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A STUDY OF THE SEPARATION OF PARTICLES FROM GASES

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ABSTRACT

Cyclones are the simplest and most reliable means of particle and gas separation. They also function as a method of air pollution control and as a cost efficient way of doing so. These basic machines have been in use for many years, and based on advances in technology, cyclones have now been designed for specific applications and conditions. These applications are restricted by inherent properties of the construction of the cyclone, and the materials being separated within the cyclone.

INTRODUCTION

Cyclones are the main type of gas-solid separators on the market today using centrifugal force. They are popular for a few reasons. First, and most importantly, they are the most efficient inertial devices, and at the same time, very inexpensive. Secondly, they come in varieties, which are based on their intended use and function. This flexibility allows them to operate at extreme temperatures and pressures. These conditions are possible as long as certain guidelines are met. The particles must adhere to size criteria, which will allow for a long period of use. Also, in addition to the particles being restricted in size, other factors must be considered. Density of particles, gas velocity and behavior, and dimensioning must also be carefully observed. Being there are an array of cyclones, they have been categorized as; returned or reverse flow tangential cyclones, axial flow cyclones, and uniflow cyclones. These cyclones have, more or less, gone through an evolutionary stage, where older models were replaced with newer, more efficient designs based on extensive research and studies. Currently, the high efficiency/reverse flow cyclone is most commonly used as to its predecessors.

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BODY

Reverse flow cyclones are the most commonly used. Here, the dust-laden gas enters the top section of the cylinder tangently. The cylinder induces a vortex, which in turn, causes the particles to be thrown outward by centrifugal force. These particles then fall down the wall due to the force of gravity into a dust collector often referred to as a bunker. As the dust particles fall, the now clean air re-entrains upward to the outlet tube at the same as those that envelop the other forms, such as the axial flow and uniflow cyclone.

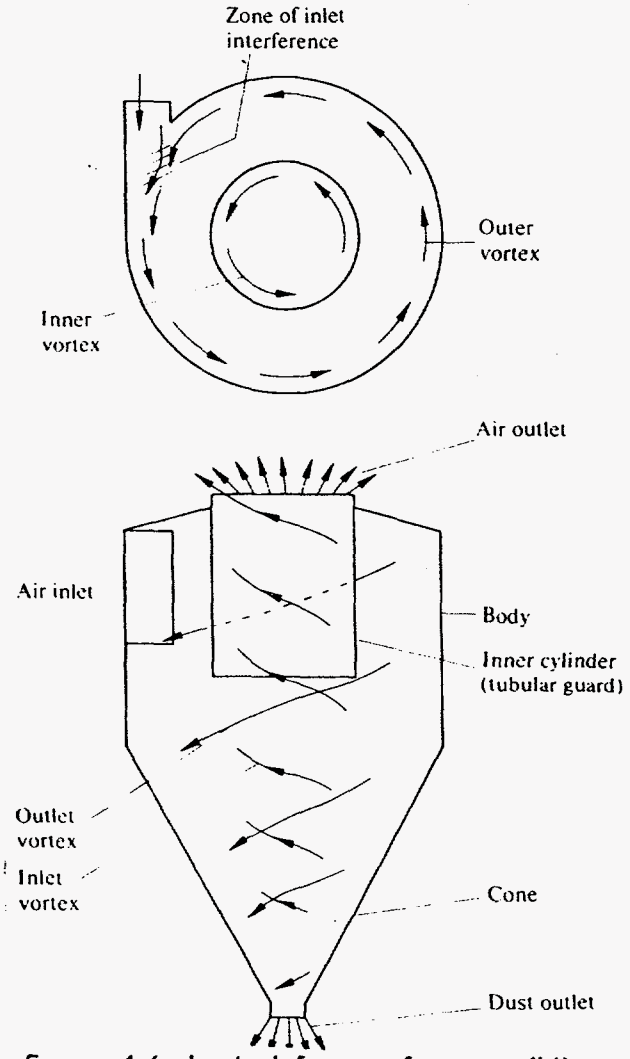

figure 1.(adapted from reference #4)

A major concern to industries who utilize cyclone filter systems is application and efficiency. The desired performance is achieved by a compilation of several factors. They include; size, proportion, pressure drop, gas density, and inlet velocity.

Looking at size first, in most cases, smaller cyclones are more efficient than larger cyclones. Obviously, because of size, larger cyclones are able to separate higher capacities of dust-laden gas, to equate this, multiple smaller cyclones are ran in parallel. These factors described are under the assumption that the proportionality of the cyclone is correct for its desired function. Computer programs are currently used by industries that give the appropriate dimensions for cyclones based on applications.

Another factor, which is dependent upon the dimensions of the cyclone is pressure drop. As pressure drop increases, so does the performance of the cyclone. Directly varied with pressure drop is gas density. When gas density is increased, as stated, pressure drop increases, and therefore, again there is an increase of efficiency. The gas density is closely related to the flow behavior of the gases induced into the system.

Particle diameter and density, has a very obvious effect on the efficiency of the system. A cyclone filtering particles of 5 micrometers had a low total efficiency, but when the particles are reduced to .1 to .2 micrometers, 98% efficiency is obtainable. Also observed, as the particle diameter increases, efficiency increases until the limit of cyclone's design is reached. (see fig3)

Lastly, but equally as important, the velocity of the incoming gas is very crucial. If the velocity is not high enough, the dust is capable of settling in the pipe and obstructing the gas flow. Also, on the other hand, if the velocity is too high, possible abrasion damage can occur. As long as the velocity is within the confines of the limitations of the cyclone, generiсly speaking, higher velocities prove for high efficiency.

No system is totally fail proof, nor flawless. But with the cyclone, most trouble or failure is due to carelessness or blatant misuse. Proper materials are required in the construction. The materials used, must be able to remain in a smooth state to minimize turbulence in the spinning column. The material must also withstand high temperature and pressure as well as abrasion. In addition to this, there must be rigid adherence to the specifications of size and application of size and application.

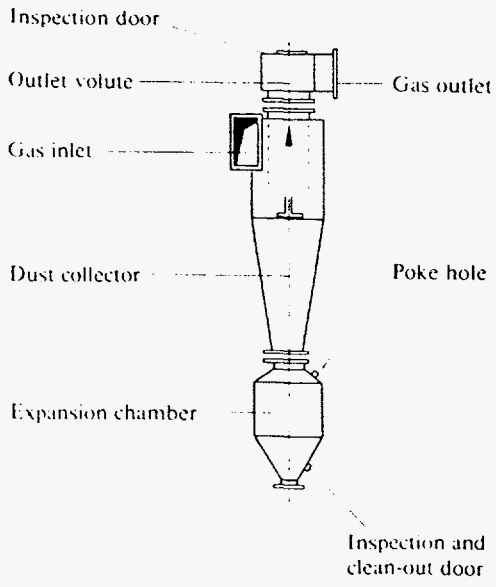

figure 2.(adapted from reference #4)

In most cases, malfunctions occur from some of the following:

-a hole in the cyclone body,
-a cyclone volute plugged,
-inappropriate modifications for unintended original use, which includes cutting of pipes, or dishing of heads,
-an improperly sealed dust bunker, and
-excessive gas inlet velocity.

To avoid such mishaps, proper data collecting software tools are necessary for calculating and monitoring dust-gas behavior. Also, these software tools aid in the improvement of design for cyclones.

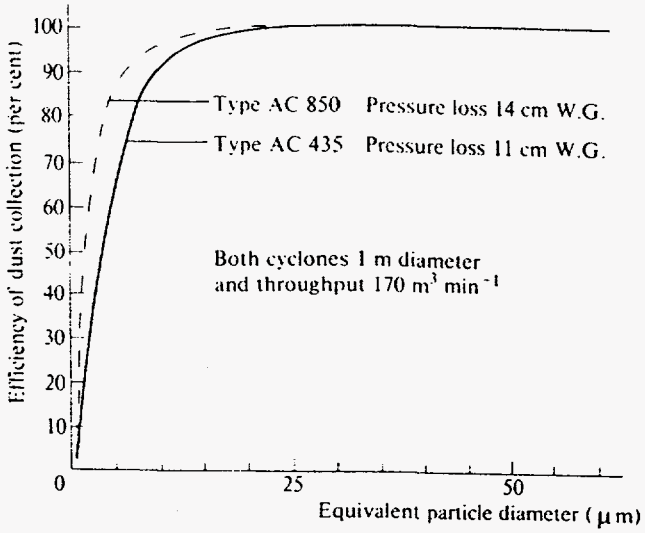

figure 3.(adapted from reference #4)

CONCLUSION

Cyclones are a very cost effective means of filtering solid particles from gases. They come in a variety of sizes and have a variety of applications. Their efficiency is dependent upon size, proportion, pressure drop, gas density, and gas inlet velocity. Cyclones will perform for long periods of time as long as they are properly monitored and maintained. These key factors make them very popular, and more importantly, very effective.

ACKNOWLEDGEMENTS

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REFERENCES

1. Designing efficiency into cyclones.
PROCESS ENGINEERING. April 92. pg106-07.

2. Understand Cyclone Design
Chemical Engineering Progress. Coker, A. Dec 93. pg51-55.

3. Separation of Particles from Air and Gases
Akira Ogawa, Dr. Eng. CRC Press, Boca Raton, FL. 1984 pg1-10, 13-17.

4. Industrial Air Pollution Handbook.
Ed. A. Parker. McGraw-Hill Book Co. (UK) Limited 1978.