Project Research — Development of a Supply/Demand Infrastructure for Next-generation Electric Power

Utilization of Low-grade Fuel

Background and Objective

The diversification of fuel species such as sub-bituminous coal, the advanced management of boiler tube surfaces, and the improvement of environmental preservation are necessary to keep coal-fired power plants in good working order. In this research subject, a combustion method to increase the blend ratio of sub-bituminous coal in bituminous coal and an estimation method for the grindability of sub-bituminous coal are developed. For the advanced management of boiler tube surfaces, the clarification of the characteristics of hydrogen sulfide (H_2S) formation and the development of a coating technology to prevent sulfidation corrosion are advanced. Furthermore, the factors affecting the behavior of ash deposition on the tube surface are studied to prevent fouling and slugging. To improve the environmental preservation, countermeasures to trace elements in coal-fired power plants are studied.

Main results

1 Increase of the Sub-bituminous Coal Blend Ratio and the Estimation of Sub-bituminous Coal Grindability

The blend ratio of sub-bituminous coal could be increased up to 75% by adjusting air injection conditions such as the flow rates of primary, secondary, tertiary air at the burner, including staged air, through the use of a pulverized coal combustion test furnace at CRIEPI (Fig. 1) (M11022). On the other hand, the grindability of coal could not be evaluated by simple HGI* when the adherent moisture content on the surface of the coal is high. Therefore, the advanced method modified with adherent moisture content was proposed (Fig. 2) (M11016).

2 Advanced Management of Boiler Tube Surfaces

(1) H_2S formation characteristics

The organic sulfur and pyritic sulfur in coal were readily released to the gaseous phase and formed H_2S in the pulverized coal combustion field. The amount of sulfur released could be estimated by the analysis of the forms of sulfur in the coal (Fig. 3). The sulfur-release area in the co-firing of sub-bituminous coal moved to the downstream region due to the ignition delay of the coal (M11003). A numerical simulation model for the H_2S formation characteristics was developed from these results and was validated by the experiments of the pulverized coal combustion test furnace (Fig. 4) (M11020).

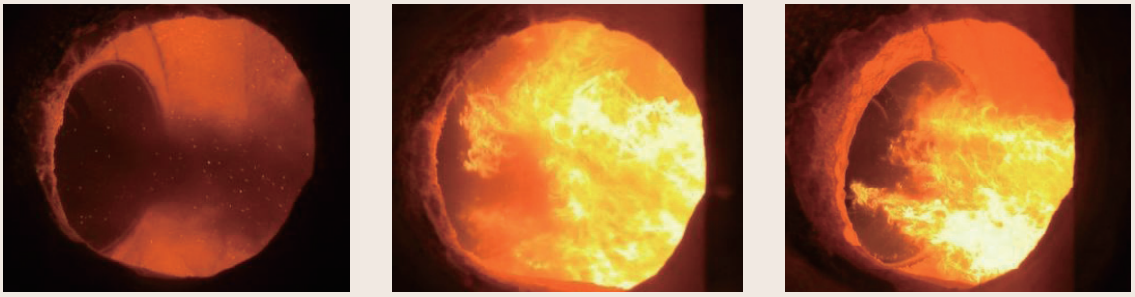
(2) Countermeasure for preventing sulfidation corrosion

The corrosion amount is estimated using the equation of the sulfidation corrosion rate that was derived for a laboratory corrosion test. The estimated corrosion amount showed good correlation with the corrosion amount of the water wall tube in a thermal power plant. Our coating technology for the prevention of sulfidation corrosion was improved in durability, and the durability of the coating is now under testing at some thermal power plants.

3 Improvement of Environmental Preservation at Coal-fired Power Plants

The prevention of oxidation from Se^{4+} to Se^{6+} by the addition of Mn^{2+} into the liquor of flue gas desulfurization (FGD) contributes to a decrease in cost for the wastewater treatment of FGD. The experiment results using the FGD unit in our coal combustion test facility revealed that the oxidation of Se^{4+} was prevented by retaining the Mn^{2+} concentration in FGD liquor (Fig. 5).

*HGI: Hardgrove Grindability Index; HGI is the index of the grindability of coal. It is known that HGI is related to the grinding work index, which is used to estimate power consumption at mills.



①The ignition position moves downstream with the increase of a primary air flow rate.

②Ignition becomes stable by decreasing the two-stage combustion ratio and increasing the ratio of the secondary air flow rate to the tertiary air flow rate.

③The ignition also becomes stable by decreasing the burner load from 100% to 85%.

Fig. 1: Combustion flame at 75% of the blended ratio of sub-bituminous coal

It was clarified that the ignition became stable by adjusting the air injection conditions of the burner. Furthermore, it was found that the decrease of burner load from 100% to 85% enabled stable ignition.

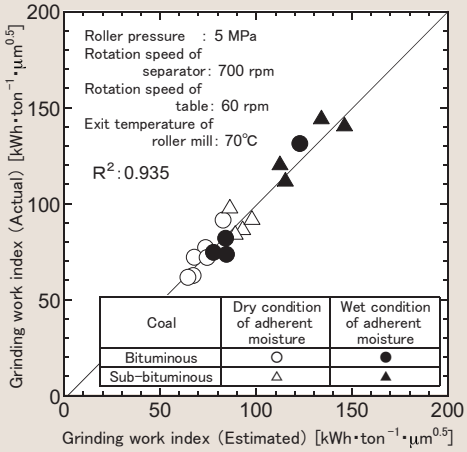


Fig. 2: Correlation between the actual grinding work index and the estimated grinding work index

The grinding work index for a roller mill can be estimated from the HGI and the adherent moisture content on the coal surface.

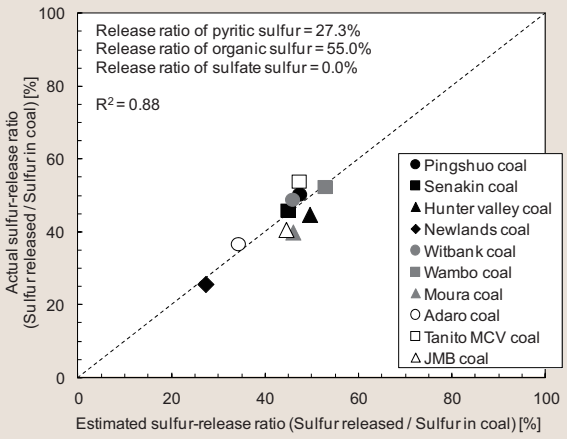


Fig. 3: Influence of sulfur form on the sulfur-released ratio

The organic sulfur and pyritic sulfur in coal are readily released to the gas phase compared to the sulfate sulfur. Such sulfur is converted into H_2S in the pulverized coal combustion field.

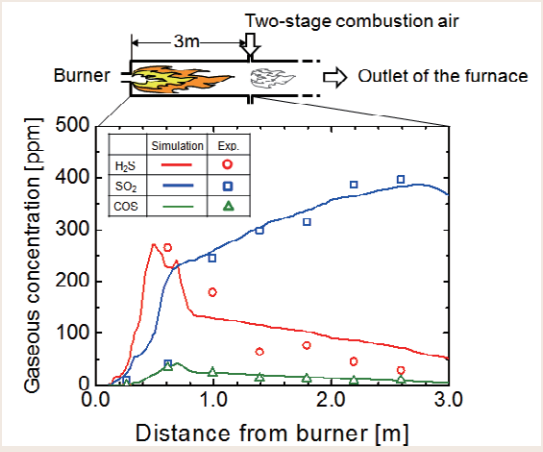


Fig. 4: Distribution of hydrogen sulfide along the central axis of the coal combustion test furnace

The numerical calculation of hydrogen sulfide concentration between the burner and the two-stage combustion air ports is qualitatively in good agreement with the experimental result.

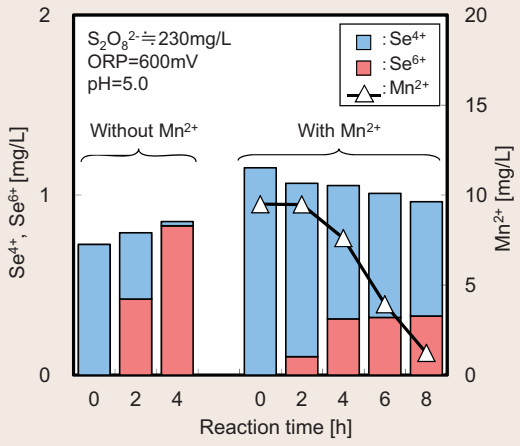


Fig. 5: Prevention of the oxidation of Se^{4+} by the addition of Mn^{2+}

The oxidation of Se^{4+} to Se^{6+} by $S_2O_8^{2-}$ is prevented in the presence of Mn^{2+} because $S_2O_8^{2-}$ oxidizes Mn^{2+} selectively instead of Se^{4+} in FGD liquor.