LECTURE 9: POWDER METALLURGY

1.1 Introduction

Powder metallurgy uses raw material in the form of very fine powder, blended (mixed), pressed into a desired shape (compacted), and then heated (sintered) in a controlled atmosphere at a temperature below the melting point of the major constituent for sufficient time to bond the contacting surfaces of the particles and establish desired properties.

This process has many interesting uses include: balls used in ball-point pens, gears, cams, cutting tools, porous metal filters, oil-impregnated bearings, piston rings in engines, etc. Common metals used for P-M include iron, stainless steel, tin, nickel, titanium, aluminum etc. Some examples are in the image below.

•1930's carbide tool materials

•1960's automobile parts

•1980's aircraft engine turbine parts

Figure (1): Examples of Powder metallurgy parts

1.2 Some important properties of powder metallurgy

● Used in mass production of small parts of high precision,

● No or little material is wasted,

- Usually no machining is required,
- Semi skilled labor is sufficient,
- Some unique properties, such as controlled degrees of porosity or built-in lubrication can be obtained.

1.3 Powder Properties

- Flow characteristics of the powder is very important, since it determines the final density.
- The strength of a product depends on the chemical composition of the powder and the final density. The greater the density, the higher the strength is.
- Pure metal and non-metal powders can be mixed.
- Pre-alloyed powders can be used.
- Precoated powders can be used.

1.4 Basic Steps of Powder Metallurgy

1. Powder manufacture (Producing a fine metallic powder),
2. Powder blending (Mixing and preparing the powder for use),
3. Compacting in a die (Pressing the powder into the desired shape),
4. Sintering (Heating the compacted product).
5. Secondary (Finishing) Operations (Optional)

1.5 Powder manufacture

Metal powder can be produced by several processes.

(i). Melt atomization

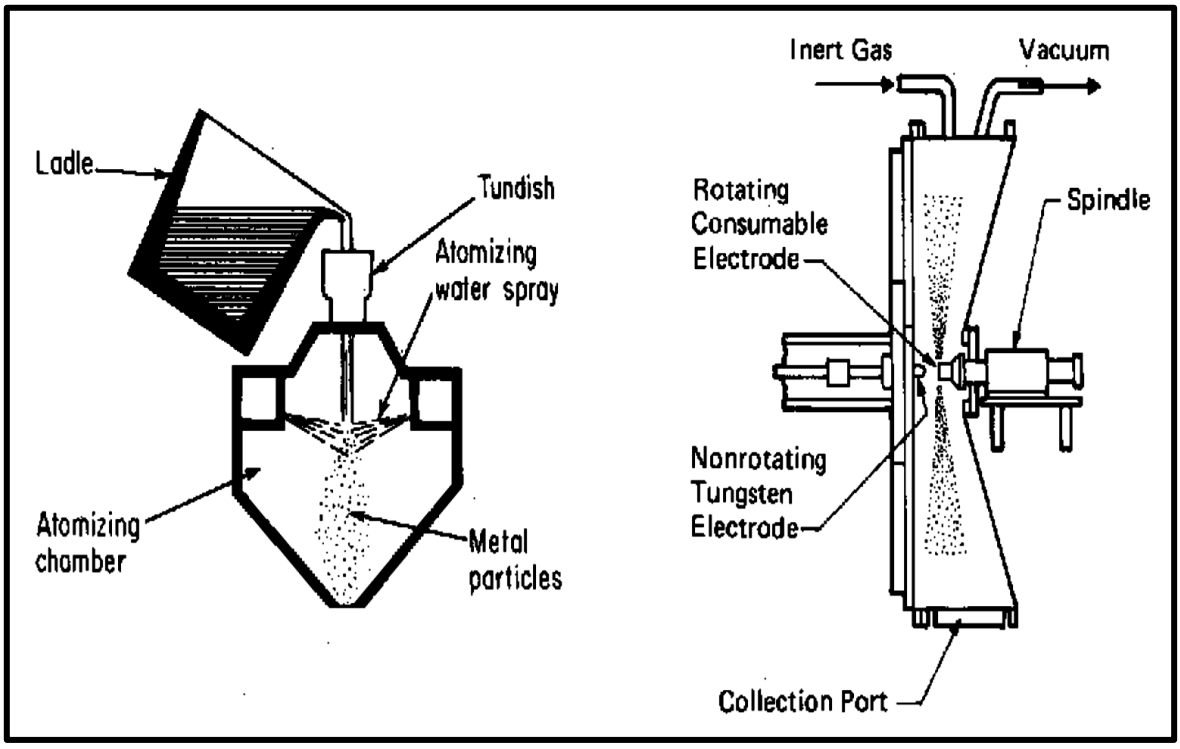
Spray liquid metal through a small opening (nozzle); a jet of inert gas or liquid is used to break the flowing liquid into tiny balls and simultaneously cool them to solidify as particles.

(ii). Chemical methods (Reduction of oxides or ores)

Metal oxide can be reduced by passing hydrogen or carbon monoxide over crushed oxide powder at high temperature. Chemical processes are also used to produce **nanoparticles**, which are particles of extremely small size, and which are finding many exciting new applications in modern manufacturing.

(iii). Electrochemical action (Electrolytic deposition from solutions or fused salts)

A solution of a salt of the metal can undergo electrolysis to yield the metal in powder form.



Melt Atomization Rotating Electrode Method

1.6 Powder Blending

Before compacting, powder is mixed and blended to,

1. Obtain uniform particle size distribution,
2. Mix powders of different materials must be mixed uniformly. It is done in shaking/rotating containers called blenders.

3. Coat powder particles with lubricants. In some cases, a lubricant is (graphite or stearic acid) added to the powder to improve the compaction of the powder in the die.

1.7 Compacting (Pressing)

This is the step when the powder is given the shape of the part being produced by pressed the powder to achieve the required compaction. Metal injection molding may also be used in some cases to force-flow the metal powder through the die. Compacting is an important step, since,

1. Powder is formed into the desired shape,
2. It determines the density of the product,
3. It determines the uniformity of the density.

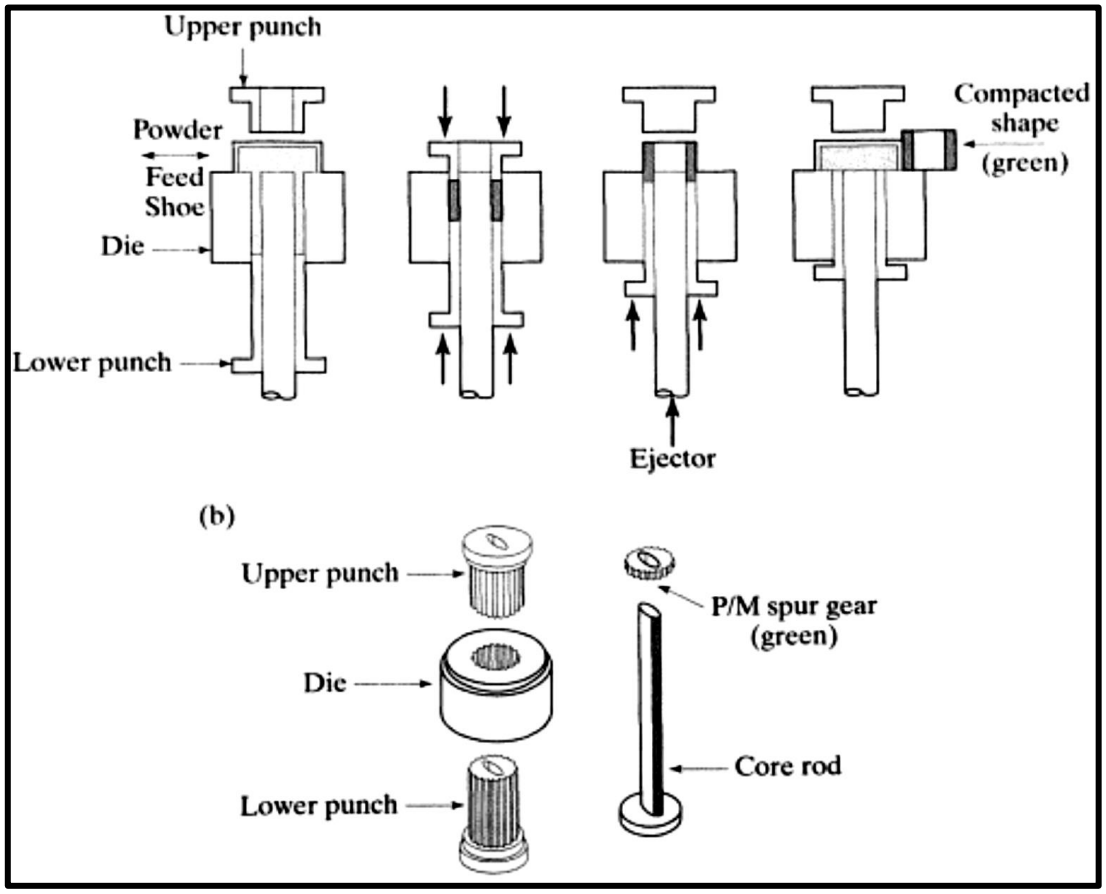
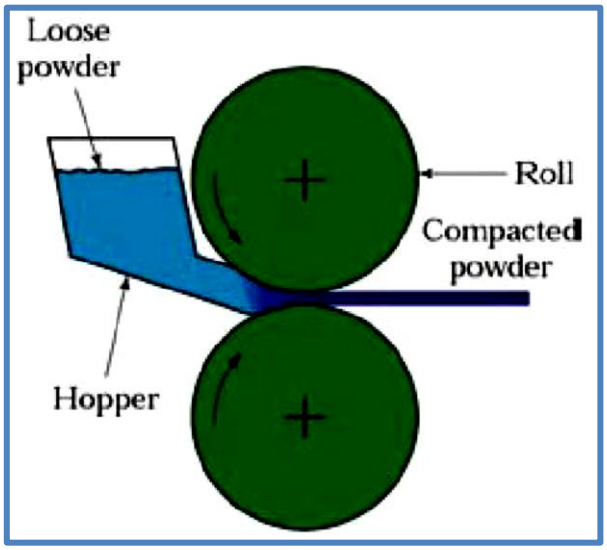
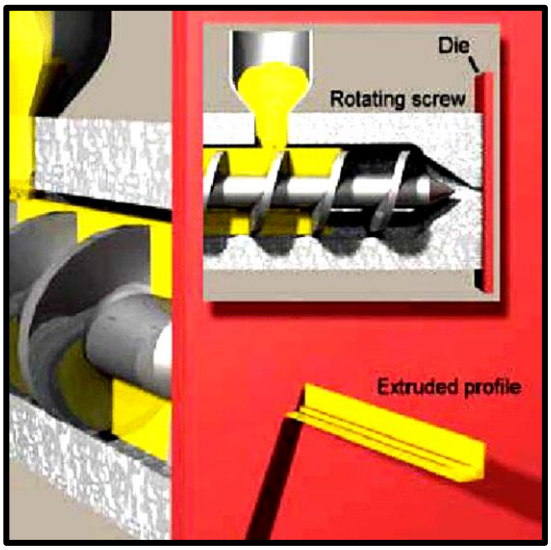


Figure (2): Compaction operation to create a green molded part



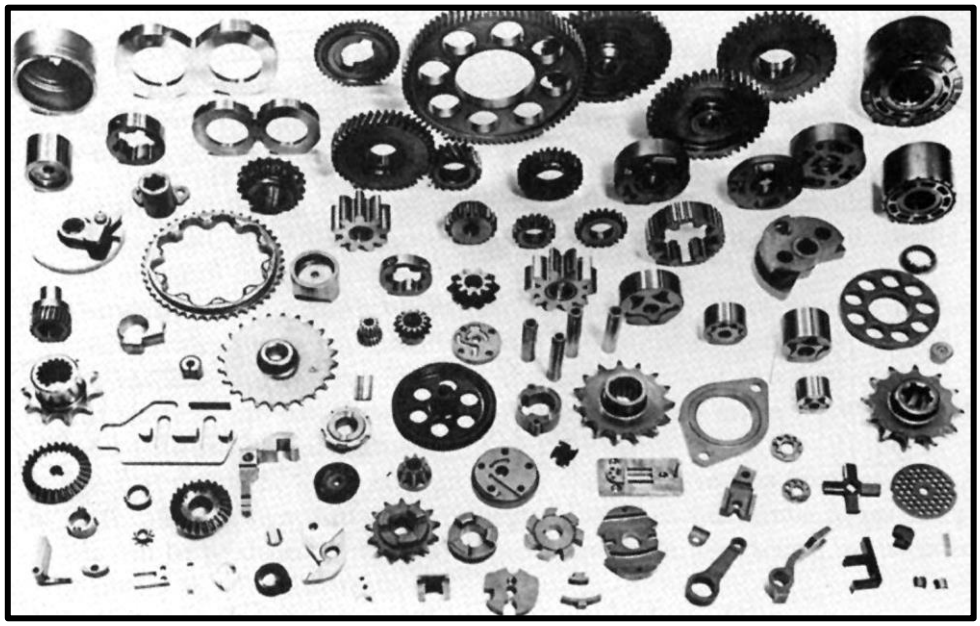


1.8 Sintering

The compacted part is called a **green part**, or a **green compact**. It is weak, since the particles are held together mostly by friction. The green compact is put into an oven and heated to a high temperature -- approximately 70% to 90% of the melting point of the metal or alloy.

1.9 Classification of P/M Products

1. Porous products, such as bearings, filters, and pressure or flow regulators.
2. Products of complex shapes that would require considerable machining when made by other processes. (e.g. Small gears, pawls, cams, small activating levers.)
3. Products made from materials that are very difficult to machine. (e.g. Tungsten carbide cutting tools.)
4. Products where the combined properties of two metals, or of metals and nonmetals are desired. (e.g. Motor generator brushes, electrical contacts, bearings.)



Sample Parts made by P/M