# MANUFACTURING PROCESS

## POWDER METALLURGY

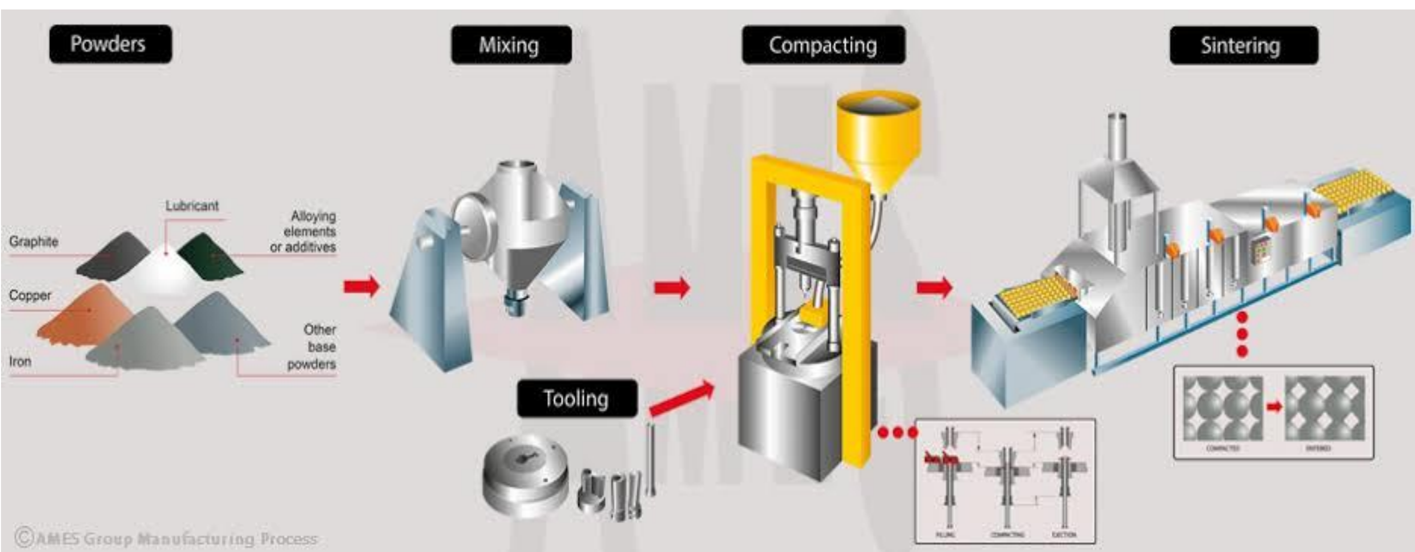
### INTRODUCTION

Powder metallurgy is used for manufacturing products from powdered metals by placing these powders in molds and are compacting the same using heavy compressive force. Typical examples of such products are grinding wheels, filament wire, magnets, welding rods, tungsten carbide cutting tools, bearings and turbines blades having high temperature strength.

The manufacture of parts by powder metallurgy process involves the manufacture of powders, blending, compacting, sintering and a number of secondary operations such as sizing, coining, machining, impregnation, infiltration, plating, and heat treatment.

The compressed products are then heated to temperatures much below their melting points to bind the particles together and improve their strength and other properties.

The products made through this process are very costly on account of the high cost of metal powders as well as of the dies used. The application of powder metallurgy process is economically feasible only for high mass production. Parts made by powder metallurgy process exhibit properties, which cannot be produced by conventional methods. Simple shaped parts can be made to size with high precision without waste, and completely or almost ready for installation.

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**POWDER METALLURGY PROCESS**

The powder metallurgy process consists of the following basic steps:

1. Formation of metallic powders.
2. Mixing or blending of the metallic powders in required proportions.
3. Compressing and compacting the powders into desired shapes and sizes in form of products.
4. Sintering the compacted articles in a controlled furnace atmosphere.
5. Subjecting the sintered articles to secondary processing if needed so.

**PRODUCTION OF METAL POWDERS**

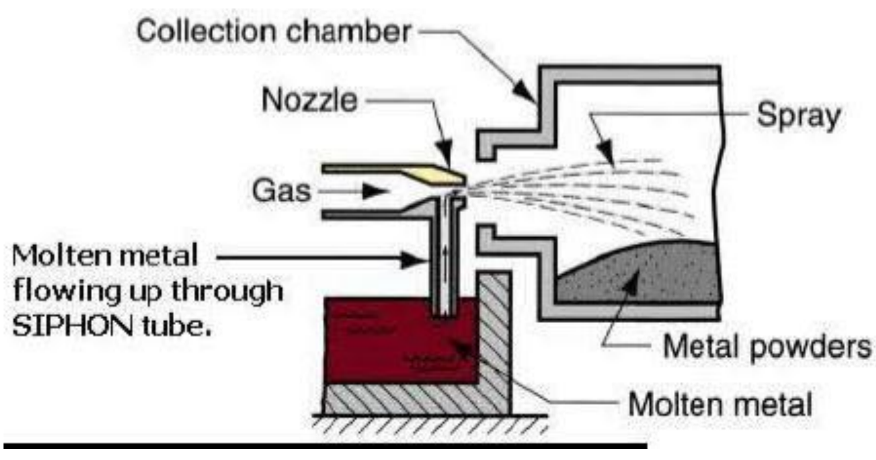
Metallic powders possessing different properties can be produced easily. The most commonly used powders are copper-base and iron-base materials. But titanium, chromium, nickel, and stainless steel metal powders are also used. In the majority of powders, the size of the particle varies from several microns to 0.5 mm. The most common particle size of powders falls into a range of 10 to 40 microns.

There are various methods of manufacturing powders. The commonly used powder making processes are given as under.

1. Atomization
2. Crushing process
3. Milling process
4. Electrolytic process

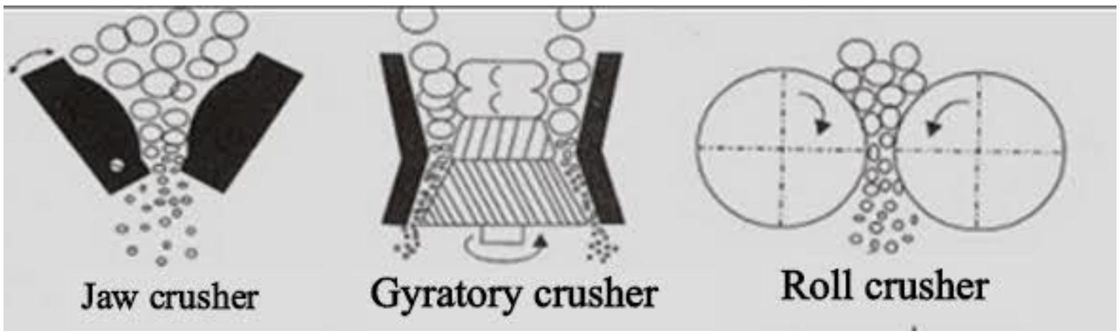
**Atomization**

Atomization involves the formation of powder from molten metal using a spray of either a gas or liquid. This is the most significant method of producing metal powder particles. In gas atomization, generally inert gases like nitrogen, helium, or argon are used for breaking up the stream of molten metal.



## Crushing Process

The crushing process requires equipments such as stamps, crushers or gyratory crushes. Various ferrous and non-ferrous alloys can be heat-treated in order to obtain a sufficiently brittle material which can be easily crushed into powder form.

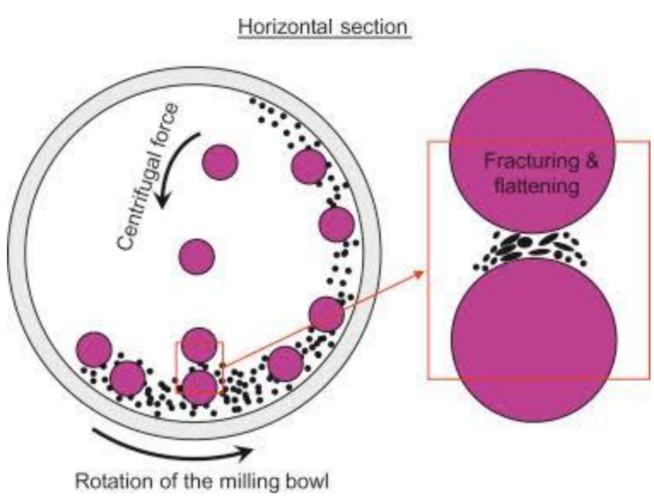



## Milling Process

The milling process is commonly used for production of metallic powder. It is carried out by using equipments such as ball mill, impact mill, vortex mill etc. Milling and grinding process can easily be employed for brittle, tougher, malleable, ductile and harder metals to pulverize them.

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 and abrade any powder particles that are introduced into the container.

Generally, a large mass to be powdered, first of all, goes through heavy crushing machines, then through crushing rolls and finally through a ball mill to produce successively finer grades of powder.



**Electrolytic Process**

Electrolysis process is quite similar to electroplating and is principally employed for the production of extremely pure, powders of copper and iron. For making copper powder, copper plates are placed as anodes in a tank of electrolyte, whereas, aluminium plates are placed in to the electrolyte to act as cathodes. High amperage produces a powdery deposit of anode metal on the cathodes. After a definite time period, the cathode plates are taken out from the tank, rinsed to remove electrolyte and are then dried. The copper deposited on the cathode plates is then scraped off and pulverized to produce copper powder of the desired grain size.

**COMPACTING OF POWDER**

Compacting is the technique of converting loose powder in to compact accurately defined shape and size. This is carried out at room temperature in a die on press machine. The press used for compacting may be either mechanically or hydraulically operated. The die consists of a cavity of the shape of the desired part.

Metal powder is poured in the die cavity and uniform pressure is applied using punches, which usually work from the top and bottom of the die as shown in Fig 25.1. Dies are usually made of high grade steel.

The metal parts obtained after compacting are not strong and dense. To improve these properties, the parts should be sintered.

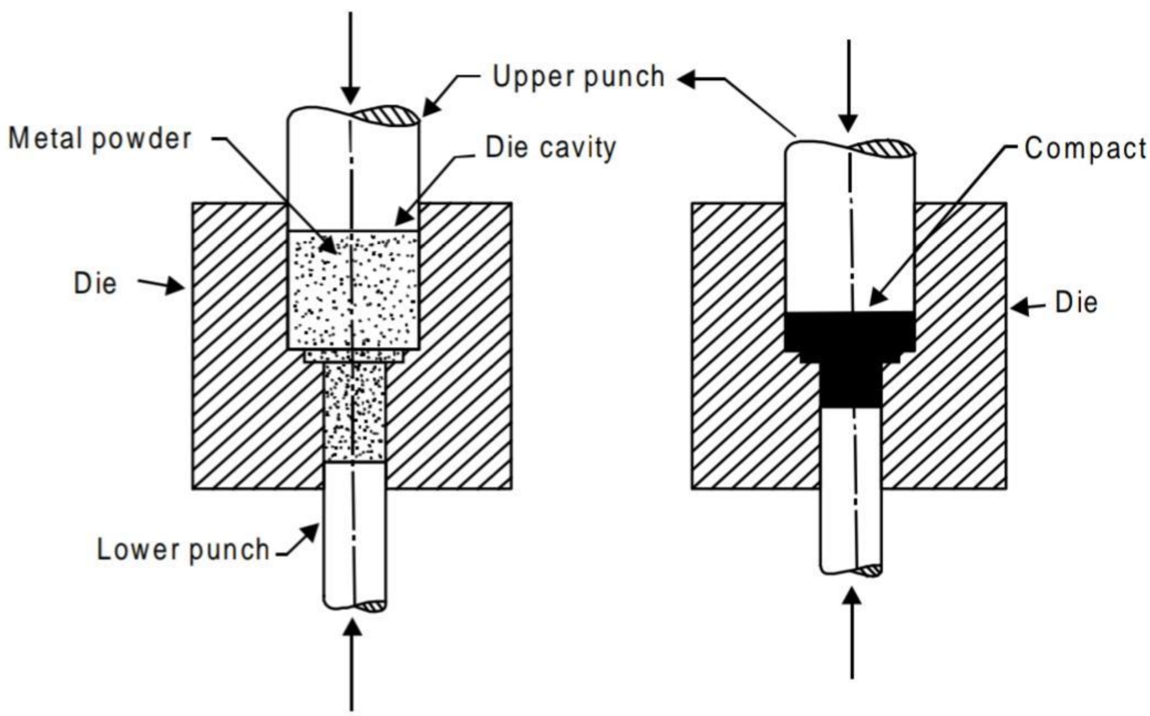
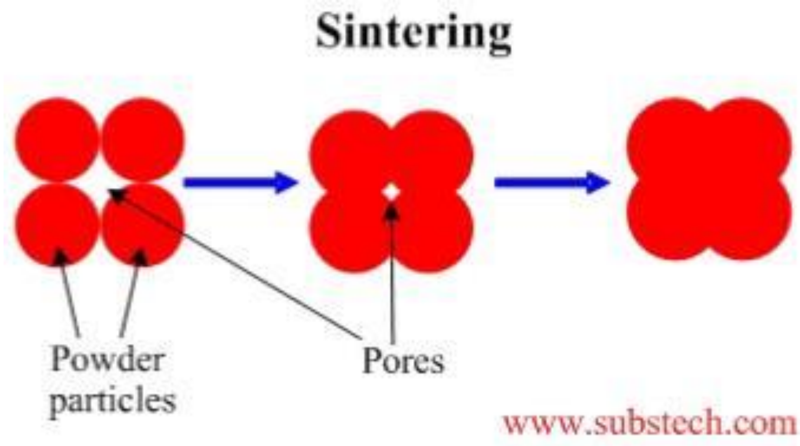



**Fig. 25.1** Powder metallurgy die setup

**SINTERING**

Sintering is the process of heating of compacted products in a furnace to below the melting point of at least one of the major constituents. In the sintering furnace, the metal parts are gradually heated at the required temperature. During this gradually heating process, powders bond themselves into coherent bodies. Sintering results in strengthening of fragile green compacts produced by the pressing operation. It also increases electrical conductivity, density and ductility of the powder metal parts.




**CHARACTERISTIC OF METAL POWDERS**

The performance of powder metallurgical parts is totally dependent upon the characteristics of metal powders. Most important characteristics of metal powders are powder particle size, size distribution, particle shape, purity, chemical composition, flow characteristics and particle microstructure. Some of the important properties are discussed as under.

**Powder Particle Size and Size Distribution**

Particle size of metal powder is expressed by the diameter for spherical shaped particles and by the average diameter for non-spherical particle as determined by sieving method or microscopic examination. Metal powders used in powder metallurgy usually vary in size from 20 to 200 microns. Particle size influences density/porosity of the compact, mold strength, permeability, flow and mixing characteristics, dimensional stability, etc. Particle size distribution is specified in terms of a sieve analysis.

**Particle Shape**

There are various shapes of metal powders namely spherical, sub-rounded, rounded, angular, sub-angular, flakes etc. Particles shape influences the packing and flow characteristics of the powders.

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**Chemical Composition**

Chemical composition of metallic powder implies the type and percentage of alloying elements and impurities. It usually determines the particle hardness and compressibility. The chemical composition of a powder can be determined by chemical analysis methods.

**Particle Microstructure**

Microstructure of these powders will reveal not only various phases, inclusion impurities and internal porosity, but also the particle size, relative size distribution and particle shape.

**Apparent Density**

Apparent density is defined as the weight, of a loosely heated quantity of powder necessary to fill a given die cavity completely.

**Flow Characteristics**

Flow-ability of metal powders is most important in cases where moulds have to be filled quickly. Metal powders with good flow characteristics fill a mould cavity uniformly. On the other hand poor flow properties of the powder result in slow and uneconomical feeding of the cavity and the possibility during pressing of uneven filling of the die cavity.

**ADVANTAGES OF POWDER METALLURGY**

1. The processes of powder metallurgy are quite and clean.
2. Any complicated shape can be manufactured.
3. The dimensional accuracy and surface finish obtainable are much better for many applications and hence machining can be eliminated.
4. Unlike casting, press forming machining, no material is being wasted as scrap and the process makes utilizes full raw material.
5. High production rates can be easily achieved.
6. The components produced by this process are highly pure and bears longer life.
7. Parts with wide variations in compositions and materials can be produced.
8. Highly skilled labor is not required.

**DISADVANTAGES OF POWDER METALLURGY**

1. Powder metallurgy process is not economical for small-scale production.
2. The cost of tool and die of powder metallurgical set-up is relatively high
3. It is not easy to convert brass, bronze and a numbers of steels into powdered form.
4. It may be difficult sometimes to obtain particular alloy powders.
5. Complex shapes produced by casting cannot be made by powder metallurgy because metallic powders lack the ability to flow to the extent of molten metals.
6. Metal powders are expensive and in some cases difficult to store.

7. The equipment used for the operation is costly.

## APPLICATIONS OF POWDER METALLURGY

1. Porous products such as bearings and filters.
2. Products of complex shapes that require considerable machining when made by other processes namely toothed components such as gears.
3. Refractory parts such as components made out of tungsten and molybdenum are used in electric bulbs, radio valves, oscillator valves, X-ray tubes in the form of filament etc.
4. Components used in automotive part assembly such as electrical contacts, crankshaft drive or camshaft sprocket, piston rings etc.
5. Various machine parts are produced from tungsten powder.
6. Copper and graphite powders are used for manufacturing automobile parts and brushes.