Powder Metallurgy

Bachelor of Industrial Technology Management with Honours
Semester I Session 2013/2014

TOPIC OUTLINE

- What Is Powder Metallurgy (P.M)?
- Powder Metallurgy Processes
  - ✓ Blending And Mixing
  - ✓ Compaction
  - ✓ Sintering
  - ✓ Finishing Operations
- Advantages and Disadvantages of P.M
- Design Considerations

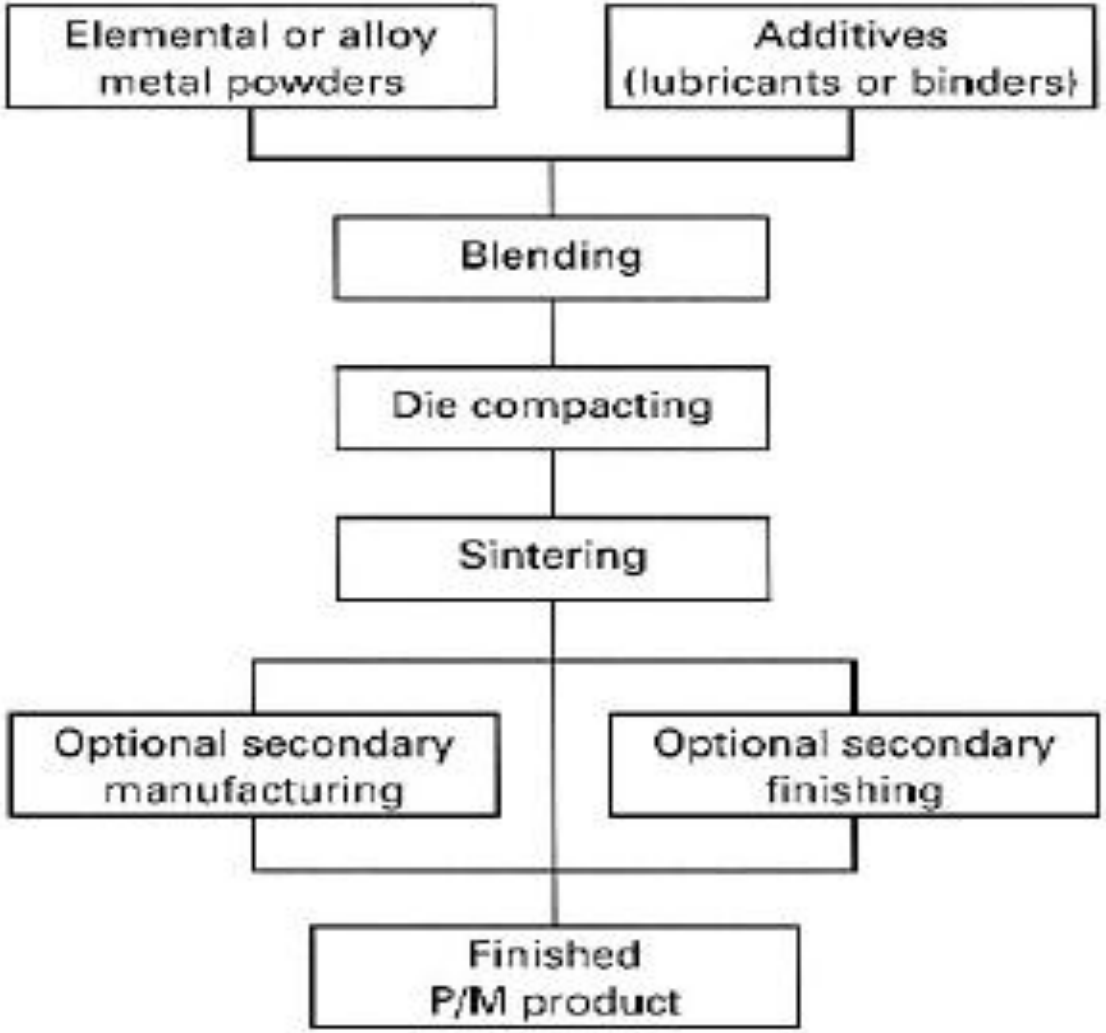
What Is Powder Metallurgy?

- A processing technology in which parts are produced by *compacting* and *sintering* metallic and/or non-metallic powders.
- Competitive with processes such as casting, forging and machining.
- Nearly 70% of the P.M part production is for automotive applications.
- Size range from tiny balls for ball-point pens to parts parts as large as 20 kg but most products are less than 2 kg.

Applications of P.M

1. Production of net-shape or near-net shape parts made of expensive materials. P.M process is capable of less than 3% scrap losses.
2. Parts with porosity such as filters can be made.
3. Bearings especially so-called permanently lubricated bearings, in which air pores in the P.M parts are filled with oil.
4. Metals and metal alloys that are difficult to fabricate by other methods (carbide tool inserts, tungsten, ceramics, etc.)
5. Materials with special and unique properties such as alloys that cannot be produced by other processes (high melting point materials such as tungsten, iridium, carbon and carbides).
6. Can create material mixtures that cannot be made any other way such as metal and ceramic composite, metal and polymer composites etc.

Powder Metallurgy Processes

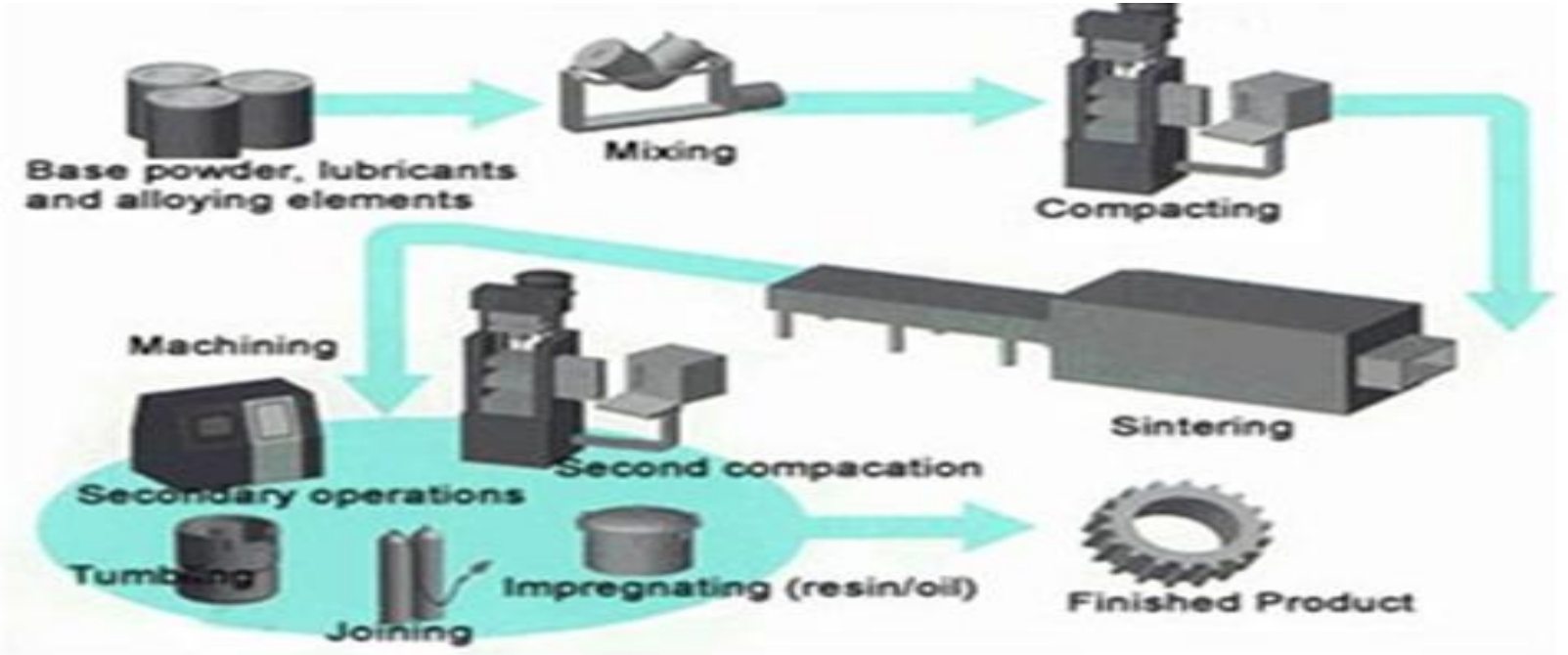


Sequence of operations in powder metallurgy process

Powder Metallurgy Processes

Three major steps:

1. Blending and mixing of powders
2. Compaction
3. Sintering
4. Optional and finishing secondary operations

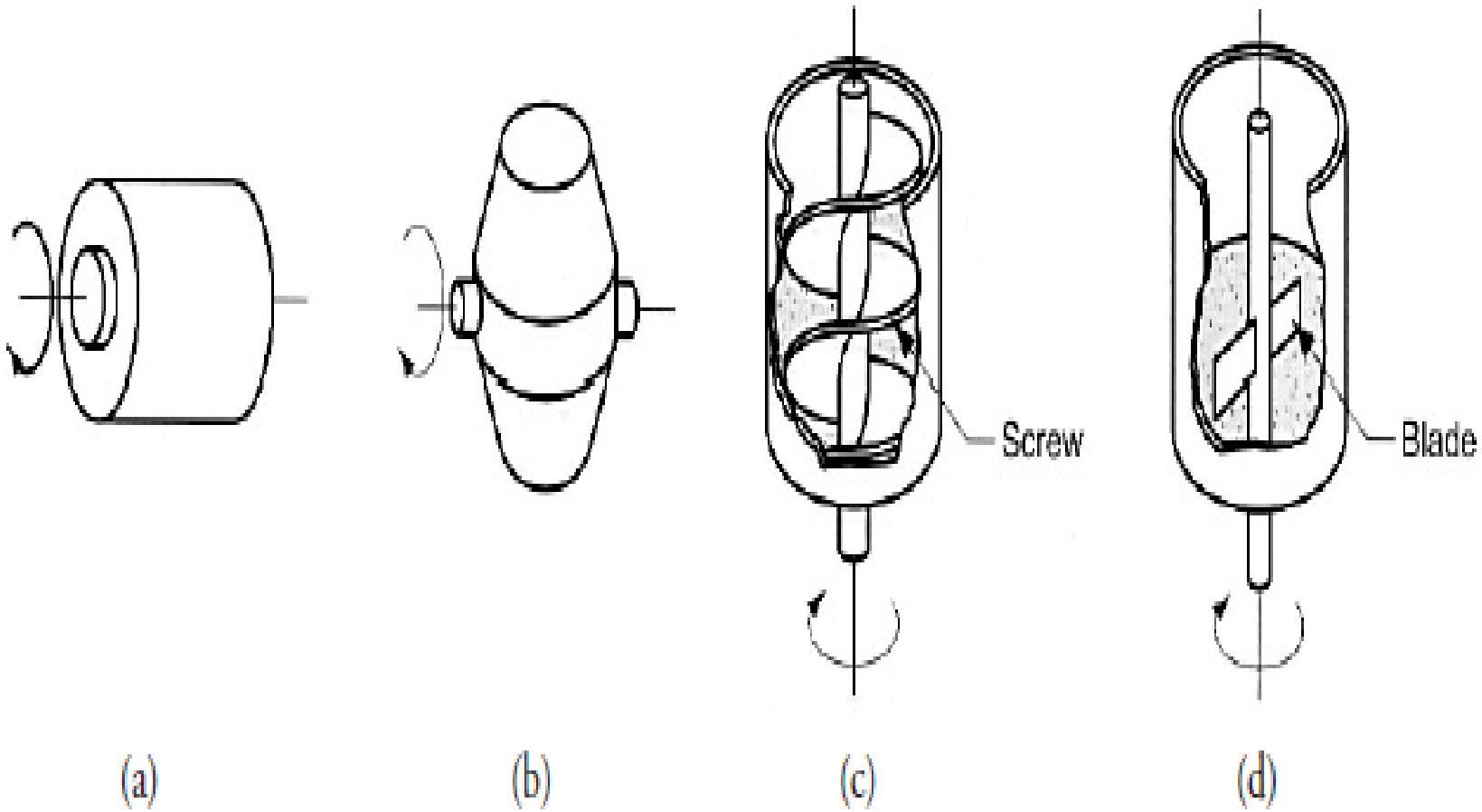


Blending and Mixing

- Blending : mixing powder of the same chemical composition but different sizes.
- Mixing : combining powders of different chemistries
- Blending and mixing are accomplished by machinery
- Except for powders; some other ingredients are usually added:

  1. Lubricants - to reduce the particles-die friction
  2. Binders - to achieve enough strength before sintering
  3. Deflocculants - to improve the flow characteristics during feeding

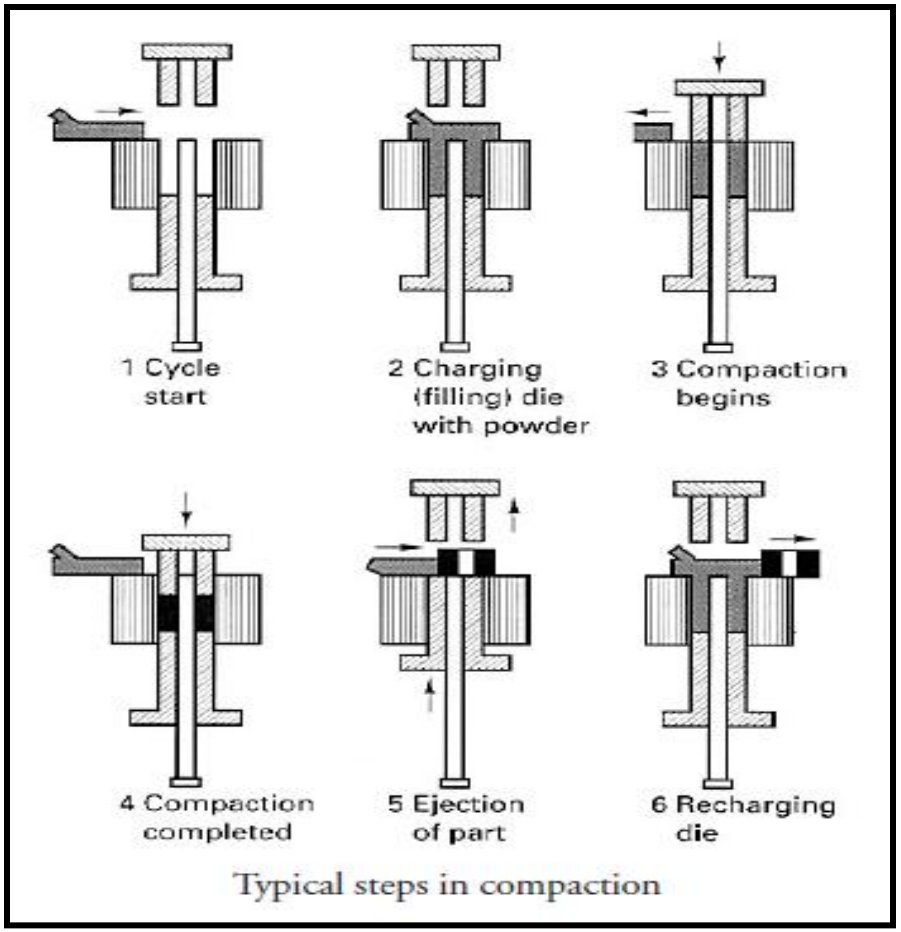
Blending and Mixing



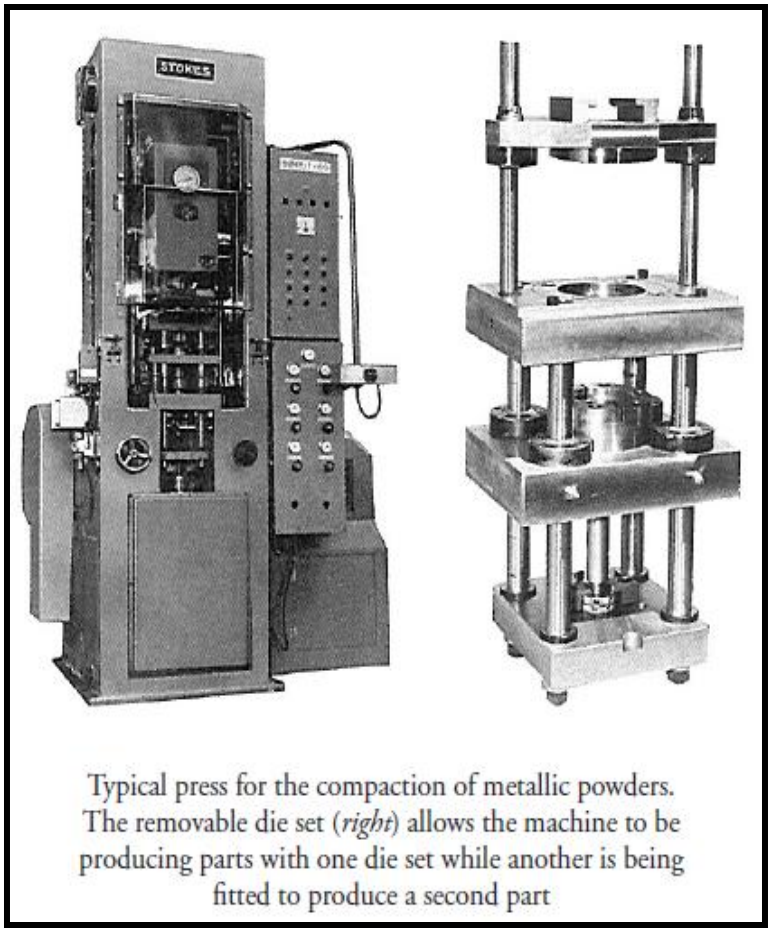
Several blending and mixing devices: (a) rotating drum, (b) rotating double cone, (c) screw mixer, (d) blade mixer

Compaction

Blended powers are pressed in dies under high pressure to form them into the required shape.



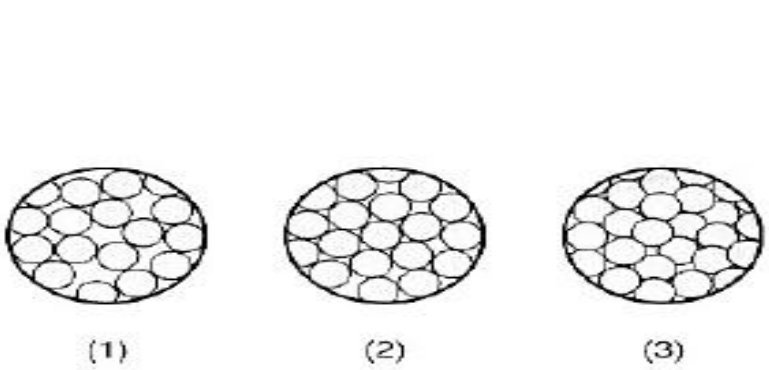
Typical steps in compaction

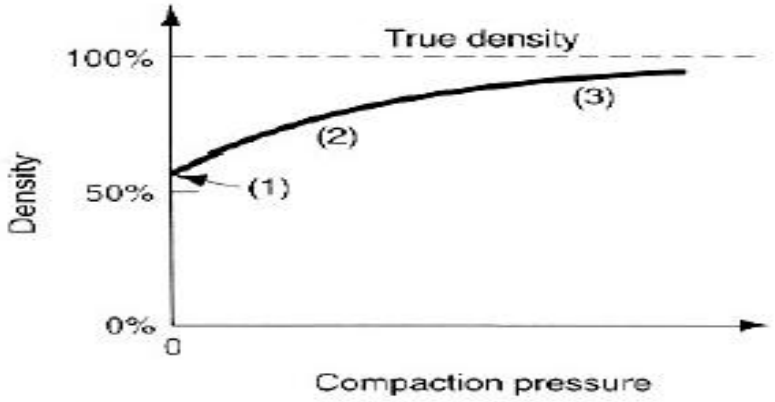


Typical press for the compaction of metallic powders. The removable die set (*right*) allows the machine to be producing parts with one die set while another is being fitted to produce a second part

Compaction

Density is much greater but vary across the part volume and depend on pressure in compaction.



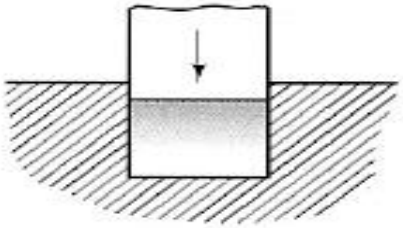


Effect of applied pressure during compaction: (1) initial loose powders after filling, (2) repacking, and (3) deformation of particles.

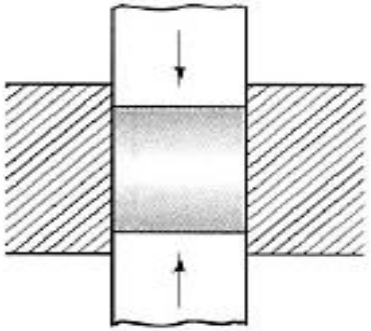
Ways to improve the density distribution:

1. Application of double acting press and two moving punches in conventional compaction
2. Isostatic pressing - pressure is applied from all directions against the powder, which is placed in a flexible mould

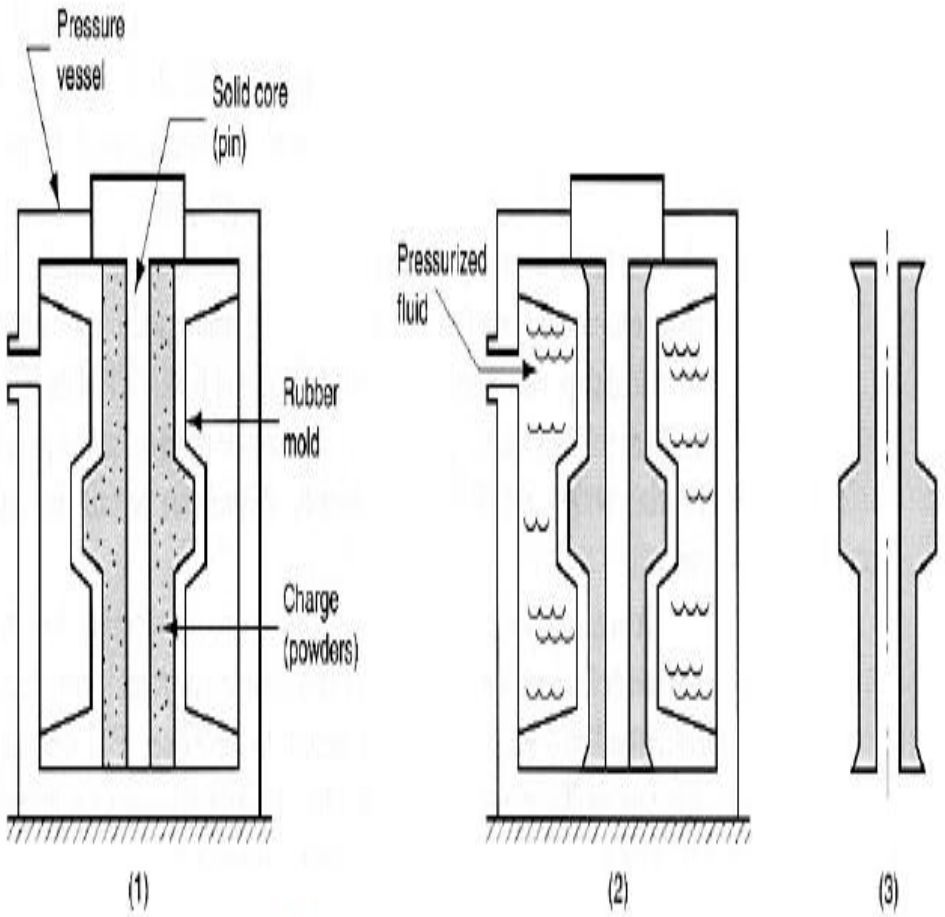
Compaction



Compaction with a single punch, showing the resultant nonuniform density



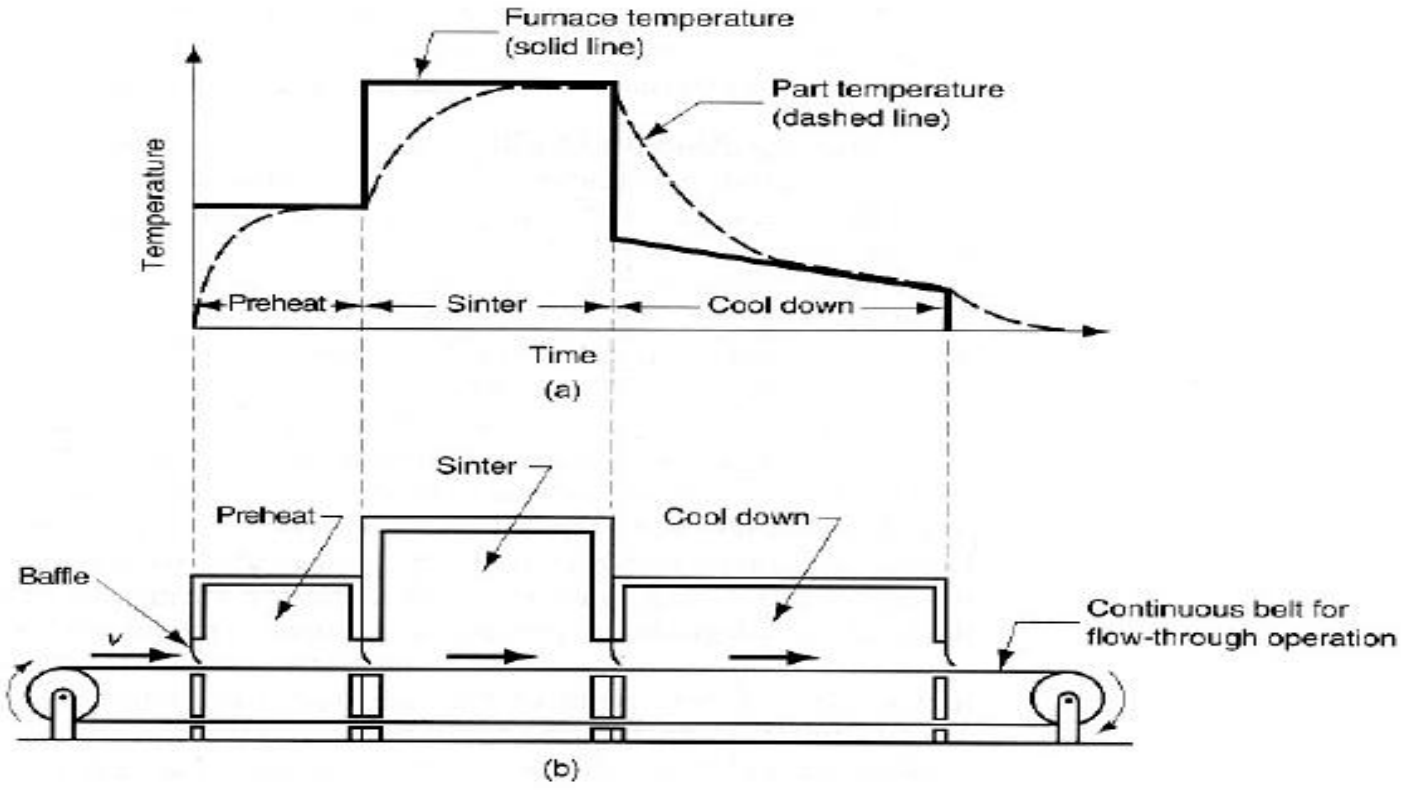
Density distribution obtained with a double-acting press and two moving punches



Cold isostatic pressing: (1) powders are placed in the flexible mold; (2) hydrostatic pressure is applied against the mold to compact the powders; and (3) pressure is reduced and the part is removed.

Sintering

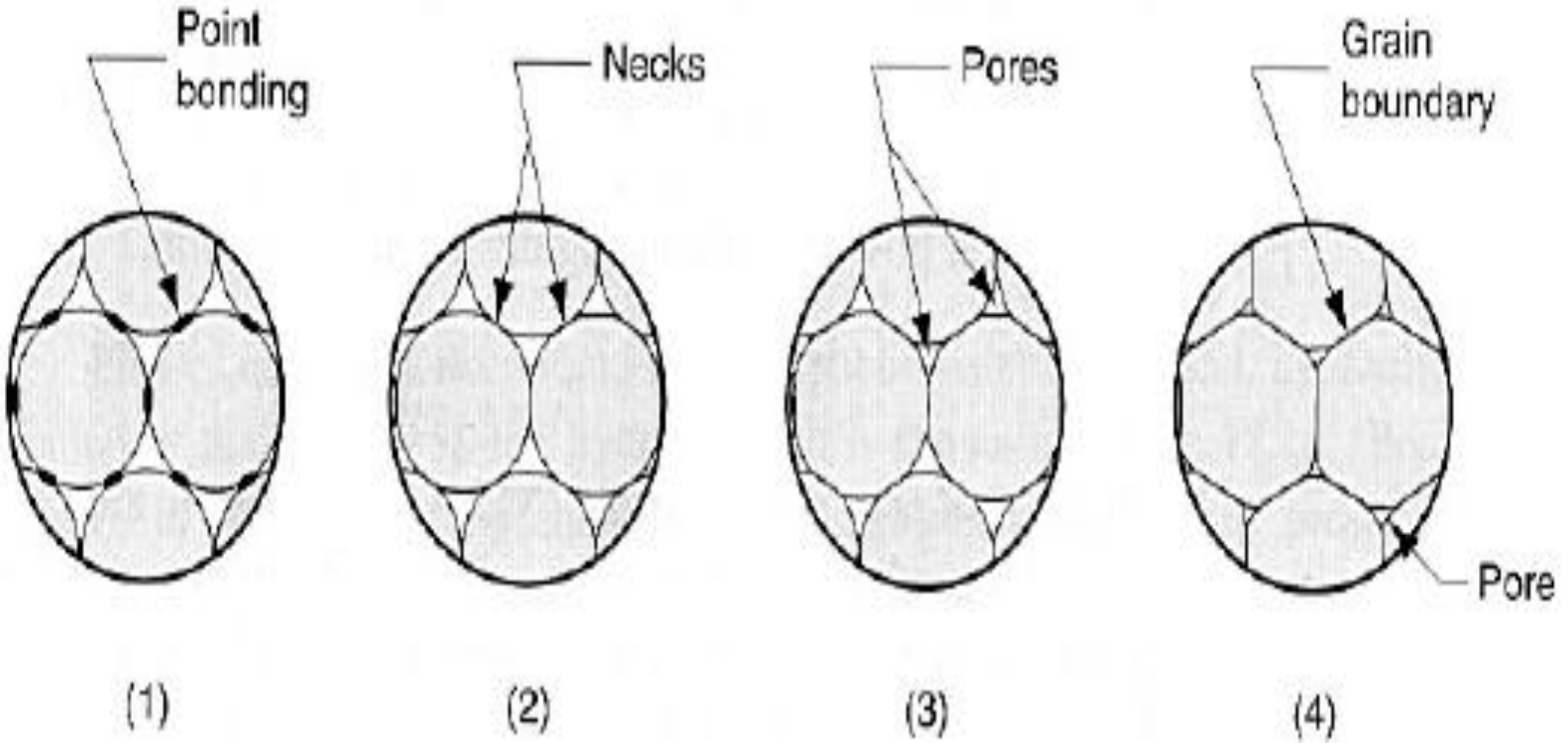
Compressed metal powder is heated in a controlled-atmosphere furnace to a temperature below its melting point, but high enough to allow bounding of the particles.



(a) Typical heat treatment cycle in sintering; and (b) schematic cross-section of a continuous sintering furnace

Sintering

Formation and growth of bonds between the particles:



Sintering on a microscopic scale. The illustration shows different stages in development of grain boundaries between particles.

Finishing Operations

A number of secondary and finishing operations can be applied after sintering, some of them are:

1. Sizing - cold pressing to improve dimensional accuracy
2. Coining - cold pressing to press details into surface
3. Impregnation - oil fills the pores of the part
4. Infiltration - pores are filled with a molten metal
5. Heat treating, plating and painting

Advantages & Disadvantages

Advantages:

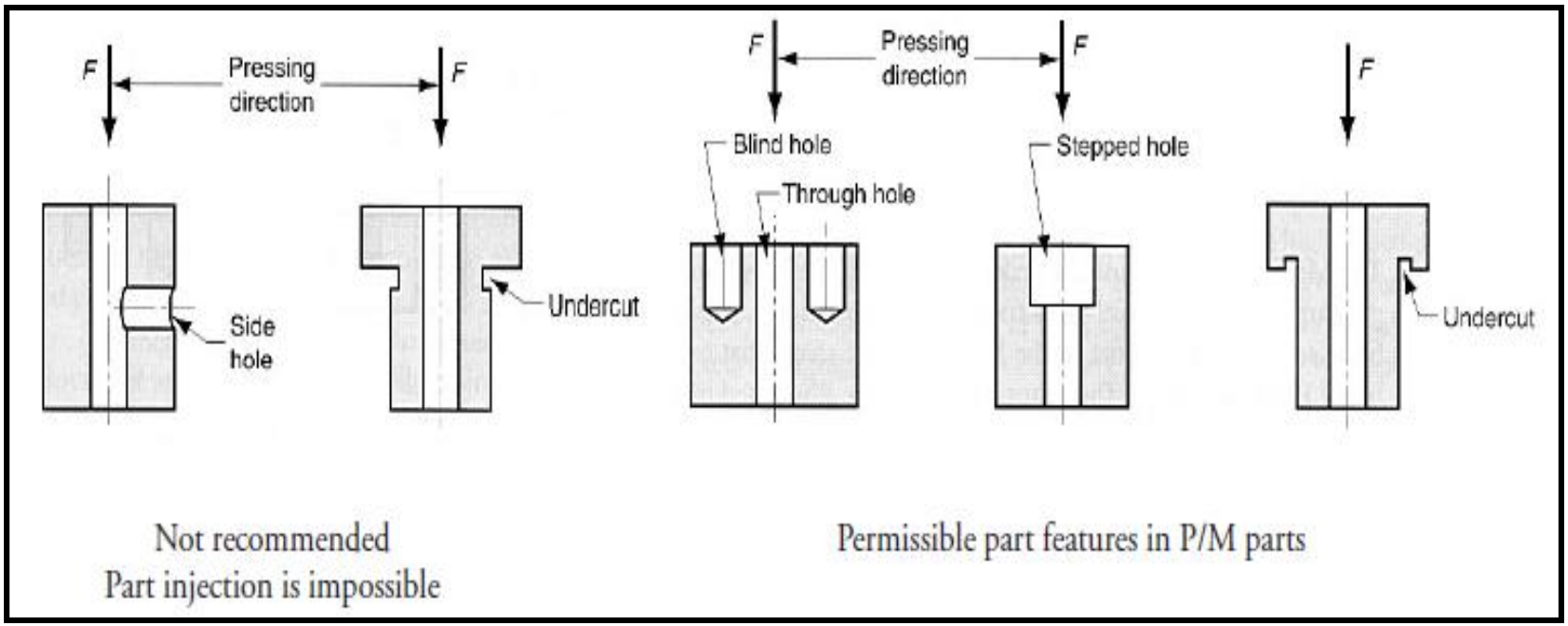
1. Availability of a wide range of compositions
2. Net- or near-net-shape technique
3. Use materials which are otherwise difficult to process

Disadvantages:

1. Size and complexity limitations
2. High cost of powder metals compared to other raw materials
3. High cost of tooling and equipment for small production runs

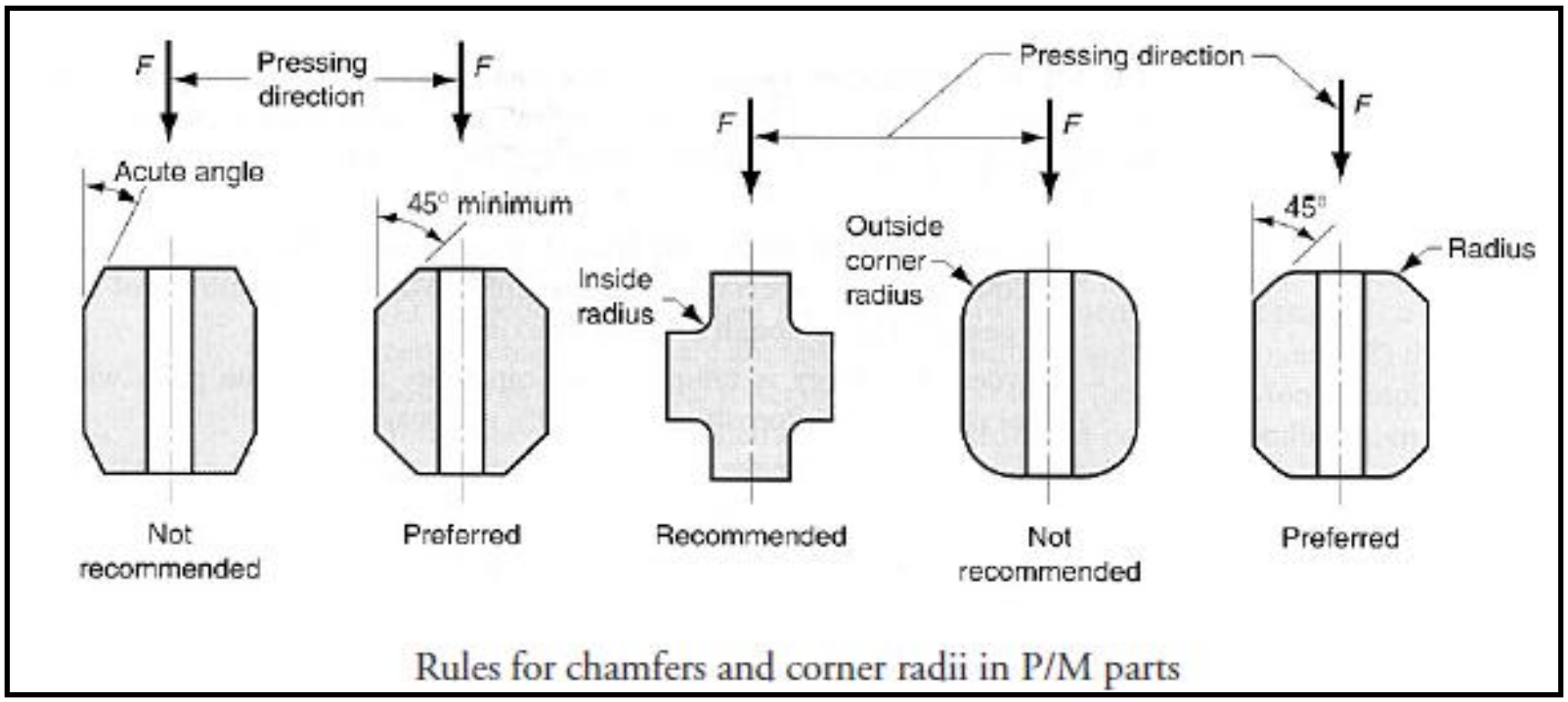
Design Considerations

1. The shape of the parts must be as simple as possible.
2. P.M parts should be made with the widest tolerances. The P.M process is capable of achieving tolerances of bigger than 0.1 mm.
3. Hole and grooves must be parallel to the direction of ejection.



Design Considerations

4. Sharp corners, radii, thin section must be avoided. Minimum wall thickness is 1.5 mm.



Rules for chamfers and corner radii in P/M parts

5. Provisions must be made for ejection of the green compact from the die without damaging the compact.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