EXPERIMENT NO 7

Solid state sintering

Objective:

To study the sintering behavior of alumina powder compact in air environment.

Basic Theory:

- Sintering is one of the most important steps in Powder Metallurgy processing.
- It is the process of consolidating either a loose aggregate of powder or a green compact of the desired composition under controlled conditions of temperature and time.
- Sintering may involve:
  1. single component system (e.g., pure metals and ceramics), where in shrinkage is major factor
  2. Multi component system, involving more than one phase, where several processes like solid solution formation and liquid phase formation may also occur in addition to densification.

Major variables in the sintering process are following:

1	**Sintering Temperature**
2	**Sintering Time**
3	**Sintering Atmosphere**

- Sintering is the bonding together of particles at high temperature.
- Particles are sintered by atomic motions, which eliminate the high surface energy associated with powders.
- Smaller particles with high specific surface areas have more energy and sinter faster.
- The sintering mechanism describes the path of atomic motion, which produces the mass flow.
- For metal powders, the mechanisms are diffusion processes over the surfaces, along the grain boundaries, or through the crystalline lattice.
- The structural changes associated with neck growth during sintering depend upon transport mechanisms, which is mainly diffusion process.
- Diffusion process is thermally activated, meaning that specific energy is necessary for atomic movement.

- Sintering processes are broadly classified as pressure less sintering and pressure assisted sintering.
- ***Pressure assisted sintering:*** most useful in processing materials that are unresponsive to traditional sintering cycles: for example, composites and high temperature intermetallic.

- ***Pressure less sintering:*** Most sintering processes, which are performed without an external pressure, are known as pressure less sintering. Pressure less sintering technique is further categorized into solid state sintering and liquid phase sintering.
- Sintering forms solid bonds between particles when they are heated.
- The bonds reduce the surface energy by removing free surfaces with the secondary elimination of grain boundary area via grain growth.
- With extended heating, it is possible to reduce the pore volume, leading to compact shrinkage.
- In many sintering systems dimensional change is undesirable. Structural materials such as silicon nitride, alumina, cemented carbide, silicon carbide and steels are processed to full density by sintering at relatively high temperatures.

Equipment/ Raw Materials:

- Powder
- Lubricant
- Cotton
- steel die-punch set
- powder compaction unit
- High Temperature Tube Furnace

Powder compaction unit

steel die-punch set

Tube furnace

Lab Deliverables:

1. Write a full lab report based on your observations and results.

2. What are the practical precautions required before beginning powder sintering?

Sol:

- Preheat the furnace to the desired sintering temperature according to the powder material you are using.

- Prepare the powder. If the powder is not dry, dry it before sintering to prevent steam explosions. If the powder is too fine, it may clump together and prevent uniform sintering.
- Always wear appropriate personal protective equipment
- Take precautions to prevent powder dust from escaping into the air
- Allow the furnace to cool down completely before unloading the sintered powder

3. Weight the sintered compact and determine shrinkage

Sol:

Load (Ton)	***Weight in air (g)***	***Weight in water (g)***	W_{air}-W_{water}	***Density of sinter (g/c.c.)***
8	1.861	1.235	0.626	2.97
6	1.847	1.271	0.576	3.21

For 8 ton:

Density = weight/volume = 2.1832 gm/c.c

Densification parameter: $(\rho_s - \rho_g)/(\rho_t - \rho_g) = 1.53$

Shrinkage = $1 - (\rho_g/\rho_s)^{1/3} = 0.098$

For 6 ton:

Density = weight/volume = 2.204 gm/c.c

Densification parameter: $(\rho_s - \rho_g)/(\rho_t - \rho_g) = 2.03$

Shrinkage = $1 - (\rho_g/\rho_s)^{1/3} = 0.12$

4. Write down the name of most common sintering atmosphere.

Sol: Argon is the most common sintering atmosphere.

5. Explain sintering mechanism.

Sol:

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Observations and Calculations

Al_2O_3 Sample (Sintered):

Load (Ton)	***Weight in air (g)***	***Weight in water (g)***	W_{air}-W_{water}	***Density of sinter (g/c.c.)***
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Conclusions

- The solid state sintering of Aluminum powder compact shows us comparatively greater increase in sintered density which has to be there for having enough strength hardness and several other properties.
- Shrinkage is also high enough in case of our sample which implies the particles are packed well enough to be mechanically strong and bear loads