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RESEARCH ARTICLE OPEN ACCESS

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

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Abstract:
The development of Powder metallurgy to revolutionize manufacturing 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 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 mechanical properties in the final specimen are fabricated as per ASTM Standards.

Keywords: Powder metallurgy, Aluminum and its alloys, Surface finish, mechanical properties.

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I. INTRODUCTION

Powder Metallurgy (PM) is a manufacturing process that involves producing and utilizing metal powders to create various metallic components and products. This method offers unique advantages in terms of material utilization, precision, and the ability to create complex and intricate shapes that are often challenging with traditional manufacturing techniques.

The origins of powder metallurgy can be traced back to ancient times when humans discovered methods to create objects from metal powders. The modern era of PM began in the early 19th century with the advent of industrial processes for producing iron powders. Significant advancements during the 20th century, particularly in the automotive and aerospace industries, propelled PM into a critical manufacturing technique.

The basic principles of Powder metallurgy encompass several fundamental steps:

- **Powder Production**: Metal powders are produced through various methods, including atomization, chemical reduction, and electrolysis. Each method results in powders with distinct characteristics such as particle size, shape, and purity.
- **Blending and Mixing**: Different metal powders and additives are blended to achieve desired material properties and uniformity.
- **Compaction**: The blended powder is compacted into a desired shape using a press, forming a 'green' compact. This step is crucial for achieving the required density and mechanical properties.
- **Sintering**: The green compact is heated in a controlled atmosphere furnace to bond the particles metallurgically without reaching the melting point. Sintering enhances strength and structural integrity.
- **Secondary Operations**: Depending on the application, secondary operations such as machining, heat treatment, or surface finishing may be performed to achieve the final specifications.

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 untravel its complexities for the benefit of diverse industries.

The introduction of this specimen development 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 real 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%
Tungsten (W)	0.20% - 0.40%

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 is utilized in this study was AA5083, with the reinforcement nanoparticles selected as Carbon nanotubes (CNTs) and Molybdenum disulfide (MOS_2) 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 ranging from 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.

Kh.A. Abuhasel, et al. [7], the present study was carried out on two Al–Si alloys viz. B319.2 and A390.1, in order to determine their impact toughness under certain test conditions. The results show that due to the presence of mixed types of silicon in the A390.1 alloy, it is not possible to quantify their sizes. Moreover, due to the difference in the densities of Si and Al, the primary Si particles tend to segregate in certain areas, leading to an inhomogeneous distribution of these particles, and, in turn, a marked deviation in the alloy toughness from one sample to another. The presence of Fe-based intermetallics was shown to have lowered the impact energy values of the B319.2 alloy (with 7% Si) in the as-cast condition to reach those values obtained in the A390.1 alloy (with 17% Si). The B319.2 alloy demonstrated a noticeable response to the applied heat treatment. The A390.1 alloy, however, did not exhibit such a variation in toughness as a function of test condition. This was primarily attributed to the presence of a large number of coarse primary Si Alloy.

Ashish Kumar Gurjar, et al. [8], natural fiber-reinforced composite materials are highly beneficial due to their excellent strength-to-weight ratio, and the compression molding process is frequently used to prepare natural fiber composites. The primary objective of the present work is to optimize the process parameters of the compression molding method to prepare luffa fiber-reinforced natural rubber composite and investigate the influence of process parameters on mechanical properties. Pre-processing parameters, specifically oven-dry temperature and time, processing parameters such as soaking temperature, time, and compression pressure, and post-processing parameters, such as oven-dry temperature and time, were considered to optimize. The ASTM standard is followed while testing the composite samples to determine their density, shore A hardness, and tensile strength. The density of the composite is unaffected by the process parameters; however, the shore A hardness of the composite is significantly affected.

Y.A. El-Shekeil, et al. [9], the recent focus on enhancing sustainability has emphasized the proper utilization of natural fibers and waste materials. Natural fiber reinforced composites have emerged as a promising solution for future bio-based products. This study aims to investigate the synergistic effects between date palm fiber (DPF) and Nitrile Butadiene Rubber (NBR) in order to develop innovative bio-based composites suitable for diverse industrial applications. The composites were produced through a mixing process using a Brabender internal mixer, followed by rolling. Various reinforcement materials and processing conditions were employed to characterize and analyze the mechanical properties of the composites. These properties included tensile strength, tensile modulus, strain, tear resistance, mechanical hardness, and compression behavior, assessed according to ASTM standards.

Louis G. Malito, et al. [10], this is the first study to simultaneously measure material properties in tension, compression, nanoindentation as well as microstructure (crystallinity and lamellar level properties) across a wide variety of clinically relevant ultra-high molecular weight polyethylene (UHMWPE) formulations. Methodologies for the measurement of UHMWPE mechanical properties-namely elastic modulus, yield stress, yield strain, ultimate strength, energetic toughness, Poisson's ratio, hardness, and constitutive variables-are evaluated. Engineering stress-strain behaviour is compared to true stress-strain behavior for UHMWPE across a range of cross-linking and antioxidant chemistry.

Mohamad Alagheband, et al. [11], in order to optimize the heat treatment process following hot induction forming, our study focused on investigating the impact of quenching and tempering temperature on the mechanical properties and microstructure of ASTM A860 Gr WPHY 65 hot formed 30-inch elbow steel, which is utilized in high strength low alloy (HSLA) pipelines for oil and gas applications. The desired properties for these steels include high mechanical strength, toughness, ductility, and weldability. Our experimental approach involved varying the soaking temperatures at 960 °C, 1000 °C, and 1050 °C, and subsequently cooling the samples in water at 20 °C, followed by tempering at 670 °C and 700 °C. Through the use of experimental design techniques, we determined the optimal heat treatment parameters. The results indicate that soaking at 1050 °C and tempering at 700 °C were the most effective treatment conditions in terms of mechanical strength.

Edward Cyr, et al. [12], Additive Manufacturing (AM)" refers to processes used to synthesize an engineering part, where successive layers of material are formed under computer control to create a three-dimensional object. AM methods allow for production of parts with complex geometries and exceptional properties, which is of particular interest of automotive, aerospace, marine, and defence industries. Most of the parts produced for these applications are non-critical, however applications involving large deformations, such as impact, are of serious interest to industry. Unlike most conventional materials, AM metals do not have the same compressive and tensile behaviour. This paper presents a preliminary study of experimental results of the tensile and compressive behaviour of additively manufactured Maraging Steel (MS1) using Digital Image Correlation (DIC) technique. Compression and tension samples in the form of cubes and rods were prepared using Direct Metal Laser Sintering (DMLS) technique through an EOS M290 machine.

Lei Xiao, et al. [13], effects of extrusion ratio and subsequent solution + aging treatment on the tension-compression yield asymmetry (TCYA) of extruded Mg-4.58Zn-2.6Gd-0.18Zr alloys were investigated. When the extrusion ratio increased from 10:1 to 15:1 and 30:1, the TCYA, which was determined as the ratio between compressive yield strength to tensile yield strength, was gradually improved from 0.79 to 0.84 and 0.89. The texture intensity decreased and deviation angle of the basal plane from extrusion direction increased with increasing the extrusion ratio, and resulted in the improvement of the TCYA.

Marwan T. Mezher, et al. [14], In the single point incremental hole flanging (SPIHF) process, a sheet material with pre-cut holes is deformed using the SPIF technique to generate a flange, making it an effective approach for low volume manufacturing and quick prototyping. In the case of the SPIHF technique, the post-forming hardness property, the forming limit diagram (FLD), and spring-back phenomena are not completely evaluated. To this end, this paper employs experimental investigation and numerical validation to analyse the impact of SPIHF process parameters like tool diameter, feed rate, spindle speed, and initial hole diameter on these aspects for the truncated incrementally formed components made from AA1060 aluminium alloy and DC01 carbon steel. The plasticity behaviour of both sheet metals was simulated using the Workbench LS-DYNA model and ANSYS software version 18.

Ahmad Hosseini, et al. [15], The growing demand for sustainable, lightweight yet rigid and cost-effective materials for airplane construction served as the impetus for this work. An E-glass fiber (400 GSM) is layered in a 6:2 ratio with natural basalt fiber and infused with graphene nanoparticles to produce a more appealing 40% lighter hybrid composite of 1.1 mm thickness for the aviation industry. Samples of hybrid composites with 1% and 2% graphene-to-fiber filler weight ratios are used. Then, using ASTM standard analysis tools, the damage that is caused on toughened laminates during low-velocity drop weight impact tests, tensile, 3-point bending, and Compression After Impact (CAI) is evaluated.

Jan Seyda, et al. [16], some reports on the mechanical testing of pure rhenium can be found in the literature. However, very few studies have been published regarding the fatigue properties of rhenium. To gain new knowledge on this subject, the present research aimed to determine mechanical properties in monotonic tension, hardness, and stress-controlled fatigue tests of sintered rhenium. The results of the basic mechanical tests are in agreement with data in the literature. The determined exploratory S–N fatigue curve for pure, sintered rhenium is a unique result, and it cannot be compared with others. Based on the monotonic tests data, estimated S–N curves were also determined. The comparison of the experimental curve and the estimated curves showed the usefulness of approximation methods to estimate the fatigue properties of rhenium. Considering the high cost of conducting research on rhenium, this is especially important for engineering design.

C. Anand Chairman, et al. [17], the effect of weave pattern on the mechanical properties of basalt- reinforced epoxy composite was investigated. Basalt in the plain and twill weave fabric forms were used for reinforcement, and lapox (L-12) epoxy resin was used as the matrix. Different weave types and their effect on mechanical properties of the weave were considered in the present study. The composite laminate was fabricated by the compression molding technique. Mechanical tests including tensile, compressive, and hardness tests were conducted as per the ASTM standards.

III. OBJECTIVE AND METHODOLOGY

3.1 OBJECTIVE

The main objective is to develop powder metallurgy setup and 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.

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.

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.

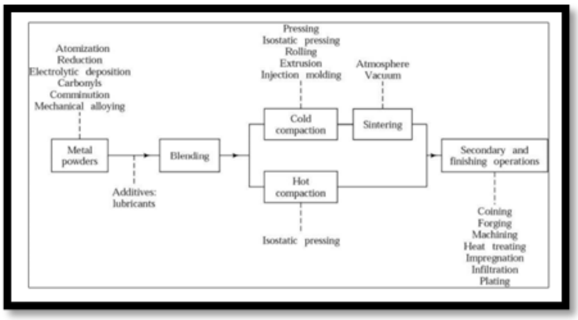

Fig: 1 Working Process Flowchart

Work process of Powder metallurgy are

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

4. Sintering.

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 avoid contamination 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.

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 and Fig: 6 are 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.

IV. PROJECT WORK PROCESS

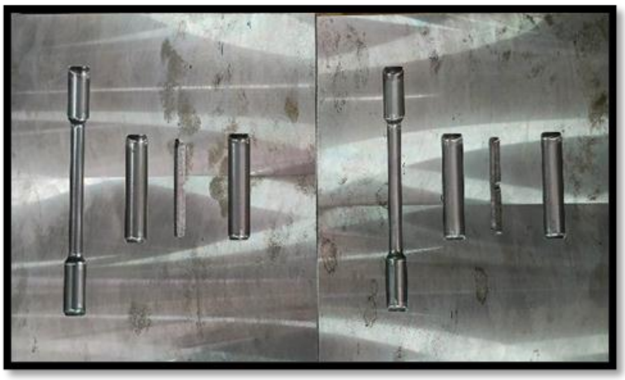

Fig: 2 Powder Metallurgy Setup For Preparation of Specimens As Per ASTM Standards By Using Mould.

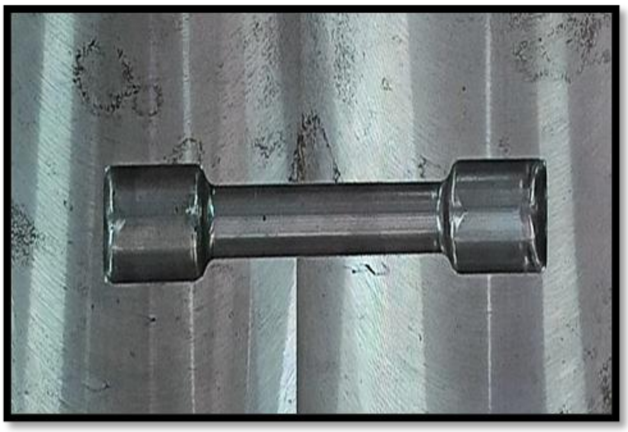

Fig: 3 Tension Specimen Mould According to ASTM E-8 Standards.

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.

4.1 Analysis Process

The specimens are prepared as per ASTM standards. Hardness Specimen is to find out the hardness, tensile Specimen for strength, Compression Specimen to check capacity of load bearing and Impact Specimen to evaluate how a material or object reacts to a sudden load, such as an impact. They measure the material's ability to resist deformation and absorb energy.

4.1.1 Tensile Die Mould

The tensile Specimens are fabricated as per ASTM E8 Standards and the dimensions are tabulated in the below table as per ASTM E8 Standards. The Table 1 Shows the dimensions of tensile die mould specimen.

The reduced section may have a gradual taper from the ends toward the center, with the ends not more than 1 % larger in diameter than the center (controlling dimension). If desired, the length of the reduced section may be increased to accommodate an extensometer of any convenient gauge length. Reference marks for the measurement of elongation should, nevertheless, be spaced at the indicated gauge length, The Fig 7: Shows the dimension model of tensile specimen.The gauge length and fillets may be as shown, but the ends may be of any form to fit the holders of the testing machine in such a way that the force shall be axial. If the ends are to be held in wedge grips it is desirable, if possible, to make the length of the grip section great enough to allow the specimen to extend into the grips a distance equal to two thirds or more of the length of the grips. The Fig. 8: Shows the die of tensile specimen.

Table 1: Dimensions of Tensile Die Mould Specimen.

SL. NO	Description	Dimension	Tolerance
1	Length of specimen (A)	62.5 mm	± 0.1 mm
2	Width (W)	12.5 mm	± 0.2 mm
3	Thickness (T)	20 mm	± 0.1 mm
4	Radius of fillet (R)	10 mm	-
5	Overall length (L)	154.5 mm	± 0.2 mm
6	Length of reduced (L-A)	62.5 mm	± 0.2 mm
7	Length of grip section (B)	30 mm	± 0.2 mm
8	Width of grip section (C)	20 mm	± 0.2 mm
9	Edge distance from pin	4 mm	± 0.1 mm

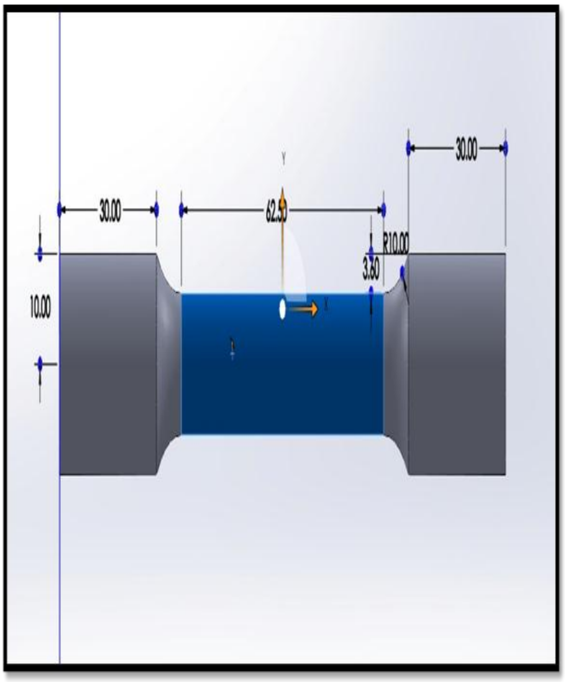

Fig. 7: Shows the Dimension Model of Tensile Specimen.

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Fig. 8: Shows the Die of Tensile Specimen.

On the round specimens the gauge lengths are equal to four [E8] or five times [E8M] the nominal diameter. In some product specifications other specimens may be provided for, but unless the [E8M] ratio is maintained within dimensional tolerances, the elongation values may not be comparable with those obtained from the standard test specimen.

4.1.2 Compression Die Mould

The Compression Specimens are manufactured as per ASTM E9 Standards and the dimensions are tabulated in the below table as per ASTM E9 Standards. The Table 2 Shows the dimensions of compression die mould specimen.

The definitions of terms relating to compression testing and room temperature in Terminology E6 and Specification, respectively, shall apply to these test methods. Definitions of Terms Specific to This Standard. In addition to compressive failure by crushing of the material, compressive failure may occur by elastic instability over the length of a column specimen due to non-axiality of loading, inelastic instability over the length of a column specimen, a local instability, either elastic or inelastic, over a small portion of the gage length, or a twisting or torsional failure in which cross sections rotate over each other about the longitudinal specimen axis. These types of failures are all termed buckling. The Fig. 9: Shows the dimension model of compression specimen.

- A Compression member that is axially loaded and that may fail by buckling.
- radius of gyration—the square root of the ratio of the moment of inertia of the cross section about the centroidal axis to the cross-sectional area

  $\rho=(I/A)^{1/2}$

  where

  ρ = radius of gyration,

  I = moment of inertia of the cross section about centroidal axis (for specimens without lateral support, the smaller value of I is the critical value).

  A = cross-sectional area.

Table 2: Dimensions of Compression Die Mould Specimen.

SL. NO	Cylindrical Specimen Type	Diameter in mm (D)	Length in mm (L)
1	Short	30 mm 13 mm	25 mm
2	Medium	13mm 20 mm 25 mm	38 mm 60 mm 75 mm

		30 mm	85 mm
3	Long	20mm 32mm	160 mm 320 mm

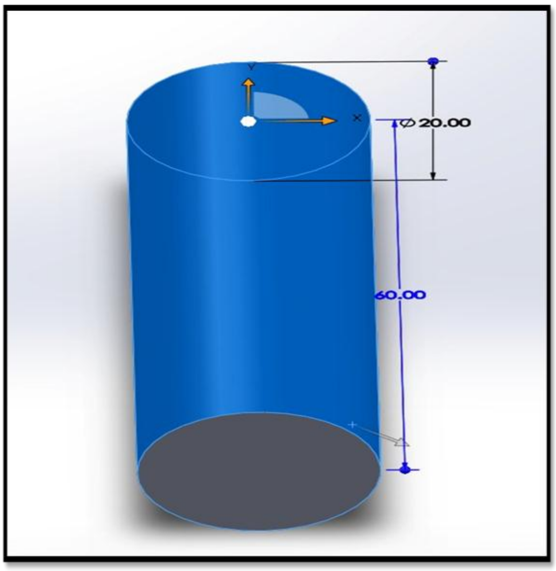

Fig. 9: Shows the Dimension Model of Compression Specimen.

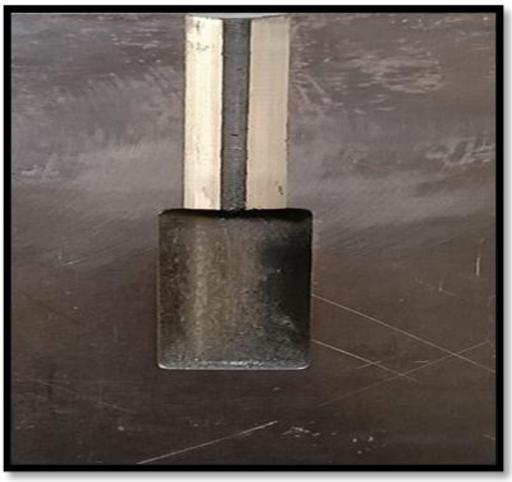

Fig. 10: Shows the Die of Compression Specimen.

critical stress—the axial uniform stress that causes a column to be on the verge of buckling. The critical load is calculated by multiplying the critical stress by the cross-section area. The Fig. 10: Shows the die of compression specimen.

buckling equations—If the buckling stress is less than or equal to the proportional limit of the value may be calculated using the Euler equation

If the buckling stress is greater than the proportional limit of the material its value may be calculated from the modified Euler equation

4.1.3 Impact Die Mould

The Impact Specimens are manufactured as per ASTM Standards and the dimensions are tabulated in the below table as per ASTM Standards. The Table 3 Shows the dimensions of Impact die mould specimen.

Table 3: Dimensions of Impact Die Mould Specimen.

SL. NO	Description	Dimension	Tolerance
1	Length of specimen (L)	75 mm	+0/-2.5 mm
2	Notch to top	28 mm	-
3	Notch length to edge	90°	±2°
4	Adjacent sides angle	90°	±0.17°
5	Width (W)	10 mm	±0.025 mm

6	Thickness (T)	10 mm	±0.025 mm
7	Ligament length	8 mm	±0.025 mm
8	Radius of notch (R)	0.25 mm	±0.025 mm
9	Angle of notch	45°	±1°
A	Surface finish requirement	2 µm (Ra)	-
B	Surface finish requirement	4 µm (Ra)	-

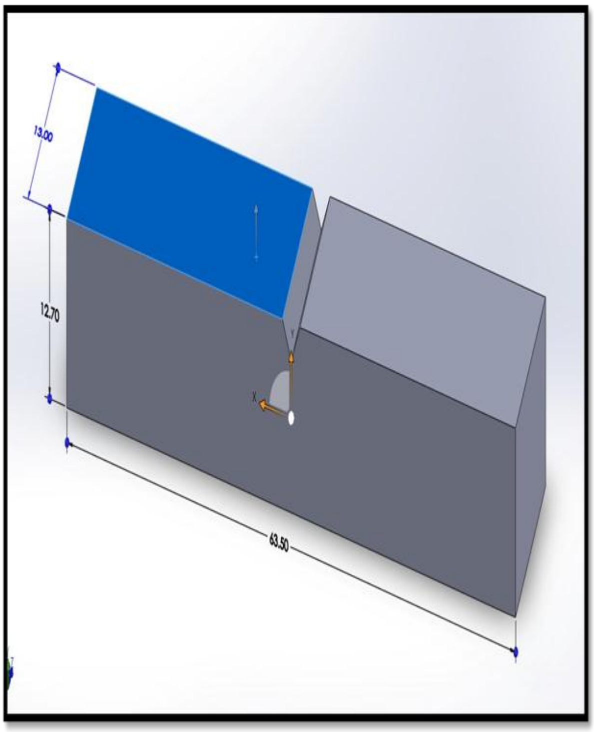

Fig. 11: Shows the Dimension Model of Impact Specimen.

Configuration and Orientation Specimens shall be taken from the material as specified by the applicable specification, The Fig.11 Shows the dimension model of Impact specimen. The type of specimen chosen depends largely upon the characteristics of the material to be tested. A given specimen may not be equally satisfactory for soft nonferrous metals and hardened steels; therefore, many types of specimens are recognized. In general, sharper and deeper notches are required to distinguish differences in very ductile materials or when using low testing velocities. The specimen shown those most widely used and most generally satisfactory. They are particularly suitable for ferrous metals, The Charpy specimen designation is V-notch.

Fig. 12: Shows the Die of Impact Specimen.

The specimen commonly found suitable for powder metallurgy materials are shown in Fig.12 Powder metallurgy impact specimens shall be produced following the dimensions. The impact of these materials is affected by specimen orientation. Therefore, unless otherwise specified, the position of the specimen in the machine shall be such that the pendulum will strike a surface that is parallel to the compacting direction. For powder metallurgy.

5.1.4 Hardness Die Mould

The Hardness Specimens are manufactured as per ASTM E10 Standards and the dimensions are tabulated in the below table as per ASTM E10 Standards. The Table 4 Shows the dimensions of hardness die mould specimen.

- Calibration—determination of the values of the significant parameters by comparison with values indicated by a reference instrument or by a set of reference standards.
- Verification—checking or testing to assure conformance with the specification.
- Standardization—to bring in conformance with a known standard through verification or calibration.

Table 4: Dimensions of Hardness Die Mould Specimen.

SL. NO	Cylindrical Specimen Type	Diameter in mm (D)	Length in mm (L)
1	Short	30 mm 13 mm	25 mm
2	Medium	13mm 20 mm 25 mm 30 mm	38 mm 60 mm 75 mm 85 mm
3	Long	20mm	160 mm
		32mm	320 mm

- Brinell hardness test—an indentation hardness test using a verified machine to force an indenter (tungsten carbide ball with diameter D), under specified conditions, into the surface of the material under test. The diameter of the resulting indentation d is measured after removal of the force.
- Brinell hardness number—a number, which is proportional to the quotient obtained by dividing the test force by the curved surface area of the indentation which is assumed to be spherical and of the diameter of the ball. The Fig. 13: Shows the die of hardness specimen.

Fig. 13: Shows the Die of Hardness Specimen.

- Brinell hardness scale—a designation that identifies the specific combination of ball diameter and applied force used to perform the Brinell hardness test.
- Brinell hardness testing machine—a Brinell hardness machine used for general testing purposes.

- Brinell hardness standardizing machine—a Brinell hardness machine used for the standardization of Brinell hardness test blocks. The standardizing machine differs from a regular Brinell hardness testing machine by having tighter tolerances on certain parameters.
- Force-diameter ratio—a number calculated as the ratio of the test force in kgf to the square of the indenter ball diameter in mm.

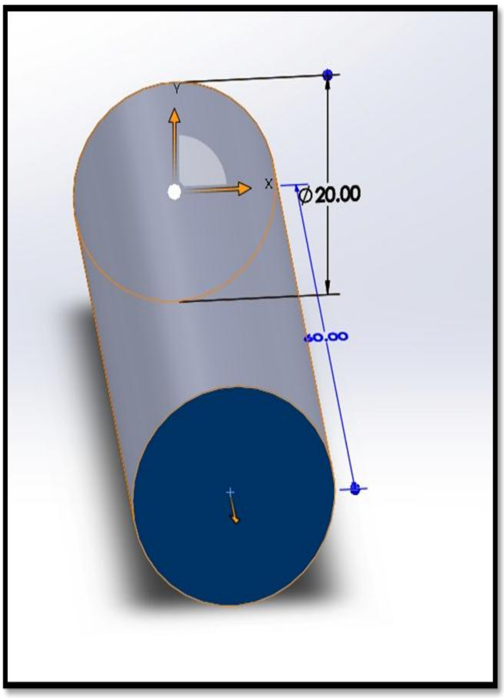

Fig. 14: Shows the Dimension Model of Hardness Specimen.

V. CONCLUSION

By contributing to the evolution of powder metallurgy, this work aspires to address these industry needs and challenges. The findings aim to establish a robust framework to produce components that not only meet but exceed the expectations for mechanical strength, wear resistance, and dimensional accuracy. Moreover, the work envisions a more sustainable future for manufacturing by reducing waste and optimizing material utilization.

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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