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Development of Powder Metallurgy Setup for Preparation of Specimens as per ASTM Standards

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Abstract: The development of Powder metallurgy setup aim to revolutionizemanufacturing processes through the utilization of metal powders and its alloys. This innovative approach involves the production of intricate components by compacting and sintering fine metal powders. The Development of powder metallurgy setup encompasses a comprehensive exploration of powder metallurgy techniques, emphasizing the advantages of this method, such as enhanced material utilization, reduced waste, and improved mechanical properties. The research work begins with an in-depth analysis of various metal powders, their characteristics, and the selection criteria for specific applications and the intricacies of powder compaction, studying parameters like pressure, temperature, and dwell time to optimize the forming process. Additionally, sintering parameters are meticulously examined to achieve the desired density and mechanical properties in the final specimen are fabricated as per ASTM Standards.

Keywords: Powder metallurgy, Aluminum and its alloys, Surface finish,objective, and methodology, Working principle.

I. INTRODUCTION

The Development of powder metallurgy setup places a particular emphasis on the systematic exploration of various metal powders and their characteristics. An exhaustive analysis of different types of powders, including their composition, particle size distribution, and surface characteristics, forms the foundation for informed decision-making in the selection of materials for specific applications. This meticulous approach ensures that the Development of powder metallurgy setup outcomes are grounded in a deep understanding of the raw material’s inherent properties.

Powder metallurgy, as a manufacturing method, entails the utilization of powdered metal materials to produce intricate components through processes like compaction and sintering. Unlike conventional methods that involve casting and machining, powder metallurgy offers unique advantages, such as improved material utilization, reduced waste, and the ability to create complex shapes with precision. This Development of powder metallurgy setup recognizes the transformative potential of powder metallurgy and seeks to unravel its complexities for the benefit of diverse industries.

The introduction of thisDevelopment of powder metallurgy setup begins with a comprehensive exploration of the historical evolution of powder metallurgy, tracing its roots and milestones. From the early experiments with metal powders to the modern, sophisticated techniques employed today, understanding the historical context provides valuable insights into the trajectory of this field and underscores its significance in the realm of materials science.

OHNS (Oil Hardening Non-Shrinking) steel is a type of tool steel that is commonly used in applications where high hardness, good wear resistance, and excellent dimensional stability are required. Here are some properties and details of OHNS material are Chemical Composition, Hardness, Wear Resistance, Dimensional Stability, Machinability, Weldability, Heat Treatment, Surface Finish and Applications.

The composition of OHNS (Oil Hardening Non-Shrinking) steel can vary slightly depending on the specific grade and manufacturer. However, a typical composition range for OHNS steel is as follows:

- Carbon (C): 0.85% - 1.00%
- Manganese (Mn): 1.00% - 1.20%
- Silicon (Si): 0.20% - 0.40%
- Chromium (Cr): 0.40% - 0.60%
- Vanadium (V): 0.10% - 0.30% (sometimes added for increased wear resistance)
- Tungsten (W): 0.20% - 0.40% (sometimes added for increased hardness and wear resistance)

II. LITERATURE SURVEY

Sergei Alexandrov, et al. [1], The method of moving coordinates is widely used for determining characteristic nets and, as a result, stress fields in plane strain problems of classical plasticity of rigid plastic material obeying a pressure-independent yield criterion. A great number of boundary value problems related to metal-forming processes have been solved by this method. In particular, the method is efficient for constructing the characteristic net in the vicinity of a traction free surface. However, many materials reveal pressure-dependency of the yield criterion, this criterion generalizes Tresca's yield criterion. The general problem of determining the state of stress in plane strain deformation is reduced to the equation of telegraphy in characteristic coordinates. This equation can be solved by the method of Riemann. Then, the mapping between the characteristic and Cartesian coordinates is given by simple algebra.

Clayton Andre Oliveira da Motta, et al. [2], The utilization of fly ash as reinforcement in composites offers a cost-effective alternative for applications involving ductile metallic matrices. Ash is a by-product of coal combustion in thermoelectric plants, and its use can serve as an environmentally friendly option. Fly ash exhibits characteristics of a ceramic material. However, there are gaps in understanding the mechanical and metallurgical behaviour resulting from the interaction between the matrix and the fly ash-based reinforcement. This study aims to develop and evaluate the application of various amounts of fly ash as reinforcement in metal matrix composites through the powder metallurgy process.

T. Sathish, et al. [3], Aluminium alloys are indispensable in all manufacturing industries, particularly mechanical engineering. The objective of this study is to enhance the mechanical, wear, and corrosion properties of aluminium alloy AA5083 by incorporating nanoparticles as reinforcements, thereby creating hybrid aluminium nanocomposites. The base material utilised in this study was AA5083, with the reinforcement nanoparticles selected as Carbon nanotubes (CNTs) and Molybdenum disulfide (MoS2) at concentrations of 5 % and 3 % respectively.

Serkan Ozel, et al. [4], In this study, Cu-20wt.Sn alloy was produced by powder metallurgy (PM) method by using high purity element powders. The phases in the microstructure of the produced alloy were determined by XRD study. The phase transformation behaviour of the alloy was investigated by DSC and modelling method. Moreover, the Cu-20wt.Sn alloy system was modelled with molecular dynamics (MD) simulation based on modified Embedded Atom Method (MEAM).

Kanhu Charan Nayak, et al. [5], Metal matrix composite has high specific strength and it retained its properties at high-temperature applications compared to traditional materials. In the present work, a novel mathematical model has been developed for the weight percentage of reinforcement addition in a specified weight of the matrix using a theoretical approximation. This model provides the maximum weight fraction of reinforcement addition in a metal matrix. Further, the developed model has been demonstrated experimentally using alumina and SiC as reinforcement particles with the aluminium matrix synthesized by the powder metallurgy (PM) technique.

F.S. Qu, et al. [6], For studying the vacuum isothermal cogging technology for V-5Cr-5Ti alloy, the isothermal hot compression tests are conducted in the deformation temperature rangingfrom 1150 °C (1423 K) to 1400 °C(1673 K) with an interval of 50 °C, strain rate ranging from 0.001 to 1 s^{-1} and height reductions of 55% on a computer-controlled thermal simulation machine. The three kinds of constitutive equations of V-5Cr-5Ti alloy are deduced based on the true stress–strain curves. The analysis is carried out for the error for constitutive models and the optimum deformation condition.

III. OBJECTIVE AND METHODOLOGY

3.1 OBJECTIVE

The main objective of a Development of powder metallurgy setup is to manufacture components with specific properties and characteristics by utilizing metal powders as the primary raw material. This manufacturing process provides several key advantages, including the ability to create intricate shapes, achieve high material utilization, and produce components with enhanced mechanical properties.

The main objectives of thisDevelopment of powder metallurgy setup include:

- Powder metallurgy is a highly developed method of manufacturing ferrous and nonferrous products. It is a chipless working process.
- The high production rate varies from 500-1000 parts/hour.

- It eliminates or minimizes machining.
- Parts with close dimensional accuracy and good surface finish can be produced.
- Cost Effectiveness and Versatility.
- Reduced Machining Requirements.
- The process can be fully automated hence unskilled labour can be employed which reduces labour cost

3.2 METHODOLOGY

Powder metallurgy – The science of producing metal powders and making finished /semifinished objects from mixed or alloyed powders with or without the addition of nonmetallic constituents. Powder metallurgy (PM) is a versatile manufacturing process that involves the production of metal or alloy components from metal powders. The methodology for a Development of powder metallurgy setup typically encompasses several key steps, each contributing to the successful creation of a high-quality final product.

Steps in powder metallurgy:

- Material Selection.
- Powder Preparation.
- Compaction.
- Sintering.
- Post-Sintering Operation.
- Quality Control.
- Documentation and Reporting.

IV. WORKING PRINCIPLE

The working principle of powder metallurgy (PM) revolves around the transformation of metal powders into solid components through a series of controlled processes. This method involves several key steps as shown in the Fig: 1 Working Process Flowchart.

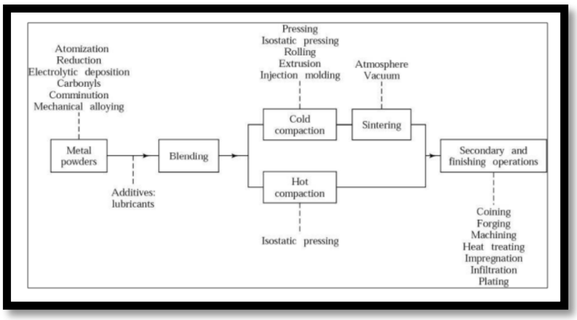

Fig: 1 Working Process Flowchart

(A) Primary Process.

1. Blending of Powder
2. Compacting
3. Pre-sintering (Not done when machining is not required).
4. Sintering.

(B) Secondary Operations.

1. **Blending of Powder**
   - Blending means the intermixing of powders of two or more materials. Intermixing of a powder and binder or intermixing of a powder and lubricants. blending of metal powder is done under controlled conditions to avoidcontamination and deterioration. It fulfills the following purposes.
   - It produces a uniform distribution of particle shape and size.
   - It allows different metals to be mixed to obtain specific physical properties.
   - It improves metal powder interaction by the addition of lubricants (e.g. stearic acid, Zinc stearate in a proportion of 0.25 to 0.5% by weight) to the powder improves the flow characteristics of the powder. Such blends result in reduced friction between the metal particles, improved flow of powder metal into dies, and longer die life.

2. **Compacting**
   - The mixed powders are compacted in a die to form the size and shape of the desired part, the parts so produced are known as green compact. The density after compaction is called green density.
   - Depends upon the compaction pressure, dimensions of the compacted parts, and powder hardness. The compacting is carried out at room temp. in dies. The die cavity is filled with the required amount of blended powder for uniform distribution of pressure two punches are generally used one from the top and the other from the bottom side of the powder.
   - The green compact expands slightly when taken out of the die for elastic recovery this expansion depends on the pressure and extent of plastic deformation in powder particles.

3. **Pre-sintering (Not done when machining is not required)**
   - It is defined as a process in which green compact is heated to a temperature below the final sintering temperature to increase its strength. It also removes the lubricant and binders added during blending. After this, the final sintering operation is performed.

4. **Sintering**
   - Sintering is the process of heating the material to a temp. below the melting temp. but high enough to allow the bonding or fusion of individual particles under a protective atmosphere to prevent oxidation. Continuous sintering furnaces are used which have 3 chambers.
   - A chamber to volatile (easily becoming goes or dangerous) the lubricants in the green compact to improve bond strength and prevent cracking it. It is called the brunt-off chamber. It slowly raises the temp. in a controlled manner.
   - A high-temperature chamber for sintering for bonding b/w the powder particles the time during the second stage must be sufficient to produce the desired density and final properties and a cooling chamber.

(C)Secondary Operations.

These operations are carried out to obtain desired dimensional tolerances, physical property improve its strength, hardness and wear resistance etc. Finishing operations are often performed after sintering for better dimensional accuracy different machining operations are performed. Heat treating the sintered part will improve its hardness, strength and wear resistance. The finishing operation is performed to improve the surface characteristics of the part. The Fig: 2,Fig: 3,Fig: 4,Fig: 5 andFig: 6are the Powder Metallurgy Setup for Preparation Of Specimens As Per ASTM Standards By Using Mould, Tension, Compression, Impact and Hardness specimens of the mould as shown in the figures.

V. FIGURES

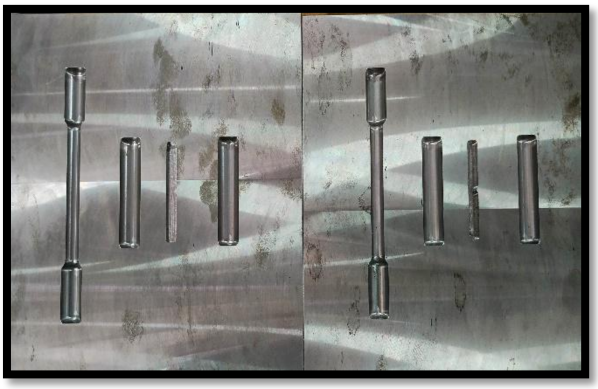

Fig: 2 Powder Metallurgy Setup for Preparation of Specimens as Per ASTM Standards by Using Mould.

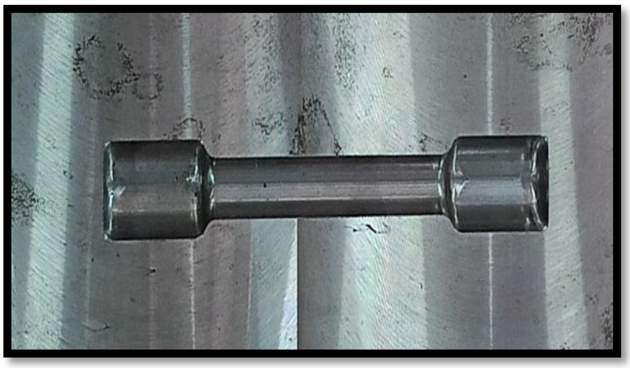

Fig: 3 Tensile Specimen Mould According to ASTM E-8 Standards.

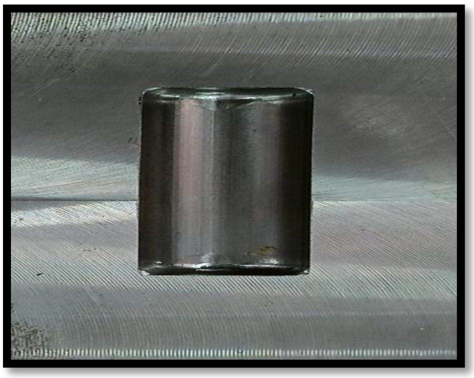

Fig: 4 Compression Specimen Mould According to ASTM E-9 Standards.

Fig: 5 Impact Specimen Mould According to ASTM E-23 Standards.

Fig: 6 Hardness Specimen Mould According to ASTM E-10 Standards.

VI. CONCLUSION

Based on the above works, the following conclusions are drawn: -

1) Successfully fabricated powder metallurgy setup.
2) Near net shape or ready to use specimens were obtained as per the ASTM Standards.
3) Tension, compression, Impact and Hardness, these tests were carried out successfully.
4) Results obtained are inline within the respected values.

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