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PERFORMANCE OF A CYCLONE COMBINED WITH ELECTROSTATIC PRECIPITATOR

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In the present investigation a cylindrical electrostatic precipitator was built into a cyclone's outlet tubes, and was tested at various dusts and voltages. It has been found that the penetration (the unremoved fraction of the dust) for the airborne particles ($d < 10$ mm) in the case of working built in electrostatic precipitator, decreased to 5–10% of the penetration of the (only) mechanical cyclone operation. The penetration data is given at various dusts and voltages. All are proving that the method is working satisfactorily. If the voltage was smaller than the on set voltage of the discharge, the better performance could be observed. It means that with electric field it is possible to utilize the tribo-charge of the dust particles caused by the collision with the wall of the cyclone.

Keywords: *cyclone, electrostatic precipitator, airborne dust*

Introduction

One of the most serious problems nowadays is the environmental pollution. In air pollution some important measures have been established since decades, and the emission of some dusts and gases can be stopped by precipitators, such as by cyclone, electrostatic precipitator, and others. Unfortunately, the mission of airborne dust is still causing environmental and health problems worldwide, which need to be solved.

It is well known that cyclones can remove dust successfully if the sizes of the particles are above 20–30 mm. The removal efficiency can be improved by increasing gas speed, if it is below 16–20 m/sec.

The electrostatic precipitators are working well if the average particle diameter is above 10–20 mm. The removal efficiency is decreasing by increasing gas speed. The optimal value is below 2 m/sec. If the length of the electrostatic precipitator (ESP) is increasing, and the gas speed is decreasing then the smaller diameter particles are removable. Unfortunately, the size of the equipment is too large, and the cost is too high in these latter cases.

At the first extent the combination of the cyclone and the electrostatic precipitator seems to be senseless, but if we consider that the motion of the gas and the particle in the tube of the outlet (dip pipe) at the center of the cyclone is still circular; and the gas will turn around the internal perimeter of this tube more than 5–10 times, then we can realize that the particles move along this surface a long way.

Considering those facts, we built a cylindrical electrostatic precipitator into the outlet tube in order to remove airborne dust ($d < 10$ mm) from flue gases.

In literature very few papers are dealing with cyclone and electrostatic precipitator combined in some sense. One of them is the Handbook of electrostatic (Masuda, 1980). Papers dealing with the removal of airborne dust by using combined cyclone and electrostatic precipitator did not appear to the author of this paper.

Materials and methods

A cyclone was made with the geometry indicated in Fig. 1.

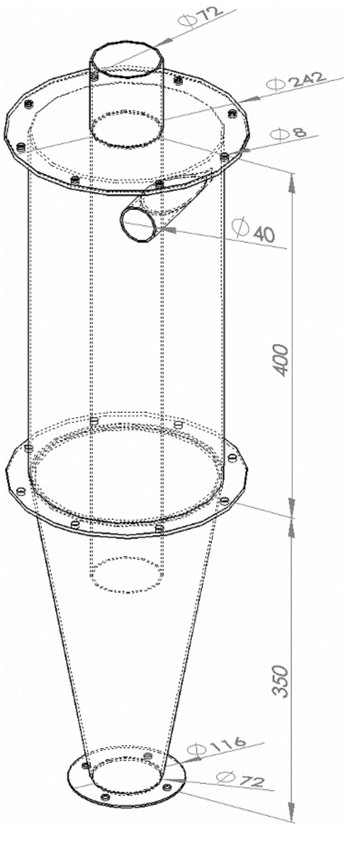

Fig. 1. The cyclone built for the investigation

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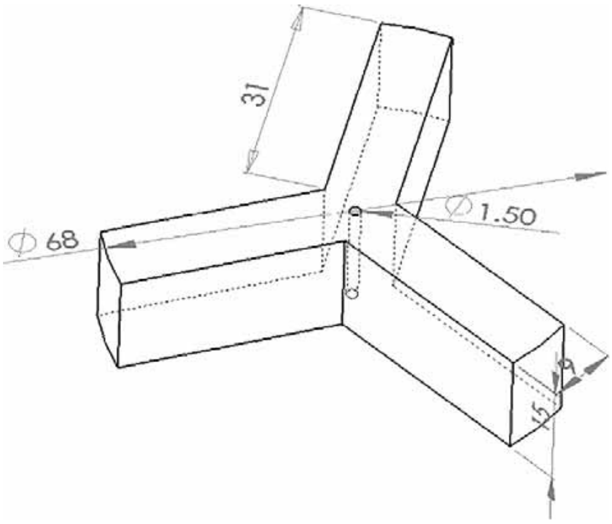

Fig. 2. The supporter of center wire placed in the ends of the dip pipe

The internal diameter of the dip pipe is 68 mm. A wire with the diameter of 0.7 mm was fixed at the center by to supporter shown in Fig. 2.

A DC high voltage power supply was made which could operate between 0 and 20 kV. The negative pole of the power supply was connected to the wire at the center, and the positive was fixed to the cylinder (of the dip pipe) and the cylindrical part of the cyclone.

As the result, the dip pipe (the outlet tube) is working as a 500 mm long electrostatic precipitator.

The speed of the ambient air introduced to the cyclone (and therefore to the electrostatic precipitator) was varied between 3 and 12 m/sec. Most of the data were taken around 8 m/sec air speed.

The particles tested were selected gypsum (d = 10 mm and 20 mm), a sieved plaster material (d = 6 mm), graphite powder (d = 8 mm) used in foundry,

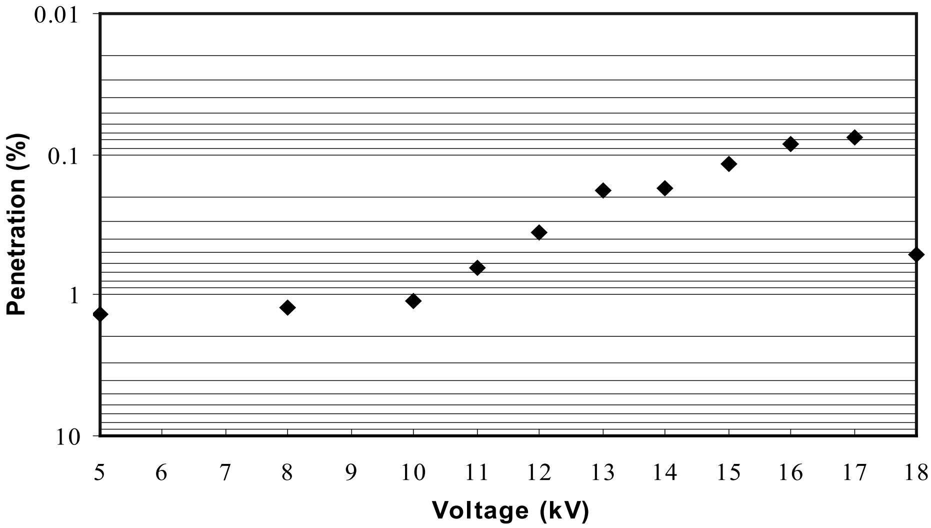

Fig. 3. The penetration of the ESP combined cyclone as the function of applied DC voltage with gypsum (d = 20 mm) powder at 8 m/sec air speed

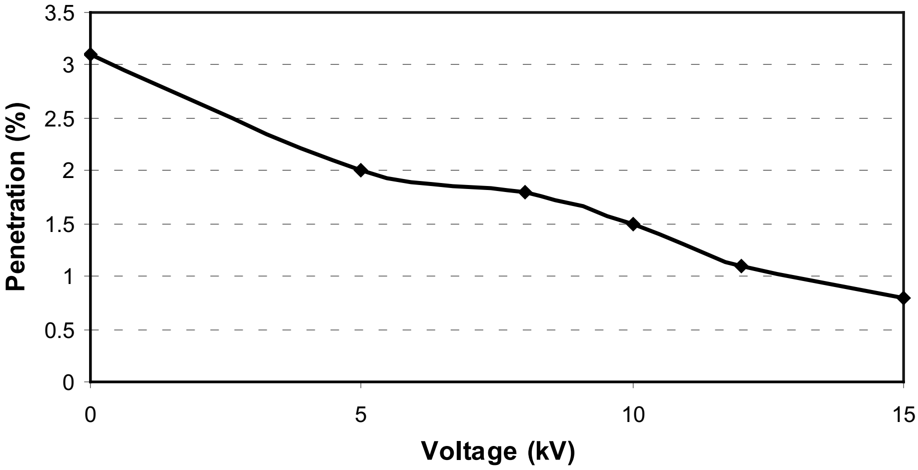

Fig. 4. The penetration of the cyclone combined by ESP vs. DC high voltage in case of gypsum powder with the mean diameter of 10 mm at 7 m/sec air inlet speed

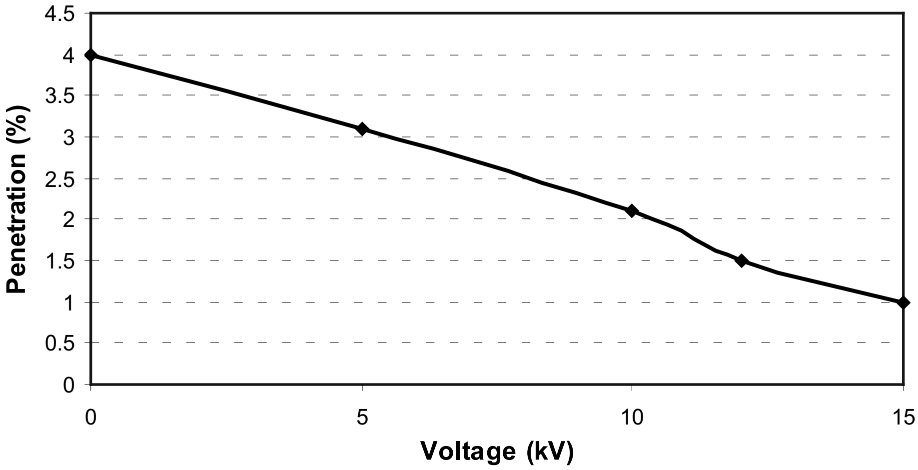

Fig. 5. The penetration of the cyclone combined by ESP vs. DC high voltage in case of graphite powder with the mean diameter of 8 mm at 7 m/sec air inlet speed

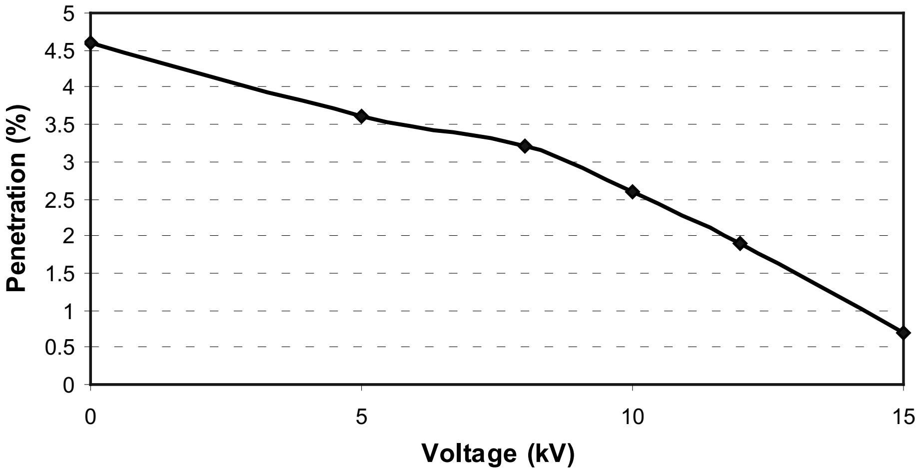

Fig. 6. The penetration of the cyclone combined with ESP vs. DC high voltage in case of a sieved plaster material powder with the mean diameter of 6 mm at 7 m/sec air inlet speed

a medical powder ($d = 4$ mm), aluminum oxide powder ($d = 1$ mm), and many other.

The temperature of the air was between 22 and 24 °C, and its relative humidity was between 75 and 80%.

To determine the removal efficiency (η) and the penetration (P, which is $100 - \eta$, if both measured in %), the mass of the fed dust was measured, and at the outlet the precipitated dust mass was also measured by bag filter. The penetration is the ratio of the latter and the former expressed in percentage.

Results

The cyclone itself (without electrostatic field) has efficiency above 90% for the powders investigated. The efficiency was improved by increasing air speed.

If the DC high voltage power supply was switched on, the efficiency increased, and the penetration decreased for all of the tested dusts.

In case of gypsum powder the penetration at 8 m/sec is plotted against the applied DC voltage in Fig. 3. In this figure the results are displayed in the traditional ESP manner.

It is important to mention that the penetration at 0 kV was about 3%, and the corona onset voltage is about 9–10 kV at this geometrical arrangement. It means that the particles have own electric charges when they enter into the ESP. This charge can be a tribo-charge caused by the collision of the particle with the wall of the cyclone.

The decrease of the penetration at 18 kV is caused by some random breakdowns of the ESP, above that voltage the operation was hampered by sparks.

The penetration of gypsum with the mean diameter of 10 mm is plotted against the DC voltage of the ESP is given in Fig. 4.

In foundry industry graphite powder is used quite often, and by the end of the casting process it is blown out from the factory into the environment. Before discharging the exhaust gas, it is filtered, but the filtering out of these fine particles is a rather difficult task. Cyclone itself cannot solve the problem, but by combination with ESP we can keep the environment by removing the ultrafine particles, as the experimental results indicated. The penetration of the graphite powder with the mean diameter of 8 mm is given as the function of the ESP's DC high voltage at 8 m/sec inlet air speed in Fig. 5. The penetration of some sieved plaster material is given in Fig. 6.

Summary

The cyclone combined with electrostatic precipitator can remove airborne particles (dusts with the mean diameter of less then 10 mm) of various forms. The ordinary cyclone can be modified very easily by building in an ESP into the dip pipe. The power supply is rather cheap. The performance of the new equipment can be better than that of the ordinary ESP.

It is suggested to name the new device electrostatic precipitator enhanced cyclone, ESPEC. The application of this device to remove airborne particles from flue gases is recommended.

Reference

Masuda, S: Handbook of electrostatic, OMU, Tokyo, Japan, 1980, p. 264