Module 6. Powder Metallurgy

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PM is a metal processing technology in which, the powder is compressed into desired shape, and then heated to cause bonding of the particles into a hard, rigid form. Heating treatment also known as sintering is performed at temperature below the melting point of the metal. Here are two videos show the application and basic of PM process:

The main attributes of PM which made it an important commercial technology include:

- PM parts can be produced to net shape, eliminating the need for post processing.
- This process involves almost zero waste of material.
- Production of porous metal parts, such as oil-impregnated bearing and gears are possible by PM.
- Production of parts with certain metals such as Tungsten which are difficult to fabricate by other methods are possible by PM.
- Metal alloy combinations can be formed by PM.
- Dimensional accuracy with tolerance $\pm 1mm$ can be achieved.
- PM process can be automated.

In general PM has disadvantages, such as expensive tools, metallic powders are expensive, and storing and handling of powder is difficult.

The large application of metals for PM are iron, steel, and aluminum. Others are copper, nickel, and tungsten. Small size (a few mm) to larger parts (500 mm) can be made by PM. Most PM parts are limited up to 2.5 Kg.

Image Source: https://www.pm-review.com/introduction-to-powder-metallurgy/why-powder-metallurgy/

Porosity of PM parts make it possible to create products by filling the available pore space with oils or polymers. The oil-impregnated parts are used for journal bearings or gears.

When parts are impregnated with polymer resins that seep into the pore spaces in liquid form and then solidify creates a pressure tight part.

The four attributes of PM, cost, rate, quality, and flexibility is summarized in the following table.

	Cost	Rate	Quality	Flexibility
PM	High	Medium	Medium-High	Low -Medium

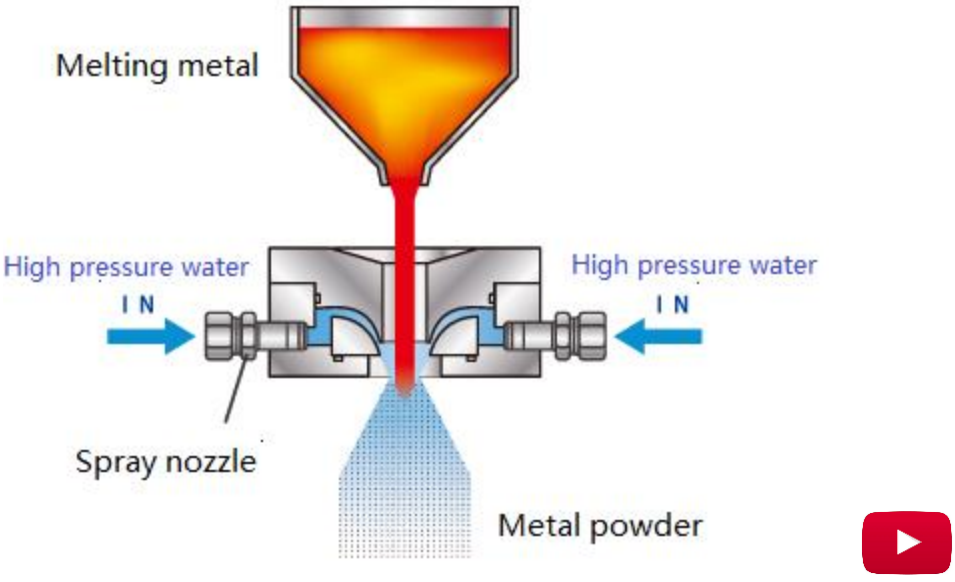
Characteristics of metallic powders:

Particle size and shape:

Screens of different mesh sizes are used to sort and obtain particle size data. Smaller particles result in higher inter-particle friction. As shape deviate from sphere, the friction increases. Lower inter-particle friction results in easier flow of powder inside a mold. Lubrications (oil) are often used to reduce inter-particle friction and facilitate flow during pressing.

Production of metallic powder:

Water atomization method is usually used to produce metallic powder. The process involves use of high-pressure water jets to break up a molten metal stream into fine droplets which solidify into fine particles.

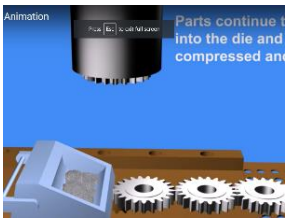


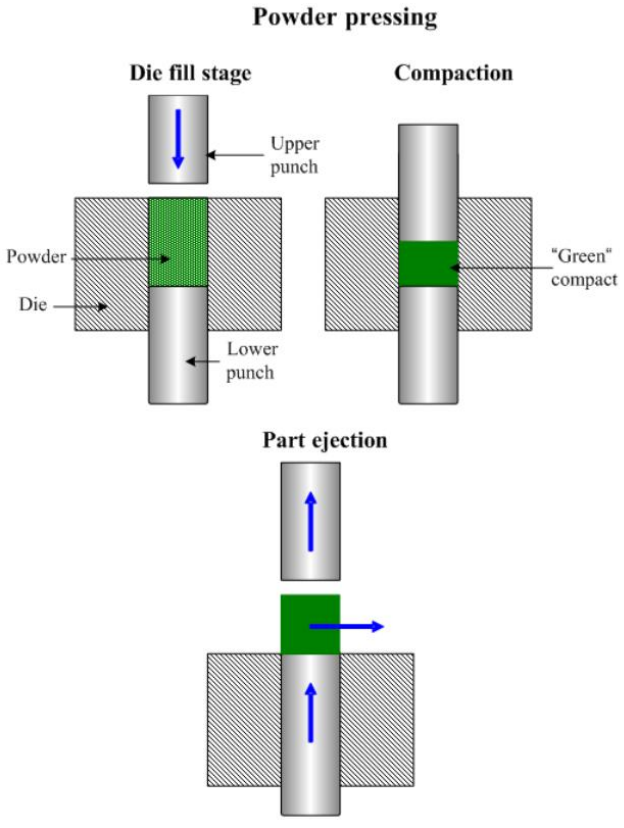
Source: http://www.mt-innov.com/index.php?ac=article&at=list&tid=12

The sequence of PM process:

- **Blending** (powder of same chemistry but different particle sizes, for reducing porosity) and **mixing** (powders of different chemistry) of powders
- **Pressing** the powder into desired shape. These parts are called green compact, which have enough strength only for handling to the oven.
- **Sintering** which involves baking the part at temperature below the melting (usually 70-90% below the melting point) for bonding.

Here are an animation and a video which explains these steps:

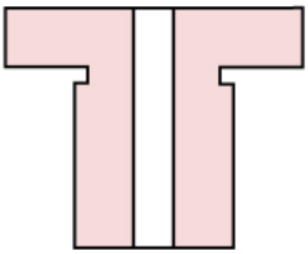




Source: https://www.substech.com/dokuwiki/doku.php?id=methods_of_shape_forming_ceramic_powders

Here a video which summarizes the PM process:

Design Consideration in PM:



Study from this link:

https://www.pickpm.com/design-resource-center/design-considerations/