DeNO$_x$, DeSO$_x$, and CO_2 Removal Technology for Power Plant

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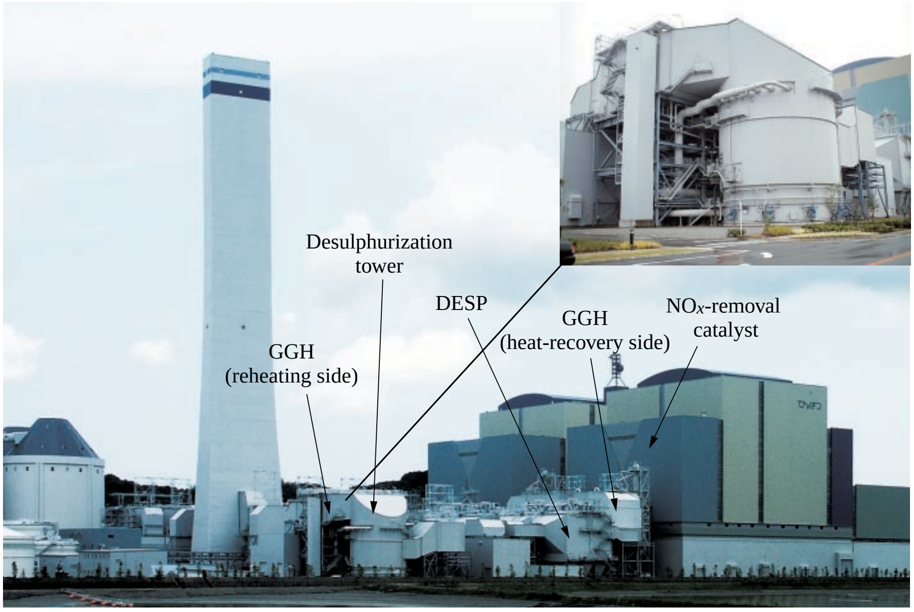
OVERVIEW: Flue gas generated when fossil fuels like coal are burned in thermal power plants contains constituents that are potential causes of global warming and acid rain. Moreover, it affects the environment of not only the home country where it was discharged but also the whole world at large. Babcock-Hitachi K.K. is developing technology for reducing NO_x generated when coal is burned in thermal power plants to the minimum possible level as well as developing technology for efficiently removing the generated NO_x, SO_x, and so on. Furthermore, in regard to CO_2, we are continuing to develop CO_2 removal technology that can be applied at coal-fired power plants. Exploiting these flue-gas treatment technologies, we will continue to build on our already substantial accomplishments and, in cooperation with Hitachi Group companies outside Japan as well as in Japan, we will contribute significantly to environmental preservation through licensing of our technology and exporting our products.

INTRODUCTION

IN regard to thermal power plants, NO_x (oxides of nitrogen) and SO_x (oxides of sulfur)— which are generated when coal or heavy oils are burned — are causative agents that cause atmospheric pollution. From the viewpoint of controlling this pollution, purification processing on these agents is thus imperative. As a world leader in the field, Babcock-Hitachi K.K. has developed and commercialized flue-gas treatment technology for highly efficient elimination of NO_x and SO_x from flue gas.

Furthermore, in regard to CO_2 (carbon dioxide), which is one of the substances contributing to global warming, we have developed a system for absorbing and recovering CO_2 from flue gas by means of a unique amino solvent, and in collaboration with Tokyo Electric



GGH: gas-gas heat exchanger
DESP: dry electrostatic precipitator

Fig. 1—External View of New Flue-gas Treatment System Applied at Tachibanawan Power Station Unit 2 of Electric Power Development Co., Ltd. At Babcock-Hitachi K.K., we are contributing to environmental protection all over the world through development and practical application of new flue-gas treatment systems for efficiently cleaning up flue gas from thermal-power-plant boilers.

Power Co., Inc. (TEPCO), we confirmed that this system (installed at a pilot plant using flue gas from actual equipment of TEPCO's Yokosuka Thermal Power Station) attained high CO_2-elimination performance[1].

In this way, targeting realization of a clean environment, Babcock-Hitachi K.K. is advancing the development of cutting-edge flue-gas treatment technology. In the rest of this report, development achievements and future undertakings in regard to a NO_x removal catalyst, a wet desulphurization unit, and CO_2-recovery technology installed at a coal-fired thermal power plant are described as some typical examples of this technology.

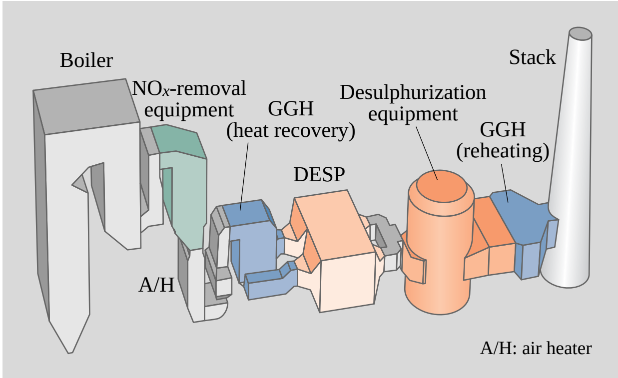


Fig. 2—Process Flow of New Flue-gas Treatment System.
By means of the GGH, the gas temperature at the DESP is lowered, and dust-removal performance is improved.

REGULATORY TRENDS AND FLUE-GAS TREATMENT SYSTEMS

As for thermal power plants in Japan, in accordance with the strengthening of environmental regulations that started in the 1970s, world-leading flue-gas treatment technology [such as NO_x reduction and desulphurization ($DeSO_x$) systems] has been applied and, today, this technology represents the top technological level in the world. Flue-gas treatment technology accumulated by Babcock-Hitachi K.K. over many years is making a contribution to this field in the form of licensed technology and product exports in cooperation with Hitachi Group companies not only in Japan but around the world as well. In the United States, regulations on concentration of PM (particulate material) as well as on NO_x and SO_x are being strengthened in a stepwise fashion[2], and the need for flue-gas treatment technology continues to grow. Moreover, the quality of coal used for thermal power generation in the USA is lower than that used in Japan; as a result, it is often the case that higher purification performance than that needed in Japan is necessary in the USA. Such advanced flue-gas treatment technology is also considered useful in the case that lower quality coal is used in Japan in the future. In the meantime, with the absorption of new members into the European Union (EU), the need for environmentally friendly plants, particularly in regions where environmental measures are insufficient (namely, countries of Eastern Europe), is growing stronger.

As for flue-gas treatment technology, it is important to not only improve the performance of individual pieces of equipment in a system but also to raise the removal efficiency of the entire flue-gas treatment system. For example, in regard to PM removal, it is effective to improve soot-removal efficiency by lowering the gas-emission temperature at the inlet of the DESP (dry electrostatic precipitator) by the GGH (gas-gas heat exchanger). The first units applying these methods have been installed at Tachibanawan Power Station Unit 2 (1,050 MW) of Electric Power Development Co., Ltd. (see Fig. 1) and are attaining high efficiency[3].

An example of the process flow of a current flue-gas treatment system is shown in Fig. 2. This system was considered as an effective countermeasure against SO_3 (sulphuric-acid mist) in case of coal from the eastern part of the USA (which contains a lot more sulfur than coal used in Japan and is hereafter referred to as "eastern bituminous high-S coal"), and its excellent performance was confirmed by means of verification testing on equipment in the USA[4]. In addition, to handle a wide variety of coals from around

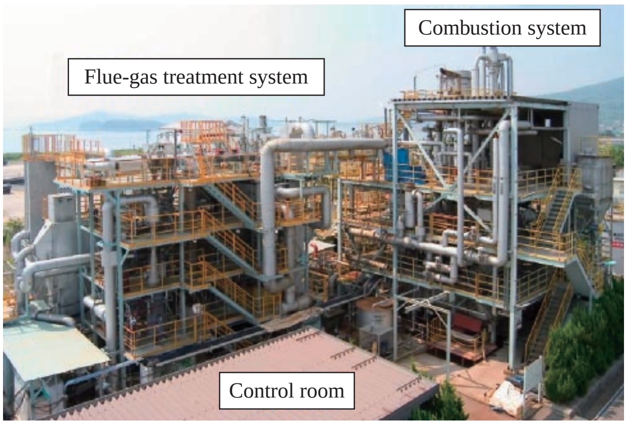


Fig. 3—Test Plant of Total System for Combustion and Flue-gas Treatment (2,000 Nm^3/h).
Flue-gas-treatment characteristics when burning coal from various countries of the world are evaluated and reflected in the design.

the world with different characteristics, development with the use of a test plant for a total system for combustion and flue-gas treatment — on which various pieces of flue-gas treatment equipment are installed — is continuing (see Fig. 3).

DENO$_x$ CATALYST

Characteristics of Plate Catalyst

When coal is burned in a boiler, part of the nitrogen contained in the coal and air reacts with oxygen and NO_x is generated. At Babcock-Hitachi K.K., we have established and practically applied a new concept called "NO_x reduction in flame"—namely, breaking down NO_x efficiently by controlling combustion conditions in a flame[(5)]. Moreover, we are currently developing a technology for reducing the concentration of NO_x emitted from a boiler[(6)]. With these technologies, it is possible to reduce the concentration of NO_x to a certain level without the use of a catalyst; however, to reduce NO_x concentration below that level, a catalyst and ammonia which is used as a reducing agent are required.

With the catalyst developed by Babcock-Hitachi, which has a plate form as shown in Fig. 4, few blockages and little wear due to ash occur, and it is expected to provide high performance over a long lifetime. As a result, it achieves high reliability in use in coal-fired power plants in the world, and currently holds a 30% share of the world market for NO_x-removal catalysts.

High Functionality (Low SO_2 Oxidation Catalyst)

Flue gas generated when coal is burned contains SO_2 (sulfur-dioxide) gas at a concentration of several hundred to a several thousand ppm (parts per million). At power plants in the USA using eastern bituminous high-S coal, the concentration of SO_2 in flue gas is high, and part of that is oxidized by NO_x-removal catalyst to generate SO_3, which is becoming a major problem in plume. To address that problem, a new catalyst whose SO_2 oxidation rate was lowered under a fifth of a conventional one was developed through improvements in catalyst composition[(7)]. As a world's first, this catalyst has been applied at a plant fired with eastern bituminous high-S coal.

What's more, through application of nanotechnology, development of groundbreaking NO_x-removal technology, such as high-performance catalysts (whose performance reduction is only small despite the presence of constituents in the flue gas that reduce the catalyst performance), is continuing.

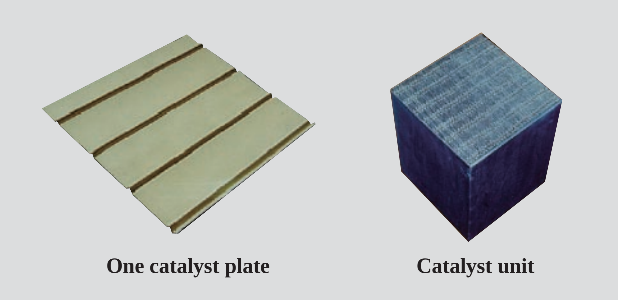


Fig. 4—External View of Plate-type Catalyst.
This is a plate-type denitration catalyst with low pressure drop and with which blockage and wear due to ash are difficult to generate.

DESULPHURIZATION SYSTEM

Basic Principle

Using limestone (which is available cheaply around the world), the limestone-gypsum process performs desulphurization by eliminating hazardous SO_2 from flue gas. After SO_2 is absorbed and reacts with the limestone, gypsum is generated by oxidization (see Fig. 5). The generated gypsum can then be effectively utilized as a raw material for cement or plasterboard.

Babcock-Hitachi has been performing absorption and oxidation of SO_2 in a single absorber tower (a process conventionally done in separate absorbers), and first practically applied an in-situ forced-oxidation

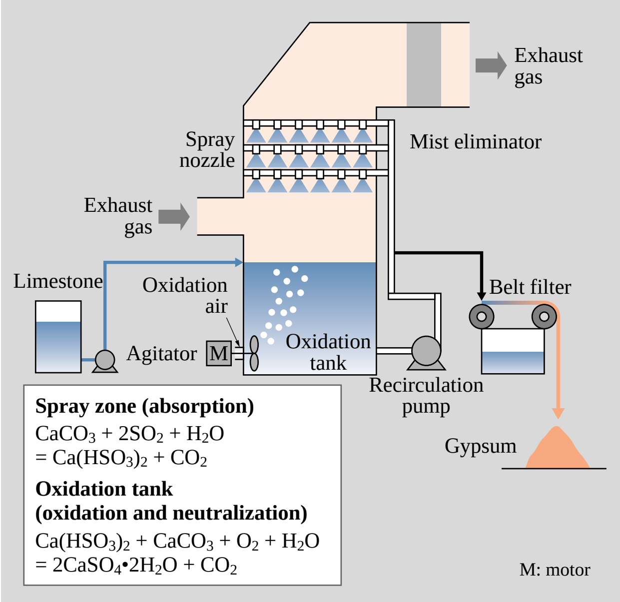


Fig. 5—Process Flow and Reaction Formulae for Desulphurization Equipment (In-situ Forced Oxidation System with Limestone-gypsum Process).
Gypsum (which has high desulphurization performance and high industrial value from low cost limestone) is recovered.

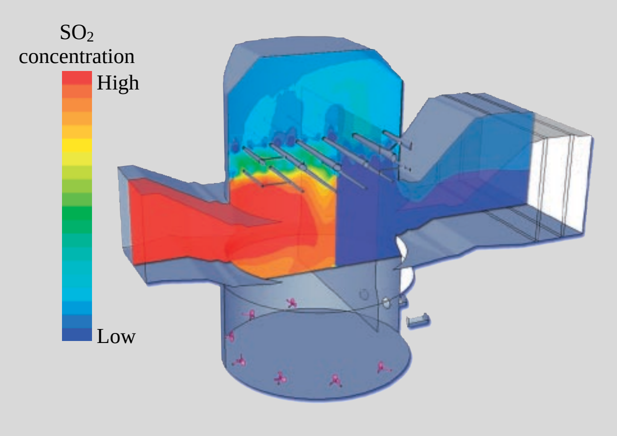


Fig. 6—Calculation Results on SO_2 Concentration in Desulphurization Unit.
Distribution of SO_2 concentration in actual equipment is calculated accurately and contributes to compactification of the equipment.

system using the limestone-gypsum process in 1990 as a world first. After that, we developed new techniques using high gas-flow rate, high-concentration slurry, and high-liquid-density spray, thereby achieving high desulphurization performance and dust removal performance with compact equipment.

Boosting Efficiency (Compact Absorption Tower)

Unique numerical-calculation software coupled with the absorption and oxidation reactions of SO_2 in the gas flow in the desulphurization tower was created and used to evaluate performance of actual equipment at high accuracy (see Fig. 6). By means of this software, the position of spray nozzle suitable for preventing ununiformity of flow in the tower was determined, and the liquid-circulation volume for satisfying required desulphurization performance was reduced.

Furthermore, flue gas from a 1,000-MW boiler (which conventionally requires two absorbers) can be treated in a single absorber. As a result, cubic capacity of the absorber was halved over ten years, and liquid circulation volume was lowered by 25%. At present, utilizing this calculation software allows us to make the absorber more compact and to reduce power consumption in contrast to desulphurization conditions outside Japan (under which SO_2 concentration is higher than that common in Japan). Moreover, at Babcock-Hitachi, we have practically applied a return-flow-type desulphurization unit (which further increases gas flow rate in the absorber and allows the absorber to be made more compact with increased efficiency) and confirmed its high performance[8]. As for development of this desulphurization unit, while gathering basic data on a pilot plant, we are utilizing the numerical-calculation software described above.

CO_2 REMOVAL TECHNOLOGY

CO_2 Removal Method

The system for removing CO_2 from the flue gas from the boiler has two processes: (1) an alkaline-absorption process — which salvages high-concentration CO_2 after CO_2 is absorbed in an alkaline absorbent and heated — and (2) an oxidation combustion process — which principally composes the flue gas as CO_2 and water (by providing the necessary oxygen for combustion) and compresses and salvages CO_2 while coal is burned by supplying oxygen into circulation gas and flue gas is circulated. Among the various alkaline-absorption methods, amine solvent is successful as a method for removing CO_2 contained in natural gas. The boiler flue gas, however, contains acidic gas (like SO_2) other than CO_2 as well as constituents that facilitate degradation of the amine solvent. For practical application, an inhibitor for repressing the degradation of the absorbent is used.

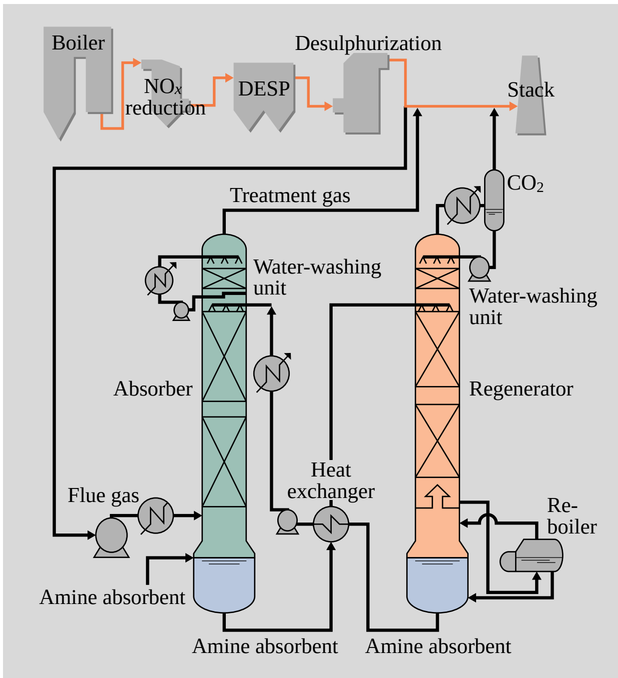


Fig. 7—Process Flow of CO_2 Recovery Pilot Plant (1,000 Nm^3/h).
CO_2 in the flue gas is recovered by a newly developed amine solvent.

Actual Gas Testing

Babcock-Hitachi K. K. has developed an amine absorbent with superior CO_2 absorption and desorption performance as well as superior degradation (due to SO_2) performance. To validate the performance of this absorbent, we set up a pilot plant with a flue-gas processing capacity of 1,000 Nm^3/h at TEPCO's Yokosuka Thermal Power Station as a collaborative research project with TEPCO (see Fig. 7) and ran continuous testing of this pilot plant for 2,000 hours[9].

According to the test results, in the case of flue gas from actual plant producing a high concentration of SO_2 (average: 30 ppm), CO_2 removal rate of 90% (set as a target value for CO_2 removal performance) and CO_2 purity of 99% were achieved[9]. From now onwards, we are planning to perform such performance testing of similar pilot plants in Europe and the United States.

CONCLUSIONS

This report described development results and future activities in regard to NO_x removal catalyst, wet-type flue-gas desulphurization equipment, and CO_2-recovery technology at coal-fired power plants. Gas emissions from thermal power plants contain constituents that are potential causes of acid rain and global warming, so such emissions affect not only the environment of the homeland of those plants but also that of the world at large. To sustain societies that can progress without interruption, it is thus necessary to keep that effect to a minimum by applying advanced flue-gas treatment technology in all the countries of the world. With that necessity in mind, from now onwards, the Hitachi Group will continue developing flue-gas treatment technology for keeping our environment clean and, in doing so, contribute to environmental preservation on a world scale.

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