Understand Cyclone Design

Here are equations and a software program to design cyclones properly.

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Cyclones are widely used for the separation and recovery of industrial dusts from air or process gases. Cyclones are the principal type of gas-solids separator using centrifugal force. They are simple to construct, of low cost, and are made from a wide range of materials with an ability to operate at high temperatures and pressures. Cyclones are suitable for separating particles where agglomeration occurs. Pollution and emission regulations have compelled designers to study the efficiency of cyclones.

Cyclones offer the least expensive means of dust collection. They give low efficiency for collection of particles smaller than 5 μm. A high efficiency of 98% can be achieved on dusts with particle sizes of 0.1 to 0.2 μm that are highly flocculated.

Cyclone reactors permit study of flow pattern and residence time distribution *(1,2)*. For example, see the studies by Coker *(3,4)* of synthetic detergent production with fast reaction. Reactor cyclones are widely used in separating a cracking catalyst from vaporized reaction products.

Reverse flow cyclones are the most common design, in which the dust-laden gas stream enters the top section of the cylindrical body either tangentially or via an involute entry. The cylindrical body induces a spinning, vortexed flow pattern to the gas-dust mixture. Centrifugal force separates the dust from gas stream; the dust travels to the walls of the cylinder, and down the conical section to the dust outlet. The spinning gas also travels down the wall toward the apex of the cone, but reverses direction in an air core and leaves the cyclone through the gas outlet tube at the top. This consists of a cylindrical sleeve, the vortex finder, whose lower end extends below the level of the feed port. Separation depends on particle settling velocities, governed by size, density and shape.

Stairmand *(5)*, Strauss *(6)*, and Koch and Licht *(7)* have given guidelines for designing cyclones. The effects of feed and cyclone parameters on the efficiency are complex, as many parameters are interdependent. Figure 1 shows the design dimensions of a cyclone; Table 1 gives the effects on cyclone performance in the important operating and design parameters.

Cyclone design procedure

The computation of a cyclone fractional or grade efficiency depends on cyclone parameters and flow characteristics of particle-laden gases. The procedure involves a series of equations containing exponential and logarithmic functions. Koch and Licht *(7)* described a cyclone using seven geometric ratios in terms of its diameter as:

$$\frac{a}{D_c}, \frac{b}{D_c}, \frac{D_e}{D_c}, \frac{S}{D_c}, \frac{h}{D_c}, \frac{H}{D_c}, \frac{B}{D_c},$$

They further stated that certain constraints are observed in achieving a sound design. These are:

$a < S$ to prevent short-circuiting;

$$b < \frac{1}{2}(D_c - D_e)$$

to avoid sudden contraction;

$S + 1 \leq H$ to keep the vortex inside the cyclone;

$S < h;$

$h < H;$