EXPERIMENT NO 8

Liquid phase sintering

Objective:

To study the sintering behavior of cobalt alloy powder, compact in argon environment.

Basic Theory:

Liquid phase sintering method is getting more and more common, in which the presence of liquid phase during all or part of the sintering cycle of material is used for enhanced densification. There are two variations of the process:

(a) normal liquid phase sintering for which the formation of the liquid phase is associated with one or more components contained in the original green compact.

(b) infiltration of the original green compact with a liquid formed outside the compact during the very early period of sintering. Although simultaneous infiltration and sintering appears to be dominant, infiltration of a previously sintered part is also practised.

During liquid phase sintering three stages 'rearrangement' or 'liquid flow', 'accommodation' or 'dissolution and reprecipitation and 'coalescence' or 'solid phase sintering' take place. These stages follow in the approximate order of their occurrence, but there may be significant overlapping for any specific system. Figure 6.1 shows the densification stages during liquid phase sintering. With progress in liquid phase sintering the densification kinetics is lowered. Increasing the liquid content up to approximately 35 volume percent aids initial densification. A coarse particle size and a high green density act to offset the favorable effects of the melt. In case the second stage is not effective, the melt will penetrate along the interparticle interfaces and cause particle separation. This will contribute in swelling.

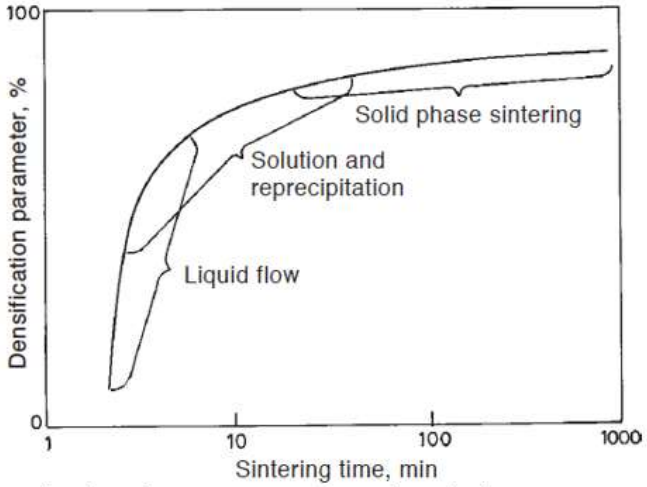

Figure 6.1: The densification stages during liquid phase sintering.

A small dihedral angle inhibits coalescence of neighboring particles. Application of liquid phase sintering technology is widely made in the field of sintered steels, cemented carbides, heavy alloys, bronzes and silicon nitride systems.

Equipment/ Raw Materials:

- Powder
- Lubricant
- Cotton
- steel die-punch set
- powder compaction unit
- compacted sample
- high temperature tube furnace
- argon gas cylinder

Powder compaction unit

steel die-punch set

powder

Procedure:

1. Select high temperature tube furnace.
2. Place the sample in the middle of the furnace using suitable crucibles/boats
3. Switch on the furnace and programme as desired time temperature schedule.
4. Seal the tube furnace for Ar atmosphere
5. Run the programme and observe the furnace for leak proof and any abnormality during heating or cooling.
6. Switch off the furnace properly once the programme is over and take the sample out when cooled.

Lab Deliverables:

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

2. Weight the sintered compact

Sol:

Weight after sintering:

Sample	***Weight (g)***
Cu-10% Sn	Water: 4.619 Air: 4.511
Cu-30% Sn	Water: 4.188 Air: 4.5

3. Explain mechanism of liquid phase sintering.

Sol: The process has three stages:

- Rearrangement
- Coalescence
- Solidification

As the liquid melts, capillary action will pull the liquid into pores and also cause grains to rearrange into a more favorable packing arrangement. The liquid will then coalesce into larger droplets, which will continue to grow until they form a continuous liquid phase. Finally, the liquid will solidify, creating a permanent bond between the powder particle

4. What is densification parameter? How do you measure it?

Sol: The densification parameter is a measure of the degree of densification achieved by liquid phase sintering. It can be calculated by dividing the density of the sintered compact by the theoretical density.

Observations and Calculations:

Before Sintering:

Sample	Weight (g)	Thickness (mm)	Diameter (mm)
Cu-10% Sn	4.619	3.92	15.1
Cu-30% Sn	4.918	4.39	12.22

After Sintering:

Sample	Weight (g)	Thickness (mm)	Diameter (mm)
Cu-10% Sn	Water: 4.619 Air: 4.511	3.82	14.85
Cu-30% Sn	Water: 4.188 Air: 4.5	4.02	12.1

For Cu-10% Sn: $\rho_a = W_a/(W_a-W_{water}) = 7.05$gm/c.c.

For Cu-30% Sn: $W_a/(W_a - W_L) = 14.42$gm/c.c.

Conclusions:

- Liquid phase sintering gives apparent density of both the compact in Cu-10% Sn and Cu-30% Sn sample, which is nearly 2 times in value