CHAPTER 6

SIZE SEPARATION

Author

Mr. Gaurav Pratap Singh,
Assistant Professor, Dr. K N Modi Institute of Pharmaceutical Education & Research, Modinagar, Uttar Pradesh, India

Abstract

Size separation is a crucial process in pharmaceutical manufacturing that involves the classification of particles based on their size. This operation is essential for achieving uniform particle size distributions, which directly impact drug dissolution, bioavailability, and manufacturing efficiency. Various methods of size separation are employed, including sieving, elutriation, and sedimentation. Sieving, the most common technique, uses a series of mesh screens to separate particles of different sizes. The principles of sieve analysis and the importance of selecting appropriate sieve sizes are discussed. Factors affecting sieving efficiency, such as particle shape, moisture content, and sieving time, are examined. Air classification and cyclone separators are explored as alternatives for fine powder separation. The concept of particle size distribution and its measurement using various techniques, including laser diffraction and image analysis, is introduced. Size separation plays a critical role in quality control, ensuring batch-to-batch consistency and meeting regulatory requirements for particle size specifications.

Keywords: *Sieving, Particle classification, Size distribution, Powder technology, Quality control, Batch uniformity*

Learning Objectives

After completion of the chapter, the student should be able to:

- Define size separation and its significance in pharmaceutical processing.
- Explain the principles of various size separation techniques.
- Describe different types of sieves and sieving equipment used in pharmaceuticals.
- Discuss the factors affecting the efficiency of size separation processes.
- Explain the concept of particle size analysis and its importance.
- Compare and contrast different methods of particle size measurement.
- Analyze the applications of size separation in various pharmaceutical operations.

SIZE SEPARATION

Size separation (or classification) is a process in which particles of desired size are separated from other fractions.

Classification of powders according to IP

During the process of size reduction, it is not possible to obtain the particle of uniform size. Hence special technique is used to **separate particles of a specified size**, which is known as the process of size separation. 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

When the fineness of the powder is described by means of a number, it is intended that all the particles of the powder shall pass through a sieve of which the nominal mesh aperture, in µm , is equal to that number.

Official Standard for Powder: IP (Indian Pharmacopoeia). Coarse or fineness of powder is expressed by Reference to the nominal mesh aperture size of the sieve through which powder is able to pass.

Table: Indian pharmacopoeia- 5 grade of powder

S. No.	Grade of powder	All particles must pass through Sieve No. /Nominal mesh aperture	Sieve through which 40% of the particles pass/ Nominal mesh aperture
1	Coarse powder	10 /(1700 µm)	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)	Not specified
5	Very fine powder	120/(125 µm)	Not specified

Official Grade of powder as per Indian Pharmacopoeia/IP

A) Coarse Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 1.70 mm/1700 µm (**Sieve No. 10**) and not more than 40% pass through nominal mesh aperture of 355 µm (**Sieve No. 44**) is called a **Coarse Powder**.

B) Moderately Coarse Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 710 µm (**Sieve No. 22**) and not more than 40% pass through nominal mesh aperture of 250 µm (**Sieve No. 60**) is called a **Moderately Coarse Powder.**

C) Moderately Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 355 µm (**Sieve No. 44**) and not more than 40% pass through nominal mesh aperture of 180 µm (**Sieve No. 85**) is called a **Moderately Fine Powder.**

D) Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 180 µm (**Sieve No. 85**) is called a **Fine Powder.**

E) Very Fine Powder:

- All the particles of which pass through a sieve with nominal mesh aperture of 125 µm (**Sieve No. 120**) is called a **Fine Powder.**
- **Note:**
    - For Fine & Very fine grade of powder: IP has prescribed only the upper limit (Fine & Very fine)
    - Fineness of powder is described by means of Number: it indicates that all particles of powder shall pass through that sieve number (respective nominal mesh aperture in µm).

F) Microfine powder

A powder of which not less than 90 percent by weight of the particles pass through a sieve with a nominal mesh aperture of 45 µm.

G) Superfine powder

A powder of which not less than 90 percent by a number of the particles are less than 10 µm in size.

Cyclone separator

Principle

Cyclone separator is a type of sedimentation technique that works on the principle of centrifugal force rather than gravitational force. Thus, based on the fluid velocity, a cyclone enables the separation of all the particles or only the coarse particles can be removed, leaving behind the particles which are then carried away by the fluid.

Construction

Comprising a cylindrical vessel with a conical base, the cyclone separator is designed to optimize its functionality. The upper section of the vessel is equipped with a tangential inlet and a fluid outlet, while the base is fitted with a solid outlet for particle discharge.

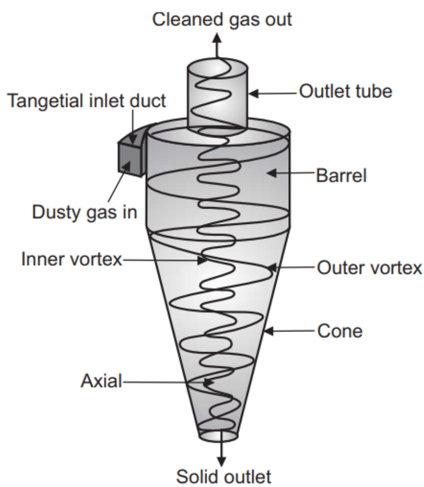


Figure: Cyclone Separator

Working

To initiate the process, a gas suspension carrying solid particles, typically air, is introduced into the vessel with a tangential entry at an exceptionally high velocity, thereby creating a rotational motion within the system. The fluid is subsequently extracted from a central outlet located at the top. As the gas circulates within the cyclone separator, the centrifugal force comes into play, exerting its influence on the particles. This force propels the solids towards the walls, ultimately leading them to descend and collect at the conical base, ready for expulsion through the solids outlet.

Applications

The applications of cyclone separators extend to the separation of solid suspensions in gas, particularly air. Additionally, these separators can also be utilized for liquid suspensions containing solid particles. By harnessing the power of centrifugal force, cyclone separators provide an effective means of achieving particle separation and enhancing the efficiency of various processes.

In pharmaceuticals, it employs cyclones to segregate fine particles from larger granules. These cyclones play an important role in tablet compression by extracting excess powder, ensuring it is removed prior to reaching the central extraction system.

Advantages:

- It is Highly Efficient
- Cost-Effectiveness
- Compact and Space-Saving

Disadvantages:

- Cyclone separators require adequate space for installation due to their design.
- Required more energy input.
- Required a Large amount of air to be introduced.

Cyclone Separator Variants

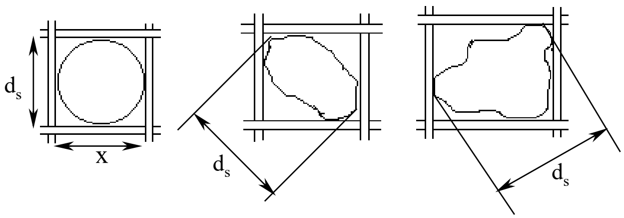
The cyclone separator, a versatile apparatus, finds utility not only in gas-solid separation but also in the separation of solid particles suspended in a liquid medium. This variant, known as a wet or liquid cyclone, capitalizes on the contrasting densities of the solid and liquid particles involved. Notably, when dealing with a liquid suspension, the task becomes more intricate due to the heightened viscosity of water in comparison to air.

To achieve effective separation in such cases, a greater centrifugal force must be exerted. One method to amplify this force involves reducing the diameter of the vessel, thereby intensifying the effects of centrifugation. As the cyclone separator operates, coarse particles, propelled outward by the formidable centrifugal force, the journey toward the vessel walls and eventually gather at its base. Concurrently, the lighter particles, alongside the liquid medium, make their escape through the outlet positioned atop the vessel. This interplay of forces and dynamics showcases the efficient functionality of the cyclone separator in the context of liquid-solid particle separation.

SIEVE ANALYSIS

Equivalent diameter

Sieve diameter, d_s, is the particle dimension that passes through a square aperture (length = x).



Sieve diameter, d_s for various particle shapes

Range of analysis

The International Standards Organization (ISO) sets lowest sieve diameter of 45μm. Powders are usually defined as particles having a maximum diameter of 1000μm, so this is the upper limit. In practice sieve analysis can be done over a range of 5 to 125000μm.

ISO Range :	45 to 1000 μm
Range available in practice:	5 to 125000 μm

Sample preparation

- Powders in dry state is usually used.
- Powders in liquid suspension can also be analyzed by sieve.

Principle of measurement with sieve

Sieve analysis utilizes a set of sieves. Each sieve is a woven, punched or electroformed mesh, often in brass or stainless steel, with known aperture diameter which form a physical barrier to particles. In sieve analysis a set of sieves (known as 'stack' or 'nest' of sieves) are arranged in such a way that the smallest aperture will be at the bottom and the