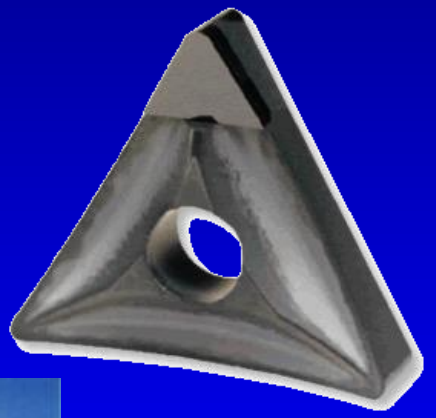
TOZ METALURJİSİ (PM)

- PM metal tozlarının endüstriyel uygulamlarda kullanımıdır





UYGULAMALAR

- Consolidation into dense parts & shapes
  - Structural / machine parts
  - Cutting tools
  - Filters
- Fusion / Welding
  - Solder and brazing pastes
  - Welding and thermal spray
- Other
  - Chemical
  - Agricultural
  - Food and pharmaceuticals

Why PM?

- Cost advantage
- Only option
- Better properties

Applications

- The vast majority of PM application is the consolidation of powder onto dense parts and shapes

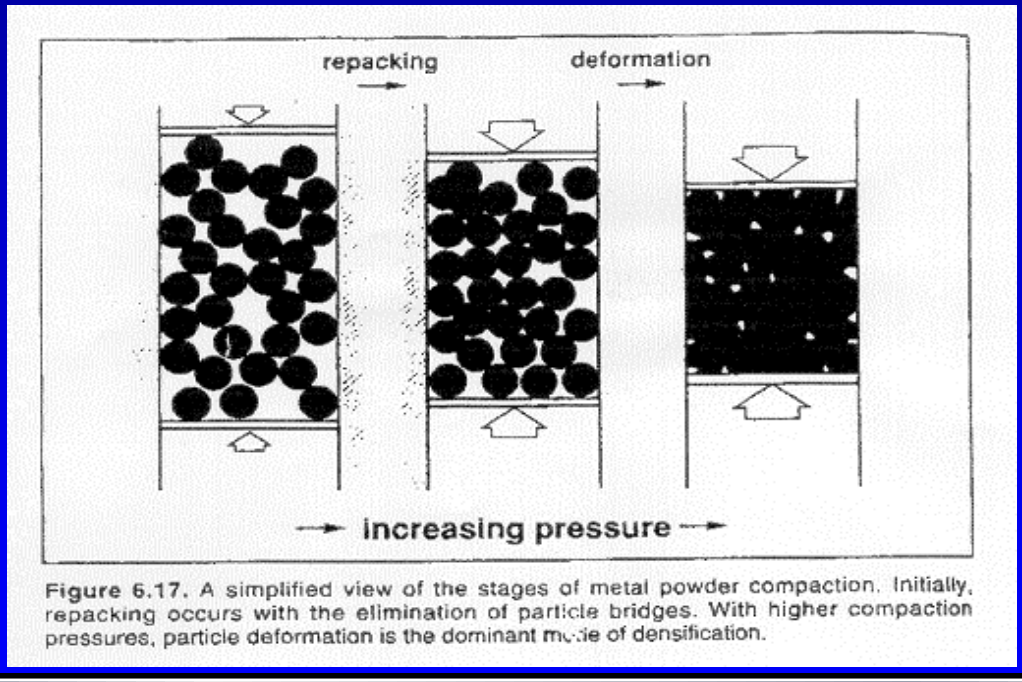


Figure 6.17. A simplified view of the stages of metal powder compaction. Initially, repacking occurs with the elimination of particle bridges. With higher compaction pressures, particle deformation is the dominant mode of densification.

Process Steps

- Powder manufacturing
- Powder mixing and or blending
- Powder compacting into shape
- Powder bonding
  - Density
  - Mechanical properties
  - Metallurgical integrity

İŞLEM BASAMAKLARI

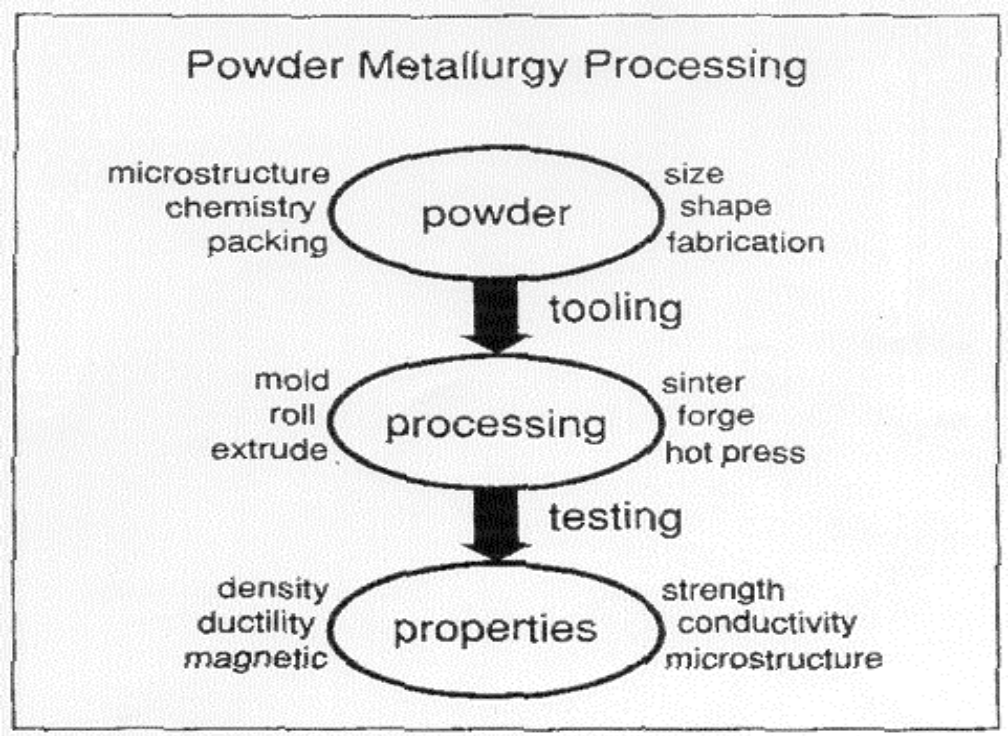


Figure 1.1. The conceptual flow for powder metallurgy from the powder through the processing to the final product. Example concerns are given for each of the three main steps.

TOZ KAYNAKLARI

- Atomization of liquid metal
  - Gas, water/oil, and mechanical
- Chemical
  - Reduction, reaction, precipitation, and electrolytic
    - » Fe_2O_3 (s) + $3H_2$ (g) → 2Fe (s) +$3H_2O$ (g)
    - » $Fe(CO)_5$ (g) + catalysis → Fe (s) + 5CO (g)
    - » Ni (s) + Al (s) → NiAl (s)
    - » $2AgNO_3$ (aq) + $2K_2SO3$ (aq) → 2Ag (s) + K_2SO_4 (aq) + $2K_2NO_3$ (aq) SO_2 (aq)
    - » Cu^{++} + 2e → Cu (s)
- Mechanical: milling and or grinding

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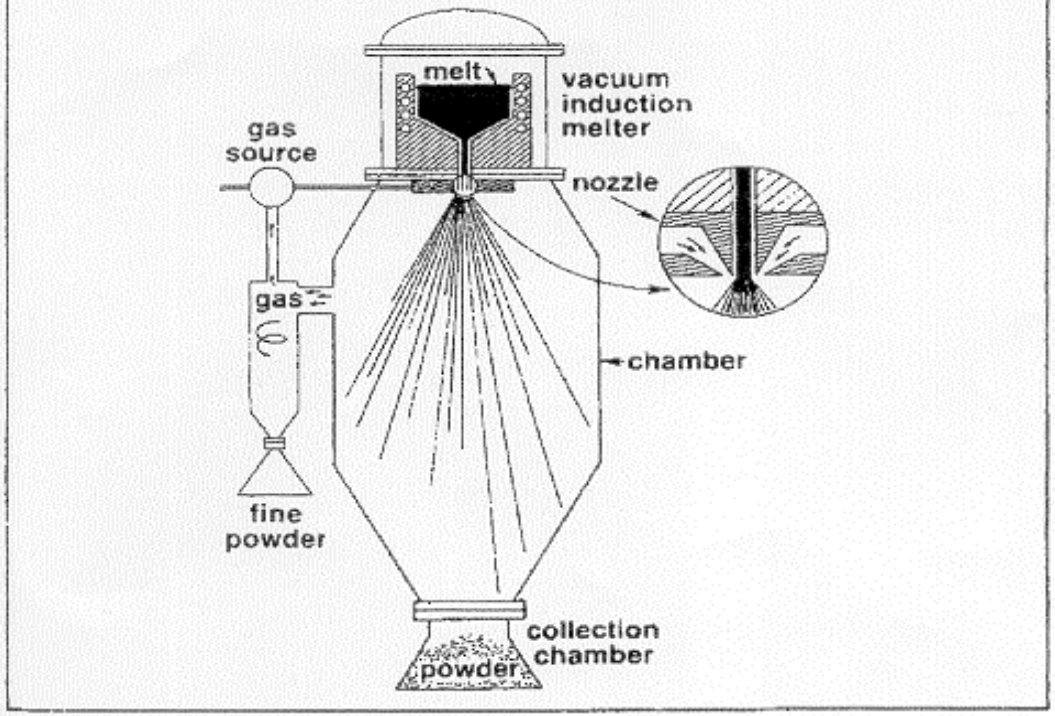

Figure 3.15. A vertical gas atomizer. The main features are a vacuum induction melter, gas expansion nozzle, gas recirculation and supply system, free-flight chamber, and powder collection chamber. An expanded view of the nozzle region is given to show the close proximity of the gas and melt streams needed for efficient atomization.

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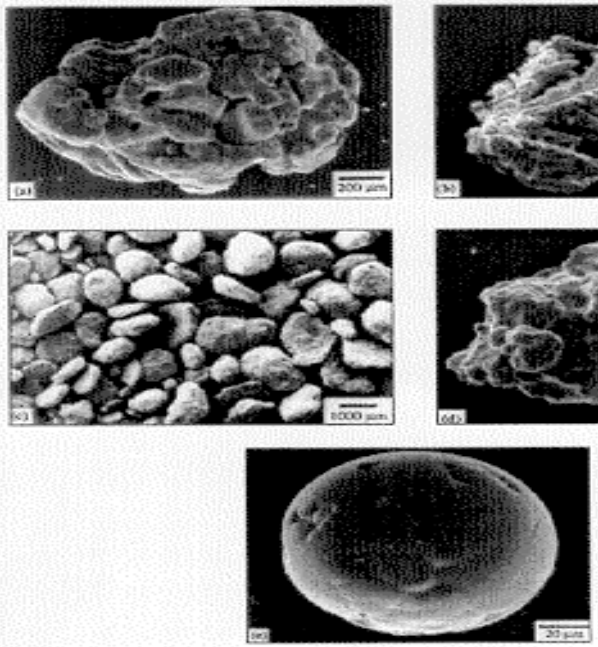

Figure 1. Representative metal powders: (a) chemical: sponge iron-reduced ore; (b) Electrolytic: copper; (c) Mechanical: milled aluminum powder; (d) Water Atomization: iron; (e) Gas atomization: nickel-base alloy (3).

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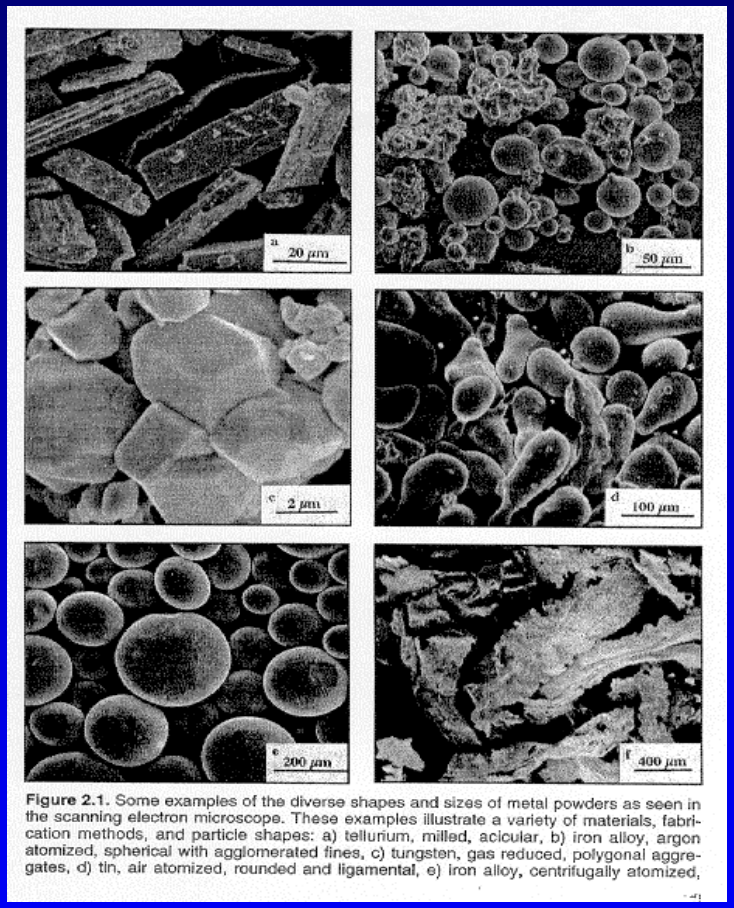
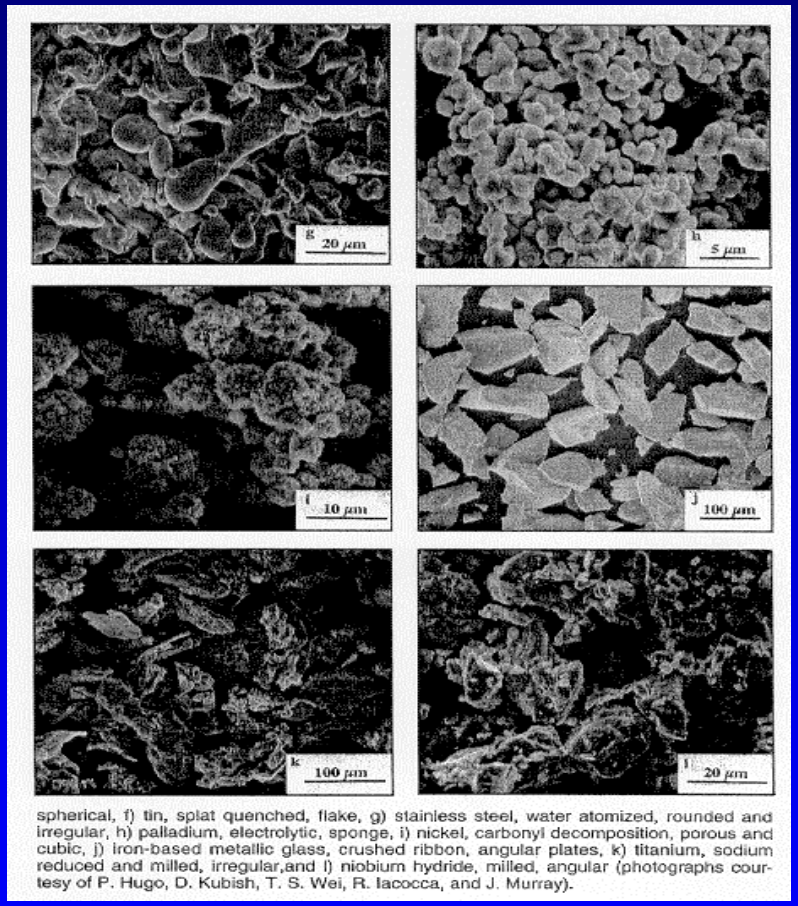


Figure 2.1. Some examples of the diverse shapes and sizes of metal powders as seen in the scanning electron microscope. These examples illustrate a variety of materials, fabrication methods, and particle shapes: a) tellurium, milled, acicular, b) iron alloy, argon atomized, spherical with agglomerated fines, c) tungsten, gas reduced, polygonal aggregates, d) tin, air atomized, rounded and ligamental, e) iron alloy, centrifugally atomized,



spherical, f) tin, splat quenched, flake, g) stainless steel, water atomized, rounded and irregular, h) palladium, electrolytic, sponge, i) nickel, carbonyl decomposition, porous and cubic, j) iron-based metallic glass, crushed ribbon, angular plates, k) titanium, sodium reduced and milled, irregular,and l) niobium hydride, milled, angular (photographs courtesy of P. Hugo, D. Kubish, T. S. Wei, R. Iacocca, and J. Murray).

TOZ KARAKTERLERİ

- Particle size and size distribution
- Particle shape
- Physical properties
  - Hardness and Ductility
- Chemical
  - Composition, reactivity, and impurities
- Bulk properties
  - Flow properties, apparent density, tap density, compressibility, and green strength

Consolidation

- Consolidation = to impart shape or form
- Net shape methods
  - Pressing, die compaction (hot or cold)
  - Metal injection molding (MIM)
  - Cold isostatic pressing (CIP)
- Bulk shape methods
  - Hot isostatic pressing (HIP)
  - Cold isostatic pressing (CIP)
  - Roll
  - Extrude
  - Spray form

Consolidation – *Net Shape*

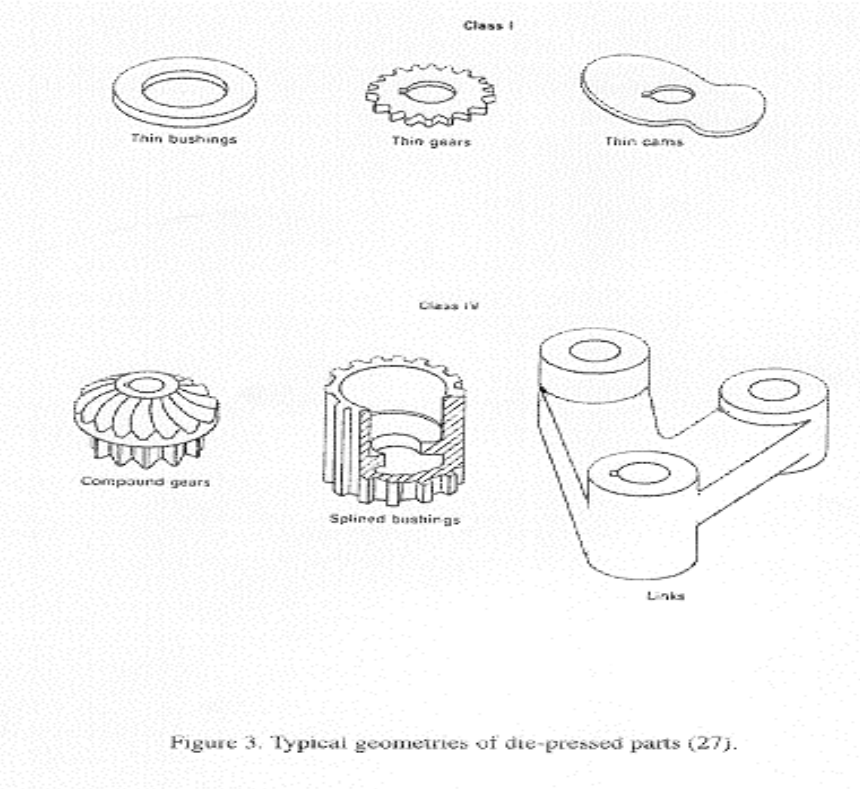


Figure 3. Typical geometries of die-pressed parts (27).

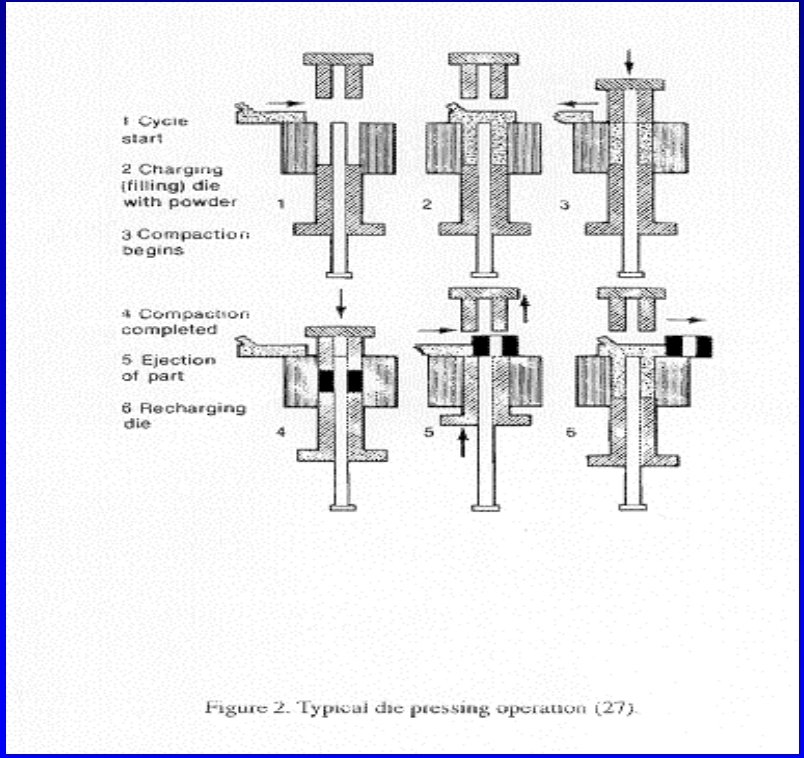


Figure 2. Typical die pressing operation (27).

Consolidation – *Net Shape*

Consolidation - *MIM*

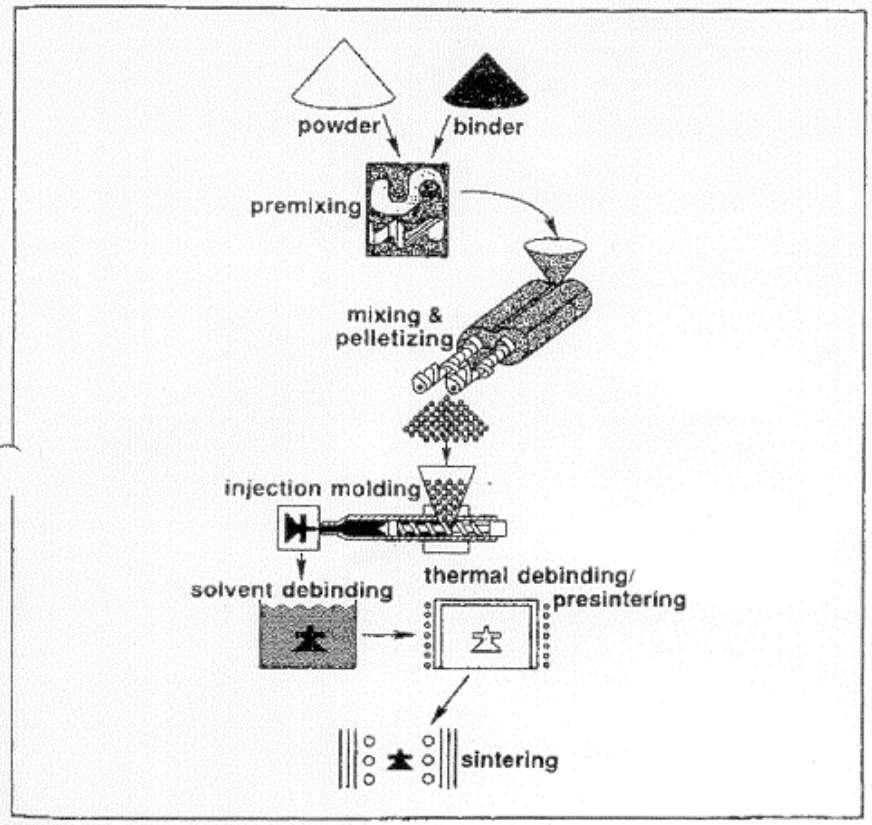


Figure 6.1. The conceptual sequence of steps involved in powder injection molding, where a binder and powder are mixed to form a feedstock which is molded, debound, and sintered. Injection molding relies on the thermoplastic for shaping at slightly elevated temperatures, typically near 150°C.

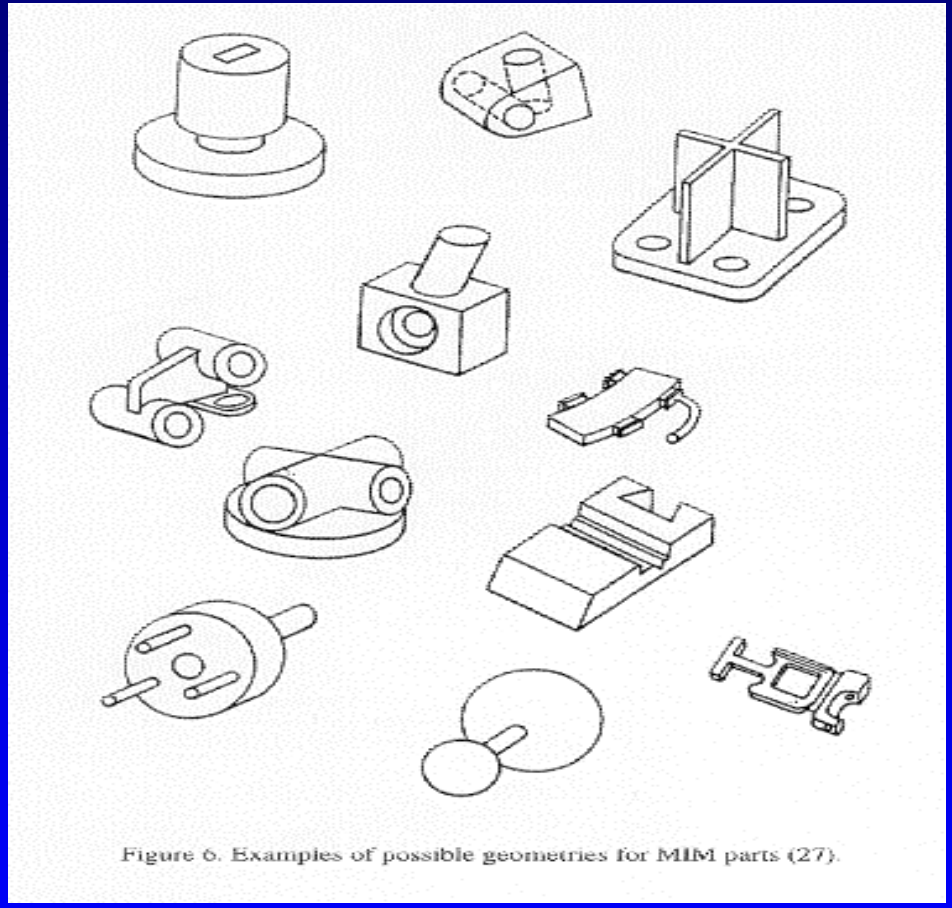


Figure 6. Examples of possible geometries for MIM parts (27).

Consolidation - *Bulk*

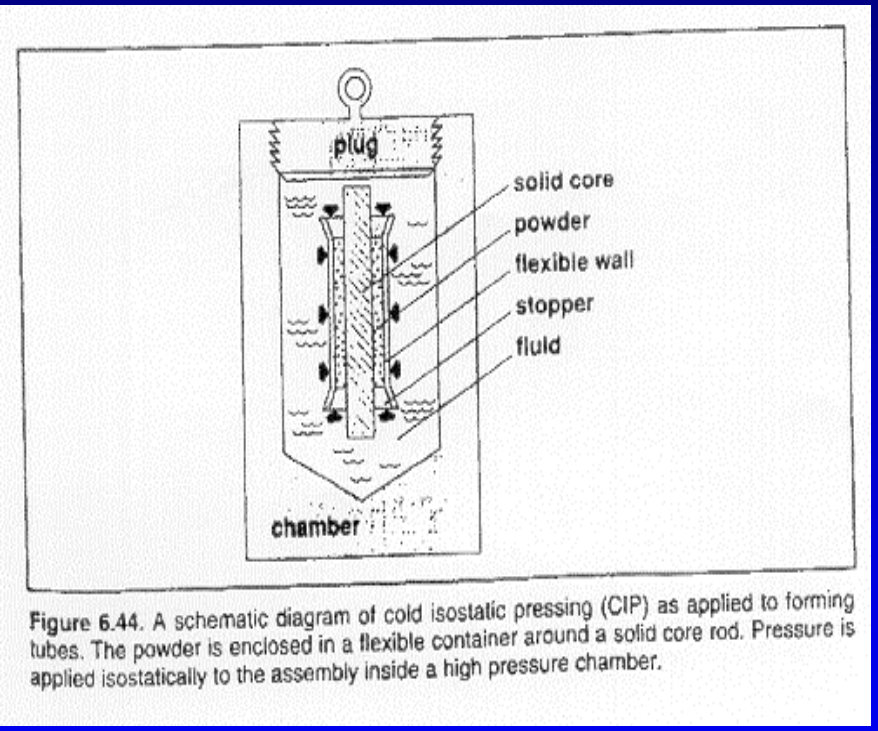


Figure 6.44. A schematic diagram of cold isostatic pressing (CIP) as applied to forming tubes. The powder is enclosed in a flexible container around a solid core rod. Pressure is applied isostatically to the assembly inside a high pressure chamber.

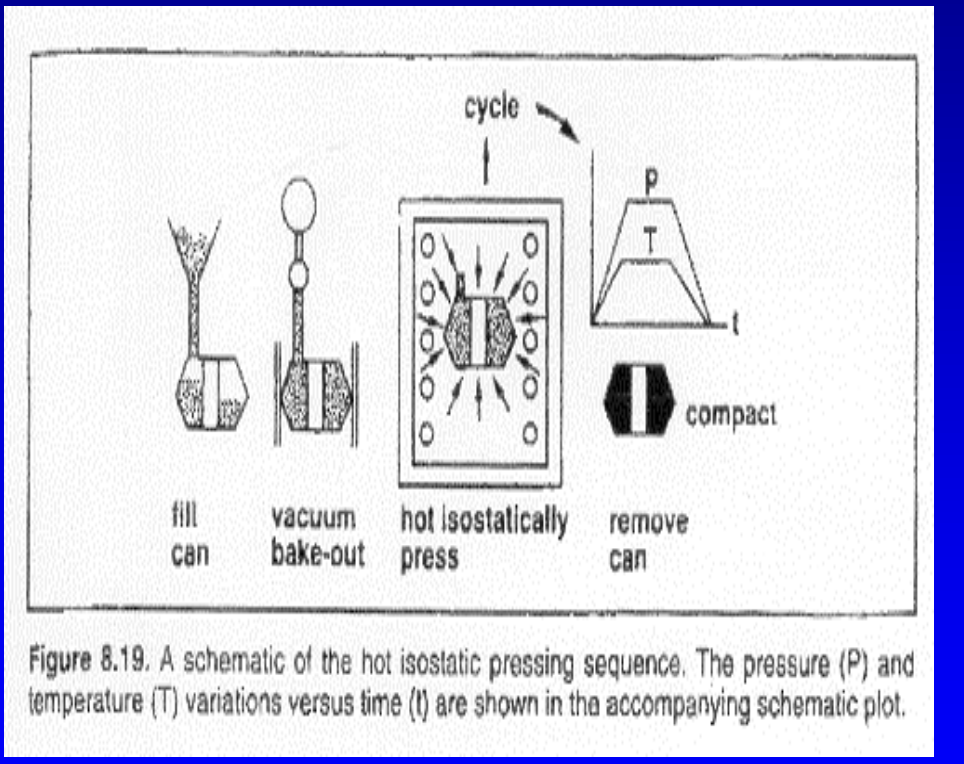


Figure 8.19. A schematic of the hot isostatic pressing sequence. The pressure (P) and temperature (T) variations versus time (t) are shown in the accompanying schematic plot.

Consolidation - *Bulk*

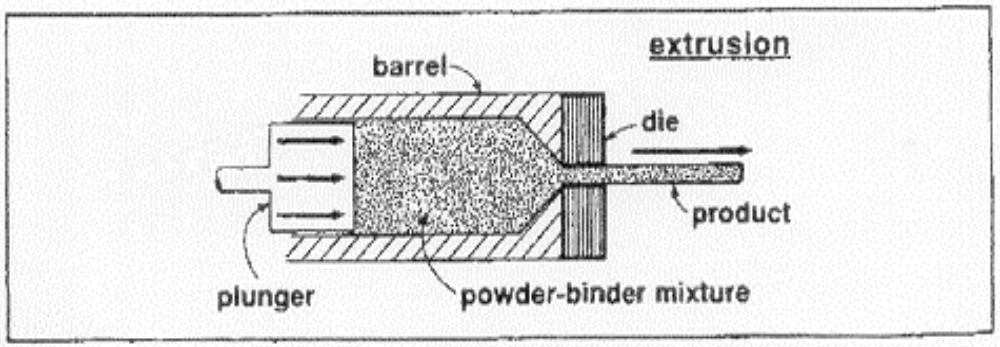


Figure 6.15. The extrusion process forces a slurry of powder and binder through a constriction to shape a continuous product such as a rod, tube, or honeycomb.

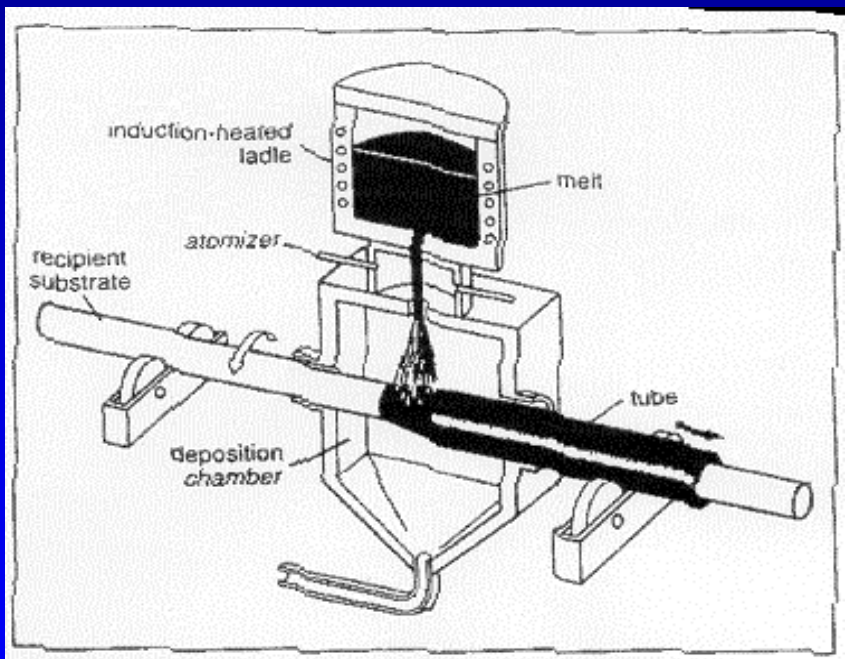


Figure 8.34. The spray forming process uses a gas atomizer to generate a spray of particles deposited on a moving substrate to form a rapidly solidified, nearly full density structure.

SİNTERLEME

- Metallurgical bonding of powder particles
  - Solid state diffusion
  - Liquid phase
- Thermal activated event
  - Atomic transport
  - Particle rearrangement
  - Particle growth
- Results
  - Densification, yield useful physical properties (UTS, YS, ductility, and fatigue strength)

SİNTERLEME

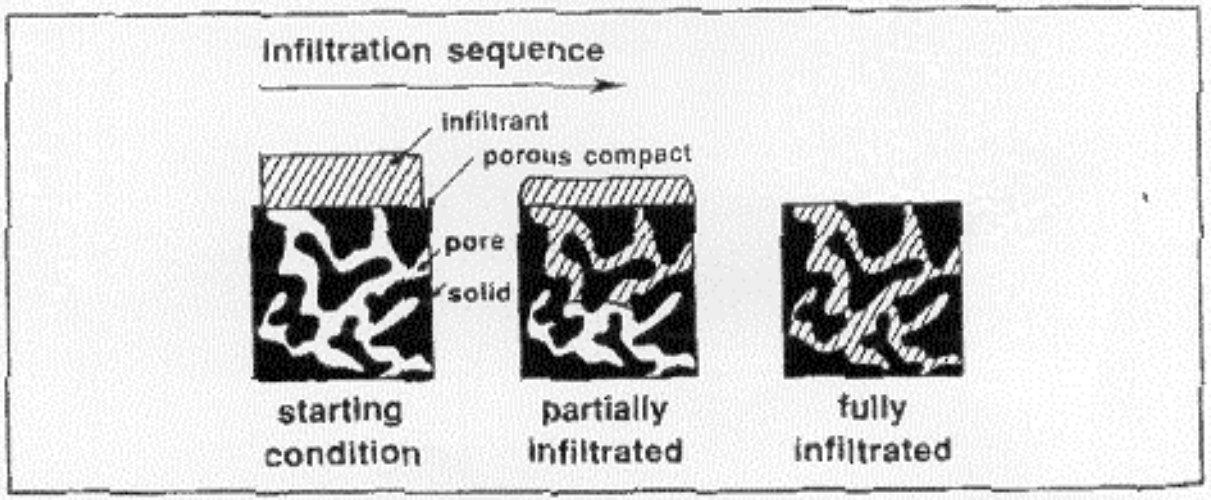
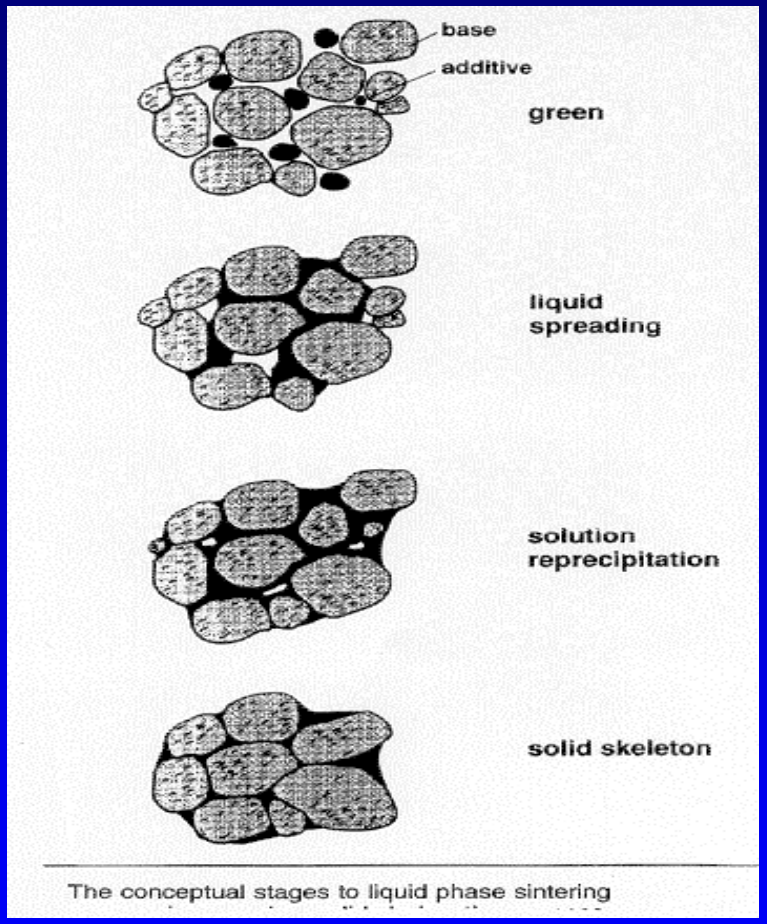


Figure 8.9. A sketch of the infiltration sequence where capillary forces pull a molten metal into the open pores of a sintered compact.

SİNTERLEME



The conceptual stages to liquid phase sintering

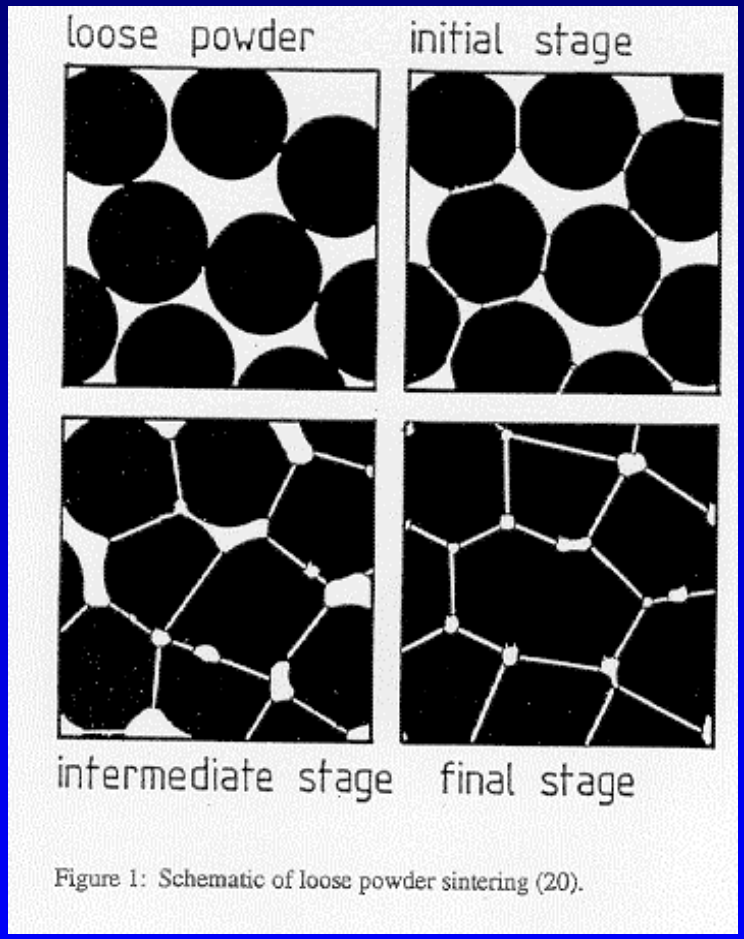


Figure 1: Schematic of loose powder sintering (20).