Properties and Testing of Metal Powders

The main purpose of powder testing is to ensure that the powder is suitable for subsequent processing.

The basic properties or characteristics of powder are:-

2. Particle size and its distribution.
3. Particle shape.
4. Particle porosity.
5. Particle microstructure.

The secondary properties or characteristics are:-

1. Specific surface.
2. Apparent density.
3. Tap density.
4. Flow rate.
5. Compacting characteristic.

The important secondary properties such as apparent density and flow rate are most widely used in specification and control routine.

So the basic characteristic are:-

1) Chemical composition

The chemical composition of powders is the outstanding characteristic. It usually reveals the type and percentage of impurity and determines the particle hardness and compressibility.

The term impurity refers to some elements or compounds which has an undesirable effect. Impurities influence not only the mechanical properties of the powder compacts, but also their chemical – electrical and magnetic properties. It may also exert a decisive effect on pressing, sintering and other post – sintering operation which are essential for the production of finished product from powders.
The chemical composition of a powder is determined by the well established standard techniques of chemical analysis. Oxygen content is determined either by wet analysis or by loss of weight in hydrogen. Some oxides may not be reduced at all or there may be error due to incomplete reduction of oxides, therefore it is desirable for both processing and optimum properties of the final product to have a low oxygen content.

2) Particle size

The particle size has a great important in P / T because it affects most of the properties such as mold strength, density of compact, porosity, expulsion of trapped (occluded) gases, dimensional stability, agglomeration and flow and mixing characteristics.

Particle size is expressed by the diameter for spherical shaped particles and by the average diameter for non – spherical particles. Average employed is defined in different ways according to the method employed for size distribution. When the method involves sizing, the particle size is measured as the opening of a slandered screen which just retains or passes the particle. When determined by micro count method, the diameter is measured by averaging several dimensions.

According to the sedimentation method the particle size is defined as the diameter of the spherical particle having the same specific gravity and setting velocity as the non – spherical particle under test. The average diameter in the case of large particle sizes can be determined by counting and weighing at the cube root of the volume. In practical P / T powders are divided into three distinct classes. 1-sieve -2- sub sieve and sub – micron or ultrafine.

The screen with the opening of finest standard mesh – sieve for production purposes is the 325 mesh screen having the aperture of 44 micron.
Sub sieve particles are smaller than the aperture of such a screen but greater than 1 MM. This class of powder is used for the production of refractory metals, hard carbides and magnetic cores. As the name suggests, the sub – micron powder particle size is smaller than 1mm and is used for the manufacture of dispersion strengthened high – temperature alloy, bearing and micro porous component magnetic material.

3) particle shape

There are various shape of metal powders such as

1-spherical
(carbonyl iron, condensed size, lead, atomization, precipitation from aqueous solution by gases).

2- rounded or droplets
(atomized copper, zinc, aluminum, tin, chemical composition).

3-angular
(mechanically disintegrated sb, cast iron, stainless steel obtained by intergranular corrosion).

4-acicukar
(chemical decomposition)

5-dendritic
(electrolytic silver, iron powder).

6-Flakes
(ball milled copper, Aluminum, and stamped metals).

7-porous
(reduction of oxides).

8-irregular
(atomization, reduction, chemical composition).

9- fragmented.

Particle shape has a pronounced effect on the packing of powder and has an influence on its compacting and sintering properties and the
mechanical strength of the sintered product thus, irregularly shaped particles have reduced apparent density and flow rate, good pressing and sintering properties, while a spherical particles have maximum apparent density and flow rate but reduced pressing properties and good sintering characteristic.

In the same way, dendritic powders result in reduced apparent density and poor flow rate.

4) Particle Microstructure.

In general, the metal powder is mixed with bakclite powder in the proportion of 1 : 8 mounted in the mounting press, polished with slight pressure at every stage, etched in a suitable etchant washed with hot water and alcohol and dried in hot air blast and examined under microscope, Another method involves the mixing of a small amount of metal powder in an epoxy – filled metal cylinder which , after the resin hardness, is remounted in alongiliudinal direction and the section ground and polished. The metallographic examination of these powders will reveal not only various phases, inclusion impurities, fissures and internal porosity, but also the particle size, relative size distribution and particle shape.

Other characteristics

1) Specific Surface

The specific surface of a powder is defined as the total surface area per unit weight (cm$^2$ / gm). It depends on size, shape, density and surface condition of the particle. The compacting and sintering properties are considerably influenced by contact between the metal particles. High specific surface not only results in high sintering rate, but also causes entrapment of air and bridging effects there by causing the compact to
crack either before or during sintering. Coarser powders with smaller contact areas have an inferior sintering characteristic and therefore, mechanically weak. There are several methods for determining specific surface.

2) Apparent Density

Apparent density is not only of importance in P/T but also in other fields such as point, pigments, chemical reagents and pyrotechnical applications.

The apparent density of a powder sometimes called packing density or loading weight is defined as the mass per unit volume of loose or unpacked powder. Thus it includes internal pores but excludes external pores. It is governed by chemical composition, particle shape, size, size distribution, method of manufacture of metal powders as well as shape and surface condition which can vary from 20 to 50% of the theoretical density. The apparent density decreases with the decrease of particle size, and increase of surface roughness.

The main factor is not the particle size but the particle size distribution for altering the apparent density. Thus the uniform and identical particles occupy a constant fraction of the available space but various sized.

3) Tap density

Tap density is the apparent density of the powder after it has been mechanically shaken down or tapped until the level of the powder no longer falls.

It appears to be widely used for strong, packing or transport of commercial powders and also as a control, test on mixed powders. Since tapping of vibration tends to segregate fines, different sized particles and materials with different specific gravities, it interferes with the uniform packing of particles.
There are various methods to determine it, and they differ only in the method of type or vibrating the receptacle containing the powder. It has been found that the Ro-tap, tap density determination method yields highly reproducible results, within a short time (10 to 15 min) using a universally available Ro tap machine.

4) Flow Rate
The flow rate is a very important – characteristic of powders which measures, the ability of a powders to be transferred. It is defined as the rate at which a metal powder will flow under gravity from a container through – an orifice, both having the specific shape and finish. The powder filling of die must be rapid and uniform without bidge formation for obtaining a rapid rate of production consistent compacts and economy.

On the other hand poor flow properties of the powder result in slow and uneconomical feeding of the cavity and the possibility during pressing of uneven filling of the die cavity. It is affected only by particle size, size distribution and shape, but also by absorbed air or gas, moisture, lubricant, coefficient of inter particle friction etc. In general line or dendritic, irregular, coarse and spherical powders have poor, reduced, good and maximum flow rates respectively.

Flow rate increases with decreased particle irregularly and increased particle size, specific gravity, and apparent density. It can also be increased by tapping or vibrating.