5B4. Particulate Treatment Technology and Trace Element Removal Technology

Technology overview

1. Background

Like NOx, emissions of particulate matter are regulated, with acceptable concentration levels set according to the type of fuel and size of boiler. At present, however, some regions are subject to a "total amount control," which provides for a region-wide overall emissions level as is the case with sulfur and nitrogen oxides. To comply with the regulations, the world's first electrostatic precipitator was employed in a Yokosuka thermal power plant in 1966 and many other thermal power plants have followed suit. To improve power generation efficiency, the development of pressurized-bed combustion and coal gasification combined-cycle technologies that use cyclones and ceramic/metal precision-removal filters is underway.

On the other hand, trace element control is now being intensified, such as through the addition of boron (B) and selenium (Se) to the regulated wastewater materials, and through the application of U.S. regulations for mercury (Hg).

2. Technology

(1) Electrostatic precipitators

Research and development:

Mitsubishi Heavy Industries, Ltd.; Hitachi, Ltd.; Sumitomo Heavy Industries, Ltd.; others

Overview

Electrostatic precipitators remove particulate matter in exhaust gas in accordance with the theory that dust charged by a negative corona at a discharge electrode adheres to a positive dust-collecting electrode.

The particulate matter that adheres to the electrode is removed and falls when the cathode is tapped with a hammering device. The effectiveness of the dust removal depends upon the electrical resistance of the particulate matter, and is most effective in an electrical resistivity range of particles 10^4-10^{11}Ω·cm in size. Pulverized coal, where the thermal electrical resistance of many particles is high, requires various countermeasures be taken against such particles.

One such measure involves adjusting the temperature conditions for dust collection; electrical resistance changes are shown in Figure 2. Those successfully developed and commercialized based on such characteristics are a high-temperature electrostatic precipitator operated at 350°C, a higher temperature than that of conventional low-temperature electrostatic precipitators (130-150°C), in order to lower the electrical resistance, and an advanced low-temperature electrostatic precipitator, with its electrical resistance lowered by operating it at a dew point or lower temperature of 90-100°C. Other than these, successful commercialized technology includes a moving electrode method, which brushes off particulate matter by moving the electrode to prevent back corona due to dust accumulation at the electrode, and a semi-wet electrostatic precipitator where a liquid membrane is applied to wash away dust. Other methods are commercialized electric discharge technologies, including an intermittent charge system to supply a pulsed voltage of several milliseconds, and a pulse charging system for several tens of microseconds.

At present, leading pulverized coal-fired plants built in and after 1990 employ very low-temperature electrostatic dust collection processes that can treat particulate matter with various properties and shapes.

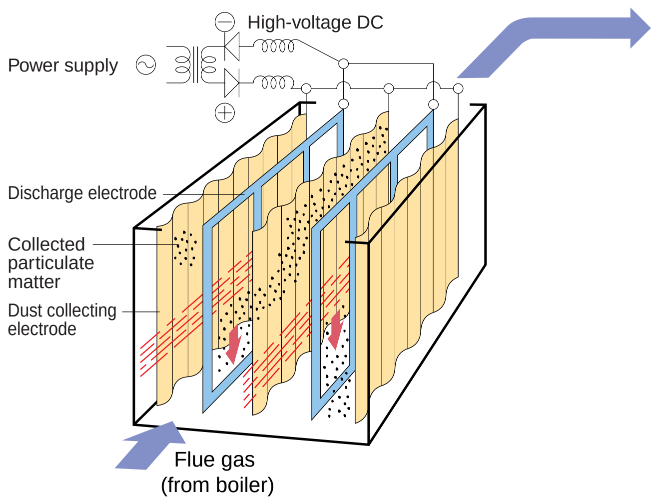

Fig. 1 Theory behind electrostatic precipitator

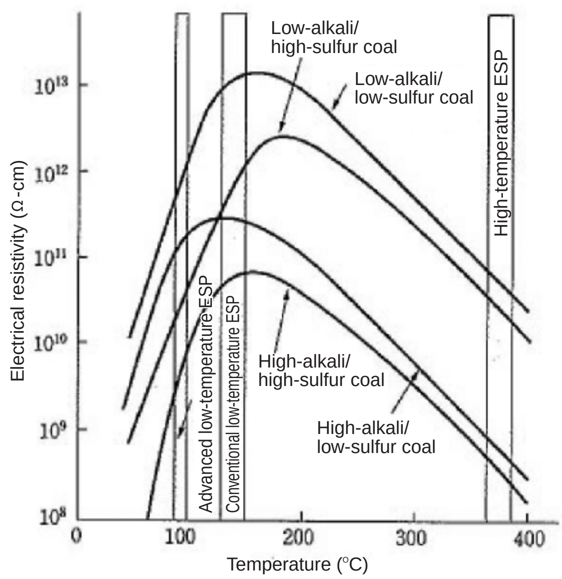

Fig. 2 Temperature effects on electrical resistance of coal ash

(2) High-temperature dust collection method

Research and development: Mitsubishi Heavy Industries, Ltd.; Hitachi, Ltd.; Kawasaki Heavy Industries Co., Ltd.; others

Overview

The high-temperature dust collection method is under development as a technology to remove particulate matter from hot gas for pressurized-bed combustion and integrated gasification combined-cycle (IGCC) power generation processes. This technology utilizes a multi-cyclone, a ceramic- or metal-based filter and a granular-bed method using silica or mullite to remove particulate matter. Multiple cyclones are mainly used for coarse, imprecise removal. Those used for precision removal include ceramic or metal filters of a cylindrical porous body into which SiC and other inorganic materials and iron-aluminum alloys are formed (Photo 1). The filters used for this method were developed by Nihon Garasu Kogyo or overseas by Paul Schumacher. Such technologies, now under durability evaluation/demonstration, are used for pressurized-bed combustion power generation at Hokkaido Electric Power's Tomatoh-Atsuma thermal power plant, with their verification tests conducted not only for IGCC at 200-tons/day at the Nakoso IGCC pilot plant but also under the EAGLE project. These technologies are also expected to be used at a 250MW IGCC demonstration unit slated for initial operation in 2007.

Photo 1 SiC ceramic filter

(3) Trace element removal method

Research and development: Japan Coal Energy Center

Project type: Subsidized coal production/utilization technology promotion project

Overview

Among the trace elements of coal, mercury is cited as the material released into the atmosphere at the highest rate, and approximately 30% of the mercury not removed by the precipitators/desulfurizers is thought to be released. However, nearly all bivalent mercury (Hg^{2+}) is removed, leaving behind nonvalent mercury (Hg) as the discharge matter. A method to remove this nonvalent mercury is being actively reviewed. The Japan Coal Energy Center, though still in the process of basic research, selected active carbon, natural inorganic minerals, and limestone as materials that can absorb mercury. Their absorption characteristics are now being evaluated. The research results prove that if a method to inject active carbon or an FCC ash catalyst into the flue for the removal of metal/mercury is combined with removal at the flue gas desulfurizer, 90% or more of the mercury can be easily removed.

References

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