PRACTICAL WORKBOOK

MY-406: POWDER METALLURGY

Name___________________________

Roll No__________________________

Batch___________________________

Year____________________________

Department_____________________

Department of Metallurgical Engineering

NED University of Engineering and Technology

Karachi-75270, Pakistan

PRACTICAL WORKBOOK

MY-406: POWDER METALLURGY

PREPARED BY:

Dr. Rizwan
(Assistant Professor MYD)

This is to certify that this practical book contains _____________ pages.

Approved by:

Chairman, MYD

Department of Metallurgical Engineering

NED University of Engineering and Technology

CERTIFICATE

It is certified that Mr. / Ms. _______________student of class __SE__Batch, bearing Roll No. MY __________ has completed his / her course work in the subject of **Powder Metallurgy (MY-406)** as prescribed and approved by Board of Review of Metallurgical Engineering Department.

His/her performance is reflected by the performance rubrics of his/her practical workbook. This overall performance of the student is going to address the assigned learning attribute.

____

Course Teacher

TABLE OF CONTENTS

MY-406 POWDER METALLURGY

Experiment No. 1

Aim of the Experiment

To study risks, hazards and safety precautions in Powder metallurgy laboratory.

Instructions

1. Wash your hands before entering in the lab and wear protective clothing, such as lab coats or aprons, gloves, and eye wear. Be sure that your work area should be clean and dry.
2. Never attempt to operate any equipment without prior instruction.
3. Work in the laboratory only when a lab instructor is present, and only on authorized experiments.
4. Do not bring any unnecessary items into the lab. Do not place any personal items (purses, book bags, coats, umbrellas, etc.) on the lab table or at your feet.
5. Make sure all apparatus is supported and squarely situated on the table.
6. Do not put anything in your mouth while in the lab. Never eat, chew gum, drink, taste chemicals, mouth pipette, lick labels, smoke, or store food or drink in the lab. DO NOT bring food and drink into the laboratory.

Powder Handling Precautions

Certain powders of metals and metallic compounds can have harmful effects on users exposed to these powders. Powder handling requires proper safety precautions and cleanliness. Persons exposed to metallic dust can be affected by respiratory diseases or other dysfunctions. The particle size and the specific gravity of the material largely determine the deposition site for a respirated particle. Coarse particles are trapped on the precious membranes and do not reach the lungs; fine particles, however, can reach the lungs and may be dissolved into the body. However, special care is needed when using elemental powders as alloying elements (e.g. Cr, Ni, As, Cd). Contact with these metals in the powdered state should be minimized whenever possible.

Another hazard with aluminum based powders and several others is their thermal instability in the presence of oxygen. Aluminum powders in a finely divided state are pyrophoric (burn in air) and potentially explosive. Aluminum powders require very little oxygen content in the atmosphere (less than 3 %), have a low ignition temperature (less than 600 °C) and very low explosive limit (20-50 g/m3).

Explosion and fire prevention is based on the evaluation of:

- Potential ignition sources (e.g. Electrostatic discharge);
- Dust cloud generators;
- Gaseous atmosphere composition.

If a fire occurs in a metal powder, the fire should be approached with extreme caution. The best way to attack burning metal powder is with special dry-type fire extinguishing agents. Water should never be applied to fires of metal powders.

Powder Compaction Precautions

- Never place your hand or any part of your body in compaction press.
- Never operate press when it is not working properly, stop working and immediately inform to your instructor.

- Never approach press up to its limit or beyond always keep load at least 5 tons less than its upper limit for safe operation.
- Clean pressing area after each job.
- Never try to change die or place your finger without first releasing the pressure.

Sintering Precautions

- Immediately inform to your instructor if atmospheric gas is found to be leaking.
- Never try to pick parts with bare hands when they are hot after sintering
- Do not operate the sintering furnace once sintering cycle has started.

Questionnaires 1

Q1. Write down the names of materials which can be carcinogenic in particulate form.

Q2. Name the type of fire extinguishers/fire extinguishing techniques for different types of fires.

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Experiment No. 2

Aim of the Experiment
Operate the flow meter **under supervision** to determine apparent density and powder flow rate.

Materials & Apparatus
Metal powder, Flowmeter, and Stop watch.

Theory
Flow rate and apparent density are two most important characteristics of metal powders. Both of these tests are performed with the help of a simple apparatus called Flowmeter. These two tests are very common in Powder Metallurgy industries. These tests are very helpful in the determination of die filling capability of metal powders.

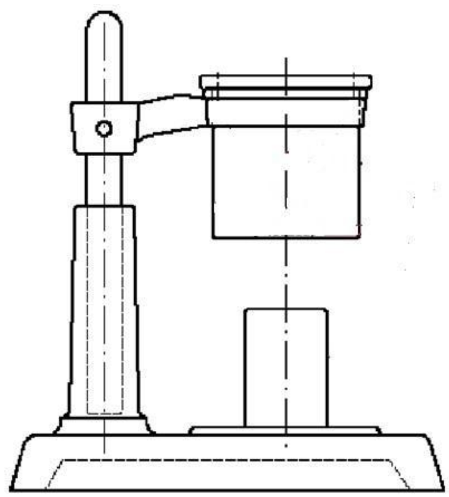

Fig.1: Schematic view of Flowmeter

Measuring Flow Rate by Flow Process
1. Take 50 gm powder which has to be tested in a density cup.

2. Carefully fill powder into the Flowmeter funnel keeping the discharge orifice at the bottom of the funnel closed by placing a dry finger under it.

3. The stop watch should be started at the instant when powder starts coming out of the orifice after the removal of finger from the discharge orifice and stopped at the instant the last of the powder leaves the funnel.

4. The elapsed time in second shall be recorded.

5. Same procedure should be repeated three times with different samples.

6. Take the mean of reading which will be the flow rate of powder

Observation

S.No	Flow Rate (sec/50gm)	Average Flow Rate (secs/50gm)
1.		
2.		
3.		

Apparent Density

1. The test specimen shall consist of a volume of 25 c.c. of metal powder whose apparent density to be carried out.

2. The entire specimen should be carefully loaded into the flow meter funnel and permitted to flow through the discharge orifice into the density cup having capacity of 25c.c.

3. When the powder completely fills and overflows the periphery of the density cup, the funnel shall be rotated approx 90` in a horizontal flare so that the remaining powder falls away from the cup.

4. Using a non-magnetic spatula with the blade hold perpendicular to the top of the cup, the powder in excess will be removed this way.

5. The density cup along with the filled powder is now placed on the mass balance & the mass of powder is calculated.

6. The observed mass is now divided by the volume i.e. 25c.c to get the apparent density of the powder used.

Observation

S.No	Apparent Density (gm/cm^3)	Average Apparent Density (gm/cm^3)
1.		
2.		
3.		

Result

Average flow rate of metal powder is found to be______________secs/50gm

Average flow rate of metal powder is found to be______________gm/cm^3

Questionnaires

Q1. Define and compare the following terms:
Apparent density, Tap density, Bulk Density, Green Density.

Q2. What is Carney funnel and why it is used?

Q3. Write down the name of standard which deals with the chemical composition of Metallic powders.

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Experiment No. 3

Aim of the Experiment
Operate ball milling **under supervision** to reduce the particle size of given powder(s).

Material and Apparatus
Planetry ball mill, grinding media (ethanol), and Metal powder.

Theory
Planetry mill is high energy mill widely used for production of metal, alloy and composite powders. Planetry ball milling has four ball milling tanks on a big tray. The planetary ball mill performs mixing by continually revolving the large plate and rotating the containers concurrently. Both the plate revolution (centrifugal) speed and container rotation (planetary) speed are independently adjustable. To further improve the mixing efficiency, grinding media can be added into the containers. The basic principal of milling process is the application of impact and shear forces between two materials, a hard and a soft, causing soft material to be ground into fine particles. The basic apparatus consists of A ball mill or jar mill which mainly consists of a rotating drum lined from inside with a hard material. Hard balls, as a grinding medium, which continue to impact the material inside the drum as it rotates/rolls. Major parameters for milling are:

- Milling time
- Milling speed

Higher the milling speed the finest of powder increases. Milling time and milling speed are inversely related. Milling of coarse or bulk material occur in stages. In the initial stage of milling of ductile materials, individual particles are deformed by microforging resulting in welding and fracture. After a period of cold welding and fracturing, steady state equilibrium is achieved.

Fig.2: Planetry Ball Mill

Procedure

Observation

S.No.	Material	Milling speed	Milling time

Questionnaires

Q1. Discuss the effect of milling parameters on particle size?

Q2. Write down the main objectives of milling?

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Experiment No. 4

Aim of the Experiment

Operate laser particle analyzer **under supervision** to determine the particle size of powders before and after ball milling.

Material and Apparatus

Metal powder, Laser particle analyzer, and Deionized water.

Theory

Light scattering provides a rapid, reproducible and convenient method of determining particle size and size distribution. Light incident on small particles is scattered through angles that are inversely proportional to particle size. Scanning of the angular distribution of scattered light flux provides information of particle size and size distribution. The system consists of optical, electronic and sample handling units. The powder sample is suspended in liquid medium and placed in sample zone. This zone is then illuminated by a helium-neon light. The particles cause the light to be scattered, which is collected by a lens and directed towards an optical filter. The transmitted light from the filter is focused on to a photo detector, which produces electrical signals. These electrical signals are converted to digital signals and used to compute particle size distribution. Typical analysis time varies from one to several minutes for most materials.

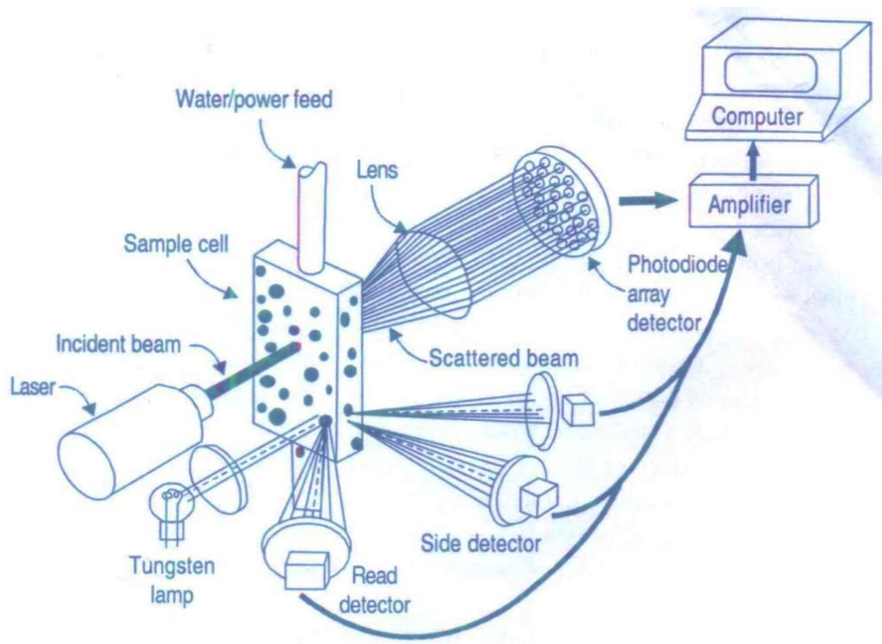

Fig.3: Laser particle size analyzer - schematic

Procedure

Observations

S.No.	Material	Particle Size Before Ball Milling	Particle Size After Ball Milling
1.			
2.			
3.			

Questionnaires

Q1 What is the effect on size of particle?

Q2 Write down advantages and disadvantages of laser particle analyzer?

Q3 Why particle distribution is very necessary?

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Experiment No. 5

Aim of the Experiment

Operate the compaction equipment **under supervision** to study the effect of compaction pressure on the green density of the compacted parts.

Material and Apparatus

Metal powder, Binder, Compaction press, Vernier caliper and Weighing balance.

Theory

Compaction is an important step in powder processing as it enables the forming of loose metal powders into desired shapes with sufficient strength to withstand handling till sintering is over. This step is also a precursor to the manufacture of near net shape parts, which is an important advantage of P/M processing. Metal powders are mixed with a lubricant prior to compaction. The term compaction is used to describe consolidation of powder particles without the application of heat. Compaction is followed by sintering to make the finished parts. There are many methods of compaction and the choice is dependent on the application as well as the scale and economy of operation. In many cases, it is advantageous to cold press a mixture of the component powders because of ease of compaction. However, it may be advantageous always: for example sintering of compacts containing elemental zinc is difficult, while pre-alloyed brass powders is easily cold pressed and sintered. Generally, pre-alloyed powders are hard and cannot be readily cold pressed.

Fig.4: Compaction Press

Procedure

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Observations

Specimen	Compaction pressure (Mpa)	Green density (g/cm^3)
1.		
2.		
3.		
4.		

Questionnaires

Q1. Write down the names of several compaction techniques used in Powder metallurgy.

Q2. What are different types of lubricating techniques, write down their advantages and disadvantages?

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Experiment No. 6

Aim of the Experiment
Operate the sintering furnace **under supervision** to study the effect of different sintering temperatures on the microstructure of sintered body.

Material and Apparatus
Compacted samples, microscope, and suitable etchant.

Theory
Sintering is one of the most important steps in Powder Metallurgy processing. It is the process of consolidating either a loose aggregate of powder or a green compact of the desired composition under controlled conditions of the temperature and time. Sintering may involve:

(1) single component system (e.g. pure metals and ceramics), where in shrinkage is major factor.
(2) multiucomponent system, involving more than one phase, where several processes like solid solution formation and liquid phase formation may also occur in addition to densification.

Major variables in the sintering process are following:

(1) Sintering Temperature
(2) Sintering Time
(3) Sintering Atmosphere

Temperature is an important parameter in sintering and must be closely controlled in order to achieve the desired density and properties. Too high or too low a temperature during sintering will have adverse effects on the microstructure as well as properties.

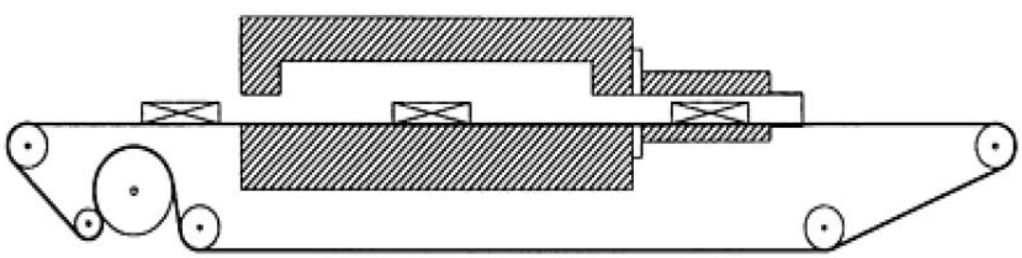

Fig.5: Schematic representation of industrial sintering furnace

Procedure

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Conclusion

Questionnaires

Q1. Write down the name of most common sintering atmospheres.

Q2. What is sinter hardening?

Q3. What is spark plasma sintering?

Q4. What are Ostwald ripening and what effect it produces on sintering?

Q5. What is the mechanism of sintering also draw a diagram to explain sintering mechanism?

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Experiment No. 7

Aim of the Experiment
To demonstrate and design a compaction die by using lathe machine.

Material and Apparatus
Lathe machine, and Die material.

Theory
Parts are produced from metal powders in a metal processing technology named as powder metallurgy (PM). In the powder metallurgy, metal powders are compressed into a desired shape in a die and heated to cause the bonding of the particles forming a hard rigid mass below the melting point of the metal. The heating process is called sintering. Dry powder lubricants such as stearates and waxes are added to reduce the friction between the powder particles and between the particle and the die wall. Split dies are not acceptable in this process.

Typical characteristics and applications
PM parts up to a length of 15 cm are common. These parts might be intricate in shape but usually preferred to have parallel sides and are usually net-shaped or near-net-shaped which do not require subsequent machining. Even parts can be produced with certain level of porosity which helps bearings and gears to be self-lubricating.

Die materials & apparatus
For soft powders (aluminum, copper, lead) => air hardened steels, die steels are used for making die. For hard powders => tool steel are used. For More hard & abrasive powders(steel) => tungsten carbide dies and coated dies with hard & wear resistant coating material like titanium nitride or titanium carbide can be used, lathe machine

Design recommendations for compact dies
Draft
Draft is not desirable and creates problem in the production phase. If draft is not avoidable, an exception is the side wall of the recesses formed by a punch entering the top side of a part. In these cases a draft of 20 is advisable. When recesses occur in the top of a part, 2° minimum draft assists removal of the upper punch.

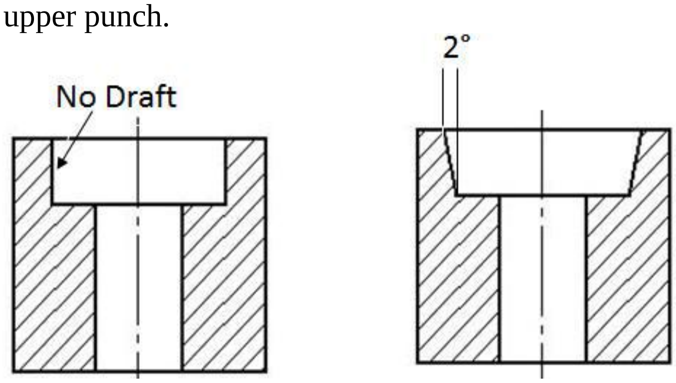

Fig.6: Schematic representation of Draft

Wall thickness

A component of extremely complicated shape in which wall thickness varies over a very wide range is more advantageous in this process. The recommended minimum wall thickness is 1.5mm. Similar recommendations are also applicable to the walls between hole and outside surface of the part and the wall between two holes

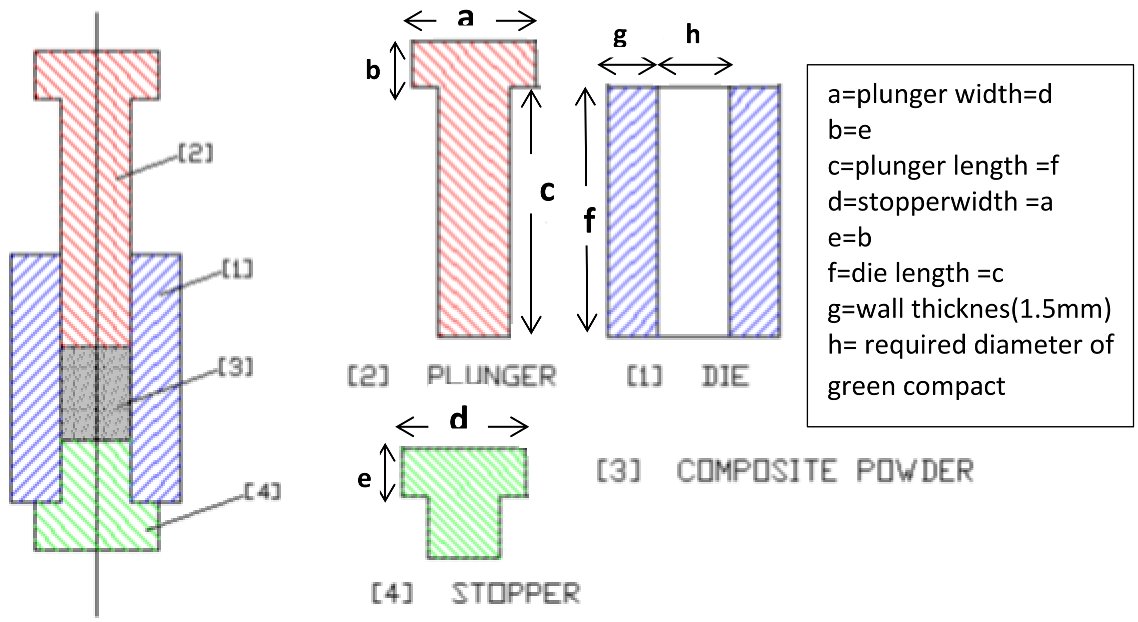

Fig.7: Design parameters of Compaction Die

Radii

Smaller radius at component corners for both internal and external can be advantageous to tool life. Considering extremely large radius in a particular direction may induce density variation problem. When curved surfaces adjoin one another, special care must be taken because necessary punches might have fragile feather edges

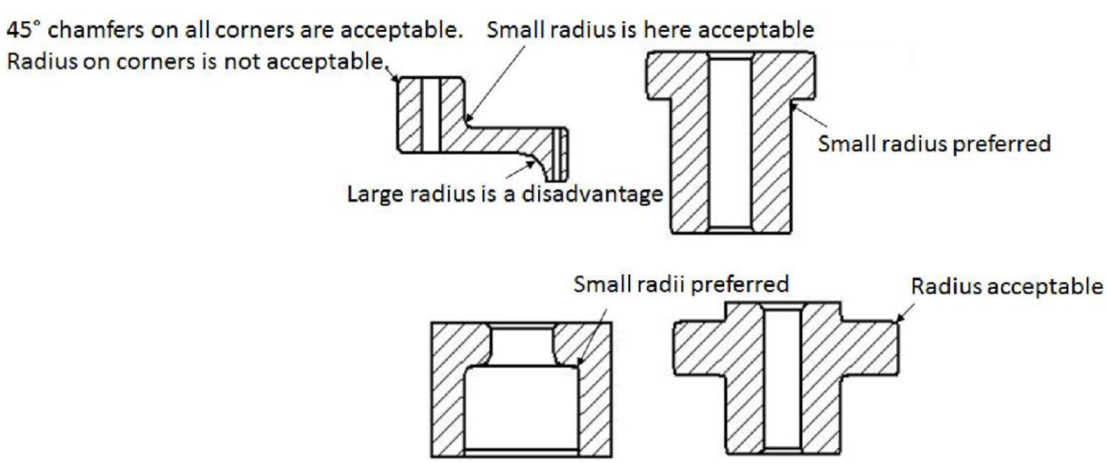

Fig.8: Schematic representation of preferred Radii

Holes
Holes in the direction of pressing are freely accepted but holes at right angles to pressing are not recommended. Minimum diameter of holes should be 1.5mm.

Under cuts
Undercuts are not permissible due to the problem in ejecting the component from the die.

Angled side walls
This can cause tooling problem if the angle is too small or the intersection of the angled wall with other surface is a single edge.

Spherical surfaces
It has similar molding characteristics to those of tapered surfaces. Die damage is avoided if a narrow flat is provided at the parting line.

PROCEDURE

CONCLUSION:

Questionnaires

Q1. Discuss the properties of die materials required for compaction process?

Q2. Write down the name of materials used for compaction die?