

## **Introduction**

Powder technology (P / T) processing has become an advanced important technique, which many materials were produced by these processes.

The most important reason to use ( P / T) that many materials are difficult to melt and cast, as for example ceramic materials, hard metals, cermet or refractory metals, Another reason for using powder technology may be that it is economically attractive to make mass production complex shaped structural parts by powder compaction and sintering,

Though many of the engineering applications are served by metals and alloys, other engineering materials like ceramics and polymers still does play some crucial roles in engineering. Ceramics are especially important in many high temperature applications. Important applications of ceramics involve, for example, tools, protection covers from extreme environments.

Ceramics form an important part of materials group. Ceramics are compounds between metallic and nonmetallic elements for which the inter-atomic bonds are either ionic or predominantly ionic. The term ceramics comes from the Greek word *keramikos* which means 'burnt stuff'.

### **Characteristics of ceramics are:**

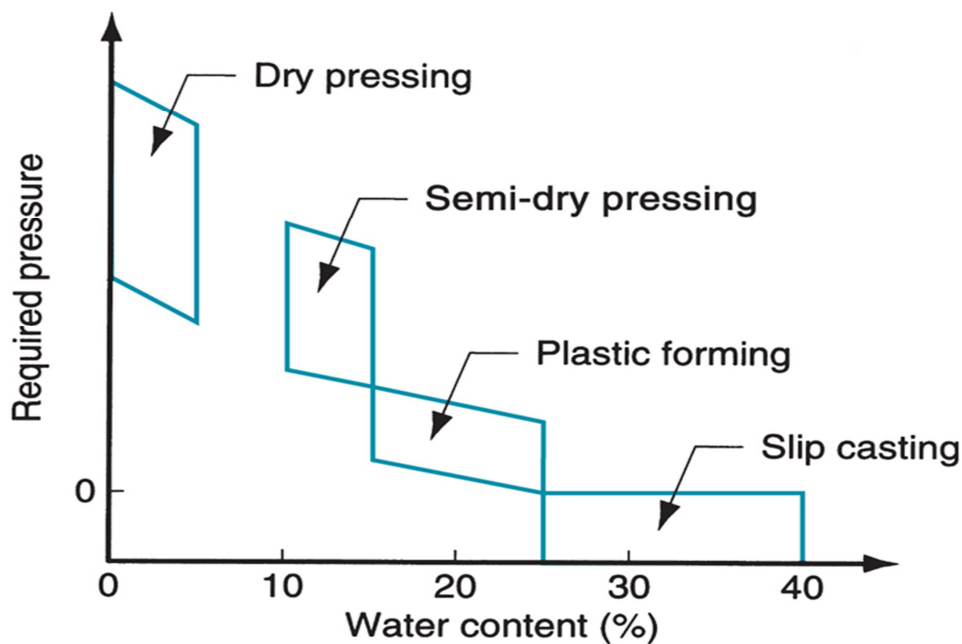
1. High temperature stability
2. High hardness
3. Brittleness
4. High mechanical strength
5. Low elongation under application of stress
6. Low thermal and electrical conductivities.

### **Classification**

Ceramics are classified in many ways. It is due to divergence in composition, properties and applications.

- Based on their composition,
  1. Oxides
  2. Carbides
  3. Nitrides
  4. Sulfides
  5. Fluorides

- Based on their specific applications,
  1. Glasses
  2. Clay products
  3. Refractories
  4. Abrasives
  5. Cements
  6. Advanced ceramics for special applications
- Based on their engineering applications
  1. Traditional ceramics – most made-up of clay, silica and feldspar  
 Traditional ceramics are made from minerals occurring in nature, Powders are mixed with water to bind them together and achieve proper consistency for shaping, Fig -1- show the effect of water content in shaping processes.  
 Products: pottery, porcelain, bricks, and cement
  2. Engineering ceramics (new ceramics) – these consist of highly purified aluminium oxide ( $\text{Al}_2\text{O}_3$ ), silicon carbide (SiC), silicon nitride ( $\text{Si}_3\text{N}_4$ ), Carbon Boron Nitride (CBN), Titanium Carbide (TiC), and Tungsten Carbide (WC). For new ceramics substances other than water are used as binders during shaping  
 Products: cutting tools, artificial bones, nuclear fuels, substrates for electronic circuits.



(Fig-1) Effect of Water Content in Shaping Processes

## **POWDER SYNTHESIS METHODS**

### **INTRODUCTION**

A variety of methods exist for the synthesis of ceramic powders. It divided them into two categories: mechanical methods and chemical methods.

Mechanical methods are generally used to prepare powders of traditional ceramics from naturally occurring raw materials. Powder preparation by mechanical methods is a fairly mature area of ceramic processing in which the scope for new developments is rather small.

Chemical methods are generally used to prepare powders of advanced ceramics from synthetic materials or from naturally occurring raw materials that have undergone a considerable degree of chemical refinement. Powder preparation by chemical methods is an area of ceramic processing that has seen several new developments in the past 25 years and further new developments are expected in the future. Table 1 provides a summary of the common powder preparation methods for ceramics.

#### **A. Mechanical Processes**

powder preparation by mechanical disintegration widely employed in P / M. This is however a time – taking process rendering low yields. There are six methods of mechanical combination of metals and alloys, as indicated above.

##### **1) Machining**

This method is employed to produce filings, turnings, scratching's, chips, etc. which are subsequently pulverized by crushing and milling. Since relatively coarse and bulky powders entirely free from fine particles are obtained by this method. The powder particles produced are of irregular shape. This method is highly expensive and therefore has a limited application.

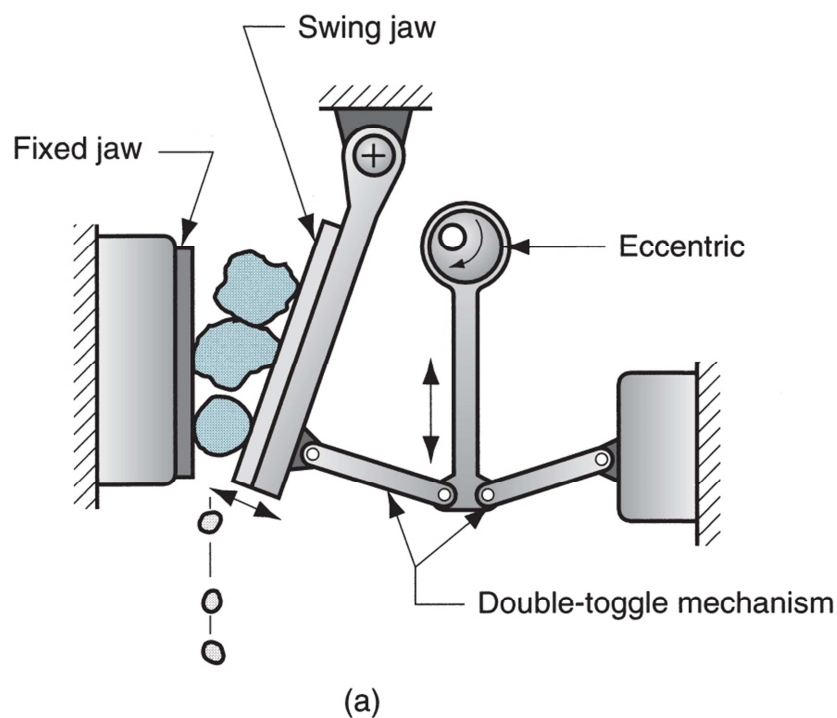
This is especially employed where cost is not excessive in relation to the cost of the powders themselves.

## 2) crushing

This method is mostly used for disintegration oxides (subsequently reduced to metal powders) and brittle materials, Any type of crushing equipment such as a tamps ; hammers, jaw crushers (fig -2) or gyratory crushes may be employed for crushing brittle powders.

Various alloys, can be heat treated in order to obtain a sufficiently brittle material which can be easily crushed into powder.

The powder produced by this method are of angular shape which are subsequently comminuted by milling to attain the required fineness of the powder for processing by (P / M) technique.



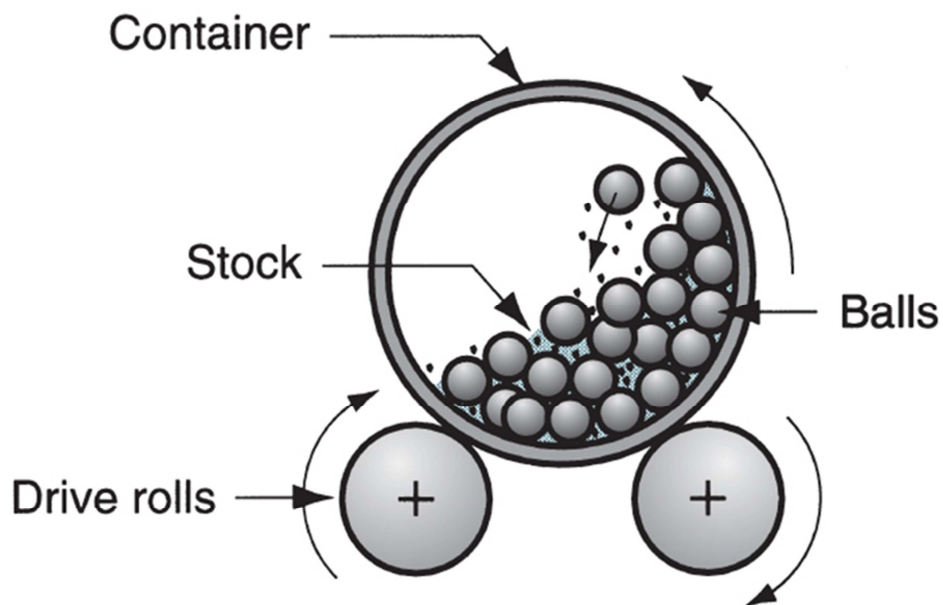
**(Fig-2) Jaw Crusher**

## 3) Milling

Milling is the most important and widely used method of producing powders of the required grade of fineness, Milling or grinding

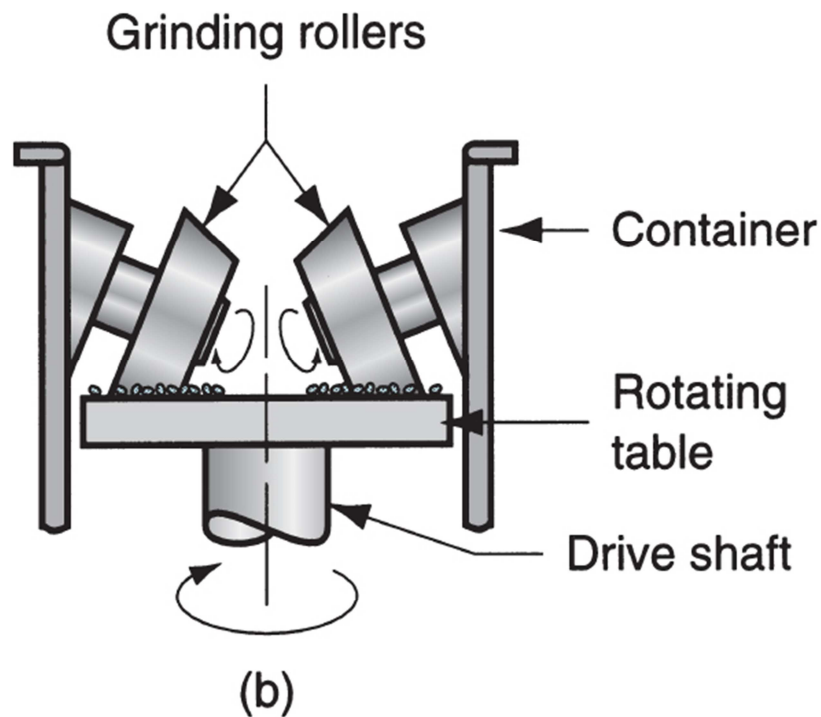
can be classified as comminution of brittle, friable, tough and hard materials and pulverization of malleable and ductile metals. It involves the application of impact force on the material being comminuted. The milling action is carried out by the use of a wide variety of equipment's such as ball mill, roll mill, impact mill, disk mill, eddy mill, vortex mill, etc.

(Fig -3) shows a schematic diagram of a simple ball mill, In the ball milling method, the material to be disintegrated is tumbled in a container together with a large number of hard wear resistant, solid balls which by hitting the materials, cause them to break down. The ball mill are of two types rotary mill and vibratory mill. Mixture is carried upwards in container as it rotates, then dropped by gravity to accomplish grinding action.



(a)

**(Fig-3) Ball mill**



**(Fig-4) Roll mill**

The latter produces equivalent grinding in a very short time as compared with the former type and more efficient grinding action takes place due to vibration with rotary motion.

The powder so produced is also less contaminated because of smaller wear on balls and mills. The drums of rotary mills are usually made of stainless steel or steel lined with hard alloy plate are most frequently used since milling by other means will cause the contamination of the finished powder by iron (greater than 0.5%) due to wear of the lines and balls

#### **4) Shooting**

The method consists essentially in pouring a fine stream of molten metal through a vibrating screen into air or neutral atmosphere. In this way, molten metal stream is, disintegrated into a large number of droplets which solidify as spherical particles during its free fall. All metals and

alloys can be shot, the size and character of the resultant shot depending on the temperature of molten – metal and gas, diameter of the holes and frequency of vibration in case of vibrating screen. One drawback of this process is formation of high oxide content which can be minimized with the use of inert gas.

### **5) Graining**

Graining involves the same procedure as the shooting the only difference being that the solid defecation is allowed to take place in water. In similar manner, other pulverization methods are used for the production of very fine powders.

### **6) Atomization**

Basically atomization consists of mechanically disintegration a stream metal into the fine particles by means – of a jet of compressed air, inert gases or water. The method has gained greater use because of the following advantages and benefits:-`

- 1) virtually any material that can be melted can be made into powder by this technique.
- 2) Relative ease of preparing high purity metals, and prealloyed powders directly from the melt.
- 3) Similar and uniform composition of atomized powder .
- 4) Control of particle size, size distribution, shape and structure are made possible by the control of atomization processing parameters, i.e liquid metal super heat or viscosity, atomization pressure, geometry and of the atomization stream.
- 5) Lower capital or investment cost and.
- 6) High product, for example, it is shown, it is now possible to atomize to tons.