The Functions and the Characteristics of Combustion and Flue Gas Treatment on the Coal Combustion Characteristic Evaluation Test Facility
− The Role on the Development of the Advanced Pulverized Coal Combustion Power Generation Technology −

Background

In a pulverized coal-fired power generation, the diversification of the coal type, the reduction of generation cost and further improvement are an extremely important task. To perform these tasks for the advancement of pulverized coal combustion power generation technology, two research subjects were set in CRIEPI. One is the development of the combustion technology for up-grading ash quality, which reduces unburned carbon concentration of the ash and the fluctuation of the concentration, controlling the generation of NOx to various coals. The other is the development of the integrated evaluation technology for coal adaptation to power plants, which makes the adaptability of unused coals to power stations clear. To advance this project, the coal combustion characteristic evaluation test facility (Coal feed rate: 300kg/h , the name commonly called: MARINE facility, Figure 1) that was able to simulate the combustion of actual power plants and the operating conditions of the flue gas treatment system was set up in 2002.

Objectives

To contribute to the development of the advanced pulverized coal combustion technology, the combustion characteristic and the flue gas treatment characteristic of the MARINE facility are clarified.

Principal Results

(1) The main features and functions of MARINE facility

- The MARINE facility has the vertical furnace where three burners are arranged in the upper, middle and lower stage. The operating condition and the blending coal ratio of each burner can be changed to develop mono-coal and blending coal combustion technology of the low rank coal (sub-bituminous coal) in multi-burner system. Moreover, the combustion in the multi-burner system of the actual boiler can be simulated by enabling the change in the two staged combustion ratio and the air injection position. In addition, there are the burner functions that can adjust the fuel feed rate, the operating condition, the kinds of fuel, and the blending fuel ratio etc.
- To study on the behavior of various materials such as NOx, SOx, ash and trace elements etc in the plant. , NOx removal equipment (SCR method [*1]), the electrostatic precipitator and the desulfurization equipment (limestone- gypsum method) similar to actual power plants are adopted.

(2) Combustion and flue gas treatment characteristics

The influence of the two staged combustion air ratio and the air injection position on the characteristics of NOx emission and unburned carbon concentration (Figure 2), and the relationship between NOx concentration and unburned carbon concentration, Uc (Figure 3) were clarified. These characteristics of the MARINE facility were similar to those of the existing coal combustion test facility (the name commonly called: BEACH furnace [*2]) where huge test data and the correlation with actual power plants were obtained. In addition, it was confirmed to be able to simulate the combustion characteristic of actual power plants and to have the possibility of the direct evaluation of the unburned carbon concentration, shape and specific surface area of ash because the unburned carbon concentration of the MARINE facility is almost the same as actual power plants at the same NOx concentration (Figure 3). For the flue gas treatment, the basic performance of the NOx removal equipment, the electrostatic precipitator and the desulfurization equipment (Figure 4 and Figure 5) were clarified, and also it was shown that there is the great possibility to evaluate the behavior of various materials such as NOx, SOx, coal ash and trace elements etc.

Future Developments

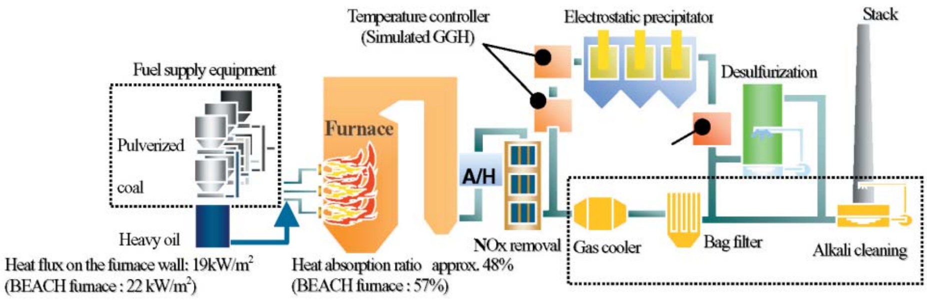
The MARINE facility will be used for the developments of the combustion technology for up-grading ash quality to various coals, the integrated evaluation technology for coal adaptation to power plants and detailed investigation for the behavior of trace elements.

Main Researcher: Hiromi Shirai, Ph.D.,
Senior Research Scientist, Fuel and Combustion Engineering Sector, Energy Engineering Research Laboratory

Reference

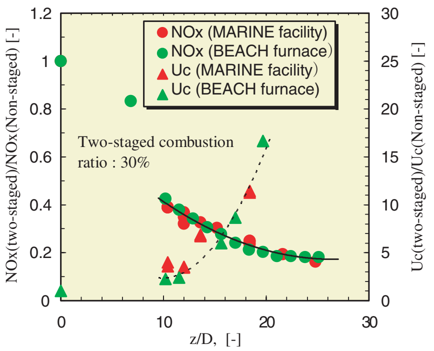
H. Shirai et.al, 2004, “The functions and the characteristics of combustion and flue gas treatment on the coal combustion characteristic evaluation test facility”, CRIEPI Report, W03025

＊1：Selective Catalytic Reduction method: NOx is decomposed to N_2 and H_2O on the catalyst using NH_3
＊2：Horizontal furnace with single burner (Coal feed rate: 100kg/h)



Main characteristics	Functions
The temperature profile in actual boilers can be simulated.	・The vertical-type furnace with three burners (CI- α burner, 100kg/h × 3) was installed.
Coal, biomass and other solid fuels can be supplied, and advanced burner systems can be developed by optimizing the burner position, size of pulverized fuel, co-firing conditions , etc.	・Two different kinds of fuel can be supplied for each burner (Each burner has two bins.) ・The burners have tilting mechanism (± 10deg), and clearance between burners can be changed (± 100mm). ・Size of pulverized fuel can be changed (50%size : 10～70 μ m). ・Distribution of temperature and gas compositions (O_2, CO, CO_2, NOx, SO_2) can be changed. ・The fouling test sections and heat flux probes were installed.
The exhaust gas treatment equipments, which are operated in various temperature conditions, were installed, and the behaviors of environmental pollutants can be evaluated.	・De-NOx equipment with SCR method was installed. ・The charging method and operating temperature of the electric static precipitator can be changed. ・Desulfurization equipment with limestone-gypsum method was installed. ・Ash can be sampled from each exhaust gas treatment equipment. ・HCl, HF and mercury can be monitored continuously.
The Emulsion fuels can be evaluated.	・Three heavy oil burners were installed.

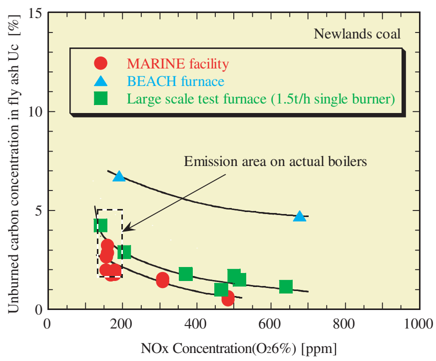
Fig.1 The process flow, features and functions of MARINE facility



z ： Distance from burner to two-staged combustion air port [m]
D ： Diameter of burner [m]

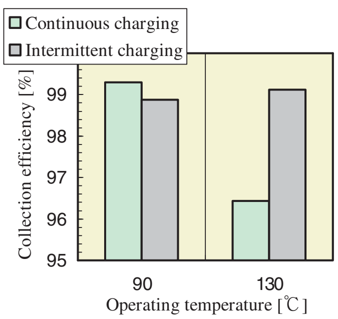
The characteristics of NOx and unburned carbon at changing air injection position are similar to those the BEACH furnace

Fig.2 Effect of position of two-staged combustion air port on NOx and unburned carbon concentration



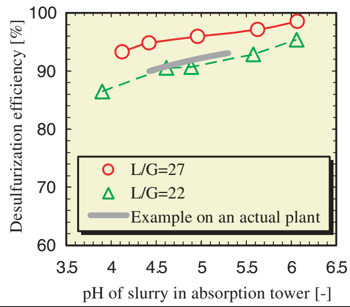
Unburned carbon concentration is almost the same as actual power plants.

Fig. 3 Emission characteristics of NOx and unburned carbon concentration in fly ash



At 90 ˚C, the efficiency at continuous charging is higher than that at intermittent charging. At 130 ˚C, the efficiency at continuous charging is lower than that at intermittent because electric resistance of ash becomes higher.

Fig.4 Effect of charging method on collection efficiency



The efficiency of more than 90% is obtained at the same pH range with actual plants. The efficiency becomes higher as the ratio (L/G) of sprayed absorbent L[ℓ / h] to treated gas G[m³/h] increase.

Fig.5 Relationship between pH of absorbents and desulfurization efficiency