5. POWDER METALLURGY

POWDER METALLURGY: It's one of the oldest manufacturing processes. Finished or Semi-finished products are manufactured by using powders of different materials blended, compacted and sintered.
E.g. Filament of bulb, Carbide cutting tools

REASONS FOR SELECTION OF POWDER METALLURGY:

1. Melting Point Temperature: High melting point temperature Materials are not possible to melt to make component. Eg. Refractive material (W, Nb, Mo, Ta)
2. Large difference in melting point temperature: Large difference in melting point temperature of two or more materials are not possible to make an alloy (E.g. Fe (1535°C) + Sn(380°C))
3. Large difference in density of materials: Large difference in density of two or more materials are not possible to make an alloy. (E.g. Fe (7.869 g/ cc) + Al (2.19 g/ cc))
4. Processing Cost: Very low cost.
5. Bulk Production is possible.

STEPS INVOLVED IN POWDER METALLURGY:

A) Making powders	**B) Adding Additives**	**C) Compaction/ Pressing**	**D) Sintering**	**E) Final Product:**
1. Mechanical Grinding 2. Atomization 3. Chemical Electrolysis		1. Cold Compaction • Cold Iso-Static Pressing • Die compaction • Extrusion • Injection moulding		**Note:** Hot Compaction directly gives final product.
		2. Hot Compaction • Hot Iso-Static Pressing		

MECHANICAL GRINDING: E.g. Ball Milling.

- By using this method, powder are produced by using mechanical energy as source of energy.
- This method is not Suitable for ductile materials (E.g. Al, Cu, Au…). Because Flanky shape powder generated in ball milling are breaks/ fails in Compression.
- This method is more suitable for brittle materials.

ATOMIZATION PROCESS: Spherical Forms of Grains.

- Powders are produced by heating the metal in a furnace and sending into a cold chamber through nozzles. Liquid droplets are released from nozzles and solidifies in cold chamber.
- This method is not suitable for high melting point temperature metals.

CHEMICAL ELECTROLYSIS:

- The powders are produced by using current or electricity as a source of energy to make powder.
- This method is not suitable for electrical insulating materials.

Note: The powders of different materials are produced by using different method based on properties of materials.

CHARACTERISTICS OF POWDERS:

1) **Shape of the powde**r:

Best Suitable powder: Spherical	$Shape\ Factor = \frac{Surface\ Area\ of\ Powder}{Volume\ of\ Powder} * Equivalent\ Spherical\ diameter.$

Conclusion: The Shape Factor of the powder must be low to make good powder metallurgical products.
($(SF)_{Spher} < (SF)_{Eliptical} < (SF)_{Pinned}$)

2) **Size of the powder:** The Size of the powder is analysed based on aspect ratio. $Aspect\ Ratio = \frac{Large\ Dimension}{Small\ Dimension}$

Conclusion: The Size of the powders/ Aspect Ratio must be low (E.g. Sphere). To make good powder metallurgical products.

3) **Distribution of the powder**: Distribution of the powder is analysed based on frequency mode.

Conclusion: The frequency mode of the powders must be low make good powder metallurgical products.

CONCLUSION: TO MAKE GOOD POWDER METALLURGICAL PRODUCT, SPHERICAL SHAPED OF THE POWDERS WITH WIDE DISTRIBUTION OF SIZES OF POWDERS ARE BEST SUITABLE.

ADDING ADDITIVES: After making powders of different materials mixed/ Blended properly to get homogeneous composition and hence uniform properties are generated in final product.

Mixing: Powders of Different Chemistry material.	**Blending:** Powders of Same Chemistry material.

NOTE: Lubricants are added to improve powder flow characteristics. E.g.

1. To reduce the friction between powders & Die walls. 2. To increase flowability	3. To increase compressibility 4. To reduce porosity.

NOTE: Binders are added to bind the powders and hence, green strength of the body increased. E.g. Low Melting point metals, Waxes, Thermoplastic Materials.

COMPACTION / PRESSING:

GREEN COMPACT: After adding additives and blending, pressed uniformly to get final shaped of the component is known as green compacted component. It's Semi-finished body and strength of the final product is directly proportional to the strength of green compact.

1.	$Compressibility = \frac{Volume\ of\ the\ powder\ Befor\ compaction}{Volume\ of\ the\ powder\ After\ compaction}$	$Strength_{component} \propto Compressiblity$
2.	Carr Index = % of Volume compressed	$Strength_{component} \propto Carr\ Index$

Only point of contact happened after compression.

COMPACTION/ PRESSING TYPES		
Cold Compaction		**Hot Compaction**
Die Compaction	**Cold Iso-Static Pressing**	**Hot Iso-Static Pressing**
• Piston Plunger Arrangement • Non-Uniform Properties • Bulk Production • Compressibility is low • Porosity is high	• P =1000 MPa, pressing form all direction in rubber tube filled with hydraulic fluid. • Isotopic Properties • Can't use for bulk production • Less porosity. • Can't use for explosive materials. E.g. Mg, Ti, Zr, Cd, Be.	• In addition to Cold Iso-Static Pressing, Hitting takes place simultaneously. • P_{max} =100 MPa, pressing form all direction in rubber tube filled with hydraulic fluid. • No sintering required. • Same Points like Cold Iso-Static Pressing.

SINTERING: It's the final powder metallurgical step. In this process, the green compact is heated up to a sintering temperature. To form chemical bonds between powders.
Sintering temperature: Less than least melting point of all powders.
Initially at the time of heating, **Neck Formation** happened. After Necking Electrons transfers and **Chemical bonds** forms. At the end it gives very high strength.

SOME SECONDARY PROCESS:

IMPREGNATION	**INFILTRATION**
In this process, The Pours of a powder metallurgical product is filled with **oil**. E.g. Impregnated Gears & Bearings	In this process, The Pours of a powder metallurgical product is filled with **Filler Material** and due to this surface porosity removed.

Advantages	Dis- Advantages
1. Well-Shaped Composite, Ceramics & Alloys refractory materials are easy to produce. 2. Processing cost/ Unit is low. 3. Mass Production. (1,00,000 Units) 4. High Compressive Strength.	1. Porosity is high. 2. Brittle in nature. 3. Variety of products not possible. 4. Initial cost is more. E.g. Equipment & Tooling Cost is more.