Micro Meretics

Unit - IV

It is the study of the fundamental and derived properties of individual as well as collection of particles.

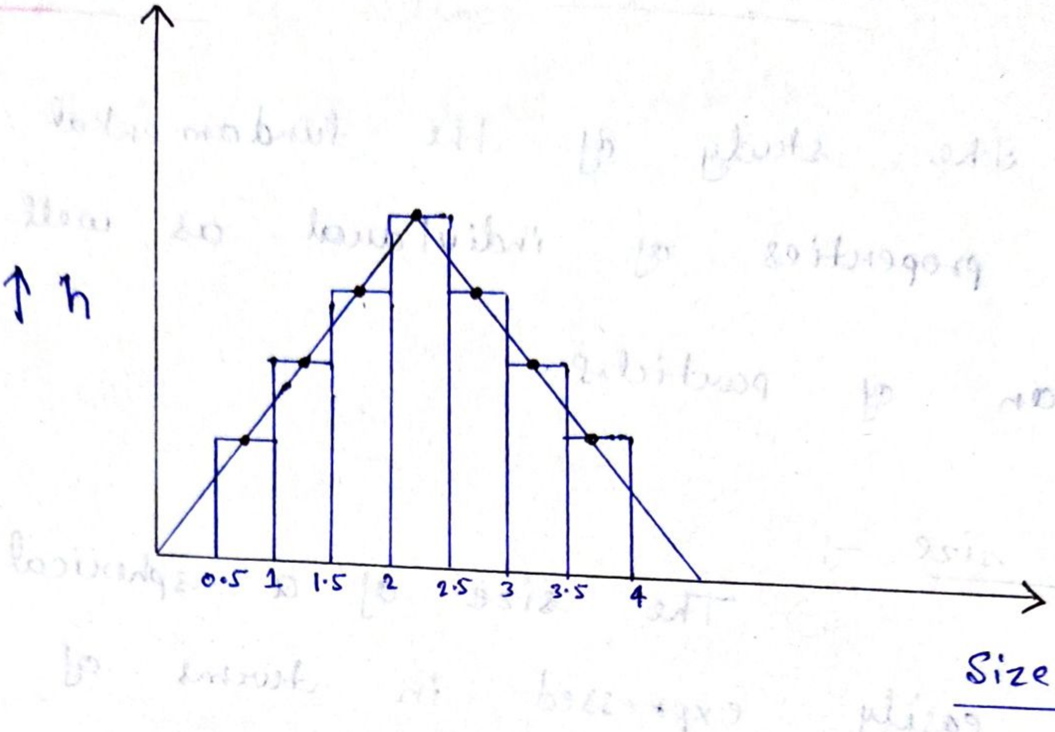
Particle size :-

The size of a spherical particle can be easily expressed in terms of it's diameter.

* The avarage particle size of powder may be calculated by —

$$\boxed{\text{Average particle size} = \frac{\Sigma nd}{\Sigma n}}$$

S.N	Size range (µm)	mean size rang (µm)	No. of particle (n)	nd
1	0.5–1	0.75	04	3
2	1 – 1.5	1.25	18	22.5
3	1.5 – 2	1.75	39	68.25
4	2 – 2.5	2.25	73	164.25
5	2.5 – 3	2.75	24	66
6	3 – 3.5	3.25	14	45.5
7	3.5 – 4	3.75	02	7.5



ⓐ For a perfect sphere —

$$\boxed{\text{Surface area } (S) = \pi d^2}$$

$$\boxed{\text{Volume } (V) = \frac{\pi d^3}{6}}$$

ⓑ For a non-spherical particle → Particle size can be calculated in terms of equilivalent spherical diameter. that is surface are, volume, diameter, projected diameter and stokes diameter.

Particle size distribution :-

A collection of particles having mixture of varying size and shape, the number of particle of same size range present in a sample is k/as size distribution.

* Particle size distribution can be calculated by following two ways—

(I) By determining number of particles present in each size range (microscopy technique).

(II) By determining weight of particle present in each size range (sedimentation and seiving method).

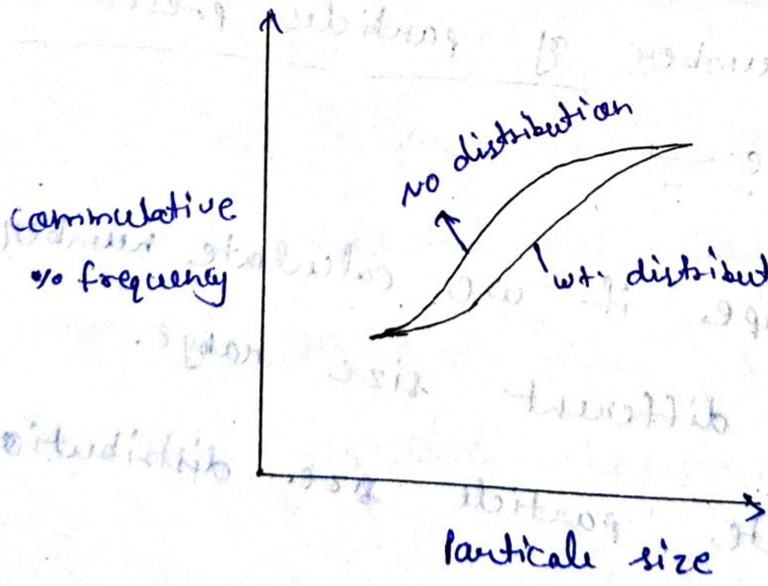
(I) By determining number of particles present in each size range :-

* By using microscope if we calculate number of particle in different size range.

* We can calculate particle size distribution by using table below—

S.N.	Size range (µm)	Mean size (d) range (µm)	No. of particle frequency (n)	% f	Frequency commulative
1	0.5-1	0.75	04		
2	1-1.5	1.25	18		
3	1.5-2	1.75	39		
4	2-2.5	2.25	73		
5	2.5-3	2.75	24		
6	3-3.5	3.25	14		
7	3.5-4	3.75	02		

When the number of particle is plotted against the mean particle size, the curve obtained is k/as number frequency distribution curve.



(11) By determining weight of particle present in each size range (sedimentation and seiving) :-

* To determine weight of particle present in each size range, we can use seiving method.

* In this method we can arrange seive according to the descending order of their pore size.

* After shaking seive for sufficient time.

* The particle settle of seive according to their size.

* By weighing particle on seive, we can obtain weight of particle according to their size.

Seive no.	Pore size	Frequency wt. (gm).	% F	Cummulative % F

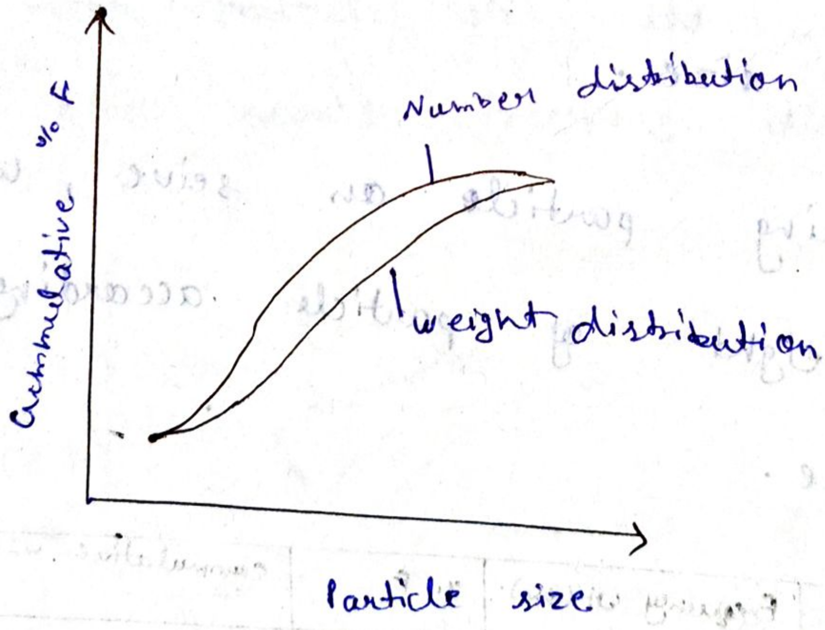
When the weight of particle is plotted against mean particle size, the curve obtained is k/as weight distribution curve.

$$\frac{\%\ \text{Frequency}}{\%\ \text{weight}} = \frac{\text{weight obtained}}{\text{Total weight}} \times 100$$

Cummulative % Frequency = (i) 1%

(ii) 1% + 2%

(iii) 1% + 2% + 3%



Particle number

The particle number is defined as the number of particles per unit weight of a powder. It can be obtaine by —

$$\boxed{N = \frac{1 \text{ gm of powder}}{\text{mass of one particle}}}$$

where —:

Volume of single particle $= \frac{\pi d^3}{6}$

$\because$ density $= \frac{\text{mass}}{\text{volume}}$

$\therefore$ mass $=$ volume $\times$ density

mass $= \frac{\pi d^3}{6} \rho$

$$\boxed{N = \frac{1 \times 6}{\pi d^3 \rho}}$$

Q-1 → If mean volume number diameter of a sample powder is 3.62 mm.

If the density of the powder is 3 gm/cm3, what is the number of particle per gram.

$$N = \frac{6}{\pi d^3 \rho}$$

$$N = \frac{\cancel{6}\ 2}{3.14 \times 3.62 \times 3.62 \times 3.62 \times 10^{-12} \times 3}$$

$$N = \frac{2}{3.14 \times 3.62 \times 3.62 \times 3.62} \times 10^{12}$$

$$N = \frac{200 \times 10^{10}}{47.43 \times 3.14}$$

$$N = \frac{200}{149} \times 10^{10}$$

$$N = 1.34 \times 10^{10}$$

Particle size determination

The fallowing methods are generally used for the determination of particle size and particle size distribution.

1- Microscopic technique :-

This technique can be used for particle size in the range 0.2 µm – 100 µm.

* A dilute suspension of the particles is prepared in the liquid in which it is insoluble.
* A drop of suspension is mounted on a slide and observed under the microscope.
* The eye piece of the microscope is fitted with a micrometer.
* All particles observed in field are counted through eye piece.
* The data may be scientifically represented as size frequency distribution curve.
* The average particle size and size distribution

is determine.

* For measuring very small particle an electran microscope or scanning electron microscope may be used.

Advantages :-

* Agglomerates as well as particles of more than one components can be determined by this method.

Disadvantages :-

* The measured diameter of the particle represent two dimensions that is length and breadth and an estimate of the depth is not obtained.

Q1 → The following data was obtained by means of an optical microscope.

Particle size	Number of particle (n)	nd
5	3	15
10	8	80
15	4	60
20	2	40

calculate the average particle size

$$= \frac{195}{17} = 11.47\ \mu m.$$

2 → Sieving method (techniques) :-

* In this technique the powder whose particle size is to be determined is placed on the seive placed on one another.

* The sieve of largest aperture is placed on top followed by sieves of decreasing pore size.

* The powder is shaken for a definite period of time by mechanical shaker.

* The powder passes through sieve and retain on that sieve depending upon their size.

* The data obtained is analyzed and particle size as well as size distribution is calculated.

* This technique is suitable for coarse particle (not less than 50 μm).

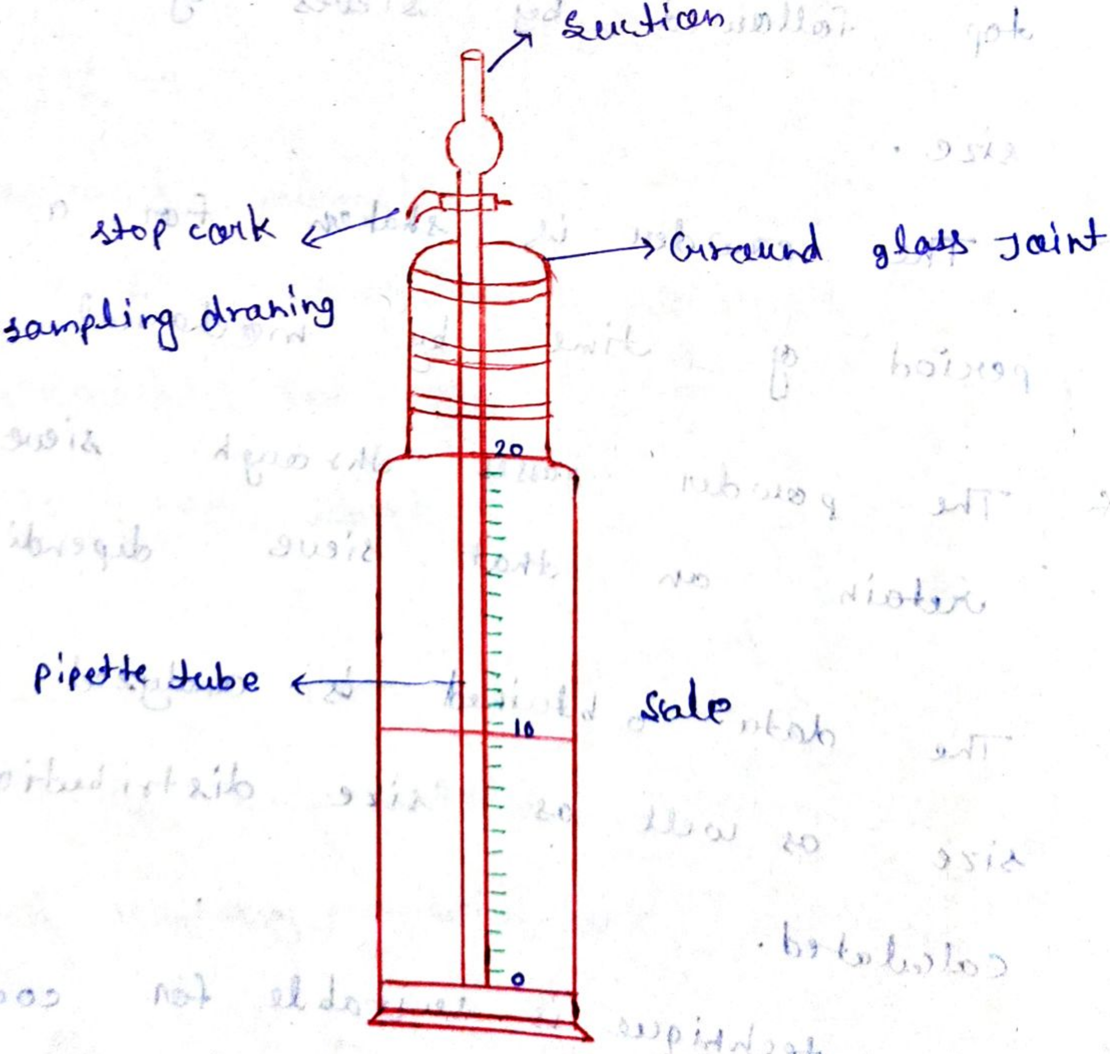
Disadvantages

* Attrition of particles during sieving may lead to size reduction.

* Sieve loading and duration of mechanical shaking can influence the result.

* Moisture may lead to aggrigation of powders.

3- Sedimentation techniques -:



Andreasen pipette

* This method is used for particle size distribution by sedimentation technique.

* The apparatus consist of 550 ml stopperd cylindri-cal vessel.

* The vessel has 5.5 cm. internal diameter and a vertical scale of 0-20 cm. on it.

* The stopper has 10 ml bulb pipette and a side tube for sample discharge.

* The pipette has lower tip 20 cm. below the surface of suspension.

* For analysis, 1-2% suspension of powder is prepared in a medium.

* The suspension is introduced into the vessel upto 550 ml mark.

* The vessel is stopperd and shaken to distribute the particle.

* The pipette is than placed and constant temperature bath.

* At various time intervalls 10 ml sample of suspension are withdrawn.

* The sample is taken in previously weight china dish.

* The samples are evaporated and weighed.

* The particle diameter is calculated by stocks equation —

$$\boxed{V = \frac{h}{t} = \frac{d_{st}^2 (\rho_s - \rho_o) g}{18 \eta_o}}$$

Where →

V = Rate of settling.

h = distance of fall in time (t)

d_{st} = Mean diameter of particles

ρ_s = Density of particle.

ρ_o = Density of medium.

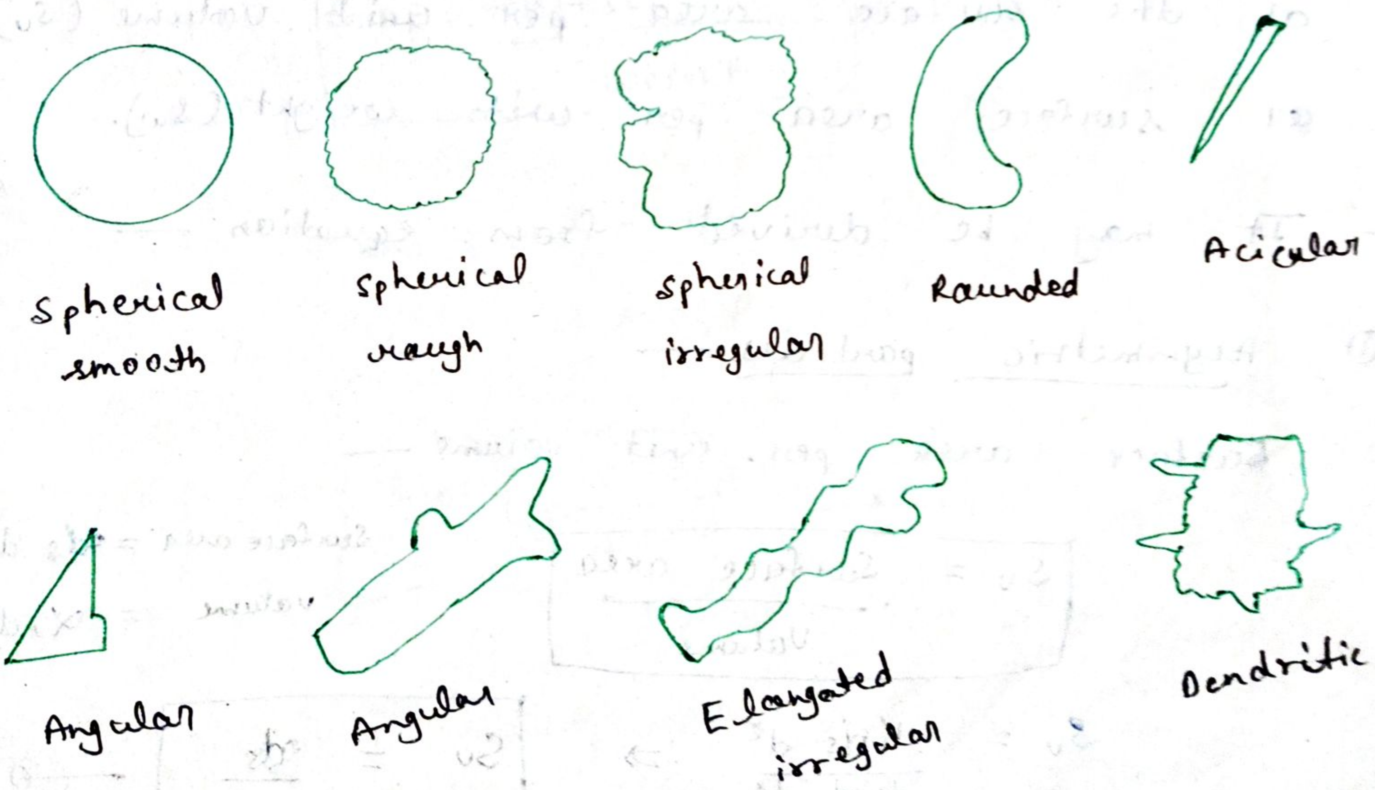
g = Acceleration due to gravity

η_o = Viscosity of medium

* The weight of each sample is called the weight under size and the sum of successive weight is k/as cummulative weight under size.

Particle shape

* The particle shape is its geometric shape and surface irregularlity, it affect packing property.
* The shape of particle may be of fallowing types —



* A sphere has minimum surface area.
* A sphere is categarised by its diameter.
* Asymmetric particles have greater surface area.
* Asymmetric particles surface diameter is measured interms of equivalent spherical diameter.
* Equivalent spherical diameter of sphere have same surface area as symmetric particle.

Specific surface

Specific surface of a powder is defined as the surface area per unit volume (S_v) or surface area per unit weight (S_w).

* It may be derived from equation —

(1) Asymmetric particles —

Surface area per unit volume —

$$\boxed{S_v = \frac{\text{Surface area}}{\text{Volume}}}$$

Surface area $= \alpha_s d^2$

volume $= \alpha_v d^3$

$$S_v = \frac{n \alpha_s d^2}{n \alpha_v d^3} \Rightarrow \boxed{S_v = \frac{\alpha_s}{\alpha_v d}} \quad \text{— (1)}$$

Surface area per unit weight —

$$\boxed{S_w = \frac{\text{Surface area}}{\text{Weight}}}$$

$$S_w = \frac{\cancel{h} \alpha_s d^2}{h \alpha_v d^3 \rho} \Rightarrow \boxed{S_w = \frac{\alpha_s}{\alpha_v d \rho}} \quad \text{—— (ii)}$$

(ii) Spherical particle —

Surface area per unit volume —

$$S_v = \frac{\cancel{h} \cancel{\pi} d^2 6}{\cancel{h}\cancel{\pi} d^3} \qquad \boxed{S_v = \frac{6}{d}} \quad \text{—— (i)}$$

Surface area per unit weight —

$$\boxed{S_w = \frac{\text{Surface area}}{\text{weight}}}$$

$$S_w = \frac{\cancel{h} \cancel{\pi} d^2 6}{h \pi d^3 \rho}$$

$$\boxed{S_w = \frac{6}{d\rho}} \quad \text{—— (ii)}$$

Method for determining surface area

The surface area can be determined by one of the following 2 methods —

① Adsorption method.

② Air permeability method.

1 - Adsorption method —

The amount of gas or solute adsorbed on the sample of powder is found out, and the surface area of the powder is determined —

① By using a solute which form a monolayer —

* This method involve the adsorption of solute from it's solution on the surface of powder whose area is to be determined.

* Firstly a solution of suitable solute is prepared in powder insoluble medium.

* A known amount of powder is added in solution.

* After equilibrium the powder is filtered and remaining solute is determined.

* Difference b/w quantity added and remaining gives the amount adsorbed.

* If X gm of solute adsorbed.

* 1 gm. mole of material contain avogadro's number 6.0223×10^{23} number of molecules.

* Total number of molecules will be —

$X \times 6.0223 \times 10^{23}$.

* Surface area of 1 molecule of solute is known surface area of powder can be calculated.

(ii) By using adsorption of gas on powder :-

* Quantasorb is an instrument used for determination of surface area by gas adsorption method.

* The powder whose surface area is to be determined is introduced into a cell.

* Nitrogen is used as adsorbed gas and helium is an inert gas and passed through the powder in the cell.

* A thermal conductivity dedector measures the amount of nitrogen adsorbed at every equilibrium pressure.

* A bell shaped curve is obtained on a strip chart recorder.

* The signle weight gives the rate of adsorption of nitrogen gas.

* The area under curve gives the amount of gas adsorbed on the powder sample.

* The volume of nitrogen gas [(V_m) in cm^3] adsorbed by 1 gm. of powder is given by BET equation —

$$\boxed{\frac{P}{V(P_0 - P)} = \frac{1}{V_m b} + \frac{(b-1)P}{V_m b P_0}}$$

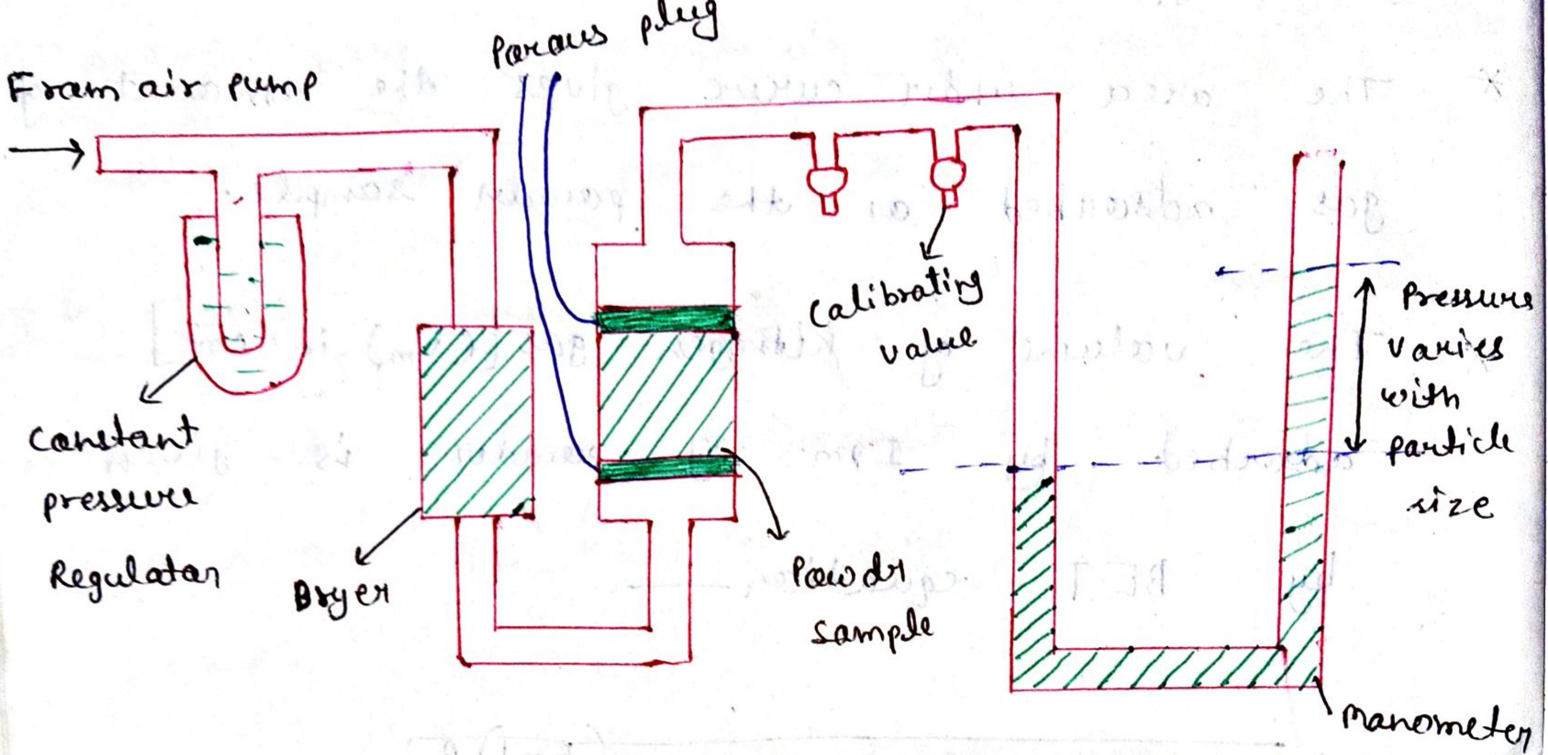
Where →

V = Volume of gas in cm^3 adsorbed per 1gm. of powder at pressure (P).

P_0 = Saturated vapour pressure of liquid nitrogen at the temperature

b = Constant.

2- Air permeability method →



Fisher sub siever sizer

* It is based on the principle that the resistance offered to the flow of air through the compact powder is proportional to the surface area of the powder.

* The greater the surface area per gram of the powder, the greater is the resistance to flow

* When the air is allowed to pass through the plug of powder resistance to the flow of air occurs.

* This resistance is related to the surface area of the powder.

* The specifics surface (S_w) can be calculated by Kozency - carman equation —

$$\boxed{V = \frac{A}{\eta S_w^2} \cdot \frac{\Delta P}{Kl} \cdot \frac{\varepsilon^3}{(1-\varepsilon)^2}}$$

where →

A = Cross sectional area of the plug.

K = constant.

ε = Porosity

V = Volume of air flowing.

l = length of powder ped.

ΔP = Pressure difference.

Derived properties of powder

* A part from fundamental properties, there are derived properties which are based on funda-mental properties.

* These are as follows —

1- Porosity.
2- Packing arrangement.
3- Densities → Bulk density, tap density, granular density.
4- Particle volume → Bulk volume, tap volume, void volume.

5- Bulkiness.

6- Angel of repose.

7- Compaction.

1- Porosity of powder →

Porosity is defined as the ratio of void volume to bulk volume

$$\boxed{\varepsilon = \frac{V_b - V_p}{V_b}}$$

Porosity is expressed as percentage —

$$\boxed{\% \varepsilon = \frac{V_b - V_p}{V_b} \times 100}$$

* In a non-porous material, the bulk volume is equal to the true volume.

* Most of the solids are porous that is (i.e.) they have internal pores, hence the bulk volume is greater than the true volume.

* The volume of space is k/as the void volume given by —

$$\boxed{V = V_b - V_p}$$

<u>Where</u> → V_B = Bulk volume

V_p = True volume.

<u>Intraparticle porosity</u> –

It means space ~~b/w~~ within a single large particle.

$$\boxed{\% \; \varepsilon = \left(1 - \frac{\rho_g}{\rho}\right) \times 100}$$

<u>Where</u> → ρ_g = Granular density

ρ = True density

Inter partical parosity →

It means space b/w two or more than two particles.

$$\boxed{\% \ \mathcal{E} = \left(1 - \frac{\rho_b}{\rho}\right) \times 100}$$

Where → ρ_b = Bulk density.

ρ = True density.

Q-1 → True density of a given powder is 2.46 gm/cm³ and 100 gm of sample ocupy bulk volume 80 c.m³. calculate % parosity.

True density = 2.46 gm/cm³

mass = 100 g.

Bulk volume (V_b) = 80 c.m³

$$D = \frac{m}{V}$$

$$2.46 = \frac{100}{V_p}$$

V_p = 40.65 cm³

$$\% \varepsilon = \left(\frac{V_b - V_p}{V_b}\right) \times 100$$

$$\% \varepsilon = \left(\frac{80 - 40.65}{80}\right) \times 100$$

$$\% \varepsilon = \frac{39.35}{80} \times 100$$

$$\boxed{\% \varepsilon = 49.1 \%}$$

Q-2 → Calculate the intraparticular porosity of Sulfadiazine granules having a granule density of 1.12 gm/cm3. and true density of 1.5 gm/cm3.

$$\boxed{\varepsilon = \left(1 - \frac{\rho_g}{\rho}\right) 100}$$

$$\varepsilon = \left(1 - \frac{1.12}{1.5}\right) 100$$

$$\varepsilon = (1 - 0.74) 100$$

$$\varepsilon = 0.26 \times 100$$

$$\boxed{\varepsilon = 26 \%}$$

2-Packing arrangement in powder bed -;

* Particles of powder in a heap are constant with one another.
* Two types of packing are possible theoratically these includes —
  i) closet
  ii) losest

Thearatical	closest 26%	losest 48%
Practically	30%	50%

* If spherical particles are present in heap:
* Theoratical porosity of 26% in closest & 48% in losest packing are possible.
* But in actual situation porosity of 30% & 50% are received.
* If particles have different sizes, porosity lowers upto 26% theoretically.
* Becoz particles fit in void spaces.
* If particles contain aggregates, the porosity may go beyond 48% thearatical.
* In case of crystallin materials porosity less then 1% are possible.

Density –

* Density is defined as mass per unit vol.

* There are 3-types of densities –
(i) True density
(ii) Bulk density
(iii) Granular density

(i) True Density :- It is defined as the ratio of the given mass of the powder & its volume.

It is the actual density of solid material Devoid of free space.

$$\boxed{\text{True Density} = \frac{\text{Mass}}{\text{True Vol.}}}$$

$$\boxed{\text{True volume} = \text{Bulk vol.} - \text{Void vol.}}$$

* True density can be determined by –

(i) Gas – Displacement Method → In this method gas such as Helium or Hydrogen is used.

* Difference b/w volume of Helium filling the empty apparatus & the volume of Helium filling in the presence of powder gives true volume of powder.

(ii) Liquid – displacement Method :–

* True density is the ratio of weight of the material & weight of the liquid it displaces

* A liquid in which the solid is in soluble is used.

* powder whose density is to be determined is ~~called~~ added in to the flask of known volume & weight determined.

* The liquid fills up void spaces b/w the particles.

(ii) Bulk Density ⇒ It is defined as the ratio of the mass of the powder & its bulk volume.

$$\boxed{\text{Bulk Density} = \frac{\text{Mass}}{\text{Bulk vol.}}}$$

$$\boxed{\text{Bulk vol.} = \pi r^2 h}$$

where

r = radius of measuring cylinder

h = height of powder

π = constant (3.14)

(iii) Granular Density => It is the ratio of mass of the granules & the volume of the granules.

$$\boxed{G.D = \frac{\text{Mass of granules}}{\text{granular vol.}}}$$

* granular density is determined by liquid displacement method by using Mercury as liquid.

Bulkiness

* The reciprocal Bulk density is known as Bulkiness.

* Bulkiness usually increases with dec in particle size.

* In a mixture of particles with diff. sizes the bulkiness may get reduced becoz small particles fit b/w large ones.

* Bulkiness is useful while chosing suitable container for packing.

Flow property of powder

* Powder may be free flowing or may have a poor flow.

* The poor flow may be due to —

1- Cohesiveness or stickiness b/w particles due to vanderwall's, surface tension, electro static forces.

2- Adhesion b/w the particles and the container wall due to the above forces.

3- Friction b/w particles due to rough surface.

4- Physical interlocking of particles due to irregular shape.

* Poor flowing powders or granules present many difficulties in pharmaceutical industries such as in tablet and capsule.

* The flow property can be assessed by

determining the angle of repose of the powder.

$$\boxed{\theta = \tan^{-1}\frac{h}{r}}$$

Where :- θ = Angle of repose.

h = Height of heap.

r = Radius of heap.

* Angle of repose and flow property relationship are—

Angle of repose	Flow property
< 25	Excellent.
25 - 30	Good.
30 - 40	Satisfactory
40 - 50	Poor
> 50	Very poor

Improvement of flow properties

Flow property can be improved by following methods —

1 - **Altering particle size** -

$\uparrow$ing particle size improves the flow properties due to reduction in cohesive forces.

2 - **Removal or addition of fines** -

An optimum concentration of fines is desirable to to improve flow properties.

3 - **Altering the particle shape** -

Spherical particle have better flow as compair to irregular particles.

4 - **Removing extra moisture** -

Drying of powder can improve the flow properties by $\downarrow$ing the ~~adhes~~ cohesiveness.

5- Adding glidants or flow activators :

Glidants such as talc and starch improve flow properties of powder.

Shear →

Shear can be considered as an internal friction of a fluid caused by molecular attraction which makes it resist a tendency to flow.