INTRODUCTION

The process may be interpreted to mean both degassing of solids and dedusting of the solids.

3 phases may be distinguished in any gas cleaning process, i.e;

- transport of particles onto a surface (separation)
- collection of separated particles from the separation surface into discharge hoppers (or particle fixation)
- disposal of the collected particles from the gas cleaning equipment

All phases are equally important as the failure of any of the phases will result in the failure of the separation process


SAJJAD KHUDHUR ABBAS
Chemical Engineering
Oil & Gas Safety and Health Professional
Trainer of Trainers (TOT)

General characteristics of equipment

The factors affecting the choice of gas cleaning equipment. For any particular application are;

1. flowrate-pressure drop relationship
2. efficiency
3. economic criteria
4. suitability for different conditions (the nature of both solids and ga)
5. solids concentration,
6. method of disposal
7. reliability


SAJJAD KHUDHUR ABBAS
Chemical Engineering
Oil & Gas Safety and Health Professional
Trainer of Trainers (TOT)

Gas Solid Separation: Cyclone

SAJJAD KHUDHUR ABBAS
Chemical Engineering
Oil & Gas Safety and Health Professional
Trainer of Trainers (TOT)

Definition of cyclone separators

- A cyclone separator is an equipment for the removal from air streams of particles above 10 micrometer in diameter.
- The equipment is a settling chamber in the form of a vertical cylinder, so arranged that the particle laden air spirals round the cylinder to create centrifugal forces which throw the particles to the outside walls (Learle, 1966)

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Chemical Engineering
Oil & Gas Safety and Health Professional
Trainer of Trainers (TOT)

Advantages/disadvantages

The advantages of cyclone and all aero-mechanical dry separators include:

- Simple design
- Low capital cost
- Suitability for higher temperatures
- Low energy consumption
- Product is dry
- Reliability

Disadvantages:

Their relatively low efficiency for very fine particles which leads to their frequent role as a pre-cleaner

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Chemical Engineering
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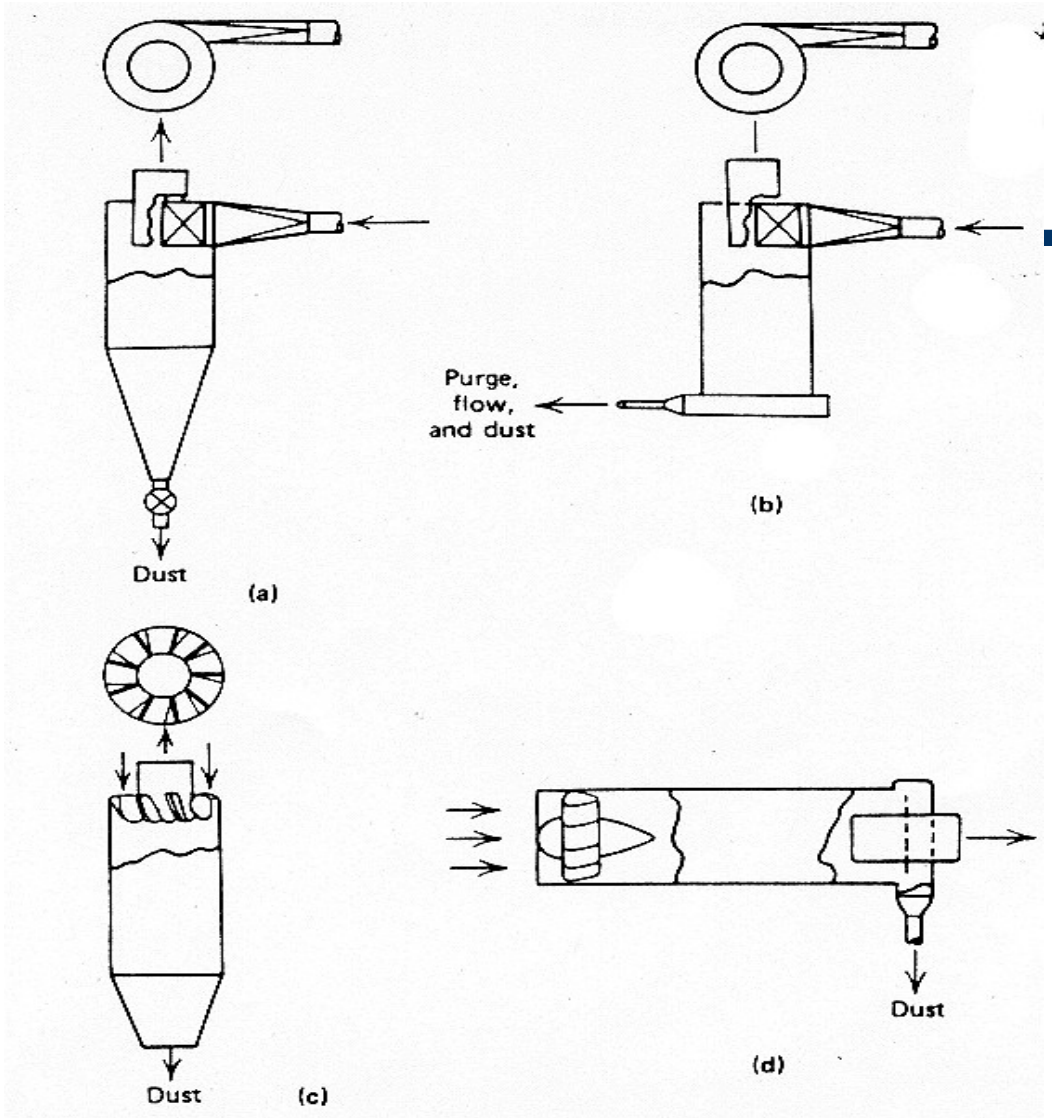
Cyclone types most commonly used

- Cyclone separators can be classified according to either their geometrical configuration in (tangential inlet axial discharge, tangential inlet peripheral discharge, axial inlet and discharge, and axial inlet peripheral discharge, Figures a-d below, respectively)
- or their efficiency in ((high efficient (98-99%), moderate efficient (70- 80%),and low efficient (50%)) (Othmer,1978) and (Storch et al.,1979).



- Figures (Othmer, 1978.) [112]
  Figure a. Tangential inlet, axial discharge.
  Figure b. Tanential inlet, peripheral discharge
  Figure c. Axial inlet, axial discharge
  Figure d. Axial inlet, peripheral discharge

Operating principles of cyclone separators

- Although there are four commonly used cyclone separators, their operating principles based on that of the conventional cyclone, are very similar
- In the conventional cyclone, the gas enters a cylinder tangentially, where it spins in a vortex as it proceeds down the cylinder.
- A cone section causes the vortex diameter to decrease until the gas reverses on itself and spins up the center to the outlet pipe or vortex finder.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Operating principles of cyclone separators

- A cone causes flow reversal to occur sooner and makes the cyclone more compact.
- Dust particles are centrifuged toward the wall and collected by inertial impingement.
- The collected dust flows down in the gas boundary layer to the cone apex where it is discharged through an air lock or into a dust hopper serving one or more parallel cyclones (Othmer, 1978) .
- Although conventional cyclones can be built to larger diameter, they are commonly 600 to 915 mm in diameter.

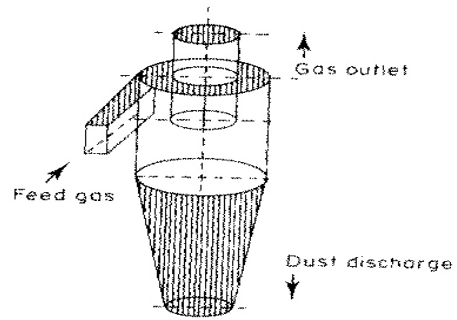

Figure 8.2 Schematic diagram of a reverse-flow gas cyclone.

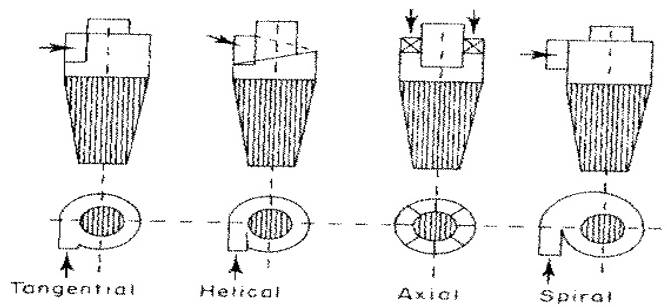

Figure 8.3 Types of inlet.

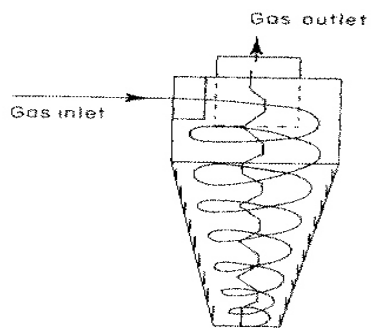

Figure 8.4 Gas flow in a gas cyclone.

Applications of cyclone separators

- Cyclones can be used for separating particles from liquids as well as from gases and they can also be used for separating liquid droplets from gases (Learle,1966).
- The first cyclones used for dust separation probably were built about 1885 by the Knickerboker Company (U.S.Pat.325,521) (Othmer, 1978).
- In industries such as food industries, cyclones are used for removing the dry product from the air.

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Chemical Engineering
Oil & Gas Safety and Health Professional
Trainer of Trainers (TOT)

Applications of cyclone separators

- In synthetic detergent production, fast reactor cyclones are used in separating a cracking catalyst from vaporized reaction products (Coker, 1993).
- Cyclones are used for classification as for example, in the degritting of kaolin clay where sand is removed from the crude clay suspension before finer classification in a conveyor discharge centrifuge and final product recovery in a disk centrifuge.

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Chemical Engineering
Oil & Gas Safety and Health Professional
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Key parameters of cyclone separators

- The most important parameters of a cyclone as for any separating device are its collecting efficiency and the pressure drop across the unit. (Storch ,et al.,1979).
- The collecting efficiency of a cyclone is defined as its **ability to capture and retain dust particles**
- whereas the pressure drop is the amount of power that the unit needs to do so.

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Chemical Engineering
Oil & Gas Safety and Health Professional
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Pressure Drop

- Factors that contribute to cyclone pressure drop (static pressure differential across the cyclone):

1. Gas expansion as it enters the cyclone
2. Formation of vortex
3. Wall friction
4. regain of rotational kinetic energy as pressure energy

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Chemical Engineering
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Pressure Drop

$$\Delta P = Eu\left(\frac{1}{2}\rho_f v^2\right)$$

EU is a resistance coeff., the Euler no.

ρ_f is the gas density

ν is the characteristic velocity

$$v = 4Q/\left(\pi D^2\right)$$

Q is the gas flow rate

D is the cyclone inside diameter

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Efficiency

- Is defined as the fraction of particles of acertain size that are collected by the cyclone.
- It increases with:

1. Increasing particle diameter and density
2. ⇑ gas inlet velocity
3. ⇓ cyclone diameter
4. ⇑ cyclone length
5. Drawing some of the gas from the cyclome through the dust exit
6. Wetting the cyclone walls

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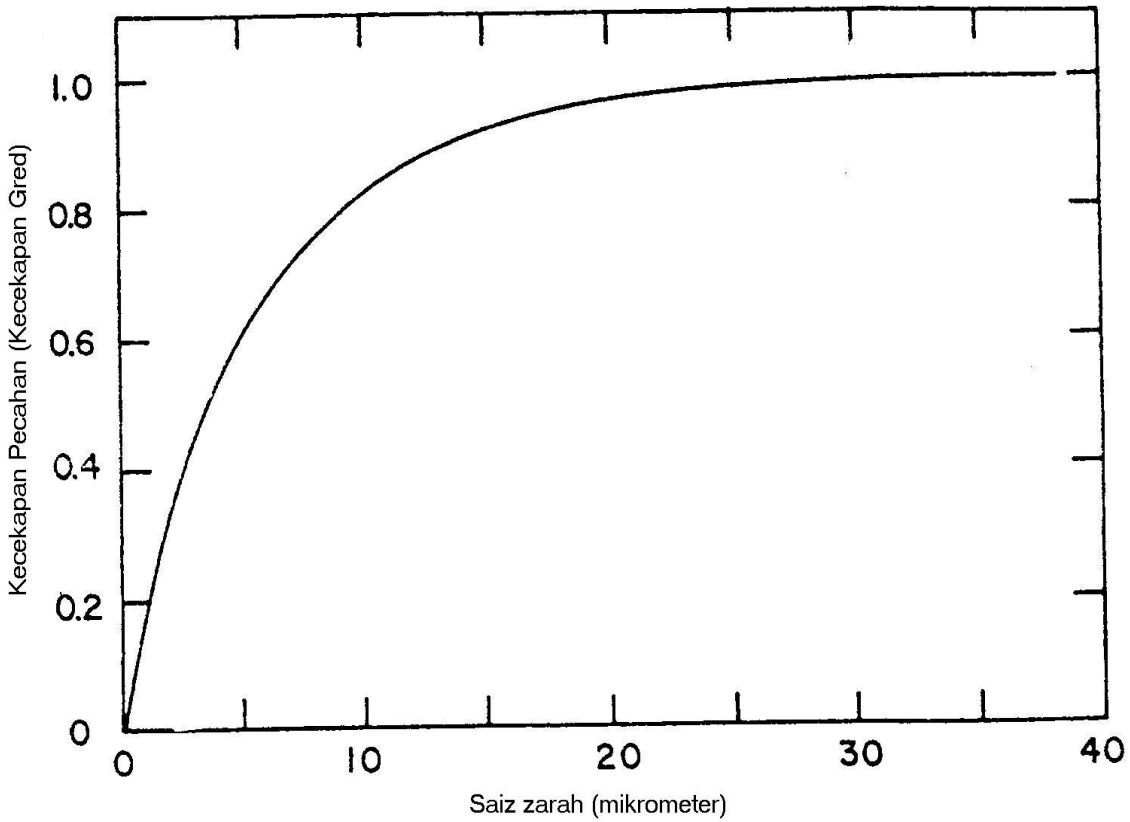
Typical cyclone fractional efficiency curve



The particle size for which the grade efficiency is 50%, d_{50} is often used as a single number measurement of the efficiency of the ccyclone.

d_{50} –the cut size of the cyclone (or other separation device)

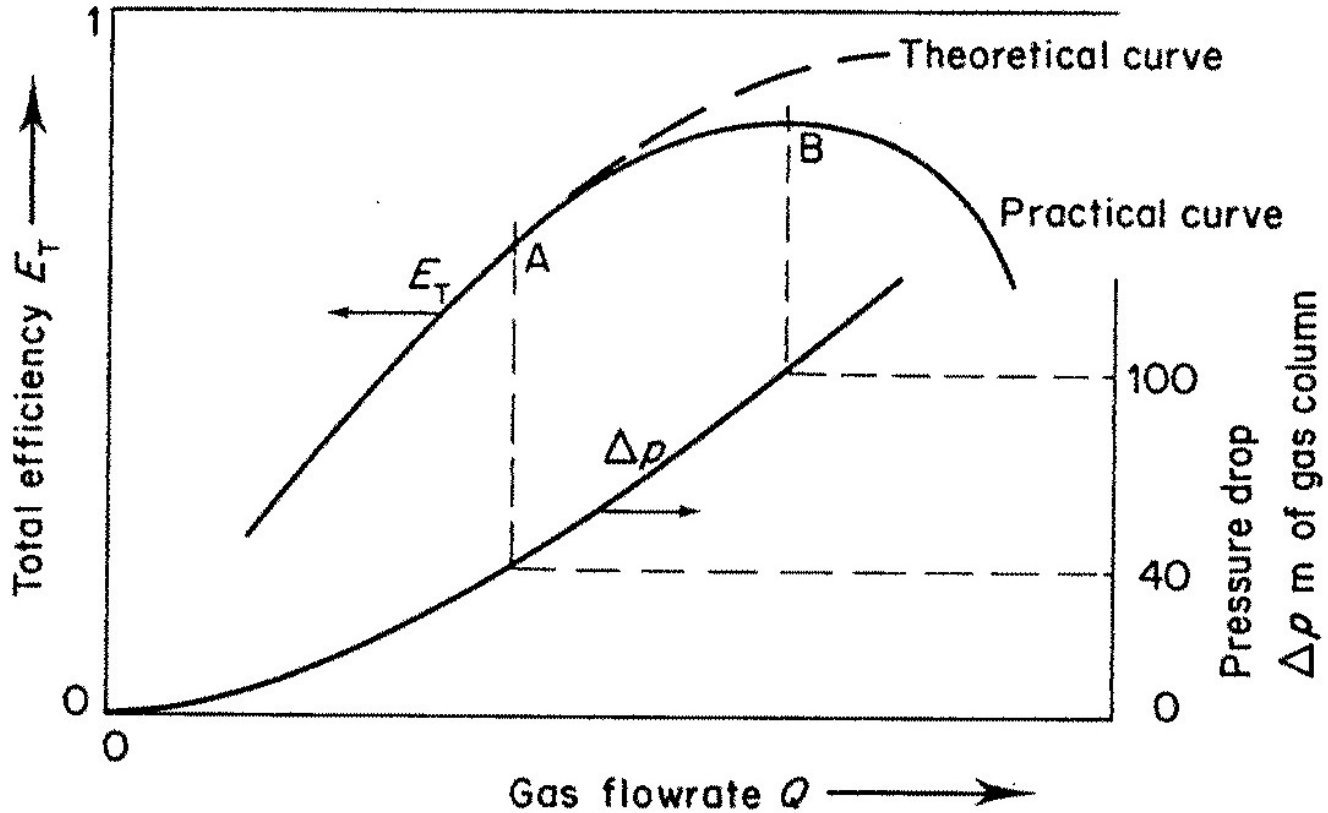


Fig. 8.6 Typical operational characteristics of gas cyclones