Wide Air Quality Control System (AQCS) Product Line-up to Meet the Needs of Any Country World Wide

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As is common knowledge, emissions from thermal power plants contain PM and SOx, and can cause problems such as acid rain and health damage. Therefore, it is absolutely necessary for power plants and factories to have environmental equipment for the removal of such air pollutants (i.e., electrostatic precipitator and desulfurization equipment). In Japan, environmental issues became serious from the 1960s, and to address these issues, emission regulations were progressively introduced and laid down stricter standards. The current regulations in effect have some of the most stringent criteria in the world.

As a pioneer in developing flue gas treatment technologies, Mitsubishi Hitachi Power Systems, Ltd. (MHPS) has designed and supplied environmental equipment mainly for use at domestic/overseas thermal power plants, thus taking part in environmental conservation. Recently, environmental regulations are being reinforced in many countries. We are facing the challenge of adapting our Japan-developed advanced flue gas treatment technology in ways that suit the different conditions of flue gas based on the wide range of fuel supply situations and surrounding environment of relevant countries around the world, to be chosen as highly reliable technology.

1. Introduction (technology development)

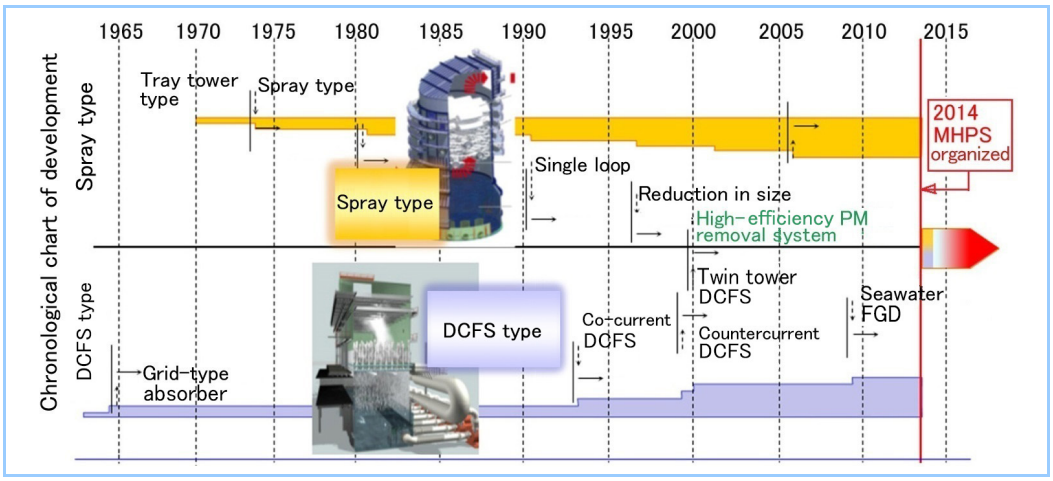

Figure 1 History of desulfurization technology development

The Japanese SOx and PM emission standards are more stringent than any other country. In recent years, global emission standards have become more demanding every year. In addition to an increase in the number of regulated substances, new types of fuel and more extensive operating conditions are also included and prescribed in the regulations. MHPS is a new company formed on

February 1, 2014 integrating the thermal power generation systems businesses of Mitsubishi Heavy Industries, Ltd. (MHI) and Hitachi, Ltd. MHPS merged with Babcock-Hitachi K.K. on October 1, 2014. MHI and Babcock-Hitachi K.K. had a history of developing relevant technologies even before the implementation of domestic environmental regulations for more than half a century and served as leading environmental plant suppliers. Their technology developments also contain practical applications of Japan's original environmental protection technologies such as high-efficiency PM removal systems (**Figure 1**).

Our desulfurization equipment has been used in countries around the world. We boast the top level of market share in both the domestic and global markets

2. Overview of MHPS product line-up

The line-up of our flue gas desulfurization equipment and related systems is presented below.

2.1 Wet-type desulfurization equipment

There are three major types of desulfurization processes for the flue gas of thermal power plants: wet, dry and semi-dry, and the wet-type desulfurization process is the most prevalent method for the power plant field because of its reliability and cost effectiveness. Of these, our products mostly employ the wet-type process. The following are plant examples of its distinct features.

(1) Limestone-gypsum wet desulfurization equipment for bituminous/subbituminous coal-fired boilers

Of the wet desulfurization processes, the wet limestone-gypsum method is the technology that has been used most commonly, and can be used in the treatment design with a high desulfurizatoin rate covering flue gas with a wide range of inlet SO_2 levels. In this method, naturally-produced limestone is used as an absorbent and gypsum (which is a by-product) is recovered as a valuable resource for recycling. Our desulfurization equipment is grounded in our extensive expertise accumulated from the very beginning of its development, and is highly valued by domestic/overseas clients especially in terms of reliability. MHPS' recent provision of desulfurization equipment includes one example in the U.S. that has the world's largest flue gas treatment capacity of more than 4 million Nm3/h through the use of a single tower, and another in Poland which collectively treats flue gas emitted from five different boilers through the use of a single tower (**Figure 2**).

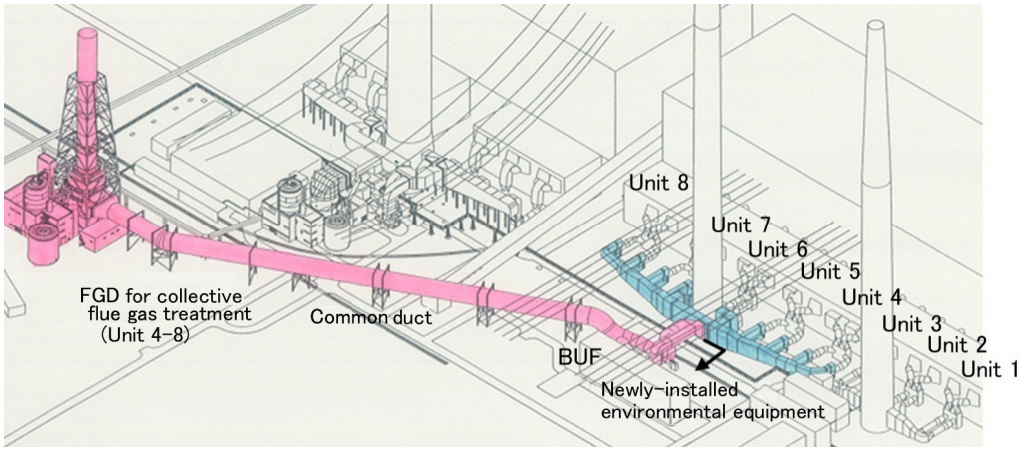

Figure 2 Desulfurization equipment installed at Kozienice power plant
Desulfurization equipment installed at Kozienice power plant, Poland. Collective treatment of flue gas from four boilers. Equivalent to 800 MW. Supplied in 2006.

(2) Limestone-gypsum wet desulfurization equipment for lignite-fired boilers

Because of its relatively abundant reserves and economic advantages, the amount of lignite used has tended to increase in recent years. Generally, compared with bituminous or subbituminous coal-fired boilers, lignite-fired boilers have a tendency of both moister content in flue gas and the sulfur content in the coal being high. Therefore, in many cases, the desulfurization equipment should be capable of treating high-temperature flue gas with a high SO_2 removal rate. MHPS has designed and provided desulfurization equipment that can handle flue gas with an inlet SO_2 level exceeding 18,000 mg/Nm^3. We can therefore offer equipment

specifically designed to satisfy the requirements of our clients who are engaged in producing lignite with such properties in the vicinity.

(3) Limestone-gypsum wet desulfurization equipment for heavy oil-fired boilers

The residues of petroleum refining were conventionally disposed as waste, but recently they are often used as fuel for thermal power generation. Because the residues are rich in sulfur and their flue gas contains higher concentrations of SO_2 as well as SO_3, flue gas treatment technology suitable for such types of flue gas is necessary. MHPS has developed a comprehensive flue gas treatment system for practical use, which can handle flue gas containing higher concentrations of SO_3 under stable operation. Thus, we can offer equipment specifically designed for the particular conditions of flue gas and performance required by our clients.

(4) Seawater desulfurization equipment

In this desulfurization system, no chemicals such as magnesium hydroxide or limestone are used as absorbents. Instead, alkaline compounds naturally contained in seawater are utilized for desulfurization. This simple framework of a desulfurization system can serve as an alternative method even when the plant location makes it difficult to prepare absorbents or handle by-products. There has been a noticeable increase in the number of power plants that employ this seawater desulfurization process, especially in emerging countries such as India and those in Southeast Asia and the Middle East. The mechanism of seawater desulfurization is the absorption of SO_2 in flue gas into seawater at the absorption tower, followed by the formed sulfite ions (HSO_3^-) being oxidized through contact with large quantities of aeration air in the aeration basin, thus producing harmless sulfate ions (SO_4^{2-}). As sulfate ions are contained abundantly in seawater, there is little impact on the marine environment. Simultaneously in the aeration basin, pH values are adjusted by means of neutralization and aeration and lowered levels of dissolved oxygen are recovered by oxidation, before the treated seawater is ultimately discharged into the sea. MHPS' supply of seawater desulfurization equipment includes one installed at a heavy oil-fired plant that treats flue gas with one of the highest SO_2 levels for desulfurization using seawater (Saudi Arabia), and another installed at the world's largest class 856 MW coal-fired plant (Indonesia). Both have been in operation without problems. Based on such experiences, we tailor the design of seawater desulfurization equipment that can satisfy the diverse needs of our clients (**Figure 3**).

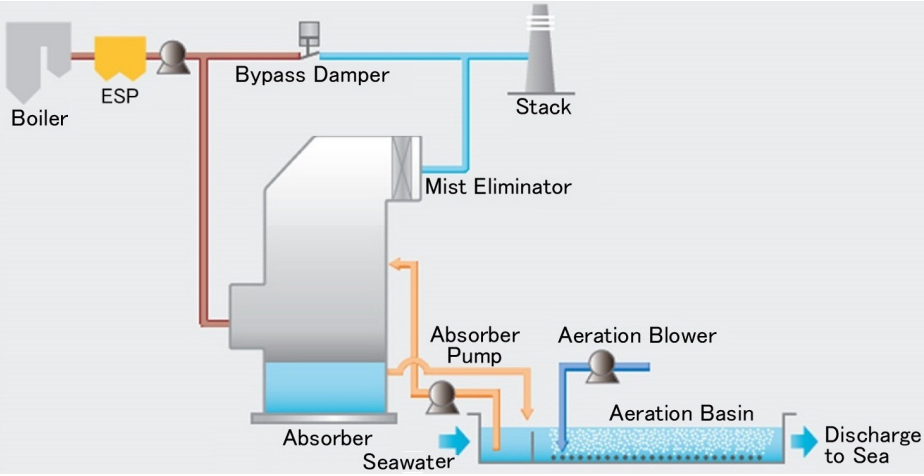

Figure 3 System flow of seawater desulfurization equipment
In seawater desulfurization, alkaline compounds naturally contained in seawater are used to absorb SO_2 before conversion into harmless chemicals through neutralization and oxidation.

2.2 High-efficiency PM removal system, including PM2.5

The high-efficiency PM removal system has been developed to satisfy the stringent Japanese criteria on PM emissions and employs a technology with electrostatic precipitators owing to GGH with the heat medium circulation being placed upstream of the electrostatic precipitator (**Figure 4**). In Japan, new thermal power plants are supposed to be equipped with this system as the standard specifications. This high efficiency PM removal system is also becoming common in other countries such as China.

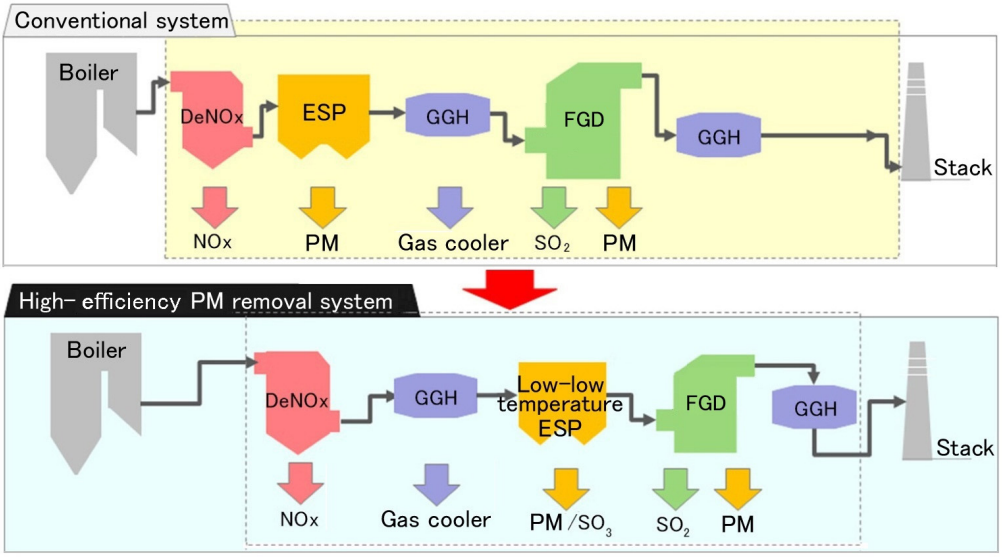

Figure 4 High-efficiency PM removal system
Installed as the standard in Japan and under increasing attention from overseas

2.3 ZLD (zero liquid discharge) technology

There has recently been an increasing need for reducing the amount of effluent produced by the wet limestone-gypsum process. This is especially the case with plants with limited water resources available or that are not allowed to discharge because of local regulations. This trend to achieve zero emissions (zero liquid discharge) is expected to intensify. MHPS has developed technologies including a simple Wastewater Evaporation System (WES) in which effluent is directly sprayed to the flue and evaporated therein, and a Wastewater Concentration and Solidification system (WCS) in which effluent is externally evaporated and dried before undergoing stabilization treatment. These technologies have already been applied to actual units. We have further developed a Wastewater Spray Dryer (WSD) system with improved maintainability, so that ZLD equipment can be used in plants with flue configurations for which it is difficult to install WES or with plant conditions for which it is difficult to operate WCS, promoting application to actual units (**Figure 5**). This technology involves the installation of a flue duct that bypasses the pre-air heater, effluent sprayed and evaporated in the small amounts of high-temperature flue gas flowing in the bypass duct, and the collection of produced salts and heavy metals with precipitators, whereby ZLD can be achieved efficiently. The equipment achieves high reliability with a compact layout and a simple system configuration.

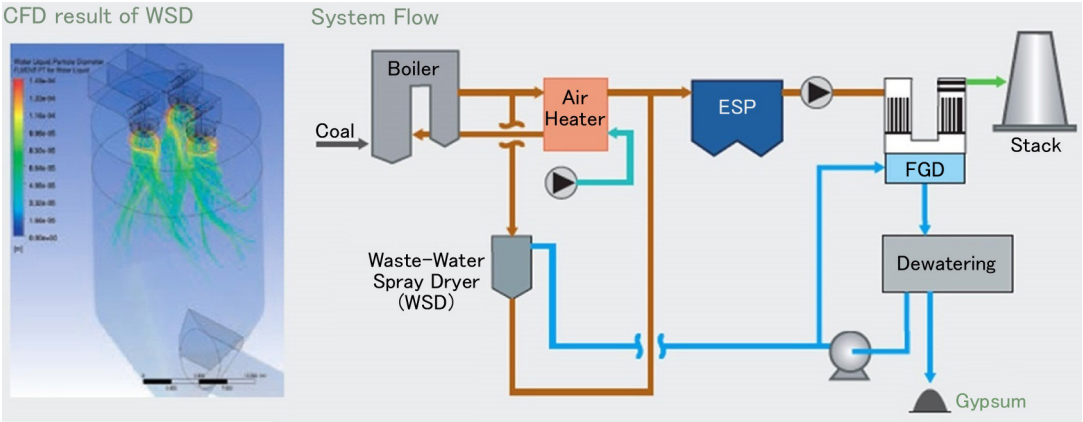

Figure 5 ZLD (zero liquid discharge) system
ZLD system in which residual heat of flue gas is used to treat the effluent produced by the wet limestone-gypsum method

3. Conclusion

Both MHI and Babcock-Hitachi K.K. were top companies in the field of desulfurization/PM removal systems. By combining their technologies and expertise, MHPS can offer eco-friendly solutions to sulfur oxide reduction, which can satisfy the diverse needs of our clients.