Particle Size Separation

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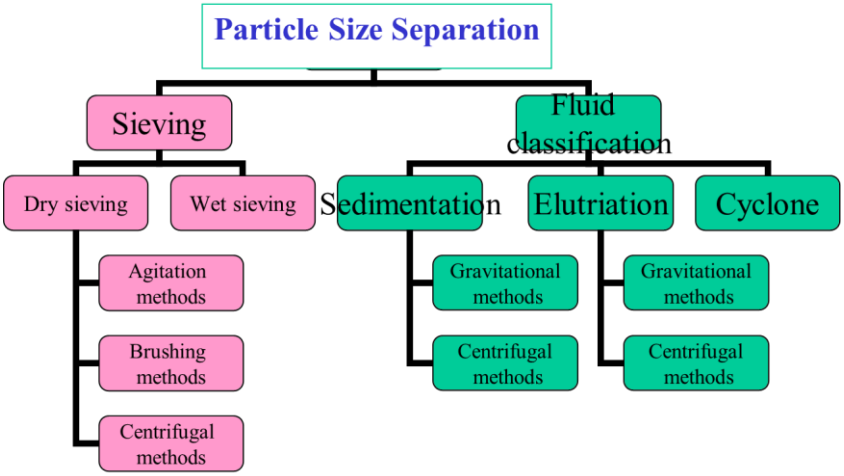
Particle Size Separation

It is the classification of powder into separate particle size ranges.
Solid separation is the removal (separation) of powder particles from gases or liquids.



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Size-Separation Methods

Size separation by sieving

❖Principle of operation is similar to the use of sieving in particle size analysis with the following differences:

- Sieves should be resistant to chemical action with the material to be sifted (It is more suitable to use stainless steel sieves than brass or bronze sieves).
- The amount of material is larger in case of particle size separation than in particles size analysis, and therefore:
  - requires larger sieves
  - there are several techniques to encourage the particles to separate into their appropriate size fractions.

- Size separation can be done by dry or wet sieving.

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Size-Separation Methods

Size separation by sieving

- Sieves are described by :
  - Opening size
  - Number of opening per linear inch (mesh number)

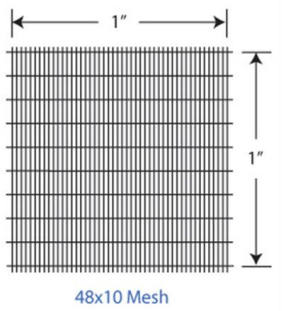

Table 3 Openings of Standard Sieves, U.S. Series

Assigned number	Sieve opening
2	9.5 mm
3.5	5.6 mm
4	4.75 mm
8	2.36 mm
10	2.00 mm
14	1.40 mm
16	1.18 mm
18	1.00 mm
20	850 μm
25	710 μm
30	600 μm
35	500 μm
40	425 μm
45	355 μm
50	300 μm
60	250 μm
70	212 μm
80	180 μm
100	150 μm
120	125 μm
200	75 μm
230	63 μm
270	53 μm
325	45 μm
400	38 μm

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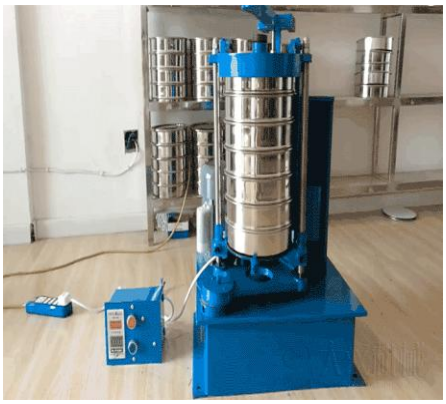
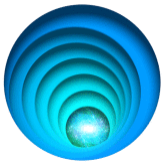
Dry sieving techniques

1.Agitation methods:

- In these methods size separation is induced by vibrations which facilitate passing of particle through pores.
- Alternatively, by suitable way gyration of sieves can be used which causes the particles to spin, and thereby changing continuously their orientation.
- The output from gyratory sieves is often greater than that obtained by vibration sieving.



gyration



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Dry sieving techniques

2. Brushing methods:
   - A brush is used (manually on small scale and mechanically on large scale) to reorientate particles on the surface of a sieve and prevent blocking of pores.

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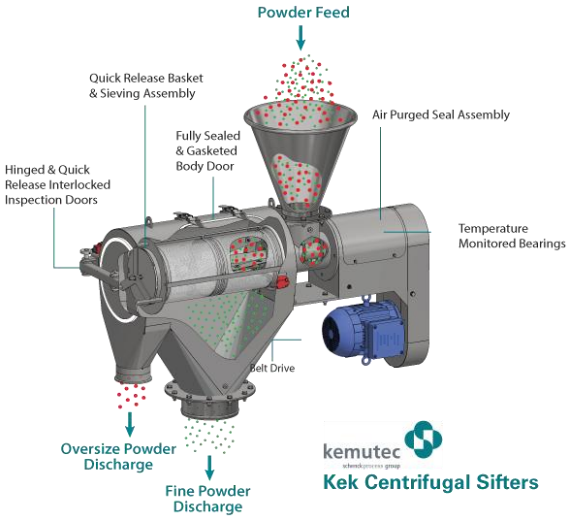
Dry sieving techniques

3. Centrifugal methods:

- Particles are thrown outwards onto a vertical cylindrical sieve under the action of high-speed rotor inside the cylinder.
- The current of air created by the rotor also assists in sieving.



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Wet sieving

- Wet sieving is generally more efficient than dry sieving.

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Size separation by fluid classification

Sedimentation methods

- Principles of operation

Gravitational methods

- Simple forms of sedimentation classification uses a chamber containing a suspension of solid particles in a liquid.
- After predetermined time , particles less than a given diameter can be recovered by a pipette placed at a fixed distance below the liquid surface, or alternatively by a pump.

Alternative technique

- Continuous settling chamber: Particles in suspension enter a shallow container and they are acted by a driving force divided into two components:

1. horizontal due to particle velocity and
2. vertical due to gravity and corresponds to Stoke's settling velocity.

- The coarsest particles will sediment closest to the inlet, whereas the finest particles will sediment furthest from the inlet.

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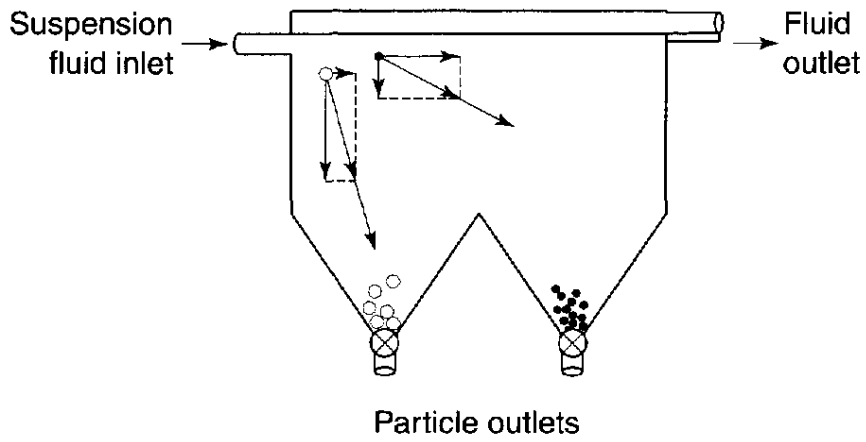

Fig. 12.4 Continuous settling chamber showing vectors of particle movement for different sizes.

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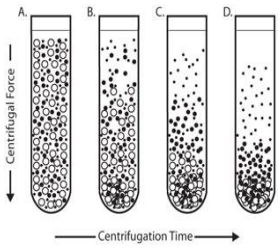
Size separation by fluid classification

- Very fine particles will not sediment efficiently under the influence of gravity due to Brownian diffusion.
- In order to increase the driving force of sedimentation, centrifugal methods can be used.



Centrifugal methods

- Single cylindrical centrifuges can be used to remove single size cuts from a fluid stream.
- Multiple chamber centrifuges can separate a number of size ranges.

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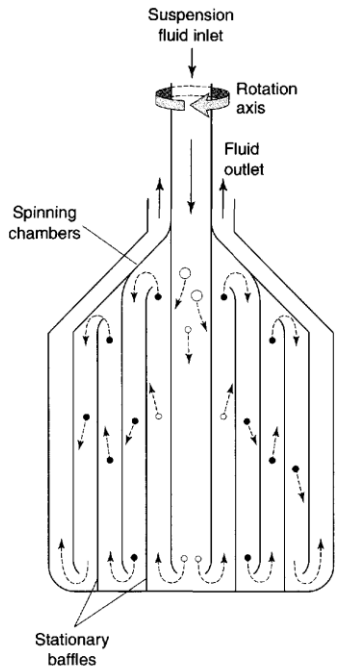
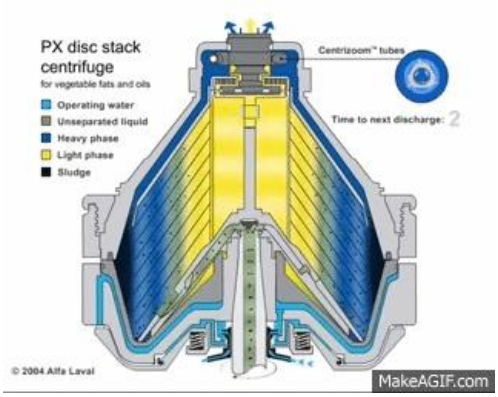


Fig. 12.5 Multiple-chamber separation centrifuge.



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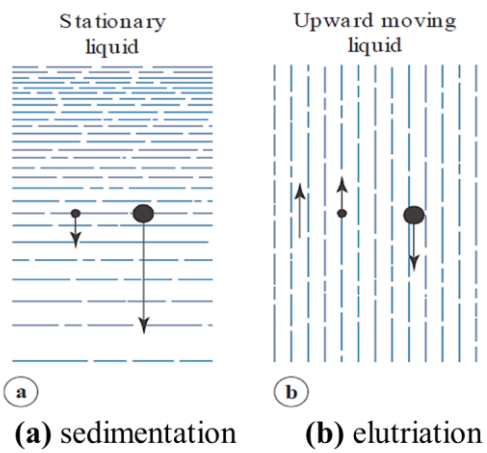
Size separation by fluid classification

Elutriation methods

- Elutriation is a technique in which the fluids flows in an opposite direction to the sedimentation movement.
- Particles are divided into different size fractions depending on the velocity of the fluid.



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Size separation by fluid classification

Elutriation methods

- The simple way is the separation of particles when they are suspended in a fluid moving up a column.
- In practice , the fluid velocity in a tube is not uniform.
- The highest velocity is found in the center and the lowest velocity at the tube walls.
- Particles can be seen to rise with the fluid and then to move outwards to the tube wall, where the velocity is lower and then tend to fall down.
- A separation into two sizes occur, but the size cut will not be clearly defined.

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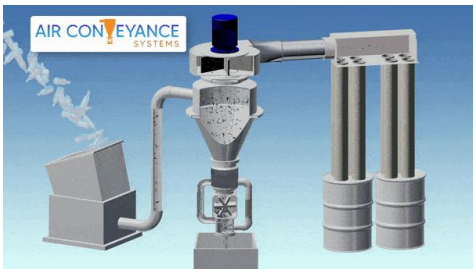
Size separation by fluid classification

Elutriation methods

- Upward airflow elutriator
  - Particles are held on a supporting mesh through which air is drawn.
  - Classification occurs within a very short distance of the mesh.
  - Any particles remaining entrained in the air stream are accelerated to a collecting chamber by passage through a conical section.



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Size separation by fluid classification

Multistage elutriators

These are gravitational elutriator used to separated powders into several size fractions.

It is composed of columns with increasing diameters.

As the **diameter** increase the fluid velocity decrease and smaller particles can be separated.

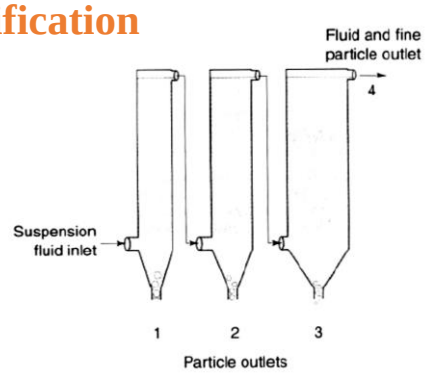
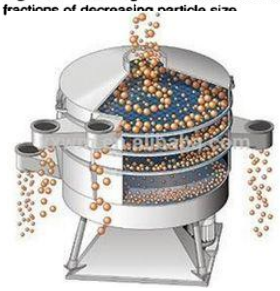


Fig. 12.9 Multistage elutriator. Particle outlets 1 to 4 collect fractions of decreasing particle size.



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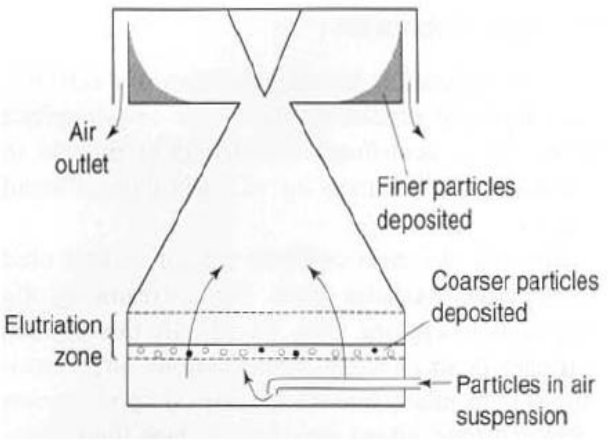

Fig. 12.10 Upward airflow elutriator.

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Size separation by fluid classification

Cyclone methods

Principle of operation:

- The most common type of cyclone used to separate particles from fluid stream is the reverse-flow cyclone.
- In this system, Particles in air or liquid suspension are introduced tangentially into the cylindrical upper section of the cyclone.
- The relatively high fluid velocity produces vortex that throws solid particles out onto the walls of the cyclone.

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Size separation by fluid classification

Cyclone methods

- The particles are forced down the conical section under the influence of the fluid flow.
- At the tip of the conical section the vortex of fluid is above the critical velocity at which it can escape through the narrow outlet and form an inner vortex which travels back up the cyclone.
- Coarser particles separate from fluid and fall out on the cyclone, while finer particles leave with the fluid through the vortex finder.

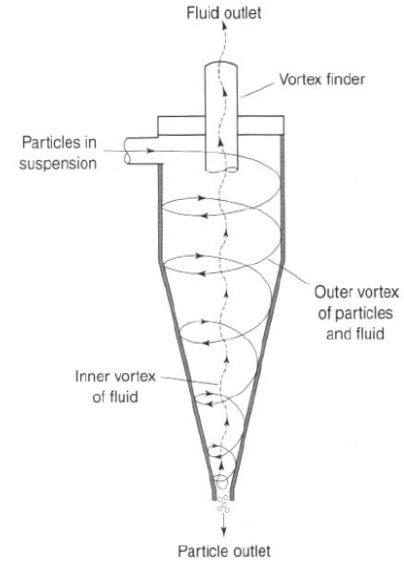

Fig. 12.12 Reverse-flow cyclone separation.

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Method	Separation range
Sieving	Available range ≈5 – 125 000 μm Pharmacopoeial range ≈38 - 9500 μm
Gravitational sedimentation	≈ 5 – 1000 μm
Centrifugal sedimentation	≈ 0.1- 5 μm
Gravitational elutriation	10 – 500 μm
Centrifugal elutriation	0.5 - 50 μm
Cyclone	5 - 150 μm

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