Chapter - 1 Scope of powder metallurgy.

Define powder metallurgy.

- Powder metallurgy may be defined as the art and science of producing fine metal powders and then making finished or semi finished objects from these metal powders.
- Sometimes metal powders are incorporated with non-metals, metallic compounds.

Depict the historical development of powder M/c

- Powder metallurgy process dates back to 3000 B.C. when it was adopted by Egyptians to manufacture weapons.

3) Advantages of powder metallurgy:-

1:- High production rate can be achieved.

2:- Good surface finish and close dimensional tolerances can be maintained.

3:- Highly skilled laboan is not required

4:- Quite complex shapes can be produced.

5:- This process makes use of 100% raw material i.e no material is wasted as scrap.

6:- Porous parts can only be produced by this process.

7:- The use of diamond in industry is possible mainly through this method.

8:- Non-metallic substances can be introduced as required.

9:- A wide range of properties i.e porosity, density, size can be obtained for particular applications.

10:- Components obtained possess excellent reproducibility.

Disadvantages of powder Metallurgy :-

1.- The metal powders are very expensive to produce

2.- Storing of metal powders is very difficult due to fire hazards.

3.- This process is not economical for small scale production.

4.- Relatively high tool and die cost is required.

5.- High investment is needed for making large parts.

6.- There are size and shape limitations for the articles produced by this process.

7.- A comparatively dense and compact metal structure can't be produced by this process.

8.- It is difficult to obtain particular alloy powder i.e. brass, bronze, steel etc.

9.- Sintering of low melting point metal powders are very difficult.

10.- Power metallurgy products possess poor plastic properties i.e plasticity, elongation etc.

Primary and Secondary characteristics of powders:

The powder metallurgy process depends on the primary and secondary characteristics of the initial metal powders. The characteristics of metal powders depends upon the method of production of metal powders.

PRIMARY CHARACTERISTICS:-

The basic primary characteristics of metal powders are:-

1- Purity:- The metal powders should be pure.

2. Chemical composition:- The chemical composition of a powder can be determined by chemical analysis methods. chemical composition implies the type and percentage alloying elements and impurities.

3- Particle size:- The particle size is determined by sieving method. metal powder used in PM usually vary in size from 4-200 microns. Particle size influences flow and mixing characteristics, permeability, porosity, density etc.

4- Size distribution:- Size distribution is specified by sieve analysis. Size distribution influences packing of the powder and its behaviour during compacting and sintering.

5- particle shape :- particle shape influences the flow and packing characteristics of powders. There are various shapes of metal powders i.e spherical angular, irregular etc. spherical particles have excellent sintering and irregular particles have superior compacting quality.

6- particle microstructure :- particle microstructure shows various phases, impurities, inclusions and internal porosity.

Secondary characteristics:

The important secondary characteristics of metal powders are:

1- Specific Surface :- The specific surface of a powder is defined as the total surface area per unit weight. (cm^2/gm). It depends on size, shape, density and surface conditions of particles.

2. Apparent density :- Apparent density is defined as the weight of a loosely heaped quantity of powder necessary to fill a given die cavity completely. It is influenced by chemical composition, particlesize, shape, size distribution and method of manufacture.

3- Tap density :- Tap density is the apparent density of the powder after it has been mechanically shaken down or tapped. It depends upon particles size, shape and roughness. It is determined by Ro-tap method.

4- Flow rate :- Flow rate measures the ability of a powder to be transferred. It is defined as the rate at which a metal powder will flow under gravity from a container through an orifice. Flow rate depends upon size, shape and apparent density. Powders of high flow rate are better for high rate of production and economy.

Spherical shaped powder has maximum flow rate and dendritic shaped powder has ~~maximum~~ minimum flow rate.

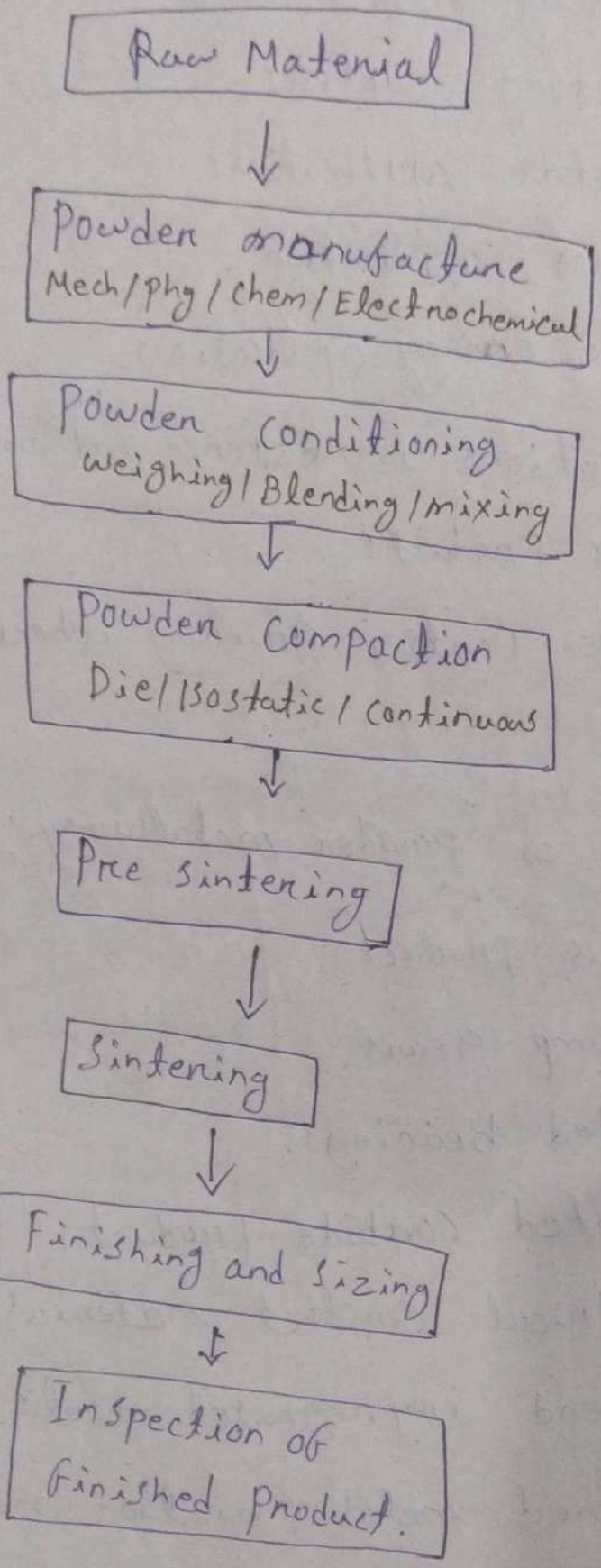
Application of powder Metallurgy:

1- Refractory metals.
2- Refractory Carbides.
3- Automotive applications
4- Aerospace applications.
5- Atomic energy applications.
6- Applications in defence and military
7- porous products
8- Tungsten parts, grinding wheels.

Products of powder metallurgy:

1- Ferrous product
2- oil pump gears.
3- Babitted bearings.
4- Cemented Carbide product.
5- Electrical Contact materials.
6- Diamond impregnated tools.
7- Sintered metal friction materials

4) Flow Diagram of powder metallurgy:-



Chapter - 2 Methods of powder production.

A - MECHANICAL METHODS:

(i) Atomization
(ii) Crushing
(iii) Grinding / Milling
(iv) Machining
(v) Shotting
(vi) Grading

B - PHYSICO - CHEMICAL METHOD:

(i) physical method:-
- Condensation
- Thermal decomposition.

(ii) Chemical method:-
- Reduction
- Intergranular corrosion
- Oxidation and decarburizati

(iii) Electro - chemical method:-
- Electro - deposition

Short note of metal powder:-

=> The particle size of metal powders falls in a range of 1 - 100 μ and the range of 10 - 20 μ being predominent. (N.B: 1 μ = 10⁻⁶ mt)

-> There are various methods of producing powder of this size range.

Different shapes of metal powder:-
- Spherical - Rounded - Angular - Acicular - Irregular

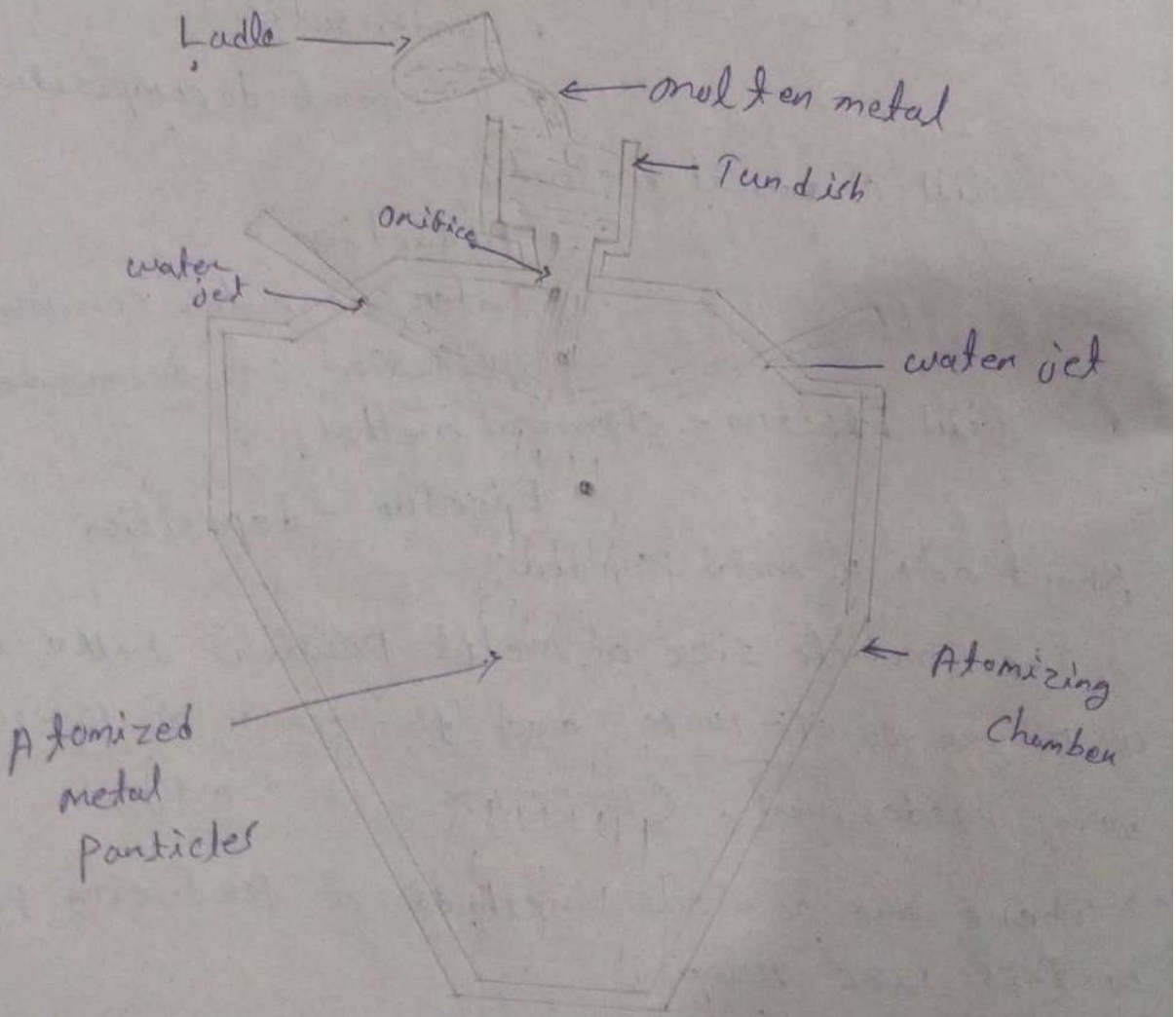
Brief description of methods:-

Atomization:-

- Atomization is utilised to produce metal powder
- In Atomization; the molten metal is forced through an orifice and as it emerges, a high pressure stream of liquid falls on it, causing it to atomize into fine particles. An inert gas is employed to improve the purity of the powder.

⇒ Generally atomization is used for low melting point metals because of the corrosive action of metal on the orifice at high temperature.

Diagram of atomization



CRUSHING :-

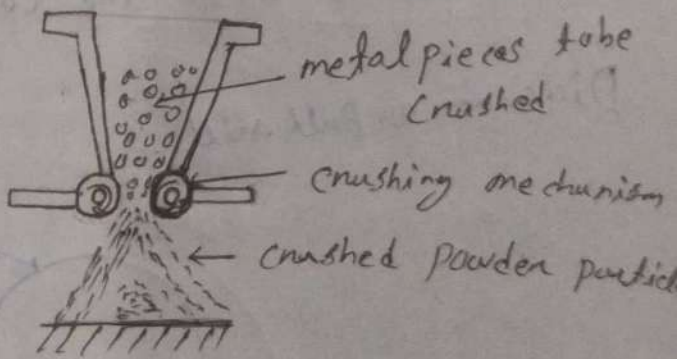
=> This method is mostly applicable to brittle materials.

=> Any type of crushing equipment i.e stamps, hammers, jaw crushers or gyratory crushers may be employed for crushing.

=> Various ferrous and non-Ferrous alloys are heat treated in order to obtain sufficiently brittle material which can be easily crushed in to powder from.

=> The powders produced by crushing are of angular shape which are further comminuted by Grinding to attain required fineness of powder suitable for P/M.

Diagram of crushing



MILLING :-

=> It is the most widely used method of producing powders.

=> Milling or grinding involves the Comminution of brittle, friable, tough and hard materials.

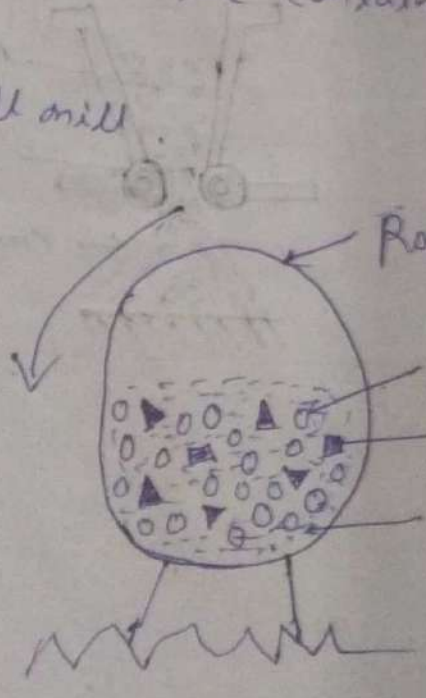
=> It involves the application of impact force on the material being Comminuted.

=> Milling requires equipments like ball mill, Rod mill, impact mill etc.

=> Very fine powder particles can be produced by milling operation.

=> A Ball mill is a horizontal barrel-shaped Container holding a quantity of balls, which being free to tumble about as the container rotates crush the particle that are introduced into the container.

Diagram of Ball mill



Physical method :

CONDENSATION :-

=> This technique is used for metals like Zinc Magnesium and Cadmium, which can be boiled and the vapour are condensed in a powder form.

=> This method is not used for large scale production.

=> very fine powder of high purity can be obtained by this method.

chemical method:

Reduction:-

=> In reduction process, the compounds of metals are reduced with CO or H_2 at temperatures below the melting point of the metal in an atmosphere controlled furnace. The reduced product is then crushed and ground.

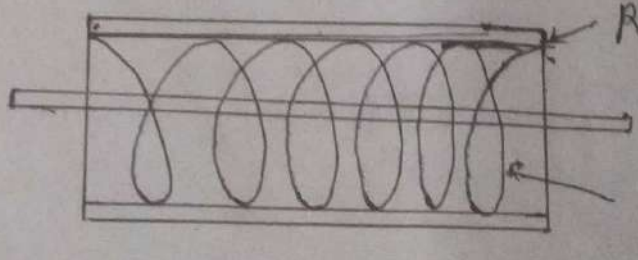
=> Large quantities of iron powder are produced by reduction of the appropriate metal oxide. Sponge Iron powder is produced in the way.

=> Powders of Copper, Tungsten, Molybdenum, Nickel and Cobalt are also manufactured by reduction method.

=> Reduction process is a convenient, economical and flexible method of powder production.

=> The largest volume of metallurgical powders are made by reduction method.

Diagram of Reduction



electro - chemical method:-

ELECTRODEPOSITION:-

This method is mainly used for the production of extremely pure powders of iron and copper.

=> Electrodepsition is similar to electroplating process.

=> For making copper powder; copper plates are placed as anodes in a tank of electrolyte. Aluminium plates are placed as cathodes in the electrolyte.

=> High electric current produces a powdery deposit of anode metal on the cathodes.

=> After a definite time period, the cathode plates are taken out from the electrolytic tank, rinsed to remove the electrolyte and dried.

=> Then the copper deposited on the cathode plates is scraped off and pulverised to produce powder of desired grain size.

Diagram of electrodeposition