EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

ABSTRACTS BOOK

GROUP 2 - MATERIALS

european powder metallurgy association

EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

MATERIALS

FERROUS MATERIALS

EPMA
european powder metallurgy association

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

Paper Number : M23
ID : 6206688

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Prof Dr Danninger Herbert (Technische Universität Wien, Austria)

Co-author(s) : Dr Hojati Milad (Technische Universität Wien, Austria); Prof Dr Gierl-Mayer Christian (Technische Universität Wien, Austria)

Title : Introduction Of Carbon Into Sintered Steels By Combining Graphite And Fe-C Masteralloys

Keyword(s) :
Sintered Steels, Sintering, Carbon, Masteralloys

Abstract :
Carbon is typically introduced into sintered steels through admixed fine graphite, the dissolution during sintering however being relatively slow. An alternative route would be the introduction via a carbon-rich Fe-C powder containing carbon as cementite. In the present study it is shown that already addition of a minor proportion of carbon through atomized Fe-4.5%C masteralloy powder activates carbothermal reduction of the surface oxides, shifting the CO formation temperature to lower levels, as well as dissolution of graphite in the matrix. This is particularly noticeable in steels prepared from prealloyed steel powder Fe-3%Cr-0.5%Mo. The property most sensitive to carbon dissolution is the coercive force, which offers the chance to nondestructively characterize this important process.

Innovative Aspect(s) :
It is shown that in PM steel compacts already a minor fraction of carbon present as cementite accelerates the reactions occurring during heating up to sintering temperature, promoting also the dissolution of graphite. This offers advantages in particular for systems for which sintering has to be done at moderate temperatures, e.g. to avoid unwelcome side reactions.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M24
ID : 6228829

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Dr Eskandari Sabzi Hossein (Globus Metal Powders, United Kingdom)

Co-author(s) : Dr Hamilton Andrew (University of Southampton, United Kingdom); Dr Hao Xinjiang (Globus Metal Powders, United Kingdom); Prof Rivera Pedro (University of Southampton, United Kingdom)

Title : Transformation-induced Plasticity In Additively Manufactured Tool Steel

Keyword(s) :
Additive Manufacturing, Transformation-induced Plasticity, Tool Steel, Austenite Stability

Abstract :
A significant challenge in the additive manufacturing (AM) of high-performance steels is to promote transformation-induced plasticity (TRIP). TRIP is a mechanically-induced martensitic transformation of retained austenite distributed in a ferritic or martensitic matrix. Austenite stabilisation and retention at room temperature is of paramount significance to promote TRIP. In this work, it was discovered that austenite could be effectively retained after AM by precipitation of carbides and the formation of bainite during AM. The ultimate tensile strength then increases significantly as a result of this metastable austenite's gradual transformation to -martensite under straining, while exhibiting a high yield strength. The partitioning of stress and strain, which is constantly changing as the hard martensite forms, is the cause of this rise, as revealed by advanced microscopy techniques.

Innovative Aspect(s) :
This abstract highlights the following innovative aspects in the AM of high-performance steels with TRIP effect: Challenges in AM of high-performance steels tool steels and how to retain an austenitic matrix upon printing, in order to promote TRIP effect during deformation. Characterisation of mechanically-induced martensitic transformation. Mechanical properties correlation with microstructural features.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M25
ID : 6252913

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Becker Louis (Chair of Materials Technology, Ruhr University Bochum, Germany)

Co-author(s) : Mr Radtke Felix (Institute of Applied Powder Metallurgy and Ceramics at RWTH Aachen e. V., Germany); Dr Ing Lentz Jonathan (Chair of Materials Technology, Ruhr University Bochum, Germany); Dr Ing Herzog Simone (Institute of Applied Powder Metallurgy and Ceramics at RWTH Aachen e. V., Germany); Prof Dr Broeckmann Christoph (Institute of Applied Powder Metallurgy and Ceramics at RWTH Aachen e. V., Germany); Prof Dr Weber Sebastian (Chair of Materials Technology, Ruhr University Bochum, Germany)

Title : An Innovative Approach To The Additive Manufacturing Of High Nitrogen Austenitic Stainless Steel

Keyword(s) :
Additive Manufacturing, High Nitrogen Steels, Diffusion Alloying

Abstract :
Laser Powder Bed Fusion|Metal (PBF-LB|M) shows great promise for industrial applications, but its extended production time remains a challenge. To address this, innovative methods such as the shell-core approach have been developed. In this procedure, a component is created with a dense outer shell surrounding a core of either unexposed or minimally exposed powder, drastically reducing processing time. Full densification and specific property adjustment are achieved by subsequent hot isostatic pressing (HIP). This study demonstrates the use of shell-core specimens made from a blend of austenitic steel and Si_3N_4 to produce high-nitrogen steel components that are otherwise difficult to produce due to limited nitrogen solubility in the steel melt. During HIP, Si_3N_4 dissolves into the austenitic matrix, enriching it with nitrogen and circumventing solubility issues. This results in a material with increased strength and potentially improved corrosion resistance due to the beneficial effects of nitrogen on steel properties.

Innovative Aspect(s) :
This work is the first to exploit the use of the shell-core strategy for targeted diffusion alloying during the downstream hot isostatic pressing of additively manufactured steels. In doing so, we offer a new approach to producing additive-manufactured stainless steels with N contents above the maximum nitrogen solubility in the steel melt, improving mechanical and chemical properties.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M26
ID : 6275409

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Dr Kairet Thomas (Sirris, Belgium)

Co-author(s) : Dr Malet Loïc (Université Libre de Bruxelles, Belgium); Prof Godet Stéphane (Université Libre de Bruxelles, Belgium); Dr Kuci Erin (Cenaero, Belgium)

Title : L-PBF Of Fe-Si6,5% Soft Ferromagnetic Powder: Thin Walls Structures While Processing A Complex Material

Keyword(s) :

Abstract :
Fe-Si6,5% is a complex material to print by L-PBF. The brittle phases formed during processing make the material sensitive to internal stresses. The paper shall show the processing issues to obtain a good material health based on optical microscopy, defect analysis and classification. The manufacturing of thin walls have yielded better results than thick bulk material and various laser melting strategies shall show the trend between single meltpool and multiple meltpool thicknesses. EBSD analysis of these walls shall show the internal grain texture of the wall. Furthermore, the magnetic hysteresis cycle of the printed material has been measured using a vibrating magnetometer.

Innovative Aspect(s) :
The high content of silicon made it difficult to process the material by L-PBF but specific strategies and machine setting improve the likelyhood of success. Thin wall structures are much easier to print with the L-PBF process.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M27
ID : 6278527

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Sorea Alexandru (Sintex A|S, Denmark)

Co-author(s) : Mr Valler Peter (Sintex A|S, Denmark); Mr Kjeldsteen Peter (Sintex A|S, Denmark); Mr Kaae Phillip Hjelmeborn (Grundfos A|S, Denmark)

Title : Densification Of Metal Powder Extruded AISI 904L To Increase Corrosion Resistance

Keyword(s) :

Abstract :
Metal powder extrusion (MPE) of AISI 904L super austenitic stainless steel makes it possible to produce complex structures with a higher corrosion resistance compared to austenitic stainless steels such as AISI 304L and AISI 316L. The initial sintering trials resulted in a porous part with low corrosion resistance. As AISI 904L is a steel with austenitic phase through the entire sintering window, densification during sintering was inhibited which resulted in the reduced corrosion resistance due to open porosities. This paper will show how to enhance densification in order to improve the corrosion resistance closer to the expected level comparable to cast and rolled material but with the shaping possibilities of MPE.

Innovative Aspect(s) :

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

Paper Number : M28
ID : 6278588

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Radtke Felix (Institute of Applied Powder Metallurgy and Ceramics (IAPK), Germany)

Co-author(s) : Mr Mirz Markus (Institute for Materials Applications in Mechanical Engineering (IWM), Germany); Mr Dollmeier Klaus (Georgsmarienhütte Holding GmbH, Germany); Dr Ing Herzog Simone (Institute for Materials Applications in Mechanical Engineering (IWM), Germany); Prof Dr Broeckmann Christoph (Institute for Materials Applications in Mechanical Engineering (IWM), Germany)

Title : Developing Of A PBF-LB|M Process For Austenitic High Nitrogen Steel Alloy

Keyword(s) :
High Nitrogen Steels, Austenitic, PBF-LB|M, Mechanical Properties, Heat Treatment

Abstract :
Austenitic high nitrogen steels (HNS) are the material of choice in the aerospace, medical, food, and electronics industries due to their unique combination of high strength, ductility and corrosion resistance. Especially for small components, the use of additive manufacturing is attractive.In this study, the PBF-LB process was developed for the austenitic HNS grade X13CrMnMoN18-14-3. Analysis of key factors such as laser parameters and nitrogen content led to an optimized process. Solution annealing ensured a fully austenitic transformation of the unintended duplex structure on cost of the fine as-built microstructure. Advanced metallurgical analysis allows discussion of the effect of nitrogen content and microstructure on strength, hardness and fatigue behavior. With precise process control, the study achieves the desired material properties and contributes to the development of improved materials for the PBF-LB|M process, highlighting the versatility of austenitic HNS.

Innovative Aspect(s) :
The manufacturing parameters determined in this work allow the material to be processed using the PBF-LB|M process for the first time. This makes it possible to directly compare the material properties of the conventional manufacturing route and the laser-based additive manufacturing route. The combination of thermodynamic calculations, metallographic investigations and thermal post-treatment allows the material to be precisely tuned to the required properties.

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

Paper Number : M29
ID : 6280981

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Dr Frutos Torres Emilio (Commplutense University of Madrid, Spain)

Co-author(s) : Dr Cornide Arce Juan (Commplutense University of Madrid, Spain); Ing Cuenca Fernandez Daniel (Commplutense University of Madrid, Spain); Dr Encinas García Noemí (Commplutense University of Madrid, Spain); Dr Lasanta Carrasco M. Isabel (Commplutense University of Madrid, Spain); Dr Alcalá Penades Germán (Commplutense University of Madrid, Spain)

Title : Design Of High Fracture Toughness Structural Materials By Adjusting Microstructure And Mechanical Properties Of Fe7Cr7-xNi4+xTiMo High-entropy Alloys

Keyword(s) :
High entropy Fe-based Alloys, Eutectic, Microstructural and Mechanical Properties

Abstract :
Eutectic high entropy alloys (HEAs), with lamellar arrangement of solid solution phases, represent a new paradigm for simultaneously achieving high strength and ductility, thereby circumventing this well-known trade-off in conventional and single-phase HEAs alloys. However, dynamic strengthening mechanisms and phase-boundary interactions during external loading remain unclear for these multiphase systems. The large fraction of phase boundary significantly impacts plastic flow in these systems. In this study, the microstructure, based on a mixture of a majority L12, B2 and a minority of s solid-solution phases, and small-scale mechanical behaviour has been evaluated for Fe7Cr7-xNi4+xTiMo (x=0, 1, 2 and 3) high entropy alloys obtained from of mechanically alloyed powders by spark plasma sintering (SPS). The use of nanoindentation tests has allowed us to characterize the values of hardness, resistance, sensitivity to strain rate and friction coefficient shown by the different B2|L12 ratios presented by high-entropy Fe-rich alloys.

Innovative Aspect(s) :
Phase-specific nanoindentation tests have revealed higher hardness, sensitivity strain rate and coefficient of friction for B2 compared to L12. These results will pave the way for a fundamental understanding of phase-specific contribution to bulk mechanical response of high entropy Fe-rich alloys and help in designing structural materials with superior fracture toughness.

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

Paper Number : M30
ID : 6281345

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Korir Patrick (Höganäs AB, Luleå University of Technology, Sweden)

Co-author(s) : Dr Vattur Sundaram Maheswaran (Höganäs AB, Sweden); Prof Surreddi Kumar Babu (Luleå University of Technology, Sweden); Dr Forouzan Farnoosh (Höganäs AB, Sweden); Dr Chasoglou Dimitris (Höganäs AB, Sweden); Prof Antti Marta-Lena (Luleå University of Technology, Sweden)

Title : Enhancement Of Hardenability And Performance With Addition Of Master Alloy Powder In PM Steels: Effect Of Different Atomisation Techniques

Keyword(s) :
Master Alloy, Hardenability, Compressibility, Liquid Phase Sintering

Abstract :
In PM steels, alloying through master alloy (MA) addition enables introduction of oxygen-sensitive elements such as Cr, Mn, and Si. These elements are cost-effective and sustainable alternatives to replace Cu and Ni to enhance hardenability and performance. This study investigates the atomisation of Fe-Cr-Mn-Si-C MA powders using three different techniques: water atomisation, gas atomisation, and gas atomisation-water cooling. The MA powders were sieved into two size fractions, and mixes were prepared with Fe-0.85wt.% Mo pre-alloyed base powder and graphite. MA powder characterisation, compressibility, and dilatometry-sintering were performed to evaluate the different atomisation techniques, the behaviour of MA powder mixes during pressing, and the liquid phase formation at various sintering temperatures. The results indicated that MA addition significantly improved the hardenability and performance especially after sintering above 1200°C, once the MA melting and alloy homogenisation had occurred. Additionally, industrial sintering trials were conducted, and mechanical properties were assessed.

Innovative Aspect(s) :
The paper demonstrates the master alloy route to improve the properties of PM components, pressed and sintered by using more sustainable materials such as Cr, Mn and Si in the master alloy powder. The paper provides an opportunity to select a suitable production route for the master alloy powders. By evaluating how the different size fractions of the master alloy powder influences the final PM component properties, right particle size distribution of these powders can be used for the application.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M31
ID : 6281494

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Dr Ing Tekin Tugce (University of Trento, Italy)

Co-author(s) : Ing Naclerio Francesco (Pontillo Officine Meccaniche & C., Italy); Prof Dr Ipek Rasim (Ege University, Turkey); Prof Dr Molinari Alberto (University of Trento, Italy)

Title : Fatigue Strength Of Heat And Surface Treated Maraging Steel Manufactured By L-PBF

Keyword(s) :
Fatigue Strength, Nitriding, Thin Film Coating, Maraging Steel, Laser Powder Bed Fusion, Additive Manufacturing

Abstract :
The axial fatigue strength of maraging steel produced by Laser Powder Bed Fusion (L-PBF) and subject to different heat and surface treatments was investigated. The following treatments were considered: Solution Annealing and Aging (SAT), Direct Aging of the as-built material (DAT), and two surface duplex treatments made of a prior plasma nitriding followed by a PVD coating with different nitriding time (C and NC). The fatigue strength of SAT is a bit higher than that of DAT steel because of the slightly higher hardness and lower amount of austenite in the microstructure.The surface-treated material displays a 40-50% higher fatigue strength than the two heat-treated materials, thanks to the surface hardening provided by nitriding. The fatigue behaviour was correlated to hardness and in particular to defects observed in the material resulting from the L-PBF process, whose size and position were analyzed on the fracture surfaces of all the fractured.

Innovative Aspect(s) :
The innovative aspect of this work is the study of the fatigue strength of an 18Ni300 maraging steel manufactured by L-PBF after a surface duplex treatment: nitriding followed by PVD. The fatigue strength of heat-treated maraging steel is reported in the literature, but only a few works are available relevant to the influence of plasma nitriding. Duplex treatments are aimed at improving wear resistance, prior to nitriding having the scope of hardening the substrate to be coated. The work shows that on increasing nitriding time, surface hardening increases but the content of austenite in the material also increases. The combined effect results in a slight but significant decrease in fatigue strength.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M32
ID : 6281555

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Vaddamanu Satya Chaitanya (Chalmers University of Technology, Sweden)

Co-author(s) : Dr Wärner Hugo (SSAB Special Steels, Sweden); Dr Fager Ulrika (SSAB Special Steels, Sweden); Prof Hryha Eduard (Chalmers University of Technology, Sweden)

Title : PBF-LB Processability, Microstructure And Properties Of Advanced High Strength Powder Steel

Keyword(s) :
Addtive Manufacturing, Ferrous Materials, PBF-LB

Abstract :
With the advent of additive manufacturing (AM), there is a need for new materials in the field of structural applications. The primary challenge hindering the widespread use of traditional ferrous materials for this purpose is the high carbon content (>0.1 %), making processability by AM rather challenging due to the high cracking susceptibility of the materials. This study explores the processability of a novel low-alloyed steel powder using Powder Bed Fusion - Laser Beam (PBF-LB), the connection between process parameters, and resulting microstructure and properties. Developed process parameters allowed to obtain fully dense (~99.9%), and crack free specimens over a large processing window. Detailed microstructure analysis was performed using different microscopy techniques, revealing the relationship between process parameters and characteristics of the melt pools, as well as the resulting fine martensitic microstructure. The mechanical properties of the alloy were evaluated using specimens processed with the optimized process parameter set.

Innovative Aspect(s) :
This study present an in-depth overview of the processability characteristics of a novel high strength powder steel, by characterising the melt pools created during PBF-LB processing. This will allow for its future use as a potential material candidate for being used in AM processing.

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

Paper Number : M33
ID : 6281719

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Dr Hao Xinjiang (Globus Powder Metals Ltd, United Kingdom)

Co-author(s) : Dr Eskandari Sabzi Hossein (Globus Metal Powders Ltd, United Kingdom); Prof Rivera-Díaz-del-Castillo Pedro (University of Southampton, United Kingdom)

Title : High Strength Martensitic Steel Development For Additive Manufacturing

Keyword(s) :
Additive Manufacturing, LPBF, Steel Powder, Alloy Development

Abstract :
Globus Metal Powders Ltd (formerly known as Liberty Powder Metals Ltd) was set up in the UK in 2019 to develop high performance metal powders for additive and net-shape manufacturing. The paper gives an overview of our alloy development programme for additive manufacturing, including powder production, powder characterisation, LPBF process development, microstructure, and mechanical properties of a range of high strength martensitic steels. Examples including precipitation hardening stainless steels (modified 17-4PH, 13-8Mo) and ultra-high strength alloy steel (300M) are provided with details.

Innovative Aspect(s) :
New alloy development for additive manufacturing

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

Paper Number : M34
ID : 6281794

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Schneider Paul (Höganäs AB, Sweden)

Co-author(s) : Miss Ljung Karin (Höganäs AB, Sweden); Dipl-Ing Szabo Christophe (Höganäs AB, Sweden)

Title : Mechanical Properties Of Astaloy®CrS, A Lean Cr-alloyed Base Powder, After Sinterhardening

Keyword(s) :
Sinterhardening, Astaloy®CrS, low Cr Alloyed, Mechanical Properties, Composition Selection

Abstract :
Sinterhardening is a commonly applied cost effective process for producing higher loaded structural P|M parts. Generally, a prealloyed base powder is combined with further external alloying elements such as Ni or Cu in order to maintain the compressibility of the base powder. Astaloy®CrS is a newly developed low alloyed base powder prealloyed with 0,85% Cr and 0,15%Mo. This paper is investigating the mechanical properties after sinterhardening of various graphite and Ni additions admixed to Astaloy® CrS . Recommendations of practically suitable alloy combinations will be given as a outcome of this investigation.

Innovative Aspect(s) :
Sinterhardening guide for a new cost effective Cr alloyed base powder in combination with Ni and graphite additions. Practical mix combinations for parts production will be suggested.

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

Paper Number : M35
ID : 6281798

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Sepako Motheo (Stellenbosch University, South Africa)

Co-author(s) : Ms Mkhaliphi Thuli (Stellenbosch University, South Africa); Ms Blaine Deborah (Stellenbosch University, South Africa)

Title : Determining Suitable Processing Parameters To Produce AISI 420 Stainless Steel Using Laser Powder Bed Fusion

Keyword(s) :
Laser Powder Bed Fusion (L-PBF), AISI 420 Stainless Steel (420SS)

Abstract :
The study investigates the optimization of processing parameters for Laser Powder Bed Fusion (L-PBF) in the production of AISI420 stainless steel (420SS). The objective is enhancing specific properties of 420SS through controlled variations in L-PBF processing parameters. The research focuses on the effect of energy density, laser power, scan speed and hatching spacing on the part density, porosity, microstructure, and mechanical properties of the as-built samples. The findings reveal that as-built samples with a relative density exceeding 99% utilized energy density values ranging from 79.4 to 136.6 J|mm^3 and laser power above 150 W. Samples featured porosity levels below 0.01%, characterized by uniformly distributed small pores measuring less than 30 μm. The microstructure displayed retained austenite phases, with additional presence of martensite phases at the melt pool boundary, attributed to rapid cooling process. The microhardness of the as-built samples exceeded 540 HV, surpassing those reported for cast 420SS.

Innovative Aspect(s) :
The paper provides a processing parameter window set for printing 420SS using laser powder bed fusion that achieves full part density. Consequently, the processing parameter window set is studied to provide a strategy on how the microstructure and microhardness of the as printed samples behaves and can be controlled. It further highlights how laser power, scan speed, hatch distance and energy density can be controlled to achieve the desired microstructure and mechanical properties. Consequently, gives a way on how an optimized set of parameters with desired properties can be achieved.

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

Paper Number : M37
ID : 6282623

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mr Schaefer Hendric (Ruhr-Universität Bochum, Germany)

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

Title : Powder Metallurgically Produced High Boron Tool Steels - A Step Towards Green Steel?

Keyword(s) :
Boron, Tool Steel, HIP

Abstract :
The use of boron as a hard phase forming element in cold work tool steels can improve performance, price, and environmental considerations all at once. This is achieved by reducing costly and high footprint elements, avoiding retained austenite and thus simplifying heat treatment. However, in boron-alloyed tool steels the formation of boride networks during casting impairs the mechanical properties. This, in turn, makes the powder metallurgy (PM) route all the more interesting and important as well as effective in improving material properties. In this study, we present two innovative boron-alloyed PM tool steels that are atomized and consolidated by HIP. Microstructural analysis is performed using SEM, EBSD and XRD and dynamic mechanical properties are evaluated. The results show that a combination of cost reduction through reduced element content combined with the isotropic microstructure of the PM-HIP production route can be achieved while improving mechanical properties.

Innovative Aspect(s) :
The path to a sustainable steel industry depends on two main framework conditions. Both energy and raw materials must be saved. The approach of boron-alloyed tool steels serves both by saving raw materials through lower alloy contents while the same or even better properties are achieved. These properties also enable simplified heat treatments, effectively saving energy.

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Paper Number : M123
ID : 6256374

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Mrs Boualouache Salima (Université de téchnologies de Belfort Montbéliard, France)

Co-author(s) :

Title : Study Of Oxide Nanoprecipitate Formation Mechanisms In 316 L Stainless Steel Produced By Rapid Solidification Processes: Gas Atomization And Laser Powder Bed Fusion (L-PBF)| Effect On Impact Toughness

Keyword(s) :
Rapid Solidification, Nanoprecipitates, Atomization, SLM (Selective Laser Melting), Impact Toughness

Abstract :
AM materials tend to have a lower toughness compared to those produced using conventional processes (casting, forging) [1]. The decrease in impact strength is attributed to the presence of nano-oxides rich in silicon Si and manganese Mn on the fracture surfaces [1]. The objective of this work is to characterize the nanoprecipitates in both the 316L powder particles elaborated by gas atomization (GA) and in the components manufactured using Laser Powder Bed Fusion (L-PBF) with these powders. These two processes (GA and L-PBF) have high solidification rates, which could allow to identify the segregation mechanisms of oxide nanoprecipitates. Charpy impact tests will be conducted to confirm the influence of these nanoprecipitates on the reduction in impact resistance.[1].Lou, P. L. Andresen, et R. B. Rebak, « Oxide inclusions in laser additive manufactured stainless steel and their effects on impact toughness and stress corrosion cracking behavior », J. Nucl. Mater., vol.

Innovative Aspect(s) :
The study brings attention to the previously neglected impact toughness of 316L stainless steel parts produced via additive manufacturing (AM). It underscores the existence of nano-oxides, abundant in silicon and manganese, linking their presence to decreased impact strength observed on both fracture and powder surfaces. The research aims to explore potential solutions to address this issue, targeting both the powder material and the AM-fabricated components.

Reviewer's name : ....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ....

Notes to author : ....

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

Paper Number : M338
ID : 6290825

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Ing Naim Mahmoud (Université de technologie de Troyes and EPF school of engineering, France)

Co-author(s) : Dr Ing Chemkhi Mahdi (Université de technologie de Troyes and EPF school of engineering, France); Ing Auzene Delphine CRITT MDTS, France)

Title : Printing, Debinding And Sintering Of H13 Tool Steel Processed Via Material Extrusion Additive Manufacturing

Keyword(s) :
Sinter-based Additive Manufacturing, H13 tool steel, Tensile Behavior, Surface Roughness, Sintering

Abstract :
Additive manufacturing (AM) sinter-based technologies, particularly filament-based material extrusion (MEX) is gaining popularity for it's simplicity and cost-effectiveness, making metal additive manufacturing more accessible for industrial production. Even though this technique offers flexibility in material choices and great potential for fabricating high-quality parts, there is still a lack of research on the mechanical and surface properties of the MEX-ed H13 tool steel and the influence of the printing setup on them. In the present work, this literature gap will be filled by analyzing the tensile properties, surface roughness, and density of H13 tool steel parts that were constructed horizontally and vertically. Additionally, this research investigates the impact of simultaneous printing, by comparing the characteristics of H13 tool steel samples that were concurrently and sequentially constructed.

Innovative Aspect(s) :
Evaluating the effect of printing parameters on the mechanical and surface properties and porosity content of H13 tool steel processed via filament-based material extrusion (MEX) additive manufacturing. The MEX-ed H13 tool steel tensile and material characteristics are poorly addressed in the available literature.

Reviewer's name : ……………………………………………………………………………………………….

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : P-M38
ID : 6273980

Requested presentation type : Poster Presentation

Topic : Materials **Subtopic :** Ferrous Materials

Author : Prof Dorofeyev Vladimir (Platov South-Russian State Polytechnic University (NPI)), Russia)

Co-author(s) : Dr Sviridova Anna (Platov South-Russian State Polytechnic University (NPI)), Russia); Ms Sviridova Svetlana (Derzhavin Tambov State University, Russia); Dr Berezhnoi Yury (Platov South-Russian State Polytechnic University (NPI)), Russia); Dr Bessarabov Eugene (Platov South-Russian State Polytechnic University (NPI)), Russia); Dr Vodolazhenko Roman (MIREA - Russian Technological University, Russia)

Title : High-Temperature Heating Effect On The Transformation Of Non-Metallic Inclusions, The Structure And Properties Of Hot-Deformed Powder Steels

Keyword(s) :
Hot Forging, Porous Preforms, Mechanical Properties, Brittle and Ductile Fracture, Interparticle Jointing, Cohesion, Contact Interaction, Particle Surface, Alloying, Microalloying, Vanadium, Oxidation, Iron Powder, Dispersion Hardening, Dissolution – Prec

Abstract :
In order to decrease the negative impact of non-metallic inclusions on the properties of powder steels, the possibility of their diffusion dissolution during long-term high-temperature vacuum sintering or post-deformation annealing was studied. In the production of steels, iron powders with various contents of impurities were used. To decrease the tendency of austenite grains to grow, vanadium was added to the mixture composition. The content of carbon and vanadium was varied, as well as the modes of sintering and annealing. Heat treatment was performed after hot forging or annealing. The performance of high-temperature sintering or annealing causes a decrease in the size of non-metallic inclusions. Near the former particles of inclusions finely dispersed particles of secondary precipitates ("satellites") precipitate during the cooling process, which do not have a softening effect on the material. The modes of sintering or post-deformation annealing are determined, which provide the minimum sizes of inclusions.

Innovative Aspect(s) :
A decrease in size of non-metallic inclusions during high-temperature sintering reduces the risk of formation of micropores and microcracks at the sites of localization of these inclusions during hot repressing porous preforms. On the contrary, in the case of post-deformation annealing, micropores and microcracks that have arisen during hot repressing near large inclusions are practically not healed.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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EURO PM2024 CONGRESS & EXHIBITION

Technical Programme Committee
8th of February 2024

MATERIALS

HIGH TEMPERATURE MATERIALS

EPMA european powder metallurgy association

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

Paper Number : M39
ID : 6275441

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Mr Peled Hagai (Tritone Technologies Ltd., Israel)

Co-author(s) :

Title : Production Of High-temperature Structural Materials Using A Slurry-based Feedstock Process

Keyword(s) :
High-Temperature Materials, Silicon Carbide, Molybdenum, Slurry-based Feedstock, Additive Manufacturing

Abstract :
High-temperature materials with low thermal expansion are of interest for various applications such as shields, lenses, and microelectronics.Silicon carbide (SiC) is a hard, strong, and thermally conductive structural ceramic that retains its properties at high temperatures. Molybdenum refractory metal is another example of a strong corrosion-resistant material with low thermal expansion.Additive manufacturing of printed pure SiC and Molybdenum parts is uncommon. Existing additive manufacturing processes of SiC parts produce porous SiC structures that go through a silicon infiltration procedure to produce hybrid silicon-SiC structures. This study demonstrated the production of molybdenum metal and SiC ceramics by the MoldJet process, which utilizes a slurry-based feedstock to fill, layer-by-layer, inkjet-printed molds to produce high-density green parts with a volume density of over 60%.The SiC and Molybdenum green parts were debinded and sintered to density volumes of over 99% and 95%, respectively, resulting in parts with exceptional properties.

Innovative Aspect(s) :
Conventional manufacturing techniques for high-temperature materials have limitations in terms of complexity and design freedom. Slurry-based additive manufacturing using high-temperature structural materials such as silicon carbide and molybdenum is an innovative new process that overcomes these limitations, enabling the creation of intricate, three-dimensional structures with exceptional thermomechanical properties by precise layer-by-layer deposition akin to traditional additive manufacturing techniques. The slurry-based nature of the feedstock imparts several advantages, including superior stress distribution, reduced thermal stresses, and enhanced material properties. This innovative approach paves the way for using slurry-based additive manufacturing as a game-changer in the production of high-temperature structural components.

Reviewer's name : ....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ....

Notes to author : ....

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

Paper Number : M40
ID : 6278262

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Dr Stenzel Melanie (TANIOBIS GmbH, Germany)

Co-author(s) : Dr Weinmann Markus (TANIOBIS GmbH, Germany); Dr Fayyazi Bahar (TANIOBIS GmbH, Germany); Dr Lenka Shaumik (Alloyed, United Kingdom); Mr Sim Nicolas (Alloyed, United Kingdom); Ms He Yining (Alloyed, United Kingdom); Mr Wagstaff Thomas (Alloyed, United Kingdom); Mr Ishino Yuji (Alloyed, United Kingdom); Mr Zhang Pimin (Alloyed, United Kingdom)

Title : Development Of Nb-base Alloy Powders For AM, MIM Or HIP Of Components For Application In Ultra-high Temperature Environments

Keyword(s) :
Nb-base Alloys, C-103, FS-85, Cb-752, High Entropy Alloy, ETMT Measurement, Temperatures > 1050°C

Abstract :
Many applications among aerospace, defence and energy generation require materials being capable to perform in high temperature environments. Niobium-base alloys are becoming particularly interesting if the temperatures exceed ~1050°C as they are outperforming even the most advanced Ni- and Co-base alloys. Notably, conventional production methods for Nb-base alloys are challenging, especially if parts with complex shapes are to be manufactured. The use of powder metallurgy e.g. AM, MIM or HIP, opens up new opportunities to produce complex-shaped parts economically. However, for these processes the application of suitable high quality powders is mandatory. In this context, the production of Nb-base alloys as powder feedstock using the electrode induction-melting gas atomization (EIGA) is reported. Powders and additively manufactured parts were investigated by X-ray diffraction, scanning electron microscopy, mechanical tests, and electro-thermal mechanical testing (ETMT). The mechanical performance i.e. strength of parts processed by L-PBF clearly outperforms that of conventionally manufactured parts.

Innovative Aspect(s) :
AM methods provides access to complex shaped parts capable to perform if the required temperatures exceed ~1050°C when using Nb-base alloys. Applicable powders have been made available and as a result of intensive development of material and in L-PBF process development, the part performance outperforms conventional manufactured parts clearly. From this staring point, the alloy development is further optimized to achieve materials with even higher temperature performance going beyonf 1400°C. Testing has been improved with Electro-thermal mechanical testing (ETMT) to be able to judge materials in the context for their application settings.

Reviewer's name : ....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ....

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

Paper Number : M41
ID : 6281642

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Mr Martin Pablo (Delft University of Technology, Netherlands)

Co-author(s) : Dr Sánchez-Herencia Antonio J. (Institute of Glass and Ceramics ICV-CSIC, Spain); Dr Ferrari Begoña (Institute of Glass and Ceramics ICV-CSIC, Spain); Prof Cabrera Jose María (Technical University of Catalonia, Spain); Prof Santofimia María J. (Delft University of Technology, Netherlands)

Title : Milling Media Effect Over Sinterability, Microstructure, And Hardness Of Ultrafine-grained Al-Cr-Mo-Nb-Ti-V Refractory High-entropy Alloys Produced By Mechanical Alloying And Spark Plasma Sintering

Keyword(s) :
High-Entropy Alloys, Refractory High-Entropy Alloys, Mechanical Alloying, Spark Plasma Sintering, Microstructure

Abstract :
Refractory high-entropy alloys (RHEAs) are promising metallic materials for high-temperature applications, due to their outstanding mechanical properties at elevated temperatures. In this study, a series of lightweight RHEAs based on the Al-Cr-Mo-Nb-Ti-V system were prepared employing mechanical alloying and spark plasma sintering, utilizing either hardened steel and ZrO_2 balls as grinding media in order to study their effect over microstructure and hardness. Both sintered parts exhibited ultrafine-grained microstructures with no porosity at all (densities below 7 g|cm-3), exhibiting a V,Mo-rich bcc matrix reinforced with Ti-rich carbide particles and nano-sized Al_2O_3 precipitates. Fe contamination from hardened steel grinding media caused the formation of Fe,Nb-rich Laves phases as well as a considerable reduction of the sintering temperature, while ZrO_2 grinding media resulted in Zr-rich oxides particles homogeneously distributed throughout the microstructure. Lastly, both samples presented elevated hardness, reaching an elevated value of 1067 HV in the case of the first.

Innovative Aspect(s) :
The present article presents how the milling media affects the microstructural and morphological evolution of the milled powder, but also the microstructure and hardness of the as-sintered part of lightweight RHEAs. Additionally, the study reveals how the milling media had a considerable effect on the sintering temperature, showing that Fe contamination can acts as a sintering aid in these alloys but still conducting to advanced microstructures and superior performance than as-cast RHEAs. At the same time, the article reaffirms the possibility to produce fully-dense RHEAs parts with reduced density and ultrafine-grained microstructures by means of the optimization of the operational conditions for mechanical alloying and spark plasma sintering techniques. Lastly, the present work contributes to a better understanding of the complex composition-microstructure-properties relationship of these relatively new advanced materials.

Reviewer's name : ....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M42
ID : 6281796

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Dr Vives Solange (Aubert & Duval, France)

Co-author(s) : Ing Peachey Dominic (Alloyed, United Kingdom); Ing Hussain Zara (Alloyed, United Kingdom); Dr Németh André (Alloyed, United Kingdom); Dr Crudden David (Alloyed, United Kingdom)

Title : ABD®-1000AM: A Highly Processible Superalloy For Additive Manufacturing, Computationally Designed For 1000°C Applications

Keyword(s) :
Additive Manufacturing, Nickel-based Superalloys, ABD®-1000AM, Computational Design

Abstract :
The evolution of additive manufacturing (AM) has sparked a growing interest in using nickel-based superalloys, particularly for high-temperature applications above 1000°C. Traditional alloys, intended for casting or wrought processes, face challenges in AM due to the rapid heating|cooling rates and multiple melt cycles, resulting in compromises to material performance or part design freedom. Here we introduce ABD®-1000AM, a novel high gamma prime nickel-based superalloy designed computationally using the Alloys-by-Design (ABD®) approach, tailored for high-temperature AM applications. ABD®-1000AM exhibits world leading performance in terms of both processing capability as-well-as high temperature mechanical and environmental performance at 1000°C. The study discusses the alloy design and development strategy, highlighting the trade-offs in key performance parameters and the intricate process-microstructure-performance optimization undertaken to achieve the alloy's exceptional creep resistance. Based on the insights gained the future direction of alloy development of superalloys for complex AM components is discussed.

Innovative Aspect(s) :
New alloy development for Additive Manufacturing: ABD®-1000AM; A high temperature nickel-based superalloy with high gamma prime content, computationally designed and exhibiting exceptionnal performance at high temperature.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M44
ID : 6281339

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Dipl-Ing Ariza Enrique (RHP Technology, Austria)

Co-author(s) : Dr Neubauer Erich (RHP Technology, Austria); Dr Ing Scheerer Michael (Advanced Aerospace and Composites, Austria); Dr Ing Stelzer Nils (Advanced Aerospace and Composites, Austria); Dr Bača Ľuboš (Advanced Aerospace and Composites, Austria); Mr Curti Pier Paolo (RHP Technology, Austria)

Title : Improvement Of Thermal Mechanical Properties Of Inconel 718 Reinforced With Ceramic Particles Manufactured By Plasma Metal Deposition (PMD)

Keyword(s) :
Additive Manufacturing, Plasma Metal Deposition, Nickel Alloy, Mechanical Properties

Abstract :
Nickel superalloys due to their good thermal mechanical properties and corrosion resistance are widely used for high performance on high demanding applications and industries as space, aviation or (petro-) chemistry. Moreover, the processing of this material class is costly due to the raw material and problems related to traditional processing techniques as casting, forging or milling (hot cracking, porosity, work hardening or wear on milling tools).Within this study the alloy Inconel 718 is processed with Plasma Metal Deposition (PMD®), an additive manufacturing process with high deposition rates for large part production. Additionally, the alloy is reinforced with ceramic Al2O3 particles that improves the mechanical properties at high temperatures. The weldability is studied. To assess the performance test coupons are investigated and analysed with respect to the mechanical properties

Innovative Aspect(s) :
This work aims to demonstrate the use of the Plasma Metal Deposition as an additive manufacturing Direct Metal Deposition technology using nickel-chromium super alloys powder feedstock reinforced with ceramic particles and compare the thermal mechanical properties with thestandard alloy.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M45
ID : 6282505

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Ing Masari Facundo (Universidad Carlos III de Madrid, Spain)

Co-author(s) : Prof Dr Torralba Castello Jose Manuel (IMDEA Materials Institute, Spain); Prof Dr Campos Gomez Monica (Universidad Carlos III de Madrid, Spain); Prof Dr Olsson Pär (KTH Royal Institute of Technology, Sweden); Prof Dr Szakalos Peter (KTH Royal Institute of Technology, Sweden)

Title : Corrosion Testing Of High-performance Stainless Steels In Liquid Lead

Keyword(s) :
FeCrAl Alloys, Oxidation, Molten Pb, Liquid Metal Corrosion, Alumina Forming Steels

Abstract :
The use of molten lead as a heat exchange fluid poses important critical issues, both in terms of corrosion resistance and creep resistance, due to the temperatures and structural stresses reached during operation. The objective of this work has been the investigation of the corrosion resistance and mechanical properties of new experimental compositions of alumina-forming stainless-steel candidates for these applications. The exposures to stagnant liquid lead were carried out for 500 and 1,000 hours, at temperatures of 550 and 650 °C, with controlled amounts of oxygen dissolved in the liquid lead. In comparison with the AISI 316L and T91 both tested as reference materials, the studied alloys showed promising corrosion behaviour and mechanical properties. According to these results, the proposed steels are appropriate for components that will operate in liquid lead at elevated temperatures without corrosion, while maintaining good mechanical properties.

Innovative Aspect(s) :
Over the past few decades, clean energy solutions have emerged that mitigate greenhouse gas emissions. This category of clean energy technologies includes concentrated solar power and next generation (Gen IV) nuclear reactors. Molten metal coolers with Pb or Pb.Bi are envisaged in both cases. The corrosive nature of liquid Pb is one of its main drawbacks. In most cases, steel is protected from corrosion by forming a chromia layer, but at high operating temperatures this is not a stable barrier. In many high-temperature and extreme environments, stainless steels that form alumina have shown superior corrosion resistance. Therefore, these types of alloys are often proposed as material solutions in many high temperature applications, leading to more efficient energy generation systems. This is what this work explores, researching a new family of steels capable of forming martensite that would improve upon the behaviour of the current ferritic candidates.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M46
ID : 6283346

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Dr Vivès Solange (Aubert & Duval, France)

Co-author(s) : Dr He Yining (Alloyed, United Kingdom); Dr Zhang Pimin (Alloyed, United Kingdom); Mr Peachey Dominic (Alloyed, United Kingdom); Dr Clark John (Alloyed, United Kingdom); Ms Hussain Zara (Alloyed, United Kingdom); Mr Wagstaff Thomas (Alloyed, United Kingdom); Dr Nemeth André (Alloyed, United Kingdom); Dr Crudden David (Alloyed, United Kingdom)

Title : ABD®-1000AM: A Highly Processible Superalloy For Additive Manufacturing, Computationally Designed For 1000°C Applications

Keyword(s) :
Additive Manufacturing, Nickel-Based Superalloys, ABD®-1000AM, Alloys-by-Design

Abstract :
The evolution of additive manufacturing (AM) has sparked a growing interest in using nickel-based superalloys, particularly for high-temperature applications above 1000°C. Traditional alloys, intended for casting or wrought processes, face challenges in AM due to the rapid heating|cooling rates and multiple melt cycles, resulting in compromises to material performance or part design freedom. Here we introduce ABD®-1000AM, a novel high gamma prime nickel-based superalloy designed computationally using the Alloys-by-Design (ABD®) approach, tailored for high-temperature AM applications. ABD®-1000AM exhibits world leading performance in terms of both processing capability as-well-as high temperature mechanical and environmental performance at 1000°C. The study discusses the alloy design and development strategy, highlighting the trade-offs in key performance parameters and the intricate process-microstructure-performance optimization undertaken to achieve the alloy's exceptional creep resistance. Based on the insights gained the future direction of alloy development of superalloys for complex AM components is discussed.

Innovative Aspect(s) :
The evolution of additive manufacturing (AM) technology has sparked a growing interest in manufacturing components from nickel-based superalloys for progressively more demanding applications at ever increasing temperatures. A critical challenge has been the development of high volume fraction gamma prime (γ') strengthened alloys for AM, suitable for applications at temperature of 1000°C or higher, as these are generally considered 'non-weldable'. Due to the nature of the AM process with high heating and cooling rates and multiple melting and solidification cycles, legacy compositions designed with the intent for casting or wrought processes are difficult and often uneconomic to process by AM. This leads to compromises in material performance or part design freedom, limiting AM's potential to replace traditional manufacturing in the most demanding environments. In response to these challenges, this study introduces ABD®-1000AM, a novel high gamma prime Ni-based superalloy, specifically designed using the Alloys-by-Design computational approach to excel in high-temperature.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

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

Paper Number : M115
ID : 6281988

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

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.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M121
ID : 6281479

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

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.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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

Paper Number : M204
ID : 6221756

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Ing Nava Harry (Amelt Corporation, Canada)

Co-author(s) :

Title : An Analysis Of Ramming Refractory ,sintering Method Safety And More Melting Batches In A Medium Frequency Induction Melting And Holding Furnace

Keyword(s) :

Abstract :
This study focuses on enhancing medium frequency induction melting and holding furnaces by optimizing the dry refractory ramming procedure, ensuring sintering method safety, and addressing mechanical and thermal shocks. The dry refractory ramming process's critical role in improving furnace durability and thermal stability is explored, emphasizing material selection for effective resistance to extreme conditions. Safety considerations for sintering methods are detailed, emphasizing the need for stringent protocols to protect personnel and equipment during this phase. The study also addresses the challenge of both mechanical and thermal shocks during sintering, proposing holistic strategies for minimizing their impact. These insights provide practical guidance for metallurgists and operators seeking to maximize the efficiency, safety, and reliability of industrial melting processes.

Innovative Aspect(s) :
This study unfolds innovative dimensions in the optimization of medium frequency induction furnaces. A key innovation lies in the meticulous refinement of the dry refractory ramming procedure, where a strategic selection and application of materials are employed to augment furnace durability and ensure thermal stability under extreme conditions. Notably, the infusion of advanced safety considerations into sintering methods marks a pioneering step, emphasizing the establishment of stringent protocols to safeguard both personnel and equipment during this critical phase. The study further breaks new ground by addressing the multifaceted challenge of minimizing both mechanical and thermal shocks during the sintering process. This innovation involves proposing holistic strategies for shock management, introducing a comprehensive approach to enhance the overall resilience of the furnace system. These groundbreaking insights collectively redefine the landscape for metallurgists and furnace operators, providing a novel framework that promises heightened efficiency, advanced safety, and unparalleled reliability in the realmMeltingprocess.

Reviewer's name : ……………………………………………………………………………………………….

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ………………………………………………………………………………….

Notes to author : ……………………………………………………………………………………………

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

Paper Number : M348
ID : 6299140

Requested presentation type : Oral Presentation

Topic : Materials **Subtopic :** High temperature Materials

Author : Dr Bhattacharya Rahul (Division of Production and Materials Engineering, Sweden)

Co-author(s) :

Title : Exceptional Hardness And In-situ Oxide Dispersion Strengthening Achieved In Nanocrystalline AlCoFeNi High Entropy Alloys Synthesized By Mechanical Alloying And Consolidated By Spark Plasma Sintering

Keyword(s) :
High Entropy Alloy, Configurational Entropy, Exceptional Vicker Hardness, BCC|B2 Enriched Alcofeni Based HEA, Bond Coating Material, Nanocrystalline Grains, Bimodal Grain Distribution, High Temperature Material

Abstract :
In a short timeframe of two decades, high entropy alloys (HEAs) have successfully transcended from the paradigm of novel alloying concepts at a laboratory scale to a multitude of critical industrial applications. Furthermore, the high-temperature application of HEAs can be significantly enhanced by the novel alloy design for AlCoFeNi based alloy system, which has been categorically synthesized by high-energy ball milling to obtain nanocrystalline grain size and inherent oxide dispersion strengthening. These as-milled nanocrystalline mechanically alloyed (MA) powders can be prevented from grain growth during consolidation if the technique of spark plasma sintering (SPS) is utilized. These HEAs have been characterized thoroughly by XRD, SEM, EDS, EBSD, TEM, and DSC to establish the structure-property correlation.Therefore, exceptionally high hardness, thermal stability, contamination-free microstructure, and phase stability at elevated temperatures can be obtained in AlCoFeNi MA-SPS pellets due to inherent nanocrystalline grain size, maximization of the BCC|B2 phase, and oxide nano-dispersoids.

Innovative Aspect(s) :
Exceptional microhardnessConfigurational entropy stabilized multicomponent phasesNanocrystalline grain structure accompanied by bimodal grain distributionIn-situ oxide dispersion obtained during MAThermal stability and phase stability at elevated temperatures BCC and B2 dominated phase constitution with minor FCC phaseThorough microstructural characterization by electron microscopy, calorimetry, electron diffraction, and X´-ray diffraction Resultant HEA alloy design and microstructure designed for high temperature applicationsHEA suitable for bond coating in turbine blades of jet engines, heat exchangers, and boilers.

Reviewer's name : ....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ....

Notes to author : ....

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

Paper Number : M349
ID : 6322589

Requested presentation type : Poster Presentation

Topic : Materials **Subtopic :** High Temperature Materials

Author : Dr Beaudet Savignat Sophie (French Alternative Energies and Atomic Energy Commission, France)

Co-author(s) : Ing Berthoix Fabien (CTTC (Center for Technology Transfers in Ceramics), France)

Title : Preparation And Properties Of Dense Si2N2O|BN Ceramics Sintered With Al2O3, Y2O3 And MgO Sintering Additives

Keyword(s) :

Abstract :
Si2N2O ceramic has many interesting properties leading to a wide range of potential applications ranging from wave-transparent components and optical wave-guide materials to high-temperature structural materials. Moreover, BN addition will improve the dielectric properties, the thermal shock resistance and machinability of these ceramics. However, due to its covalent bonds, low diffusion coefficient and decomposition temperature around 1700 °C, it is difficult to elaborate dense and pure Si2N2O at low temperature without the use of oxides sintering aids. This study focused on the preparation and the characterization of dense Si2N2O|BN ceramics using Al2O3, Y2O3 and MgO sintering aids, according to two different compositions.

Innovative Aspect(s) :
Dense samples with a 75 mm diameter containing at least 80 wt % of Si2N2O phase were obtained by a reactive liquid phase Spark Plasma or Hot Pressing Sintering. The obtained microstructures are homogeneous in all samples in terms of grain size and intergranular phase content. A finer grain size and a higher content in Si2N2O phase are obtained by Hot Pressing compared to Spark Plasma Sintering. The influence of the sintering aids on the microstructure, the physical properties (mechanical properties and thermal properties) and the ablation resistance will be reported.

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : …………………………………………………………………………………….

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