WORLD PM2022 CONGRESS & EXHIBITION

ABSTRACTS – GROUP 2

FERROUS MATERIALS

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225364378

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Shirafuji Tsukasa (Kobe Steel, Ltd., Japan)

Co-author(s): Mr Taniguchi Yuji ; Mr Nishida Satoshi (Kobe Steel, Ltd., Japan) ; Dr Hongu Junichi ; Prof Koide Takao (Tottori University, Japan)

Title: Effect Of Surface-rolling On Tooth Bending Fatigue Strength Of Sintered Pre-alloyed Steel Gear

Keyword(s):
Pre-alloyed steel powder, Sintered gear, Fatigue strength, Residual stress

Abstract:
It is general that the fatigue strength of sintered steel is lower than that of conventional low-alloyed steel, such as JIS SCr420 and JIS SCM420, due to the porosities inside of the material. On the other hand, it has been reported that the tooth bending fatigue strength of the sintered gear manufactured by 46F4H (0.5Ni-1.0Mo Pre-alloyed Steel Powder) is improved by surface-rolling and the fatigue strength is equal or higher than that of the gear manufactured by the wrought steel. In this study, it is found that the reason why surface-rolled sintered steel gear has high fatigue strength is caused by both of decreasing the size of initiation fatigue crack due to compiling the porosities in the vicinity of surface of the gear and high compressive residual stress.

Innovative Aspect(s):
It is found that the tooth bending fatigue strength of sintered gear is improved by surface-rolling because the size of the initiation fatigue crack is decreased by surface-rolling and it is indicated that this improvement of the fatigue strength corresponds well to Murakami's equation considering the term of mean stress. Also, according to evaluation by modified Goodman diagram, it is considered that the reason why the tooth bending fatigue strength of surface-rolled sintered gear is higher than that of molten steel gear manufactured by conventional steel is due to high compressive residual stress introduced into the surface of the sintered gear.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367467

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Ing Norda Michael (Fraunhofer IFAM, Germany)

Co-author(s): Ing Köhler Marie Luise ; Ing Herzog Simone ; Prof Dr Broeckmann Christoph (RWTH Aachen | IWM, Germany) ; Prof Dr Petzoldt Frank (Fraunhofer IFAM, Germany)

Title: Processing And Corrosion Behavior Of Metal Powder Blends In LPBF

Keyword(s):
LPBF, Powder blends, Corosion, Duplex

Abstract:
Laser Powder Bed Fusion (LPBF) has become an attractive alternative to conventional processing routes over the past years. While some alloys are already processed in series production, the overall amount of available materials is low. Due to the high price of specially atomized powders, material variation is often neglected. This work covers the blending, in-situ processing and testing of metal powder blends and the produced specimen. Different metal powders are blended to create a Super Duplex Steel. The powder blend quality is assessed by different methods. Heat treatments , corrosion tests and EDX analyses determine the specimen quality as well as tensile tests. The properties of the created alloy is compared to conventionally produced duplex and super duplex steels in order to show the potentials of this approach.

Innovative Aspect(s):
The innovative aspects are: Method to blend and quality assurance of powder blends New approach for processing and alloying powder blends Corrosion behaviour and comparison of blends to conventional specimen.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367526

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dipl-Ing Geroldinger Stefan (TU Wien, Austria)

Co-author(s): Prof Dr de Oro Calderon Raquel ; Prof Dr Gierl-Mayer Christian ; Prof Dr Danninger Herbert (TU Wien, Austria)

Title: Properties Of PM Steel Alloyed Through The Masteralloy Route - A Comparison To Conventional PM Grades

Keyword(s):
Master alloys, Properties, PM-steel, New materials

Abstract:
The PM steel industry is heading for radical changes, especially concerning the mobility sector. This is accompanied by challenges: New markets for the PM industry should be acquired, and with that, improved materials are mandatory for the future. On the other hand, well established alloying elements such as Cu and Ni undergo critical price fluctuations and are increasingly considered as strategic materials. Alloying elements well known in ingot metallurgy, such as Cr, Mn and Si, are attractive in their effects but limited in PM applications due to their high O affinity. The masteralloy (MA) route using MAs containing Fe, C, Si, Mn and | or Cr is a promising technique making these alloying elements available for the PM route. In this study, PM steels alloyed with MA are compared to commercially available pre-alloyed and diffusion alloyed powders in terms of microstructure, hardness, young's modulus, flexural strength and impact energy.

Innovative Aspect(s):
Using MA and plain Fe powder combines the good compressability of the base powder and an alloying technique suiteable for oxygen affine elements. Sintered under right conditions these new materials show competitive properties to commercial powder grades, without any Ni, Cu and Mo.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367621

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Stewart David (Rolls-Royce, United Kingdom)

Co-author(s): Dr Jones Gary ; Mr Thatcher Daniel ; Mr Sulley John (Rolls-Royce, United Kingdom)

Title: Influence Of Powder Characteristics On Resultant Hot Isostatically Pressed Low Alloy Steel Grade 508 Alloy

Keyword(s):
HIP, Low alloy steel, Nuclear Products, Lead time reduction, Cost reduction, Powder Specification

Abstract:
This paper presents the work conducted by Rolls-Royce to develop hot isostatically pressed low alloy steel (LAS) grade material. The LAS grade is an ASME 508 alloy steel which is used for the manufacture of pressure vessels. A key part of this work has been to assess the influence of the powder chemistry characteristics on the HIP consolidated material. This is needed to understand the key manufacturing variables to determine a powder manufacturing route which gives the optimum output which here is defined achieving both the mechanical property specification requirements and the forged equivalent. The paper reports our studies on a number of powder batches that have been made, against the same powder requirements. Powder and resultant HIP consolidated properties are presented and discussed with regards to key powder characteristics such as oxygen content and key mechanical properties such as strength and toughness.

Innovative Aspect(s):
Rolls-Royce has developed world-first demonstrators and has utilised HIP for products not previously created via a powder process. This innovation provides the opportunity to manufacture Nuclear products at a much faster rate, supporting the demands of 2050 carbon-zero global initiatives where Nuclear is a fundamental industry to achieve carbon reduction targets.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225368071

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Monier Leo (SIMap, France)

Co-author(s): Dr Despres Arthur ; Dr Martin Guilhem ; Dr Blandin Jean-Jacques ; Prof Veron Muriel (SIMap, France)

Title: Grain Refinement And Texture Randomization In Austenitic Stainless Steels Produced By L-PBF

Keyword(s):
Additive manufacturing, 316L austenitic stainless steel, Microstructure

Abstract:
Additive manufacturing is an opportunity for the energy field to produce sophisticated geometries. However, there are still several roadblocks to its use to make a wide variety of parts. One needs to demonstrate that parts produced with conventional processing routes can be substituted by parts fabricated by additive manufacturing. Parts made of 316L stainless steels have been fabricated using two different powder batches while keeping the exact same processing conditions. The nominal composition of the two initial powder batches differs slightly, but it led to very different microstructures. Powder batch 2 leads to a finer grain structure that goes along with texture randomization. The underlying mechanism responsible for grain refinement and texture randomization is discussed and can be considered as an alloy design strategy in the framework of additive manufacturing.

Innovative Aspect(s):
CO2 emissions can be reduced by generating more energy from non-fossil-fuel sources such as nuclear power plants. Additive manufacturing is a disruptive technology allowing the replacement of some components of nuclear power plants to increase their lifetime. One of the main alloys used in nuclear application is the 316L austenitic stainless steel. However, to use the fabricated components, one needs to prove that they have properties as good as their conventional counterparts. In particular, microstructure inherited from L-PBF is anisotropic with coarse columnar grains with a strong crystallographic texture. Finding ways to produce more isotropic microstructures by additive manufacturing is an interesting pathway. In this work, we identify a solidification mechanism leading to grain refinement and texture randomization in additively manufactured 316L. Promoting this mechanism is believed to be an interesting pathway to make the 316L alloy produced by AM suitable for nuclear applications.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225368665

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Gargalis Leonidas (CONIFY P.C., Greece)

Co-author(s): Dr Deligiannis Stavros ; Dr Kousiatza Chara ; Dr Karaxi Evangelia (CONIFY P.C., Greece) ; Mr Dimitriadis Spyros ; Mr Bakas George ; Dr Koumoulos Elias (IRES, Belgium)

Title: A Comprehensive Characterisation Protocol Towards Degradation Assessment And Rejuvenation Protocol Of Metal AM Powder Feedstock: A Case Study On Duplex|super Duplex Stainless Steel Grade Powders In Laser Powder Bed Fusion

Keyword(s):
Powder recycling, Laser Powder Bed Fusion, Duplex|super duplex stainless steel, Reuse

Abstract:
The recycling and reuse of powder in Laser Powder Bed Fusion (LPBF) is directly related to the sustainability and cost-effectiveness of the additive manufacturing process. The aim of this paper is to study the effect of powder recycling and reuse of duplex|super duplex stainless steel, high strength corrosion resistant alloys, processed through LPBF. A comprehensive degradation assessment and comparative study of pristine vs. unfused powder is conducted considering flowability, composition, morphology, and particle size distribution variations. A proprietary image analysis software based on machine learning is used for the analysis of particle size|shape aspects. Finally, guidelines and recommendations for recycling|rejuvenation are given based on the observed degradation level making it feasible to reuse duplex and super duplex stainless steel powder without noticeable impact on the powder performance in LPBF.

Innovative Aspect(s):
Metal additive manufacturing (AM) via laser powder bed fusion (LPBF) and powder-based direct energy deposition (DED) is challenged by inconsistencies in powder quality. The ability to reuse metal powder is critical towards AM processes of high efficiency and improved sustainability. The innovation of the proposed research is in the applied methodology of assessing powder degradation|utilisation limits and applying the necessary actions for reconditioning and reusing duplex and super duplex stainless steel powders commonly utilised in the oil and gas industry. This research establishes a comprehensive multi-characterisation procedure with the use of state-of-the-art techniques for screening powder with regards to critical quality characteristics (e.g. particle morphology and size distribution, impurity pick-up, etc.). A proprietary image analysis software based on machine learning customised to the needs of metal additive manufacturing industry for fast statistical analysis of powder feedstock is used to assess both virgin and used powder quality.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225369499

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Schneider Markus (GKN Sinter Metals Engineering GmbH, Germany)

Co-author(s): Dr Ing Schwarz Jack ; Ing Simon Christian ; Mr Schütz Wolfgang (GKN Sinter Metals GmbH, Germany)

Title: Fatigue And Reliability Of MIM 42CrMo4

Keyword(s):
Metal Injection Molding, High cycle fatigue, MIM 42CrMo4, Low alloy steel, Notch sensitivity

Abstract:
MIM 42CrMo4 is a versatile low alloy steel and commonly used in the forging industry. Its properties can be varied with a tailored hardening and tempering treatment over a wide range of strength|ductility combinations. Its high ductility is beneficial for gears, connecting rods, crankshafts, pistons and other automotive and machinery components. This makes that steel grade also attractive for the Metal Injection Molding and Additive Manufacturing industry. Therefore, MIM 42CrMo4 hardened was chosen as third material – after MIM 8620 case-hardened and MIM 100Cr6 hardened – for the internal high cycle fatigue and notch sensitivity study. As presented in the years before, two different injection molding methods and resulting weld line positions were compared. Moreover, the mean stress sensitivity, notch sensitivity, scatter and further s-N line parameters were discussed and compared with the previously characterized MIM steel grades. Its response on a variety of tempering regimes was investigated too.

Innovative Aspect(s):
Fatigue of Metal Injection Molding materials is rarely in investigated.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225369527

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Schneider Markus (GKN Sinter Metals Engineering GmbH, Germany)

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

Title: Effect Of Tempering Temperature And Nitrogen Content On The Heat-treated Impact Toughness Of Sintered Steels

Keyword(s):
Sintered steels, Induction hardening, Induction tempering, Blue brittleness, Aging, Nitrides

Abstract:
Induction hardening and induction tempering gain increasing importance for heat treating of sintered steels due to high reproducibility and the chance for subsequent soft machining of not heat-treated part regions. Due to the high heating rates and the short processing times during the inductive heating the diffusion processes have to be accelerated by higher temperature. This results in higher austenitizing and tempering temperatures compared to classical furnace heat treatments. In the presence of absorbed nitrogen higher tempering temperatures might result in blue brittleness (300 °C embrittlement), an aging effect caused by the precipitation of nitrides. Based on that working hypothesis four different sintered steels were hardened and tempered under varying conditions. The hardness and the impact toughness were analyzed to check whether a drop of the toughness can be observed at a certain tempering temperature level. Moreover, the absorbed nitrogen contents were measured.

Innovative Aspect(s):
Induction hardening is rarely investigated in PM.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225369574

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Nezhadfar Pooriya Dastranjy (Auburn University, USA))

Co-author(s): Mr Verquin Benoit ; Dr Lefebvre Fabien ; Mr Robert Maxime ; Dr Reynaud Christophe (CETIM, France) ; Prof Shamsaei Nima (Auburn University, USA)

Title: Effect Of Heat Treatment On The Tensile And Fatigue Behavior Of 17-4 PH Stainless Steel Additively Manufactured By Metal Binder Jetting.

Keyword(s):
Metal Binder Jetting, Heat treatment, Fatigue strength

Abstract:
Metal Binder Jetting (MBJ), a sintered-base AM process, enables to fabricating of complex geometries without residual stresses. Various materials have been successfully manufactured via the MBJ process; however, appropriate post-process heat treatments are required to be conducted to enhance their mechanical performance as compared to the wrought or other additively manufactured counterparts. This study aims to investigate the effect of post-manufacture heat treatment on the microstructure and mechanical properties of MBJ 17-4 PH stainless steel (SS). Various heat treatment procedures following the standard routes for the wrought 17-4 PH SS are conducted to evaluate their effects on the tensile and fatigue behavior of MBJ 17-4 PH SS. The mechanical behavior of the MBJ 17-4 PH SS in various heat treatment conditions is discussed based on their corresponding microstructure.

Innovative Aspect(s):
We undelight the influence of heat treatments through the characterization of the microstructure by EBSD analysis but also through the tensile and fatigue behavior. The results of this study show that optimal heat treatments for the sintered material are different from those usually used for wrought 17-4PH SS. A comparison will also be made with other AM process as L-PBF.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225370510

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Tönnißen Nicklas (Max-Planck für Eisenforschung GmbH, Germany)

Co-author(s): Mr Hussain Shohag ; Prof Dr Uhlenwinkel Volker (Leibniz-Institut für Werkstofforientierte Technologien - IWT, Germany) ; Prof Dr Springer Hauke (Max-Planck für Eisenforschung GmbH, Germany)

Title: In-situ Heat Treatment Of FeTiB2 High Modulus Steel By Additional Laser Exposure In L-PBF Process

Keyword(s):
Metal-matrix composites, Laser powder bed fusion, Density, Cracks, Stiffness, Heat treatment

Abstract:
Additive manufacturing of Fe-Ti-B high modulus steels using the laser powder bed fusion (L-PBF) synthesizes innovative process technology with targeted alloy design which enable next generation lightweight design solutions. By the inherent rapid solidification and in-situ precipitation an even distribution of nanometer-sized TiB2-particles in a α-matrix is achieved. Porosity and cracks can be eliminated by high substrate preheating up to 800 °C. The substrate preheating temperature can be substantially reduced by use of intermittent laser exposure between layer depositions. Hence, the molten surface is treated in a second exposure step with a reduced laser power (i.e. 25 – 75 %) as an in-situ heat treatment, aiding in the transformation of brittle metastable compounds to the equilibrium constituent's ferrite and TiB2. These are not only desirable for improving the stiffness|density ratio, but also exhibit much less susceptibility for cracking, and allow to reduce the preheating temperature down to 400 °C.

Innovative Aspect(s):
Additive manufacturing of Fe-Ti-B high modulus steels using the laser powder bed fusion (L-PBF) is an ideal showcase how innovative process technology coupled with targeted alloy design can enable next generation lightweight design solutions.. Finding of a new process route with an additional exposure. In-situ heat treatment during the L-PBF process.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225370723

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Shirani Amir (H.L. Blachford Ltd, Canada)

Co-author(s): Dr V. Reid Jean (H.L. Blachford Ltd, Canada)

Title: Advance Rheological Investigation Of Lubricant Particle Size On Powder Properties Of Metal Powder Mixture Using FT4 And Granutools

Keyword(s):
Lubricants, Powder flow, FT4, Granutools

Abstract:
Powder properties of powder metallurgy (PM) premixes (metal powder with alloying ingredients and lubricant) are influenced by PM lubricants. The chemistry, particle size, shape, and crystalline structure of the lubricant affect its performance in the premix. Ethylene-bis- stearamide (EBS) is one of the conventional ingredients commonly used in PM lubricants. In this investigation, the rheological characteristics of iron-based premixes, with various particle sizes of EBS but the same crystalline phases and particle shape, were investigated using the FT4 Powder Rheometer® and Granutools™ instruments. The powder flowability of conditioned and consolidated powder was examined in FT4 and compared with the cohesion index obtained as a function of rotating speed in Granudrum™. The density evolution of powder and powder compaction kinetics were classified in the FT4 compressibility program and Granupack™ tools, respectively. This work confirmed that the larger lubricant particle size and lower amount of graphite resulted in faster powder flow.

Innovative Aspect(s):
The focus of this research was to investigate only one factor (lubricant particle size) on the metal powder properties while the other factors, such as lubricant particle shape its crystalline structure, metal powder mixture, and method of mixing was kept constant. Powder properties were compared using the advanced method of characterization (FT4 and Granutools) and are compared with the classical method of measurements. The obtained results were analyzed and discussed based on the theoretical concepts of powder properties (powder flow, density, etc.).

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371495

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Benzaama Habib (Ecole Nationale Polytechnique d'Oran Maurice Audin, Algeria)

Co-author(s): Mr Ahmed Bensoltane Abdelaziz ; Mr Mokhtari Mohamed ; Mr Abdelouahed Elamine (Ecole Nationale Polytechnique d'Oran Maurice Audin, Algeria)

Title: Steel Tee Pipes Damage Analysis Under Bending And Pressure Loading

Keyword(s):
XFEM (Extended Finite Element method), Damage model, Crack propagation

Abstract:
A T-reduced connection in X70 steel of category 8"x4" under oriented loading and internal pressure with or without the presence of a defect was studied in this work with the XFEM technique. A numerical prediction took the objective to evaluate the dependent parameters such as the location and the type of fault as well as the mode and the level of accumulated loading. The loading mode clearly showed a large difference between the response up to the damage level. These results are presented by curves which present at the same time the response of a structure in forces-displacement and the propagation of crack. The location of the defect in the structure is oriented according to the loading. The type of defect is linked by its location according to the thickness in the form of a metallic pullout.

Innovative Aspect(s):
This analysis of the damage shows that the parameters studied in the structure clearly condition the level and the mode of failure as well as their response. There are few numerical works on the bends responsible for the damage of the structures. Through a numerical study with the XFEM technique, we place a reduced T connection in the most complex and real fault conditions. The study is complete and the results are very clear.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371528

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Olsson Fredrik (Höganäs AB, Sweden)

Co-author(s): Dr Vattur Sundaram Maheswaran ; Ing Johansson Pernilla (Höganäs AB, Sweden)

Title: Electron Backscatter Diffraction Investigation Of Tempered Martensite In Chromium Pre-Alloyed PM Steels

Keyword(s):

Abstract:
The enhanced strength and performance of the PM steels are attributed to its martensitic microstructure from heat treatment process. However, in the as-quenched state, the metastable martensite is brittle, and to improve the toughness and the phase stability, tempering is performed. In PM steels, the performance can be further enhanced by the addition of Ni and heat treatment after sintering in form of casehardening by low-pressure carburizing (LPC). The combined effect on the obtained microstructure needs to be understood and optimized to maximize the overall performance. This paper investigates the effect of microstructural changes due to tempering a chromium pre-alloyed PM steel with and without Ni additions after LPC utilizing Electron Backscatter Diffraction (EBSD).

Innovative Aspect(s):
Advanced characterisation of PM steels : EBSD characterisation of martensite and retained austenite upon tempering of case hardened PM steels. We can argue from the TRS values of the tempered specimens, show very high value, which means it is important to understand microstructurally the phases that are present up on tempering.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371564

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Ing Vikner Peter (Aubert & Duval, France)

Co-author(s): Dr Ing Mayer Charlotte ; Mr Egea Philippe (Aubert & Duval, France) ; Mr Muner Corrado (Texer design, Italy)

Title: Effect Of Process Parameters And Heat Treatment On Microstructure Of L-PBF Processed Pearl® Micro TS700

Keyword(s):
Precipitation strengthening maraging steel, Hot tolling, Aluminum die casting, As built microstructure vs. energy density, HAZ between TS700 and H11, Heat treatment

Abstract:
Pearl® Micro TS700 is a new precipitation hardening steel with high temperature resistance and excellent hot hardness developed for additive manufacturing of aluminium die casting tooling. TS700 parts were produced by L-PBF on a plate made in H11 tool steel treated at 45HRC. The interface between TS700 and H11 is investigated, as well as the microstructure evolution versus energy density (for different laser powers and scan speeds). The evolution of the microstructure with subsequent heat treatments is presented as well as some mechanical properties associated to the different microstructures obtained.

Innovative Aspect(s):
The different process parameters were investigated not only in terms of porosity or productivity but also in terms of as built microstructure. The fraction of big austenite grains through smaller martensite was correlated to the energy density input. Such big grains do not affect the alloy when heat treated above AC1 but for direct ageing treatement, they shall be avoided because of their negative impact on KV. The HAZ at the interface with H11 at 45HRC hardness is also studied.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371658

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Villaret Flore (EDF-R&D, France)

Co-author(s): Dr de Carlan Yann ; Dr Garnier Jérôme ; Dr Aubry Pascal (Université Paris-Saclay, CEA, France) ; Prof Dr Fabrègue Damien ; Dr Ing Boulnat Xavier (Université de Lyon, France)

Title: Design Of Duplex And Graded Austenitic-to-martensitic Steels By Powder Metallurgy: Interdiffusion, Microstructure And Strength Composite Effect

Keyword(s):
SPS, HIP, Multi-material, Duplex steel, 316L, Fe-9Cr

Abstract:
The use of several different steel powders allows to obtain either multi-material junctions, when they are stacked, or new duplex alloys when they are mixed. The study presented focuses on the new materials obtained by SPS or HIP from an austenitic 316L steel powder and a martensitic Fe-9Cr steel powder. These materials are characterized at different scales: metallography, electron microscopy, EDX and EBSD, hardness and tensile tests. The observed microstructures are explained by compositional changes from one steel to another and by the diffusion of chemical elements during sintering. Reuss and Voigt models are then used to analyse and model the mechanical properties of the resulting composites. This original mechanical analysis highlights the results of the interaction between the two metals during the sintering process.

Innovative Aspect(s):
This study presents a new way of sintering duplex stainless steels, a complete study of the materials obtained and an original analysis of their mechanical properties.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371682

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dipl-Ing Vinčić Josip (Politecnico di Torino, Italy)

Co-author(s): Prof Manfredi Diego ; Prof Lombardi Mariangela ; Dr Aversa Alberta (Politecnico di Torino, Italy)

Title: Repairing D2 tool steel parts by directed energy deposition using a hot work tool steel or a metal matrix composite

Keyword(s):
Directed energy deposition, Cold work tool steel, Hot work tool steel, Metal matrix composite

Abstract:
The D2 tool steel is a cold work tool steel with high hardness and high wear resistance, but not easy to be welded due to its high carbon content. On the other hand, as a result of the growing need for faster production, industries are facing higher tool wear than expected. The high costs of replacing tools has prompted thinking about repairing them. The aim of this study was to evaluate the possibility to repair D2 tool steel parts with a hot work tool steel or with a metal matrix composite using directed energy deposition (DED). The optimal parameters were found by depositing and analysing first single tracks, then single layers and ultimately multi-layers. The samples were analysed from a microstructural point of view, by optical and electron microscopy, and from a mechanical point of view, by hardness measurements. This work demonstrates the potential of DED for repairing industrial tools.

Innovative Aspect(s):
This research work aims to investigate the potential of using directed energy deposition (DED) for repairing steel tools. In order to make it feasible, it is necessary to analyse and optimize process parameters for the powder materials to be deposited on the substrate, which in this case is an industrial blade in cold work tool steel. This represent the first innovative issue in DED: usually the powders are of the same material of the substrate. In this study two materials that could guarantee a very high hardness are chosen for repairing: a hot tool steel and a metal matrix composite. This choice is attractive but also challenging, due to the different thermal expansion coefficients. Moreover, the composite deposition was preformed using two powder feeders, one containing ceramic|metal powder mixture and other only metal powder in order to modulate the ceramic content in the composite final part.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

Notes to author: .....

WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371745

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Reynaud Christophe (CETIM, France)

Co-author(s): Dr Ing Baulin Oriane ; Ing Reinwalt Bastien (CETIM, France)

Title: Development Of X40CrMoV5-1 (H13) On Binder Jetting Technologies

Keyword(s):
H13 tool steel, Binder jetting, Additive manufacturing

Abstract:
Cetim has launched further material project development on binder technologies. This work deals with the development of the tool steel X40CrMoV5-1 or H13 on two Metal Binder Jetting technologies, namely DM P2500 (Digital Metal) and Lab P-1 (Desktop Metal). The whole MBJ H13 has been developed by adjusting the 17-4PH powder printing parameters and by developing a specific sintering recipe by using a vacuum metallic furnace under controlled atmosphere (one step debinding sintering). The presentation will be focused on sintering development. Controlling the final carbon content and achieving high density level without excessive component distortion by using SLPS process are the main challenges to overcome. The microstructure and the mechanical properties are compared. For both technologies, as sintered mechanical properties are consistent with data coming from MIM H13 materials and wrought materials.

Innovative Aspect(s):
Implementation of H13 tool steel on DM P2500 et P-1 BJ technologies. Not yet available on these printer machines. Comparison of the 2 technologies.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371757

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Ing Charron Quentin (CETIM, France)

Co-author(s): Dr Trump Anna ; Mr Cunnigham Jeff ; Dr Dary François (Desktop Metal, USA) ; Dr Ing Reynaud Christophe ; Dr Ing Baulin Oriane (CETIM, France)

Title: Development Of AISI 304L For Metal Binder Jetting

Keyword(s):
Binder Jetting, AISI 304L, Additive manufacturing

Abstract:
Processing of the AISI 304L Stainless Steel on Desktop Metal's Binder Jetting Shop System suite (both printer and sintering furnace) has been investigated. This development has been performed in close collaboration between Desktop Metal and Cetim. Several printing and sintering parameters such as green density, sintering atmosphere or sintering temperature were studied and their impact on microstructure and mechanical properties is evaluated and discussed. It has been demonstrated that high green density and nitrogen-based atmosphere are key factors for dense parts and optimal material performance. Final material exhibits mechanical properties compliant with MIM 316L standards (MPIF Std 35 | ISO 22068) and with ASTM A420. It opens several key markets for Metal Binder Jetting, including luxury, energy…

Innovative Aspect(s):
Implementation of AISI 304L on Shop System suite. Not yet available.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371801

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Schade Chris (Hoeganaes Corporation, USA)

Co-author(s): Mrs Junghetu Corina ; Miss Horvay Kerri ; Mr Murphy Thomas (Hoeganaes Corporation, USA)

Title: Microstructure and mechanical properties of heat treated FSLA steel produced by the binder jet process

Keyword(s):
Low Alloy Steel, Binder Additive Manufacturing, Materials Mechanical Properties

Abstract:
An alloy, called FSLA (free-sintering low-alloy), was designed and implemented for use with binder jet printing. This work focuses on various heat treatments that can be utilized with the alloy to produce a range of properties for various applications. The microstructure of the alloy can be varied post-sintering, by heat treatment, to give a wide range of mechanical properties that are suitable for automotive components. Balancing the carbides in the structure along with the amounts of ferrite and martensite|bainite give a range of ultimate tensile strengths from approximatelt 490 to 1000 MPa. Unlike other low alloy steels, the material has been designed to have a high degree of sinterability which allows densities of the order of 98% to be reached while sintering at temperatures typically used in metal injection molding (1380 degrees Celcius).

Innovative Aspect(s):
Because one alloy gives a wide range of mechanical properties, the development of printing and sintering parameters, which is often difficult for multiple grades of material, only needs to be developed once. The material then can be heat treated to mimic a range of low alloy steels that are commerically available. Also due to the fact that the microstructure during sintering is a mixture of ferrite and austenite the density that can be achieved is much higher than a material that can is sintered in either of the single phase regions (i.e. ferrite alone or austenite alone).

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371903

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dipl-Ing Hutsch Thomas (Fraunhofer IFAM, branch lab Dresden, Germany)

Co-author(s): Dipl-Ing Zhou Xin ; Dr Ing Penter Lars ; Prof Dr Ihlenfeldt Steffen (Technical University Dresden, Germany) ; Dr Ing Weißgärber Thomas (Fraunhofer IFAM, branch lab Dresden, Germany)

Title: Iron-based Graphite Composite - Manufacturing And Use As Damping Material In Machine Tools

Keyword(s):
Iron graphite composite, Sintering, Damping, Machine tool

Abstract:
Superior manufacturing precision and high axes dynamics for a maximum chip removal rate are main selling points for machine tools. They require large stiffness-to-weight ratio, high vibration damping and reduction of noise emission at the same time. Because iron-based graphite unites high specific stiffness and excellent damping behavior, it is a potential material to meet these demands. The presentation discusses powder metallurgical methods to manufacture these composites and elaborates on resulting properties such as density, damping, and elastic as well as shear modulus. Cross section views demonstrate the alignment of graphite. Subsequently, the implementation of a component made from metal graphite composite into a machine tool rig, shows how simulated and measured damping ratio compare and how it changes the overall system behavior. Finally, the presentation derives design rules for practical application of metal-graphite composites.

Innovative Aspect(s):
Manufacturing precision and speed are directly connected to the damping behaviour of a machine tool. Machining with a minimum amount of vibration excitation leads to longer tool life, higher cutting precision and to lower emission of noise. Iron graphite composites enable the integration of damping materials close to the zone with large vibration amplitude. Press and sinter or pressure assisted sintering can tailor the composites properties and shape exactly to the dynamic needs of the machine tool.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371912

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Şelte Aydin (Uddeholms AB, Sweden)

Co-author(s): Dr Oikonomou Christos (Uddeholms AB, Sweden) ; Dipl-Ing Åsberg Mikael (Karlstad University, Sweden) ; Dipl-Ing Strandh Emil (SWERIM, Sweden)

Title: Industrial Development And Verification Of Cr-Mo-V Based Cold Work Tool Steel Parts Produced Via Electron Beam Melting (EBM)

Keyword(s):
Cold work tool steel, Electron beam melting, Punching, SOFS test, Industrialization

Abstract:
Being a fast, powerful and crack-free manufacturing process, electron beam melting (EBM) has been gaining importance for tooling industry for the recent years. EBM allows processing high melting materials under vacuum atmosphere with high building rates, which offers less residual stresses caused by the complex thermal history and high cooling rates during the manufacturing. Uddeholms AB has previously shown on a pilot scale the performance capabilities of the EBM process in respect to the high alloyed and commercially available tool steel powder grade Vanadis® 4 Extra AM. In this study, industrial scale demonstrators and application tools were produced from Vanadis® 4 Extra AM powder. Industrialization of the concept studies was completed. Verification of the parts were conducted by using a slider-on-flat-surface (SOFS) wear tester and a semi-industrial punching test. Moreover, the dimensional tolerances, need of post-processing treatments and product qualities were emphasized within the scope of this investigation.

Innovative Aspect(s):
Tool steel powder for EBM High alloyed cold work tool steel powder for AM High builds with EBM Real-time application areas.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372029

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Takashita Takuya (JFE Steel Corporation, Japan)

Co-author(s): Dr Unami Shigeru (JFE Steel Corporation, Japan)

Title: The Influence Of Cu Pre-alloying And Its Precipitating Behavior On The Compressibility And Hardenability Of Fe-Mo Alloyed Steel Powder

Keyword(s):
As sintered components, Atomized steel powder, Compressibllity, Hadenability, Pre-alloyed steel powder

Abstract:
Both compressibility and hardenability are required for the alloyed steel powder for the as-sintered process. In this research, the Cu pre-alloying for the Fe-Mo alloyed steel powder, which has good compressibility, is investigated for improving hardenability. As a result, the unique phenomena was found that both compressibility and hardenability of the Fe-Mo alloyed steel powder was improved by Cu pre-alloying. And the mechanism of the phenomena was investigated by the TEM observation. The size of Cu precipitates in Fe-Mo alloyed steel powder increased with an increase in Cu pre-alloying, and it improved the compressibility. In addition, Cu precipitates were solute into the matrix of the sintered microstructure during sintering, and solute Cu improved the hardenability. As a result, the as-sintered material with bainite and martensite microstructure was obtained. Because of these improvements of the compressibility and the hardenability, higher strength as-sintered material was obtained compared with conventional as-sintered material.

Innovative Aspect(s):
The innovative aspects of this study is that improvement of compressibility by precipitation controlling of Fe-Cu pre-alloyed steep powder. By using the technique, the alloyed steel powder with high compressibility and hardenability was obtained.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372227

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Prof Dr Ozaki Yukiko (Kyushu University, Japan)

Co-author(s): Mr Ando Isshin ; Dr Ing Aramaki Masatoshi ; Dipl-Ing Tsuji Takeshi ; Mr Nakamura Koji (Kyushu University, Japan) ; Dr Ing Hirayama Kyosuke (Kyoto University, Japan) ; Dr Ing Jiang Fei (Yamaguchi University, Japan) ; Dr Ing Ashizuka Kosuke (JFE Steel Co.,

Title: Analysis Of The Mechanism Of Ductile Crack Initiation In High Densely Sintered Iron - Visualization And Quantification Of The 3D Pore-configurations By Synchrotron X-ray Tomography And Persistent Homology

Keyword(s):
Ductile fracture, 3D pore configuration, X-ray CT, Persistent homology

Abstract:
For a high-density pure iron sintered compact without open pores, the 3D pore configurations at different strain levels during ductility tests were visualized by X-ray computed tomography (CT). In addition, each three-dimensional structure was quantified as a two-dimensional scatter plot by persistent homology (PH) analysis. By comparing the scatter plots, specific local pore configurations sensitive to changes in strain were extracted. The results showed that, just prior to fracture, a specific closed pore cluster consisting of extended pores with high aspect ratios coalesced to form the first crack. This process is consistent with the theory of ductile fracture of metallic materials proposed by MacLintock.

Innovative Aspect(s):
Prior to the present study, a similar approach was applied to elucidate the important role of open pores in crack formation during the ductile fracture process of pure iron sintered bodies with open pores. In this presentation, we clarify the mechanism of fracture crack initiation in high-density sintered iron without open pores. It is hoped that this will lead to a better understanding of fracture in high density sintered materials.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372306

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Christos Christos (Uddeholms AB, Sweden)

Co-author(s): Mrs Sivertsen Sebastian (Uddeholms AB, Sweden)

Title: Innovative Solutions For High Pressure Die Casting Tooling Applications Via Laser Powder Bed Fusion - Processing And Performance Of X35CrMoV5-2 Tool Steel

Keyword(s):
Tooling, Additive Manufacturing, High Pressure Die Casting

Abstract:
The Laser Powder Bed Fusion (L-PBF) process, is offering increased complexity in design that is not possible to achieve with other manufacturing routes. Such features are implemented as solutions in High Pressure Die Casting (HPDC) applications, for the design of more efficient tooling dies due to the presence of conformal cooling channels that yield improved thermal management.In order to achieve a successful total solution by utilizing AM in HPDC tooling applications, the material selection is critical. Typically, maraging steels are preferred today due to their ease in the L-PBF manufacturing process without though satisfying the material profile required for the tooling environment. The present study describes the development of an innovative martensitic carbon based tool steel of superior toughness and high temperature strength than reported today. Process validation and scalability have been verified with the L-PBF in respect to actual tool geometries, reaching productivity levels up to 20cm3|hr.

Innovative Aspect(s):
Full scale development (large sized geometries) of a martensitic carbon based tool steel with a pre-heat temperature below 200°C. High productivity rates in L-PBF of fully dense material up to 20 cm3|hr with a single laser source. Superior impact toughness values compared to other reported conventional, or L-PBF manufactured tool steel grades. Reported bulk properties values for different hardness levels in both Room Temperature and at elevated temperatures (up to 600°C). Experimental investigations coupled to simulation modeling utilizing commercially available software solutions.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225380713

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Traversier Mathieu (MINES SAINT ETIENNE, CNRS, UMR 5307 LGF, France)

Co-author(s): Mr Rigal Emmanuel (Université Grenoble Alpes, CEA LITEN, France) ; Mr Boulnat Xavier (Université de Lyon, INSA Lyon, MATEIS, UMR CNRS 5510, France) ; Mr Tancret Franck (Nantes Université, CNRS, Institut des matériaux de Nantes Jean Rouxel, IMN, France) ;

Title: Powder Nitriding Route For Improvement Of Mechanical Properties Of A Co-free High Entropy Alloy

Keyword(s):
Powder metallurgy, High entropy alloys, Interstitial alloying, Mechanical properties, Microstructure characterization

Abstract:
Interstitial alloying of High Entropy Alloys (HEAs) from the CoCrFeMnNi family is an efficient way of improving the intrinsically low strength of these single-phase austenitic alloys. Nitrogen is one of promising elements of concern owing to its large solubility.In this work, a Co-free HEA powder was successfully gas nitrided at high temperature and subsequently densified by Hot Isostatic Pressing to produce a bulk material. Such process increases the efficiency of introducing nitrogen into the matrix, due to the high surface area of the powders.Electron microscopy and X-ray diffraction showed an efficient absorption and diffusion of nitrogen during the nitriding step, as lattice parameter expands and nitrides are observed. Post HIP heat treatment succeeded in dissolving the nitrides, leaving all nitrogen in solid solution without significant grain growth. Tensile tests showed that nitrogen improves the mechanical resistance by solid solution hardening, without ductility loss.

Innovative Aspect(s):
In current metallurgic processes, nitrogen is introduced in bulk alloys during the fusion step. The liquid metal is exposed to a nitriding atmosphere which will induce the nitrogen adsorption. However, the amount of nitrogen introduced is proportional to the square of the nitrogen pressure which means that in order to introduce large amount of nitrogen a huge pressure is needed. In this study, nitrogen alloying is achieved by nitriding powders and densifying them to get a nitrogen-rich bulk alloy. Due to the high surface area, it is easier to introduce large amount of nitrogen compared to the cast procedure. This strategy also benefits from the common advantages of the powder metallurgy.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225381791

Requested paper type: Oral Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Dr Ing Ordas Nerea (Ceit, Spain)

Co-author(s): Dr Ing Roldan Marcelo ; Dr Leon Edgar (Ciemat, Spain) ; Dr Leguey Teresa (University Carlos III Madrid, Spain) ; Dipl-Ing Cardozo Evelin ; Dr Iturriza Iñigo (Ceit, Spain)

Title: Towards The Upscaling Of ODS Steels: STARS ROUTE®

Keyword(s):
ODS steels, Gas atomization, Oxides, Prior Particle Boundaries, Precipitation, HIP consolidation, Warm rolling

Abstract:
14Cr-2W-0.3Ti-0.3Y2O3 Oxide Dispersion Strengthened (ODS) Ferritic Stainless Steels are promising candidates for structural components in future nuclear systems. Their outstanding properties are attributed to an ultrafine microstructure and a very stable dispersion of Y-Ti-O oxide nanoparticles (NPs). The STARS Route® developed to produce ODS alloys avoids the need for mechanical alloying to dissolve the oxide-former elements in the matrix and relies on Ceit's capability to introduce them during gas atomization as oversaturated solid solution. Warm rolling after HIPing introduces a high density of dislocations, preferential nucleation sites. Final annealing heat treatment precipitates the NPs through an internal oxidation process: the metastable oxides formed at the surface of powder particles after atomization dissociate, and oxygen, Ti and Y diffuse towards the dislocations, where they precipitate as Y-Ti-O nano-oxides. This work shows the microstructural evolution of ODS steels obtained with the STARS Route®, and the role of process parameters on mechanical properties.

Innovative Aspect(s):
The conventional manufacturing process to obtain ODS ferritic steels includes Mechanical Alloying (MA) of gas atomized Fe-14Cr-2W-0.3Ti powder and Y2O3 to dissolve Y in ferrite. During HIP consolidation at high temperature Y precipitates and reacts with oxygen and Ti, as Y-Ti-O NPs. Hot deformation by rolling or extrusion and final annealing improve the mechanical behavior. However, MA involves several drawbacks: high time and cost inefficiencies, contamination from grinding media or atmosphere, difficulties in controlling the compositional homogeneity, presence of batch-to-batch heterogeneities and low availability of industrial mills to perform MA of large batches of powder. Ceit has succeeded in atomizing powders containing Y, so MA is no longer required. The up-scalability to industrial atomizers has been also demonstrated. The STARS Route is also valid for stainless steels containing a wide variety of oxide NPs (Y-Al, Y-Hf, Y-Zr) and even for Ni-base superalloys like Inconel MA 758, INCOLOY MA956 and PM2000.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225364342

Requested paper type: Poster Presentation

Topic: Materials / **Subtopic:** Ferrous materials

Author: Mr Hojati Milad (Technische Universität Wien, Austria)

Co-author(s): Prof Gierl-Mayer Christina ; Prof Danninger Herbert (Technische Universität Wien, Austria)

Title: Monotonic And Cyclic Properties Of Sinter Hardened Sintered Steels Prepared By Hybrid Alloying

Keyword(s):
Sintered steels, Alloying, Masteralloy, Fatigue, Sinter hardening

Abstract:
For PM steel precision parts, high mechanical loading is very common in service. In particular for automotive applications, fatigue up to very high loading cycle numbers may be encountered. Advanced alloying concepts for sintered steels are required, involving also alloy elements with high oxygen affinity. In the present study, hybrid alloyed sintered steels were prepared based on prealloyed steel powder Fe-1.8%Cr, and Mn and Ni, respectively, were admixed as well as a masteralloy containing Mn and Si. After sintering the specimens were quenched with cold nitrogen, to simulate sinter hardening, and characterized. Ni alloying proved to be positive both for the impact energy and the gigacycle fatigue strength while Mn was less effective, in part because of intergranular embrittlement. The Mn-Si masteralloy also showed some intergranular failure, but in particular at N>10E8 the fatigue endurance strength was similar to that of the Ni alloyed type, however with lower scatter.

Innovative Aspect(s):
Using the hybrid sintered steels with high oxygen affininty in order to produce highly loaded PM parts, through admixig Chromium prealloyed powder with with elemental powders as well as a masteralloy powder.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371754

Requested paper type: Poster Presentation

Topic: Materials / **Subtopic:** Ferrous materials

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

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

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:
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 and the optimal combination of properties.

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.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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