Operation Of Mechanical Collectors

Introduction

Mechanical collectors are particulate mater control devices that use **gravity settling, inertia,** and **dry impaction** processes to collect pollutants. Mechanical collectors are reasonably tolerant of high dust loadings. The primary operating parameter for evaluating mechanical collector performance is the static pressure drop. Other performance indicators include opacity and solids discharge rates.

Mechanical collectors use:
- *Gravity settling*
- *Inertia*
- *Dry impaction*

The primary operating parameter for evaluating mechanical collectors is static pressure drop.

Two categories of mechanical collectors are covered in this lesson: **large-diameter cyclones** and **multicyclone** collectors. Figure 7-1 illustrates the structural components of a typical cyclone. Cyclones are found at many industrial sites, where they are often used as precleaners for other, more efficient air pollution control devices (ESPs and fabric filters).

Two major categories of mechanical collectors:
- *Large-diameter cyclones*
- *Multicyclones*

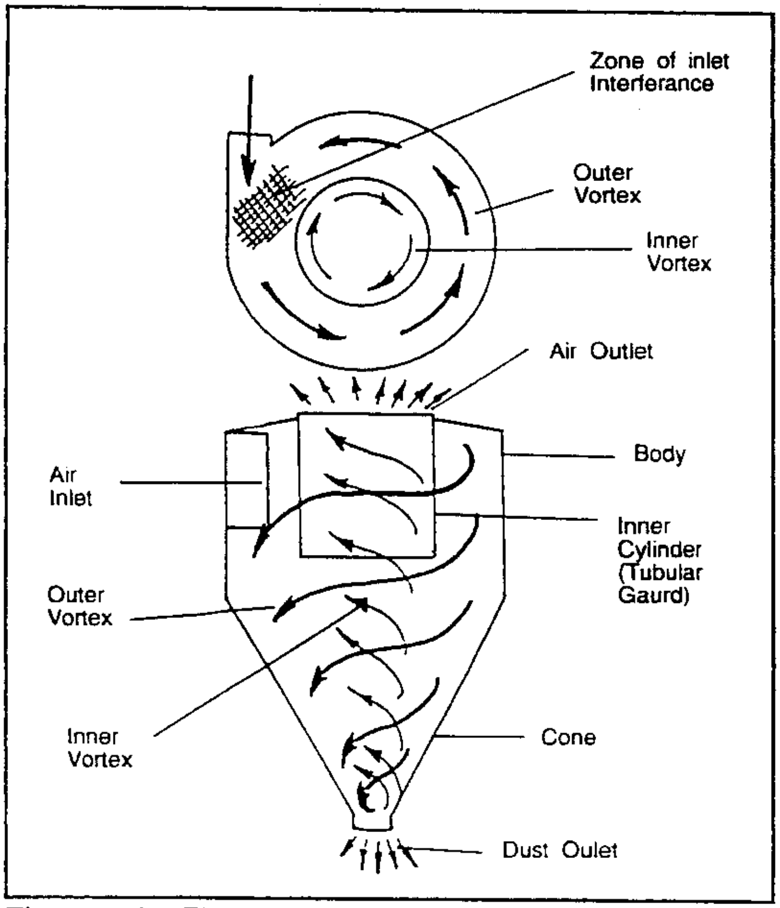

Figure 7-1. Flow Pattern In A Reverse-Flow Cyclone

Operating Principles

Gas flows in a spiral pattern in a cyclone.

Large particles break out of the gas stream and hit the wall of the cyclone.

Cyclones force incoming gas streams to abruptly change direction in a tight, spiral pattern. Large particles entering with the gas stream cannot turn with the gas because of their momentum (or inertia). As a result, these particles "break out" of the gas stream and hit the wall of the cyclone. The particles then fall down the wall and are collected in a hopper.

The spiral pattern of gas flow in a cyclone is influenced by the method in which the gas is introduced. Typically, the gas enters along the side of the cyclone body wall and turns a number of times to spiral down to the bottom, much like the funnel of a tornado. When the gas reaches the bottom of the cyclone, it reverses direction and flows up the center of the tube, also in a spiral pattern. Figure 7-2 shows a typical top entry cyclone. These cyclones have a distinctive and easily recognized form and can be found in many industrial applications (e.g., lumber companies, feed mills, cement plants, power plants, and smelters).

Figure 7-3 illustrates an axial entry cyclone, in which the gas inlet is parallel to the axis of the cyclone body. Here, the exhaust gases enter from the top and are forced into a vortex pattern by the vanes attached to the central tube. Axial entry cyclones are commonly used in multicyclones.

Figure 7-4 illustrates a large cyclonic-type separator that is often used after wet scrubbers to collect particulate matter entrained in water droplets. The gas enters tangentially at the bottom of the drum, forming a vortex. The large water droplets are forced against the walls and are removed from the gas stream.

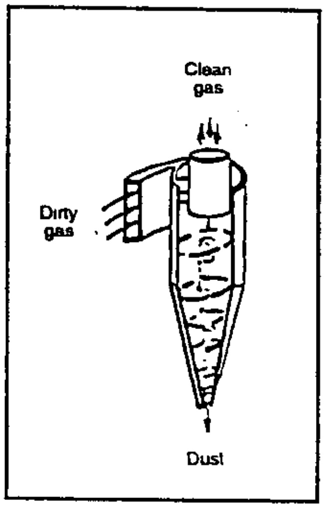

Figure 7-2. **Top Inlet**

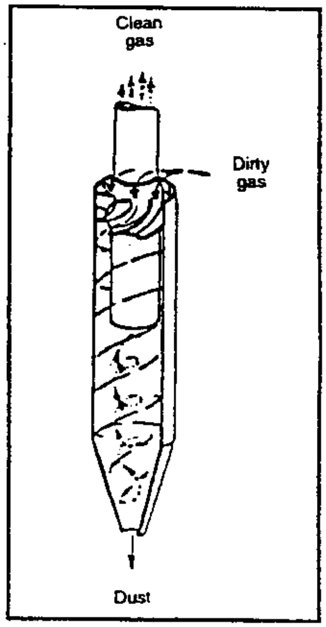

Figure 7-3. **Axial Inlet**

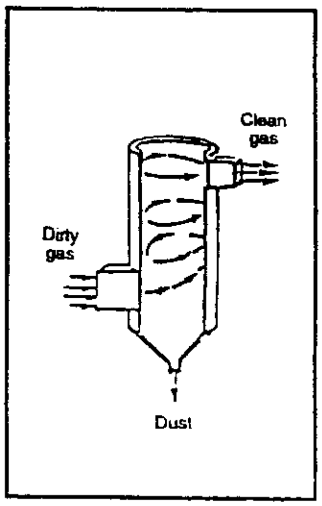

Figure 7-4. **Bottom Inlet**

How Efficient Are Cyclone Collectors?

The particle collection efficiency of a cyclone depends on a number of factors, including the dimensions (length and diameter) of the cyclone, the inlet gas velocity, the particle size, and the dust concentration in the gas stream. Collection efficiency tends to increase when inlet gas velocity increases and when particle size and dust concentrations increase. Also, smaller cyclones are usually more efficient than are larger cyclones.

Collection efficiency depends on:

- *Cyclone dimensions*
- *Inlet gas velocity*
- *Particle size*
- *Dust concentrations*

Collection efficiency increases as gas velocity, particle size, and dust concentrations increase.

The physical condition of the cyclone body also affects removal efficiency. Dents, riveted joints, and other surface irregularities can disrupt the vortex within the cyclone, thereby causing particles to bounce back into the center of the cyclone instead of being concentrated near the cyclone wall. Air infiltration through the solids discharge valve, holes, or weld failures can also disrupt the vortex.

The physical condition of the cyclone body affects collection efficiency.

Large-Diameter Cyclone Collectors

A single, tangential-entry, large-diameter cyclone is illustrated in Figure 7-5. The gas stream enters near the top of the cyclone through the tangentially oriented inlet duct. A typical large-diameter cyclone ranges from 1 to 12 ft. in diameter. The static pressure drop, a function of gas flow rate, varies from 1 to several inches of water column. (Note: 1 psi = 27.7 in. of water column.) Large-diameter cyclones are effective on only relatively large particles.

Large-diameter cyclones effectively remove relatively large particles.

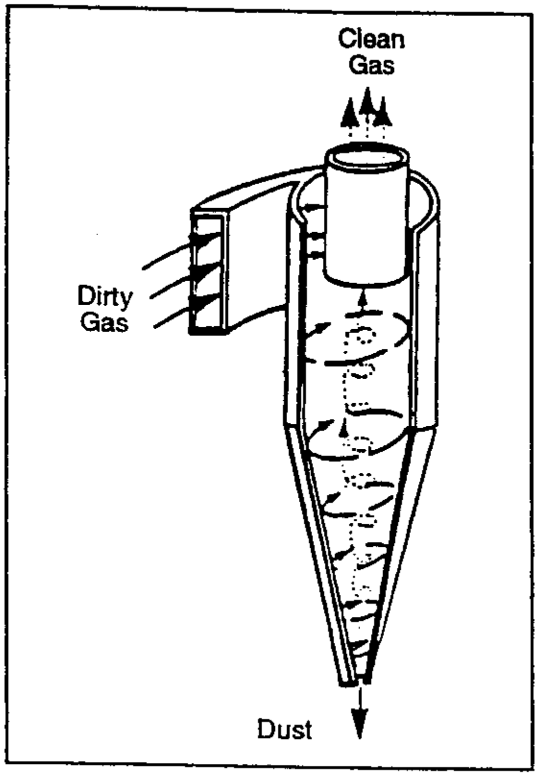

Figure 7-5. Single, Tangential-Entry, Large-Diameter Cyclone

Multicyclone Collectors

A common multicyclone unit is illustrated in Figure 7-6. The gas stream enters the multicyclone between the clean- and dirty-side tubesheets. **Spinner vanes**, mounted near the top of each cyclone tube, cause the gas to rotate as it passes downward (Figure 7-7).

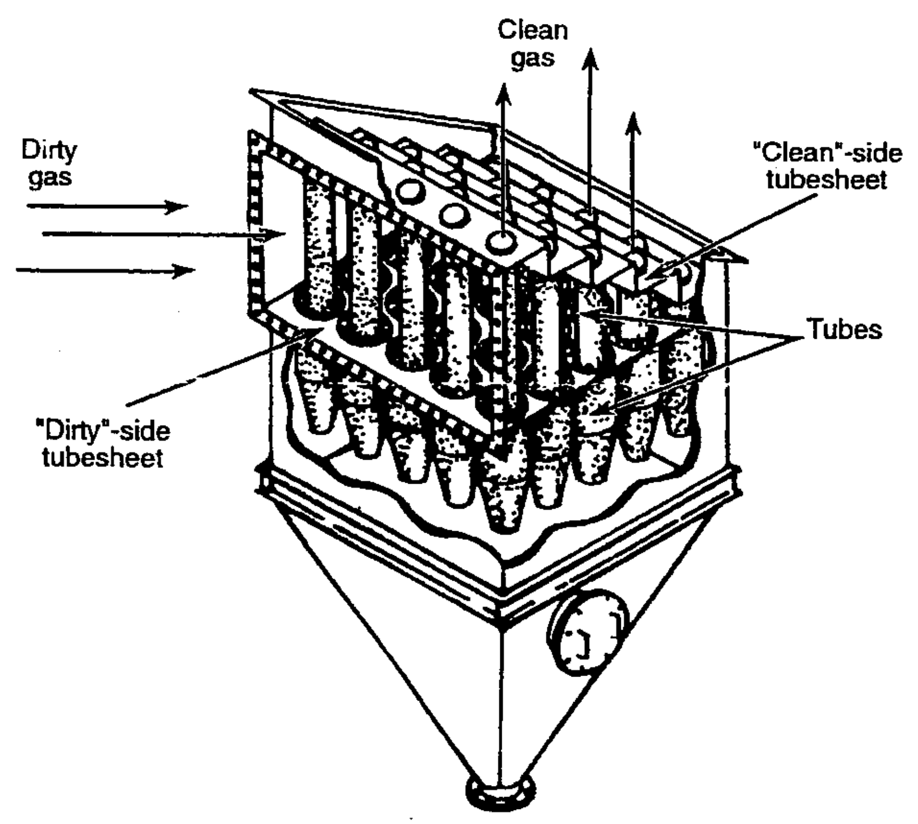

Figure 7-6. Typical Multicyclone With Axial-Entry Cyclones

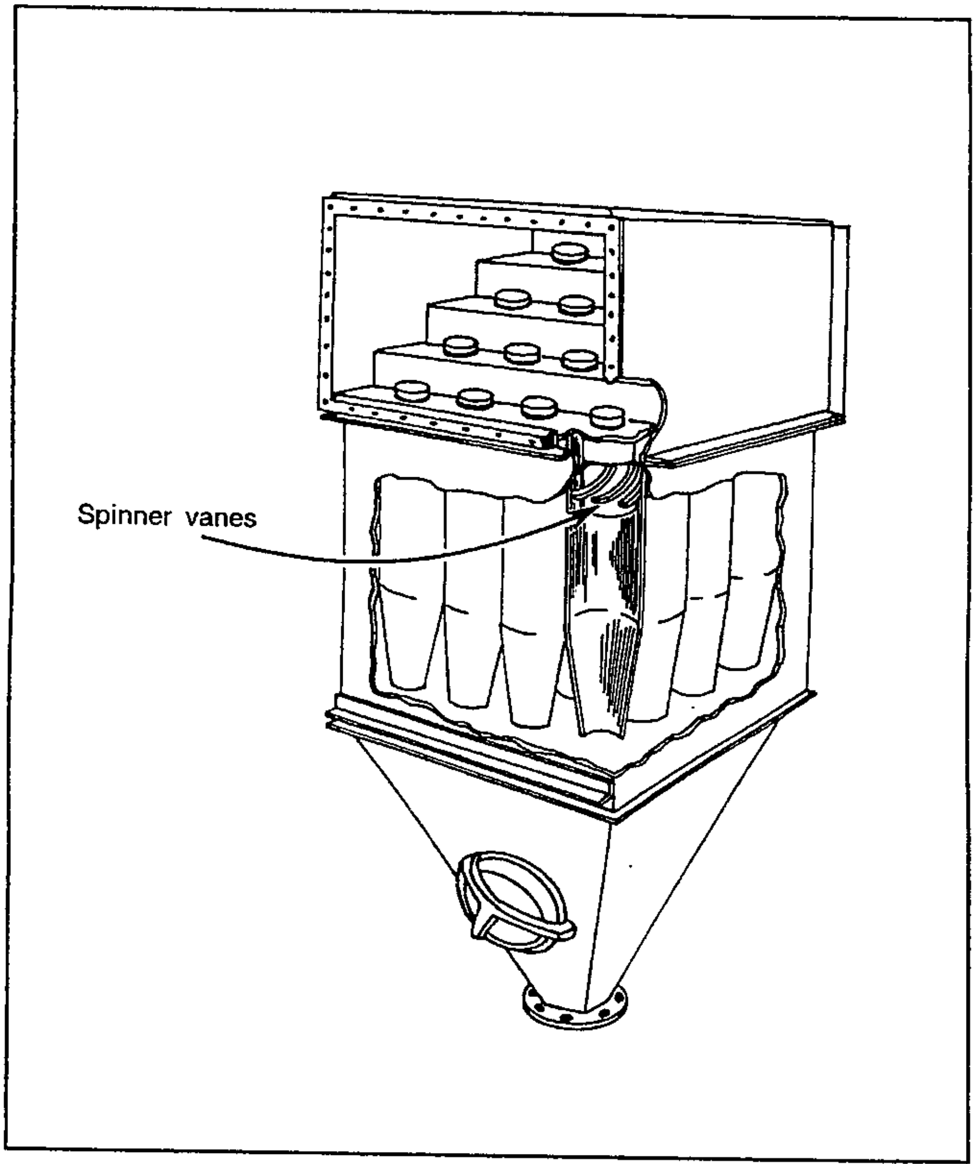

Figure 7-7. Spinner Vanes In A Typical Multicyclone

How Do Multicyclone And Large-Diameter Cyclone Collectors Differ?

Multicyclone collectors are more efficient, because they use a number of small-diameter cyclone tubes mounted in a single chamber. Commercial multicyclone units have 16 to 200 individual tubes in a single collector.

Multicyclone collectors contain a series of small cyclones.

Compared to large-diameter cyclones, the higher centrifugal forces within the small (3- to 12-in.) tubes of a multicyclone increase the collection efficiency for small particles. This increased efficiency is achieved at the expense of a higher static pressure drop (2 to 8 in. of water) across the unit.

Multicyclones effectively remove relatively small particles.

Common operating problems of multicyclone collectors include spinner-vane pluggage, outlet-tube erosion, gasket failure, air infiltration, and hopper overflow.

Typical Emission Points

Emissions can occur at corrosion and erosion points.

The uncontrolled effluents or emissions from a mechanical collector are usually emitted through a stack or vent. Emissions can occur at points where holes have developed, through corrosion and erosion of the mechanical collector and associated ductwork.

Typical Inspection Areas

The major inspection areas for the mechanical collector system include:

- Stack or vent exit.
- Physical condition of the unit (corrosion and erosion).
- Internal physical condition (inspect only when out of service).
- Pressure gauge.
- Solids discharge valves.

Summary

Mechanical collectors control particulate pollutant emissions by using gravity settling, inertia, and dry impaction. Static pressure drop is the most important factor in evaluating these control devices. Opacity and solids discharge rates are other factors helpful when evaluating mechanical collector performance.

Two types of mechanical collectors that are most useful, depending upon the size of the particle being captured, are large-diameter cyclones and multicyclones. Cyclones are frequently used as precleaners for ESPs and fabric filters.

Large-diameter cyclones are most effective in removing relatively large particles from a gas stream. Multicyclone collectors use a number of small cyclone tubes to remove small particles from a gas stream effectively.

Review Exercises

1. Particles are collected in cyclones because:

   a. Their inertia causes them to break out of the gas stream and hit the wall of the cyclone.
   b. They are electrostatically attracted to the walls.
   c. The gravitational forces overcome the centripetal forces.
   d. They are affected by sieving action.

2. Particle collection efficiency in a cyclone depends upon a number of factors that include:

   a. Cyclone dimensions
   b. Inlet gas velocity
   c. Particle size
   d. Dust concentration
   e. All of the above
   f. a, b, and c only

3. True or false? Small cyclones are less efficient than are large cyclones, especially for collecting smaller particles.

4. True or false? Multicyclone collectors have a higher static pressure drop than do large-diameter cyclones.

5. True or false? As the gas flow rate in a cyclone increases, the efficiency of particulate matter collection decreases (assume all other factors remain constant).

Answers

1. a. Their inertia causes them to break out of the gas stream and hit the wall of the cyclone.

2. e. All of the above

3. False. The higher centrifugal forces within small cyclones increase collection efficiency for small particles.

4. True

5. False. Collection efficiency tends to increase when gas velocity increases.