**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 (1535C) + Sn(380C))
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:**

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

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| --- | --- |
| Best Suitable powder: Spherical |  |

**Conclusion:** The Shape Factor of the powder must be low to make good powder metallurgical products. ( )

1. **Size of the powder:** The Size of the powder is analysed based on aspect ratio.

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

1. **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.

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

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

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| 1. To reduce the friction between powders & Die walls. 2. To increase flowability | 1. To increase compressibility 2. 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.

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| 1. |  |  |
| 2. | Carr Index = % of Volume compressed |  |

Only point of contact happened after compression.

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| **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. * Pmax =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**:

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| **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. |

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| 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. |