WORLD PM2022 CONGRESS & EXHIBITION

ABSTRACTS – GROUP 8

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ABSTRACTS – GROUP 8

COMPACTION AND SINTERING

WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367791

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Mr Wehrli Alex (Osterwalder AG, Switzerland)

Co-author(s):

Title: Energy Efficiency Of Press Drives - A Closer Look

Keyword(s):
Energy efficiency, Powder compacting, Press drives, Sustainability, Electric drive, Hydraulic drive

Abstract:
Energy cost and overall equipment efficiency have triggered the development of large electric powder compacting presses. Additionally, several OEMs have announced the implementation of stronger regulations in their supply chain with the aim to reduce the grey energy. With the increased complexity and precision of PM parts, hydraulic CNC presses have replaced the mechanical presses. By implementing high|low-pressure systems, fast movement actuators and intelligent pump technology, the energy efficiency was increased, but there remains a very high energy demand compared to the actual net energy required for compacting a part. In this study the energy consumption of hydraulic and electric drive systems for the upper ram and the die of a compacting press is calculated and compared with the actual net energy demand of a compaction part. It will be shown why and by what amount the electric drive outperforms the hydraulic drive when it comes to energy efficiency.

Innovative Aspect(s):
Hydraulic drive systems of smaller powder compacting presses have been widely replaced by electric drive system. But most large presses (>2000kN) are still equipped with hydraulic drives for the main drives (upper ram and die). In this paper, electric and hydraulic drive systems are compared on a theoretical, physical basis, analyzing the powder compacting and ejecting process. The surprisingly low energy efficiency of hydraulic systems will be explained using sample parts. And it will be explained why the PM industry needs to reach out to more sustainable technologies.

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: WP225368345

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Ms Shimamoto Hanako (JFE Steel Corporation, Japan)

Co-author(s): Dr Unami Shigeru (JFE Steel Corporation, Japan) ; Dr Mizukami Masashi ; Prof Kurihara Kazue (Tohoku University, Japan)

Title: Evaluation Of Frictional Properties And Molecular Orientations Of Thin Film Surface Of Solid Lubricants For Powder Metallurgy

Keyword(s):
Lubricant, Zinc stearate, EBS, Friction, Resonance shear measurement, Surface analysis, XRD, Sum-frequency generation spectroscopy

Abstract:
Iron-based powder mixtures for the powder metallurgy (PM) process commonly contain solid lubricants. Both zinc stearate (ZnSt) and N,N'-ethylenebis(stearamide) (EBS), which are conventional lubricants in this field, exhibit the similarly adequate lubrication performances. However, their effects on the powder mixture flowability are different; that is, EBS more reduces the flowabilities than ZnSt. In this study, the frictional properties of the two lubricants thin films were investigated using resonance shear measurement. The frictional forces for the iron-EBS and EBS-EBS combinations were larger than those for iron-ZnSt and ZnSt-ZnSt under low applied loads (< ca. 1.0 mN). This result suggests that the frictional properties of lubricants under low applied loads determine the powder mixture flowability. In addition, XRD and sum-frequency generation spectroscopic analysis of the surfaces of those lubricant films showed that there were differences in the molecular orientation of the surfaces.

Innovative Aspect(s):
The most innovative aspect of this work is that frictional properties of the two lubricants were investigated in states of thin films by resonance shear measurement. If these properties were compared in states of powders, they would be affected by not only the chemical compositions but also the sizes and shapes of the powder particles. On the other hand, the samples of this study are thin films which are the almost same in surface roughness and thickness, so that the discussion about the difference of the properties between lubricants derived from only their chemical compositions is made possible.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225368618

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Dr Zago Marco (University of Trento, Italy)

Co-author(s): Ing Rambelli Alex ; Dipl-Ing Foschi Davide (Sacmi Imola s.c., Italy) ; Prof Dr Cristofolini Ilaria (University of Trento, Italy)

Title: Filling density and green density of different ring-shaped parts as affected by filling strategy

Keyword(s):
Powder compaction, Filling strategy, Filling density, Green density

Abstract:
The influence of compaction strategy on compressibility and densification of metal powders has been extensively studied in previous work; effective compaction mechanics relationships and a densification model have been derived on experimental basis. Nevertheless, such studies also highlighted the need for further investigation concerning filling step, playing major role in obtaining high density, homogeneously distributed. This work focuses on filling step, considering the influence of both geometry, and filling strategy. Ring shaped parts with different height to thickness ratios (H|T) have been produced, also varying filling parameters as filling shoe speed, suction speed, and number of shakes of the filling shoe. Filling density was derived, as a function of above parameters, also highlighting the most critical parameters affecting filling density. Moreover, green density was measured in different points, referring to filling shoe movement, aiming at identifying the effect of filling strategy on flatness and parallelism of planes resulting from compaction.

Innovative Aspect(s):
Some literature studies have investigated how filling density is affected by filling parameters at laboratory scale. However, a systematic study which employed an industrial press is currently missing on literature. A clear knowledge of the parameters which influence the filling density is crucial for optimizing the compaction routine and for obtaining high geometrical precision of real product. For these reasons, this work aims at identifying the most critical filling parameters and correlating them with the geometrical form error of green products.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225369746

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Dr Molla Tesfaye (The University of Melbourne, Australia)

Co-author(s):

Title: Computational Alloy Design For Process-related Uncertainties In Powder Metallurgy

Keyword(s):
Integrated Computational Materials Engineering (ICME), Alloy design, High speed steels (HSSs), Supersolidus liquid phase sintering (SLPS)

Abstract:
An integrated computational materials engineering approach to design alloys for supersolidus liquid phase sintering has been developed. The method aims to minimize the sensitivity of the alloys to variabilities in material (e.g., composition) as well as process parameters (e.g., temperature) during their sintering cycle while also maximizing mechanical properties. This is achieved by developing a fast acting and high throughput design models that can quantify the processability (which is defined as the sensitivity of the alloy to process and composition variables) and the resulting mechanical properties of the alloys. A highly processable alloy is one that is tolerant to both composition and process conditions such that changes in either do not materially affect the alloy properties. The models are validated using measurement data from literatures. Design exercises are also performed that resulted in unique high speed steel alloys with enhanced processability for powder metallurgy routes.

Innovative Aspect(s):
Computational design of PM alloys for supersolidus liquid phase sintering high throughput design models that can describe teh sensitivity of alloys for materials and process variabilities.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225369905

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Prof Bao Chongxi (NBTM New Materials Group Co., Ltd, China)

Co-author(s): Mr Zhang Chen (NBTM New Materials Group Co., Ltd., China) ; Prof Fang Dong (Kunming University of Science and Technology, China)

Title: Effect Of Brazing Material Pretreatment And Sintering Atmosphere On PM Sinter-brazing

Keyword(s):
Brazing , Brazing material, Pretreatment, Sintering atmosphere

Abstract:
Sinter-brazing process is a common joining process for powder metallurgy components and is ofen used in production of planetary gear carrier、reducer hub which need connection. The result of sinter-brazing are affected by condition of brazing material and sintering atmosphere. The effect of condition of brazing material and sintering atmosphere on sinter-brazing were discussed, the wetting angle and penetration depth were characterized by stereoscopic microscope .The results showed that brazing material pre-sintered at 800℃ and sintering in a endothermic atmosphere can achieve a well welding state.

Innovative Aspect(s):
We study the wettability of brazing material with iron-based material by pre-sintered and sintering atmosphere. Then we get condition of brazing material which we can achieve a high qualification rate.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371412

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Mr Nogueira Gilmar (Université Grenoble Alpes, France)

Co-author(s): Prof Martin Christophe (Univ. Grenoble Alpes, France)

Title: Using Discrete Simulations Of Compaction And Sintering To Predict Final Part Geometry

Keyword(s):
Powder Compaction, Sintering, Discrete Element Method

Abstract:
A DEM (Discrete Element Method) model is used to simulate compaction and sintering. A double-action die has been implemented for the compaction stage. The process kinematics are decomposed into loading, unloading, and ejection of the pellet. Interactions between the particles and the die are considered elastoplastic by implementing a large-density model. A qualitative approach is used in the sintering stage. The results are in good agreement with experimental data and FEM simulations from the literature, regarding density gradient, elastic spring-back, and final geometry. The simulations show that the friction coefficient is the primary factor for the density gradient in the pellet. This density gradient induces a non-homogeneous sintering, which results in a final geometry with a so-called diabolo effect. This is the first time that it has been reproduced by DEM with the advantage of more closely reproducing the particulate microstructure of the powder.

Innovative Aspect(s):
FEM has been able to propose simulations for the PM community that model both compaction and sintering. In particular, the effect of friction between the die and powder on the density gradient and the final part distortion has been treated by FEM. However, FEM necessitates the use of complex constitutive equations that are difficult to identify. On the other hand, DEM (Discrete Element Method) allows to simulate those processes with a simpler approach, but at the cost of large CPU times. Here, we propose a DEM approach that is both fast in terms of CPU consumption and effective in terms of its predictive capability.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372077

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

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

Co-author(s): Prof Hryha Eduard ; Prof Dr Nyborg Lars (Chalmers University of Technology, Sweden) ; Mr Gårdstam Johannes (Quintus Technologies AB, Sweden) ; Dr Vattur Sundaram Maheswaran ; Dr Andersson Michael (Höganäs AB, Sweden)

Title: Effect Of Process Control On The Densification Of Cr-prealloyed PM Steels Through Vacuum Sintering In Conjunction With Capsule-free Hot Isostatic Pressing

Keyword(s):
Low vacuum, High temperature sintering, PM steels, Full densification, Capsule-free hot isostatic pressing

Abstract:
In this study, compacts of Cr-prealloyed steel with admixed nickel and graphite, produced through cold isostatic pressing (CIP), were sintered in low vacuum at 1150 °C and at 1250 °C in a HIP furnace, followed by the capsule-free hot isostatic pressing (HIP) at 1150 °C in the same HIP furnace in argon. Microstructures of these compacts sintered at 1250 °C revealed the complete closure of surface pores, after which densification to near full density (99.8%) has been achieved by the final HIP stage. Hardness measurements and chemical analysis were also employed. Carbon as a reducing agent played a crucial part to reach very low oxygen content of 0.02% after sintering and HIP. This study finds the possibilities of achieving full density in high performance powder metallurgy (PM) steels through novel approach of CIP and in-situ vacuum sintering in combination with capsule-free HIP using a two-stage final densification process.

Innovative Aspect(s):
This work deals with the enhancement of density of Cr-prealloyed steel. Some of the innovative aspects are: Sintering in HIP furnace and continue to HIP in the same furnace, which reduces one processing step. Applying capsule-free hot isostatic pressing methodology, an economical route thats provides promising final product properties.

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225372160

Requested paper type: Oral Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Ing Baselli Silvia (University of Trento, Italy)

Co-author(s): Prof Molinari Alberto (University of Trento, Italy)

Title: Cold Compacted Green Parts: A Focus On The Role Of The Structural Activity On Sintering Shrinkage

Keyword(s):
Sintering shrinkage, Driving force, Structural, Geometrical activity

Abstract:
The thermodynamic driving force of sintering is the decrease of the Gibbs free energy related to the excess of specific surface area of the powder. Nevertheless, for cold compacted green parts, the mass transport mechanisms which allow atoms to move to form the neck are promoted by the deformation in compaction that acts as a mechanical driving force expressed through the geometrical and structural activity. The powder particles are in contact over a surface, condition that affects the geometrical relationships in the neck region. The material is strain hardened, the concentration of structural defects is higher than that in the starting powder (enhanced diffusivity). The effect on sintering shrinkage of the geometrical activity has been explained in previous works and a theoretical model is available. To highlight how structural activity acts, a dilatometry study has been carried out on ferrous materials (plain iron and AISI 316L) and different powder morphology.

Innovative Aspect(s):
The present work proposes an interpretation of the role of the structural activity in the sintering shrinkage of cold compacted green parts. To this purpose a dilatometry study has been carried out on ferritic and austenitic ferrous materials.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371363

Requested paper type: Poster Presentation

Topic: Consolidation technologies / **Subtopic:** Compaction and Sintering

Author: Dr Olmos Luis (Universidad Michoacana de San Nicolás de Hidalgo, Mexico)

Co-author(s): Dr Bouvard Didier (Université Grenoble Alpes, France) ; Dr Alvarado-Hernández Francisco ; Dr Mihalcea Elena (Universidad Autónoma de Zacatecas, Mexico) ; Dr Jimenez Omar (Universidad de Guadalajara, Mexico)

Title: Development Of A Two-material Ti64|Ta Part By Pressing And Sintering For Biomedical Applications

Keyword(s):
Sintering, Porous core, Ti6Al4V, Tantalum, Mechanical properties, Biomedical materials

Abstract:
This investigation aims at fabricating a novel two-layer material composed of a porous tantalum (Ta) core and a dense Ti-6Al-4V titanium alloy (Ti64) outer ring by press and sintering. Sintering behavior of samples was studied by using dilatometry, at temperatures between 1400-1500°C. SEM analysis was used to observe the microstructure, focusing on the interphase bonding between Ti64 and Ta layers. These layers were clearly distinguished and the strong bonding between them was considered to be developed by solid state diffusion of Ta into Ti64 alloy. The mechanical properties of the component are mainly dominated by the presence of the porous layer. The wide pore size distribution of this layer is supposed to enhance the cell and bone growth. Moreover, the weight density of such component is considerably lower than the one of dense Ta. It was concluded that the Ti64|Ta hybrid biomedical material developed could improve the osseointegration of implants.

Innovative Aspect(s):
Co-sintering of Tantalum and Ti6Al4V Porous core composed of Ta improves the bone growth Light materials for bone implants compared to the conventional ones used Mechanical properties in the range of that human bones.

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WORLD PM2022 CONGRESS & EXHIBITION

ABSTRACTS – GROUP 8

FIELD ASSISTED SINTERING TECHNOLOGIES

WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225364568

Requested paper type: Oral Presentation

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

Author: Dipl-Ing Tekin Tugçe (EGE UNIVERSTY, Turkey)

Co-author(s): Dipl-Ing Aydin Söhret Melda ; Dipl-Ing YahŞİ Yasemin ; Mr FerİK Semih R. ; Prof Dr İPek Rasim (EGE UNIVERSTY, Turkey)

Title: Mechanical And Micro-structural Properties Of Mechanically Alloyed Mgal Sintered Cith Electric Field Technique

Keyword(s):
Powder Metallurgy, Metal Matrix Composites, Magnesium|Aluminium, Mechanical Alloying, FAST Technique

Abstract:
In this study, Mg22Al, which consists of %22 Al, mechanically alloyed for 18 h (Mg22Al18) were sintered with AC- electric field technique (FAST) at between 100-300 ∘C temperatures for 15 min. under 30 MPa. The microstructure of the samples is analysed using an optical microscope, SEM, EDS and XRD. In addition, mechanical properties such as microhardness, density and compression strength are carried out. The sample of Mg22Al18 at 300 ∘C reached nearly full density (≈ 0.99 ρt) that which has 510,4 MPa compression strength and 167,90 HV hardness value as the highest value among the samples. These results can be attributed to the existence of Al which play a role as bonding materials between particles.

Innovative Aspect(s):
Maintaining mechanically alloying micro-structural benefits because of the rapid and low-temperature sintering facility of FAST. The existence of Al in Mg matrix play a role as a bonding material that improves the interface of the particles.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367167

Requested paper type: Oral Presentation

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

Author: Mr Berment-Parr Iain (The Manufacturing Technology Centre, United Kingdom)

Co-author(s):

Title: Dissolvable Inserts Enabling Complex And Porous Structures To Be Net Shape Manufactured At Low Cost; Showcased Via FAST Of Hydrogen Electrolyser Plates From Sustainable Titanium Powder

Keyword(s):
Net shape, HIP, FAST, SPS, Dissolvable Insert, Salt, NaCl, Porous Structure, Hydrogen, Electrolyser, Electrolyzer, Fuel Cell, Bipolar plate, Porous Transport Layer, Gas Diffusion Layer, Titanium, Powder, Sponge, HDH, Hydride-de-hydride, Recycled, Low cost

Abstract:
Net shape manufacturing is commonly perceived as a slow and costly method to make intricate components in small batches for high value applications. This work seeks to challenge that perception by introducing the use of dissolvable inserts. These provide a simple and low cost method to manufacture large numbers of highly complex parts from powder. The MTC has evaluated the use of table salt (NaCl) in various forms as an insert for controlling the consolidation of titanium powder via both HIP and FAST. It has been shown that NaCl is very capable at forming both intricate geometries and holding a porous structure within the resulting titanium component, which can easily be extracted by dissolving the NaCl in water. In addition, the work explored the use of more sustainable and lower cost titanium powder within a circular economy. A hydrogen electrolyser component has been fabricated to showcase a potential future application.

Innovative Aspect(s):
The MTC believes this is the first demonstration of dissolvable inserts within net shape powder metallurgy, allowing the manufacture of intricate structures with integrated porosity. This opens up a huge range of possibilities for making large and complex components at lower cost and with better microstructural properties than achievable through additive manufacture or casting. It is envisaged that high throughput and rapid prototype manufacturing will be possible as multiple small parts could be processed in one HIP|FAST cycle by stacking within a simple cylindrical canister|die. This technique has been applied to the highly topical application of hydrogen generation. Innovative titanium bipolar plates for PEM electrolysis were constructed with both fully consolidated and porous sections. Sustainable titanium powder sources have been evaluated, such as raw sponge and recycled HDH, which takes into account the circular economy and mitigates a huge portion of the embodied carbon emissions within traditional titanium supply chains.

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367285

Requested paper type: Oral Presentation

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

Author: Mr Egreteau Baptiste (ONERA, France)

Co-author(s): Dr Davoine Cécile ; Dr Vermeersch Olivier ; Dr Thomas Marc ; Dr Méry Fabien (ONERA, France)

Title: Manufacturing Of A Porous Metallic Panel By Spark Plasma Sintering For Hybrid Laminar Flow Control Application

Keyword(s):
Spark Plasma Sintering, Ti64

Abstract:
Hybrid laminar flow control uses wall suction through a porous panel to delay the so-called laminar-turbulent transition, thus reducing the aircraft fuel consumption. This technology requires a structural panel with very good transverse permeability and an excellent surface finish. Currently, laser micro-perforated titanium panels are used, but the minimum diameter of the holes is limited, hindering a better suction distribution. Moreover, these titanium panels are difficult and expensive to produce. This is the reason why spark plasma sintering is used here to produce a porous material through partial densification of Ti64 powder. The as-received samples have been characterised through tomography, permeability and acoustical tests to correlate the material's structure with its acoustic response. In order to enhance the transverse permeability, attempts have also been made by using space-holders. The resulting internal morphologies of these samples and the titanium panels are compared in terms of suction efficiency.

Innovative Aspect(s):
As spark plasma sintering is an electric field assisted fabrication process, it is supposed that the out coming material should present an anisotropic porosity network. Such a characteristic would be interesting for the hybrid laminar flow control application. This is the reason why the geometry of the porosity network will be characterised through the analysis of tomography scans. This characterisation should allow the control of the porous network geometry through the choice of process parameters.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225367764

Requested paper type: Oral Presentation

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

Author: Dr Fais Alessandro (EPoS Technologies SA, Switzerland)

Co-author(s):

Title: Advancements And Possibilities In Electro-Sinter-Forging

Keyword(s):
Electro-Sinter-Forging, eForging, Field Assisted Sintering Techniques, FAST, Full density, Metals, MMCs, Functional materials, Innovation, Disruptive innovation

Abstract:
Based on the most recent data on new electro-sinter-forged materials and components a summary of the advancements in this technique is presented. Novel materials and applications for powder metallurgy will be discussed and shown to understand the potentialities of this emerging technology in expanding the world of powders outside its current boundaries. Technological limitatons and future areas of development will finally be discussed.

Innovative Aspect(s):
Electro-sinter-forging is the first single pulse discharge sintering technique to have produced parts in continuous series and to have gone beyond a lab and supplied industries. Thanks to its unique characteristics we have developed novel materials such as: Theoretically dense metal-metal composites without intermetallic phases. Composites of Nd-Fe-B and precious metals to produce hard magnetic 18kt gold. Composites of Nd-Fe-B and high melting point metals (such as molybdenum). Highly porous filters made of metal powders and fibers. The completely novel materials and components will be publicly shown for the first time and discussed during the presentation.

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WORLD PM2022
CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225370249

Requested paper type: Oral Presentation

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

Author: Ing Aydin Sohret Melda (EGE UNIVERSITY, Turkey)

Co-author(s): Ing Tekin Tuğçe ; Prof Dr IPEK RASIM (EGE UNIVERSITY, Turkey)

Title: Experimental Investigation Of The Relationship Between Powder Geometry And Pore Ratio Of Mg Powders Sintered By FAST

Keyword(s):
Magnesium, Field-assisted sintering technique, Mechanical milling

Abstract:
Commercial purity Mg powders were sintered at 300°C for 15 minutes with alternating current electric field-assisted sintering technique (FAST) under the pressure of 30 MPa after mechanical milling for 4-8-12-16-20 hours. Powder geometries, sizes and microstructural properties of the powders were investigated depending on the milling time. The relationship between the pore ratio and pore structure of the sintered samples and their powder geometries was investigated. Depending on the powder microstructure and geometry, the realization mechanism of FAST has been examined and evaluated with the results of compressive strength and hardness tests. The results were supported by optical microscope images, Scanning Electron Microscope (SEM) images. It has been determined that powder geometries (platy-spherical) -especially in the FAST method- have a great effect on sinterability and pore size, shape, and distribution.

Innovative Aspect(s):
The contact and contact geometry of conductive powders are extremely effective in field-assisted sintering technique (FAST). In this study, the effect of different powder geometries on the mechanism of field-assisted sintering technique by modifying the powder geometries by mechanical milling was investigated. At the same time, since the contact state of the powders changes with the effect of pressure, it has been investigated how the diffusion occurs with FAST at the contact points.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371766

Requested paper type: Oral Presentation

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

Author: Mr Graham Simon (The University of Sheffield, United Kingdom)

Co-author(s): Prof Jackson Martin (The University of Sheffield, United Kingdom)

Title: Using Field Assisted Sintering Technology To Recycle Waste Aluminum Alloy Powders Which Are Out Of Size Specification For Additive Manufacturing

Keyword(s):
Field assisted sintering technology, Powder processing, Aluminium alloy, Recycling

Abstract:
Metal additive manufacturing techniques typically operate using powders with limited particle size ranges, but atomisation processes produce significant amounts of particles outside these ranges. This results in an accumulation of out of size specification metal powders, without a clear use case. Field assisted sintering technology (FAST) provides an alternative processing route for these powders, by consolidating them into billets or directly into near-net shape components. This has been realised using waste powder of A20X, an aerospace approved aluminium alloy developed by Aluminium Materials Technologies (ECKART GmbH). FAST processed material has been shown to exhibit mechanical properties exceeding conventional cast material and be comparable to additively manufactured product. The resulting billets can also be further thermomechanically processed to further enhance mechanical properties and produce various products. This shows that FAST is an effective option for recycling waste metal powders into useful products, whilst improving sustainability in the additive supply chain.

Innovative Aspect(s):
The production of significant amounts of powders which are outside the desirable range for many metal additive manufacturing techniques is a growing issue faced by powder producers. Therefore, they are actively seeking alternative technologies for processing powders which cannot be re-atomised effectively, including titanium and aluminium alloys. This research showcases an innovate method of processing these otherwise waste powders into useful components and products, whilst achieving comparable mechanical properties to those which are conventionally and additively produced. As additive manufacturing grows, more waste powder will be generated; therefore FAST could be a crucial parallel technology in enabling and sustaining this growth.

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WORLD PM2022 CONGRESS & EXHIBITION
09-13 OCTOBER

Paper number: WP225371906

Requested paper type: Oral Presentation

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

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

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Title: Field Assisted Sintering Technique|Spark Plasma Sintering (FAST|SPS) Of Self-passivating Tungsten Alloys For Future Fusion Power Plants

Keyword(s):
Tungsten alloys, Self-passivation, Fusion power plant, FAST|SPS, Oxidation under applied conditions

Abstract:
In future fusion power plants, plasma-facing materials for the first wall of the reactor have to withstand extreme conditions combining long-term stability during regular operation and suppressed oxidation in the case of an accident. Self-passivating metal alloys with reduced thermo-oxidation (SMART) are promising candidates. Based on tungsten as matrix material, the alloys contain chromium as passivating element and yttrium as active element. Recently, it has been shown that submicron grain sizes led to the best oxidation resistance. Processing of such kind of materials is challenging. Here, field assisted sintering technology|spark plasma sintering (FAST|SPS) of mechanically alloyed tungsten, chromium and yttrium powders was applied to produce submicron grained SMART materials with homogeneous microstructure and well-balanced properties. Main factors influencing the processing of SMART materials via FAST|SPS are discussed and first attempts to scale up the technology (100 x 100 mm2) are presented. Finally, oxidation resistance under accident conditions was investigated.

Innovative Aspect(s):
Processing of self-passivating tungsten alloys for extreme conditions by powder metallurgy. FAST|SPS enables full densification while keeping grain size in the submicron range. First demonstration to scale up the technology to 100 x 100 mm2. Investigation of oxidation behaviour under accident conditions.

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: WP225372019

Requested paper type: Oral Presentation

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

Author: Dr Levano Blanch Oliver (The University of Sheffield, United Kingdom)

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Title: Consolidation Of Titanium Swarf And Surplus AM Powder Via The Solid-state Processing Routes Of FAST And HIP

Keyword(s):
Field assisted sintering technology, Hot isostatic pressing, Titanium, Swarf, Surplus powder

Abstract:
Titanium alloys are well known for their high strength to weight ratio. However, its use is restricted in many sectors simply due to its high cost when processed through the conventional route. Powder metallurgy has been proven as an alternative way to reduce the cost of near-net shape titanium components. The cost of powder is related to its source, but technologies like additive manufacturing (AM) produce large quantities of surplus powder that can be reused with alternative technologies. Alternatively, the option to use titanium machining swarf as a feedstock material is also explored to further reduce the price of titanium components. In this work, Ti-6Al-4V swarf and surplus AM powder has been consolidated using field-assisted sintering technology (FAST) and hot isostatic pressing (HIP). The consolidation, microstructure and hardness has been assessed to explore and compare the potential of these technologies in the production of low-cost titanium near-net shape parts.

Innovative Aspect(s):
Reuse of waste material in the powder metallurgy sector. The consolidation of titanium swarf into a fully consolidated sample using the technology field assisted sintering technology (FAST). A direct comparison of the microstructure and mechanical properties of titanium swarf consolidated via FAST and HIP. Reuse of surplus powder via FAST and HIP. A direct comparison of the microstructure and mechanical properties of surplus titanium powder consolidated via FAST and HIP.

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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Paper number: WP225372055

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

Author: Dr Lagos Miguel Angel (Tecnalia BRTA, Spain)

Co-author(s): Ing Lores Asier ; Mr Leizaola Iñaki ; Dr Agote Iñigo (Tecnalia BRTA, Spain)

Title: SPS Cosintering Of Bimaterial Metal-ceramic Composites For High Performance Electronic Applications

Keyword(s):
FAST, Spark Plasma Sintering, Electronic packaging, Metal-ceramic composites, Electric conductivity, Resistive materials

Abstract:
Electronic packages and sensors for special purpose applications demands the use of high electrical resistivity ceramics and conductive metallic materials which are sometimes difficult to be compatibilized, and whose manufacturing process involves many different processing steps. In this study, a bi-material composite consisting on a resistive SiC-Feldspar ceramic with around 109Ω.cm and a conductive Invar36 alloy has been developed in a one-step process by Spark Plasma Sintering (SPS). The SPS process permits the fast co-sintering of the composite achieving near full densities. Also, it has been observed that the joining interface of the material is stable and crack free. Both selected ceramic and metallic materials have low and similar CTE values (3.5 ppm|K), which makes them ideal for co-processing purposes and also for applications where high dimensional stability is required.

Innovative Aspect(s):
The key innovative points of the present study are: The ability to process and manufacture a metal-ceramic composite in one step process. This study opens new scopes for the processing of bi-material parts by SPS for electronic applications. Microstructural characterization of the composites. Thermomechanical characterization of a new family of composites. Indications about possible applications.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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Paper number: WP225372097

Requested paper type: Oral Presentation

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

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Title: Mechanical Activation And SPS Sintering A Pertinent Combination To Produce Advanced Materials

Keyword(s):
SPS, Mechanical Activatio, Tensile properties, Fine microstructure

Abstract:
The work engaged for many years between the ICB laboratory and the Nexter Munitions company has clearly shown the interest of combining a high-energy mechanical milling of the metallic powders followed by a SPS sintering. Indeed, commercial powders are mechanically activated (i.e. successive actions of fracture | cold welding of the powder particles) by the use of high-energy planetary ball mill, which leads (i) to increase the agglomerate sizes, (ii) to reduce the crystallite sizes and (iii) to induce structural defects. Thus, these so-called mechanically activated agglomerates allow a densification at a lower temperature while avoiding the formation of undesirable phases and limiting the grain growth. The second interest of mechanical milling is to stabilize sometimes out-of-equilibrium phases. Several examples (nickel, maraging steels, ...) will exhibit the existence of a relationship between the powder microstructure and sintered microstructure and consequently on the tensile properties.

Innovative Aspect(s):
The main objective of this paper is to exhibit the interest to modify the microstructure of the metallic powders using high energy ball mill. The mechanical activation permits to decrease the activation energy of the powder densification by SPS which is also a fast sintering technique to obtain dense materials with a fine microstructure. Consequently, the mechanical properties are improved in comparison with materials prepared by traditional processes such as forging and casting. An example will be given on maraging.

TPC Reviewer name: .....

Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

Withdraw ☐ Reason: .....

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Requested paper type: Poster Presentation

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

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Title: The Electrothermal Processes During High-voltage Electric Pulse Consolidation Of Refractory Powder Materials

Keyword(s):
High-voltage electric pulse consolidation, Refractory powder materials, Electrothermal processes, High-voltage welding, Thermal radiation, Pulse photometry, Rogowski coil

Abstract:
The main features of high-voltage electric pulse consolidation (HVC) of refractory powder materials and the resulting unique capabilities of the method are considered. The electrothermal processes of HVC at the contacts between powder particles and at the macroscale of the entire consolidated sample are analyzed. The results of experimental studies of the parameters of high-voltage electrical impulse action in the processes of consolidation of high-temperature powder compositions, high-voltage welding of dissimilar materials, as well as high-voltage discharges in liquid are presented. The results of measuring the intensity of thermal radiation of the investigated materials under high-voltage electrical impulse action, recorded by the method of pulse photometry using photodiode sensors, which, together with the Rogowski coil, are components of the measuring complex developed by the authors, are presented.

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

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Keynote ☐ Oral ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

Poster ☐ Poster & Reserve Oral ☐

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