Program	:	B. Pharmacy
Name of Unit	:	Flow of fluids , Size separation, Size reduction
Subject /Course name	:	Pharmaceutical engineering
Subject/Course ID	:	BP 304T
Class: B.Pharm. Semester	:	III
Module	:	I
Course coordinator	:	Ms. Amanpreet Kaur, Ms.Punam Gaba
Mobile No.	:	9056661610
Email id	:	pharmaceutics23@gmail.com

Learning Outcome of Unit-1

LO	Learning Outcome (LO)	Course Outcome Code
LO1	Students will able to point out the devices used for measuring the rate of flow of fluids.	BP304.2
LO2	Differentiate between fluid statics and fluid dynamics.	BP304.2
LO3	Students will able to learn about the concept and mechanism of Size Reduction.	BP304.1
LO4	Students will able to learn about the working of various mills and shakers used for size reduction and size separation respectively	BP304.1
LO5	Importance of rotameter as a fluid flow measuring device.	BP304.3

MODULE CONTENT TABLE

No.	Topic
1.	Flow of fluids, fluid statics and fluid dynamics
2.	Manometer, measurement of fluid flow
3.	Objectives, mechanisms and factors governing size reduction.
4.	Principles, construction and working of mills.
5.	Objectives, mechanisms and factors governing size separation.
6.	Principles, construction and working of various type of shakers.

A. Flow of Fluids

A fluid is a substance that continually deforms (flows) under an applied shear stress. Fluids are a subset of the phases of matter and include liquids, gases. Fluid flow may be defined as the flow of substances that do not permanently resist distortion The subject of fluid flow can be divided into fluid static's and fluid dynamics

FLUID STATICS

- Fluid static's deals with the fluids at rest in equilibrium
- Behavior of liquid at rest
- Nature of pressure it exerts and the variation of pressure at different layers Pressure differences between layers of liquids

Consider a column of liquid with two openings which are provided at the wall of the vessel at different height. The rate of flow through these opening s are different due to the pressure exerted at the different height

Consider a stationary column the pressure ps is acting on the surface of the fluid, column is maintained at constant pressure by applying pressure

The force acting below and above the point 1 are evaluated

Substituting the force with pressure x area of cross section in the above equation

$$P_{1s} = P_{2s} + \text{volume} \times \text{density} \times \text{acceleration}$$

$$= P_{2s} + \text{height} \times \text{area} \times \text{density} \times \text{acceleration}$$

$$P_{1s} = P_{2s} + h_1 S \rho g$$

Since surface area is same

$$P_1 = P_s + h_1 \rho g$$

Pressure acting on point 2 may be written as

$$P_2 = P_s + h_1 \rho g$$

Difference in the pressure is obtained by

$$P_2 - P_1 = g (P_s + h_2 \rho) - (P_s + h_1 \rho) g$$

$$\Delta P = (P_s + h_2 \rho - P_s - h_1 \rho) g$$

$$= \Delta h \rho g$$

FLUID DYNAMICS

- Fluid dynamics deals with the study of fluids in motion
- This knowledge is important for liquids, gels, ointments which will change their flow behavior when exposed to different stress conditions

TYPES OF FLOW

Identification of type of flow is important in

- Manufacture of dosage forms
- Handling of drugs for administration

The flow of fluid through a closed channel can be *viscous* or *turbulent* and it can be observed by Reynolds experiment

Glass tube is connected to reservoir of water, rate of flow of water is adjusted by a valve, a reservoir of colored solution is connected to one end of the glass tube with help of nozzle. colored solution is introduced into the nozzle as fine stream. The velocity of the fluid is zero at the wall surface there should be some layer in viscous flow near the pipe wall which acts as stagnant layer if the flow is turbulent at the center and viscous at the surface a buffer layer exist, this buffer layer changes between the viscous to turbulent flow

BERNOULLI'S THEOREM

When the principals 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 = P_a /g ρ A

Where P_a = 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,

$$\text{Kinetic energy} = UA^2 / 2g$$

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

Total energy at point A = P_a /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 = P_a /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 = $P_B /g \rho_B + X_B + U_B^2 / 2g$

INPOUT = OUT PUT

$P_a /g \rho_A + X_A + U_A^2 / 2g = P_B /g \rho_B + X_B + U_B^2 / 2g$

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 = + wJ

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

Loss of energy due to friction in the line = FJ

$P_a /g \rho_A + X_A + U_A^2 / 2g - F + W = P_B /g \rho_B + X_B + U_B^2 / 2g$

This equation is called as Bernoulli's equation

Application

- Used in the measurement of rate of fluid flow
- It applied in the working of the centrifugal pump, in this kinetic energy is converted in to pressure.

ENERGY LOSS

According to the law of conversation of energy, energy balance have to be properly calculated fluids experiences energy losses in several ways while f lowing through pipes, they are

- Frictional losses
- Losses in the fitting
- Enlargement losses
- Contraction losses

During flow of fluids frictional forces causes a loss in pressure. Type of fluid flow also influences the losses. In general pressure drop will be

PRESSURE DROP α VELOCITY (u)

α Density of fluid(ρ)

α Length of the pipe (L)

α 1 / diameter of the pipe (D)

These relationships are proposed in Fanning equation for calculating friction losses

Fanning equation $\Delta p = 2fu^2 L\rho / D$

F = frictional factor

For viscous flow pressure drop Hagen –Poiseullie equation

$= 32 Lu\eta / D^2$

MANOMETERS

Manometers are the devices used for measuring the pressure difference

Different type of manometers are there they are

1. Simple manometer
2. Differential manometer
3. Inclined manometer

SIMPLE MANOMETER

- This manometer is the most commonly used one
- It consists of a glass U shaped tube filled with a liquid A- of density ρ_A kg /meter cube and above A the arms are filled with liquid B of density ρ_B
- The liquid A and B are immiscible and the interference can be seen clearly
- If two different pressures are applied on the two arms the meniscus of the one liquid will be higher than the other
- 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

$= P_1 + (m + R)\, \rho_B\, g$

$(m + R)$ = distance from 3 to 5

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

Pressure at 3 $= P_1 + (m + R)\, \rho_B\, g$

Pressure at 4 can be written as

$$= P_2 + gm\, \rho_B$$

or

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

Both the equations should be equal

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

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

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

$$= R\, (\rho_A - \rho_B)\, g$$

DIFFERENTIAL MANOMETERS

- These manometers are suitable for measurement of small pressure differences
- It is also known as *two – Fluid* U- *tube manometer*
- It contains two immiscible liquids A and B having nearly same densities
- The U tube contains of enlarged chambers on both limbs,
- Using the principle of simple manometer the pressure differences can be written as

$$\Delta P = P_1 - P_2 = R (\rho_c - \rho_A) g$$

INCLINED TUBE MANOMETERS

Many applications require accurate measurement of low pressure such as drafts and very low differentials, primarily in air and gas installations.

In these applications the manometer is arranged with the indicating tube inclined, as in Figure, therefore providing an expanded scale.

This enables the measurement of small pressure changes with increased accuracy.

$$P_1 - P_2 = g R (\rho A - \rho B) \sin \alpha$$

MEASUREMENT OF RATE OF FLOW OF FLUIDS

Whenever fluid are used in a process it is necessary to measure the rate at which the fluid is flowing through the pipe,

Methods of measurement are

- Direct weighing or measuring
- Hydrodynamic methods
- Orifice meter
- Venturi meter
- Pitot meter
- Rotameter
- Direct displacement meter

DIRECT WEIGHING OR MEASURING

The liquid flowing through a pipe is collected for specific period at any point and weighed or measured, and the rate of flow can be determined. Gases cannot be determined by this method

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 increase compared to up stream. This result in decrease in pressure drop and the difference in the pressure may be read from a manometer

The velocity of the fluid at thin constriction may be written as

$$U_0 = C_0 \sqrt{2g \Delta H}$$

ΔH = can be measured by manometer

C_0 = constant

U_0 = velocity of fluid at the point of orifice meter

CONSTRUCTION

- It is consider to be a thin plate containing a sharp aperture through which fluid flows
- Normally it is placed between long straight pipes
- For present discussion plate is introduced into pipe and manometer is connected at points A and B

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
- When fluid is allowed to pass through the orifice the velocity of the fluid at point B increase, as a result at point A pressure will be increased.
- Difference in the pressure is measured by manometer
- Bernoulli's equation is applied to point A and point B for experimental conditions

$$\sqrt{U_0^2} - U_A^2 = C_0 \sqrt{2g.\Delta H}$$

U_0 = velocity of fluid at orifice

U_A = velocity of fluid at point A

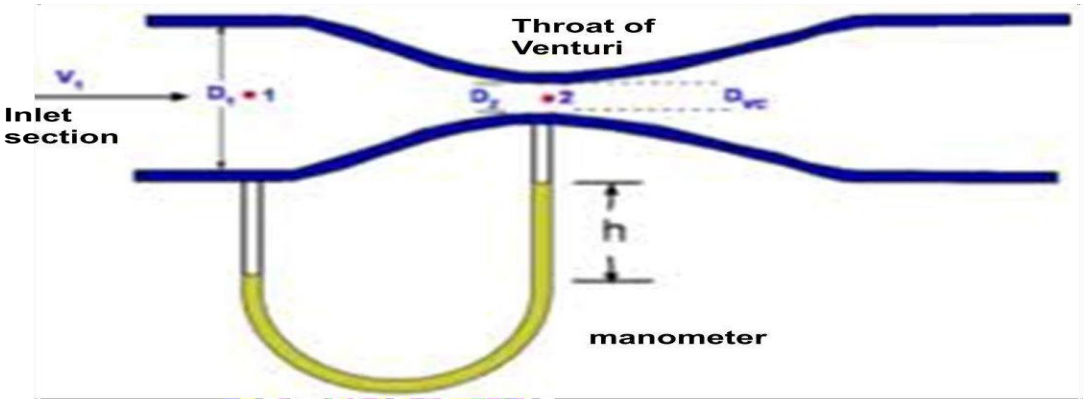
C_0 = constant

If the diameter of the orifice is 1/5 or less of the pipe diameter then U_A is neglected

Applications

- Velocity at either of the point A and B can be measured
- Volume of liquid flowing per hour can be determined

VENTURI METER



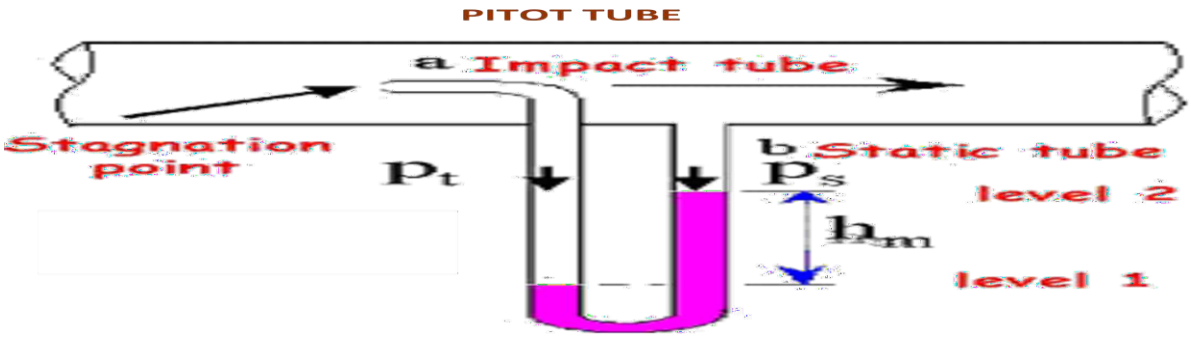
$$U_v = C_v \sqrt{2g} . \Delta H$$

Disadvantages

- Expensive
- Need technical export
- Not flexible it is permanent

Advantages

- Power loss is less
- Head loss is negligible



Construction

- It is also known as insertion tube
- The size of the sensing element is small compared to the flow channel
- One tube is perpendicular to the flow direction and the other is parallel to the flow
- Two tubes are connected to the manometer

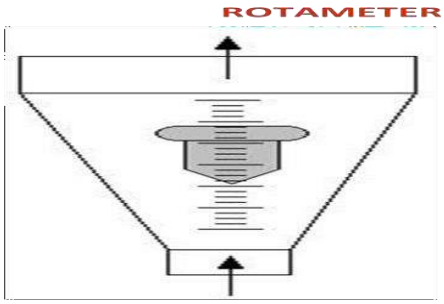
$\Delta H_p = u^2/2g$

Working

Tube are inserted in the flow shown is the figure

$U_2 = C_v \sqrt{2g.\ \Delta H}$

coefficient of Pitot tube



Construction

- It consists of vertically tampered and transparent tube in which a plummet is placed
- During the flow the plummet rise due to variation in flow
- The upper edge of the plummet is used as an index to note the reading

- Working
- As the flow is upward through the tapered tube the plummet rises and falls depend on the flow rate
- Greater the flow rate higher the rise

DIRECT DISPLACEMENT METER

Used for the measurement of domestic water supply

PRINCIPLE

In this a stream of water enters meter and strikes the moving meter, the rate of rotation of the moving membrane is proportional to the velocity of the fluid.

Valves

Valves are used to control the rate of fluid in a pipe Valves should withstand

- Pressure
- Temperature
- Distortion

It should made up of brass, iron, bronze, and cast iron . For examples

- Plug clock valve
- Globe valve
- Gate valve
- Diaphragm valve
- Quick opening valve
- Check valve

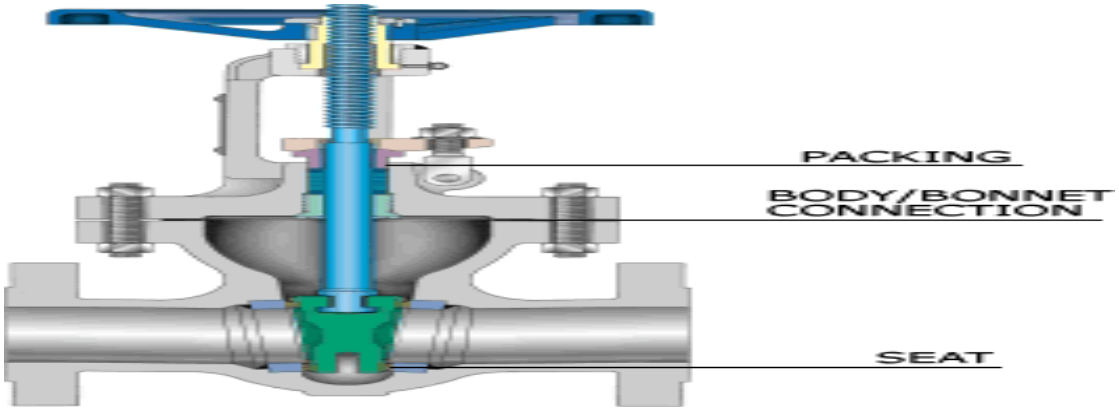
PLUG CLOCK VALVE

- It consists of casting body in to which a conical plug is fixed
- The plug has an opening through liquid will flow
- Packing material is included around the stem to close it.
- Not suitable for water due to the material of which made
- Some times plug will come out easily
- For slight rotation also grate change in the flow so difficult to operate

GLOBE VALVE

- Globe valve consists of a globular body with a horizontal internal portion
- Passage of fluid is through a circular opening which can be opened and closed by inserting the disc
- Disc is called as seating disc
- It can be rotated freely on the stem

GATE VALVE



Wedge shaped inclined seat type of gate is commonly used, pressure on the gate is controlling factor in large valves. Two type of gate valves are there in non rising stem valve thread of the valve stem engages the gate. Gate can be raised and lowered without movement of the stem. In rising stem valve length of the stem is more and gate and stem are single piece.

Advantages

- Available in large sizes, different designs.
- In minimizes the differential pressure during opening and closing.

DIAPHRAGM VALVE

- It consists of flexible physical barrier, valves are made of natural rubber or synthetic rubber faced with Teflon
- These are more suitable for fluids containing suspended solids and it can be easily sterilized

SIZE REDUCTION

Introduction:

Particle size is one of the most important factor affecting the process ability of powder including their mixing, flow and compaction properties. Particle size reduction is significant to enhance

surface area and flow property. Larger sized particles face issues with solubility as they require more time for dissolving. In certain special cases particles are not soluble in any media. In those cases, particles are to be dissolved in a suspension of particle size same as that as that of the dissolving particles. The importance of particle size in absorption is that with the decrease in particle size, there is an increase in surface area of particle which leads to increased absorption itself. The process of reducing larger solid unit masses using various techniques like jaw crusher, gyratory crusher, roll crusher, hammer mill and ball mill into smaller or finer particles is called as **size reduction.**

The principle of attrition and impact is mainly used here.

The process of size reduction, also known as comminution or diminution or pulverization is chiefly achieved by two methods – precipitation and mechanical. Precipitation involves the use of dissolution in appropriate solvent and mechanical process involves subjugation to mechanical forces using grinding machines. The former is used mainly for the production of bulk drugs or inorganic raw materials and chemicals like magnesium carbonate or calcium carbonate

Size reduction **is influenced** by various factors. These include various physical properties like moisture content, hardness, stickiness, toughness, slipperiness, abrasiveness etc. Other material properties like coarse and bulk density of the product, material structure, flow, shape and size also influences size reduction.

The **main purpose** of size reduction is to increase the surface area of the particles. Other advantages of size reduction includes enhanced and uniform mixing of powders due to the narrow size range of the particles, rapid rate of absorption, reduced sedimentation rate, improved physical appearance and increased stability in the case of emulsions.

Mechanisms of Size Reduction

The mechanisms have demonstrated that stresses of varied nature are required to achieve sizer eduction.The common mode sofsize reduction are explained as follows

Methods	**Examples**	**Approximate size of particle ((µm)**
Cutting	Scissors,Cutter mill and Shears	100-80,000
Compression	Roller mill and Pestle-Mortar	50-10,000
Impact	Hammer mill and Disintegrator	50-8000
Attrition	Colloidal mill and Roller mill	1-50
Impact and attrition	Ball mill and Fluid energy mill	1-2000

Advantages of size reduction

- Improved mixing and minimized segregation

- Improved chemical reactivity
- Improved surface area
- Rapid dissolution and increased absorption of drugs in the case of drugs
- Slower rate of settling and creaming in the case of suspensions and emulsions
- Less grittier cosmetic products

Size reduction laws:

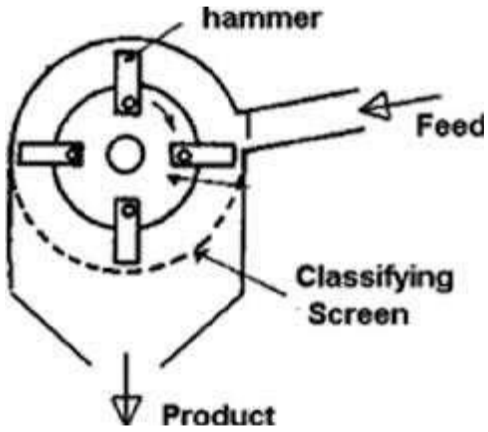
1. Kicks law states that the energy required to reduce the size of particles is directly proportional to the ratio of the initial size to the final size of the material.

2. Rittinger's law states that the energy required for size reduction is proportional to the change in surface area of the pieces.

3. Bond's law states that the work required to form particles of size Dp from very large feed is proportional to the square root of the surface to volume ratio of the product.

Hammer mill

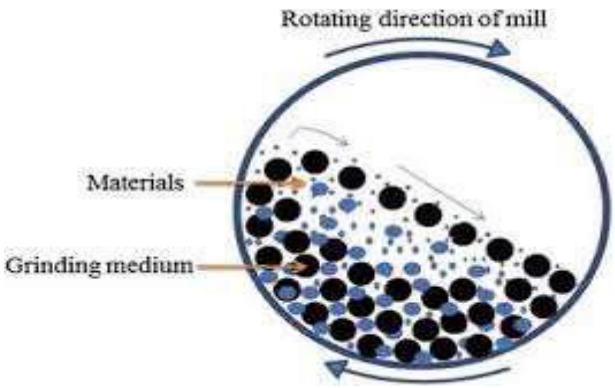
Hammer mill consist of a rapidly moving hammer connected to a high speed rotor in a cylindrical casing. Hammers upto 4 numbers are mounted on a horizontal shaft. It works on the principle of impact between the hammer and the particles to be size reduced. In hammer mill, the materials are introduced through the top of metal casing and are directly exposed to the hammer in operation thereby leading to size reduction. Later, the particles pass through a screen at the bottom and are collected at the receiver. The critical factors affecting size reduction includes – feed rate, size of the screen and rotor speed. A hammer mill is typically operated between 2500-5000 rpm.



Ball mill

The ball mill consists of hollow cylindrical rotating shell made of steel lined with porcelain or high carbon steel plate. Upto 50 % of its volume, the shell is filled with balls made of steel or pebbles. The balls are of constant weight and varying size which depend on the amount of feed. The size reduction happens due to the grinding of the balls against the material to be

comminuted. The particle size and shape of the material to be comminuted depends on the size of the ball, speed of rotation of the shell and feed rate. When the shell is rotated, centrifugal forces inside the shell carry the ball along the mill wall and get dropped when reaching a height due to gravitational force. This ensures the grinding of the material. Some of the added advantages of ball mill include the fine grinding of a large spectrum of materials and grinding of toxic substances due to the closed environment in a ball mill

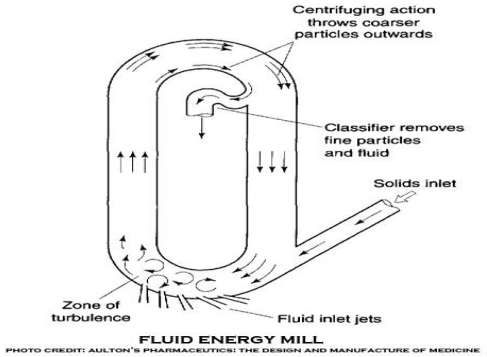


Fluidized Energy mill

Fluidized Energy mill, also known as micronizer or jet mill is a type of mill that consists of a hollow toroid that has a diameter of 20-200 mm depending on the height of the loop which can be up to 2 m. It operates by particle impaction and attrition.

A fluid or milling gas, usually air or inert gas is injected as a high-pressure jet through nozzles at the bottom of the loop. The powder particles in the mill are accelerated to high velocity.

The kinetic energy of the air plus the turbulence created causes interparticle (particle-particle collision) and particle-wall contact resulting in particle size between 2 and 10 micrometers. The fluidized effect transports the particles to a classification zone where the size classifier retains the particles until sufficiently fine to be removed.



FLUID ENERGY MILL

PHOTO CREDIT: AULTON'S PHARMACEUTICS: THE DESIGN AND MANUFACTURE OF MEDICINE

Fluidized energy mill subclasses have no moving parts and primarily are distinguished from one another by the configuration and/or shape of their chambers, nozzles and classifiers. They include;

a. Tangential jet

b. Loop/oval
c. Opposed jet
d. Opposed jet with dynamic classifiers
e. Fluidized bed
f. Moving target
g. Fixed target
h. High-pressure homogenizers

Pharmaceutical uses of Fluidized Energy mill

a. Fluidized energy is used in milling thermolabile materials
b. It is the choice of mill when a higher degree of drug purity is required
c. Fluidized energy mill is used for the fine grinding of frits, Kaolin, Zircon, titanium, and calcium, alumina.

Advantages of Fluidized Energy mill

1. The machine has no moving parts and thus the tendency of contamination due to wear of parts is minimized.
2. The equipment is easily sterilized.
3. Small particle size (between 2 and 10) is usually obtained at the end of milling.
4. Thermolabile materials can be milled with little degradation since the heat produced by the process is nullified by the cooling effect of the expansion of the compressed gas.

Disadvantages of Fluidized Energy mill

1. Tendency of forming aggregates or agglomerates after milling.
2. Generation of amorphous content due to high energy impact.
3. Formation of ultra-fine particles

EDGE RUNNER MILL

Principle

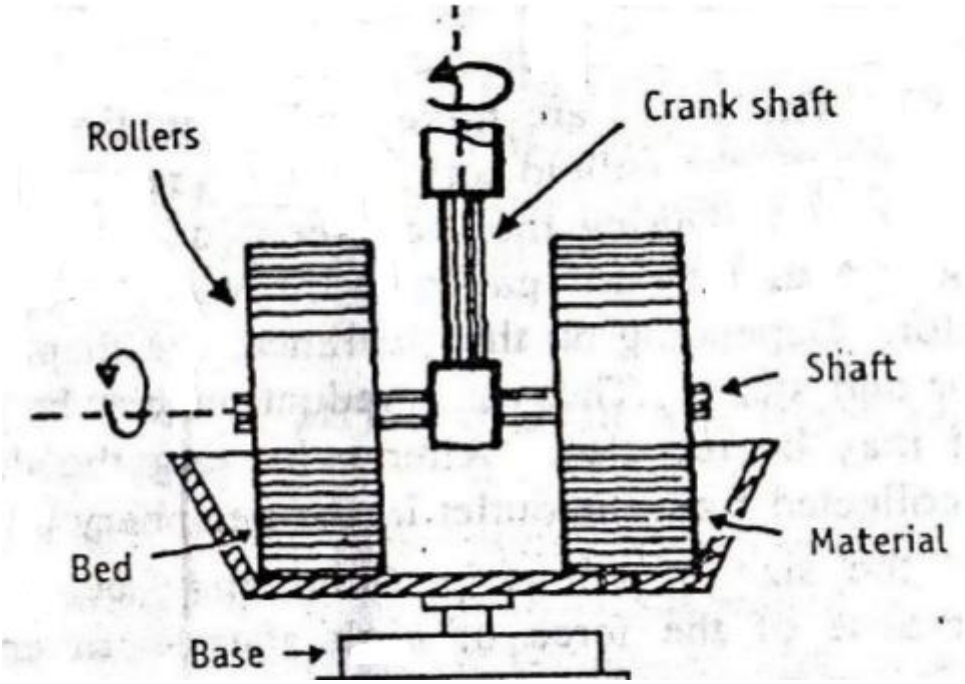
The size reduction is done by crushing due to heavy weight of stone.

Working: 22 Material to be ground is placed on the bed at the same time travel around the shallow stone bed so the size reduction is achieved by sharing as well as crushing.

Uses: Grinding tough material to fine powder.

Advantages: Does not require attention during operation.

Disadvantages: More space than other Contamination, Time mill, consuming, Not use for sticky materials.



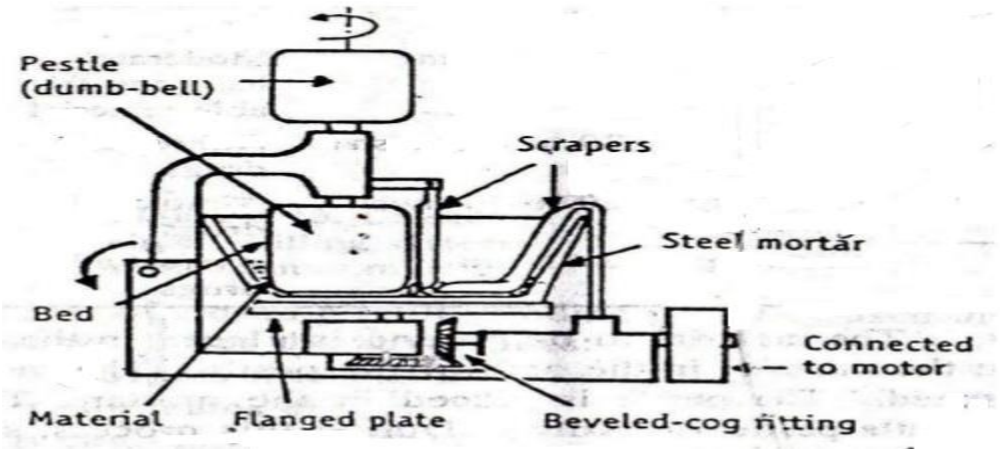
END RUNNER MILL

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

Working: 24 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: Use for fine grinding.

Disadvantages: Not suitable for unbroken or slightly broken condition of drug.



C. SIZE SEPARATION

Size separation is a unit operation that involves the separation of a mixture of various size particles into two or more portions by means of screening surfaces. Size separation is also known

as sieving, sifting, screening. This technique is based on physical differences b/w the particles such as size, shape and density.

Applications:

1. Monosized particles undergoes less segregation.
2. Filing of particles in capsule ensures more uniformity in weight and dose.
3. Coarse granules with little fine powder ensure good flow ability.
4. Fines produced during transport and processing can be separated.
5. Fine powders pass through mesh no.85 are used for topical application and mesh no. 60 are for oral administration.

Technique use to classify particles on the basis of size.

Methods of Particle size analysis:

1. Optical microscopy: (0.2-150 um): Can distinguish aggregates from single particles mage analysis computers each field can be examined, and a distribution obtained. For submicron particles it is necessary to use either TEM (Transmission Electron Microscopy) or SEM (Scanning Electron Microscopy). TEM and SEM (0.001-5µm)

2 Sieving:

1. Most widely used method of analysis.
2. Different grades of sieves are used for sifting the powders and preparing the granules of required particle size.
3. Material which does not pass through through sieve called as tailing.
4. Tailing should never be rejected because they may contain the medicinally active constituents. The tailing may be added to the next batch of the drug to be ground.

Material used for sieve:

a.Iron - Cheap but rusting may occur, so it is protected by coating. b.Copper -Avoid risk of iron contamination, but it is soft material and meshes can be destroyed easily. So use copper alloys- made of phosphorus- bronz , it possesses good resistance to corrosion. c.Stainless still: Most expensive material, and recommended for pharmaceutical purpose. d.Non metals- Man made fibers like-nylon and terylene .

Principles of sieving:(Mechanical sieving method)

1. Agitation: a. Oscillation - The sieve is mounted in a frame that oscillates back and forth, and material roll on surface. b . Vibration- Here , the mesh is vibrated at high speed, often by means of an electric device using the 50-Hertz alternations of alternating electric current. c . Gyration - The sieve is given a rotary movement of small amplitude, but of considerable intensity, giving a spinning motion to the particles.

2 . Brushing method: spiral brush rotating on the longitudinal axis of the sieve .

3. Centrifugal method: vertical cylindrical sieve with a high-speed rotor inside the cylinder, particles are thrown out because of centrifugal force.

Advantages :

- Easy to perform
- Wide size range
- Inexpensive

Disadvantages

- Known problems of reproducibility
- Wear/damage in use or cleaning
- Irregular/agglomerated particles
- Rod-like particles : overestimate of under-size
- Labour intensive

II. Sedimentation method- When particles are too small to be screened effectively or when large quantities of material are to be handled, methods involving differences in the rates of settling of particles of different sizes and of different materials are used.

Sedimentation: The process by which particulates settle to the bottom of a liquid and form sediment.

Sedimentation : Andreason pipet method : Consist of tall vessel called sedimentation vessel (500 ml), fitted to glass stoppered joint and 10 ml pipet. 1 % suspension of the powder is prepared in a suitable liquid medium which is then placed in the sedimentation vessel. 10 ml sample is withdrawn at specific time interval and samples are dried and the residues are weighed. Weights of the dried samples the percentage of the initial suspension is calculated for particles having sizes smaller than the size calculated by Stoke's equation for that time

Advantages

- Equipment required can be relatively simple and inexpensive.
- Can measure a wide range of sizes with considerable accuracy and reproducibility.

Disadvantages

- Sedimentation analyses must be carried out at concentrations which are sufficiently low.
- Large particles create turbulence, are slowed and are recorded undersize.
- Careful temperature control is necessary to suppress convection currents.
- The lower limit of particle size is set by the increasing importance of Brownian motion for progressively smaller particles.
- Particle re-aggregation during extended measurements.

- Particles have to be completely insoluble in the suspending liquid.

Particle size analysis Coulter Counter (0.6 to 120 um)

Testing tube surrounded by highly conducting electrolyte the number and size of particles suspended in an electrolyte is determined by causing them to pass through an orifice an either side of which is immersed an electrode. The changes in electric impedance (resistance) as particles pass through the orifice generate voltage pulses whose amplitude are proportional to the volumes of the particles. These pulses are amplified and counted electronically, and particles and particle size distribution is displayed on computer.

Cyclone separator: The suspension is introduced tangentially at fairly high velocity, so that a rotary movement takes place within the vessel. The rotary flow within the cyclone causes the particles to be acted on by centrifugal force, solids being thrown out to the walls, hence falling to the conical base and out through the solids discharge.

Application: suspensions of a solid in a gas, usually air.

Air Separator: It involves mechanical force for movement of air. Rotating disc and vanes develop rotatory movement of air. By controlling speed of rotation it is possible to separate particles of definite size. Fine particles are carried forward by air and velocity drops the leave air stream.

Elutriation method: Based upon counter flow of fluid(air/water) and settling particles through vertical columns. As airflow goes upwards, the dense particles leaves the stream and sediment down in bottom. So air flow carries only light particles and collected by separate vessel.

Particle size distribution: It is mathematical function that defines the relative amount, typically by mass, of particles present according to size.

PSD is also known as grain size distribution. Powders of polydispersed system and number or weight of particles lies within certain range. Measurement techniques are-Sieving, elutriation, optical counting, sedimentation.

POWDERS:

Def: A Pharmaceutical powder is a mixture of finely divided drugs or chemicals in a dry form meant for internal or external use.

Advantages of powders: 1-Flexibility of compounding. 2-Good chemical stability 3-Rapid dispersion of ingredients (because of small particle size)

Disadvantage 1-Time-consuming preparation 2-Inaccuracy of dose(size of measuring spoon, density of powder, humidity, degree of settling , fluffiness. 3-Unsuitability for many unpleasant tasting, hygroscopic and deliquescent drugs

Classification of Powders

1. Internal (Oral)
   - Divided- Simple divided, Compound, Enclosed in sachet, Tablet trituration
   - Bulk – Antacid, Laxative, Effervescent, Dietary
2. External Bulk powders – Dusting, Insufflation, Snuff, Dentifrices
3. Parenteral

Simple Powder: Only one ingredient either crystalline or amorphous.

Compound powder: Contain two or more than two API are mixed together. e.g. Rx Aspirin 300 mg Paracetamol 150 mg Caffeine 50 mg

Marketed preparation- 1.Acidin with belladona powder 2.Bismag powder

Tablet Triturates: It is mixture of dilution of mixture with potent substance. Small quantity of solids are mixed together on white paper sheet by spatula or knife. Large quantities are mixed by mortar and pestle.

Procedure: 1- Reduce the drug to a moderately fine powder in a mortar. 2-Add about an amount of diluents & mix well by thorough trituration in the mortar. 3-Done by geometrical dilutions e.g -100 mg potent drug to be mixed with 900 mg of lactose. So take 100 mg potent drug + 100 mg lactose sum is 200 mg. Then take this 200 mg of mixture and add 200 mg of lactose.

Oral rehydration powder (Effervescent Granules) : They contain a soluble medicinal agent mixed with citric acid, tartaric acid and sodium bicarbonate. Before administration they are suspended and dissolved in water, on dissolution it produces CO_2 and result acid base reaction with effervescence. The carbonated water produced serves as mask for saline and bitter taste of drug. CO_2 accelerates flow of gastric juice and accelerates absorption of medicament. Effervescent Granules are preferred over effervescent powder in order to decrease rate of dissolution of substance upon addition of water.

Method of preparation: Reaction: 3NaHCO 3 + C 6 H 8 O 7 .H 2 O = C 6 H 5 Na 3 O 7 +3CO 2 +3H 2 O (Citric acid) (sodium citrate) 2NaHCO 3 + C 4 H 6 O 6 = C 4 H 4 Na 2 O 6 + 2CO 2 + 2H 2 O (tartaric acid) (sodium tartarate) Citric acid and tartaric acid both are used because- If citric acid alone is used, it contains water molecule of crystallization which is liberated on heating, and will make the mass to wet and difficult to pass through sieve. If tartaric acid alone is used, it is anhydrous so some non-solvent liquid have to be used for granulation, otherwise the resulting granules will be firm but will crumble readily gives salty taste. Citric acid partially neutralizes NaHCO3; rest of all NaHCO3 will be neutralized by tartaric acid. Marketed Preparation: 1.Eno fruit salt (Smith kline) 2.Cetri-soda (Abbot labs) 3.Rhino (Mehta Unani) Effervescent tablet- Pepfiz (Ranbaxy lab)

Dusting Powder: (For external application) They are used for antiseptic, astringent,

antiperspirant, absorbents, protective and lubricant purpose. They are homogeneous very fine state and pass through sieve 120. They should flow easily, spread uniformly and stick to skin They are prepared by mixing two or more ingredient with starch, kaolin or talc which are sterilized before use. If get inhaled they cause pulmonary inflammation. Packaging -They are dispensed in sifter top containers or pressure aerosols, and applied by powder puff, brush or gauze.

Purified talc, sterilized 50 gm Starch,in powder 25 gm Zinc oxide 25 gm Label: Zinc, starch and talc dusting powder

Theory: Talc and Kaolin must sterilized by heating 160 C for 1hr. Purified talc has excellent flow and lubricant. Starch as an absorbents. Zinc oxide acts as an antiseptic and absorb moisture. Marketed Preparations: 1.Cibazol dusting powder (Contains- Sulphathiazole) 2.Nebasulf dusting powder (Pfizer Ltd.) 3.Salcylic acid compound dusting (Alpine)

Insufflations: Finely divided powders meant for introduction to body cavities such as ears, nose, tooth sockets. It is transfer through apparatus. Disadvantage: 1.It is difficult to obtain measured quantity of uniform dose. 2. Powder may get blocked when powder is wet or apparatus is wet.

Dentifrices : Helps the tooth brush to clean the surfaces of teeth. They have cleansing action. Marketed Tooth powder: 1.Clinso-dent (ICPA Health product) 2.Flixon flavored denture (ICPA Healyh products) Marketed Tooth pastes 1.Sensolin (Warren Pharma) 2.Mentadent (Hindustan Lever) 3.Desent tooth paste (Indoco Remedies)

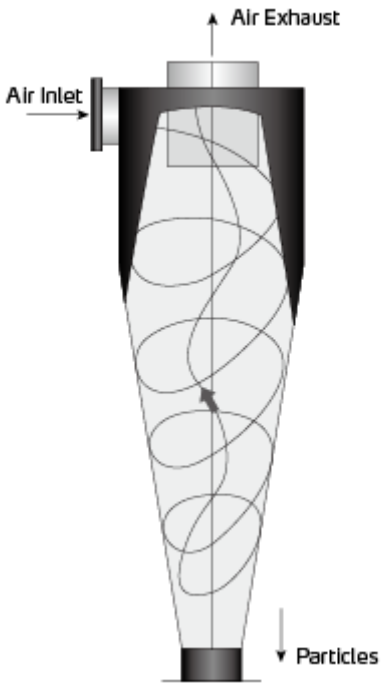
Cyclone Separator

Cyclone separator is a kind of equipment used in air-solid separation. At the end of the air conveying system, it acts as the separator for granule in the conveying air. It is a kind of purifying equipment features simple structure, convenient maintenance,high-temperature resistance which has low costs and high resistance. It has no movable parts which the service life is much longer than common filter. Therefore, the cyclone separator is widely used in plastic materials granulating and recycling as well as dust-removing in exhausted drying air. Ordinarily, cyclone separator is manufactured by welding of common steel plate, and is applicable for occasions requiring less air purity relatively. If there needs high standard of air purity, the adopting of electrolytic or stainless steel plate in process can meet the requirement.

Working Principle

Cyclone separator utilizes cyclone centrifugal force to separate granules from the air. As the below picture, granules containing air firstly enter the inner cyclone separating area of the hopper through inlet. In this area, direction of air is changed from direct entering to down-run with spiral rotating along the screw (as solid line). The high-density dust particles are dragged to

hopper lining by centrifugal force. With the air rotating along the screw and the entering of cone part, spiral airflow inside the hopper flows to the center as hopper diameter reduced. In lessened centrifugal force, granules are exhausted along inside hopper to the outlet. However the secondary vortex flow will be formed when airflow reaches the ending part of the cone hopper and will be expelled via upper exhausting pipe of the cone part.



Cyclone separator

Pressure Loss

There are varies proportions and styles of the cyclone separator, which generate different pressure losses. Usually, pressure loss of the cyclone separator is about 50~200mmAq. When cyclone separator is used in positive pressure conveying system, with the large conveying pressure, even there's much pressure loss of the cyclone separator, it just makes a little influence on the conveying effect. We generally attach more attention to the separation effect.

In negative pressure conveying system, the air-source equipment usually has low suction pressure, the less pressure loss of cyclone separator, the better. In designing of the cyclone separator, it should estimate its pressure loss precisely, and calculate the output pressure of the air-source equipment.

Separation Effect

Ordinarily, the cyclone separator is applicable to separate the non-viscous, non fiber dry dust greater than 1-3 micrometers. By accurate calculation and appropriate technological structure, it can get supreme separation effect eventually. For large size granules, the separating rate can

reach above 97%. The granule in smaller size or is more light, the more difficult to separate effectively.

Application

Currently, the cyclone separators are widely used in Shini products, they always appear in the occasions which need air-solid separation. The products include HCF Cyclone Dust Separator, ACF Cyclone Dust Collector, Blower Conveying & Cyclone Dust Collector of Shini Granulator and the conveying device of Shini Sound-proof Central Granulator.

For some plastic materials, like PET or others, during process of pre-crystallizing, drying and dehumidifying, and conveying, which contain the granules or much granules generated by friction. If there's no pre-separation for granules in the drying air of return loop or in the conveying recycling process, it will block the return-air filter or the front-set filter soon, and affect the ventilation which eventually influences the material drying and conveying capacity. Especially for large drying and dehumidifying or conveying system, granules containing airflow will affect the filter seriously. Therefore, before drying air return or conveying air passing through the filter, make it get through the cyclone separator at first can lessen filter's cleanliness and improve the operating efficiency.

Elutriation Methods:

- The size separation of powders is based on the low density of fine particles and high density of coarse particles.
- Elutriation tank is used to separate the coarse and fine particles after levigation .
- The dry powder or paste made from levigation process is mixed with large quantity of water and made suspend in the tank .
- Depending on density of particles they will settle down or suspended in water.
- The sample is drawn from different heights through outlets and dried.
- Thus the powder with various size fractions are obtained.

Advantages:

- The process is continuous
- The separation is quick as compare to that other methods of separation.
- Depending on the number of fractions required, the same number of tubes of different area of cross section can be connected
- The apparatus is more compact than as that used in sedimentation method

Disadvantages:

The suspension of solid particles has to be diluted which may not be desired in certain cases.

Important key points of Module

- Bernoulli theorem, measurement of rate of fuids
- Mechanism of size reduction
- Modes of stress applied in size reduction
- Selection of mill
- Theory and energy of communication
- Mode of motion in size separation
- Settling behavior of solids, selection of size separation equipment

QUESTION BANK

A. Question 2 Marks

1. Define pharmaceutical engineering.
2. Explain term “Head” in fluid flow.
3. What do you meant by turbulent flow?
4. What is venturimeter?
5. How ball mill reduces size of particles by impact, shear and attrition?
6. Write the principle of bag filter.
7. How is size reduction carried out for fibrous drugs?
8. Give the application of air separator.
9. State rittingers law for size reduction
10. Write the application of size separation.

B. Question 5 Marks

1. What are the objectives of size reduction ? Discuss the laws governing energy and Power requirements in size reduction.

2. Write a note on sieve shaker.
3. Describing function of hammer mill.
4. Write a note on working of rotameter.
5. Write a note on Energy losses during the fluid flow.
6. Explain in detail about orifice meter.

C. Question 10 Marks

1. Comment on “Milling is an energy intensive process”.
2. Give objectives of size reduction. Explain in detail construction and working and advantages of ball mill with diagram.
3. Explain principle, working, construction of bag filter.
4. What is the mechanism of size separations?
5. What is manometer? Derive the equation application for a simple manometer and differential manometer.