7.6 Dust Collector

7.6.1 Introduction

Dust collecting is the operation which collects and separates the particles contained in processing gases. Generally, the dust collector is used in the last step of the production process and it is called an air pollution control equipment. However, it is used in various fields with divergent purposes such as preservation of the work environment, purifying exhaust gas, recovery of useful particles and improving the purity of processes. Generally, fine particles are generated during mechanical operations such as pulverizing in addition to soot particles occurring during the combustion process, and these are generically called "dust". Here, recent techniques for collecting the dust in exhaust gas are reviewed.

7.6.2 Changes in the dust collecting techniques in Japan

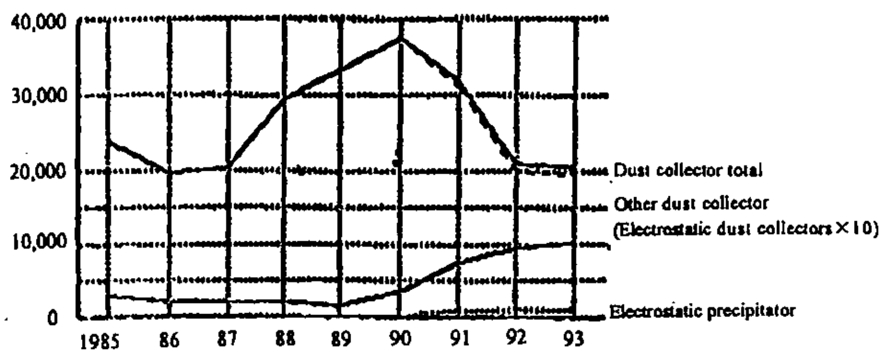
Dust collecting technology was mainly developed after the war, and, at present, the technology enables the separation and removal of minute particles to the sub-micron size. Air pollution control became regarded as highly important with the soot and dust emission standard strengthened time and again, and dust collecting techniques improved in response to this. There are limitations in dust collecting technology such as the theoretical possibility for separation and collecting of particles, especially as to particle size, and the dust collecting efficiency [1) 2)]. For example, in the past, the emission standard for dust could be cleared with scrubbing dust collector such as scrubbers and cyclones which are centrifugal dust collectors, but, with today's severe standard, the situation has reached the point where highly efficient equipments such as filter dust separator like bag filters and electrostatic precipitator (ESP) must be utilized. Moreover, in recent years, with the high temperature/high pressure technology aiming for energy saving through the use of waste heat, new high temperature dust collecting equipments such as ceramic filters and packed-bag filters has started to appear.

7.6.3 Classification of dust collector

The dust collector uses one or several methods at the same time such as gravity, inertial force, thermal power, diffusion power, electric power to separate dust from inside exhaust gas then collect it in dust hoppers. The main devices for dust collecting are classified as (1) gravity dust collectors, (2) inertial dust collectors, (3) centrifugal dust collectors (cyclones), (4) scrubbing dust collector, (5) filter dust collectors (bag filters) and (6) electrostatic precipitator [6)]. Table 7.6.1 shows the general characteristics of these main devices, with (1) to (3) having the purposes of preprocessing the high concentration dust (primary treatment) and separating and collecting from large mists, and the purpose of (4) to (6) is to reach the emission standard. Fig.7.6.1 shows the change in the number of dust collecting units produced in Japan, of which the total number reflects the business conditions. Since hitting the peak in 1990, the number of units has been declining except that among the several thousand units of ESP and other dust collector, the bag filters have been on an increasing trend.

Table 7.6.1 The practical-use range of dust collector

Name	Type	Particle size (μ m)	Pressure loss (mmH_2O)	Collection efficiency (%)	Equipment cost	Operating cost
Gravity dust collector	Baffle chamber	1,000-50	10~15	40-60	Small	Small
Inertial dust collector	Looper	100~10	30~70	50~70	Small	Small
Centrifugal dust Collector	Cyclone	100~3	50~150	85~95	Medium	Medium
Scrubbing dust collector	Venturi scrubber	100~0.1	300~900	80~95	Medium	High
Sonic precipitator		100~0.1	60~100	80~95	Medium or higher	Medium
filter dust separator	Bag filter	20~0.1	100~200	90~99	Medium or higher	Medium or higher
Electrostatic precipitator		20~0.05	10~20	90~99.9	High	Small to medium



Source: The Ministry of International Trade and Industry: " The Machine statistic yearbook"

Fig.7.6.1 Production of dust collector (Units)

7.6.4 Development of new technology

(1) Filter dust separation technology

① Ceramic filters [9]

The base materials for ceramic filters are silica, alumina, zirconia and silicon carbide, because they have to collect dust in high temperature/high pressure exhaust gases that range in temperature from 300 to 1,300℃ and at pressures from several atmospheric pressures (ATM) to 10 ATM and above. The shape is that of a porous cylinder made from woven or non-woven materials, or the cross flow as shown in Fig.7.6.2 which can cover a very large filtration area. The advantage with this equipment is that it is compact, but the negative points include increased loss of pressure, due to the dust, the life cycle, and the shaking-off characteristic of dust.

② Packed bed filters

The particle collection mechanism operates by thermodynamics accompanied by a temperature difference between the high temperature exhaust gas and the traveling particles in the packed bed, in addition to inertial force, diffusion, power interruption and gravity. The equipment which was developed for high temperature/high pressure dust collecting uses materials such as sand, gravel and ceramics several millimeters in size and is adaptable to high temperature exhaust gases of about 500℃. The dust collection efficiency is about 93% when the dust size is about

1 μ m and the pressure loss is at about the same level with the conventional bag filter.

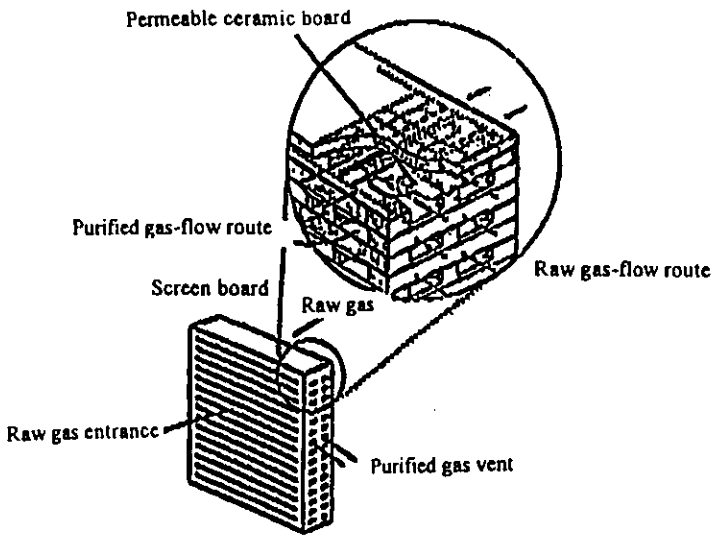


Fig.7.6.2 Ceramic cross flow filter

③ Electret filters [10]

The mechanical particle collection mechanism of previous filters was not effective in collecting particles of around 0.1 μ m. The electret filters is made of fiber with a semi permanently polarized electric charge. In addition to the mechanical particle collector, the electret filter allows the induction force to work on unelectrified particles, the electric force (coulomb force) and the induction force work on electrified particles. Therefore, particles of around the 0.1 μ m range are efficiently collected, and particles of other sizes can be collected, too, at a high degree of efficiency with the same pressure loss as that of the conventional bag filter. The electret filter is an energy-saving filter which collects particles with a high efficiency and low pressure loss.

(2) Electrostatic precipitation technology

① Pulse-charge type

A reverse corona and a reverse ionization phenomenon occur in the collection of highly electrical resistant dust such as that from coal combustion and this becomes a problem with electrostatic precipitator, which causes a remarkable decline in the collection efficiency, one piece of equipment developed to counter this problem was the pulse electric charge type of electrostatic precipitator (ESP). The conventional ESP uses direct current voltage but this equipment utilizes pulse high voltage. With the pulse electric charge, the distribution of the corona electric current can be established uniformly over a wide area without a drop in the applied voltage through adjusting the pulse frequency. Energy saving can be expected from lower power consumption and stable dust collecting, and it is possible to suitably operate because the corona electric current does not experience a reverse corona due to highly electrical resistant dust.

② Moving electrode type

As shown in Fig.7.6.3, moving the dust collecting electrode continuously to keep the dust collector's electrode surface clean minimizes the electric field formed by the layer of dust adhering to the electrode and inhibits reverse ionization. The electrode moves slowly downward, and the adhering dust is detached by a revolving brush in the non-electrified area in the lower part, keeping the electrode clean.

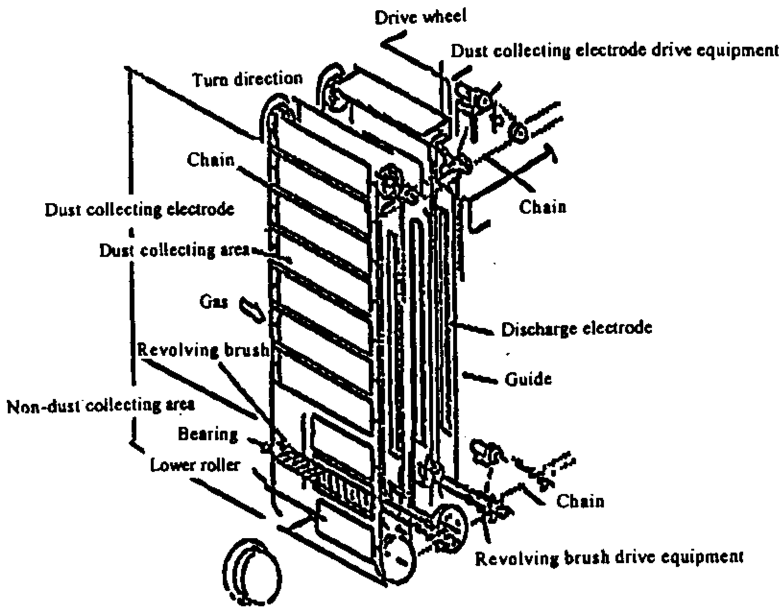


Fig.7.6.3 Structure of the moving electrode-type electrostatic precipitator

③ The high current velocity/wet process type [11]

This one narrows the interval between the dust collecting electrodes facing each other across the discharge electrodes as shown in Fig.7.6.4, quickening the flow velocity of the raw gas and realizing a compact size for the equipment. The dust collecting area is reduced substantially by almost 1/2 which increases the base raw gas flow velocity more than twice that of the past (2-3 m/s) and the discharge electric current density more than several times that of the past (0.3 mA/m^2).

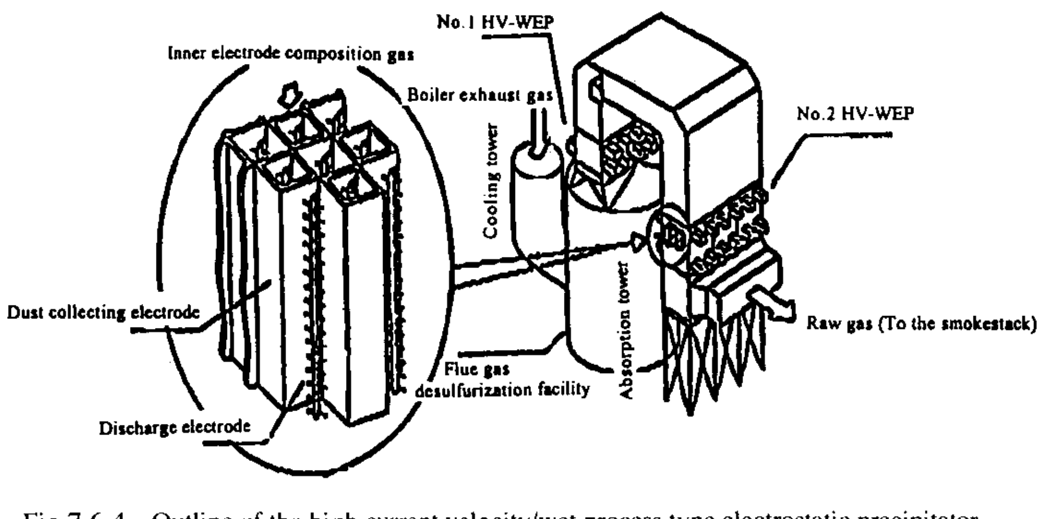


Fig.7.6.4 Outline of the high current velocity/wet process type electrostatic precipitator

7.6.5 Conclusion

Table 7.6.1 mentioned above compares the characteristics of the various dust collecting equipment. For a decision to be made on equipment selection, sufficient consideration is necessary involving the properties of the soot and dust emissions, the characteristics of the equipment, the equipment cost and cost performance. As new dust collecting technology advances steadily, there are many more than those mentioned above, please consult the reference literature and the related-industry standard given here.

Japan's dust collecting technology has reached a high technical level if it can be seen worldwide, but development of new technology in the future is important, too, and, while aiming for superior performance, precipitate technology should be expected to be energy-saving and resource-saving. Also, from the viewpoint of preserving the environment, it is necessary to examine together the reduction of the volume and the reusing of recycle from the enormous amount of dust collected.