EURO PM2023

CONGRESS & EXHIBITION

Technical Programme Committee
15th February 2023

ABSTRACTS BOOK – GROUP 10

POWDER PRODUCTION

EPMA
european powder metallurgy association

EURO PM2023

CONGRESS & EXHIBITION

Technical Programme Committee
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POWDER PRODUCTION

EPMA
european powder metallurgy association

EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235742148

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Ing Meyer Philipp (Neue Materialien Bayreuth GmbH, Germany)

Co-author(s) : Dr Ing Daoud Haneen (Neue Materialien Bayreuth GmbH, Germany), Dr Ing Schwarte Stefan (Jäkel GmbH & Co. KG, Germany), Ing Riehle Daniel (K.U.L.T. Kress Umweltschonende Landtechnik GmbH, Germany), Prof Dr Glatzel Uwe (University of Bayreuth – Chair of Metals and Alloys, Germany)

Title : Manufacturing Of WC-based Metal Matrix Composites By Wire Arc Thermal Spray

Keyword(s) :
Tungsten Carbide; Powder Atomization; Spherical Powder; Wear Resistance

Abstract :
Metal matrix composites (MMC) promote high wear and temperature resistance for various applications. The desired tribological, mechanical or thermal properties of MMC components can be specifically adjusted by an optimal combination of metallic matrix and reinforcement particles. Tungsten carbide (WC) reinforced powders for additive manufacturing are produced by premixing of both reinforced particles and matrix particles. However, due to the density differences of the two phases and the dissolution effect of WC-particles under high temperature, manufacturing of homogenous MMC-components is still challenging. In this study, a new approach to produce homogeneous, with high wear resistance WC-M powder is proposed. Therefore, cored WC-wires are atomized by newly developed wire arc thermal spray atomization method. The powders were characterized to surface morphology, particle size distribution and dissolution behavior of WC particles. The influence of atomization parameters and the use of different metal matrix materials will be discussed.

Innovative Aspect(s) :
Development of tungsten carbide reinforced metal powder for homogneous coatings with high wear resistance.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235749638

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Qaddah Baraa (IRT M2P, France)

Co-author(s) : Dr Chapelle Pierre, Prof Bellot Jean Pierre, Ing Jourdan Julien (Institue Jean Lamour, France), Prof Rimbert Nicolas (LEMTA, France), Ing Deborde Agathe, Ing Hammes Raphael (IRT M2P, France)

Title : Primary And Secondary Breakup Of Molten TA6V In An EIGA Atomizer For Metal Powder Production

Keyword(s) :
Free-Fall Atomizer; Swirling Supersonic Gas Flow; Metal Powder; Primary Fragmentation; Secondary Fragmentation; High-Speed Camera

Abstract :
Gas atomization is the predominant method of Powder Production for metal additive manufacturing. The EIGA atomizer (Electrode Induction melting Gas Atomization) is a free-fall process used to produce spherical powders, particularly for refractory and high-purity metals such as the titanium alloy Ti-6Al-4V (TA6V). In this process, a swirling supersonic gas jet hits a molten metal stream atomizing it into small droplets through various fragmentation mechanisms.To identify the different mechanisms of molten TA6V fragmentation within the process, a visualization of the metal atomization by a high-speed camera is performed in an EIGA tower. The role of the atomization gas pressure, the pressure in the melting chamber and the slit size at the nozzle outlet on the fragmentation mechanisms and on the final particle size distribution are determined. The mechanisms observed are fiber breakup, bag breakup and Rayleigh breakup for primary fragmentation and bag breakup and shear breakup for secondary fragmentation.

Innovative Aspect(s) :
Identify the different fragmentation mechanisms of molten TA6V within the EIGA atomizer using high-speed camera. Determine the role of the atomization gas on the fragmentation mechanisms and on the final particle size distribution.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235750577

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Sista Kameswara Srikar (TATA STEEL LTD, India)

Co-author(s) : Mr Pirjade Bilal Murtuza, Dr Moon Abhijeet Premkumar, Dr Dwarapudi Srinivas (TATA STEEL LTD, India)

Title : Comparative Study Of Iron Powders Synthesis From Steel Industry By-product Through Conventional And Microwave Reduction

Keyword(s) :
By-product; Iron Powder; Hydrogen; Reduction; Microwave

Abstract :
Iron powders are one of the widely used metal powders for powder metallurgy applications. Among various synthesis techniques, iron powders from chemical reduction route holds an advantage of yielding sponge like iron powders with versatile down streaming attributes. In the present work, temperature (600-900 0C) and time (30-180 min) optimization for synthesis of iron powder from iron bearing by-product of steel industry through hydrogen reduction is explored. Powders obtained are characterized for chemical, physical and morphological attributes using wet chemical analysis, X-Ray Diffraction, PT-X powder tester, BET surface area and Scanning electron microscopy. A comparative study on variation in synthesis parameters and output powder characteristics through conventional hydrogen reduction and microwave hydrogen reduction is presented. Microwave route of synthesis attracts faster and effective powder synthesis. This work paves path to modern, green and efficient methods for pure iron powder synthesis from a steel industry by-product.

Innovative Aspect(s) :
Present work brings out an important and novel comparative study of convetional hydrogen reduction vs microwave hydrogen reduction. This work elucidates the property changes of product outputs from both the processes which stands unique. It also paves path to novel, green and efficient way to iron powder synthesis from a steel industry by-product.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235755976

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dipl-Ing Choma Tomasz (Warsaw University of Technology | AMAZEMET, Poland)

Co-author(s) :

Title : Novel Approach To Manufacture Powders With Tailored Chemical Composition For Additive Manufacturing

Keyword(s) :
3D Printing; Additive Manufacturing; Metallic Powders; Materials Development

Abstract :
The technology of ultrasonic atomization itself is quite old, but due to technological and material limitations available in the 1950s-80s, it has been almost completely supplanted by gas and plasma atomization technologies. Nevertheless, these commonly used methods, despite obtaining spherical powders of high purity and appropriate granulation, require the use of a large amount of material. In industrial settings, this is an advantage in high-volume production, but unit manufacturing processes dedicated to specific implementations, or prototyping currently carried out with 3D printing technologies, require much smaller amounts of powder, which is provided by ultrasonic atomizers. This technique also has another significant advantage and other methods of manufacturing alloy powders. A small amount of batch materials allows, under laboratory conditions, rapid validation of the chemical composition, phase structure and mechanical properties of newly designed alloys with specific, strictly dedicated performance properties.

Innovative Aspect(s) :
A state of the art device has been build based on ultrasonic atomization technology that allows to highly accelerate the development of new materials. It speed up the research and highly reduce the time of testing new alloys with tailored chemical composition that are not available commercialy.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235756925

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Prof Dr Hryha Eduard (CAM2|Chalmers University of Technology, Sweden)

Co-author(s) : Dr Riabov Dmitri (Höganäs AB, Sweden), Dr Raza Ahmad (CAM2|Chalmers University of Technology, Sweden)

Title : Powder For Metal Additive Manufacturing: Production, Reuse And Degradation And Its Effect On Material Properties

Keyword(s) :
Metal Additive Manufacturing; Powder for AM; Powder Manufacturing; Surface Chemistry of Powder; Powder Degradation; Powder Reuse

Abstract :
Metal powder is the feedstock for most of the metal additive manufacturing (AM) technologies, including powder bed fusion – laser beam (PBF-LB) and electron beam (PBF-EB), binder jetting (BJT) and powder blown directed energy deposition (DED). However, even if nearly the same alloys systems are used, requirements to the powder feedstock are rather different. Processing conditions during powder-based metal AM differ significantly, depending on technology, hardware solution and process parameters employed. This results in changes in powder properties during manufacturing cycle and especially during its reuse, also having significant impact on the final component properties. This work summarizes recent experimental observations and thermodynamic simulations of the changes in powder properties during the whole life-cycle of metal powder: from its manufacturing through powder handling and AM processing by variety of powder-based metal AM technologies. Generic model of the powder degradation in dependance on alloy composition and AM technology, is elaborated.

Innovative Aspect(s) :
Paper provide the most recent overview of powder for AM, its properties and degradation in dependance on alloy composition, powder properties and AM technology, powder reuse and its impact on material properties, as a result of the 5-year work in the CAM2 centre - Centre for Additive Manufactruing - Metal.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235761079

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dipl-Ing Aderhold Dirk (Atomising Systems Ltd, United Kingdom)

Co-author(s) : Dr Dunkley John, Mr Williamson Tom, Mr Mellor Adam, Mr Westnedge Joe (Atomising Systems Ltd, United Kingdom)

Title : The Reporting Of Research On Gas Atomisation

Keyword(s) :
Gas Atomisation; Performance; Operating Parameters; Powder Testing

Abstract :
The ever-increasing interest in additive manufacturing (both binder jetting and LPBF) has led to a renewed interest in gas atomising research across the globe. As this is being done by workers with different atomising equipment, the opportunity arises to test both theoretical and empirical correlations on a variety of designs. This paper reviews some relevant literature and sets out some basic equations and the relevant parameters that should ideally figure in all reports on gas atomisation tests. A methodology is proposed to standardise reporting of date, e.g. mass-median, standard deviation, graphical methods and operating parameters to allow some benchmarking by gas atomiser operators and allow improvements to be clearly identified. Remaining unanswered questions on gas atomisation will be discussed, which would surely benefit from more comprehensive publication, in particular the question of the importance of gas pressure in determining "efficiency" of atomisation, and how "efficiency" might be assessed and compared.

Innovative Aspect(s) :
While there are lots of data presented individually, each author tends to report operating and resulting powder parameters in different ways, frequently omitting important parameters. This means that, very often, the actual "performance" of the atomising nozzle used is not readily assessed or compared with other authors' work. This paper will set out the important parameters that should, ideally, be reported, and also outline how to assess the "efficiency" of the nozzle in terms of fineness, distribution width (and hence narrow-cut yields) and Gas-Metal Ratio (GMR) which massively affects costs of operation. Reference examples will be cited. The vexed question of the role of gas pressure, as distinct from GMR, would particularly benefit from better reporting, as each system is typically only operated in a relatively narrow pressure range, but different systems operate anywhere from 10 bars to 100bars pressure.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235761175

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Wilkens Yannik (SMS group GmbH, Germany)

Co-author(s) :

Title : Influence Of Particle Size Variations And Nanoparticle Coating On Flow Behavior Of 316l Stainless Steel Powder And Mechanical Properties In Powder-based Additive Manufacturing

Keyword(s) :

Abstract :

In powder-bed-based additive manufacturing (AM) processes, the flowability of the powder is decisive for the quality of the manufactured part. Since fine particle fractions worsen the flowability, in the laser powder bed fusion (LPBF) process the lower limit of the powder fraction is usually 15 µm. Nanoparticle coatings can reduce the attractive forces between particles. It has been investigated how these fumed silica (SiO2) nanoparticle dry-coating affect the initial flow behavior of standard gas-atomized (15-45 µm) 316l powder and powders with increased content of fines (0-45 µm). It was shown that flowability and bulk density increased as a result of the coating. Relative density and mechanical properties of the LPBF specimen showed similar results compared to the un-coated powder with significantly increased tensile strength. The economic potential of coated powder for AM was demonstrated by the successful LPBF processing of fractions 0-45 µm and 0-63 µm with increased utilization.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762594

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Davies Paul (Sandvik Additive Manufacturing, United Kingdom)

Co-author(s) :

Title : Sustainable Production Of Inert Gas Atomised Metal Powders For Metal Injection Moulding & Additive Manufacturing

Keyword(s) :
Sustainability; Powder Metallurgy; Metal Injection Moulding; Additive Manufacturing

Abstract :
The sustainability of inert gas atomised metal Powder Production is a key factor in supporting the important message that Powder Metallurgy is a green technology. Especially, when applied as a raw material to the advanced manufacturing technologies of Metal Injection Moulding (MIM) & Additive Manufacturing (AM), which can be compared with conventional manufacturing technologies. The principle process steps of inert gas atomised metal Powder Production are analysed, in terms of energy consumption and carbon foot print, while factoring efficiencies, to provide a sustainable low-impact production process. A Powder Production process that ideally utilises renewable energy sources and incorporates recycled raw materials, generates low levels of waste, with efficient use of resources & logistics modes that ultimately create efficient supply chains. The principle of science based targets are embraced and environmental claims, especially for recycled content, are validated against recognised standards. The life cycle of metal powders are reviewed, from

Innovative Aspect(s) :
Setting the example of a responcible corporation by measuring and recording energy & resource consumption to ultimately reduce the enviromental impact of production of material for the powder metallurgy industry.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762802

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Altenberend Jochen (Tekna, France)

Co-author(s) : Mrs Bailly Ophélie, Dr Dolbec Richard (Tekna, Canada), Dr Vert Romain, Mr Van Wijk Pierre (Tekna, France)

Title : Recycling Of Additive Manufacturing Powders By RF Plasma Treatment

Keyword(s) :
Recycling; Sustainability; RF Plasma; Spheroidization

Abstract :
In most additive manufacturing (AM) processes, a significant fraction of the non-consolidated powder can be reintroduced into the process . However, after several cycles, altered flowability and|or oxygen pick up make such powders unsuitable for their reuse so that they become waste material. Radio Frequency (RF) plasma treatment can increase the flowability of these powders and for some materials it can even reduce oxygen content. As a result, powders initially considered as waste can now be transformed into high quality powders. In this study, examples from the literature together with original results are presented to show how RF plasma treatment can make additive manufacturing even more sustainable.

Innovative Aspect(s) :
While currently large amounts of powder are discarded as waste material the recent results show that many of these powders can be recycled.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235779996

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Urionabarrenetxea Ernesto (CEIT, Spain)

Co-author(s) : Dr Ing Avello Alejo, Dr Ing Martín José Manuel (CEIT, Spain)

Title : Advances In The Numerical Modelling Of The Close-coupled Gas Atomisation Process: Optimal Coupling Between Primary And Secondary Atomisation Stages

Keyword(s) :
Close-Coupled Gas Atomisation; Gas Atomiser; Computational Fluid Dynamics (CFD); Particle Size Distribution (PSD)

Abstract :
Efficient simulation of close-coupled gas atomisation can nowadays be used to improve machine designs and to gain understanding on the complex phenomena taking place in the atomisation process. Two-stage multiphase models can predict particle size distributions by using an Eulerian approach for the primary atomisation and a Lagrangian particle tracking for the secondary atomisation. Previous numerical results confirm that these models correctly predict trends of median particle size for varying gas-to-melt mass flow rate ratios, although significant differences between predicted and measured particle size distribution spreads indicate that models need to be improved. In this work, different coupling hypotheses between the primary and secondary atomisation stages are addressed to optimize the model's capacity to predict the entire particle size distribution. By comparing experimental results with simulations obtained with varying surfaces of particle injections and corresponding boundary conditions, an improved model with better predictive capacity has been obtained.

Innovative Aspect(s) :
The simulation of metal powder gas atomisation is extremely challenging due to huge differences in geometric and temporal scales, supersonic gas velocities, high temperature gradients, high heat transfer speeds and solidification. Although accurate modeling of all these phenomena is beyond current calculation capabilities, efficient simplified methods can be used as an effective tool to gain insight and quantify the impact of operating conditions on the particle size distributions. The main innovation of this work is the optimal coupling between primary and secondary atomization stages varying the way of injecting the particles and the imposed boundary conditions. Comparisons between simulations and experimental atomisations prove that the method correctly predicts the particle size distributions of the metal powders.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762851

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Sanchez-Valverde Andoni (Outokumpu, Germany)

Co-author(s) :

Title : Outokumpu Meets Powder

Keyword(s) :
Powder Metallurgy; Recyclability; Sustainability; Novel Materials; Laser Powder Bed Fusion (PBF-LB)

Abstract :
Outokumpu, the first and biggest stainless-steel producer in Europe, started producing spherical metal powder in a Vacuum Induced Gas Atomization (VIGA) plant in Krefeld Germany at the beginning of 2023. Using flat scrap arising from its own processes as raw material the company can produce high-quality metal powders, focusing on recyclability and sustainability. The produced metal powders are high-quality, customizable, and sustainable raw materials for production in various Powder Metallurgy (PM) technologies. Level up your manufacturing capabilities while strengthening the circular economy with Outokumpu's metal powders.

Innovative Aspect(s) :
Present Outokumpu metal powder business concept with our vision and added values to the powder metallurgy industry with a special focus on sustainability.
Introduce examples of novel stainless steel powder materials barely used nowadays in the powder industry. To be presented in the conference, elevated temperature (253MA, 1.4835) or high corrosion (904L,1.4539) grades.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235763134

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Vanzetti Matteo (Politecnico di Torino, Italy)

Co-author(s) : Mr Pavel Michael, Dr Perez Andrade Lorena, Dr Weaver Mark, Prof Dr Brewer Luke (University of Alabama, USA), Dr Padovano Elisa, Dr Aversa Alberta, Prof Dr Bondioli Federica (Politecnico di Torino, Italy)

Title : Gas Atomized AlSi10Mg+Cu Powders For Metal Additive Manufacturing

Keyword(s) :
Powders; Additive Manufacturing; Aluminum Alloy; Copper; Rapid Solidification

Abstract :
Metallic powders are one of the most common feedstock material for metal additive manufacturing (MAM). Nowadays, only few alloys can be processed by these technologies and most of them are casting alloys. This work is focused on the characterization of a novel aluminum alloy produced by a close coupled gas atomizer (CCGA) with composition AlSi10Mg + x Cu (x= 4, 8, 20 wt%). These compositions are very attractive because copper is a well-known strengthener for aluminum alloys.The produced powders have been characterized in terms of morphology, flowability, particle size distribution (PSD) and density. Furthermore, the powders microstructures have been analyzed to evaluate the composition and the morphology of the phases generated by the rapid solidification that characterized the gas-atomization process.

Innovative Aspect(s) :
A new processable alloy for Metal Additive Manufacturing and in particular for Laser Powder Bed Fusion technology.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235763265

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Abid Aamir (Retech Systems LLC, USA)

Co-author(s) : Mr Stone Matthew, Mr Dusky Goeffery, Mr D'Alba Bryce (Retech Systems LLC, USA)

Title : Plasma Gas Atomization For Reactive And Refractory Metal Alloys

Keyword(s) :
Powder Production Equipment; Plasma Gas Atomization; Refractory and Reactive Alloys; Additive Manufacturing

Abstract :
A barrier to the broader adoption of refractory and reactive metal powders (like Titanium and its alloys) is the high cost of AM-suitable powders. Additionally, though companies are producing AM powders using a range of technologies, production rates are slow compared to steel and nickel Powder Production rates. There is also a limit to the available alloys as conventional processes require the production of high-cost bar or wire feedstock. To address the above-mentioned challenges, Retech has developed an atomization system that would provide a larger production capacity for a range of metal and alloy powders utilizing Plasma Arc Melting (PAM) in combination with gas atomization. Plasma melting allows for the introduction of a broad range of feed materials including revert without incurring the additional cost of processing feed to wire or bar forms. With this flexibility of feed materials, recycling high-value materials become an economically viable option.

Innovative Aspect(s) :
Novel Plasma Gas Atomization equipment for AM Powder Production
Ability to use low cost feedstock (scrap, revert, and other forms)*Ability to use broad range of feedstock forms (does not necessarily require wire or rod)
Capable to melt and atomize at very high rates (similar to rates for Ni and Steel hot-wall systems)

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235763600

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Samokhin Andrey (Institute of Metallurgy and Materials Science, Russia)

Co-author(s) : Dr Alexeev Nikolay, Mr Fadeev Andrey, Mr Sinaisky Mikhail, Mr Dorofeev Aleksey, Mr Zavertyaev Ilya (Institute of Metallurgy and Materials Science, Russia), Dr Gryaznov Mikhail (National Research Lobachevsky State University of Nizhny Novgorod, Russia)

Title : Processing Of Tungsten Powders In DC-arc Thermal Plasma System

Keyword(s) :
Tungsten; Nanopowder; Synthesis; Granulation; Micropowder; DC-Arc Thermal Plasma; Heat Treatment; Additive Technology; LPBF

Abstract :
The paper presents the results of R&D of plasma-chemical synthesis of tungsten nanopowders, as well as their granulation and subsequent plasma treatment of produced granules for spherical tungsten micropowders production for modern 3D printing technologies. Plasma-chemical synthesis of tungsten nanopowder is based on the reduction of tungsten oxide compounds powders in the flow of hydrogen-containing low-temperature thermal plasma generated in an electric arc plasma torch. Granulation of tungsten nanopowder was carried out by spray drying using an ultrasonic nozzle. Heat treatment of nanopowder granules was realized in a low-temperature thermal DC arc plasma in both sintering and melting modes. The influence of LPBF process parameters on the structure and properties of samples obtained at a 3D printer by using produced spherical tungsten micropowders was investigated. The results of the development of DC arc plasma systems for tungsten micropowders spheroidization are presented.

Innovative Aspect(s) :
The development of technology for the production of high-quality spherical tungsten micro-powders with a submicron grain size will provide the possibility of their use in modern highly efficient additive technologies for the manufacture of complex shape parts with high performance characteristics, primarily for experimental thermonuclear installations.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235764227

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Emadinia Omid (INEGI - Institute of Science and Innovation in Mechanical and Industrial Engineering, Portugal)

Co-author(s) : Mr Silva Pedro (INEGI - Institute of Science and Innovation in Mechanical and Industrial Engineering, Portugal), Prof Dr Reis Ana, Prof Dr Vieira Manuel, Mr Zafar Fahad (Faculty of Engineering University of Porto, Portugal)

Title : Upcycling Aluminium Chips To Powder Feedstocks For Powder Metallurgy Applications

Keyword(s) :
Aluminium; Ball Milling Parmeters; Powder Characteristics; Densification; Energy; Properties

Abstract :
The aluminium scrap, either from industry or end-of-life consumer products is recycled. This approach can still consume up to one-third of the energy needed to produce primary aluminium since it also requires the addition of the pure metal apart from other processing. Aluminium metal swarf, a waste from subtractive manufacturing processes can be upcycled to produce metal powders. Conventionally, aluminium powders are produced using atomization processes with considerable energy and inert gas consumption. Thus, it is worth evaluating approaches like mechanical milling to explore the potential of energy savings as well as reducing the carbon footprint. Identifying and controlling the key milling parameters is paramount to achieving desired characteristics in the milled powders. This study explores the feasibility of the production of AlSi10Mg alloy powder by mechanical milling of waste metal swarf for sintering and additive manufacturing purposes. Material characterization, mechanical testing results and energy calculations will be presented.

Innovative Aspect(s) :
In addition to the transformation of aluminium swarf to powder feedstocks, that is an adding value to these metal residues, this study aims at optimizing milling conditions to reduce the Powder Production time and to enhance the productivity. Densification analysis for sintered materials, and the feasibility of printing classified powders through selective laser melting or even direct energy deposition by laser will be evaluated. In the meantime, the energy consumption and cost will be assessed to provide a base for comparing conventional atomization with the milling approach. Although sintering or printing are influenced by particle shape, optimization of processing conditions is opted for achieving best results.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235764483

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Prof Fang Zhigang Zak (University of Utah, USA)

Co-author(s) : Prof Fang Zhigang Zak (University of Utah, USA)

Title : A Novel Sustainable Low-Cost Process For Making Spherical Ti Alloy Powders for Additive Manufacturing

Keyword(s) :
Titanium; Powder Production; Deoxygenation; Additive Manufacturing; Sustainability

Abstract :
In the most recent decade, with the advent of additive manufacturing (AM) technologies, the manufacturing of Ti components using a laser (LPBF) or electron beam (EBM) emerged as one of the most important areas of additive manufacturing of metals. The cost of high-quality Ti and Ti alloy powder has become a glaring technical challenge. Therefore, developing a truly low-cost process for making high-quality Ti alloy powders will profoundly impact the adoption of Ti by additive manufacturing and other manufacturing processes. This presentation describes a novel method, the granulation-sintering-deoxygenation (GSD) process, that can produce spherical Ti and Ti alloy powders at a fraction of the cost of equivalent powders. Ti and Ti alloy powders produced with the GSD process have low oxygen content. GSD process can be used to upcycle high-oxygen scrap Ti alloy powder or bulk Ti alloy scraps, making the process the most sustainable Ti Powder Production process to date.

Innovative Aspect(s) :
The process that will be presented in this paper differs from the state-of-the-art processes for making spherical Ti alloy powders. The SOA process is costly. Instead of using conventional atomizing techniques, the new process is a thermochemical process that enables the deoxygenation of Ti alloy powder with high oxygen content. The new process is novel, low-cost, and sustainable.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235764662

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Gobber Federico Simone (Polythecnic of Turin, Italy)

Co-author(s) : Ing Monti Chiara, Ing Turani Matteo (inspire AG, Switzerland), Prof Dr Bambach Markus (ETH Zurich, Switzerland), Prof Dr Actis Grande Marco (Polythecnic of Turin, Italy)

Title : Innovative Al-based Powders Through Ultrasonic Vibration And Gas Atomizing

Keyword(s) :
Gas-Atomization; Ultrasonic-Vibration Atomization; AlCuTiFeCr; Powder Characterization

Abstract :
The need for spherical powders with enhanced flowability and tailored compositions has brought on new atomization techniques particularly suited for the lab-scale and highly competitive R&D activities. Among metal atomization techniques suitable for lab-scale development, those assisted by ultrasonic vibration are experiencing a notable diffusion at the R&D level. Gas-atomization is, however, the primary technique for producing spherical powders when larger batches are needed for production or R&D purposes. The present study analyzes the characteristics of an innovative Al-Cu-Ti-Fe-Cr alloy obtained by the two Powder Production techniques. At first, the two atomization processes are compared in terms of yield in specific PSD ranges, a peculiarity of the AM technologies. Then, the main body of the study presents the characterization and comparison of the powders in terms of morphology, composition, rheology, density and microstructure in different size fractions.

Innovative Aspect(s) :
Few studies in literature deal with the production and related characterization of Al-based atomized powders despite their overall employment, particularly as AM regards. This paper's innovative aspects lie in the characterization of a new Al-alloy composition, starting from a thorough description of the two atomization routes studied with related process information. Furthermore, the crossed characterization of ultrasonic-vibration atomized and gas-atomized powders, apart from the interesting scientific aspects, allows for debating the scalability from small-scale R&D to larger production batches.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235764680

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Rahimi Ehsan (Materials Processing Institute, United Kingdom)

Co-author(s) : Mr Rahimi Ehsan, Mrs Fennell Catherine, Dr Birley Richard (Materials Processing Institute, United Kingdom)

Title : A New Measure To Predict Maximum Reusability Of Virgin Powder In Powder Bed AM

Keyword(s) :
Powder Characterisation; Morphology; Flowability; Laser Powder Bed Fusion; Powder Reusability

Abstract :
The reuse of metal powder is an essential step to make the powder bed fusion (PBF) process cost-effective; therefore, understanding the capability of virgin powder is of high importance. Not all the powder is used to make parts in a PBF process. A significant proportion of the un-used powder is collected during de-powdering of the final part. This proportion and a small proportion in the waste chamber can be sieved for reuse. In this research, powder samples were reused until their flowability was below the acceptable level for re-coating. Before every process, morphology, size and flowability were evaluated using the index that was developed in the previous research presented at WorldPM2022. The index was modified based on the alloy type and reusability aspects and it has been proposed to predict the maximum reusability of virgin powder on the condition that acceptable flowability, morphological distributions and mechanical properties are maintained.

Innovative Aspect(s) :
At the Materials Processing Institute, circular economy and sustainability are at the core of the research. The Institute aims to introduce versatile methodologies to measure the quality and processability of metal powder for recycling and reuse. In one of the recent Innovate UK grant-funded projects, PRISM, a new platform was created to evaluate and classify the powder based on its reusability. This platform improves the decision-making ability of the part and powder manufacturers. In the L-PBF process, the proportion of un-used (coated and waste) powder is significantly high. The un-used powder can be sieved for reuse; however, the quality reduces every time. To ensure the powder processability, flowability performance should be re-evaluated. Therefore, a measurement methodology that can predict and grade reusability of the virgin powder before the process is a step change in materials management. This work is a continuation of the previous research presented at WorldPM2022.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765086

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Ing Pennacchio Antonio (Polytechnic University of Turin, Italy)

Co-author(s) : Dr Ing Gobber Federico Simone, Prof Dr Actis Grande Marco (Polytechnic University of Turin, Italy)

Title : Effect Of Process Gas Composition On The Characteristics Of Atomized UNS S32760 Duplex Stainless Steels Powders

Keyword(s) :
Gas Atomization; UNS S32760 (AISI F55) Powders

Abstract :
Super duplex stainless steels combine the advantages of ferritic and austenitic steels and reach an excellent combination of mechanical and corrosion properties. High chromium, molybdenum, and intermediate nitrogen concentrations confer high pitting resistance. Optimal gas process parameters are necessary to obtain UNS S32760 powders with suitable chemical composition, especially in terms of nitrogen content, for subsequent process techniques (L-PBF, 3D printing, MIM,…) to get the best pitting resistance and a good balance in the a ferrite|austenite phase. One of the main goals of the research activity is to evaluate the variation in nitrogen concentration for powders produced by Vacuum Inert Gas Atomization under two different melt chamber atmospheres, Ar or N2. After sieving, the effect of different process gases on the characteristics of the final powder, in terms of granulometry, morphology, microstructure, chemical composition (considering light elements as N, O, H, C, and S) and rheology, was investigated.

Innovative Aspect(s) :
The paper follows and extends the work presented by the authors at the WORLDPM2022. The new aspects are related to using different combinations of gases in the melting and atomization zones, comparing the different powders' chemistries, physical and morphological properties.

Reviewer's name : ……

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ……

Notes to author : ……

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765094

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Trapp Johannes (Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Branch Lab Dresden, Germany)

Co-author(s) : Mr Walther Gunnar, Dr Ing Fries Manfred (Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Germany), Prof Dr Weißgärber Thomas (Fraunhofer IFAM & Technische Universität Dresden, Germany), Mr Hoffmann Mathias (Ostec GmbH, Germany), Mr Böhme Sven (PolyMIM GmbH, Germany)

Title : Iron Powders For Additive Manufacturing And Metal Injection Molding Produced By An Environmentally Friendly Route From Steel-production Sourced Ore Wastes

Keyword(s) :
Iron Powder; Additive Manuacturing; Metal Injection Moulding; Circular Economy

Abstract :
The demand for small, spherical powders increases, for examply due to the growing additive manufacturing market. For particles = 10 µm, mainly two production routes exist: atomization and the carbonyl process. The production of such powders is costly, so alternatives are needed.We present developments in a novel solid state processing route using iron ore from the steel steeping process that otherwise might end up as waste. The ore is first granulated by wet spraying. To scale up the production to hundreds of kilograms per day, the granules are reduced and sintered in a rotary kiln to form porous but stable agglomerates and post treated in a NARA hybridizer mill to form dense particles.Pure iron particles with < 0.2 m% oxygen, an apparent density of ˜ 3 g|cm³, and a purity of > 98 % are obtained at a competitive prize of < 3 €|kg. The suitability for MIM is verified with test geometries.

Innovative Aspect(s) :
The Powder Production process is not only supposed to produce cheaper powder within Europe, but also significantly reduces the CO2 emissions due to the hydrogen based proceesing route. Finally, the starting material is waste from steel-making and contributes to an approach of a circular economy.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765259

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Sanchez Angela (IRT M2P, France)

Co-author(s) : Dipl-Ing Deborde Agathe (IRT M2P, France), Dr Cornu Jérôme, Dr Vassa Alexandre, Dr Chebab Béchir, Dr Piaget Alexandre (C-TEC, France)

Title : Effect Of Atomization Process Parameters On Properties Of Aluminium Alloy Powder For Additive Manufacturing

Keyword(s) :
Gas Atomization; Aluminium Powder; Additive Manufacturing

Abstract :
Constellium Technology Center (C-TEC) has developed new high performance aluminium alloy powders specifically designed for laser powder bed additive manufacturing processes. Rapid solidification metallurgy is used to bring properties which would not be achievable with conventional alloys. The alloys require higher melting temperatures than conventional aluminium systems.The specific optimization of the atomizing process is carried out on the new VIGA atomizer installed by IRT M2P. Effects of different process parameters on yield and process continuity were investigated: melt superheat, delivery tube diameter, gas pressure and oxygen content in the atomizing gas. Powder characterizations were then performed (PSD, morphology, oxygen content, flowability, density…). Finally, the powders were tested by Laser Powder Bed Fusion (LPBF) and the performance of the printed parts were evaluated by metallography and mechanical testing.

Innovative Aspect(s) :
High performance aluminium alloy powders.
Effect of atomization parameters on yield and process continuity.
Link between atomization parameters, powder properties and LPBF parts performance.

Reviewer's name : ……

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : ……

Notes to author : ……

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EURO PM2023 CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765262

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Pijuan Jordi (Eurecat, Centre Tecnològic de Catalunya, Spain)

Co-author(s) : Miss Cegarra Sasha (Eurecat, Centre Tecnològic de Catalunya, Spain), Dr Riera Maria Dolores (Universitat Politècnica de Catalunya, Spain)

Title : Cooling Rate Evaluation Of Al-4%Cu Alloy Powders During Centrifugal Atomization

Keyword(s) :
Powder Production; Centrifugal Atomization; Cooling Rate

Abstract :
Centrifugal atomization technique to produce metal powder offers many advantages in terms of spherical morphology of the powders, high production yield and narrow particle size distribution. Centrifugal atomization is also considered a rapid solidification technique. The final microstructure of the atomized particles is closely linked with the thermal history and cooling rates experienced during the atomization process. In this work, Al-4% Cu alloy was atomized via centrifugal atomization under different atomization conditions. Gas composition and melt superheat temperature were investigated as processing parameters that influence in the cooling history of the atomized droplets. Colling rate was experimentally evaluated by means of Secondary Dendrite Arm Spacing (SDAS) technique using several methods found in the literature, and a numerical model was implemented to study the heat transfer between the droplets and the surrounding once the particles have been expelled from the disk, to identify the correlation between theoretical and experimental results.

Innovative Aspect(s) :
Although there is numerous research in evaluate cooling rate in other atomization methods such as gas atomization, and several theoretical models adjusted for this technology, there is few information about cooling rate evaluation in centrifugal atomization. This study is the first step of investigating the correlation between theoretical models, and experimental methods based on metallography analysis, to evaluate the cooling rate using this atomization technique.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765330

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Prof Colombini Elena (University of Modena and Reggio Emilia, Italy)

Co-author(s) : Prof Veronesi Paolo, Dr Lassinantti Gualtieria Magdalena (University of Modena and Reggio Emilia, Italy)

Title : Recycling Of Spent Powders From Laser Powder Bed Fusion Processing Of Inconel 625 For The Mechanical Synthesis Of CoCrFeNiMoxNb0.4x (x=0-0.1) Multi-Principal Element Alloys (MPEAs)

Keyword(s) :
Multi-Principal Element Alloys; Recycling; LPBF

Abstract :
Laser powder bed fusion processing (L-PBF) is an emerging additive manufacturing (AM) technique particularly suitable for the production of parts with complex shapes made of materials with low machinability, such as Ni-based superalloys. Although most of the excess powder following each building cycle can be recycled in successive ones, some solid scrap consisting of large particle aggregates are sieved out from the recycled powder stream and disposed of as hazardous waste. An interesting alternative is recycling for the synthesis of products with high added value such as Multi-Principal Element Alloys (MPEAs). This was explored here for the mechanical synthesis of equimolar CoCrFeNi fcc-structured MPEA strengthened by 4d transition metals (CoCrFeNiMoxNb0.4x with x=0-0.1) originating from spent powders of Inconel 625. Results from extensive microstructural characterizations and nanoindentation analyses of the powders highlight the feasibility of using spent powders for the mechanical synthesis of fcc MPEAs with enhanced solid solution strengthening.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765429

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

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

Co-author(s) : Dr Sánchez-Delgadob Sergio, Dr Serrano Daniel, Dr Tsipas Sophia (Universidad Carlos III de Madrid, Spain)

Title : Surface Modification Of An Aluminium Alloy Powder (Al2024) With SiC Nanoparticles For Application In Additive Manufacturing

Keyword(s) :
Additive Manufacturing; Surface Functionalization; Fluidied Bed

Abstract :
Additive manufacturing (AM) is booming at an industrial level due to the possibility of producing components of complex geometry, while reducing use of raw materials, cost and time. However, in many processes there is still a lack of understanding of the composition-processing-microstructure relationship and a limited range of raw material compositions, as well as reproducibility problems. In search of improving these problems, surface modification of an aluminium alloy powder (Al2024) for its use in AM is proposed. A fluidized bed reactor was designed and built for the surface functionalization with SiC nanoparticles. SiC nanoparticles were produced by milling and dispersed in colloidal suspensions. Homogeneity, stability and rheology of the suspensions was studied. A homogeneous deposition of the nanoparticles on the host particles in the fluidized bed was obtained. The properties of samples produced with the modified powders were evaluated in comparison with samples produced with unmodified powders.

Innovative Aspect(s) :
Design and optimization of a fluidized bed reactor for surface functionalization of Al powders for AM. This study demonstrated that surface modification processes of powders can be stable at the industrial level, thus increasing versatility in the commercial raw material currently available for AM. The modified powders where used in Composite Extrusion Modelling (CEM) and LBPF processes. The properties of AM samples produced with modified powders were compared with the properties of samples produced with unmodified powders

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235765563

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Cordova Laura (Chalmers University of Technology, Sweden)

Co-author(s) : Dr Ing Raza Ahmad, Prof Dr Hryha Eduard (Chalmers University of Technology, Sweden)

Title : Analysis Of Processability And Reusability Of Ti6Al4V Powders For PBF-EB

Keyword(s) :
Powder Reuse; Powder Quality; PBF-EB; Electron Beam Melting

Abstract :
Processability in Powder Bed Fusion Electron Beam (PBF-EB) depends on the interaction of the electron beam with the metal powder. For a good, consolidated part to be processed, the powder must be smoothly applied on the powder bed and the beam transmits the electrons throughout the powder layers. Only with powder of specific characteristics, this is possible (narrow PSD, smooth and spherical morphology, high chemical purity). In this study two different TI6Al4V powder batches are analyzed, one batch presented challenges with processability even in virgin state. For both powders, an assessment of the morphology, particle size, rheology, and chemistry will determine the feasibility to achieve optimal processability and the possibility to reuse in consecutive cycles.

Innovative Aspect(s) :
This work explores the potential to use different qualities of the Ti64 powder and feasibility to reuse it. Even when the quality is not optimal. It is important to maintain the cost-effectiveness and sustainability of the process.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235766354

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Ing Molavi Kakhki Amin (Rio Tinto Metal Powder, Canada)

Co-author(s) : Dr Sander Jan (Brose Group, Germany), Mr Fischer Maximilian (Brose Group, Germany), Mrs Labrecque Chantal (Rio Tinto Metal Powder, Canada),

Title : Industrial Additive Manufacturing Using Water Atomized Steel Powder For Low To Medium Series Production

Keyword(s) :
Low Carbon Steel Powder; Water Atomized; Laser Powder Bed Fusion; Serial Production; Heat Treatment

Abstract :
Industrial application of Additive Manufacturing (AM) is recently getting more attention, as the printing technologies are evolving towards a faster printing speed and eventually lower manufacturing cost. Choosing the right part and application and an optimum set of printing parameters along a wise selection of low-cost feed material will help to extend the real industrial use of AM. In this work, ATOMET 1025, a water atomized low carbon steel powder, produced by Rio Tinto Metal Powder was evaluated as the feed material for low to medium series production of industrial parts via a high-speed Laser Powder Bed Fusion (LPBF) method, developed by Brose Group. A series of different types of heat treatment was studied on the printed samples to achieve the target mechanical properties. The results confirmed that this combination of material, printing process and post processing can lead to the properties equivalent or better than the conventional counterparts.

Innovative Aspect(s) :
Innovative way of using water atomized powder to additively manufacture cost competitve parts for low to medium series production.
Heat treatment of low carbon steel parts to target special mechanical properties.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235768771

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Henrichs Julian (Linde GmbH & Technical University of Munich, Germany)

Co-author(s) : Mr Hilbert Jimmy, Dr Ing Giglmaier Marcus, Prof Dr Adams Nikolaus A. (Technical University of Munich; TUM School of Engineering and Design, Germany), Mr Rosenberg Ronald, Mr Forêt Pierre (Linde GmbH, Germany)

Title : Experimental Investigation And Visualization Of The Transonic Gas Flow In An Industrial Scale Test Bench For Metal Powder Atomization

Keyword(s) :
Additive Manufacturing; Gas Atomization; Metal Powder Production; Schlieren Imaging; Gas Dynamics; Primary Atomization; Secondary Atomization

Abstract :
One of the current major barriers to the industrialization of metal additive manufacturing (AM) is the cost-effective production of a high-quality metal powder, usually in the range of 1-63 µm, making investigations of the atomization process essential. Numerical investigations usually reach their limits due to the massive multiscale problem, whereas experimental investigations are either performed on a laboratory scale with limited transferability or on industrial equipment with limited accessibility for measurement techniques. To face this challenge a new atomization test bench is developed which was tailored for detailed experimental investigation on the fundamentals of atomization in an industrial scale set-up. All input parameters can be set individually and are measured continuously and precisely. At the same time, the good optical accessibility allows a temporally and spatially highly resolved visualization of the gas flow as well as a detailed investigation of the mechanisms of decomposition during primary and secondary atomization.

Innovative Aspect(s) :
Atomization test bench specifically developed for investigating gas dynamics as well as primary and secondary droplet breakup phenomena present during gas atomization in a 1:1 scale test setup (nozzle and gas flow) Setup is optimized for visualization of all ongoing phenomena, this includes a high speed schlieren and shadowgraph imaging solutions which can be used over the entire length of the test chamber All process parameters like pressure, temperature and composition are easily adjustable in a broad range. Roadmap: After the test bench's commissioning, investigation of the gas structures, followed by research on liquid break up using model fluids will be conducted. In the end, results will be validated on an industrial atomizer Using this test bench in addition to traditional methods allows acceleration of R&D The new set up allows fast, cheap and resource-saving R&D, while maintaining best possible comparability and transferability to industrial atomizers.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235766782

Requested presentation type : Oral Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Prof Bengtsson Sven (Höganäs AB, Sweden)

Co-author(s) : Mr Gherekhloo Human (Höganäs AB, Germany), Ms Larsson Anna (Höganäs AB, Sweden), ,

Title : Qualification Of A New Powder Production Process For Laser Powder Bed Fusion Application

Keyword(s) :
Vacuum Melting; Inert Gas Atomization

Abstract :
The introduction of additive manufacturing in the production of advanced parts for aerospace and similar high-end applications have increased the demands on the powder. For a LPBF process not only the chemistry, but also the physical properties of the powder are critical to performance. In this report the some of the consequences of replacing an older atomizing line by a more modern equipment are outlined. The new system is easier to operate which should translate into less downtime. It also has an integrated anti-satellite system that should provide less variation in physical properties of the powder. Physical and chemical properties of several powder lots were systematically measured and compared to the older equipment. Furthermore, a number of prints using the LPBF process were performed and the mechanical properties of the printed and heat treated parts were compared.

Innovative Aspect(s) :
The Powder Production equipment and sequence of process steps is outlined.
The resulting consequences for powder quaality and printed part are is described.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762509

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Han Chulwoong (KITECH, Korea, Republic of)

Co-author(s) : Miss Kim Song-Yi, Mr Park Sung Cheol (KITECH, Republic of Korea)

Title : Nickel Nano-particle Synthesis By RF Thermal Plasma Process

Keyword(s) :
Nickel Nano-Particle; RF Thermal Plasma; Vaporization; Condensation

Abstract :
Conductive metallic nano-particles are extensively used for electrical|thermal management of electronic components in the printable electronic industries. Nickel nano-particle is a representative conductive metal for base metal multi-layered ceramic capacitor fabrication. Ni nano-particle size has been reduced in accordance with the miniaturization trend. In this study, Ni metallic nano-particle was synthesized by feeding nickel hydroxide micro-powder into argon-hydrogen thermal plasma at different mass feeding rate. Phase, morphology, and size were investigated for as-synthesized particles. Through the results, it could be proven that nickel hydroxide feedstock particle underwent a vaporization, reduction, and condensation pathway. In addition, mean particle size was increased with feedstock mass feeding rate increasing. Higher mass feed-rate increased vapor pressure of Ni when most of feedstock powder was vaporized within the scope of this study. Accordingly, increased Ni vapor pressure raised critical condensation temperature and collision and coalescence probability between particles at relatively high temperature.

Innovative Aspect(s) :

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765726

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Costa Marques Anderson (Universidade Federal Do Rio Grande Do Norte-UFRN, Brazil)

Co-author(s) : Miss Samara Vieira Pâmala, Miss Queiroz e Silva Thalita, Prof Dr Mashhadikarimi Meysam (Universidade Federal Do Rio Grande Do Norte-UFRN, Brazil)

Title : Hardening Of Copper Powder With Tungsten Carbide By High Energy Grinding

Keyword(s) :
High energy milling; Cu-WC composites; Copper powder hardening; Powder microhardness.

Abstract :
The composites produced with a copper matrix and reinforced with a ceramic material and refractory are of great importance, due to its various applications in electrical conductors and heat sinks. In this sense, the work aimed to investigate the hardening of copper powder with the addition of tungsten carbide (WC) through high energy milling in order to evaluate the influence of WC percentage and grinding time on copper powder properties. The milling of the powders was performed for 1, 2, 5, 10 and 20 hours. The results obtained showed that the milling method used in this work proved to be efficient for obtaining Cu-WC. Besides that, it was found that the milling time was an important factor to obtain a greater dispersion and homogenization of the powder particles. Finally, it is noted that the Vickers microhardness value is directly related to the amount of WC and with the grinding.

Innovative Aspect(s) :
The innovative aspect of this work is to obtain composite powders of Cu-WC, with concentrations of 5, 10, 15 and 20% (% by mass) of tungsten carbide, via high energy milling, using milling times of 1, 2, 5, 10 and 20 h, in order to verify the effect of composition (%WC) and processing (milling time) variables on morphology and crystalline structure. Moreover, another innovative characteristic of the research is the performance of Vickers Microhardness on the Cu-WC powders, aiming to analyze the effect of WC content and milling time on the hardness of the material. And with this, to obtain composites with good mechanical, electrical and thermal properties, to be applied in electrical conductors and heat sinks.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023 CONGRESS & EXHIBITION

01-04 October 2023

Paper Number : EP235765286

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dipl-Ing Planta Xavier (Eurecat,Centre Tecnològic de Catalunya, Spain)

Co-author(s) : Dipl-Ing Alberto Ruiz, Dipl-Ing Hernandez Ricardo, Dr Vilaseca Montserrat (Eurecat, Centre Tecnologic de Catalunya, Spain)

Title : Microwave-induced Plasma To Recondition Scrap Particles For Additive Manufacturing

Keyword(s) :
Plasma; Powder Conditioning; WC; Scrap

Abstract :
Metal scrap from additive manufacturing (AM) can be reused as bars for further melting and casting. Metal powder for AM and PM is usually gas-atomized from cast bars with a high energy consumption, long production times and can generate waste, as some particles cannot be used for AM or PM.The Microwave Induced Plasma (MIP) technology allows producing spherical particles from scrap or irregular shape particles. MIP can be done on-site, saving energy by 30% and reducing costs by more than 75%. MIP is oriented to the reconditioning of scrap (chips, fibres, particles) adapted to the processes and reconditioned, in the form of spherical particles, increasing its final utility and added value, being a clear demonstration of the circular economy concept. This work shows the application of MIP to some metallic (Al alloys, copper alloys, 20MnCr5 steel) and ceramic (WC) particles reconditioning to be use as a feedstock for AM

Innovative Aspect(s) :
There are several systems to produce|recover metallic powders, such as water atomization, gas atomization, centrifugal atomization, ultrasonic atomization and inductively coupled plasma atomization. Due to their cost efficiency and easy availability, water and gas atomization are popular and commercially used processes.MIP is an attractive alternative to these systems because consumes less energy and produces particles with better quality. Some of its differential characteristics are: Easy flame ignition. Laminar and supersonic flow is not necessary nor is it necessary a strong magnetic field Efficient and sustainable process. MIP consumes 5-7 KWh|kg and Inductive Coupled Plasma 17-22 KWh|kg, which is between 29-35%, means less consumption. MIP can use different types of gases at atmospheric pressure to produce plasma suitable for whatever it need Microwave-induced plasma does not use electrodes and thus there is no waste associated.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason : .....

Notes to author : .....

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EURO PM2023 CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235764653

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Lee Yongkwan (Korea Institute of Industrial Technology, Korea, Republic of)

Co-author(s) : Mr Sim Jaejin, Mr Heo Sunggue, Dr Oh Soong ju, Ms Lee Mi hye, Dr Shin Jae Hong, Dr Seo Seok jun, Dr Park Kyoung Tae (Korea Institute of Industrial Technology, Republic of Korea)

Title : Effect Of Reducing Agent And Carbon Content On Particle Properties Of Tungsten Carbide Powder Manufactured Through The SHS Process

Keyword(s) :
Tungsten Carbide; Self-Propagating High-Temperature Synthesis; Tungsten Oxide; Particle Size; Carbon

Abstract :
Tungsten carbide (WC) is the main raw material of cemented carbide (WC-Co) and is mainly used for cutting tools, wear-resistant tools, and impact-resistant tools because of its excellent high-temperature hardness and high strength. The properties of cemented carbide are greatly affected by the particle size of the tungsten carbide powder, and the development of particle size control technology of the tungsten carbide powder is being actively developed to improve the performance of the tool material. This study evaluated the characteristics according to the amount of reducing agent and carbon input to control the particle size of tungsten carbide powder. The phase composition and morphology evolution of synthesized powders has been examined by X-ray diffraction, scanning electron microscope, and particle size analyzer. As a result, WC powder with a particle size of about 0.9 nm was manufactured under optimized experimental conditions through the control of the reducing agent and carbon content.

Innovative Aspect(s) :

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023 CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235765398

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Dr Gomes Uílame (Universidade Federal Do Rio Grande Do Norte, Brazil)

Co-author(s) : Miss Galvão Kívia Fabiana, Mr Lourenço Cleber, Dr Raimundo Rafael, Mr Souza Vitor Manoel (Universidade Federal Do Rio Grande Do Norte, Brazil), Dr Lima Maria José (UFRN, Brazil)

Title : Study Of The Influence Of Milling Time On The Synthesis Temperature Of Monoclinic And Orthorhombic Nanostructured CuNb2O6 Via High-energy Milling

Keyword(s) :
CuNb2O6; Synthesis; High Energy Milling

Abstract :
Copper niobate (CuNb2O6) has been studied for technological and environmental applications, such as in solar cells and photocatalysts, for example. And to make the application of CuNb2O6 even more feasible, in this study, therefore, high-energy milling was applied in its synthesis process with variation in the milling time, from the precursor powders Nb2O5 and CuO. The calcination occurred in a muffle with temperatures in the range of 500 °C to 1000 °C, for 3 h and heating rate of 5 °|min. Then, the powders were characterized by XRD, SEM, EDS and Raman. The powders showed crystallite sizes smaller than 80 nm, good homogeneity and high purity. The particle morphologies and the raman spectrum are coherent with the literature. It was also verified that the increase in milling time reduced the initial formation temperature of the monoclinic phase and the calcination time for the complete formation of the orthorhombic phase.

Innovative Aspect(s) :
The innovation of this work consists in the study of a little explored material, both in terms of its application and its acquisition. However, CuNb2O6 has a high potential and importance for science due to the following factors: The great abundance of its precursors (Niobium and Copper), the range of properties due to its polymorphism, highlighting the good conduction and catalytic activity present in both phases that allows it to be used in important applications such as CO2 photoreduction, photocatalysts, sensors, catalysts, lithium ion batteries, capacitors and solar cells, for example. Thus, studies on obtaining and characterizing its particles are essential to define and structure the processing steps, since the properties can be altered by the way of synthesis and by the phase obtained. In addition, there is always a constant search for the ideal synthesis parameters, which benefit the product, costs and methodology.

Reviewer's name : .....

Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762517

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Han Chulwoong (KITECH, Korea, Republic of)

Co-author(s) : Miss Kim Song-Yi (KITECH, Republic of Korea)

Title : A Combined Process For Fine And Spherical Cu-Zr Alloy Particle Preparation

Keyword(s) :
Cu-Zr Alloy; RF Thermal Plasma; Spheroidization; Vaporization

Abstract :
Powder metallurgy has been a fundamental manufacturing technology and the performances of PM components depend on the feedstock particle properties. Fine and spherical metallic particles are required to meet the industrial needs such as down-sizing and good sinterability. A combined process for fine and spherical particle preparation was designed and suggested in this study. The process consisted of particle comminution and thermal plasma spherodization. Cu-Zr alloy was cast and then mechanically pulverized. After that, the broken particles were spheroidized by RF thermal plasma process. Feasibility of the process was evaluated in view of size, morphology, and chemical composition. The combined process showed high selectivity on both size and morphology. However, there was a critical limitation in the reliability of chemical composition. Vaporization of copper in the in-flight particle resulted in the deviation of chemical composition from starting feedstock particle. With the feedstock particle size decreasing, vaporization was much more

Innovative Aspect(s) :

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EURO PM2023
CONGRESS & EXHIBITION
01-04 October 2023

Paper Number : EP235762518

Requested presentation type : Poster Presentation

Topic : Powder Production **Subtopic :** Powder Production

Author : Mr Han Chulwoong (KITECH, Republic of Korea)

Co-author(s) : Miss Kim Song-Yi (KITECH, Republic of Korea)

Title : Nanoparticle Dispersed Micro-granule As A Bridge Material For Penetration Of Nanoparticle To Powder Metallurgy

Keyword(s) :
Mixture of Nanoparticle and Micro-Powder; Homogeneous Mixture; Heterogeneous Mixture; Compaction; Sintering

Abstract :
Nanoparticles dispersed micro-granules in which nanoparticles are dispersed on the surface of micro-powder are designed as a bridge powder to manipulate processing abilities of powder in the powder metallurgy technology. In the suggested nanoparticle dispersed micro-granule, spiky micro-powder was chosen as supporting constituent and RF thermal plasma synthesized nanoparticles were used as compaction and sintering activating agents. Size difference makes nanoparticles fill the pockets on the spiky micro-powder surface and micro-powder is spheroidized by nanoparticle attachment through facile 3-D turbulent mixing. Compaction behaviors of micro-granule are compared to nanoparticle and micro-powder according to weight fraction of nanoparticle in micro-granule. Besides, it is proven that nanoparticles which are located at the particle interfaces enhance sintering by the presence of double-step shrinkage in the dilatometry. Micro-granule belongs to blended elemental powder in the conventional powder metallurgy and it can be divided into homogeneous micro-granule and heterogeneous one according to chemical composition.

Innovative Aspect(s) :

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Keynote ☐ Oral ☐ 1☐ 2☐ 3☐ 4☐

Poster ☐ Poster & Reserve Oral ☐

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