7

Size Separation

Official Standards for Powders
Sieves
Modes of Motion in Size Separation
Sieve Analysis – Testing of Powder
Equipment for Size Separation

Size reduction of a solid material never gives particles of same size, but gives particles of varying sizes, i.e., distributes in different sizes. These materials must be subjected to a separation technique to obtain narrow size ranges. As far as possible size separation is included as an integral part of the size reduction process. When particle size distribution is to be controlled for the official specifications, size separation assumes greater importance and has to be handled independent of the size reduction.

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

Size separation is also known as *sieving, sifting, classifying* or *screening*. This technique is based on physical differences between the particles such as size, shape and density.

Screening is a method of separating particles according to size alone. Particles can be separated into individual sizes using sieves. The final portion consists of a more uniform size. The material that remains on the given screening surface is known as *oversize or plus material*. The material passing through the screening surface is known as *undersize or minus material*. Size separation process (or sieves) can be used:

1. As a method to determine particle size and size distribution, which are useful in the production of tablets and capsules.
2. As a quality control tool for the analysis of raw materials such as griseofulvin and aspirin.

–12

3. To test the efficiency of a size reduction equipment or process.
4. To optimise the process conditions such as method of agitation, time of screening, feed rate etc.

The testing of a powder and equipment used for classifying has been discussed in the chapter. Mainly this chapter is purported to provide adequate support to the size reduction process discussed earlier.

OFFICIAL STANDARDS FOR POWDERS

In general, powders are vaguely described as coarse and fine powders. However, it is essential to identify with some guiding specifications.

Indian Pharmacopœia has prescribed standards for powders for pharmaceutical purposes. Accordingly, degree of coarseness or fineness is expressed with reference to the nominal aperture size of sieve through which powder is able to pass. The relevant grades of powders and sieve number along with nominal aperture size are shown in Table 7-1. The IP 1996 specifies five grades of powder.

TABLE 7-1
Grades of Powders and Sieve Number along with Nominal Aperture Size as per IP

Sl. No.	*Grade of powder*	*Sieve through which all particles must pass*	*Nominal mesh aperture size*	*Sieve through which 40% particles pass*	*Nominal mesh aperture size*
1.	Coarse powder	10	1.7 mm	44	355 μm
2.	Moderately coarse powder	22	710 μm	60	250 μm
3.	Moderately fine powder	44	355 μm	85	180 μm
4.	Fine powder	85	180 μm	—	—
5.	Very fine powder	120	125 μm	—	—

Coarse powder : A powder, all the particles of which pass through a sieve with nominal mesh aperture of 1.70 mm (No. 10 sieve) and not more than 40.0 per cent through a sieve with nominal mesh aperture of 355 μm (No. 44 sieve) is called coarse powder.

In a similar way, other definitions can be written for the contents of the Table 7-1. When fineness of a powder is described by means of a number, it is an indication that all the particles of the powder shall pass through the sieve of which the nominal mesh aperture in µm, is equal to that number.

Normally, for compound powders, fine powders are preferred, while moderately coarse powder is used for the preparation of tinctures. Coarse powder without fines is employed in percolation process.

The above mentioned terminology has applications in the production of galanicals. A few examples are given in the Table 7-2.

The pharmacopœia has prescribed upper and lower limits for the three coarse grades of powder. For two fine grades, the pharmacopœia has prescribed only the upper limit.

TABLE 7-2
Some Examples of Crude Drugs and Nature of Powder Required

Liquid extracts	*Useful parts*	*Grade of powder*
Ashoka	stem bark	coarse
Nux vomica	seeds	moderately coarse
Rauwolfia	roots	moderately coarse
Ergot	sclerotia	moderately fine
Ipecac	root	fine
Ephedra	stem	fine

SIEVES

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

Construction

Sieves for pharmaceutical testing are constructed from wire cloth with square meshes, woven from wire of brass, bronze, stainless steel or any suitable materials. Sieves should not be coated or plated. There must be no reaction between the material of the sieve and the substance to be sieved.

Types of Sieves

The primary considerations for sieves are given to the size and shape of aperture opening. Square meshes are arranged as per the specifications. Sieves commonly used in pharmaceutical processing include:

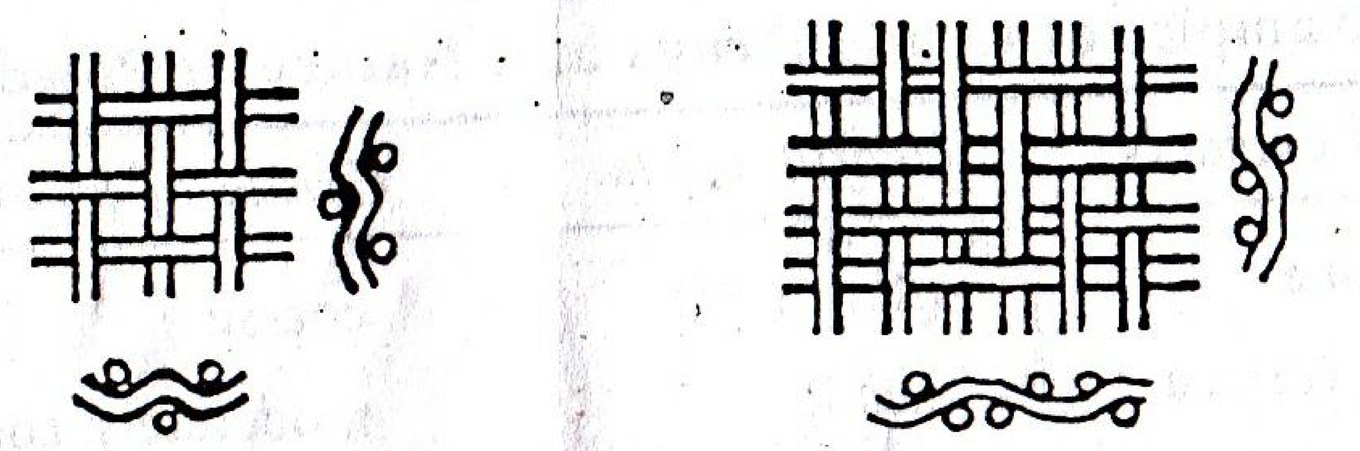
– Woven wire sieves

- Bolting cloth sieves
- Closely spaced bars (screens)
- Punched plates

Woven wire sieves : Wire woven sieves are general-purpose sieves and widely used in the pharmacy practice. The types of woven wire sieves are:

– Plain weave – Twilled weave

The nature of sieve surfaces is shown in Figure 7-1. For fine sieving, metal wire woven sieves are used. Common examples are hand sieves. These are included in roller mill, ball mill etc., during milling. In case of coarse sieves, the wire is generally given a double crimp to preserve the alignment of the wire.



(a) Plain weave sieve (b) Twilled weave sieve

Figure 7-1. The nature of sieve surfaces.

Bolting cloth sieves : Silk, nylon and cotton are generally woven from twisted multi-strand fibres. Nylon cloths are generally designated by their micrometer opening and available in different grades. These are used for the separation of fine powders. Hum-mer screen uses this type of screens.

Bar screens : Bar screens are generally used in handling large and heavy pieces of materials. The bars are fixed in parallel position and held by cross bars and spacers. Bars which taper in thickness from one end to the other are recommended, because they tend to avoid blinding. Grizzlies use this type of screens.

Punched plates (Perforated screens) : These are used for coarse sizing. The screens are prepared by using a sheet metal of varying thickness with perforated holes. The holes may be round, oval, square, or rectangular (Figure 7-2). These types of screens are used in a hammer mill.

A plate with a large number of holes and a small amount of residual metal will have a large capacity, but will wear rapidly and vice versa. In general, for openings much over 25 millimetres in diameter, a plate with

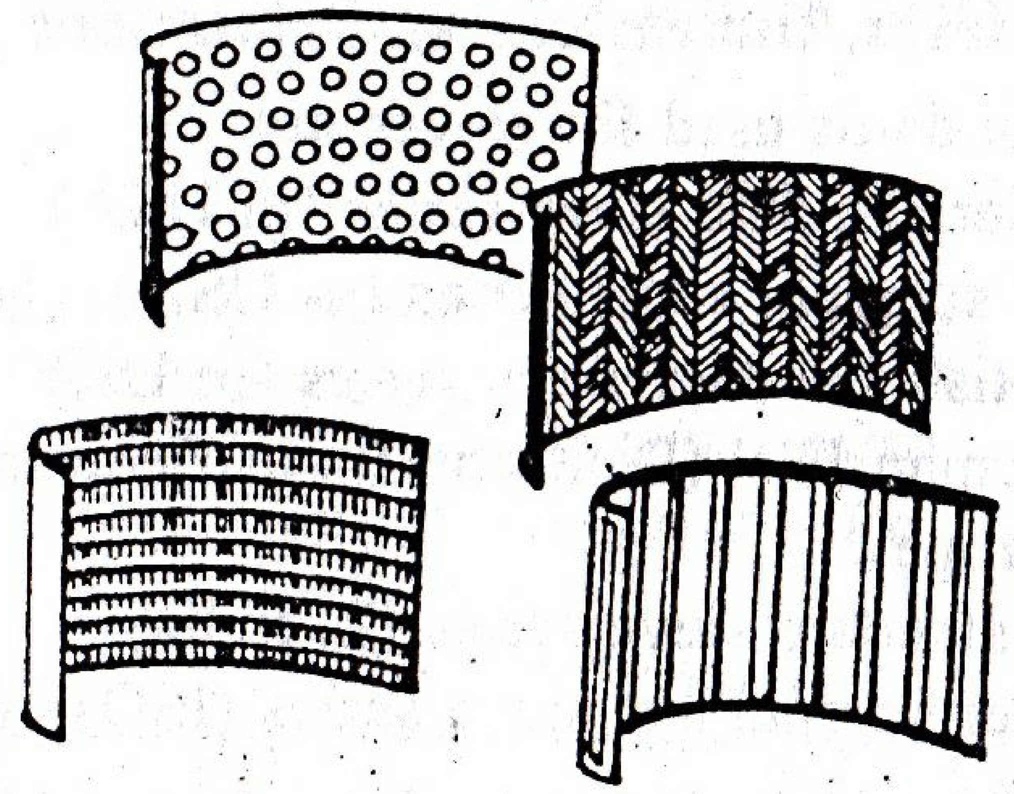


Figure 7-2. The configurations of punched plates or perforated screen.

round perforations is preferred over a wire screen. The applications of screen configurations are given in Table 7-3.

TABLE 7-3
Applications of Various Mill Screen Configurations of Perforated Screens

Perforation shape	*Recommended use*	*Comments*
Round holes	Fibrous materials	Clogs more quickly; lower hole size is limited, because of structural strength.
Herringbone screen (slots)	Amorphous and crystalline materials	Slightly coarse powder than equal-diameter round perforations
Cross-slots	Amorphous materials and slurries with coarse particles	Same grind size as of equal sized round perforation; finer slot size attainable than round perforations.

Herringbone design : Herringbone design consists of a series of slotted holes repeated across the surface of the screen. These are made at an angle of 45 degrees to the length of the screen. It is preferred for grinding crystalline materials and for continuous operation. If the width of the slot is equal to the diameter of a round hole, it grinds the particles coarser than the round hole. This design should not be used for fibrous materials, as it is possible for fibres to align themselves along the slots and pass through with inadequate size reduction.

Cross-slot screens : In this type, openings are at right angles to the path travelled by milling mechanism. These are used for milling slurries, but not used for fine grinding in hammer mills as it clogs readily.

Standards of Sieves, Dimensions and Notations

Common standards used for sieves are:

(a) Tyler standard sieve series (in USA)
(b) US standard sieve series (in USA)
(c) British standard sieve series (in UK)
(d) German DIN (Deutsche Industrienormein) (in Germany and Europe)
(e) IP standard sieve series (in India)
(f) International test sieve series (ISO) (World wide)

Tyler and US standards can be interchangeable, since the difference between the two standards is less than the allowable tolerance in weaving of the screens. These are also known as *test sieves*. Sieves used for pharmacopœial testing must match with the following specifications:

1. **Number of sieve :** Sieve number indicates the number of meshes per linear length of 25.4 millimetres.
2. **Nominal size of aperture :** Nominal size of aperture indicates the distance between the two adjacent wires. It represents the side of a square aperture. IP 1996 gives the nominal mesh aperture size for majority of sieves in mm or in μm.
3. **Nominal diameter of the wire :** Wire mesh sieves are made from the wire having the specified diameter in order to give a suitable aperture size and sufficient strength to avoid distortion of the sieve.
4. **Approximate percentage sieving area :** This standard expresses the area of the mesh as a percentage of the total area of the sieve. It depends on the size of the wire used for any particular sieve. Generally, the sieving area is kept within the range of 35 to 40 per cent in order to give suitable strength to the sieve.
5. **Aperture tolerance average size :** Some variation in the aperture size is unavoidable. This variation is expressed as a percentage and is known as the *aperture tolerance average*. In fact, it is a limit given by pharmacopœia within which a particular dimension or average aperture size can be allowed to vary and still be acceptable for the purpose for which it is used. Fine meshes cannot be woven with the same accuracy as coarse meshes. Hence, the aperture tolerance average is lower for coarse sieves than the fine sieves.

According to IP 1996, a sieve must conform to the specifications given in Table 7-4.

TABLE 7-4
Standards for Sieves—Specifications

Sl no.	*Approximate sieve number*	*Approximate percentage sieving area*	*Nominal mesh aperture size (mm)*	*Tolerance average aperture size (± mm)*
1	4	55	4.0	0.13
2	6	51	2.8	0.09
3	8	48	2.0	0.07
4	10	46	1.7	0.06
5	12	41	1.4	0.05
6	16		1.0	0.03
7	—		μm	μm
8	22	37	710	25
9	25	36	600	21
10	30	38	500	18
11	36	36	425	15
12	44	38	355	13
13	60	37	250	13 (9.9)
14	85	35	180	11 (7.6)
15	100	36	150	9.4 (6.6)
16	120	34	125	8.1 (5.8)
17	150	36	106	7.4 (5.2)
18	170	35	90	6.6 (4.6)
19	200	36	75	6.1 (4.1)
20	240	34	63	5.3 (3.7)
21	300	35	53	4.8 (3.4)
22	350	34	45	4.8 (3.1)

Note : Figures in the brackets refer to close tolerance and those without brackets refer to full tolerance.

Comparison of Ideal and Actual Screens

An *ideal screen* would sharply separates the feed mixture in such a way that the smallest particle in the oversize would be just larger than the largest particle in the undersize.

Such an ideal separation defines a cut diameter, D_{pc} that makes the point of separation between the fractions. Usually, D_{pc} is chosen to be equal to the mesh opening of the screen.

An *actual screen* is the one, which does not give perfect separation about the cut diameter.

In an actual screen, the overlap between the smallest particle in oversize and the largest particle in undersize is more pronounced, when particles:

- are needle like, fibrous.
- tend to aggregate.
- tend to strike the screen surface endwise and pass through.
- tend to strike the screen sidewise and retained.

Commercial screens usually give poorer separations than testing screens of the same mesh opening when operated on the same mixture.

MODES OF MOTION IN SIZE SEPARATION

Screening is a method of separating particles according to size alone. The basic technique involved is passing the particles through a series of sieves of uniform size. In this, the particles drop through the openings due to gravity. Coarse particles can drop easily through large openings, but it is difficult to screen the fine powders. This process can be hastened by inducing some type (mode) of motion (movement) to the particles. Size separation is basically assisted by three methods.

1. Agitation
2. Brushing
3. Centrifugal force

These modes of shaking help to shake the material so that sieving will be quick and entire sieving area can be utilised.

Agitation Method

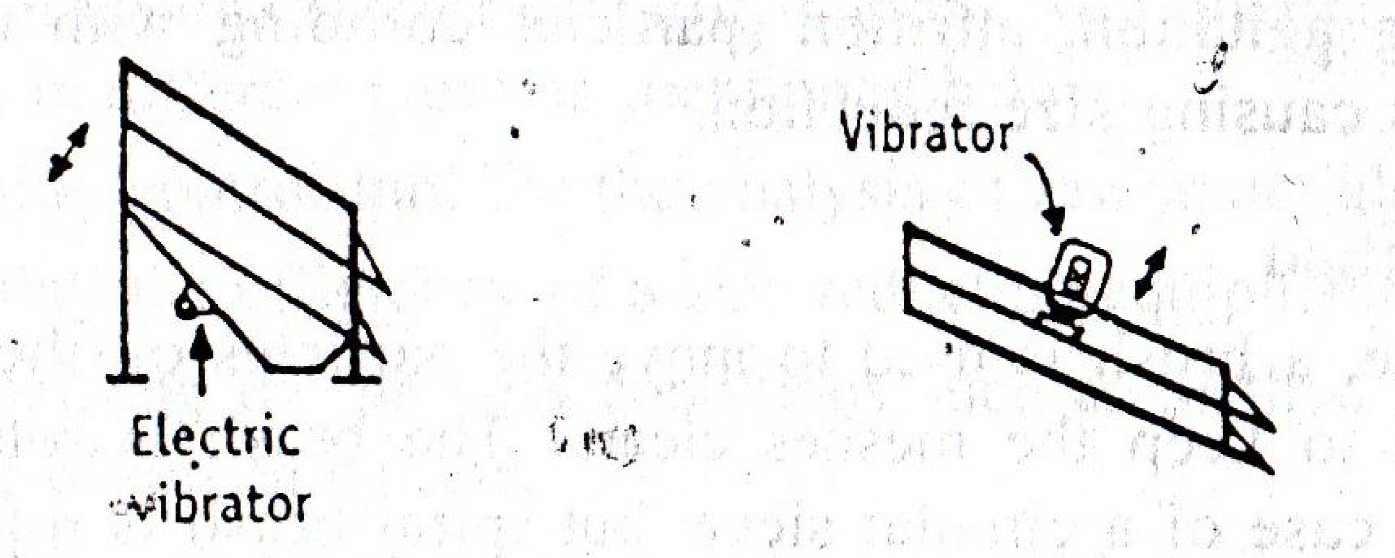
Sieves are agitated in a number of ways. Some of them are discussed below.

Oscillation : The sieve is mounted in a frame that oscillates back and forth, i.e., reciprocal motion (Figure 7-3). It is a simple method, but the

material may roll on the surface of the sieve. The motion is parallel to the plane of the sieve. The sieves can be slightly inclined. The reciprocating motion is induced by means of an ordinary eccentric on a rotating shaft.

Figure 7-3. Motion of screen, shaking (oscillations).

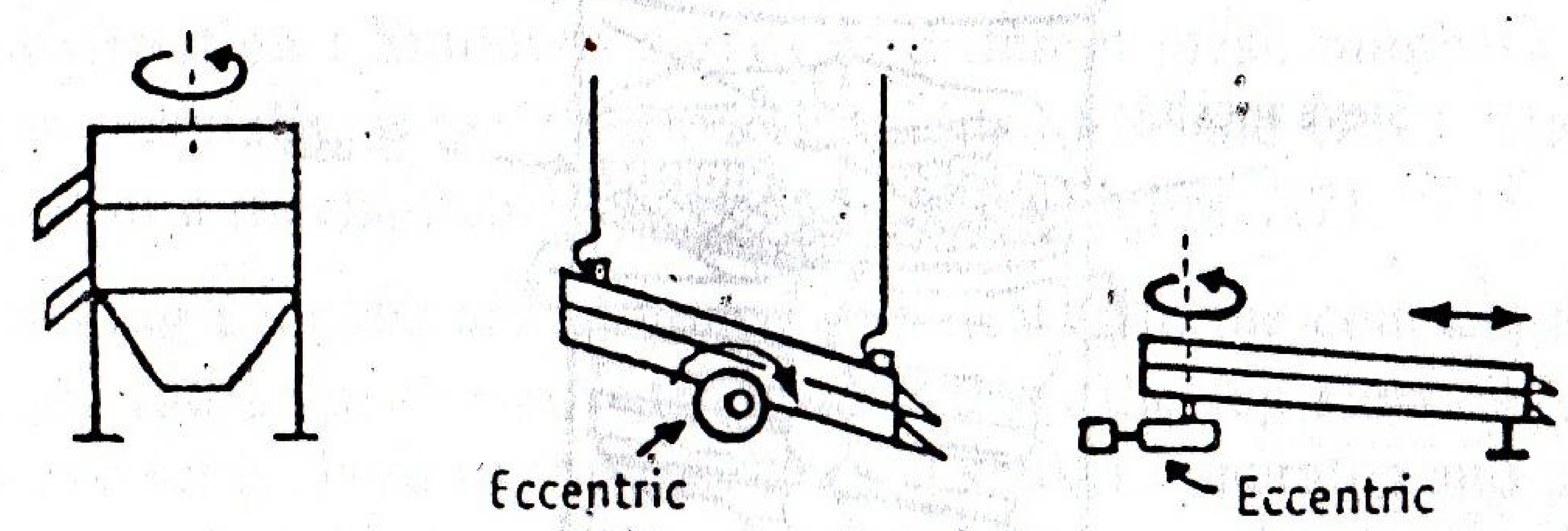
Vibration : The sieve is vibrated at high speed by means of an eccentric device (Figure 7-4) either electrically or mechanically. Rapid vibration is imparted to the particles that helps the powder to pass through the sieve. Electrically vibrated screens are particularly useful in the chemical industry. Example is hum-mer screen. They handle light, fine and dry materials successfully. Inducing vibrations also prevents blinding of meshes.



(a) Mechanically vibrated (b) Electrically vibrated

Figure 7-4. Motion of screens vibrating motion.

Gyration : In this method, a system is made so that sieve is on rubber mounting and connected to an eccentric flywheel (Figure 7-5). This gives a rotary movement of small amplitude to the sieve, which in turn gives spinning motion to the particles that helps to pass them through the sieve.



(a) Gyrations in horizontal plane (b) Gyrations in vertical plane (c) Gyration at one end, and shaking at other end

Figure 7-5. Gyratory motions of screens or sieves.

Gyratory screens are box like equipment, either round or square, with a series of screen cloths nested atop one another (Figure 7-5). Most gyratory screens have auxiliary vibrations caused by balls bouncing against the lower surface of the screen.

Agitation methods are not continuous methods. However, these can be made continuous by inclination of the sieves. Separate outlets are made for undersize and oversize particles. Normally, all the three modes of agitation are used simultaneously for an efficient size separation. Rotex screen works on this principle.

Advantages : (1) Agitation methods are inexpensive.

(2) Simple and rapid.

Disadvantages : (1) Agitation methods have lower limit of the particle size.

(2) If the powder is not dried, apertures become clogged with particles leading to improper sieving.

(3) During agitation, attrition (particles colliding with each other) occurs causing size reduction.

Brushing Method

In this case, a brush is used to move the particles on the surface of the sieve and to keep the meshes clear. The brush is rotated in the middle in the case of a circular sieve, but spiral brush is rotated on the longitudinal axis in case of horizontal cylindrical sieve. One example is brush sifter (Figure 7-6). This is used for size separation of greasy or sticky powders such as waxes and soaps.

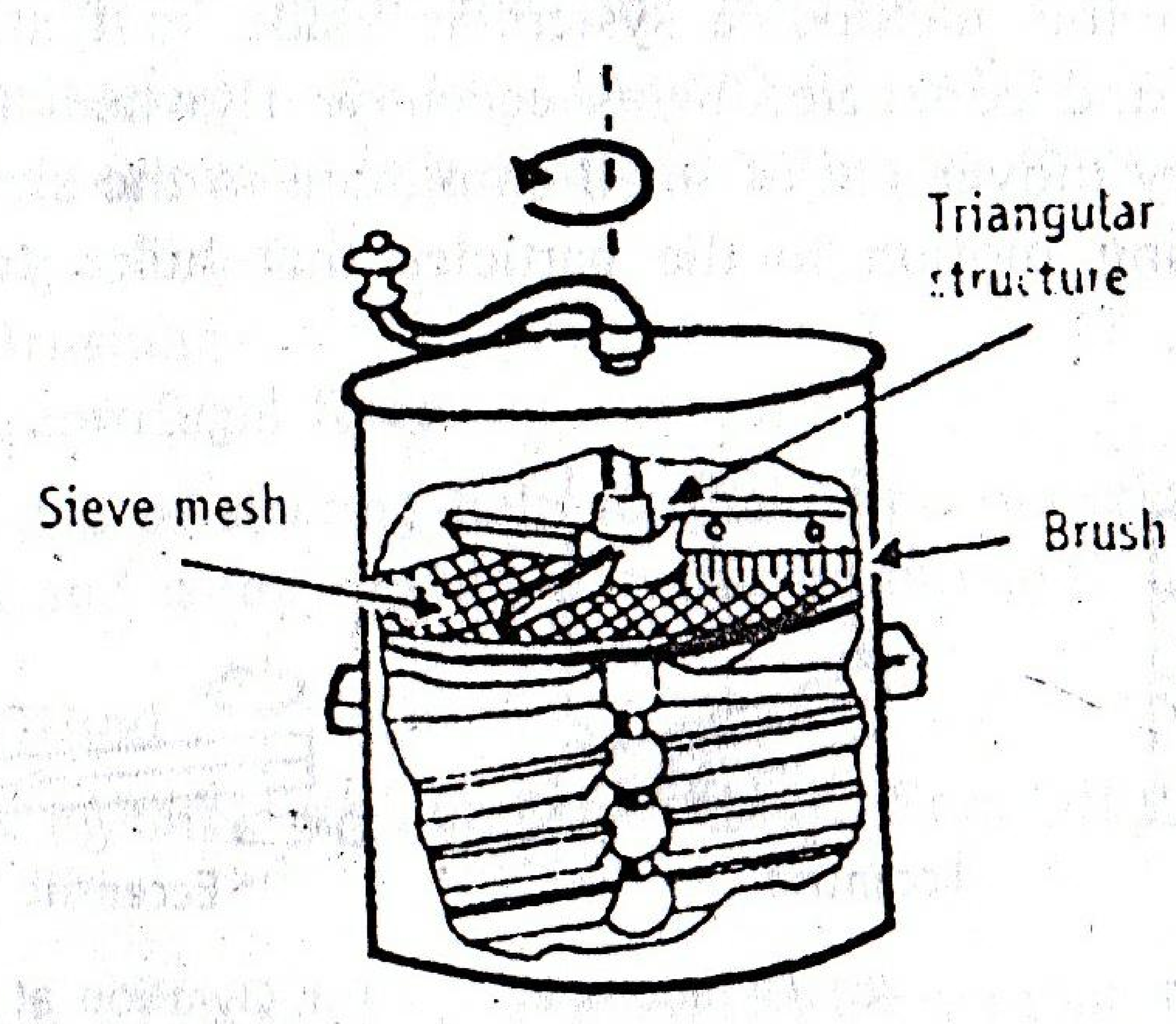


Figure 7-6. Brush sifter

Centrifugal Method

In this method, a high-speed rotor is fixed inside a vertical cylindrical sieve, so that on rotation the particles are thrown outwards by centrifugal force. The currents of air can be generated by means of a jet of air into the equipment, which helps in separating the particles. A few examples of equipment that work on this principle are cyclone separator and air separator.

Advantages : (1) Centrifugal methods are extremely useful in cases where conventional sieving tends to block the sieves.

(2) Extremely useful for fine powder, because sieves have the limitation of mesh size.

SIEVE ANALYSIS—TESTING OF POWDER

The milled material is subjected to size separation in order to obtain the powder of desired size or size distribution. Size distribution analysis is important in different areas as mentioned below.

- Quality control tool for the analysis of raw materials.
- Testing the efficiency of a size reduction equipment or process.
- Optimising the process conditions such as method of agitation, time of screening, etc.
- Selecting the sieve system for commercial equipment.

Errors can arise if the sieves are overloaded or if insufficient time is allowed for the particles to pass through.

Sieve Shaker Machine

Principle : The powdered drug is separated according to its particle size using a number of sieves in a nest. These are subjected to different types of agitation, so that size separation is rapid.

Construction : Standard sieves of different mesh numbers are available commercially as per the specifications of IP and USP. These sieves are fixed in a mechanical shaker apparatus (Figure 7-7).

Working : Sieves are arranged in a nest with the coarsest at the top. A sample (50 g) of the powder is placed on the top sieve (Figure 7-7). This sieve set is fixed to the mechanical shaker apparatus and shaken for a certain period of time (20 minutes). The powder retained on each sieve is weighed.

Practical considerations : Care should be taken in order to get reproducible results. The type of motion influences sieving; vibratory

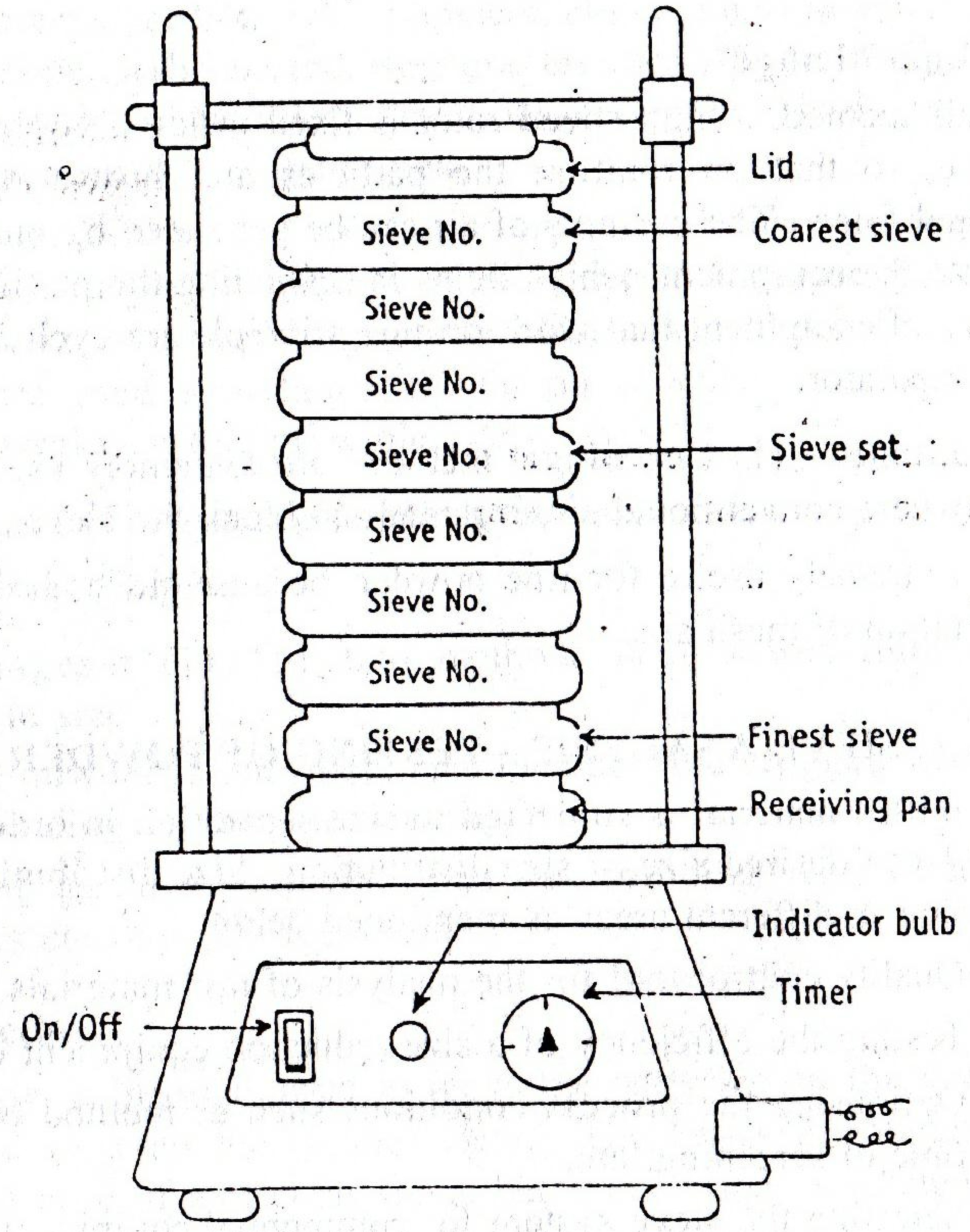


Figure 7-7. Laboratory sieve shaker machine.

motion is most efficient, followed by side-tap motion, bottom-pat motion, rotary motion with tap and finally rotary motion. The type of motion and intensity of the shaker are fixed and standardized. Shakers are commercially available.

Other factors are weight of the sample and duration of shaking. Sieves produced by photo-etching and electro-forming techniques are used to get a better estimate of the size distribution analysis with a lower limit of estimation of particle diameter 5 μm.

Advantages : It is inexpensive, simple and rapid with reproducible results.

Disadvantages : (1) Lower limit of particle size is 50 μm.

(2) If powder is not dry, apertures get clogged with particles, leading to improper sieving.

(3) During shaking, attrition (particles colliding with each other) occurs causing size reduction of particles. This leads to error in estimation.

Variants : *Electromagnetic sieve shaker*—It is useful for analysing powders under controlled conditions. *Sonic sifter* – This apparatus utilises sonic oscillations. A mechanical pulse action is used to reduce blinding and agglomeration in the sub-sieve sizes.

Alpine Airjet Sieve

Principle : In the Alpine airjet sieve, sieving action involves the application of a jet of air on one side of the sieve and suction on the other side. The material is maintained in a fluidised state on the screen by a stream of air. Vacuum is applied below the screen, so that the undersized powder is sucked through the sieve.

Construction : The construction of a Alpine airjet sieve is shown in Figure 7-8. It consists of a metal housing into which the sieve mesh is fitted. Sieve cover is placed in such a way that an air-tight seal is obtained. A slit is provided such that its upper edge is in level with the upper edge of the housing. Provision is made to pass airjet below the slit. Suction line is provided below the sieve, which can be controlled with the help of a manometer.

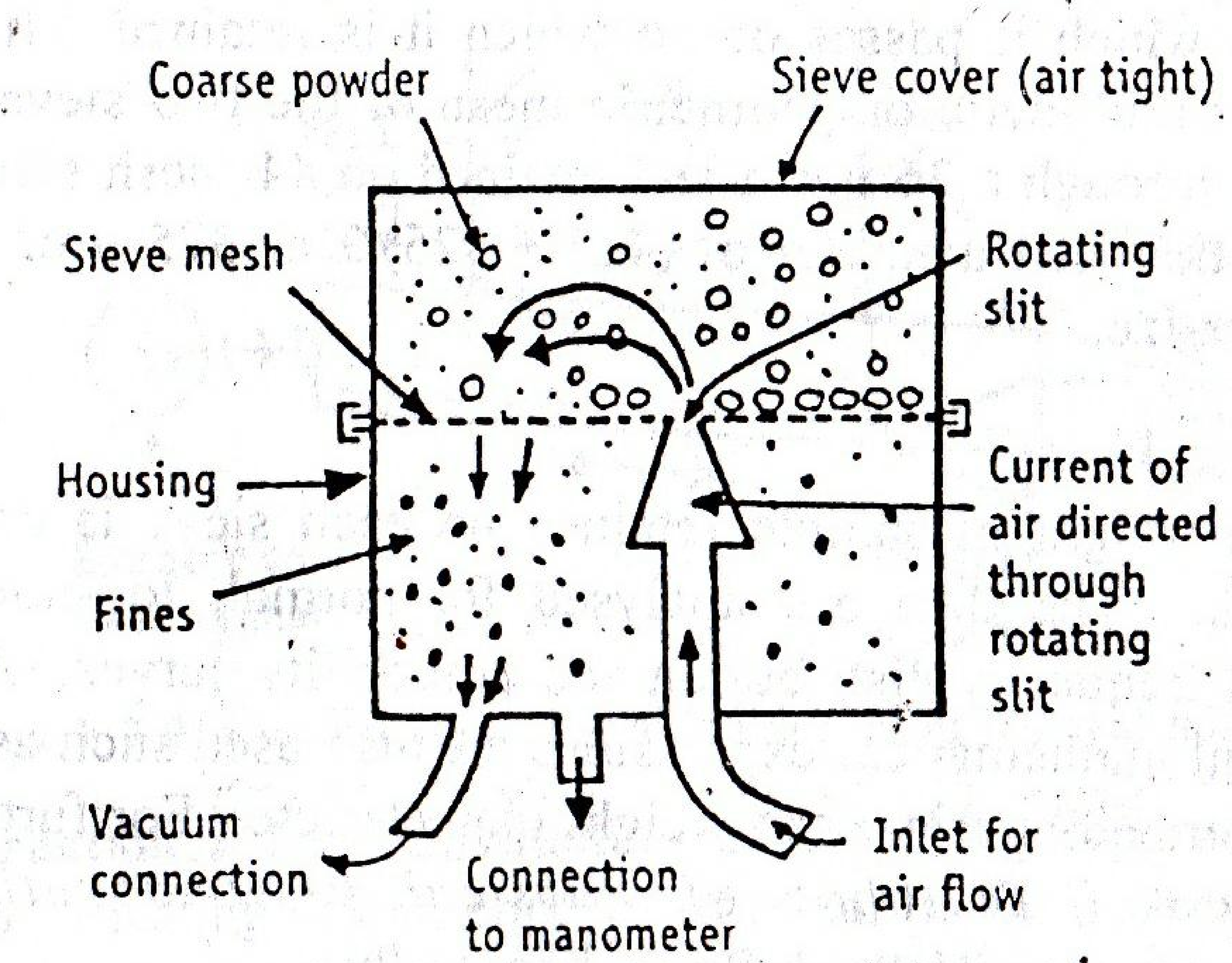


Figure 7-8. Construction of Alpine airjet sieve.

Working : A small amount of powder (about 10 g) is spread on the sieve. The cover is placed in position. The slit is set into rotation by sending a jet of air from below. The powder is fluidised in the upward jet of air. The suction is adjusted until the manometer reads about 27 kPa. The vacuum (in the interior of housing) sucks the undersized powder through the sieve. The material is recovered.

Sieving is continued for two minutes and the residual powder is weighed. This powder is transferred to the next sized mesh with a fine brush. This process is continued until all fractions are collected from the sample, by changing the sieve meshes as well as magnitude of the suction.

Uses : Alpine sieve method is used for the analysis of powder for its size distribution. This method is particularly useful in cases where conventional sieving tends to block the sieves below about 80 µm.

Advantages : (1) In Alpine airjet sieve, fluidisation of powder prevents blocking of the mesh.

(2) It is a rapid method and gives reproducible results.

(3) It is very useful for fine powders.

Disadvantages : (1) The capacity of Alpine airjet sieve is limited. Therefore, it is not useful for large-scale separations.

(2) This method is tedious, because each time only one particle size powder is obtained.

Data Presentation

Frequently a powder is assigned by a mesh number of the screen through which it passes or on which it is retained. It is expressed in terms of arithmetic or geometric mean of the two sieves, i.e., a powder passing through a 36 mesh and retained on 44 mesh sieve is assigned an arithmetic mean diameter of (425 + 325)/2 or 375 µm. This is reported as undersize.

Data Analysis

The weight of sample retained on each sieve is considered for the analysis. The data are analysed for normal, log-normal, cumulative percent frequency distribution and probability curves. Along with these, different mathematical expressions are also used such as average particle diameter, geometric mean weight diameter etc. For further analysis refer the book, "*Textbook of Physical Pharmaceutics*" by C.V.S. Subrahmanyam, Vallabh Prakashan, Delhi.

EQUIPMENT FOR SIZE SEPARATION

A wide variety of equipment have been developed differing in the scale of operation, ruggedness, method of movement of material and

material of construction. The modes of size separation are discussed earlier. Some factors to be considered are:

(a) wear of the sieves.

(b) blinding.

(c) machine noise.

General Classification of Screening Equipment

The screening or sieving machines may be divided into different classes.

(1) *Grizzles* : For coarse materials above 50 mm — large lumps.

(2) *Revolving screens* : Separations above 13 mm — trommels.

(3) *Shaking screens* : Separation from 13 mm down wards to fines.

(4) *Vibrating screens* : Coarse size (13 mm) to fines.

(5) *Oscillating screens* : Fine mesh size.

(6) *Fluidised systems* : For very fine powders.

Some important equipment are described below.

Shaking Screen

Principle : Particles of different sizes are separated by passing them through a sieve, which oscillates to and fro continuously.

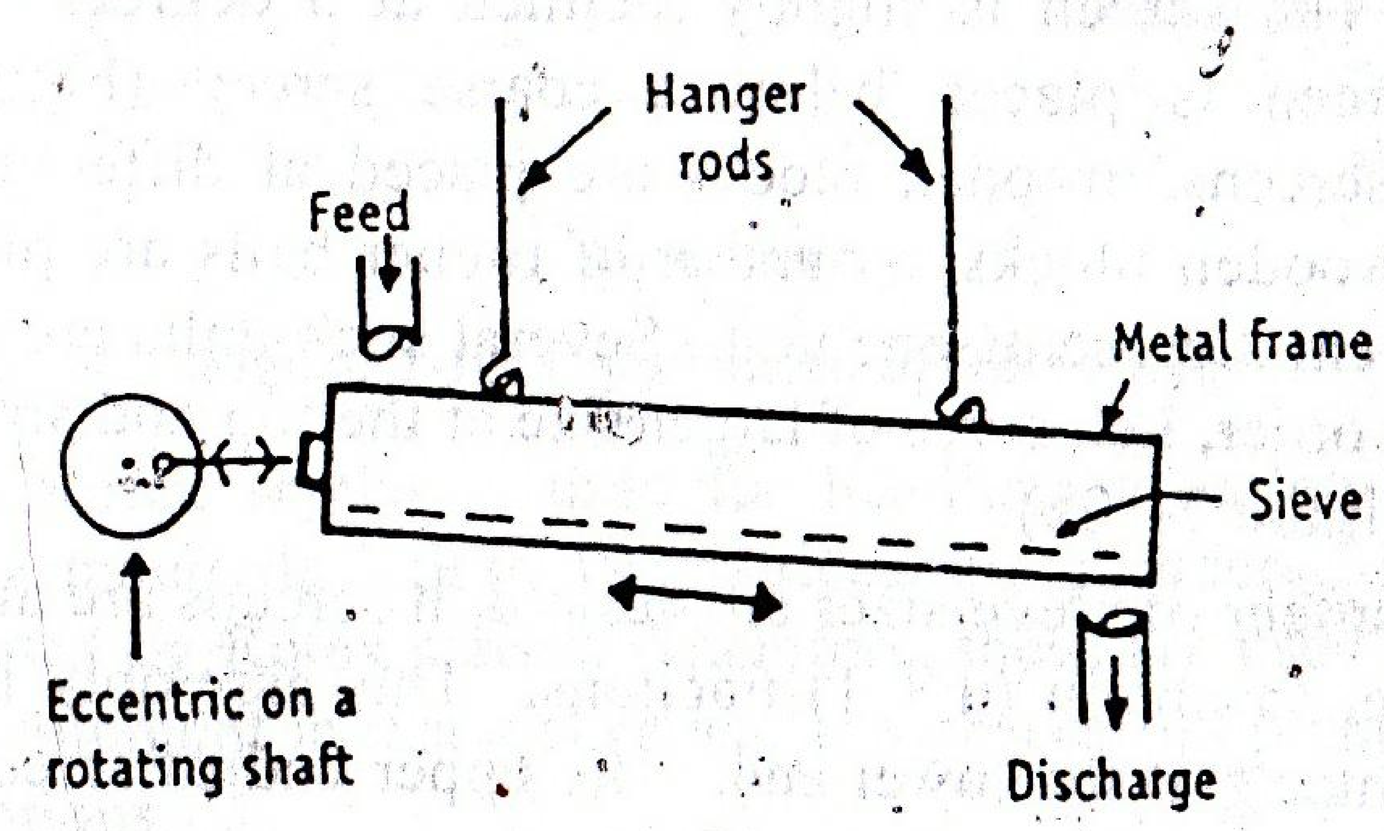


Figure 7-9. Construction of shaking screen in inclined position.

Construction : The construction of a shaking screen is shown in Figure 7-9. Shaking screen consists of metal frame to which a screen is fixed at the bottom. The screen cloth may be riveted directly or fitted using a removable bolted frame. The metal frame can be arranged horizontally or in inclined position. It is suspended by means of hanger rods, so that it can move freely. The side of the metal frame is connected to an ordinary eccentric on a rotating shaft. The entire frame can experience reciprocating motion.

Working : The screen is allowed to shake in a reciprocating motion. The feed (material to be screened) is introduced on to the screen from a side. Therefore, fine particles get screened off initially. The remaining material moves forward during the motion of the frame and gets separated. Thus, the desired size particles can be obtained from the material.

The **advantages** of shaker screen are that it requires low head-room and low power requirement.

The **disadvantages** are that shaker screen requires high cost of maintenance of screens and supporting structures. Its capacity is low.

Variants : The above screen system may be vibrated to keep the particles moving and to prevent blinding. It is used when large capacity and high efficiency is desired.

Rotex Screen

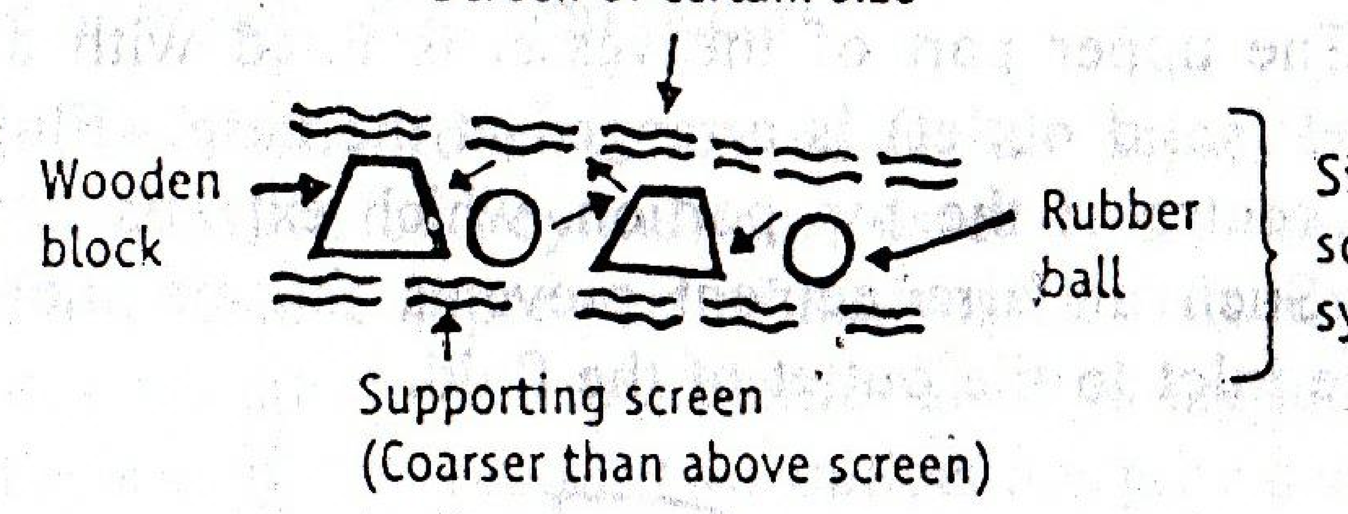
Principle : Rotex screen works on oscillating agitation (back and forth) by means of an eccentric mechanism. Further, vibrations are caused by balls bouncing against the lower surface of the screen cloth. This rapid motion helps the particles to roll on the surface of the screen and separate out.

Construction : The construction of a Rotex screen is shown in Figure 7-10. The screen is slightly inclined at 5 degrees. A coarser supporting screen is placed below a coarse screen (Figure 7-10a). Between the screens, wooden blocks are placed at different intervals. Between the wooden blocks, a number of rubber balls are placed. This two-sieve system represents one unit. Several such units are arranged in the desending order, i.e., sieve of larger size at the top and smaller one at the bottom (Figure 7-10b).

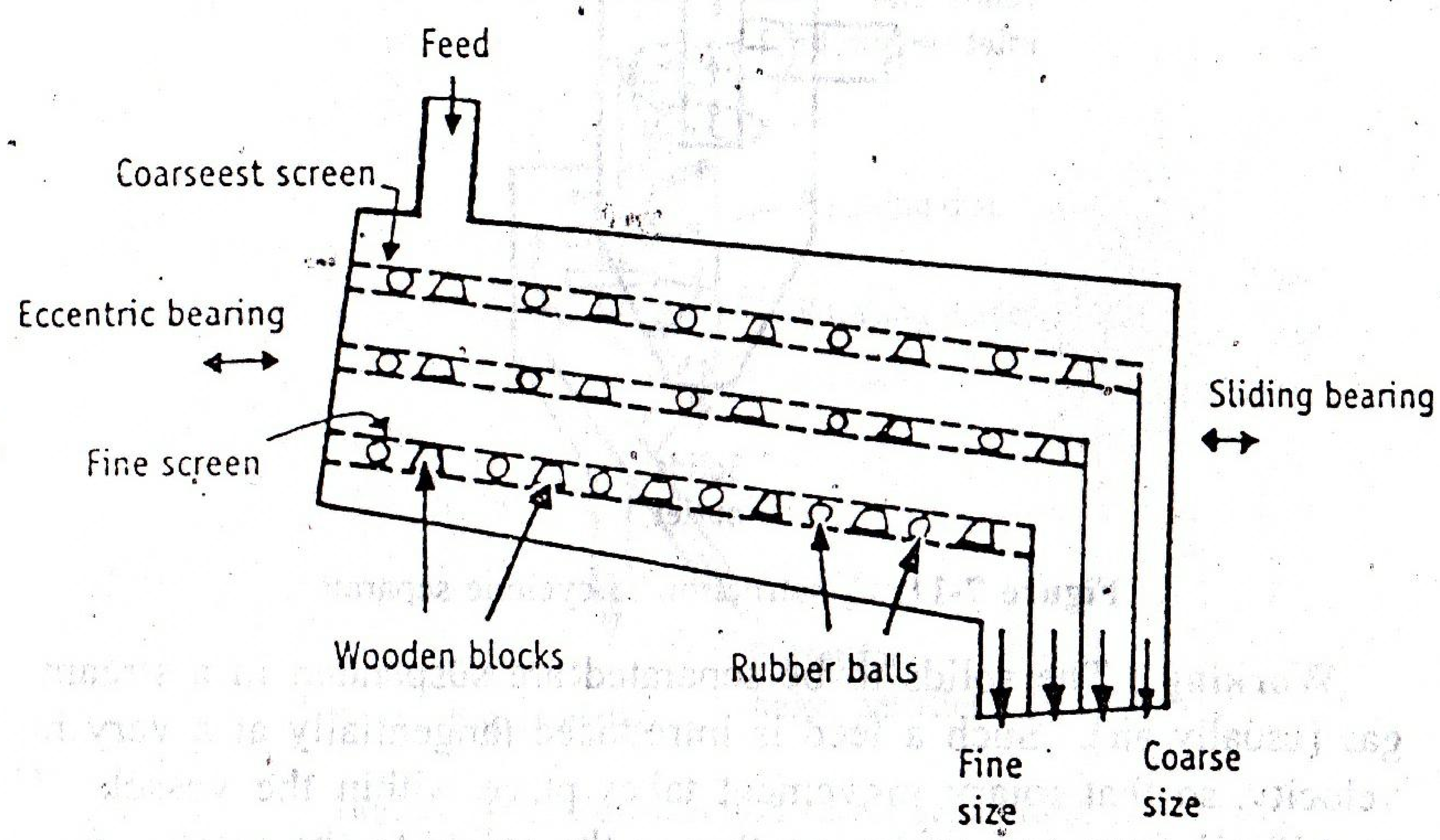
If more number of sieve sizes are desired, n screens are arranged in a similar manner to obtain (n + 1) fractions. This assembly is supported on sliding contacts at the lower end. The upper end of screen system is connected to an eccentric pin on a flywheel.

Working : The screen system is allowed to agitate with the help of eccentric. The shaking motion of the screen causes balls to fly between the screens. As they strike the inclined sides of the wooden blocks, the balls deflect upward and strike the underside of the screening cloth and thus prevent the blocking of the mesh (Figure 7-10a). The feed is introduced at the elevated end of the screen. The material passes through the upper screen and reaches the next screen. This process continues until all the material is separated into fractions. The fractions

are collected separately at the outlet point.



(a) Unit sieve system



(b) Assembly

Figure 7-10. Construction of Rotex screen.

Uses : Rotex screen is used for handling a variety of chemicals usually dry materials. Granular matrices and powdered foods are also size separated by Rotex screen. Therefore, these are used extensively as standard equipment in many chemical and processing plants for handling fine separations.

Cyclone Separator

Principle : In cyclone separator, centrifugal force is used to separate the solids from fluids. The separation process depends not only on the particle size, but also on the density of particles. Depending on the fluid velocity, the cyclone separator can be used to separate all types of particles. It is also possible to allow fine particles to be carried by the fluid.

Construction : The construction of a cyclone separator is shown in Figure 7-11. It consists of a short vertical, cylindrical vessel with a conical base. The upper part of the vessel is fitted with a tangential inlet. The outlet (solid outlet) is arranged at the base. Fluid outlet is provided at the centre of the top portion, which extends inwardly into the separator. Such an arrangement prevents the air short-circuiting directly from the inlet to the outlet of the fluid.

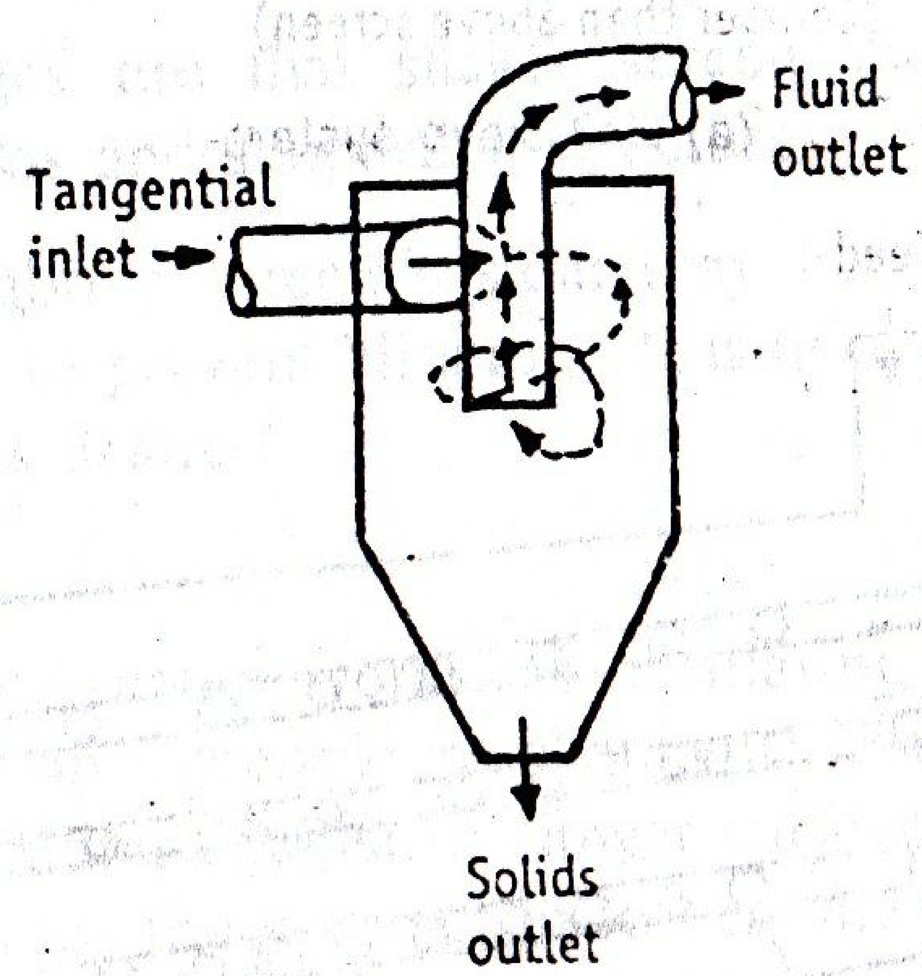


Figure 7-11. Construction of cyclone separator.

Working : The solids to be separated are suspended in a stream of gas (usually air). Such a feed is introduced tangentially at a very high velocity, so that rotary movement takes place within the vessel. The centrifugal force and vortexing throws the solids to the walls. As the speed of air diminishes, the particles fall to the conical base and are discharged through the solid outlet. The fluid (air) can escape from the central outlet at the top.

Uses : (1) Cyclone separator is used to separate the solids from gases.

(2) It is also used for size separation of solids in liquids.

(3) It is used for separating the heavy or coarse fraction from fine dust.

Variants : Cyclone separators are also used for size separation of solids suspended in a liquid such as water. Such separators are known as *wet or liquid cyclone*. One such apparatus used for this purpose is *Dorrclone*.

Air Separator

Principle : In air separator, centrifugal force is used to separate solids. The air environment is obtained by means of rotating disc and blades. To improve the separation, stationary blades are used. By controlling these blades and the speed of the rotation, it is possible to vary the size at which separation occurs.

Construction : The construction of an air separator is shown in Figure 7-12. It consists of a cylindrical vessel with a conical base. The feed inlet is fitted to the upper part of the vessel. The rotating disc and rotating blades are attached to the central shaft to produce air environment. At the base of the vessel, two outlets are provided; one for fine particles and the other for heavy particles.

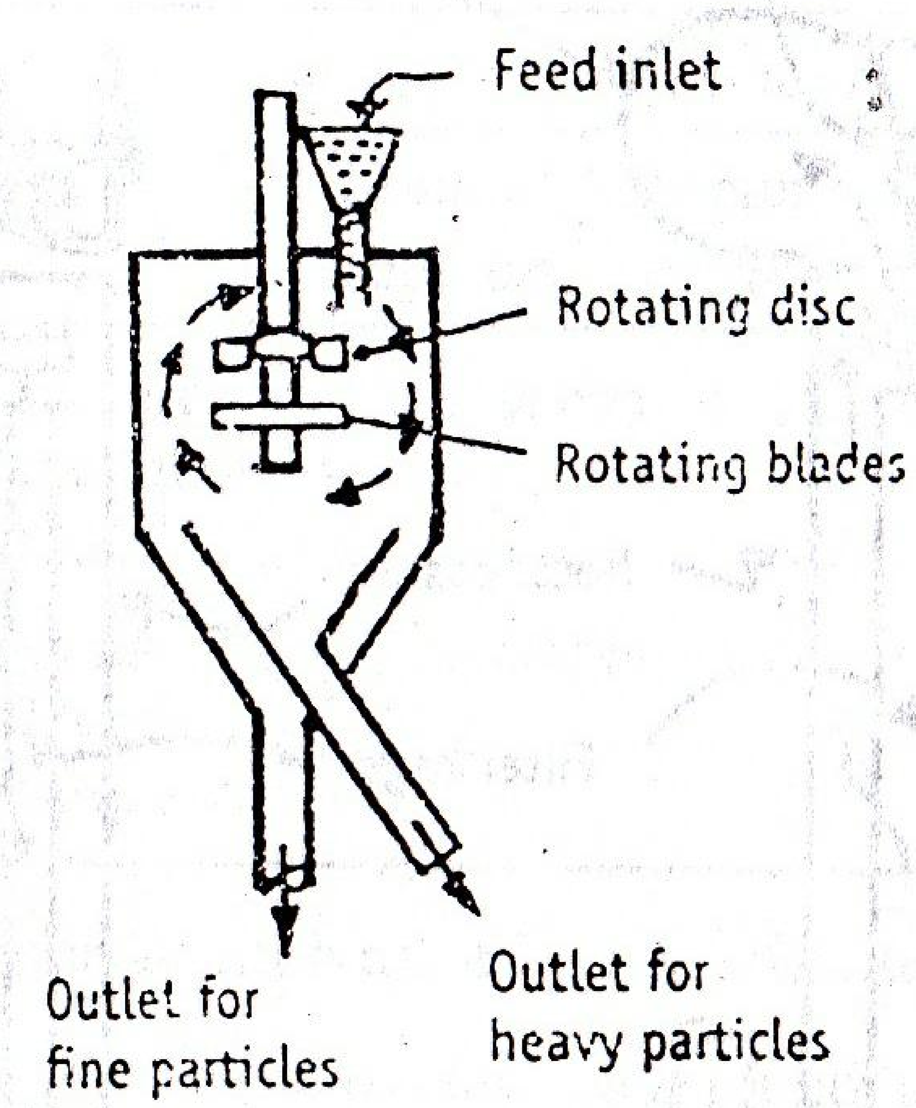


Figure 7-12. Construction of air separator.

Working : The disc and blades are allowed to rotate by means of a motor. These produce a current of air as shown by the arrows. The sample powder is introduced through the feed inlet. The feed falls on the rotating disc. The fine particles are picked up and carried into space, where air velocity is sufficiently reduced. The fine particles are dropped and are ultimately collected at the outlet meant for the fine particles. The heavy particles, which fall downward, are removed at the outlet meant for heavy particles.

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

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 filter (cloth) by applying the 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.

Construction : The construction of a bag filter is shown in Figure 7-13. It consists of a number of bags made of cotton or wool fabric. These are suspended in a sheet metal container.

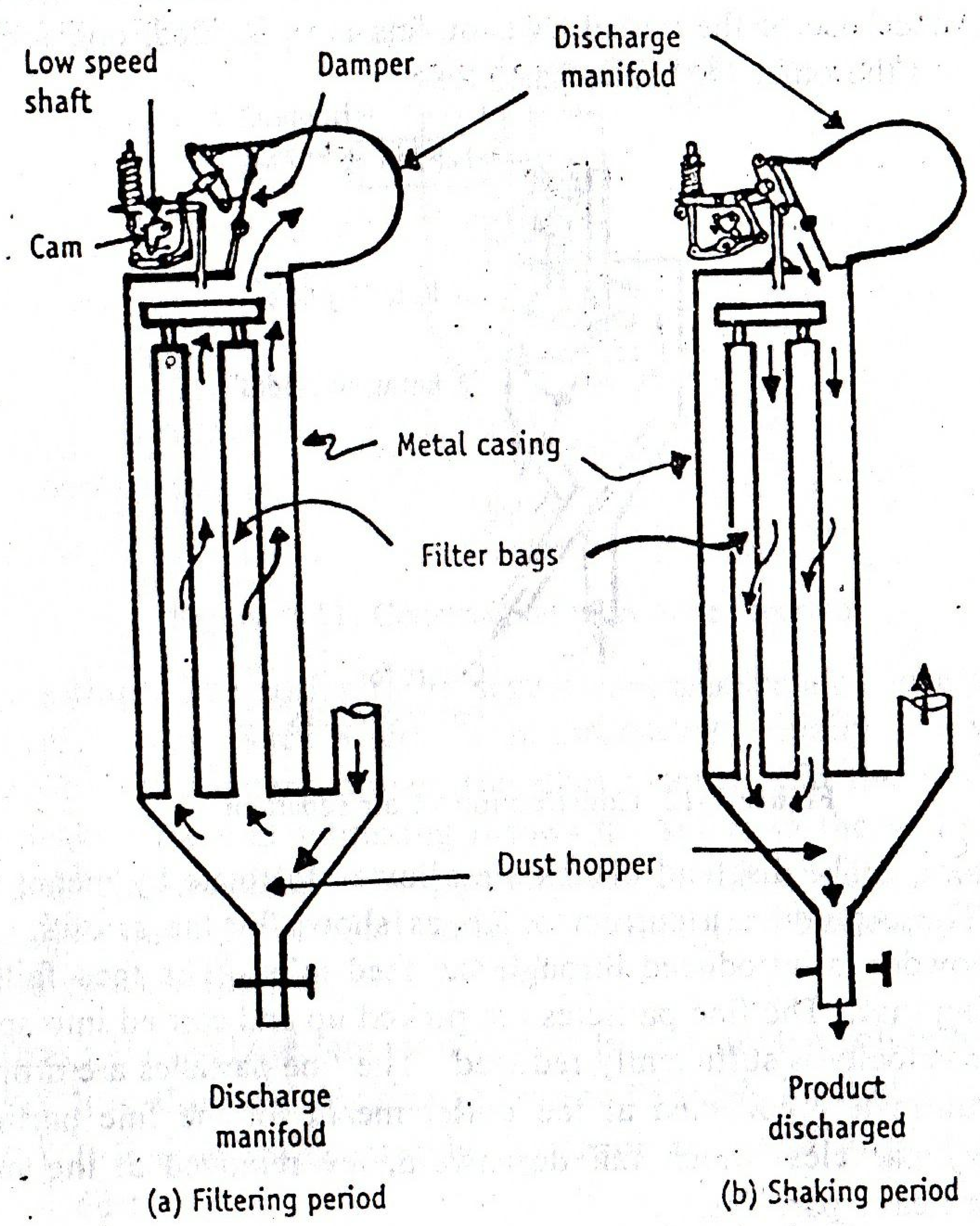


Figure 7-13. Construction of bag filter.

A hopper is arranged at the bottom of the filter to receive the feed. At the top of the metal container, a provision is made for the exhaust. Adjacent to this, a bell crank lever arrangement is made to bring the filters to normal atmospheric conditions.

Working : The working of the bag filter consists of two steps. In the first step, the feed is separated from air by passing it through the cloth

bags. In the subsequent step, the bags are shaken to collect the fines that are adhered to the bags. These two steps follow in succession and are controlled at different intervals with the help of a bell crank lever arrangement.

Bell crank lever arrangement : In this mechanism, a shaft with a cam is allowed to rotate at a low speed. During rotation, the cam can either press the bell crank lever or does not come into contact. Depending on this mechanism, the damper changes its position. The damper is a useful mechanism, which allows the two steps to occur as shown below.

Step	*Mechanism*	*Movement of damper*	
		Contact between bags and suction	*Contact between bags and atmosphere*
Filtering period	Cam does not press the bell crank lever (Figure 7-13a)	opens	closes
Shaking period	Cam presses the bell crank lever (Figure 7-13b)	closes	opens

These changes occur at intervals of a few minutes.

Filtering period : The exhaust fan positioned at the top keeps the bags under less pressure than atmospheric pressure. The gas containing fine particles (or dust) enters the hopper, as shown with arrows in Figure 7-13a, and passes up. The gas feed passes through the fabric of bag. During this process, the fines (or dust) are retained in the bags, while the gas reaches the top of the casing. Because of air, the bag remains taut during filtering operation.

Shaking period : Since vacuum is cut off in the chamber, air from outside enters the casing and passes through the bags. This results in violent shaking of the bags, so that the dust and fine particles are displaced from the bags and falls into the conical base. It is then removed at intervals.

Such devices are entirely automatic in their action and can be designed to affect very large filtering surface per unit floor space.

Uses : Bag filters are used along with other size separation equipment, for example, a cyclone separator. Bag filters are used to remove the fines from cyclone discharge. Bag filter is connected to the discharge end of the fluidized energy mill.

Advantages : (1) Bag filter is extremely useful for removing fines, which cannot be separated by other methods.

(2) These can be used even to remove dust. The ordinary household vacuum cleaner is a simple bag filter.

Disadvantage : Bag filter is not size separation equipment as such.

QUESTION BANK

Each question carries 2 marks

1. Name the standards of screens used in pharmaceutical practice.
2. What are standard sieves?
3. Differentiate ideal and actual screens.
4. List the specifications and standards for sieves.
5. Explain the term blinding of screen. How is it prevented?
6. What are various grades of coarse powders? Define them.
7. Give the classification of fine powders with definitions.
8. What are the advantages of expressing sieves by a sieve number over the nominal size of aperture?
9. Differentiate the terminology, nominal size of aperture and nominal diameter of the wire.
10. What are the uses of screen analysis? How is it expressed?
11. List the methods of sieve analysis used for testing the powders. Give their relative advantages.

Each question carries 5 marks

1. Explain the working of a cyclone separator and its usefulness.
2. Describe the method of size separation using a Rotex shaker screen.
3. Explain various grades of powders official in pharmacopœia.
4. Give details about the various standards fixed by the pharmacopœia for sieves.
5. Describe the specifications of standard sieves as per IP.

Each question carries 10 marks

1. Describe one industrial method for size separation of a powder and its applications.

8

Mixing

Section I—MIXING OF SOLIDS

Interparticle Interactions-Segregation
Mechanism of Mixing in Solids
Mixing Process-Steps
Degree of Mixing and Statistical Evaluation
Factors Influencing Mixing
Classification of Equipment for Solids Mixing
Equipment

Mixing is defined as a process that tends to result in a randomization of dissimilar particles within a system.

The term *mix* means to put together in one mass or assemblage with more or less thorough diffusion of the constituent elements among one another. The term *blending* means to mix smoothly and inseparably together. During blending a minimum energy is imparted to the bed. These terms are commonly used interchangeably in the industry.

Some of the mixing operations in the dispensing practice are spatulation, trituration, tumbling, geometric dilution etc. However, industrial pharmaceutical mixing involves large-scale equipment. A major complication in the intimate mixing of particles is the segregation of particulate solids that results from gravitational effect on the agitated bed. Mixing can also be achieved by milling, kneading etc.

The diverse characteristics of particles, such as size, shape, volume, surface area, density, porosity, flow and charge, contribute to the solid mixing. It is difficult to predict the inter-particle interactions. Therefore, some empirical correlations are possible. In practice, optimum mixing is considered satisfactory.

Depending on their flow properties, solids are divided into two classes; cohesive and noncohesive. *Noncohesive materials* such as grain, dry sand and plastic chips readily flow out of a bin or silo.