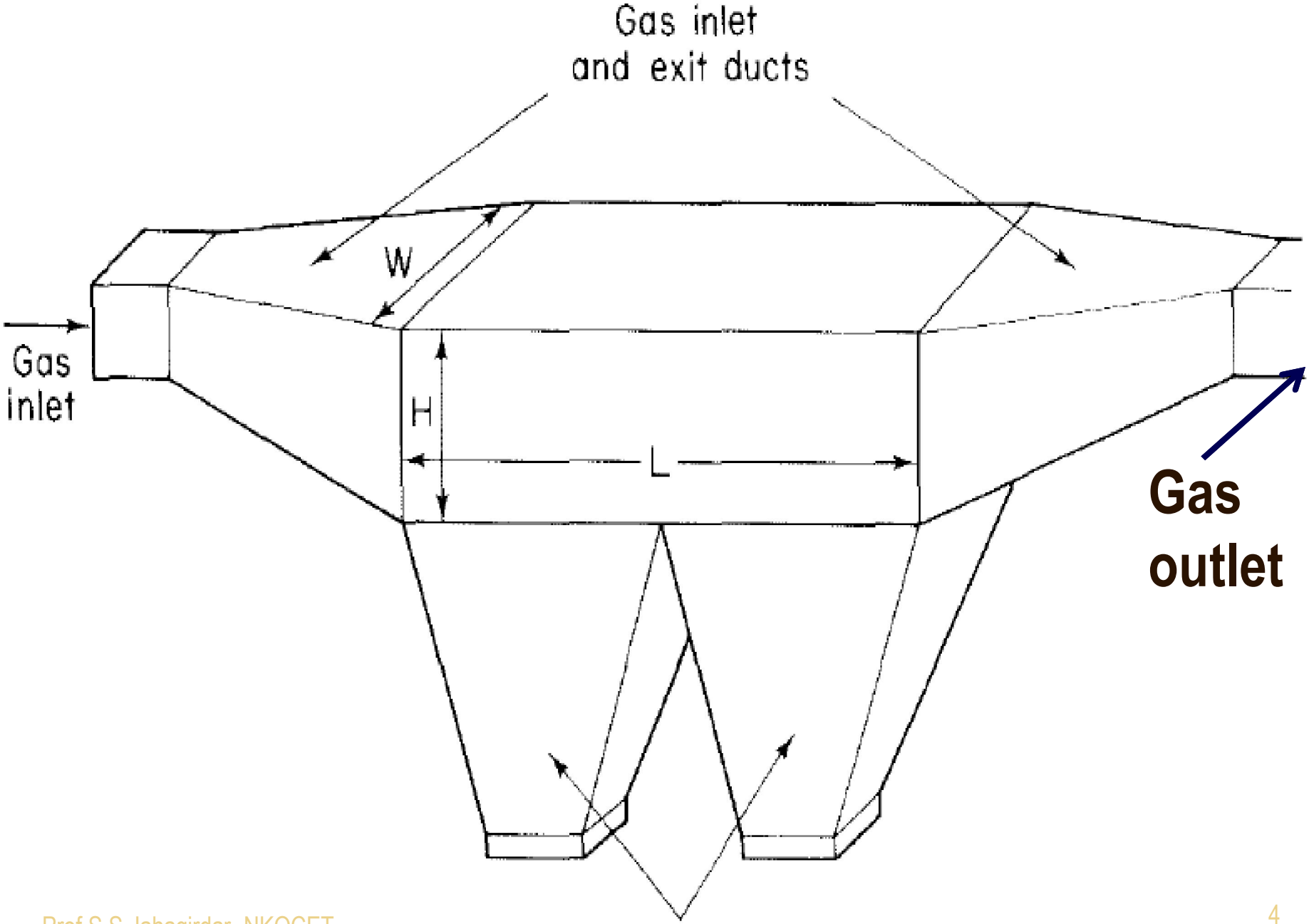
L-23
Gravity settling chamber

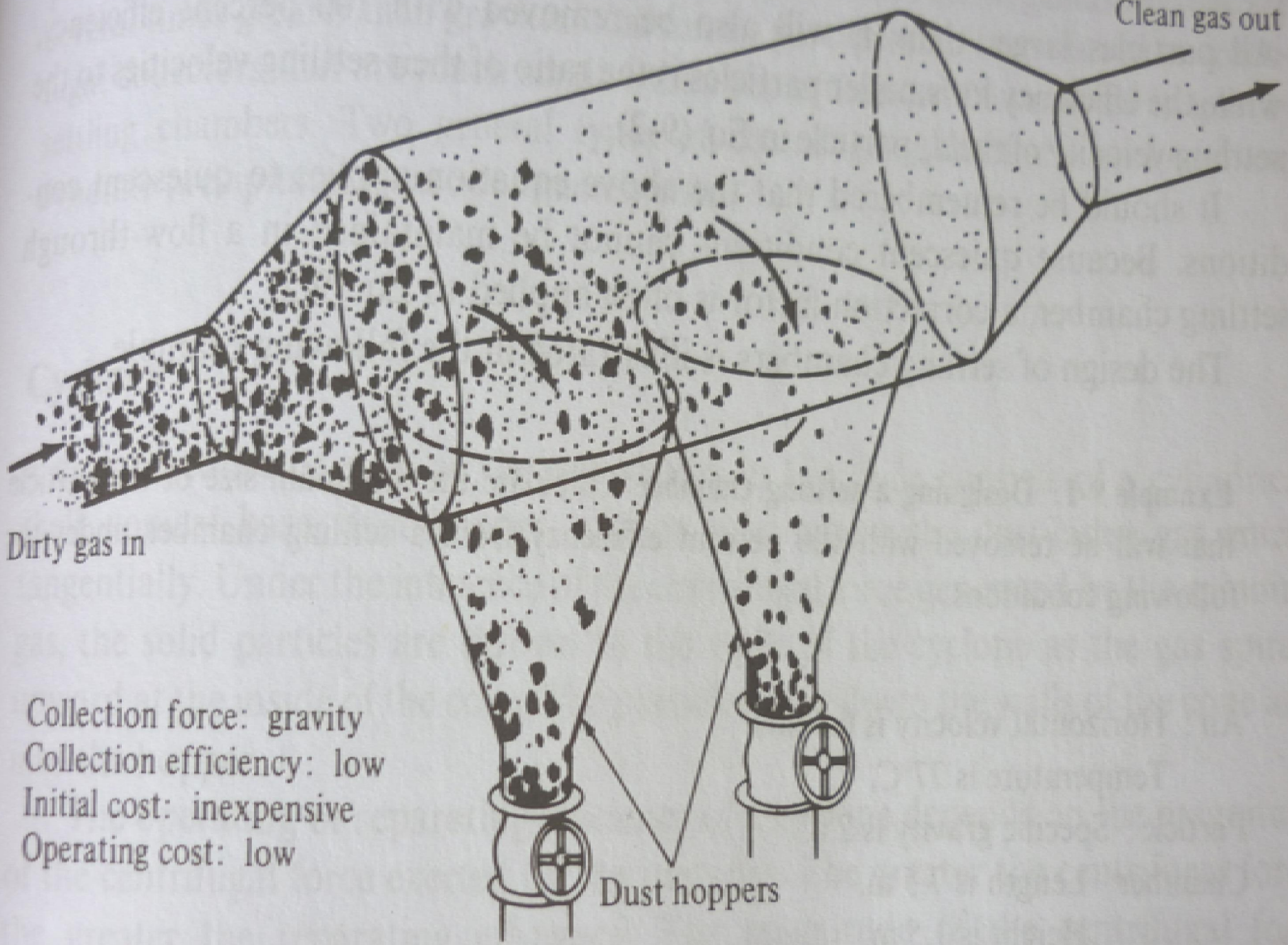
Air Pollution and Control
(Elective-I)

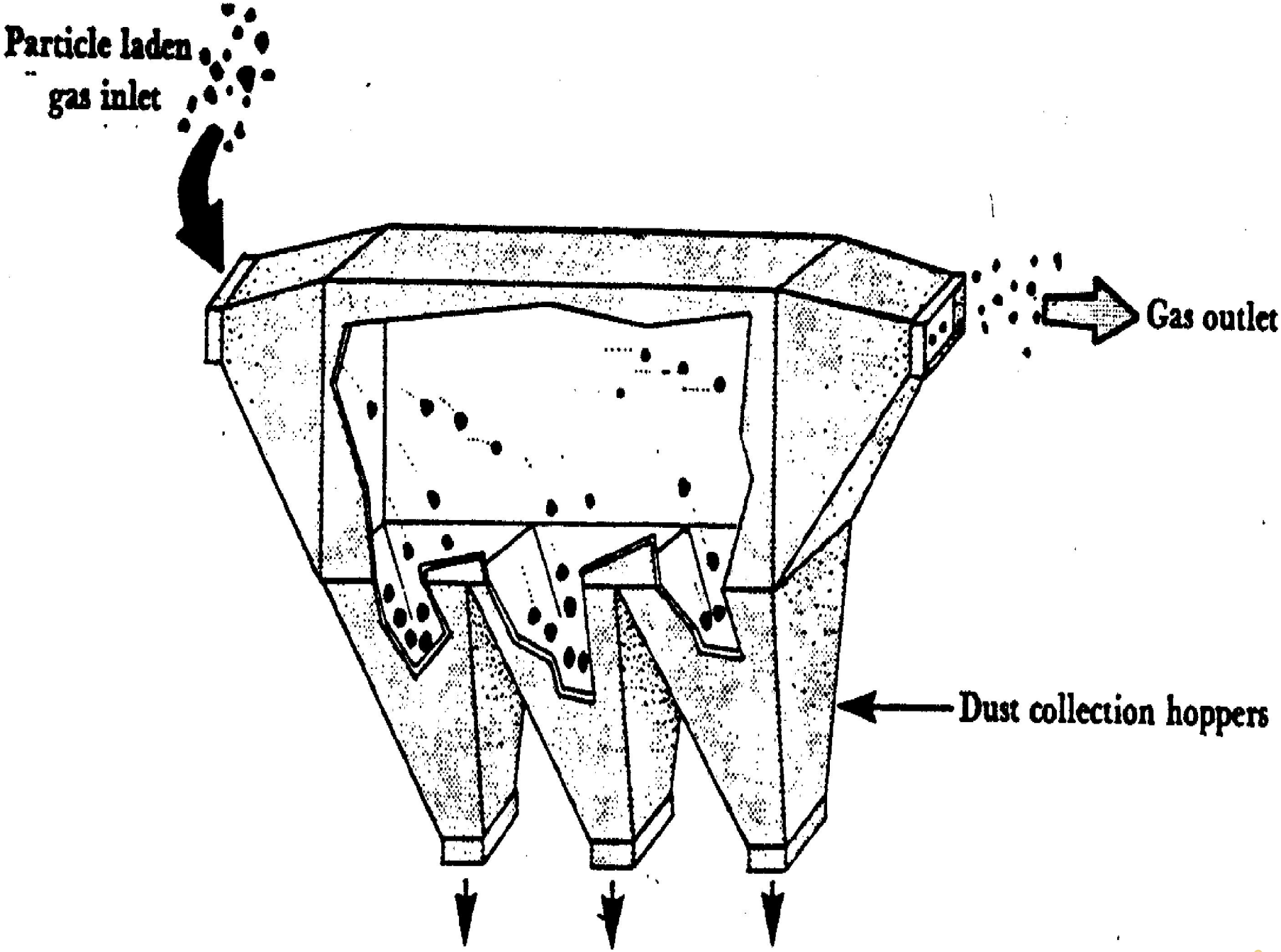
Gravity settling chamber

- Gravity settling chamber is used to remove large and abrasive particles **greater than 50 µ** from a gas stream.
- This is a simple particulate collection device using the principle of gravity to settle the particulate matter in a gas stream passing through its long chamber.

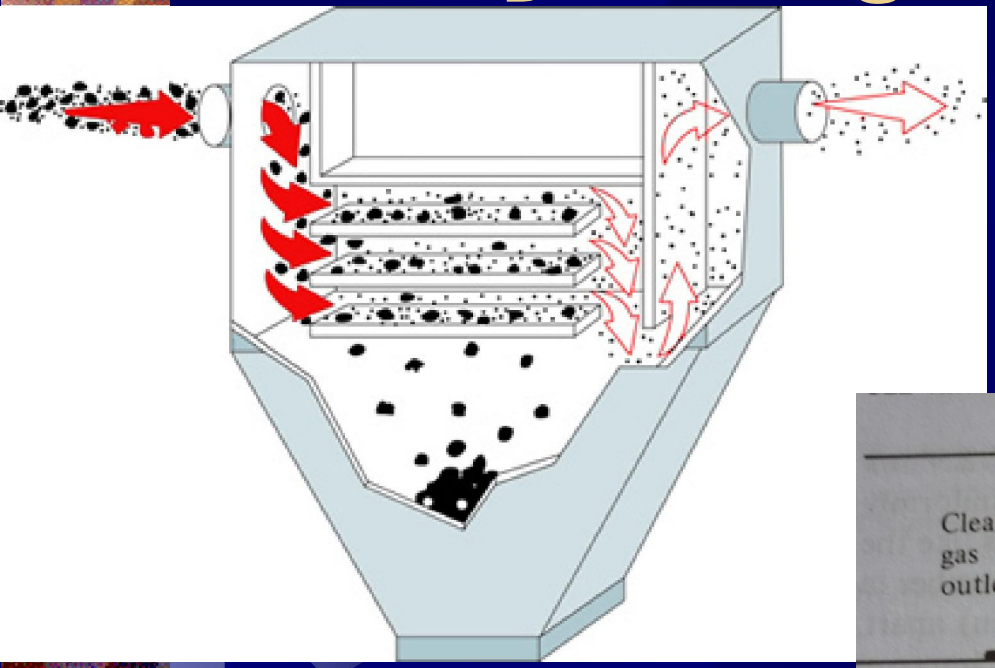
- The primary requirement of such a device would be a chamber in which the carrier gas velocity is reduced so as to allow the particulate matter to settle out of the moving gas stream under the action of gravity.
- This particulate matter is then collected at the bottom of the chamber.
- The chamber is cleaned manually to dispose the waste.

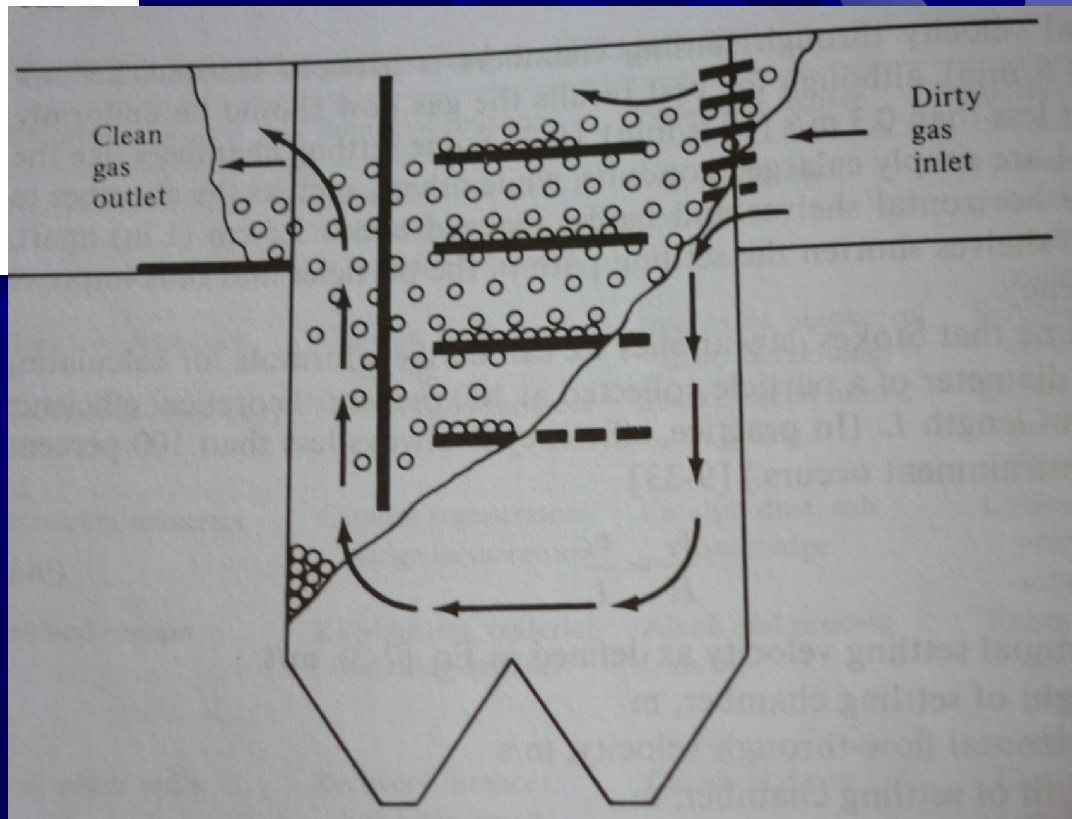

Gas inlet
and exit ducts
W
Gas
inlet
H
L
Gas
outlet
Dust-collecting hoppers


Clean gas out
Dirty gas in
Collection force: gravity
Collection efficiency: low
Initial cost: inexpensive
Operating cost: low
Dust hoppers


Particle laden
gas inlet
Gas outlet
Dust collection hoppers

Gravity settling chamber with trays





- The gas velocities in the settling chamber must be sufficiently low for the particles to settle due to gravitational force.
- Literature indicates that gas velocity less than about 3 m/s is needed to prevent re-entrainment of the settled particles. The gas velocity of less than 0.3 m/s will produce good results.

Design Parameters:-

For 100 % efficiency

$$t = \frac{H}{V_t} = \frac{L}{V_H}$$ ----------Eq -i

Where,

H= height of settling chamber

L = Length of settling chamber

V_t = Velocity of settling

V_H = velocity of flow

From equation I Settling velocity may be given by

$$Vt = \frac{V_H H}{L} = \frac{Q}{LW}$$ ----------Eq – ii

W= width of chamber

(As Q = area of inlet x velocity = $W.H.V_H$)

For streamline flow settling velocity is given by

$$V_t = \frac{g.d_p^{\,2}.\rho_p}{18.\mu}$$ ---------- Eq- iii

- Equating equations ii and iii,

$$\frac{V_H H}{L} = \frac{g.d_p{}^2.\rho_p}{18.\mu}$$

therefore, we get,

$$d_{p_{\min}} = \sqrt{\frac{18.\mu H.V_H}{g.L.\rho_p}}$$ -------Eq iv

$d_{p_{min}}$ is min size of particle that can be removed with 100 % efficiency

For better and conservative results multiplying factor 2 can be taken

$$d_{p_{\min}} = \sqrt{2 \times \frac{18.\mu H.V_H}{g.L.\rho_p}}$$

Efficiency of settling chamber is given by

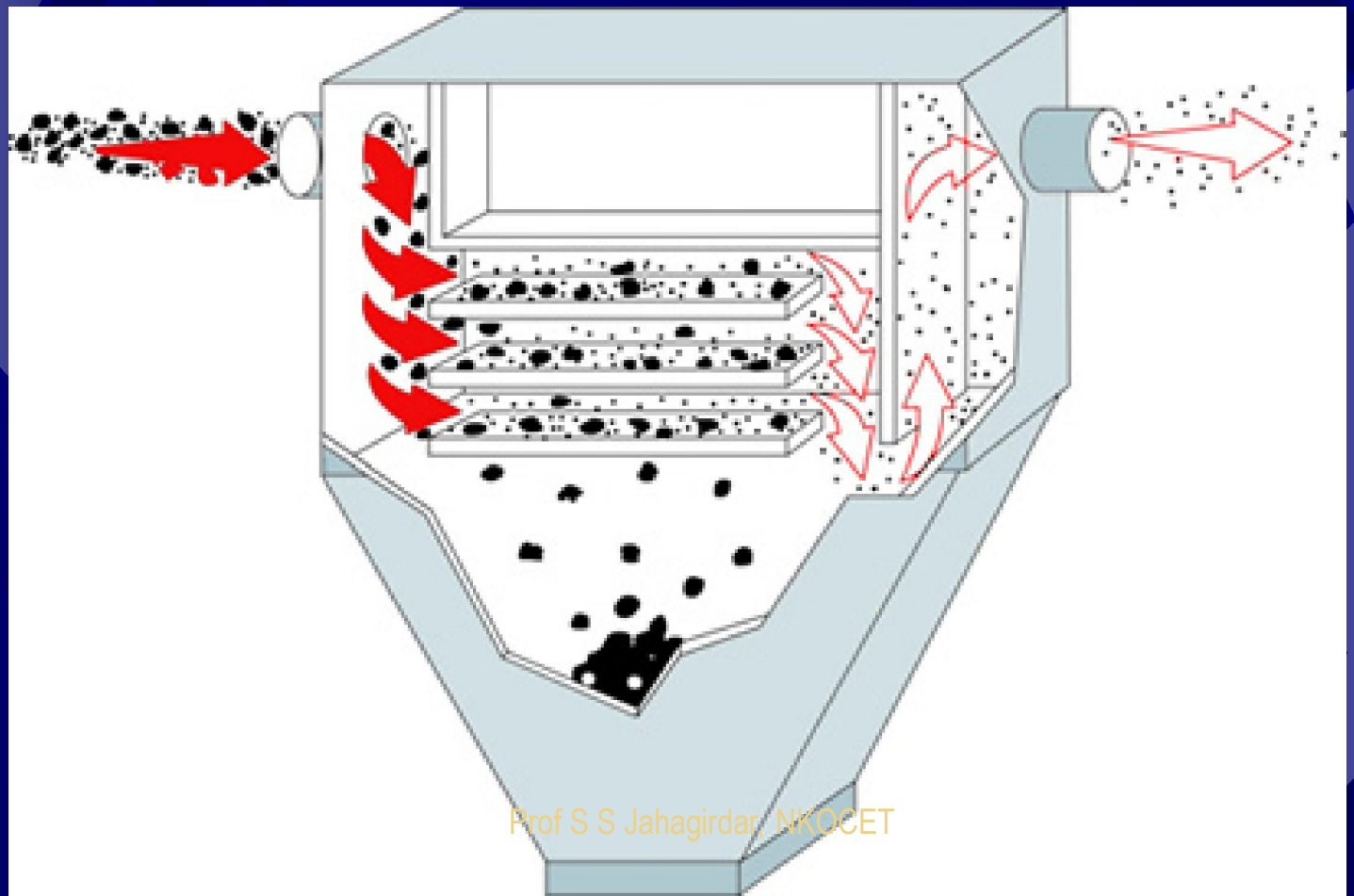
$$\eta_{d_p} = \left(\frac{d_p}{d_{p_{\min}}} \right)^2$$

- Another equation for calculation of efficiency is

$$\eta = 1 - \exp\left(- \frac{g.{d_p}^2 \rho_p.L}{18.\mu.V_H.H} \right)$$

Settling chamber with trays

Settling trays can be used to improve removal efficiency.



If, n = number of trays, then equation iv becomes

$$d_{p_{\min}} = \sqrt{\frac{18.\mu H.V_H}{n.g.L.\rho_p}}$$

Advantages

1. Low initial cost
2. Simple construction
3. Low maintenance cost
4. Low pressure drop
5. Dry and continuous disposal of collected solids
6. Can be constructed of any material
7. Temperature and pressure limitations are imposed by type of material used

Disadvantages

1. Large space requirement
2. Only comparatively large particles can be collected

Applications of settling chamber

- Settling chambers are mostly used as pre-cleaners. They are sometimes used in the process industries, particularly in the food and metallurgical industries as the first step in dust control.
- Use of settling chambers as pre-cleaners can also reduce the maintenance cost of high efficiency control equipment, which is more subject to abrasive deterioration.

Problem (Peavy -Rowe)

Example 9-1: Designing a settling chamber Calculate the minimum size of the particle that will be removed with 100 percent efficiency from a settling chamber under the following conditions.

Assume viscosity of air = 2.1×10^{-5} kg/m.s

Air: Horizontal velocity is 0.3 m/s.
Temperature is 77°C.
Particle: Specific gravity is 2.0.
Chamber: Length is 7.5 m.
Height is 1.5 m.

Solution :-

$$d_p = \left(2\frac{18\mu V_h H}{gL\rho_p}\right)^{1/2}$$

$$d_p = \left(\frac{2 \times 18 \times 2.1 \times 10^{-5}\ \text{kg/m}\cdot\text{s} \times 0.3\ \text{m/s} \times 1.5\ \text{m}}{9.81\ \text{m/s}^2 \times 7.5\ \text{m} \times 2{,}000\ \text{kg/m}^3}\right)^{1/2}$$

$$d_p = 4.81 \times 10^{-5}\ \text{m}$$

$$= 48.1\mu$$

Objective questions

Q1. Gravity settling chamber removes _____ particles.

Q2. In gravity settling chamber, the gas velocity of less than _____ m/s will produce good results.

Q3. If trays are used in settling chamber efficiency _____.

Q4. True or false?

1.Settling chamber can be connected with other control equipments in series to increase efficiency.

2. Settling chamber can remove less than 1 μ particles with 90% efficiency.
3. Increase in flow velocity increases efficiency of settling chamber.

Theory questions

Q1. Explain working of gravity settling chamber with neat sketch. Also give advantages and disadvantages.

Q2. Write a note on ‘Design of gravity settling chamber’.