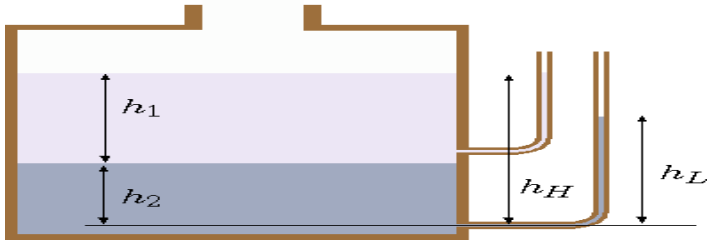
FLOW OF FLUIDS

Definition : Fluids may be defined as a substance that cannot resist deformation or distortion permanently .

Fluid flow is a part of the fluid mechanics & deals with fluid dynamics .

Fluid Statics /Hydrostatics :

- Fluid statics deals with the fluids at rest in equilibrium.
- Behavior of liquids at rest
- Nature of pressure it exerts & the variation of pressure at different layers .



MANOMETERS : Manometer are devices used to measure the pressure difference values.

A. Simple Manometer :

A simple manometer consists of a glass tube having one of its ends connected to a point. where pressure is to be measured and other end remains open to atmosphere.

Let pressure at point 1 will be P1 Pascal's and point 5 will be P2 Pascal's

The pressure at point 2 can be written as,

pressure at point 2 = P1+ (m + R) ρ B g

Where, (m + R) = distance from 3 to 5

Since the points 2 and 3 are at same level the pressure at 3 can be written as

Pressure at point 3

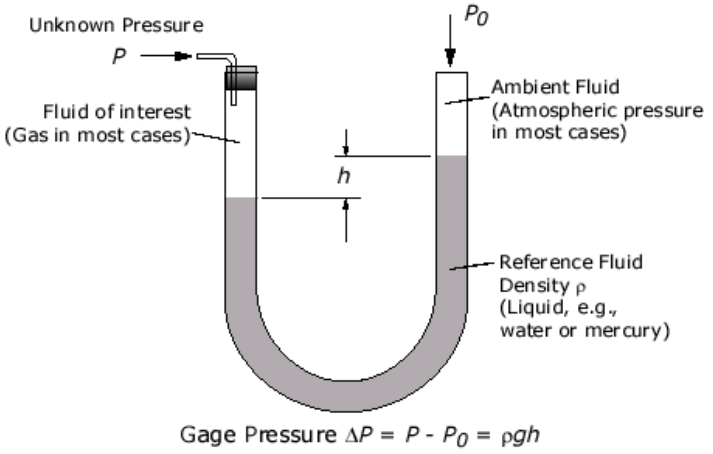
=P1+ (m + R) ρ B g

Pressure at 4 can be written as (from P2)

Pressure at point 4 = P2 + gm ρ B …… (1)

In another manner the pressure at point 4 can be written from point 3

= P1+ ρ B (m + R) g- ρ a R g .....(2)



Both the equations (1) and (2) should be equal

$P2 + gm\,\rho B = P1 + \rho B\,(m + R)\,g - \rho a\,R\,g$

$P1 - P2 = gm\,\rho B - \rho B\,(m + R)\,g + \rho A\,R\,g$

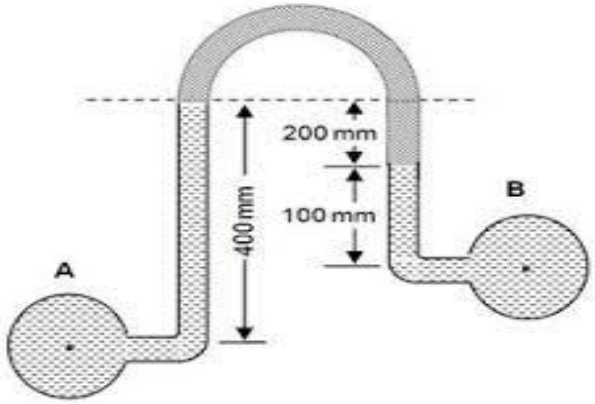
$\Delta P = gm\,\rho B - gm\,\rho B - R\,\rho B\,g + R\,\rho A$

$= R\,(\rho A - \rho B)\,g$

B.Differential Manometer:

A differential manometer is a device that measures the difference in pressure between two places. Differential manometers can range from devices simple enough to be built at home to complex digital equipment.

$\Delta P = P1 - P2 = R\,(\rho c - \rho A)\,g$



C .Inclined Tube Manometer :

Inclined tube manometer is a simple and cheap instrument that is commonly used for measuring differential pressure in a mine. It resembles to a U-tube Manometer. One limb is a tube of uniform bore (6 mm internal diameter) which is kept inclined at a low angle to the horizontal line.

$P1 - P2 = g\,R\,(\rho A - \rho B)\sin\alpha$

REYNOLDS NUMBER :

The Reynolds number is the ratio of inertial forces to viscous forces within a fluid which is subjected to relative internal movement due to different fluid velocities.

Re = Rn = (ρVL)/μ=(VL)/ν

Re = Reynolds number
\rho = density of the fluid
u = flow speed
L = characteristic linear dimension
V = dynamic viscosity of the fluid

Applications :

Reynolds number plays an important role in calculation of coefficient of friction in case of frictional loss in pipes known as Darcy-Weisbach equation .

Air is a fluid and so can be calculated its Reynolds number so it can be applied on wind tunnel testing to study the aerodynamic properties of various surface.

Energy losses in the flow of fluids

According to the law of conservation of energy, energy balance have to be properly calculated . fluids experiences energy losses in several ways while flowing through pipes , Classified as

1. Frictional losses
2. Losses in the fitting
3. Enlargement losses
4. Contraction losses

1 Friction losses:

Frictional losses and associated factors summarized by Fannings equation

ΔPf = 2fu2Lρ/ D

ΔPf- pressure drop in Pa
ρ-density of the liquid
f- frictional factor

L- length of pipe
D- diameter of the pipe
While in case of viscous fluids for calculating frictional losses Hagen-Poisuillis equation used

$\Delta P = 32Lu\eta / D$

While η is the viscosity of solution.

Frictional losses are permanent since due to conversion of kinetic and potential energy into heat.

2.Losses in fittings:

These losses may be due to

- Change in direction of flow of fluids
- Change in type of fittings
- Expressed by equivalent length of pipe

Elbow fitting- equivalent length around 32
Tee fitting - equivalent length around 90
Coupling fitting –equivalent length negligible
Globe valve coupling - equivalent length around 300 .

3. Enlargement losses

This type of pipe enlarges suddenly giving rise to losses
Sudden enlargement losses (ΔHe in meters) given by following equation

$\Delta He = (u1-u2)\ ^2/\ 2g.$

4 .Contraction losses:

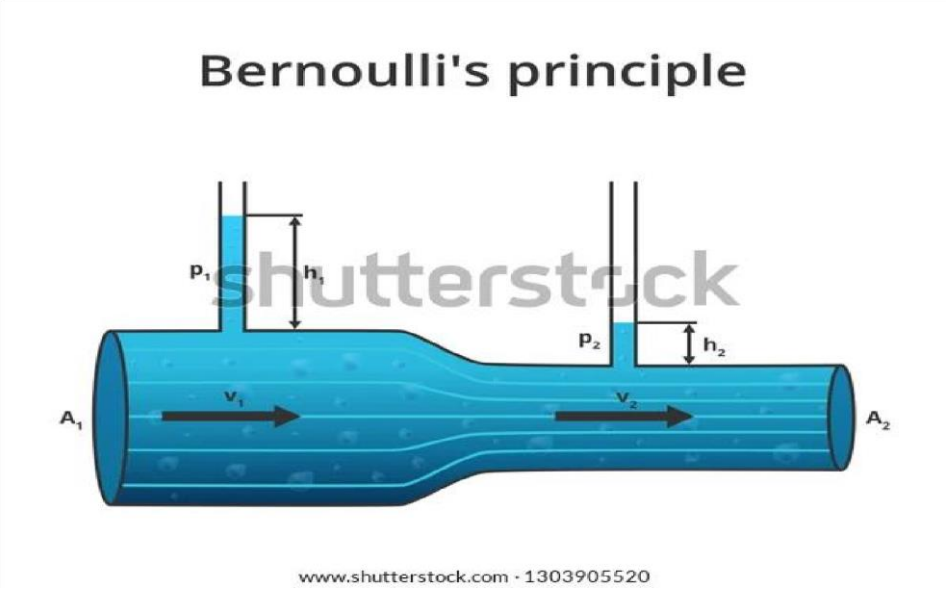
$\Delta Hc = Ku^{\ 2}/\ 2g$

K-is the constant.

BERNOULLI'S THEOREM :

When the principles of the law of energy is applied to the flow of the fluids, the resulting equation is called Bernoulli's theorem.

- Consider a pump working under isothermal conditions between points A and B
- Bernoulli's theorem states that in a steady state the total energy per unit mass consists of pressure, kinetic and potential energies are constant
- At point A, one kilogram of liquid is assumed to be entering at this point, pressure energy at joule can be written as



Pressure energy = PA /g ρ A

Where PA = Pressure at point A
g = Acceleration due to gravity ρ A = Density of the liquid

•**Potential energy** of a body is defined as the energy possessed by the body by the virtue of its position Potential energy = XA

Kinetic energy of a body is defined as the energy possessed by the body by virtue of its motion, kinetic energy = uA 2 / 2g

Total energy at point A = Pressure energy + Potential energy+ Kinetic energy

Total energy at point A = PA /g ρ A +XA + uA 2 / 2g

According to the Bernoulli's theorem the total energy at point A is constant Total energy at point

A = PA /g ρ A +XA + uA 2 / 2g = Constant

After the system reaches the steady state, whenever one kilogram of liquid enters at point A, another one kilogram of liquid leaves at point B

Total energy at point B = PB /g ρ B +XB + uB 2 / 2g = Constant

INPOUT = OUT PUT

PA /g ρ A +XA + uA 2 / 2g =PB /g ρ B +XB + uB 2 / 2g

Theoretically all kids of the energies involved in fluid flow should be accounted, pump has added certain amount of energy

Energy added by the pump = + w J

During the transport some energy is converted to heat due to frictional Forces

Loss of energy due to friction in the line = FJ

PA /g ρ A + XA + uA 2 / 2g – F + W = PB /g ρ B +XB + uB 2 / 2g

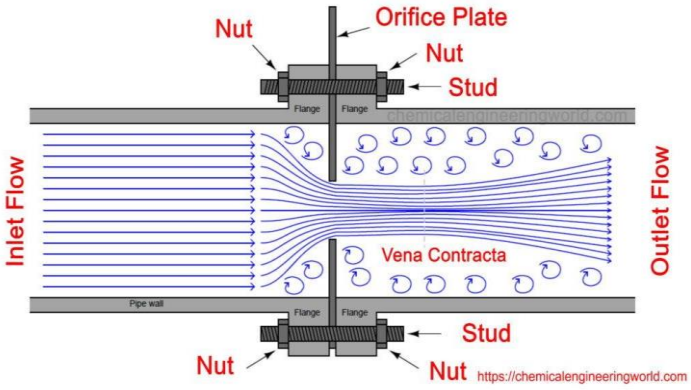
This equation is called as Bernoulli's equation

MEASUREMENT OF RATE OF FLOW OF FLUID

1)ORIFICE METER:

PRINCIPLE:

- Orifice meter is a thin plate containing a narrow and sharp aperture.
- When a fluid stream is allowed to pass through a narrow constriction the velocity of the fluid at orifice meter increase compared to the velocity of the fluid in the up stream.
- This results in decrease in pressure drop and the difference in the pressure may be read from a manometer.



WORKING:

• Orifice meter is referred as the variable head meter, i. e it measure the variation in the pressure across a fixed construction placed in the path of flow consisting of a constant area.

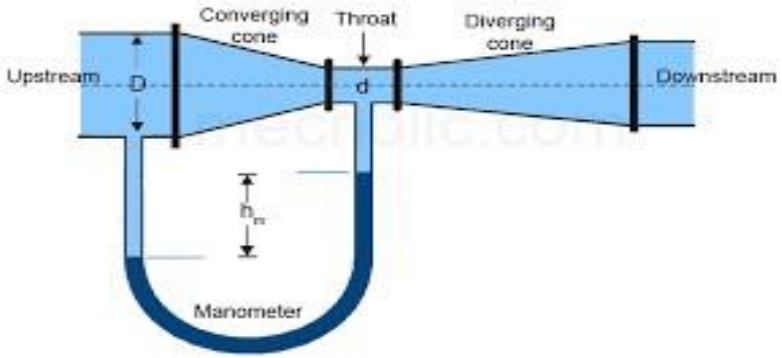
2)VENTURI METER (Variable head meter):

PRINCIPLE:

•It consists of two tapered sections in the pipeline with a gradual constriction (throat) at its centre.

• When fluid is allowed to pass through narrow throat then velocity of fluid increases and pressure decreases

•Difference in upstream and downstream pressure head can be measured by using Manometer



• **U v = C v √ 2g . ΔH**

WORKING: It also referd as variable head meter, i..e. it measures the variable differential pressure across a fixed constriction placed in the path of flow consisting of a constant area. The velocity of the fluid is increased at the throat, due to the constriction. So,

√uv 2 – uA 2 = Cv √2g. ΔH

Where, uv = velocity at the throat of the venturi, uA= velocity at point A Cv = coefficient

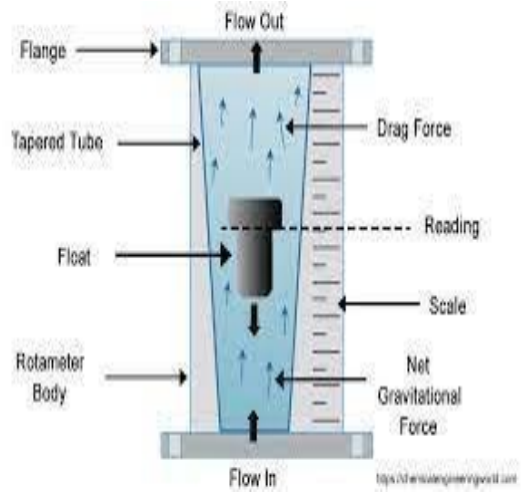
3)ROTAMETER (Variable area meter)

PRINCIPLE:

• In this device a stream of water enters Transparent tapered tube and strikes the moving plummet

• During fluid flow plummet rise or fall.

• As a result, **annular space (area) between plummet and tapperd tube may increase or decrease,** depending on
• variation of flow rate. • Head across annulus is equal to weight of plummet.



WORKING:

As the flow is upward through the tapered tube the

plummet rises and falls depend on the flow rate

As Greater the flow rate higher the rise.

REFERENCE:

1)C.V.S Subrahmanyam , J.Thimmasett Pharamaceutical Engineering unit operation principals and practice ,vallabh prakashan .,pg.no:26-56

2) Dr.Ashok A.hajare, Pharmaceutical Enginnering , Nirali Prakashan ,
pg.no:1.1-1.24.

3)Dr.M.Sentilkumar,Dr.parag.A.kulkarni , text book of Pharamaceutical Engineering Thakur publication ,pg.no.13-34.

PREPARED BY : Tanaya Bhise
Shashikala Chakkar
Janhavi Bhere
GUIDED BY : MS. kadam A.J.
ACADEMIC YEAR:2021-2022

-

SIZE REDUCTION

DEFINATION : Size reduction is the operation carried out for reducing the size of bigger particles into smaller one of desired size and shape with the help of external forces.

MECHANISM OF SIZE REDUCTION :

- CUTTING: Here the materials is cut by means of a sharp blade or bledes.

  Ex Cutter mill

- COMPRESSION: The materials is crushed between the roller by application of pressure.

  Ex roller mill

- IMPACT: Impact occurs when the materials is more or less stationary and is hit by an object moving at high speed or when the moving particals strikes a stationary surface.

  Ex hammer mill

- ATTRITION: In attribution the materials is subjected to pressure as in compression but the surface are moving relative to each other resulting in shear force which breaks the particals.

  Ex fluid energy mill

LAWS OF GOVERING SIZE REDUCTION:

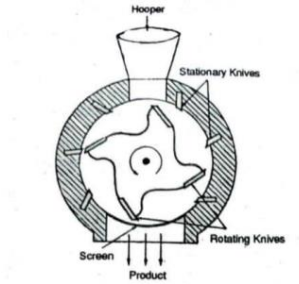
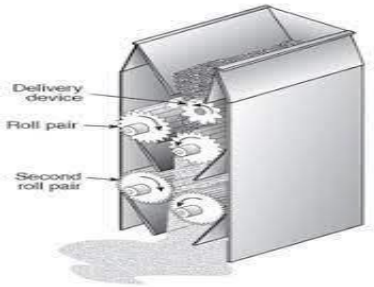
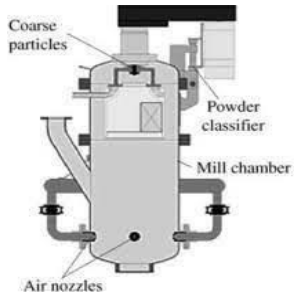


Fig. Cutter mill





- Kicks law :The energy required for producing analogous changes of configuration of geometrically similar bodies of equal technological state varies as the volumes or weights of these bodies." In other words, the energy expended is porportional to the volume reduction, instead of the diameter reduction

$$E = Kk \ln (Di / Dn)$$

Where as, k =kick's constant

Di=The average initial size of pieces

Dn=The average size of ground particales

- Rinttinger's law : The energy required for reduction in particle size of a solid is directly proportional to the increase in surface area. ... As noted by Ehmer, there is an inverse relationship between size and strength of particles: as particles get smaller, their strength increases.

$$E=Kr (Sn-Si)$$

Where,Kr=Rittingers constant

Si =initial specific surface area

Sn =final specific surface area

- Bond's law: $dE/dx= - K /x3/2 \int dE = - \int K /x3/2$ for limit x1 to x. On Integration $E = 2 KB [1/\sqrt{x2} - 1/\sqrt{x1}]$ x1 and x2 are the average size of feed and product particles. E is the energy per unit mass required to produce this increase in size and KB is Bonds

FACTORS AFFECTING SIZE REDUCTION :

1 Factors related to the nature of raw materials:

- Inflammable materials ,partical size of feed, friable materials, Plastic materials, Elastic materials, Hygroscopic materials, Thermolabile materials ,Moisture content in raw materials , Hard materials ,Melting point ,Flammable materials.

2 Factors related to the nature of finished product:

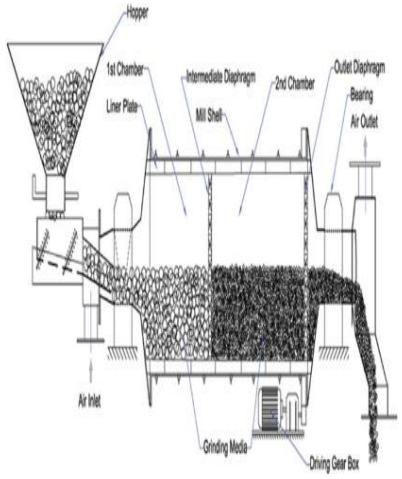
- Particle size , Sterile products, Contamination of finished product.

EQUIPMENT OF SIZE REDUCTION :

1 Ball Mill :

Principle:

A ball mill is a type of grinder used to grind and blend bulk material into QDs/nanosize using different sized balls. The working principle is simple; impact and attrition size reduction take place as the ball drops from near the top of a rotating hollow cylindrical shell.



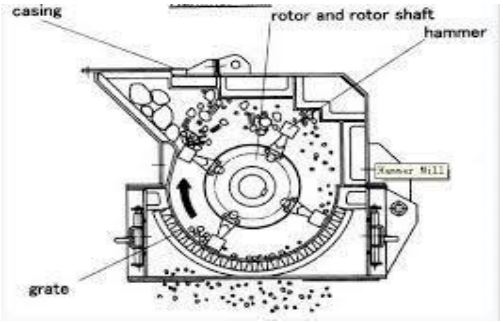
Working: Ball mills work by **using balls to grind materials**. Materials such as iron ore, pain and ceramics are added to the ball mill. ... As the ball bill rotates, the balls bounce around while striking the enclosed material. The force of these strikes helps to grind the material into a finer, less-coarse medium.

Uses : It is used for blending of explosive materials with the help of rubber ball.

2 HAMMER MILL:

Principle :

The basic principle is straightforward. A hammer mill is essentially a steel drum containing a vertical or horizontal rotating shaft or drum on which hammers are mounted. The hammers are free to swing on the ends of the cross, or fixed to the central rotor.



Working :

The basic principle is straightforward. A hammer mill is essentially a steel drum containing a vertical or horizontal rotating shaft or drum **on** which hammers are mounted .The material is impacted by the hammer bars and is thereby shredded and expelled through screens in the drum of a selected size.

Uses : It is use for reduce of brittle ,fibrous material, medium hard to soft material.

REFERENCE: 1) Dr.M.Senthil Kumar , Dr.Parag .A .Kulkarni Pharmaceutical Engineering , Thakur publication ,Pg.no 38-46

2) Dr.Ashok A.Hajare , Pharmaceutical Engineering , Nirali Prakashan, Pg No 2.1-2.13

3) Dr.Bharat Parashar ,Tripti Shukla , Book of Pharmaceutical Engineering, Nirali Prakashan , Pg .no 2.1-2.9

4) C.V.S Subhramanyam,J. Thimmasetty,Pharmaceutical Engineering Unit Operations Principle and Pratice Vallabh Prakashan Pg.No 65-79

PREPARED BY : ANANDE URMILA V.(Roll no.2)

CHAKAVE SHUBHANGI T.(Roll no.10)

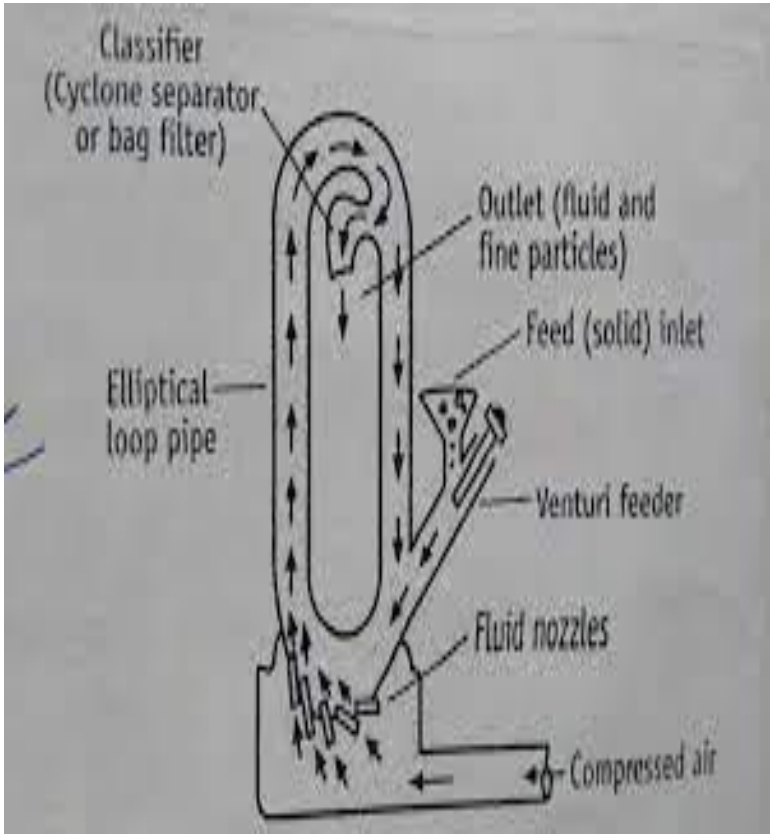
GUIDED BY: Miss.Kadam A.J.

ACADEMIC YEAR : 2021-22

3) Fluid Energy Mill:

PRINCIPLE:

Fluid energy mill operates on the principle of impact and attrition the feed stock is suspended with in a high velocity air stream.



WORKING:

powder is introduced through the inlet of venturi. The air entering through the grinding nozzles transport the powder in the elliptical or circular track of the mill. In the turbulent stream of air, the suspended particles collide with each other and break. Thus, impact and attrition forces operate in size reduction. The resultant small particles are carried to outlet and removed by cyclon or filters. The coarser particles undergo re-circulation in the chamber on account of its own weight.

USES:

1)Fluid energy mill is used to reduce the particle size (10-325mesh) of most of the drug such as antibiotics and vitamins .

2) Ultrafine grinding can be achieved moderately hard material can be processed for the size reduction.

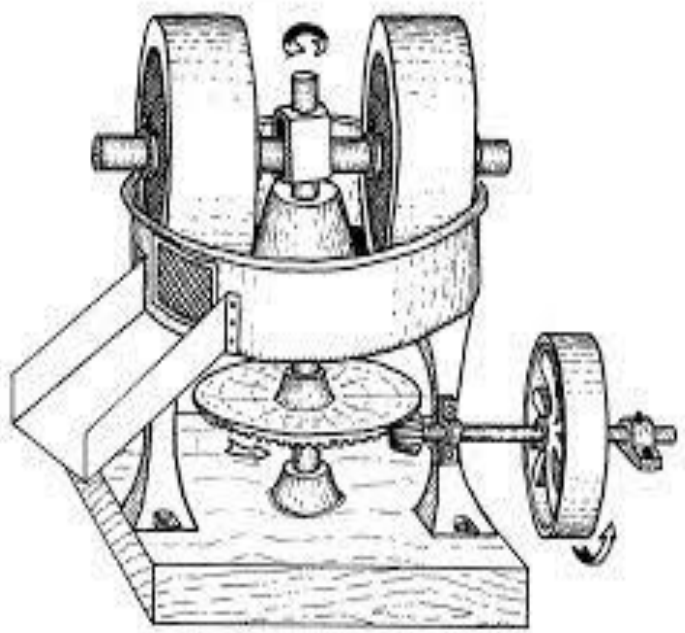
4)EDGE RUNNER MILL:-

PRINCIPLE:

The size reduction is done by crushing due to heavy weight of stone.

WORKING:

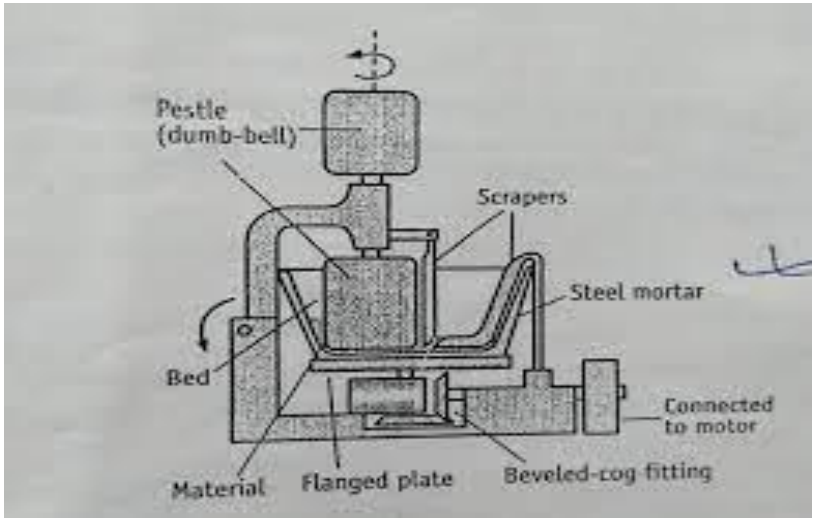
Material to be ground is put in the pan and with the help of the scrapers it is kept in the path of the rollers. The material is ground for the definite period and then it is passed through the sieve to get powder of the required size. Size reduction is achieved by sharing as well as crushing.



USES:

grinding touch material to the fine powder.

5)END RUNNER MILL:-



PRINCIPLE:

Size reduction is done by crushing due to heavy weight of steel pestleShearing stress is also involved during movement of mortar and pestle.

WORKING:

The material to be ground is placed in the mortar. The mortar revolves at a high speed.

The revolving mortar causes the pestle to revolve during this process, size reduction is achieved.

USES:

1)Use for fine grinding.

REFERNCE:

1)C.V.Subramanyam,Pharmaceutical,, Engineering Principles and Practices

1st Edition, Vallabh Prakashan,pg.No.65-85

2)Dr.Senthil Kumar & Dr.Parag.A.Kulkarni,A Text Book of Pharmaceutical

Engineering,Thakur Publication,pg.No.38-51

3)Dr.Ashok.A.Hajare,Text book of Pharmaceutical Engineering, 1st Edition,

Nirali Publication, pg.No.2.1-2.22

PREPARED BY :MS.Tanaya Bhise

MS.Rutika Awate

MS.Urmila Anande

GUIDED BY:MS.Kadam.A.J.

ACADEMIC YEAR :2021-22

SIZE SEPARATION

SIEVES: Sieves are the simplest and sieving is the most frequently used method for size separation.

OFFICIAL STANDARD FOR POWDERS:

According to degree of coarseness and fineness with reference to nominal aperture size of sieves through powder able to pass which having following standard .

Sr.no.	Grade of powder	Sieves through which all particle pass	Nominal mesh aperture size	Sieves through which 40% particle pass	Nominal mesh size
01.	Coarse powder	10	1.7mm	44	355um
02.	Moderately coarse powder	22	710um	60	250um
03.	Moderately fine powder	44	355um	85	180um
04.	Fine powder	85	180um	-	-
05.	Very fine powder	120	125um	-	-

OFFICIAL STANDARD FOR SIEVES :

According to IP1996 a sieves must conform to the specification given in table

Sr.no.	Approximate sieves number	Approximate percentage sieving area	Nominal mesh aperture size (mm)	Tolerance average aperture size (+- mm)
1.	10	46	1.7	0.06
2.	22	37	710	25
3.	30	38	500	18
4.	44	38	355	13
5.	60	37	250	13(9.9)
6.	85	35	180	11(7.6)
7.	100	36	150	9.4(6.6)
8.	120	34	125	8.1(5.8)
9.	150	36	106	7.4(5.2)

SIEVE ANALYSIS –TESTING OF POWDER

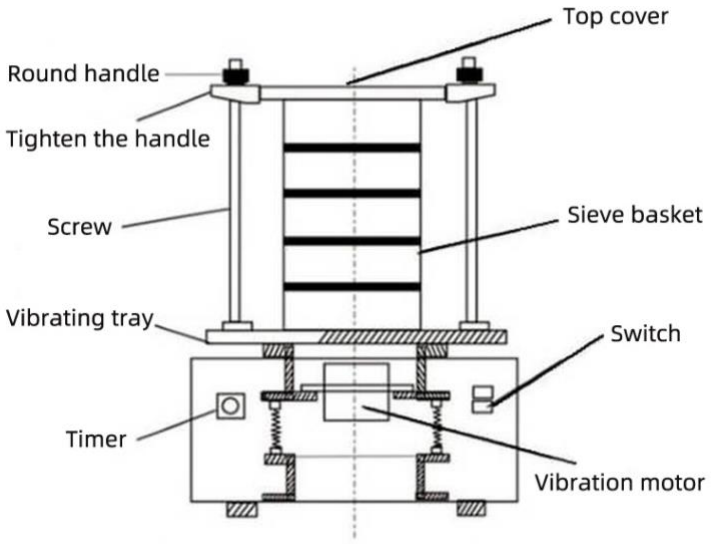
Size Distribution analysis is important in different areas

1. Quality controll
2. Size reduction processing equipments and efficiency
3. Optimizing the method of agitation and screen time
4. Sieves for commercial equipments

EQUIPMENTS

1) SIEVE SHAKER MACHINE

PRINCIPLE**:** The powderd drug is separated according to its particle size using a number of sieves in a nest .these are subjected to the different types of agitation method so that size separation is rapid .

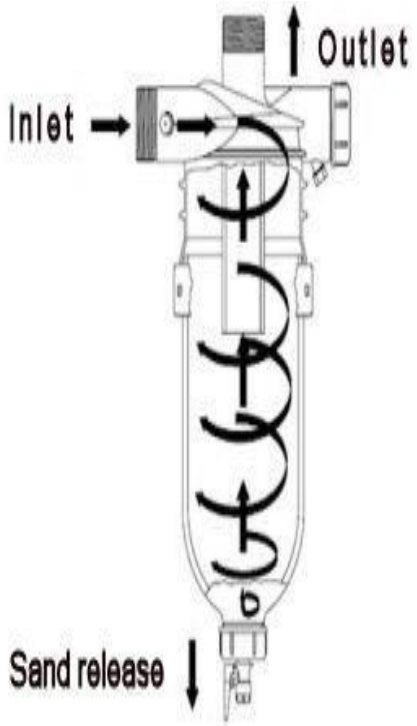


WORKING **:** Sieve are arranged in a nest with the coarsest at the top .a sample of 50gm powder is placed on top sieve .this sieve set is fixed to mechanical shaker apparatus and shaker for certain period of time (20minutes).the powder retain on each sieve is weighed .

Uses :

1) Sieve Shaker Machine used to particle size analysis of variety of materials.
2) It is suitable for coarse material down to 150 um.
3) It can be used for wet sieve analysis whee the material analysed is not affected by liquid – except to disperse it .

2) CYCLONE SEPARATOR



PRINCIPLE:

In cyclone separator centrifugal force is used to separatesolid from fluids. The separation process depends on particle size and particle density. It is also possible to allow fine particles to be carried with the fluid.

WORKING:

1)The solids to be separated are suspended in a stream of fluid (usually air or water). Such feed is introduced tangentially at a very high velocity, so that rotary movement takes place within the vessel.

2) The centrifugal force throws the particles to the wall of the vessel. As the speed of the fluid (air) diminishes, the particles fall to the base and collected at the solid outlet. The fluid (air) can escape from the central outlet at the top.

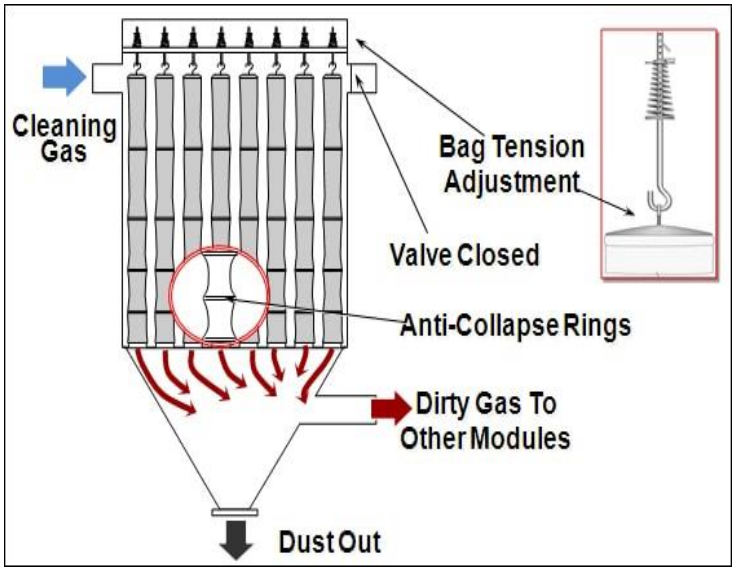
USES

1. Cyclone separators are used to separate solid particles from gases.
2. It is also used for size separation of solids in liquids.
3. It is used to separate the heavy and coarse fraction from fine dust.

3)AIR SEPARATOR

PRINCIPLE

The cyclone separator alone cannot carry out size separation on fine materials. For such separations a current of air combined with centrifugal force is used. The finer particles are carried away by air and the coarser particles are thrown by centrifugal force, which fall at the bottom.



WORKING

1)The disc and the fan are rotated by means of a motor. The feed (powder) enters at the center of the vessel and falls of the rotating plate. The rotating fan blades produce a draft (flow) of air in the direction as shown in the diagram.

2) The fine particles are picked up by the draft of air and carried into space of settling chamber, where the air velocity is sufficiently reduced so that the fine particles are dropped and removed through the fine particle outlet.Particles too heavy to be picked up by the air stream are removed at the coarse particle outlet.

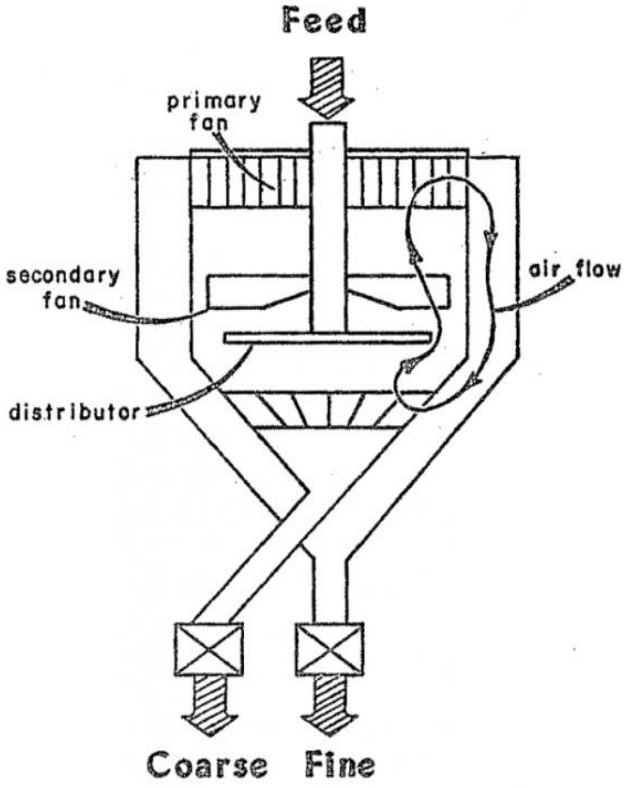
USES:

Air separators are often attached to the ball mill or hammer mill to separate and return over sized particles for further size reduction.

3)BAG FILTER :

PRINCIPLE :

In a bag filter, size separation of fines (or dust) from the milled powder is achieved in two steps. In the first step, the milled powder is passed through a bag (made from cloth) by applying suction on the opposite side of the feed entry. This facilitates the separation. In the next step, pressure is applied in order to shake the bags so that powder adhering to the bag falls off, which is collected from the conical base.



WORKING :

(1) Filtering period: During this period the vacuum fan produce a pressure lower than the atmospheric pressure within the vessel. Gas to be filtered enters the hopper, passes through the bags, and out of the top of the apparatus. The particles are retained within the bags.

(2) Shaking period: During this period the bell-crank lever first close the discharge manifold and air enters through the top so the vacuum is broken. At the same time it gives a violent jerking action to the bags so that they are freed from the dust. The fine particles are collected at the conical base.

USES :

1. Bag filters are used along with other size separation equipment, e.g. a cyclone separator.
2. They are use on the top of fluidized bed dryer for drying to separate the dusts.
3. They are used to clean the air of a room.
4. Household vacuum cleaner is a simple version of bag filter.

4) ELUTRIATION TANK

PRINCIPLE .

This process is based upon the principle of gravitational force. In this method the movement of fluid tank take place in the direction of opposite to that of sedimentation movement.

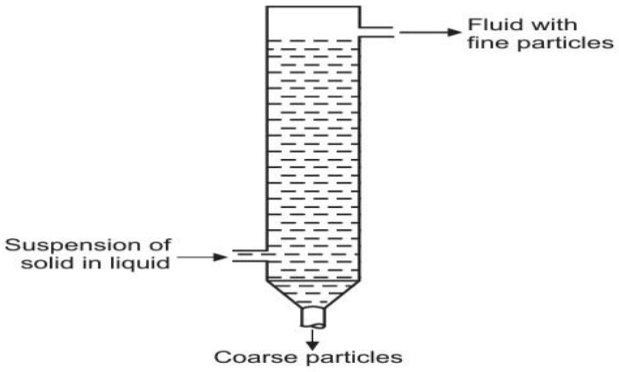


Fig. 3.8: A Schematic of Simple Elutriator

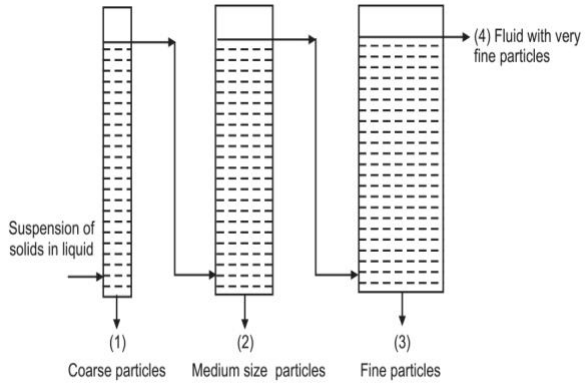


Fig. 3.9: Multi-Stage Elutriator: (1) to (4) is fractions of decreasing particle size

WORKING

1) Size separation by ellutration is based upon low density of fine particle and high density of coase particlcle and high density of coase particlecle and high density of coase particle
2) The ellutartion tank is filled with dry powder or levigated paste and is mixed with large amount of water .
3) After stirring the particle are sedfiment and it is depending on their density .
4) The sample withdrawn through the outlet provided at the different height represent the respective size fraction by this process

USES

1) It is used for separating insoluble solid into different particle sets based on their size ,shape and density .
2) When the acid is used as elutriating medium,certain fine cosmetic powders can be prepared.

REFERENCE:

1. CVS Subramanyam,Pharmaceutical Engineering ,Principle and practices first edition , Vallabh publication page no :104-115

2. Dr. Ashok A Hajare Pharmaceutical Engineering ,First edition , Nirali publication ,page no: 3.1-3.10

3. Dr. M. Senthil Kumar , Pharmaceutical Engineering First Edition ,Thakur Publication Page No – 55 – 67

4. Dr. Bharat Parashar , Pharmaceutical Engineering First Edition , Nirali Publication Page No- 3.1 – 3.16

PREPARED BY : 1.Bawane Ravi Balu
2. Arote Abhishek bhausaheb
3.Bhosale Sudarshan Sambhaji

GUIDED BY : Miss kadam A.J.

ACADEMIC YEAR : 2021-22