



A SHORT NOTE ON MANUFACTURING PROCESS OF METAL POWDERS

¹R.Raja, ²M.Rajkumar

¹Assistant Lecturer, St. Joseph College of Engineering and Technology, St. Joseph University-Tanzania, Dar Es Salaam, Tanzania, East Africa. Email: rrajanrm@gmail.com

²Assistant Professor, Dhanalakshmi Srinivasan College of Engineering and Technology, Mamallapuram, Chennai

Abstract: – In this paper, a short note on manufacturing process of metal powders was given. In addition this paper covers the advantages, applications and limitation of powder metallurgy. The design rule for powder metallurgy was given in simple diagram. Nowadays powder metallurgy plays important role for making of large variety of components like carbide cutting tools, refractory parts, tantalum, molybdenum, etc. This paper would be helpful for the mechanical engineer to understand the basics of processing of metal powders.

Keywords: - Automation, powder, grinding, finishing

1. INTRODUCTION

Generally components are manufactured to required size and shape by machining, casting hot working and cold working processes. Some metals cannot be machined to required shape. As some metal has high melting point, it cannot be easily melted and cast. The above disadvantages are overcome by a special process called powder metallurgy.

1.1 Various definition of Powder Metallurgy

- i. Science of producing metal powders and making finished or semi finished objects from mixed or alloyed powders with or without the addition of nonmetallic constituents.
- ii. The preparation and processing of powdered iron and nonferrous metal was called powder metallurgy. Simple shaped parts can be made to size with high precision about 0.1 mm.
- iii. Powder metallurgy is the process of making components with required properties and shape by mixing metal and non-metal powders.

The following figure 1 shows the several particle shapes in Powder Metallurgy.

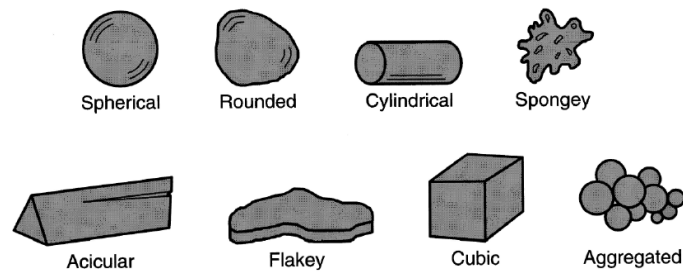


Figure 1 several particle shapes in Powder Metallurgy

1.2 Sequence of Steps involved in manufacturing process

The following figure 2 shows the various Steps involved in manufacturing process

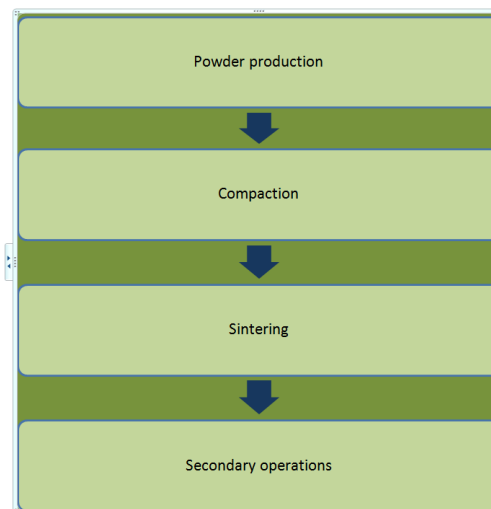


Figure 2 Sequence of Steps involved in manufacturing process

1.3 Mechanical Properties of Parts Made By Powder Metallurgy

1.2.1 Strength

The structure was not fibrous as the powder grains are only bonded together. So the products have low tensile strength.

1.1.2 Hardness

The hardness of the powder metal component was less due to the pores present in it. The hardness will not be uniform as the density varies at different locations.

1.1.3 Ductility

The powder metal component has low ductility as the structure was porous. The ductility can be increased by the hot pressing and sintering.

1.1.4 Dampness

Powder metal components have good damping properties. So they can absorb vibrations.

1.4 Important characteristics of the metal powders

The following are the important characteristics of the metal powders

1. Purity
2. Chemical composition
3. Particle size
4. Size distribution
5. Density
6. Compression ratio
7. Particle shape
8. Particle microstructure
9. Flow factor
10. Ability to be sintered

2. METHODS OF PRODUCING METAL POWDERS

Metal Powder of various metals are prepared by the following methods

- i. Atomization
- ii. Electrolytic deposition
- iii. Chemical reduction
- iv. Machining
- v. Shotting
- vi. Milling
- vii. Grinding

2.1 Atomization

Atomization of molten metal can be done in different ways depending upon the factors like economy and required powder characteristics.

2.1.1 Types of Atomization process

- i. Water atomization
- ii. Gas atomization
- iii. Vacuum atomization
- iv. Centrifugal atomization
- v. Rotating disk atomization
- vi. Ultra rapid solidification processes

2.1.2 Gas atomization working principle

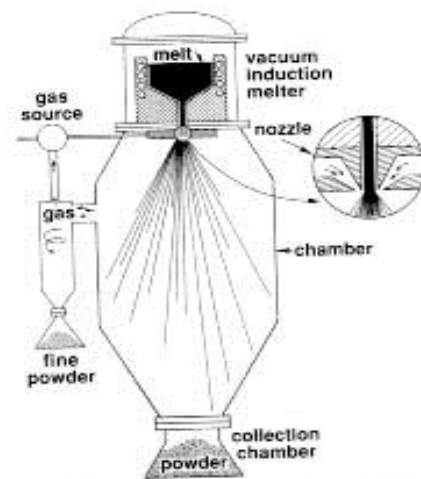


Figure 3 Atomization process

- i. In this process, the molten metal is poured into the atomizing chamber.
- ii. The molten metal comes out through an orifice provided at the bottom of the chamber.
- iii. Heating coils are provided around the chamber to maintain the temperature of molten metal.
- iv. A steam of high pressure water or air or inert gas is passed through a nozzle against the molten metal coming out of orifice.
- v. This makes the metal into finely divided particles (powder) and solidity. The metal powder is collected when falls down.
- vi. This method is used for producing powder of metals having low melting point such as aluminum, lead and zinc.
- vii. In this process the size of the particle depends upon the temperature of molten metal, Pressure and temperature of atomizing water or air or gas and Design or orifice and nozzle.

2.1.3 Advantages of Atomization process

1. Particles with any required size can be obtained.
2. The sizes of all particles are uniform.
3. The production rate is high.

2.2 Electrolytic deposition

- i. It is similar to electroplating process.
- ii. In this method, the metal to be powdered acts as anode (positive) and the metal on which the powder is to be deposited acts as cathode (negative).
- iii. The two metals are dipped into an electrolyte. When D.C. supply is given, the metal from the anode gets deposited on the cathode like sponge. Then the metal powder is separated.
- iv. Electrode is a salt solution of metal to be powdered. Copper sulphate solution is used as electrolyte to produce copper powder. Here, copper plate acts and aluminum plate acts as cathode.

2.2.1 Advantages Electrolytic deposition Process

1. Pure powder can be obtained.
2. The powder will have good moulding properties.

2.2.2 Disadvantages Electrolytic deposition Process

1. It is a slow process.
2. The operating cost is high.

2.2.3 Applications of Electrolytic deposition Process

Metals powders of copper, iron, silver and zinc can be produced by this method.

2.3 Chemical reduction or reduction of oxides

- i. In this method, metal powders can be produced by reducing the metal oxides.
- ii. This powder is heated to a temperature below its melting point in hydrogen atmosphere.
- iii. Tungsten oxide is reduced to tungsten by hydrogen in the form of spongy mass.
- iv. Hydrogen or carbon monoxide is used as reducing agent.

2.3.1 Advantages of chemical reduction process

1. The metal powder is soft.

2. Compacting can be done easily.
3. Production rate is high.

2.3.2 Disadvantages of chemical reduction process

1. It is suitable only for metals which can be reduced easily.
2. The metal oxides should be pure.

2.3.2 Applications of chemical reduction process

This method is suitable for producing powder of metals having high melting point such as tungsten and molybdenum.

3. PROCESS OF POWDER METALLURGY

The process of powder metallurgy involves different steps for the production and finishing components by this technique. The processes of powder metallurgy are divided into following stages. Steps involved in process of powder metallurgy are shown the following figure 4.

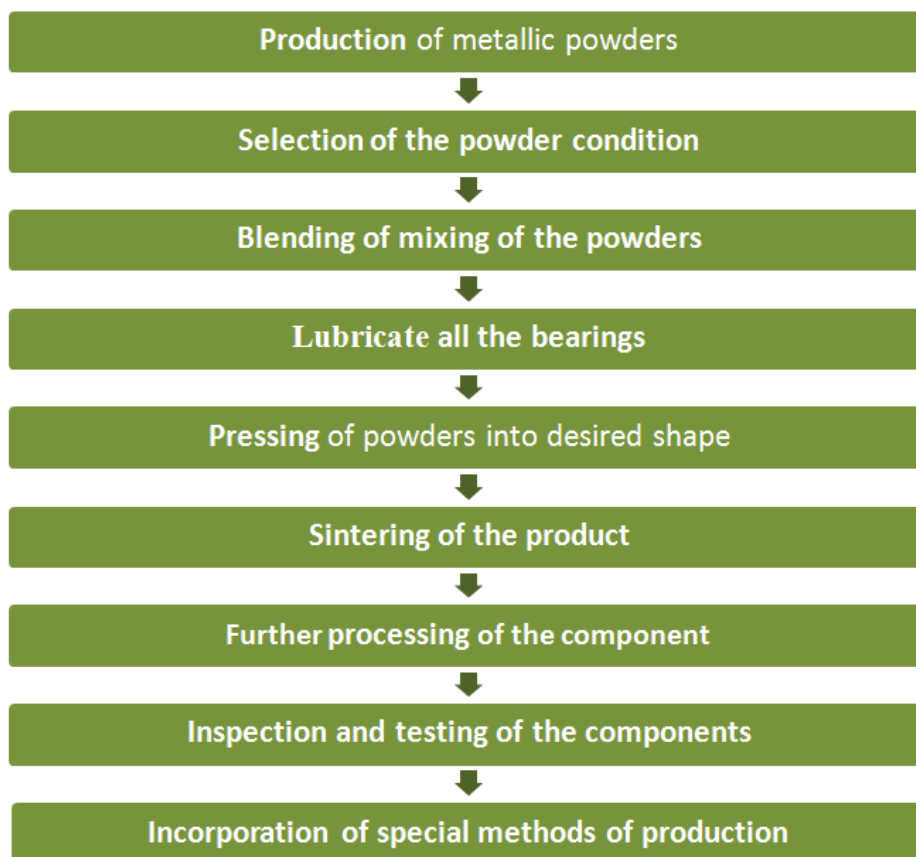


Figure 4 Steps involved in process of powder metallurgy

3.1 Blending or mixing

- i. Blending or mixing is the process of combining metal and non-metal powders with correct proportions to get required properties.
- ii. The particles are uniformly distributed during mixing by using machine. Mixing should be done only for correct duration.
- iii. The friction between die and component during pressing can be reduced by adding lubricants like graphite powder.

3.2 Pressing or compacting

- i. Pressing or compacting is the process of pressing the mixed metal powder into a die to get to get required size and shape.
- ii. It is also called briquetting.
- iii. Two types of pressing are available they are Cold pressing and Hot pressing

3.2.1 Cold pressing

- i. Mechanical or hydraulic press is used for cold pressing
- ii. In this method, the mixed powder was filled in the die cavity and pressed between upper and lower punch
- iii. Thus required shape is obtained
- iv. This process was also called as green compact

3.2.2 Hot pressing

- i. Hard materials like diamond and tungsten carbide metal powders can be pressed by using hot pressing to make the component.
- ii. The mixed metal powder is filled in the die cavity.
- iii. When temperature is below 1000°C Steel dies are used and when the temperature is above 1000°C graphite dies are used.
- iv. The metal powder is heated by the heating coils provided around the die. At the same time, the metal powder is pressed by the upper and lower punch.
- v. Hot pressing is done in vacuum or in an inert gas atmosphere.
- vi. In hot pressing, heating and pressing take place at the same time.

3.2.3 Advantages of Hot pressing

1. Components having high strength and hardness can be obtained.
2. Low compacting pressure is sufficient.
3. No lubricant is required.
4. Components with high density can be obtained.
5. Production rate is high as heating and pressing take place at the same time.

3.2.4 Disadvantages of Hot pressing

1. The cost of the die is high.
2. The life of die is less as it wears out quickly.

3.3 Sintering

- i. Sintering is the process of heating the green compact just below the melting point of its base metal in a controlled atmosphere.
- ii. Sintering process is affected by the temperature, time and atmosphere.
- iii. During sintering, the particles of green compact are fused together.
- iv. This gives required strength, hardness and properties to the component.
- v. Sintering is done in vacuum or inert gas atmosphere.

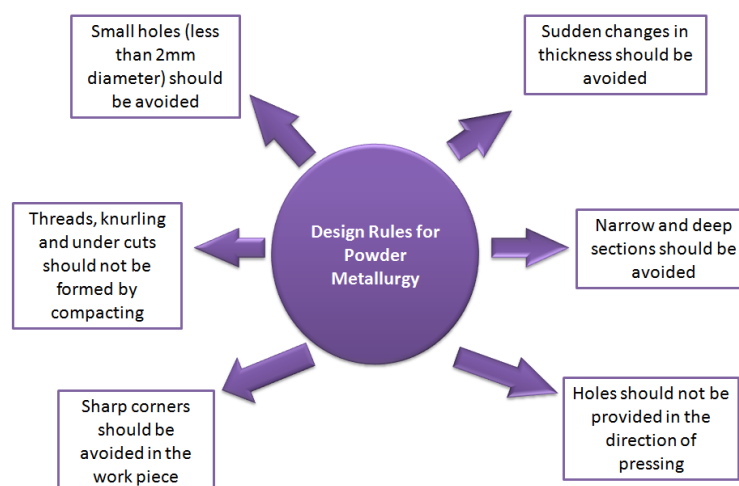
3.4. Secondary operations or finishing operations

The powder metal products can be used directly after sintering. The following finishing operations are done if more surface finish and accuracy are required. These operations are known as secondary operations.

1. Sizing or coining
2. Infiltration
3. Impregnation
4. Machining
5. Heat treatment
6. Plating
7. Joining

4. DESIGN RULES FOR POWDER METALLURGY

The following figure shows the design rules for powder metallurgy



5. APPLICATIONS OF POWDER METALLURGY

The following are the applications of powder metallurgy

1. Porous metal sheets
2. Porous bearings

3. Babbitt bearings for automobiles
4. Cemented carbides
5. Ductile tungsten
6. Cores and electrodes
7. Magnets
8. Glass metal seals
9. Metallic coating
10. Pump rotor gears
11. Motor brushes
12. Refractory material composite
13. Metallic fillers
14. Diamond tools
15. Paints and pigments
16. Metal powder also added to plastic
17. Oil well drills
18. Grinding wheel dressers
19. Diamond cutting process
20. Brake bonds
21. Welding electrodes
22. Graphite electrodes used in arc furnace
23. Cathode, anode and control grids.
24. Heavy duty electrical contacts.
25. Automobile clutch plate, brake lining and motor brushes.
26. Small gears, cam, lever, piston ring and magnets.
27. Nozzles used in rockets and missiles.

6. ADVANTAGES OF POWDER METALLURGY

The following are the advantages of powder metallurgy

1. High dimensional accuracy, shape and surface finish can be obtained
2. No material wastage. This process makes use of 100% of the material
3. The product with required density and porosity can be obtained
4. Components with required properties can be produced by combining metal and non-metal
5. The rate of production is high
6. Cleaner and quicker operation and longer life of the component
7. Super hard cutting tool bits of tungsten carbide are also made by this process
8. Relatively more uniform structure free from defects is obtained
9. Parts with wide variations in material composition can be produced
10. Production of diamond impregnated tool is possible only by this method
11. Electrical and magnetic contact materials are produced by this method
12. Highly skilled and qualified labour is not required
13. Components with complicated shapes can be produced easily.
14. The life of the products is high.
15. Components with high hardness can be made easily.

7. LIMITATIONS OF POWDER METALLURGY

1. It is not economical for small scale production.
2. The cost of equipments and die are high.
3. Large components cannot be produced.
4. The density is not uniform throughout the component.
5. When powder is stored, it may be wasted by oxidation.
6. The broken parts cannot be rejoined.
7. Explosion may occur while handling some metal powders.
8. The health of operator may be affected.
9. Good physical properties of components cannot be obtained.
10. The time for producing metal powder is more.

Conclusion

In this paper, a short note on manufacturing process of metal powders and Steps involved in manufacturing process were given. This paper also covers the advantages, applications and limitation of powder metallurgy. The design rule for powder metallurgy and Steps involved in process of powder metallurgy were given in this paper. This paper would be helpful for the mechanical engineer to study the concept of powder metallurgy.

REFERENCES

- [1] Gowri P. Hariharan, A. Suresh Babu, "Manufacturing Technology I", Pearson Education, 2008
- [2] Roy. A. Lindberg, "Processes and Materials of Manufacture", PHI / Pearson education, 2006
- [3] Paul Degarma E, Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice – Hall of India, 1997.
- [4] Sharma, P.C., "A Text book of production Technology", S. Chand and Co. Ltd., 2004.
- [5] Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 2ndEdition, TMH-2003;2003
- [6] Hajra Chouldhary S.K and Hajra Choudhury. AK., "Elements of workshop Technology", volume I and II, Media promoters and Publishers Private Limited, Mumbai, 1997
- [7] Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2006