Sintering, FAST|SPS, Steel Swarf, Circular economy

Abstract :
The grinding of steel tools to their desired form generates sludge containing metallic swarf considered undesirable for direct recycling. After cleaning and separation of this steel swarf, its morphology often leaves it unsuitable for standard powder metallurgical uses. However, the possibility exists of utilizing field assisted sintering techniques to densify this swarf directly into new parts, thereby avoiding the need for remelting. This technique also allows for the generation of new metal matrix composites through its quick sintering time. The application of field assisted sintering as a recycling tool is realized through the densification of two different steels, AISI D2 and AISI T15, exploring the influence of varied parameter sets and tool setups on their sintering. For proof of concept, a cutting disc made of AISI D2 swarf has been produced and tested.

Innovative Aspect(s) :
Direct recycling of metallic grinding waste, Demonstration on the example of steel swarfCutting disc for proof of concept, Preservation of critical elements like W or CoCircular economy

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C68
ID : 6281891

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dr Ing Daudt Natalia (UFSM, Brazil)

Co-author(s) : Ing Noal Alves Sergio (UFSM, Brazil); Dr Ing de Lima Dalton Daniel (UFSM, Brazil); Prof Dr Limberger Inacio (UFSM, Brazil)

Title : Ultra-fast High Temperature Sintering (UHS) Of Ni-NiO Composites

Keyword(s) :
UHS Sintering, Ni Alloys, Metal Matrix Composites

Abstract :
Powder metallurgy and sinter-based additive manufacturing are cost effective routes for manufacturing high value metal alloys and metal matrix composites such as Ni based alloys used in the aerospace and energy industries. Despite the development of these manufacturing techniques in recent years, the sintering step remains a challenge due to its high energy consumption and long dwell times. Ultrafast High Temperature Sintering (UHS) has emerged as an alternative capable of sintering metal alloys in just a few seconds. In this study, we evaluate the UHS sintering of Ni-NiO composites. The effects of UHS current and dwell time on the microstructure and mechanical properties of Ni-NiO was investigated. UHS should facilitate the development and manufacture of metal alloys and composites from metal powders.

Innovative Aspect(s) :
UHS sintering is very recent technology. First, UHS sintering reports were published in 2020. To our best knowledge this is the first time the technology was applied to Ni alloys and it is the first time the mechanical properties of alloy processed by this technology was investigated. This is an important step to drive the UHS to applications.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C69
ID : 6281338

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dr Rajaei Hossein (University of Trento, Italy)

Co-author(s) : Prof Molinari Alberto (University of Trento, Italy); Dr Ángel Lagos Miguel (Tecnalia, Spain); Dr Agote Iñigo (Tecnalia, Spain); Dr Ferrari Daniele (Dellas, Italy); Dr Dai Pré Marta (Plumake, Italy)

Title : Comparative Study Of FAST And Conventional Sintering Of Cutting Tool Materials

Keyword(s) :
FAST, X-ray Diffraction, Phase Characterization, Cutting Tools, Cobalt, Bronze

Abstract :
This study explores the effectiveness of Field Assisted Sintering Technology (FAST) in producing cutting tools from various materials, using powder mixes in granulated and non-granulated conditions. The goal is to demonstrate FAST efficiency across diverse materials by comparing results obtained on the same systems using a conventional sintering approach. Two powder mixtures were examined: one consisting of Bronze, containing: Co, Fe, and W; and a Co|Bronze 85|15 powder mix. Sample characterization involved Rietveld refinement of X-ray diffraction patterns coupled with microstructural analysis using SEM and EDXS. The study revealed that the sintering process significantly influenced microstructural characteristics. The FAST process maintained a consistent ratio of starting phases, unlike conventional sintering prone to reactions, diffusion, and intermetallic compound formation. Conventional sintering of the Bronze-Co-Fe-W material resulted in a lattice expansion in cobalt polymorphs with respect to the starting powder. FAST samples showed a lower volume change, due to short sintering time.

Innovative Aspect(s) :
The current manufacturing process of these parts takes several hours and is inefficient in terms of energy and material consumption. The new process will manufacture components in few seconds, allowing to obtain final parts with less energy consumption and minimum raw material wastage (it is a near net shape process); thus, contributing to the green manufacturing and environmental footprint reduction.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C70
ID : 6281129

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dr Rajaei Hossein (University of Trento, Italy)

Co-author(s) : Prof Molinari Alberto (University of Trento, Italy); Dr Ángel Lagos Miguel (Tecnalia Research & Innovation, Spain); Dr Agote Inigo (Tecnalia Research & Innovation, Spain); Dr Ferrari Daniele (Dellas SPA, Italy); Dr Dai Pré Marta (Plumake, Italy)

Title : Comparative Study Of FAST And Conventional Sintering Of Cutting Tool Materials

Keyword(s) :
FAST, X-Ray Diffraction, Phase Characterization, Cutting Tools, Cobalt, Bronze

Abstract :
This study explores the effectiveness of Field-Assisted Sintering Technology (FAST) in producing cutting tools from various materials, using powder mixes in granulated and non-granulated conditions. The goal is to demonstrate FAST efficiency across diverse materials by comparing results obtained on the same systems using a conventional sintering approach. Two powder mixtures were examined: one consisting of Bronze, containing: Co, Fe, and W; and a Co|Bronze 85|15 powder mix. Sample characterization involved Rietveld refinement of X-ray diffraction patterns coupled with microstructural analysis using SEM and EDXS. The study revealed that the sintering process significantly influenced microstructural characteristics. The FAST process maintained a consistent ratio of starting phases, unlike conventional sintering prone to reactions, diffusion, and intermetallic compound formation. Conventional sintering of the Bronze-Co-Fe-W material resulted in a lattice expansion in cobalt polymorphs with respect to the starting powder. FAST samples showed a lower volume change due to the short sintering time.

Innovative Aspect(s) :
The current manufacturing process for these parts takes several hours and is inefficient in terms of energy and material consumption. The new process will manufacture components in a few seconds, allowing for the production of final parts with less energy consumption and minimum raw material waste (it is a near-net shape process), thus contributing to green manufacturing and environmental footprint reduction.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C71
ID : 6281353

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Dr Sicard Damien (Sintermat, France)

Co-author(s) : Prof Bernard Frederic (University of Burgundy, France); Dr Naimi Foad (Sintermat, France); Dr Ariane Mostapha (Sintermat, France)

Title : Toward A Spark Plasma Sintering Digital Twin Using A Deep Learning-Based Approach

Keyword(s) :
Deep Learning, Digital Twin, Spark Plasma Sintering

Abstract :
Over the last two decades, Spark Plasma Sintering (SPS) has become a major technique for manufacturing advanced materials. Nevertheless, the control of SPS process is complex and requires the use of complex multiphysics and multiscale numerical simulations. Nowadays, the emerging data-driven approaches such as Deep Learning have proven their effectiveness in many fields. Thus, we develop a Deep Learning architecture based on Convolutional Neural Network (CNN) and Generative Adversial Neural Network (GAN). The network is train on high-throughput macroscale FEM simulation maps and associated process parameter tabular data. The power of this approach lies on the ability of the network training process to be incrementally augmented by multivariate data such as real microstructure images and real sintering signals : toward a SPS digital twin.

Innovative Aspect(s) :
The innovative aspect of the paper lies in the usage of artificial intelligences algorithms such as Deep Learning to build a Spark Plasma Sintering Digital Twin. In this purpose, a custom neural network architecture was built to allow a training on multivariate Spark Plasma Sintering Data.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C72
ID : 6274524

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Mr Carlucci Giovanni (Politecnico di Milano, Italy)

Co-author(s) : Mr Ferrario Edoardo (Politecnico di Milano, Italy); Mr Bianchi Andrea (University of Pavia, Italy); Ms Maranini Giulia (University of Pavia, Italy); Dr Coduri Mauro (University of Pavia, Italy); Prof Anselmi-Tamburini Umberto (University of Pavia, Italy); Prof Casati Riccardo (Politecnico di Milano, Italy)

Title : Microstructural And Mechanical Characterization Of A Spark Plasma Sintered Al-Containing Refractory High-Entropy Alloy

Keyword(s) :
Refractory High-Entropy Alloys, Spark Plasma Sintering, Powder Metallurgy, Alloy Design, Microstructure, Mechanical Properties

Abstract :
Over the past decade, refractory high-entropy alloys (RHEAs) have been intensively studied due to their excellent high-temperature performances. Significant effort was dedicated to reducing their density, aiming to make them competitive with Ni-based superalloys. However, RHEAs are typically produced through casting methods, which, given the high melting temperatures of their constitutive elements, may lead to inhomogeneous and coarse microstructures, thereby compromising their mechanical properties. Given this context, powder metallurgy would be a preferable route for manufacturing high-performing RHEA components. In this study, spark plasma sintering was employed to produce the biocompatible MoNbTaTiZr RHEA, later modified with the addition of aluminum to reduce its density. The microstructure and the mechanical properties of both alloys were investigated. Eventually, a component with a gradient of aluminum through its thickness was also manufactured by a diffusion couple, allowing a more in-depth investigation on the effect of aluminum content on the properties of the RHEA.

Innovative Aspect(s) :
In this work, to the best of our knowledge, the microstructure and the mechanical behavior of a spark plasma sintered AlMoNbTaTiZr RHEA were investigated for the first time. Furthermore, a compositionally graded material was employed to study in a novel way the effect of aluminum content on the properties of this alloy system. This identified SPS as a manufacturing process suitable for a high-throughput screening of the unexplored RHEA compositions.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C73
ID : 6281368

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Ing Mathey Baptiste (Burgundy University, France)

Co-author(s) : Dr Naimi Foad (Sintermat, France); Dr Ariane Mostapha (Sintermat, France); Prof Dr Bernard Frederic (Burgundy University, France)

Title : Development Of Complex Shape Parts In Large Size By Spark Plasma Sintering

Keyword(s) :
SPS, Near Net Shape, Large Size Pieces

Abstract :
Spark Plasma Sintering (SPS) technology is well-known for allowing the elaboration of enhanced and high-performance materials by fine control of the microstructure. Nevertheless, Near Net shape parts (complex shape), monitoring control (test reliability) and scale-up (industrialisation) remain a technological challenge.In this study, we present the sintering of sputtered materials (B4C + additive, 316L, Al2O3, SiC+ additive) which are adapted for the production of large-sized and complex shape parts by SPS process. We focus on development of tooling solutions (solid tooling and deforming tooling) to obtain complex shape samples and to control the thermomechanical gradient. The choice of the sacrificial material in order to not affect the property of the targeted material is also investigated. Finally, all parameters are tested to achieve enhanced properties with the finest microstructure. This study aims to in a short time an industrial scale-up and flow production.

Innovative Aspect(s) :
This study aims to the development of access a large size complex shape in Spark Plasma Sintering. It's improving the choice to use different technology of forming Near Net shape piece (additive manufacturing or other technology) and combine classical tooling or adding mobile tooling to produce large sizes Near Net shape piece. This study aims to adapt tooling and Spark Plasma Sintering technology to access fine microstructure, high performance.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C74
ID : 6269600

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Prof Grigoryev Evgeny (Merzhanov Institute of Structural Macrokinetics and Materials Science Russian Academy of Sciences, Russia)

Co-author(s) : Prof Goltsev Vladimir (NRNU MEPhI, Russia); Prof Osintsev Andrey (NRNU MEPhI, Russia); Dipl-Ing Kuznechik Oleg (SSI PMI, Belarus); Dr Chumakov Alexander (B.I.Stepanov Institute of Physics, Belarus); Dr Nikonchuk Irina (B.I.Stepanov Institute of Physics, Belarus); Prof Strizhakov Evgeny (DON STATE TECHNICAL UNIVERSITY, Russia); Prof Nescoromniy Stanislav (DON STATE TECHNICAL UNIVERSITY, Russia); Dipl-Ing Ageev Stanislav (DON STATE TECHNICAL UNIVERSITY, Russia)

Title : Features Of High-Voltage Consolidation Of Powder Materals

Keyword(s) :
High-voltage Electric Pulse Consolidation, Refractory Powder Materials, Electrothermal Processes, High-voltage Welding, Thermal Radiation, Pulse Photometry

Abstract :
The main features of the method of high-voltage consolidation of powder materials and the resulting advantages and limitations of this method are considered. The short duration of high-temperature exposure in the process of high-voltage consolidation makes it possible to preserve the structural-phase state of the initial powder material in the consolidated compact material The formation of the structure of a powder material during high-voltage consolidation is determined by processes of different scales occurring at interparticle contacts, in powder particles, in the bulk of the entire sample, and by the mutual influence of these processes. The high energy density in the particle contact zones leads to a local change in the state of aggregation of the powder substance in these zones. Along with the inhomogeneity of powder heating in interparticle contacts, a macroscopically inhomogeneous distribution of the current density in the volume of the consolidated sample is possible.

Innovative Aspect(s) :
The registration of electrothermal processes during high-voltage electric pulse consolidation of refractory powder materials makes it possible to establish the optimal parameters of high voltage consolidation for optimal structure in consolidated samples.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C75
ID : 6276957

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Prof Ctibor Pavel (Ústav fyziky plazmatu AVCR, Czech Republic)

Co-author(s) : Dr Straka Libor (Faculty of electrical engineering CTU Prague, Czech Republic); Dr Lukac Frantisek (Ústav fyziky plazmatu AVČR, Czech Republic)

Title : Copper Oxides CuO And Cu2O Produced By Spark Plasma Sintering - Electrical Characterization

Keyword(s) :
CopperOxide, Dielectric Properties, Spark Plasma Sintering, Microstructure, Phase Composition, Photoconductance

Abstract :
Commercial powders made of two copper oxides were compacted by spark plasma sintering (SPS). Their dielectric properties were studied in a broad range of frequencies and temperatures. The relaxation phenomena were demonstrated. Microstructure and phase composition were studied, and phase purity was shown for CuO, whereas Cu2O was more sensitive to carbon contamination during SPS processing and also to the oxygen reduction. Influence of the SPS temperature on microstructure and electrical properties was described for both materials. The difference between them from the electrical standpoint was finally found to be not so dramatic as the stoichiometry indicates. Both materials exhibited photoinduced electrical conductance under visible light. This photoconductance had a persistent character and was studied during a long-term exposure.

Innovative Aspect(s) :
The dielectric properties of bulk CuO and Cu2O, as well as their photoconductance were studied more deeply than (worldwide) in the past. Photoconductance was demonstrated at first time.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : P-C76
ID : 6283678

Requested presentation type : Poster Presentation

Topic : Consolidation Technologies **Subtopic :** Field Assisted Sintering Technologies

Author : Ing Chávez-Vásconez Ricardo (Universidad Técnica Federico Santa María, Chile)

Co-author(s) : Mr Acevedo Nicolás (Universidad Técnica Federico Santa María, Chile); Dr Arévalo Cristina (Universidad de Sevilla, Spain); Ing Sauceda Martínez Sergio (Universidad de Concepción, Chile); Dr Ing Pérez Soriano Eva (Universidad de Sevilla, Spain); Prof Dr Torres Yadir (Universidad de Sevilla, Spain); Dr Ing Lascano Farak Sheila (Universidad Técnica Federico Santa María, Chile)

Title : Graded Porosity Structures In High Entropy Alloys: An Innovative Synthesis Approach Utilizing Space-Holder Technique And Pressureless Spark Plasma Sintering

Keyword(s) :
Field Assisted Sintering Technology, Functional Graded Porosity, High Entropy Alloys

Abstract :
A high entropy alloy (HEA) is an innovative alloying strategy, introduced recently in materials science research, that vastly increases the number of alloy systems that can achieve properties such as high strength, high ductility, and enhanced fracture toughness. Potential applications of HEAs include the aerospace field, where the requirements for high-temperature resistance alloys are pushing the HEAs, high-speed cutting tools, nuclear industry, hydrogen storage materials, and biomaterials. In these areas some of the applications require functionalisation of the structure by porous gradual distribution to reduce weight or add functional characteristics. In this work, a consolidation route to obtain graded porosity distribution (radial and longitudinal) in samples of HEAs based on TiNbTaHfMo is presented. This approach combines the use of pre-compaction process, temporary space holder and the sintering by Field Assisted Sintering Technology|Spark Plasma Sintering in a pressureless die to consolidate radial and longitudinal samples of HEAs based on TiNbTaHfMo

Innovative Aspect(s) :
A high entropy alloy (HEA) is an innovative concept introduced by Yeh in 2004, as an innovative alloying strategy that vastly increases the number of alloy systems that can achieve properties such as high strength, high ductility, and enhanced fracture toughness. Although high entropy alloys expand opportunities for discovering alloys, they present an important challenge related to long processing time. In this sense, non-conventional and novel sintering routes, such as spark plasma sintering (SPS), presents notable advantages that allow processing HEAs with tailored microstructure and properties. Exploring this method to obtain porous structures is non- conventional way to use spark plasma sintering process. To the best of our knowledge, there are no reports of Ti-Nb-Ta-Hf-Mo with functional graded porosity.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

HOT ISOSTATIC PRESSING

EPMA

european powder metallurgy association

EURO PM2024 CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C77
ID : 6206006

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Hot Isostatic Pressing

Author : Dr Liu Yan (Simtec Soft Sweden AB, Sweden)

Co-author(s) : Dr Yan Zhenghua (Simtec Soft Sweden AB, Sweden); Mr Lv Zhoujin (CISRI-HIPEX TECHNOLOGY CO., LTD, China); Mr Li Jiawei (CISRI-HIPEX TECHNOLOGY CO., LTD, China); Dr Qi Wen (CISRI-HIPEX TECHNOLOGY CO., LTD, China); Dr Eklund Anders (CISRI-HIPEX TECHNOLOGY CO., LTD, China)

Title : Fully Coupled And Efficient Simulation Of A Hot Isostatic Pressing Furnace

Keyword(s) :
Hot Isostatic Pressing, 3D full -scale Computational Fluid Dynamics Simulation, Gas Flow, Heat Transfer, Thermal Radiation, Gas Pressure

Abstract :
Hot Isostatic Pressing (HIP) is crucial for densifying and enhancing materials in industries such as aerospace and additive manufacturing. Optimizing HIP cycles and designing efficient furnaces are critical, with computer simulation of furnace processes being indispensable.This study addresses the convergence and the time-consuming issues of traditional simulations, by using a novel, fully coupled, and highly efficient Computational Fluid Dynamics (CFD) method. It models a complete 25-hour HIP cycle for a full-scale furnace, including heating, holding, and cooling phases, based on the given furnace power. The advanced approach enables detailed, fully coupled, and full-scale 3D computations of all critical processes like gas flow, pressure build-up, thermal radiative heat transfer, convective heat transfer, and conjugate heat conduction in solids. The simulated temperature and pressure closely match the experimental results. By avoiding the common pitfalls of error-prone simplifications, this method lays a strong foundation for optimizing HIP furnace design and operations.

Innovative Aspect(s) :
This study presents an innovative approach to Hot Isostatic Pressing (HIP) simulation, crucial for industries like aerospace and additive manufacturing. Traditionally, HIP simulations are hampered by convergence issues and time-intensive processes. This research overcomes these challenges using a novel, fully coupled Computational Fluid Dynamics (CFD) method. It accurately models a complete 25-hour HIP cycle in a full-scale furnace, tailored to specific furnace power settings. The method's distinctiveness lies in its detailed 3D computations, encompassing all critical processes such as gas flow, pressure build-up, all forms of heat transfer, and conjugate heat conduction in solids. This comprehensive approach ensures a more accurate simulation of real-world conditions. Notably, the simulated temperature and pressure results closely align with experimental data, validating the method's reliability. By avoiding simplifications prone to errors, this study sets a new standard in HIP furnace design and operations, paving the way for more efficient and optimized manufacturing processes.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C78
ID : 6219721

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Hot Isostatic Pressing

Author : Mr Magnusson Anders (Quintus Technologies AB, Sweden)

Co-author(s) : Mr Shipley James (Quintus Technologies AB, Sweden); Mr Gårdstam Johannes (Quintus Technologies AB, Sweden)

Title : Combining AM And HIP For Speed And Performance

Keyword(s) :
HIP|HPHT, AM Speed Printing, Possibilities, Pitfalls

Abstract :
AM (Additive Manufacturing) technology naturally benefits from HIP (Hot Isostatic Pressing) post processing to enhance reliability and mechanical properties for components in high risk, mission critical applications. In addition to this, the past few years have seen several investigations exploring the potential of combining AM and HIP, both for reducing time and cost of manufacturing, and for improving mechanical properties of AM builds. This in using innovative concepts such as speed, shell and LoF (Lack of Fusion) printing in combination with a final densification using HIP. This presentation aims to compile and highlight potential benefits, and pitfalls, using these innovative strategies for high volume AM manufacturing of high-performance components from different metal alloys.

Innovative Aspect(s) :
We offer a summary of current state for the possibilities and pitfalls of AM speed printing as seen from the HIP equipment manufacturers point of view including examples from the research community, cost savings calculations and do|do nots' for the strategy to work.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C79
ID : 6275416

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Hot Isostatic Pressing

Author : Mr Ehrlin Niklas (Air Liquide, Sweden)

Co-author(s) :

Title : The Effect Of Hydrogen In The HIP Treatment Of Additive Manufactured IN718

Keyword(s) :
IN718, Hot Isostatic Pressing, Hydrogen Degradation, Surface Oxide Reduction

Abstract :
Hydrogen has a long history of being used as a reducing agent in many different types of heat treatments. So far, the wide application of hydrogen is limited to heat treatment processes that are in the range of atmospheric pressure. In this study, the use of hydrogen in hot isostatic pressing (HIP) was investigated and its influence on component properties was studied. By using a gas mixture with a low concentration of hydrogen in argon as the atmosphere gas in a HIP treatment of additively manufactured Inconel 718 test parts, there is a clearly visible reduction of surface oxides, compared to similar test parts HIP treated in the traditional atmosphere of 100% argon. A reduction of surface oxides could have a substantial impact on both the mechanical properties of the treated parts and on the further manufacturing steps in the production chain, where surface oxides might be problematic.

Innovative Aspect(s) :
By using a pre mixed gas containing 2.65% hydrogen in argon in HIP application, unwanted surface oxides can be reduced and even removed completly. This leads to HIP treated parts with a much more homogenous surface that can have substantial effect on the need of post processing such as polishing as well as yielding a more aestethic looking part after HIP'ing.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C80
ID : 6281533

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Hot Isostatic Pressing

Author : Mr Jabir Hussain Ahmed Fardan (Chalmers University of Technology, Sweden)

Co-author(s) : Mr Gårdstam Johannes (Quintus, Sweden); Dr Brodin Håkan (Siemens Energy, Sweden); Prof Hryha Eduard (Chalmers University of Technology, Sweden)

Title : Taming The Cracks: Overcoming Strain Age Cracking In An Additively Manufactured Non-weldable Ni-base Superalloy Through HIP

Keyword(s) :
Strain Age Cracking, Non-Weldable Ni-Base Superalloy, Powder Bed Fusion - Laser Beam, Additive Manufacturing

Abstract :
Non-weldable Ni-base superalloys processed via powder bed fusion – laser beam (PBF-LB) exhibit high cracking susceptibility, particularly during heat treatment, owing to the formation of gamma prime (?') precipitates during the first solutioning heat treatment, leading to a cracking phenomenon called strain age cracking (SAC). CM247LC is a high ?' Ni-base superalloy that is particularly prone to SAC. SAC is detrimental and hinders the usage of components manufactured by PBF-LB. This study explores the utilization of hot isostatic pressing (HIP) to mitigate SAC and enhance recrystallization in CM247LC processed by PBF-LB. Two distinct HIP strategies, both conducted above the ?' solvus temperature, were employed. Findings indicate that tailored HIP processing is promising in effectively reducing SAC and enabling the successful heat treatment of this conventionally "non-weldable" Ni-base superalloy.

Innovative Aspect(s) :
The innovative aspect of the work is to study the impact of HIP strategies to control stain age cracking and to increase recrystallization. One of the HIP strategies were found to be better indicating that strain age cracking risk can be reduced in non-weldable Ni-base superalloys manufactured by powder bed fusion-laser beam.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C81
ID : 6281909

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Hot Isostatic Pressing

Author : Prof Prikhodko Sergey (University of California Los Angeles, USA)

Co-author(s) : Dr Markovsky Pavlo (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine); Prof Dr Ivasishin Orest (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine); Dr Savvakin Dmytro (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine); Dr Stasyuk Olexandr (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine); Dr Oryshych Denis (G.V. Kurdyumov Institute for Metal Physics of N.A.S. of Ukraine, Ukraine)

Title : Titanium Based Laminates Made Using Blended Elemental Powder Metallurgy: Microstructure And Mechanical Behavior

Keyword(s) :
Titanium Alloy, Metal Matrix Composites, Layered Structure, Phase Composition, Microstructure, Mechanical Characteristics

Abstract :
Titanium-based laminates combining hard metal matrix composites (MMC) and ductile alloy layers are promising materials due to an improved set of mechanical and service characteristics. In present study the two and three-layered structures that combine MMC on the base of titanium alloy Ti-6Al-4V (Ti-64) reinforced with 5 to 40 % (vol.) of TiC or TiB particles and the layer made of the alloy Ti-64 were manufactured using press-and-sinter blended elemental powder metallurgy. The effect of processing parameters and amount of reinforcing phase on microstructure and mechanical behavior of these materials was analyzed. In addition, hot plastic deformation and hot isostatic pressing of laminates have been used to investigate the potential to improve their microstructure mechanical characteristics. It has been demonstrated that the structures made according to optimized processing parameters exhibit excellent protective performance in ballistic tests. Prospects for improving the structure and methods of making titanium-based laminates are discussed.

Innovative Aspect(s) :
Greater introduction of titanium to the industry can be achieved by reducing the cost of parts and significant improvement of their performance. A significant increase in the hardness of Ti composite made via powder metallurgy can considerably boost the use of Ti. High residual porosity may be unavoidable in composites made using blended elemental powder metallurgy when the reinforcement phase content exceeds 10%, but it can be significantly rectified by subsequent processing of composites using hot isostatic pressing, which considerably improves their hardness. The present study shows that it is possible to double the hardness of a titanium-based material without compromising its low specific weight.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

METAL INJECTION MOULDING

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C82
ID : 6278267

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Metal Injection Moulding

Author : Dr Meza Alberto (IMDEA Materials Institute, Spain)

Co-author(s) : Ing Alonso Andrea (IMDEA Materials Institute, Spain); Dr García de la Cruz Lucía (University Carlos III of Madrid, Spain); Prof Torralba José Manuel (IMDEA Materials Institute, Spain)

Title : High Entropy Alloy Components Prepared From Commodity Alloys And Metal Injection Moulding

Keyword(s) :
High Entropy Alloys, Metal Injection Moulding, Sustainable Feedstock, Additive Manufacturing

Abstract :
High entropy alloys (HEAs) are researched due to their distinct microstructures and impressive mechanical performance, which are achieved by combining multiple principal elements in nearly equal ratios. However, the inclusion of multiple elements poses challenges in HEAs fabrication by PM routes due to the high cost of pure elemental powders and the absence of readily available prealloyed HEAs compositions. Employing commodity powders such as Ni625, CoCrF75, or 316L has emerged as a viable approach, reducing manufacturing expenses and facilitating HEAs development. Furthermore, these powders ease the production of HEAs components by metal injection moulding. In this study, various binders were studied to optimise powder loadings in the feedstocks, subsequently utilised in injection or 3D printing via pellet extrusion. Debinding and sintering stages were optimised while microstructural and mechanical assessments were conducted on the final samples. The goal was to achieve a single FCC HEA phase exhibiting exceptional mechanical properties.

Innovative Aspect(s) :
This study pioneers the fabrication of High Entropy Alloys (HEAs) via Metal Injection Moulding (MIM) using readily available commercial commodity powders. Typically, these powders are mass-produced using methods like press and sinter, spark plasma sintering, or powder-related additive manufacturing, yielding components with commercial alloy compositions. However, their diverse alloying elements at specific proportions make them suitable for sourcing elements to create HEAs, deviating from their original intent. This unconventional use allows tailoring the composition and reducing costs in HEA development, contrasting with more expensive prealloyed powders processed in smaller batches. Additionally, exploring HEA processing via MIM remains an underexplored area as there are few studies in the literature about this. This study introduces innovative sustainability by employing eco-friendly binders in conjunction with these commodity powders.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C83
ID : 6278323

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Metal Injection Moulding

Author : Mr Luoto Mikael (Fraunhofer IFAM, Germany)

Co-author(s) : Dr Ing Daenicke Enrico (Rolls-Royce Deutschland Ltd & Co KG, Germany); Mr Müller Ralf (Rolls-Royce Deutschland Ltd & Co KG, Germany); Dr Hartwig Thomas (Fraunhofer IFAM, Germany)

Title : A Study On A Method Of Sinter Joining In Metal Injection Moulding Process

Keyword(s) :
Metal Injection Moulding (MIM), Sinter Joining, Sintering

Abstract :
Although Metal Injection Molding (MIM) is a process for complex designs, not all geometries are feasible. The goal of the project was to find a way to join two or more individually moulded parts between moulding and sintering steps, at first for one feedstock (material: Inconel 713L). The joining of the parts was achieved by using pastes. The achieved mechanical properties were measured on tensile, fatigue and creep tests. The tensile strength values were comparable to normal material, but a drop in elongation was observed. However, in the fatigue and creep tests the joined specimens reached the elongation properties of the normal samples. One possible application with a geometry that is not feasible on normal MIM-process was tested and it seemed plausible that the sinter joining could be used to solve this kind of challenges.

Innovative Aspect(s) :
More freedom in design for MIM-process. Higher degree of freedom in MIM production.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C84
ID : 6282995

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Metal Injection Moulding

Author : Prof Dr Herranz Gemma (Universidad Castilla La Mancha, Spain)

Co-author(s) : Ing Jimenez Juan (Universidad Castilla La Mancha, Spain); Dr Ing Hidalgo Javier (Universidad Castilla La Mancha, Spain); Dr Berges Cristina (Universidad Castilla La Mancha, Spain); Dr Ing Campana Roberto (Centro Nacional del Hidrógeno, Spain)

Title : A Synergy Approach Integrating Master Alloy Design And Powder Injection Moulding For High-performance Interconnectors Leveraging SOFCs Industry

Keyword(s) :
Powder Injection Moulding, Solid Oxide Fuel Cell (SOFC), Interconnector, Hydrogen

Abstract :
This study explores innovative approaches to boost the Solid Oxide Fuel Cell (SOFC) interconnector industry, integrating intelligent master alloy design and powder injection molding (PIM). Current challenges in interconnector fabrication via powder metallurgy include economic high-scale production of complex designs for improved SOFC performance and the restricted availability of commercial powders. To address these limitations, we propose the use of commercial high-Cr master alloys combined with ferrous powders, aiming for compositions equivalent to or surpassing standard Crofer 22. This strategy overcomes powder scarcity challenges and enables precise control over shrinkage and thermal expansion coefficient, crucial for producing ambitious large thin-walled interconnector geometries through PIM. A comprehensive comparative study, covering all PIM stages and properties characterization, is conducted, comparing Crofer 22 pre-alloyed powders with a modified Fe-Cr alloy incorporating additional elements for enhanced performance.

Innovative Aspect(s) :
This study explores innovative approaches to boost the Solid Oxide Fuel Cell (SOFC) interconnector industry, integrating intelligent master alloy design and powder injection molding (PIM).

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024

CONGRESS & EXHIBITION

Technical Programme Committee

8th of February 2024

CONSOLIDATION TECHNOLOGIES

OTHER CONSOLIDATION TECHNOLOGIES

EPMA

european powder metallurgy association

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C85
ID : 6281343

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Other Consolidation Technologies

Author : Ing Colaneri Alessandro (RINA, Italy)

Co-author(s) : Ing Lionetti Stefano (RINA, Italy); Dr Tassa Oriana (RINA, Italy); Ing Mohamed El Sayed Yasin (RINA, Italy)

Title : Heat Treatment Development On SLM 3d M300 Alloy Printed Samples To Improve Mechanical Properties

Keyword(s) :
Additive Manufacturing, Heat Treatment, Mechanical Properties

Abstract :
The purpose of this work was to develop a heat treatment to be performed on Additive Manufacturing (AM) 3D printed samples made of M300 steel in order to improve their mechanical properties, tailoring the as-built microstructure with the minimization of material defects like voids, porosity, micro-cracks, and variations in material structure. Different solution and ageing heat treatments were performed on samples printed via Selective Laser Melting (SLM) technique, testing different duration, temperatures and trends in the heating and cooling phases. The samples were microscopically analyzed and mechanically tested with tensile tests and hardness (HV10). The results were compared with as is samples showing improved mechanical properties meaning of an effective heat treatment applied.

Innovative Aspect(s) :
The innovative aspect of this work is to develop a heat treatment that allows to increase the mechanical properties of commercial steel M300 SLM printed samples.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C86
ID : 6281505

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Other Consolidation Technologies

Author : Dr Kukla Christian (Montanuniversitaet Leoben, Austria)

Co-author(s) : Mr Momeni Vahid (Montanuniversitaet Leoben, Austria); Dipl-Ing Schuschnigg Stephan (Montanuniversitaet Leoben, Austria); Prof Dr Holzer Clemens (Montanuniversitaet Leoben, Austria)

Title : Polylactic Acid (PLA) As Backbone For The Fused Filament Fabrication (FFF) Of Aluminium

Keyword(s) :
Fused Filament Fabrication, Feedstock Backbone, Aluminium

Abstract :
The backbone plays a significant role in the binder system for FFF of metals. Since the backbone is degraded thermally, the temperature for this debinding step should be below the sintering temperature of the involved metal. Thus, the low degradation temperature makes PLA a proper candidate for the backbone in feedstocks for aluminium with a relatively low sintering temperature. However, processing of PLA is challenging due to high shear and temperature sensitivity. Therefore, the printability at different nozzle temperatures (230, 250, 270 °C) was investigated for various formulations with PLA content ranging from 25 to 40 vol.% in the binder system. Solvent debinding for printed samples was conducted at room temperature and different immersion times. The results indicated the substantial impact of printing temperature on enhancing shape retention and preventing interlayer cracking during the solvent debinding process. The main binder was removed successfully without any defects during solvent debinding.

Innovative Aspect(s) :
Material extrusion of aluminium with filaments; New backbone material; New results regarding printing and solvent debinding

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....

EURO PM2024
CONGRESS & EXHIBITION
Malmö, Sweden
29 September - 02 October 2024

Paper Number : C87
ID : 6283629

Requested presentation type : Oral Presentation

Topic : Consolidation Technologies **Subtopic :** Other Consolidation Technologies

Author : Dr Raghavendra Sunil (University of Trento, Italy)

Co-author(s) : Dr Amirabdollahian Sasan (ProM Facility, Italy); Dr Perini Matteo (ProM Facility, Italy); Mr Chemello Marco (Sicor S.p.A, Italy); Prof Benedetti Matteo (University of Trento, Italy)

Title : Enhancing Worm Gear Efficiency: Directed Energy Deposition Of CuSn10 Alloy Onto Worm Gear Tooth Profiles

Keyword(s) :
CuSn10, Directed Energy Deposition, Process Parameters, Worm Gear

Abstract :
With the current development in additive manufacturing (AM) processes, such as directed energy deposition (DED), efficient usage of raw materials is possible. With the aid of this DED process, we aim to develop an efficient way to reduce the use of bronze in worm gears. Building upon insights from prior research into process parameter development, our objective is to fabricate worm gears by applying CuSn10 alloy onto a stainless steel tooth created through the LPBF process. We assess the impact of laser power, feed rate, scanning speed, and scanning strategy on the deposition process. The deposited cross-sections undergo analysis for porosity, hardness, dilution, and microstructure at various locations along the tooth profile. The optimal deposition parameters and strategy identified are then employed to coat an entire gear, subsequently subjected to testing on a worm gear test bench.

Innovative Aspect(s) :
Process optimization for DED of highly reflective copper alloys. Develop a scanning strategy for high-quality deposition on a worm gear tooth profile. Replace a complete bronze gear tooth with a tooth consisting of a steel substrate and deposited bronze alloy.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

.....