Applications

Some typical applications of P/M are:

- production of *net-shape* or *near-net shape* parts made of expensive materials. P/M process is capable of less than 3% scrap losses.
- parts with porosity such as filters can be made.
- bearings especially so-called *permanently lubricated bearings*, in which air pores in the P/M parts are filled with oil (process of *impregnation*)
- parts of certain metals and metal alloys that are difficult to fabricate by other methods (carbide tool inserts, tungsten, ceramics, etc.)
- parts of materials with special and unique properties (alloys that cannot be produced by other processes)

Limitations

There are limitations and disadvantages associated with P/M processing. These include:

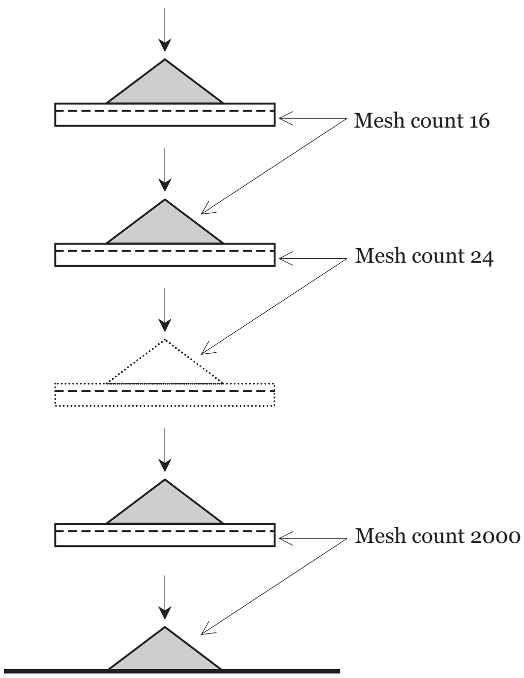
- high tooling costs
- expensive raw materials (powders)
- variation in material density and mechanical properties across the volume
- relatively long parts are difficult to manufacture
- difficult storing and handling of powders (degradation with time and fire hazard with particular metallic powders).

3.2 ENGINEERING POWDERS

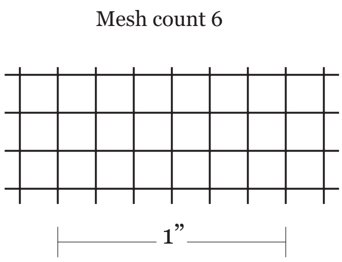
Classification of powders

The engineering powders, which are the starting material in P/M consist of fine particles of uniform sizes. These engineering powders are produced from raw metallic or nonmetallic powders, which contains particles of different sizes by separation of particles according to their size. The procedure of separating the powders by size is called *classification* of powders. Powders are classified by passing them through a series of screens of progressively smaller mesh size.

The particle size is defined by the so-called *mesh count*, term that refers to the number of openings per linear inch of mesh.



Process of powder classification

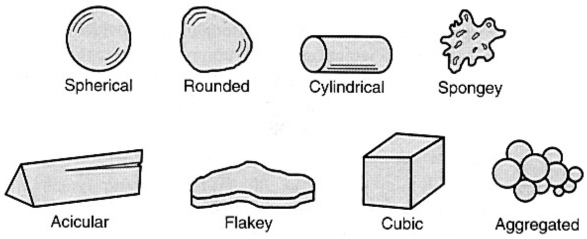


Definition of mesh count

Particle's Properties

Particle shape

The measure of particle shape is the ratio of maximum dimension to minimum one for a given particle.



Several of the possible particle shapes in powder metallurgy

Surface area

For any particle shape, the shape factor, Ks, defines the area-to-volume ratio,

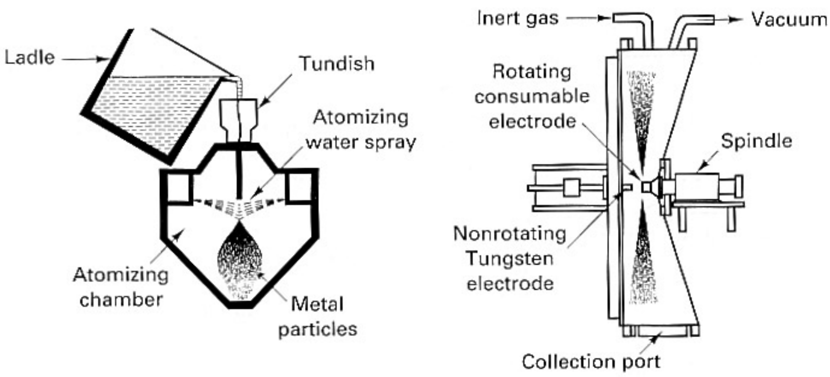
$$K_s = AD/V$$

where A is the surface area, V is the volume, and D is the diameter of a sphere of equivalent volume as the non-spherical particle.

Production of metallic powders

Atomization

Atomization involves conversation of molten metal into a spray of droplets that solidifies into powder. There are a lot of methods based on *gas* or *water atomization*, or on *centrifugal atomization*. The most popular one is the water atomization, in which a high-velocity stream of water is utilized to atomize the liquid metal.



(*Left*) Water atomization; and (*Right*) Centrifugal atomization from a consumable electrode

Chemical reduction

This method includes a variety of chemical reactions by which metallic com-pounds are reduced to elemental metal powder.

Electrolysis

In this method, an electrolytic cell is set up in which the source of desired metal is the anode. It is slowly dissolved and deposited on the cathode from where the deposit is removed, washed and dried.