3.3 WORKING PRINCIPLE, DESIGN AND PERFORMANCE EQUATIONS OF GRAVITY SEPARATORS

Working Principle

- They are generally used to remove large, abrasive particles (usually > 50 mm) from gas streams. Since most of the troublesome particles have much smaller size than 50 mm, there devices are usually used as per cleaners prior to passing the gas stream through high efficiency collection device.
- Settling chambers, which rely on gravitational settling as a collection mechanism, are the simplest and oldest mechanical collectors. Settling chambers are generally built in the form of long, horizontal, rectangular chambers with an inlet at one end and an exit at the side or top of the opposite end.
- Flow within the chamber must be uniform and without any macroscopic mixing. Hoppers are used to collect the settled-out material, though drag scrapers and screw conveyers have also been employed.
- The dust removal system must be sealed to prevent air from leaking into the chamber which increases turbulence, causes dust re-entrainment, and prevents dust from being properly discharged from the device.
- There are two primary types of settling chambers: the expansion chamber and the multiple-tray chamber. In the expansion chamber, the velocity of the gas stream is significantly reduced as the gas expands in a large chamber. The reduction in velocity allows larger particles to settle out of the gas stream.
- A multiple-tray settling chamber is an expansion chamber with a number of thin trays closely spaced within the chamber, which causes the gas to flow horizontally between them.
- While the gas velocity is increased slightly in a multiple-tray chamber, when compared to a simple expansion chamber, the collection efficiency generally improves because the particles have a much shorter distance to fall before they are collected. Multiple-tray settling chambers have lower volume requirements than expansion-type settling chambers for the collection of small particles.

- The efficiency of settling chambers increases with residence time of the waste gas in the chamber. Because of this, settling chambers are often operated at the lowest possible gas velocities.
- In reality, the gas velocity must be low enough to prevent dust from becoming re-entrained, but not so low that the chamber becomes unreasonably large. The size of the unit is generally driven by the desired gas velocity within the unit, which should be less than 3 m/s (10 ft/sec), and preferably less than 0.3 m/s (1 ft/sec).

Design and Performance Equations of Gravitational Settling Chamber:

If we assume that Stokes law applies we can derive a formula for calculating the minimum diameter of a particle collected at 100% theoretical efficiency in a chamber of length L.

$$V_{t/H}=V_{h/L}$$

$$V_t = \frac{g\left(\rho_p - \rho_a\right)d_p^2}{9\mu_a}$$

Where ,

V_t=terminal settling velocity, m/s

g=gravitational constant m/s^2

ρ_p=density of particle, kg/m^3

ρ_a=density of flue gas, kg/m^3

d_p=diameter of particle, m

µa=viscosity of air, kg/ms

H=height of settling chamber, m

v_h=horizontal flow velocity, m/s

L=length of settling chamber, m.

Solving for d_p gives an equation that predicts the largest-size particle that can be removed with 100% efficiency from a settling chamber of given dimension.

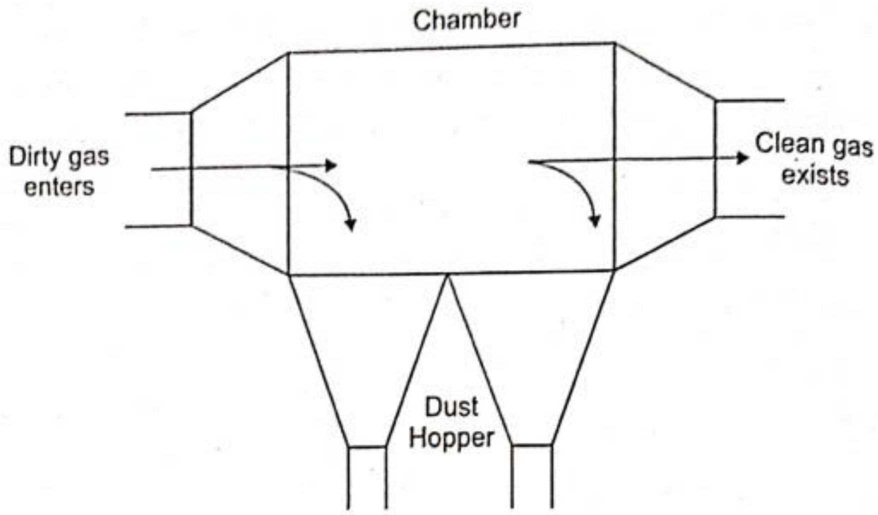

Figure3.3.1 Gravity settling chamber

[Source:https://www.degruyter.com/document/doi/10.1515/psr-2016-0122/asset/graphic/j_psr-2016-0122_figure6.jpg]

Advantages of Settling Chambers:

1. Low capital cost

2. Very low energy cost

3. No moving parts, therefore, few maintenance requirements and low operating costs

4. Excellent reliability

5. Low pressure drop through device

6. Device not subject to abrasion due to low gas velocity

7. Provide incidental cooling of gas stream

8. Temperature and pressure limitations are only dependent on the materials of construction

9. Dry collection and disposal.

Disadvantages of Settling Chambers:

1. Relatively low particulate matter collection efficiencies, particularly for particulate matter less than 50 µm in size.

2. Unable to handle sticky or tacky materials.

3. Large physical size; and

4. Trays in multiple-tray settling chamber may warp during high-temperature operations.