

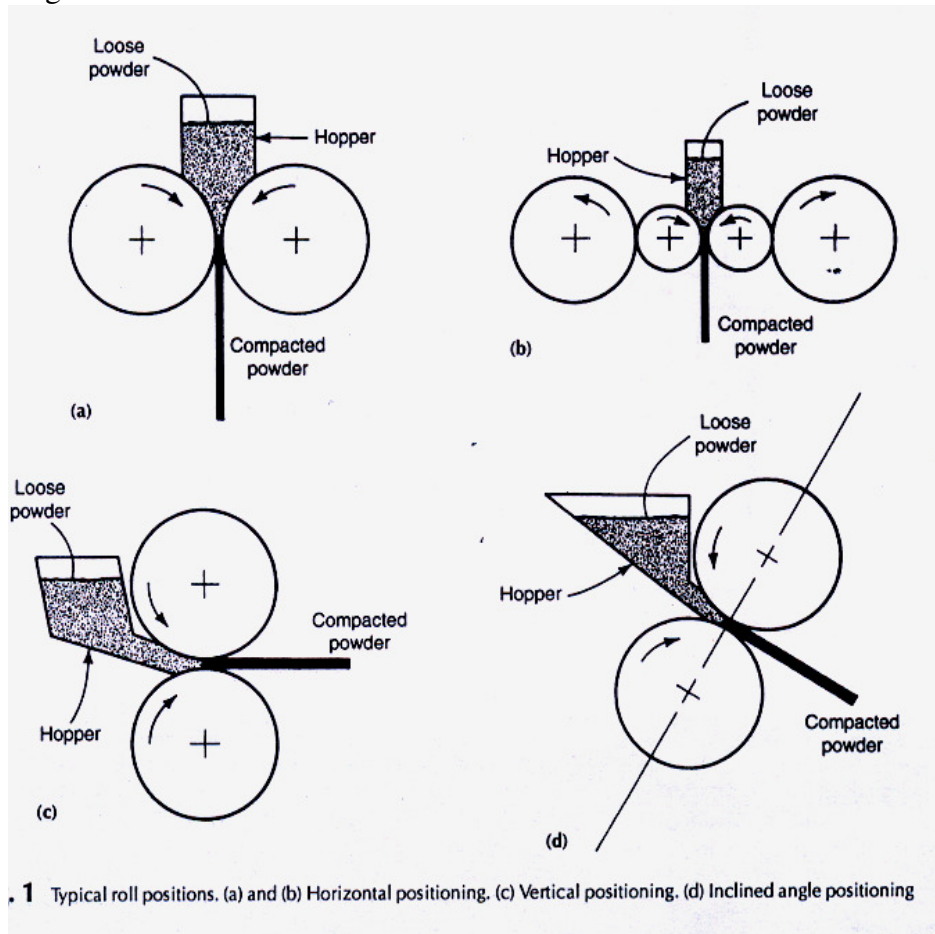
Part B

Unit8 (Class16) Powder Metallurgy

Powder Production Reduction, Electrolytic deposition, Pulverization, Mechanical Alloy and others Blending of powders Compaction of Powders Punch and Die, Rolling, Extrusion, Injection Moulding, Isostatic Pressing Sintering Typical Sintering set up

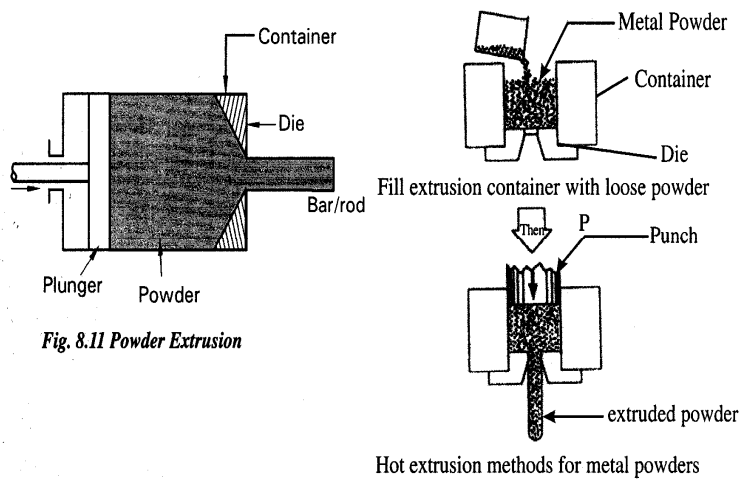
Powder Rolling

*In powder rolling (powder compaction) the powder is fed into the roll gap in a two high rolling mill and is compacted into a continuous strip at speeds up to 0.5m/s. *The process can be carried out at room temperature or at elevated temperatures. *Sheet metal for electrical and electronic components, coins can be made by powder rolling.



Powder Extrusion

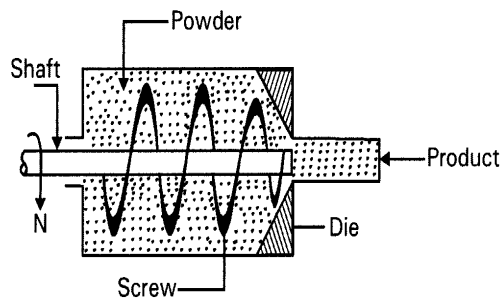
*Powders can be compacted by extrusion. *The metal powder is encased in a container and extruded. *After sintering, preformed PM parts may be rolled or forged in a closed die to their shape.



Powder Injection Moulding

*It is also called metal injection moulding.*Very fine metal powders ($<10\mu\text{m}$) are blended with a polymer or a wax based binder.*The blended mixture undergoes compaction due to pressure.*The green compacts are heated in a oven at low temperature to burn off plastic and then sintered in a furnace.

Pressing can be carried out either at room temperature or at elevated temperature.*The powder must flow easily into the die cavity.*The density of the green compact, depends on pressure applied during compaction.*By using particles of different shape, very close packing of the metal powder can be achieved*Higher density results in higher strength and higher elastic modulus of the components.



The normal compaction pressure ranges from 70Mpa for aluminium to 800Mpa for iron parts.*Crank or eccentric type mechanical presses are used for small tonnage.*Toggle or knuckle joint presses are used for higher capacities.*Hydraulic process (450MN) are employed for large components. Compaction can also be carried out by a number of other processes such as

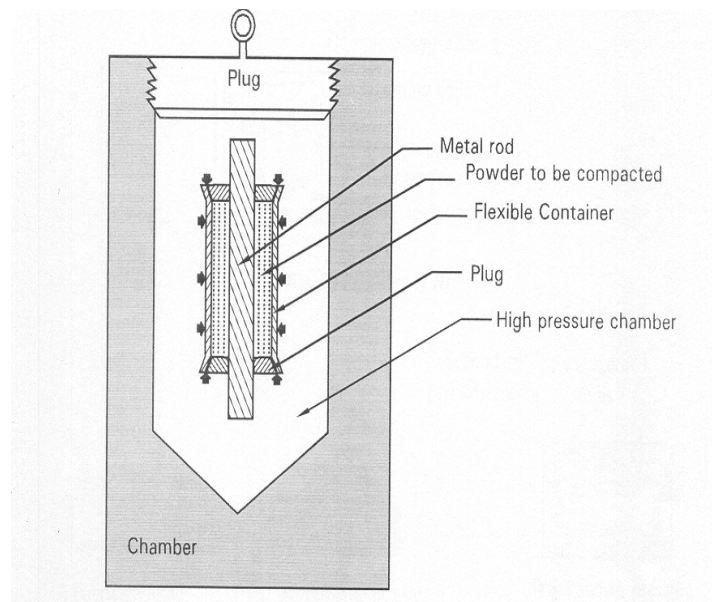
isostatic pressing, rolling and forging. *Since the density of the compacted powders can vary significantly, green compacts are subjected to hydrostatic pressures in order to achieve more uniform density.

Isostatic pressing:

*This type of operation is used for compaction of powders. *The process is similar to pressing using cupped hands for making snow balls.

Cold Isostatic Pressing

*In cold isostatic pressing (CIP) the metal powder is placed in a flexible mould made of rubber or Urethane or PVC. *The assembly is then pressurized hydrostatically in a chamber usually using water. *Pressures of 400 to 1000MPa are used.



Cold Isostatic Pressing

The powder is enclosed in flexible container around a solid core rod. Pressure is applied isostatically to the assembly inside a high pressure chamber. The powder gets compacted and the green compact is taken out and sintered.

Hot Isostatic Pressing

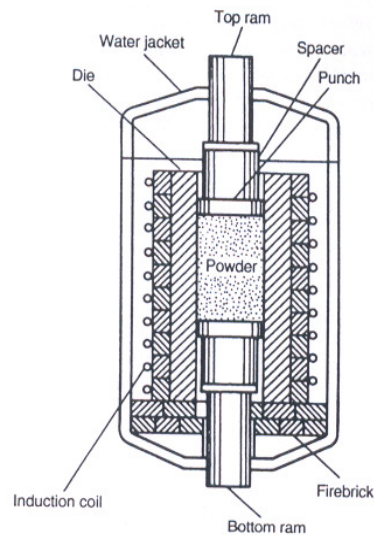
In Hot Isostatic Pressing (HIP) a metal powder is stressed using inert gas in a metal container. *Pressure of 100MPa at 1000oC is used. *Here a container made of very high melting point metal is used. *An inert gas is used as the pressuring media. The main advantage of HIP is its ability to produce compacts with essentially 100% density, good

metallurgical bonding among the particles with good mechanical properties*HIP process is relatively expensive

and is used for making super alloy components for aerospace industry.

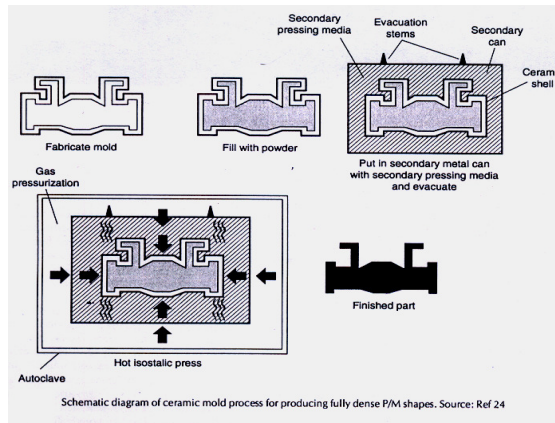
*It is regularly used for the densification of WC cutting tools and PM tool steels.

HIP is also used to close the internal porosity and improve properties in superalloy and Ti alloy castings for the aerospace industry. The main advantage of isostatic pressing is the absence of wall friction as pressure is being applied from all directions. It produces compacts of practically uniform grain structure and density irrespective of shape.



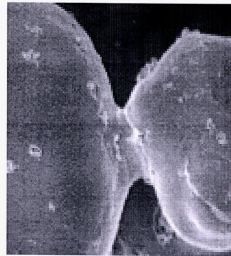
Hot Isostatic Pressing

Figure shows the details of producing PM component. Here a mold is used into which metal powder is filled. This is then surrounded by a secondary pressing media. Then vacuum is applied. The entire assembly is kept in an autoclave chamber and subjected to HIP. Necessary pressure is applied through the chamber and temperature is maintained at a known value. As a result the compacted metal powder gets sintered. Finally the component is taken out of the system to get the finished part.



Step 4: Sintering

- It is the heating of the compacted metal powders to a temperature above their recrystallisation temperature but below their melting point.



Sintering or consolidation at high temperatures

Sintering

Sintering is a process wherein the compressed metal powder is heated in a controlled atmosphere using a furnace. The temperature of the furnace will be slightly below melting point of the metal powder but above the RCT.

After sintering, the strength of the metal compact will be very high.

Sintering mechanisms are highly complex in nature & depends on the composition of the metal powder and the processing parameters.

Normally at high temperatures the particles begins to form a strong solid state bonding by diffusion. This results in high strength, high density, high ductility and other properties. During sintering the component undergoes shrinkage as in castings. This needs to be taken care of.

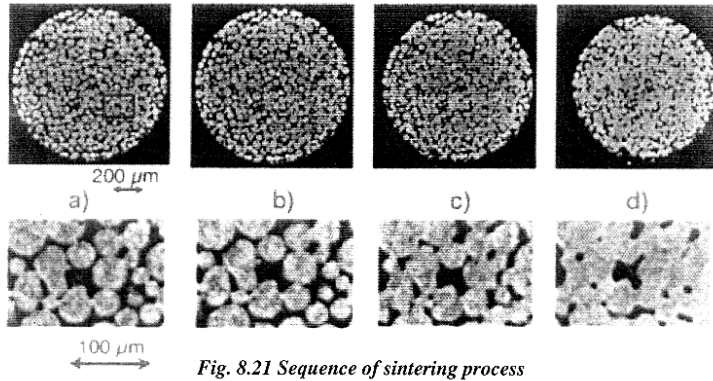


Fig. 8.21 Sequence of sintering process

The sintered component is taken and necessary grinding/finishing of the component is carried out, such that the final dimensional accuracy is achieved. For this, a variety of machining operations will be carried out.