

# Size Separation

Large pieces of material are usually estimated visually, difficulties arising only in the estimation of powders. *size separation is a unit operation that involves the separation of mixture of various size of particles into two or more portion by means of screening surface. also known as sieving, sifting, classifying or screening.*

## Standards for Powders

Standards for powders for pharmaceutical purposes are laid down principally in the **Indian Pharmacopoeia** which states, that the degree of coarseness or fineness of a powder is differentiated and expressed by the size of the mesh of the sieve through which the powder is able to pass.

# Size Separation

The IP specifies five grades of powder and the number of the sieve through which all the particles must pass.

<i>Grade of powder</i>	<i>Sieve through which all particles must pass</i>
Coarse	10
Moderately coarse	22
Moderately fine	44
Fine	85
Very fine	120

The IP specifies a second, smaller size of sieve for the coarser powders but states the not more than 40 per cent shall pass through.

The relevant grades of powder and sieve number are shown in the table:

<b>Grade of powder</b>	<b>Sieve through which all particles must pass</b>	<b>Sieve through which not more than 40 per cent of particles pass</b>
<b>Coarse</b>	<b>10</b>	<b>44</b>
<b>Moderately coarse</b>	<b>22</b>	<b>60</b>
<b>Moderately fine</b>	<b>44</b>	<b>85</b>
<b>Fine</b>	<b>85</b>	<b>Not specified</b>
<b>Very fine</b>	<b>120</b>	<b>Not specified</b>

**Thus, the full definition of Coarse Powder is that :**  
*It is powder all the particles of which pass through a No. 10 sieve and not more than 40 percent through a No. 44 sieve, this is usually referred to as a 10/44 powder.*

**Other grades are expressed in a similar way.**

- The **Indian *Pharmacopoeia*** makes two statements with regard to these `official' grades of powders in practice:
  1. It is required that, when a powder is described by a number, *all* particles must pass through the specified sieve.
  2. When a vegetable drug is being ground and sifted, *none* must be rejected.
- The reason for this will be apparent if the character of a vegetable drug is compared with a chemical substance. The latter is a homogeneous material so that, if a certain quantity, of a powder is required, an excess may be ground, a sufficient amount of the desired size range obtained by sieving, and the oversize particles (known as *tailings*) may be discarded.

**A vegetable drug**, however, consists of a variety of tissues of different degrees of hardness, so that softer tissues will be ground first and tailings obtained by sifting will contain a higher proportion of the harder tissues. In many cases, constituents are not distributed uniformly through vegetable tissues;

for example, in **digitalis** the glycosides are concentrated in the mid-rib and veins. Hence, if tailings are discarded when grinding and sifting the drug, it is likely that a high proportion of the active constituents will be lost.

In addition to the grades of powder specified by the *British Pharmacopoeia*, the *British Pharmaceutical Codex* details a further grade known as *Ultra-fine Powder*.

In this case, it is required that the maximum dimension of at least 90 percent of the particles must be not greater than  $5\mu\text{m}$  and none must be greater than  $50\mu\text{m}$ .

Determination of particle size for this grade is carried out by a microscopic method.



# **SIEVES**

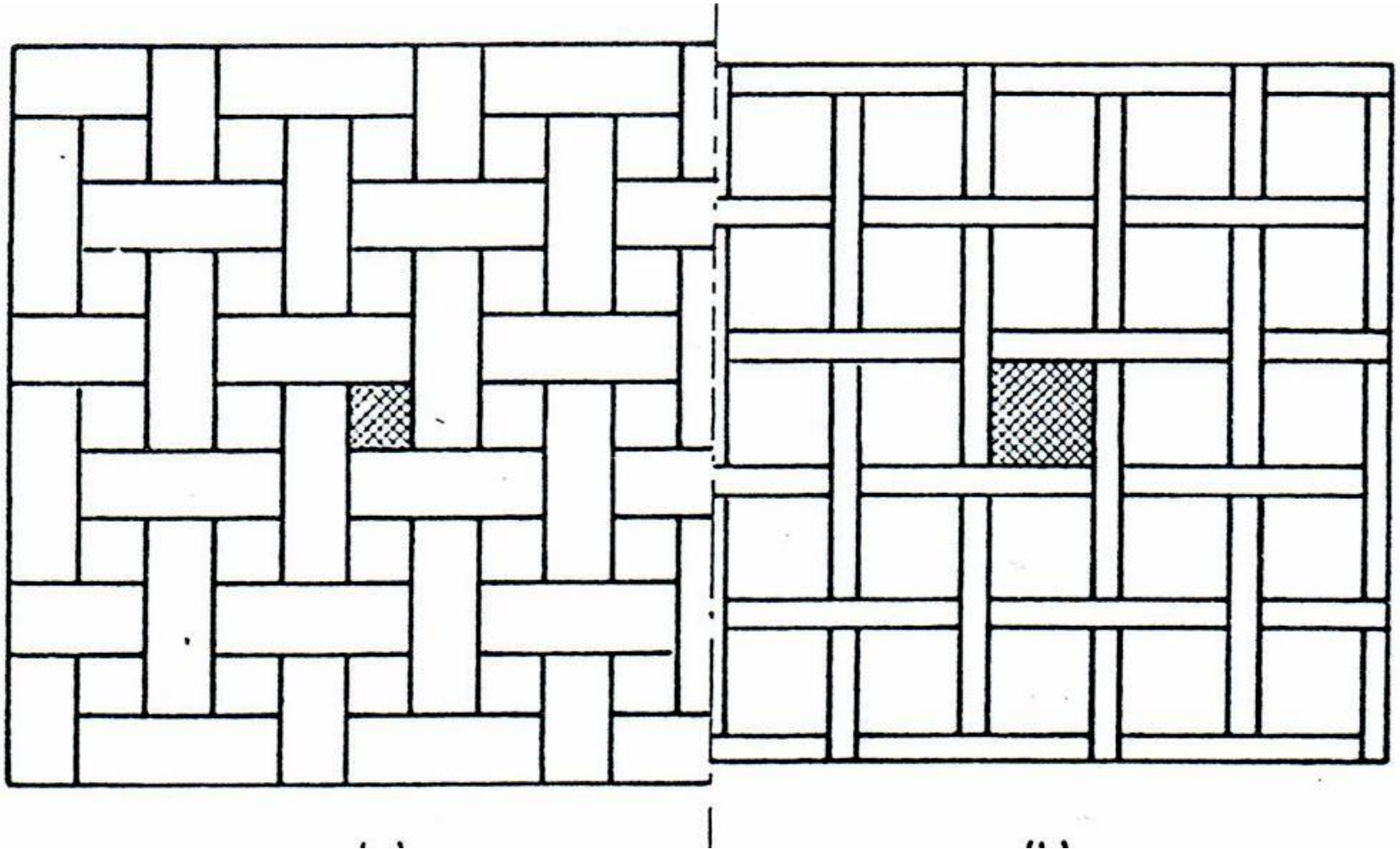
- **Sieves for test purposes are the subject of a British Standard.**
- **Most of the sieves used are of the wire mesh type, the number of the sieve indicating the number of meshes included in a length of 25.4 mm (1 inch) in each direction parallel to the wires.**

- It should be noted that it is the number of *meshes* that is specified and **not** the number of *wires*.

Thus, a No. 10 sieve has 10 meshes per inch in each direction, but it will be realized that if there were 10 wires there would be 9 meshes only.



- The simple statement of the number of meshes per unit length is not sufficient, however, as the size of the particle that will pass the sieve will depend on other factors, principally the diameter of the wire



**Effect of wire diameter on sieve mesh size.**

# **STANDARDS FOR SIEVES**

## **according to B.P.**

- **It is required that wire-mesh sieves shall be made from wire of uniform, circular cross-section and for each sieve the following particulars are stated:**

### **Sieve number**

- **This is the number of meshes in a length of 25.4 mm (1 in.), in each direction, parallel to the wires.**

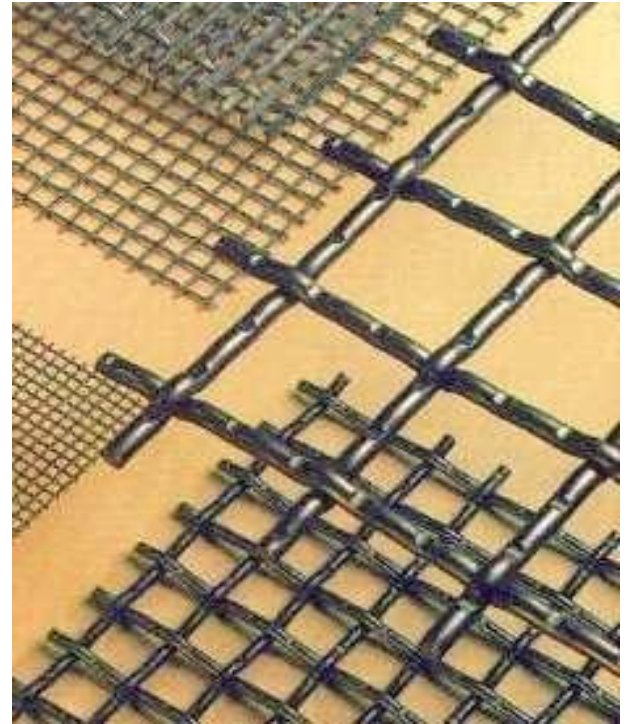


# Nominal aperture size

- This is the distance between the wires, so that it represents the length of the side of the square aperture.

## *Nominal Diameter of the Wire*

- This dimension and the number of meshes form the basic standards for the sieve.
- The wire diameter has been selected to give a suitable aperture size, but also to have sufficient strength to avoid distortion.



## ■ *Approximate Screening Area.*

**This standard expresses the area of the meshes as a percentage of the total area of the sieve.**

**It is governed by the size of wire used for any particular sieve number and is kept within the range 35 to 40 per cent.**



**This gives suitable strength to the sieve, but leaves adequate area of meshes since these are obviously the useful area of the sieve.**

## *Aperture Tolerance Average*

- **Some variation in the aperture size is unavoidable and this variation, expressed as a percentage, is known as the aperture tolerance average.**
- **The term tolerance is used in engineering practice to mean the limits within which a particular quantity or dimension can be allowed to vary and still be acceptable for the purpose for which it is required.**

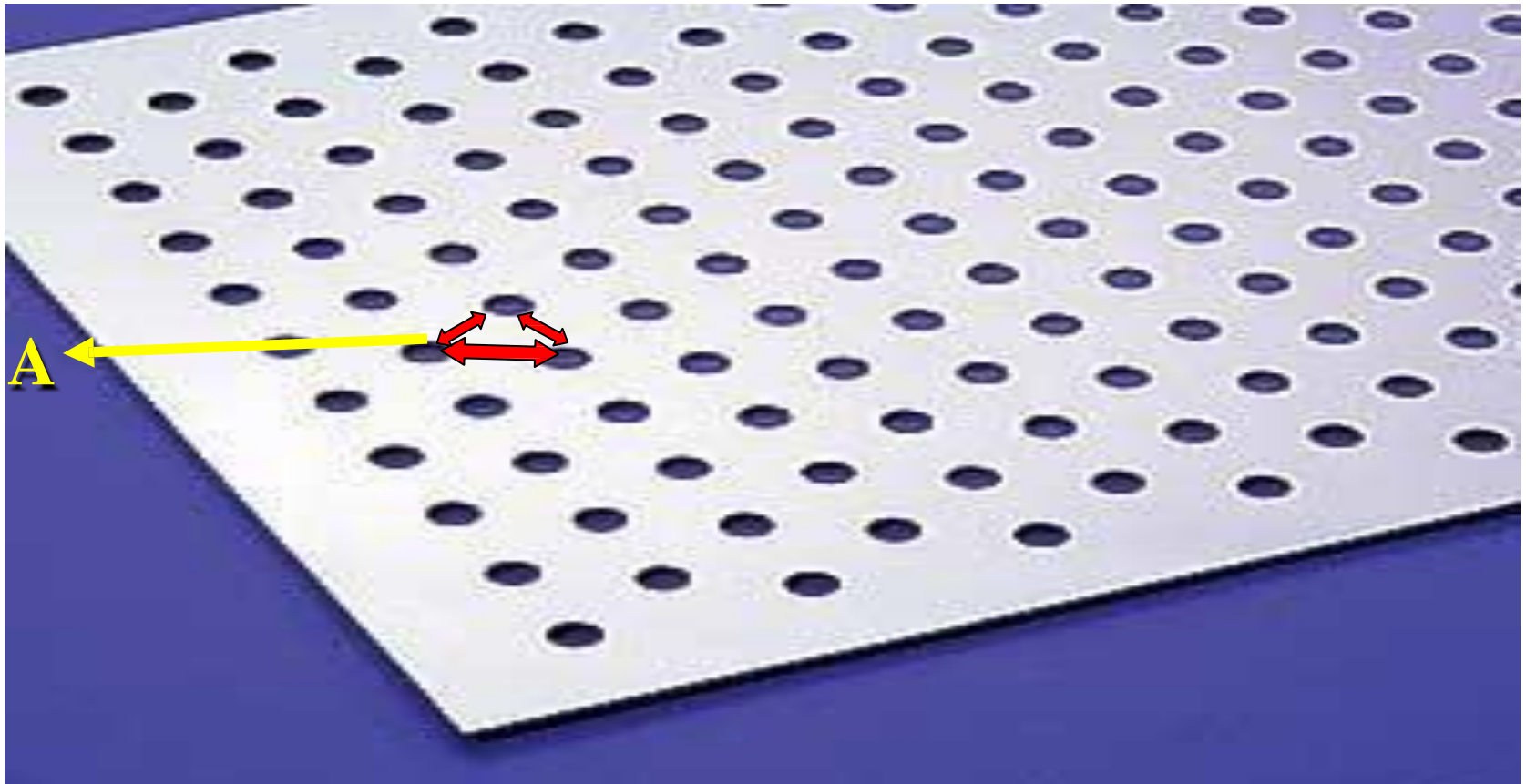
- **Finer wires are likely to be subject to a greater proportional variation in diameter than coarse.**
- **fine meshes cannot be woven with the same accuracy as coarse meshes. Hence, the aperture tolerance average is smaller for sieves of 5 or 10 mesh than is the case for 300 mesh.**



# PERFORATED PLATE SIEVES

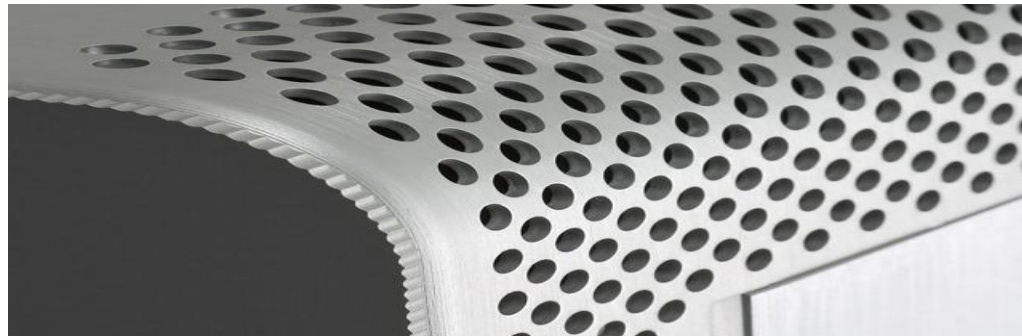
- Sieves may also be made by drilling holes in metal plate, so that this type will have *circular* apertures as against the *square* apertures of the wire mesh sieve.
- In general, these sieves are used in the larger sizes and can be made with greater accuracy than wire-mesh sieves, as well as being less susceptible to distortion in use. This type is commonly used also as screens in impact mills.

**Usually, the holes are spaced with their centers arranged at the apices of equilateral triangles, so that all the apertures are equidistant**



**Perforated plate sieve.**

- **Similar standards are laid down with the appropriate equivalent specifications for *plate thickness* and *nominal width of the bridge* (dimension *A* in the Figure) which control the strength of the sieve in the same way as wire diameter in wire mesh sieves.**

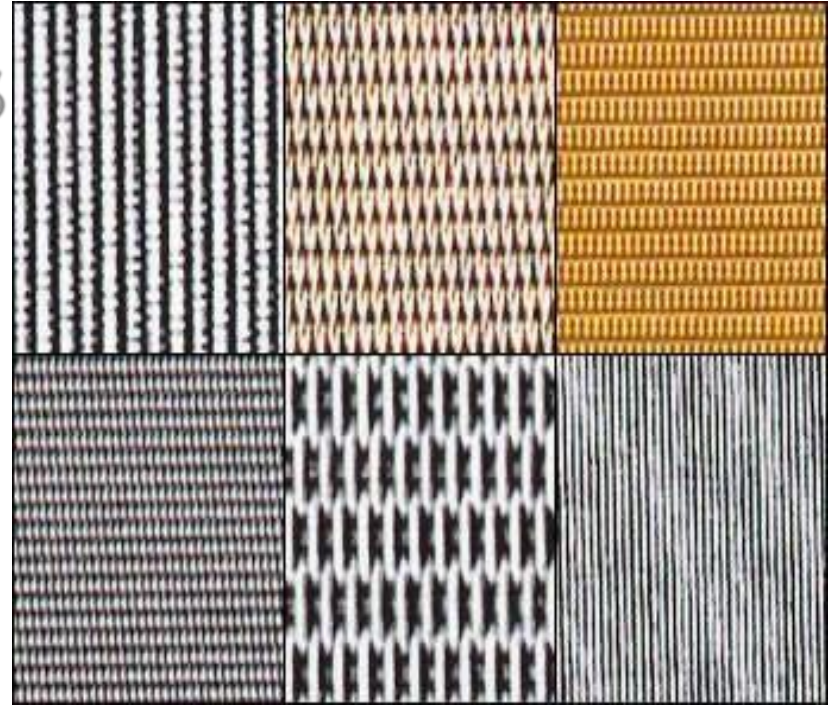


# **MATERIALS USED FOR SIEVES**

**1) The wire should be of uniform, circular cross-section.**

**2) The material should have suitable strength to avoid distortion**

**3) Be resistant to corrosion by any substances that may be sifted.**



# METALS

## ☐ *Iron wire*

### *Advantage*

**cheap,**

### *Disadvantage*

- **Rusting**
- **Iron contamination of products**

# METALS

☐ ***Coated Iron*** (coating with galvanizing or tinning).

## ***Advantage***

- **Increases the protection against corrosion**
- **Increases the strength**

## ***Disadvantage***

**Coating after manufacture lead to some variation in the mesh size.**

# METALS

## ☐ *Copper*

### *Advantage*

**Avoiding the risk of iron contamination**

### *Disadvantage*

**As a soft metal, meshes can be distorted easily.**

# METALS

## □ *Copper Alloys* (brass and phosphor-bronze)

### *Advantages*

- Resemble copper in possessing good resistance to corrosion
- Their strength is greater so that less risk of the meshes distortion.



# METALS

## □ *Stainless Steel*

### Advantages

- **Good resistance to corrosion**
- **Adequate strength**
- **The most suitable for pharmaceutical purposes.**

### Disadvantages

**Expensive**

# NON-METALS



□ **Used when all risk**

**of metallic contamination be avoided.**

□ **Used for sieves with fine meshes, since non-metal fibers are stronger than a metal wire of similar thickness.**

# NON-METALS

- Materials of natural origin (**hair** and **silk**), are used but synthetic fibers (**nylon** and **terylene**) are more suitable

## *Advantages of synthetic fibers*

- Have more strength and resistance to corrosion.
- can be extruded in all diameters, so enabling a wide variety of sieves to be made.



# **SIEVING METHODS**

- ❖ Sieves should be used and stored with care, since a sieve is of little value if the meshes become damaged or distorted.**
- ❖ With the exception of the use of sieves for granulation, material should never be forced through a sieve.**
- ❖ Particles, if small enough, will pass through a sieve easily if it is shaken, tapped, or brushed.**

# I. MECHANICAL SIEVING METHODS

## Principle:

**Based on methods as:**

***Agitation***

***Brush the sieve***

***Use centrifugal force***

# 1. *Agitation Methods*

**Sieves may be agitated in a number of different ways:**

- ***Oscillation*** (move back and forth)

**The sieve is mounted in a frame that oscillating.**

## **Advantages**

**Simple method**

## **Disadvantages**

**The material may roll on the surface of the sieve, and fibrous materials tend to “*ball*”.**



## ■ **Vibration**

**The mesh is vibrated at high speed, often by an electrical device.**

## **Advantages**

**The rapid vibration is imparted to the particles on the sieve and the particles are less likely to “blind” the mesh.**



## ***2. Brushing Methods***

- **A brush can be used to move the particles on the surface of the sieve and to keep the meshes clear.**
- **A single brush across the diameter of an ordinary circular sieve, rotating about the mid-point, is effective;**
- **In large-scale production a horizontal cylindrical sieve is employed, with a spiral brush rotating on the longitudinal axis of the sieve.**



# **3. *Centrifugal Methods***

- **Use a vertical cylindrical sieve with a high speed rotor inside the cylinder, so that particles are thrown outwards by centrifugal force.**
- **The current of air created by the movement helps sieving.**
- **Especially is useful with very fine powders.**

## **II. WET SIEVING METHODS**

- **Industrial methods of particle size separation based on sedimentation or on elutriation.**
- **Wet sieving is more efficient than the dry process, because particles are suspended readily and passing easily through the sieve with less blinding of the meshes.**

# SEDIMENTATION METHODS

## *1. Sedimentation Tank*

**A suspension of the solids in a fluid, most commonly water, is placed in a tank and allowed to stand for a suitable time.**

**The upper layer is then removed, giving a single separation, or the suspension may be collected as a number of fractions by arranging for the pump inlet to remain just below the surface.**

**The suspension pumped out will then contain successively coarser particles.**

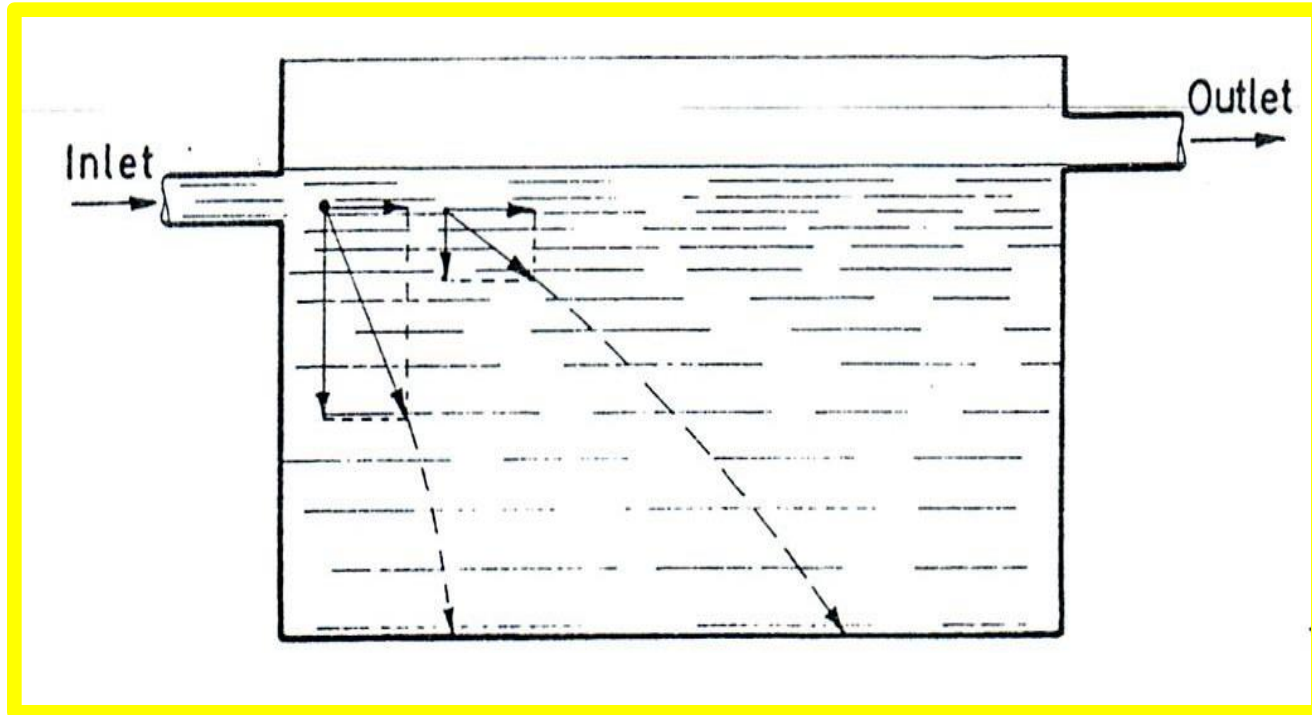
## *Advantages*

**Simple process**

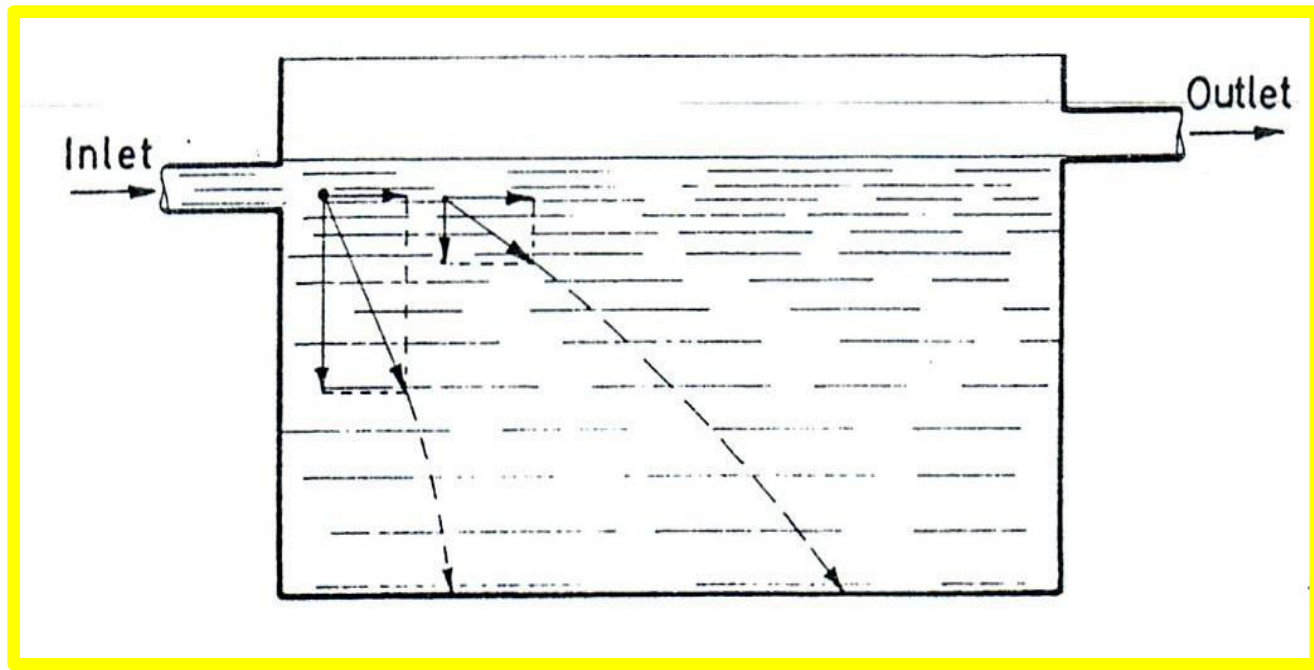
## *Disadvantages*

- **A batch process only**
- **It does not give a clean split of particle sizes because some small particles will be near the bottom of the tank at the beginning of the process and so will be removed with the coarse particles.**

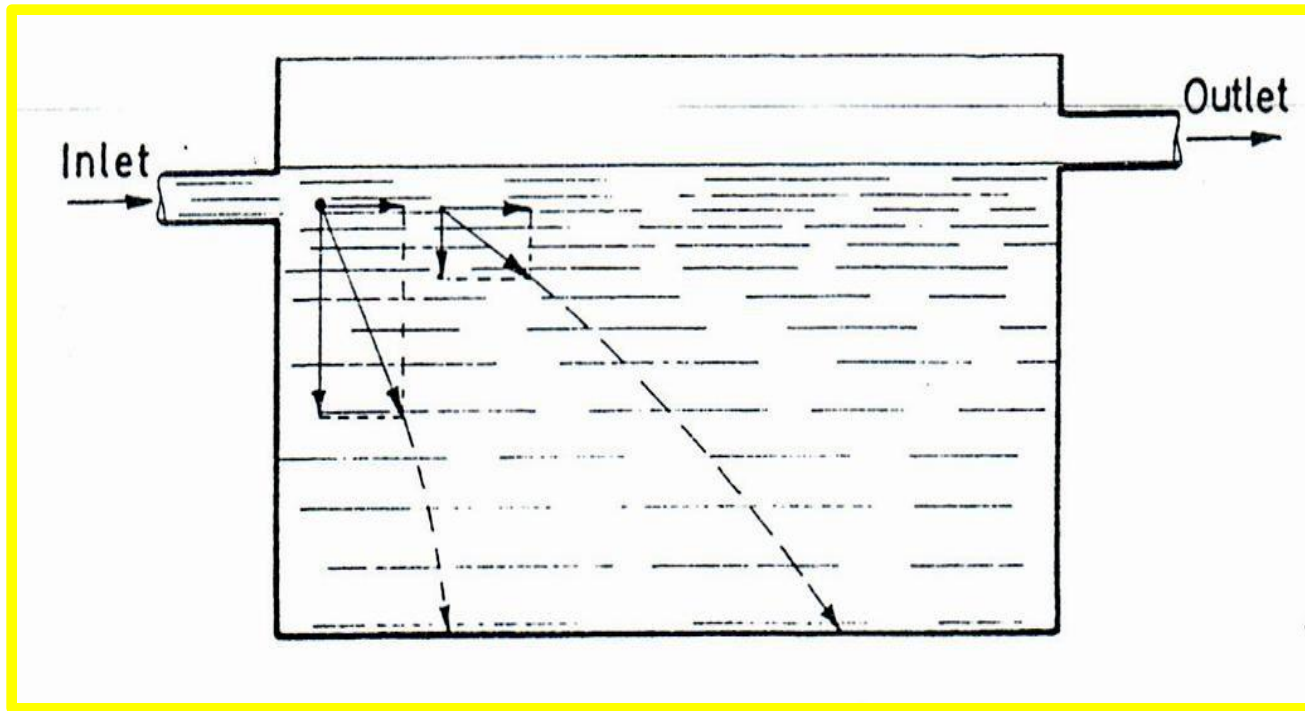
## ***2. Continuous Sedimentation Tank***



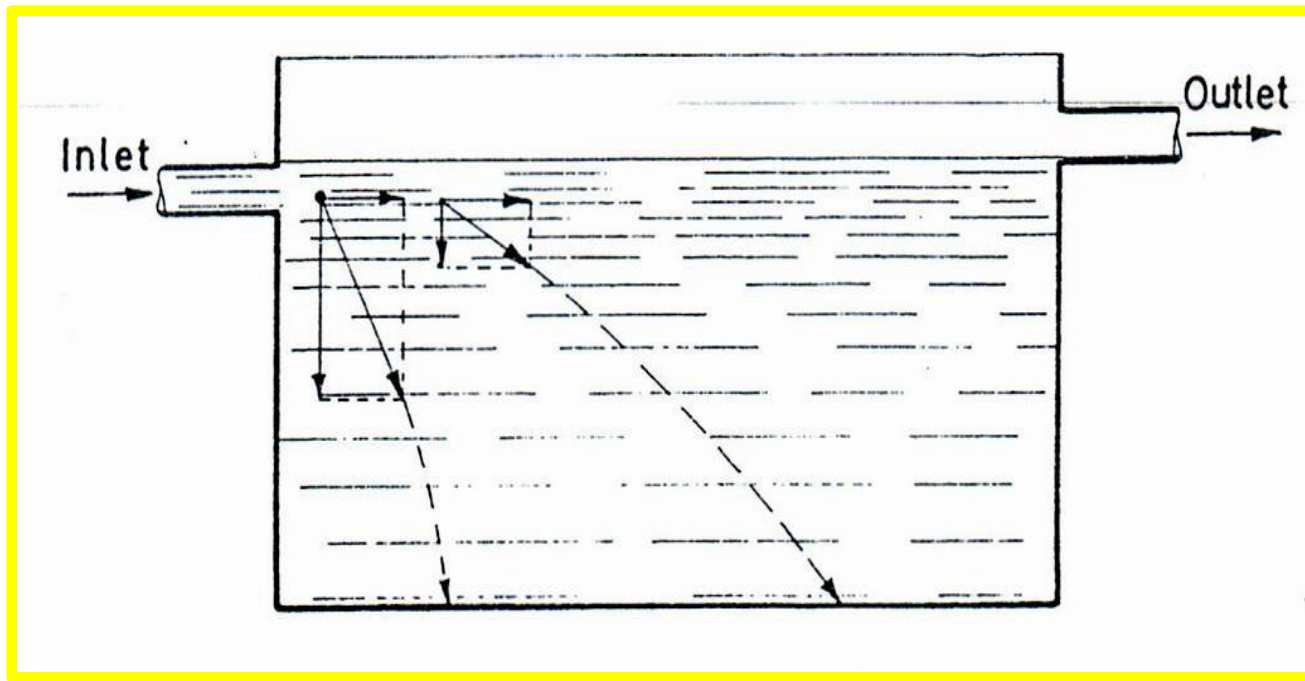
**Continuous sedimentation tank**



- **Particles entering the tank will be acted upon by a force that can be divided into two components:**
  - **Horizontal component** due to the flow of the fluid that carries the particle forward
  - **Vertical component** due to gravity, which causes the particle to fall towards the bottom of the tank.



- **The latter will depend on Stokes' law, so that the velocity of fall is proportional to the diameter. Thus, particles will settle to the floor of the tank at a point that depends on particle size, the coarsest particles being nearest to the inlet and the finest nearest to the outlet.**



- **In some tanks, partitions are arranged on the floor, enabling particular size fractions to be collected continuously. In other tanks, the flow is arranged so that only coarse particles will settle out, fine particles being carried through to the overflow and collected elsewhere by sedimentation or filtration.**

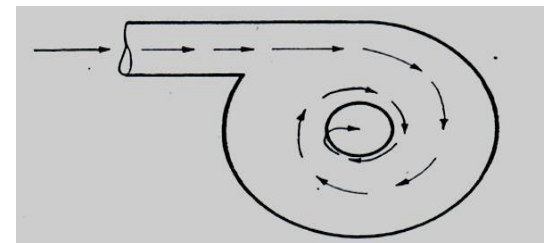
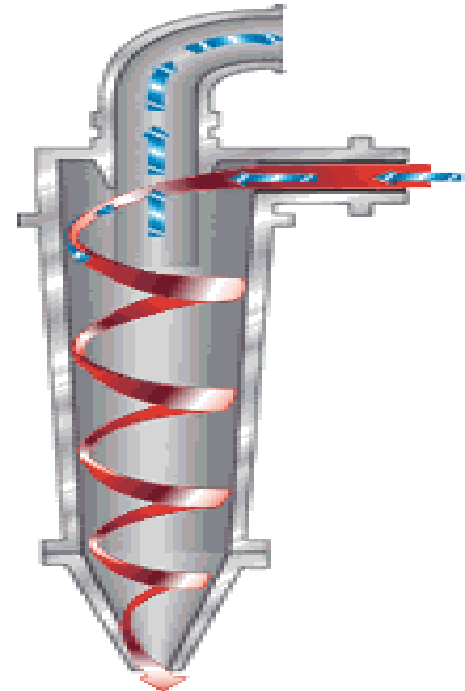


# *Advantages*

- **Simple**
- **Inexpensive**
- **Continuous in operation**
- **Gives a clean separation of particles into many size fractions as required.**

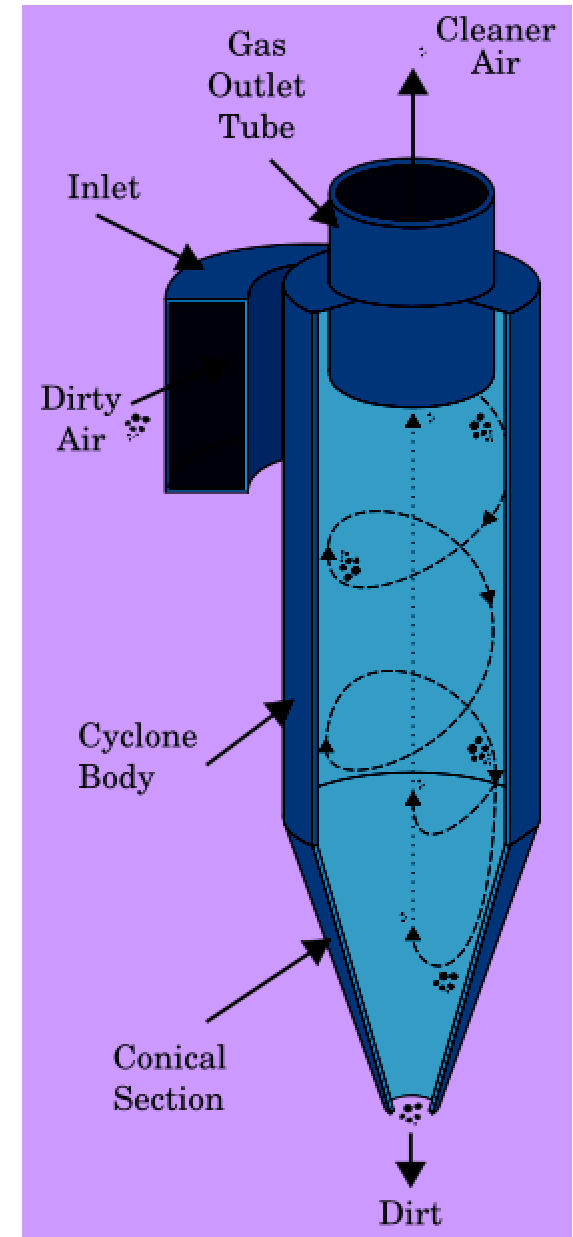
# 3. Cyclone Separator

- The cyclone separator consists of a cylindrical vessel with a conical base
- The rotatory flow within the cyclone causes the particles to be acted on by centrifugal force, solids being thrown out to the walls, then falling to the conical base and out through the solids discharge.



Cyclone separator

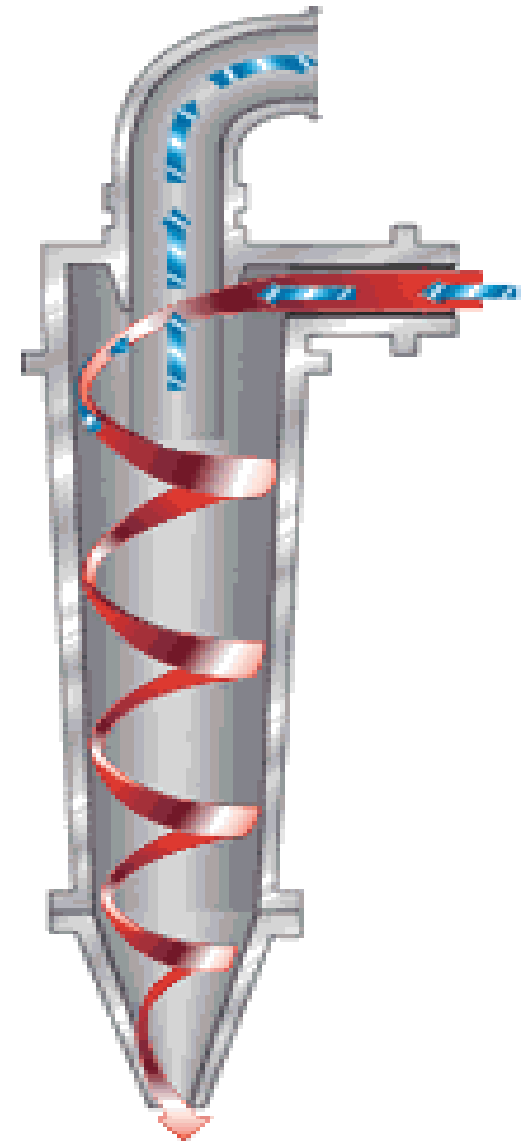
- **The suspension is introduced tangentially at fairly high velocity, so that a rotary movement takes place within the vessel, and the fluid is removed from a central outlet at the top.**



- **The separator is still a form of sedimentation, but with centrifugal force used instead of the gravitational force.**

**Hence, depending on the fluid velocity, the cyclone can be used to separate all particles or to remove only coarser particles and allow fine particles to be carried through with the fluid.**

- **Cyclones can be used with liquid suspensions of solids, but the most common application is with suspensions of a solid in a gas, usually air.**



## *4. Mechanical Air Classifier*

- **Mechanical air separation methods use similar principles to the cyclone separator, but the air movement is obtained by means of a rotating disc and vanes, and separation is improved by the use of stationary vanes.**



- **By controlling these vanes and the speed of rotation, it is possible to vary the size at which separation occurs.**
- **The method is used in conjunction with mills to separate and return oversize particles for further size reduction.**



# ELUTRIATION METHODS

- Elutriation depends on the movement of a fluid against the direction of sedimentation of the particles.
- For the gravitational system, the apparatus consists simply of a vertical column with an inlet near the bottom for the suspension, an outlet at the base for coarse particles, and an overflow near the top for fluid and fine particles.

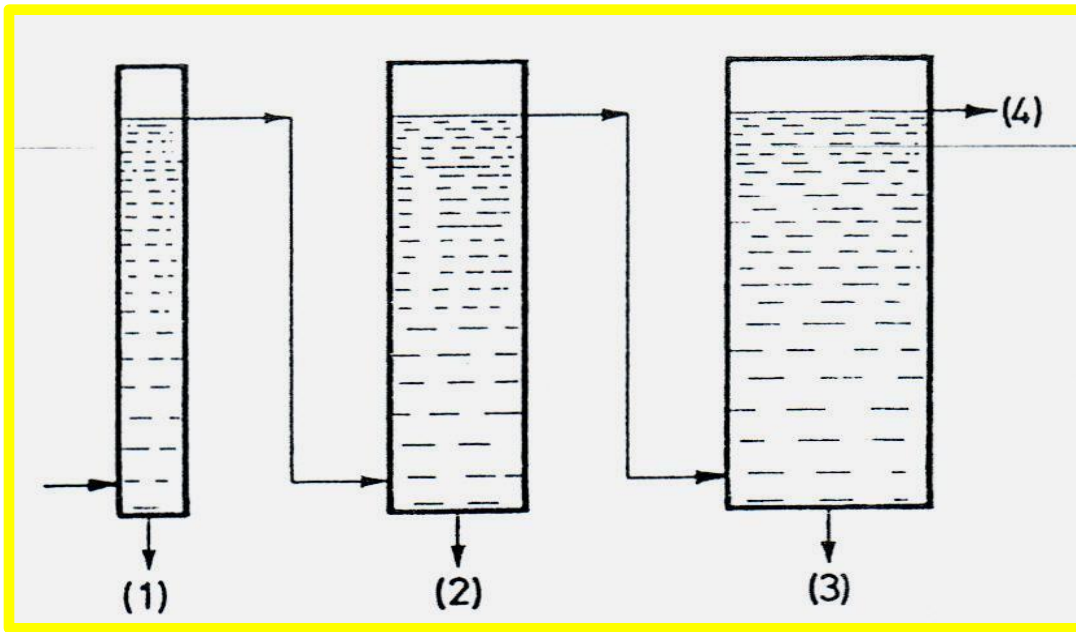


**One column will give a single separation into two fractions, but it must be remembered that this will not give a clean cut, since there is a velocity gradient across the tube, resulting in the separation of particles of different sizes according to the distance from the wall.**



**Elutriation**





**Multi-stage elutriator  
(1) to (4) are fractions of  
decreasing particle size**

- **If more than one fraction is required, a number of tubes of increasing area of cross-section can be connected in series. With the same overall flow-rate, the velocity will decrease in succeeding tubes as the area of cross-section increases, giving a number of fractions.**

## ■ **Advantages**

**A. The process is continuous.**


**B. The separation is quicker than with sedimentation**


## ■ **Disadvantages**

**The suspension has to be dilute; which may sometimes be undesirable.**

# **APPLICATIONS OF SEDIMENTATION AND ELUTRIATION**

**Both methods are used for similar purposes, usually following a size reduction process, with the object of separating oversize particles, which may be returned for further grinding, used for other purposes, or discarded according to the circumstances.**

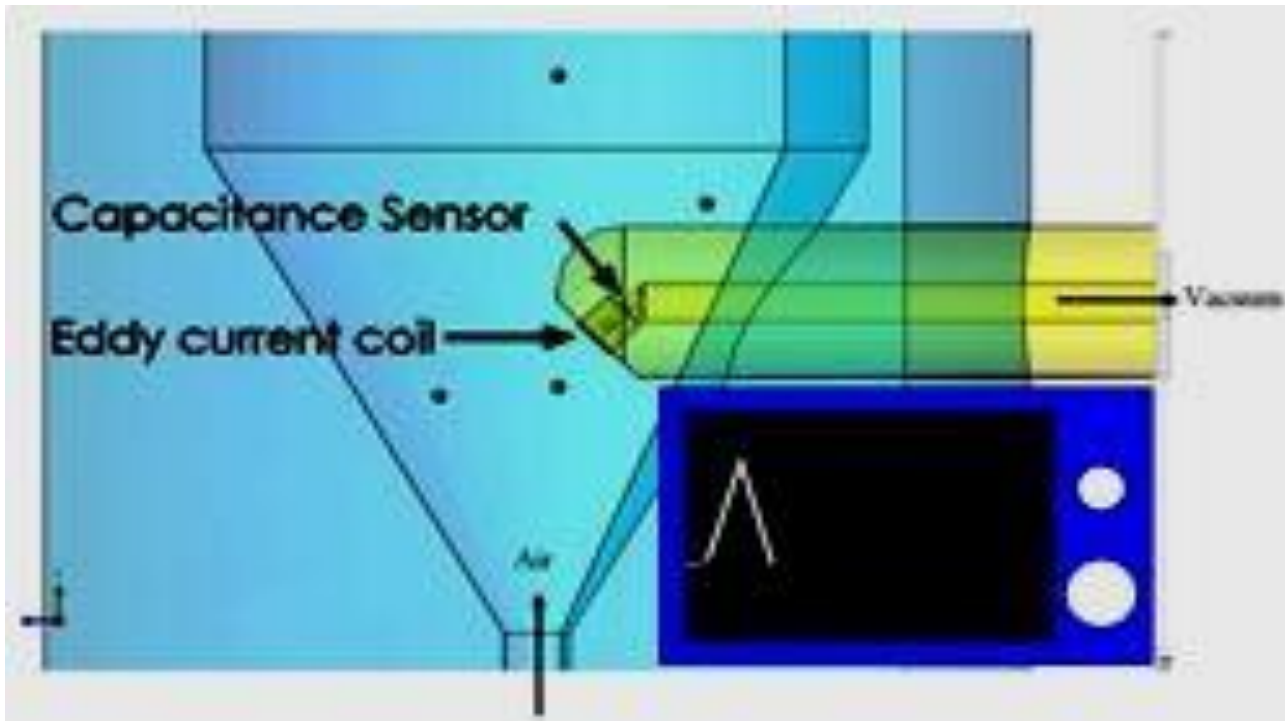
 **With liquids;** the techniques are applicable to insoluble solids, such as kaolin or chalk, which are often subjected to wet grinding followed by sedimentation or elutriation with water.

 **With gases,** the methods are applicable to finer solids that would separate too slowly in liquids, to water-soluble substances, or where dry processing is required.

Thus, a cyclone or mechanical air separator is often incorporated in circuit with a ball mill or hammer mill to separate and return oversize particles.



**Suspended TRISO fuel particles in the  
hopper for separation and individual  
transport**



**Cross-section diagram of hopper showing placement of pneumatic transfer line and selected sensors for particular TRISO fuel application**

Thanking  
you

