4.5 CERAMIC MANUFACTURING METHODS

The various steps to be considered for the processing are

(i) **raw material processing,**

(ii) **fabrication**

(iii) **densification.**

The raw material powder is thoroughly mixed with water and other ingredients to obtain flow characteristic depending on particular processing technique. The different fabrication processes that are used for many years are

(a) **casting,**

(b) **extrusion**

(c) **dry processing.**

SLIP CASTING

Casting is a familiar process used for ceramic forming. In this process, the raw materials are mixed with a stable suspension of fluid like water in the range of 25 - 30 vol.%. **This suspension is known as** *slip*.

The slip is poured into a porous mold which is made of plaster of paris. The slip is absorbed into the mold wall leaving behind a solid layer on the mold.

The thickness of solid layer depends on the length of time in mold. This process is continued until the entire mold cavity becomes solid. **This process is known as** *slip casting* and the various stages are shown in Fig. 4.21.

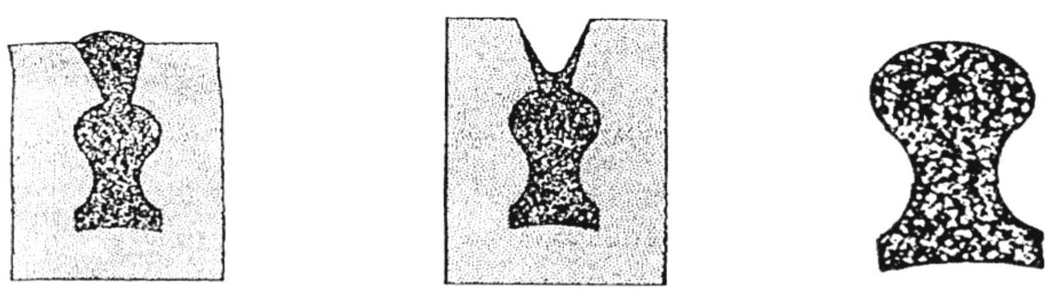

Fig. 4.5.1- Solid slip casting

Advantages:

The main advantage of slip casting is the ability to form intricate shapes at relatively low cost.

The complex ceramics shapes which are produced using slip casting include turbine engine rotors, automobile wings, etc.

ISOSTATIC PRESSING

In *isostatic pressing method*, a uniform pressure is applied on all sides.

The raw material is filled in rubber mold and it is sealed with plate and metal mandrel. The sealed rubber mold is inserted into liquid.

The liquid is kept inside the pressure vessel and preferably non compressible. The top of the pressure vessel is closed after inserting the rubber mold.

A hydraulic pressure is applied to the liquid and hence, the uniform pressure is experienced by the rubber mould in all directions. The friction of rubber mould with the walls is eliminated, which results in a uniform density of compacted material.

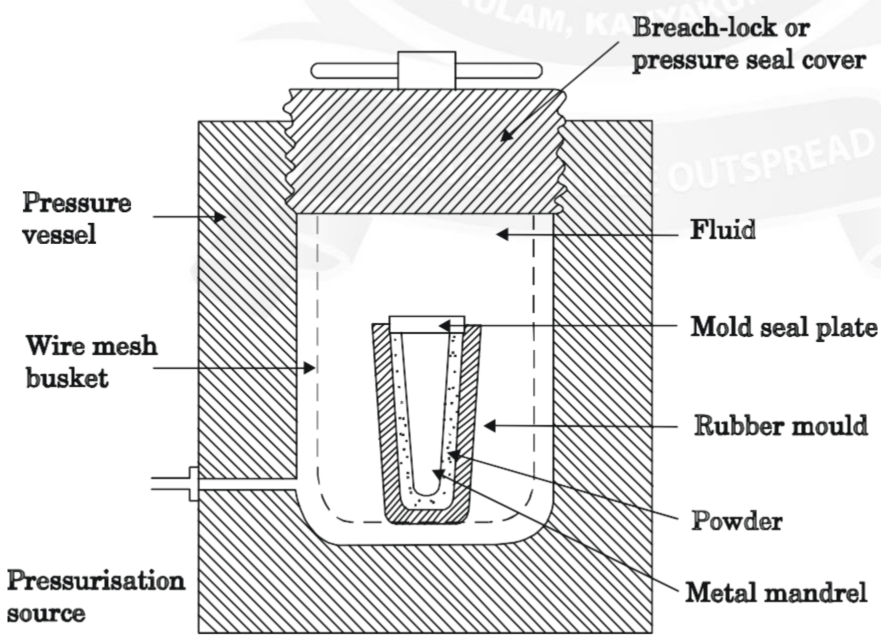

Fig. 4.5.2: Wet-bag isostatic pressing system

By removing the pressure, the rubber mould is taken out. The compacted material is removed by removing the mould sealed plate and metal mandrel.

The compacted materials are then subjected to densification resulting in more uniform shrinkage with less wrapping and cracking.

There are two different methods of isostatic pressing process

(i) wet-bag and

(ii) dry-bag processing.

In wet-bag processing method, raw material is filled in flexible rubber mold, sealed and then poured isostatically. The experimental set-up is shown in Fig. 4.22. The pressure applied in laboratory experiment process ranges from 35 to 1380 MPa.

However, in industry, the production units normally operate at a pressure of 400 MPa or even less.

This method is widely used for production of variety of products and sizes. The main disadvantages of this method are long cycle time, high labour requirements and low production rates.

GAS PRESSURE BONDING:

Hot isostatic pressure :

The hot isostatic press (HIP) uses the simultaneous application of heat and pressure. We refer to this process as HIPing and the product as being HIPed. A furnance is construction within a high-pressure vessel and the objects to be pressed are placed inside. Figure 4.5.3 shows a typical HIP arrangement.

Temperatures can be up to 2000°C, and pressures are typically in the range 30-100 MPa. A gas is used as the pressure medium — unlike in the CIP where a liquid is often used. Argon is the most common gas used for HIPing, but oxidizing and reactive gases can be used. Note that the high-pressure vessel is not inside the furnance

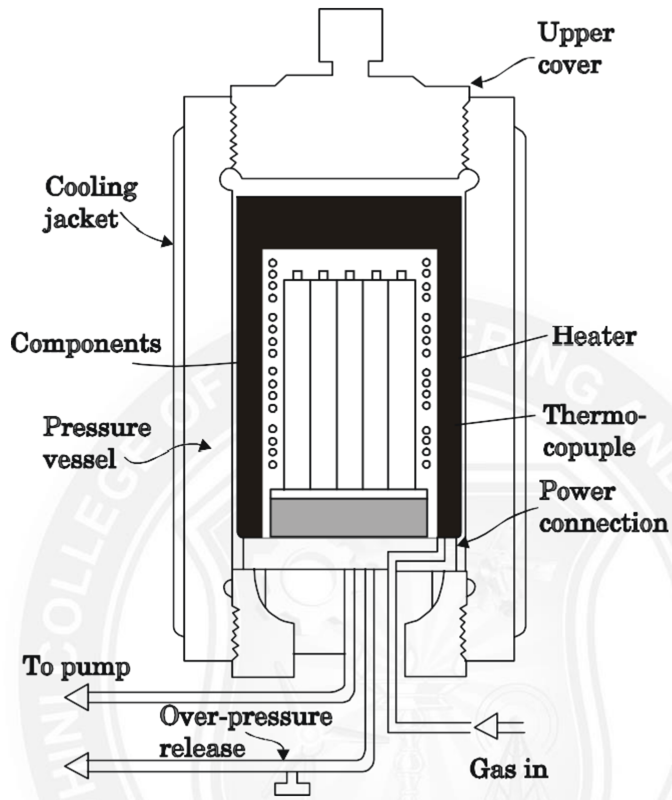

Fig. 4.5.3- Hot isostatic pressing apparatus

There are two variants of HIPing.

- Encapsulated: using a deformable container
- Not encapsulated: shape and sinter first, then HIPed
- Now HIPing is used for a wide variety of ceramic (and metallic) components, such as alumina-based tool bits and the silicon nitride nozzles used in flue-gas desulfurization plants by the utility industry.

The advantages of the HIPing process are becoming more important as interest in structural ceramics (e.g., Si_3N_4) grows.

- Nonoxide ceramics canbe HIPed to full density while keeping the grain size small and not using additives. Very high densities combined with grain sizes (because of the relatively low temperatures) leads to products with special mechanical properties.

HIPing has also been applied to the formation of piezoelectric ceramics.