Utilization of Low Grade Fuels

Background and Objective

To diversify fuel types for coal fired power generation, low grade fuels such as sub-bituminous coal have to be utilized in conventional power plants at wide load range. Improvement of combustion characteristics, management of boiler heating surface and advanced environmental preservation are the major research tasks to develop low grade fuel utilization. In this research subject, the study of combustion characteristics investigates the use of coal mixtures containing high sub-bituminous content, and the factors which affect ash properties. For boiler tube management, the sulfidation corrosion and corrosion resistant coating are studied. Ash deposition on the tube surface is also studied to prevent fouling and slugging*1. To improve environmental preservation of coal fired power plants, trace element behaviors are clarified to understand and to develop necessary countermeasures.

Main results

1. Improvement of combustibility of low grade fuels

As the blend ratio of sub-bituminous coal into bituminous coal increased, the combustibility of the blend became lower due to the moisture brought by the sub-bituminous coal. Control of combustion air in the burner system improved combustion characteristics of the blend which contains sub-bituminous coal up to 50% (Fig. 1). To promote effective use of coal ash, the control of ash properties, such as the adjustment of particle size to JIS requirement, was studied. As a result, the effects of pulverized coal properties and combustion conditions on the ash properties were clarified (Fig. 2) [M10020][M10021].

2. Advanced management of boiler tube surface

(1) Countermeasure for sulfidation corrosion in coal fired boilers

The sulfidation corrosion rate of water wall tubes in coal fired boilers was expressed in an equation based on the corrosion tests where the material temperature was set at between 723 and 823 K. [Q10018][Q10019]. Erosion resistance of anti-sulfidation coating technology was also improved under temperature cycling conditions (Fig. 3) [M10008].

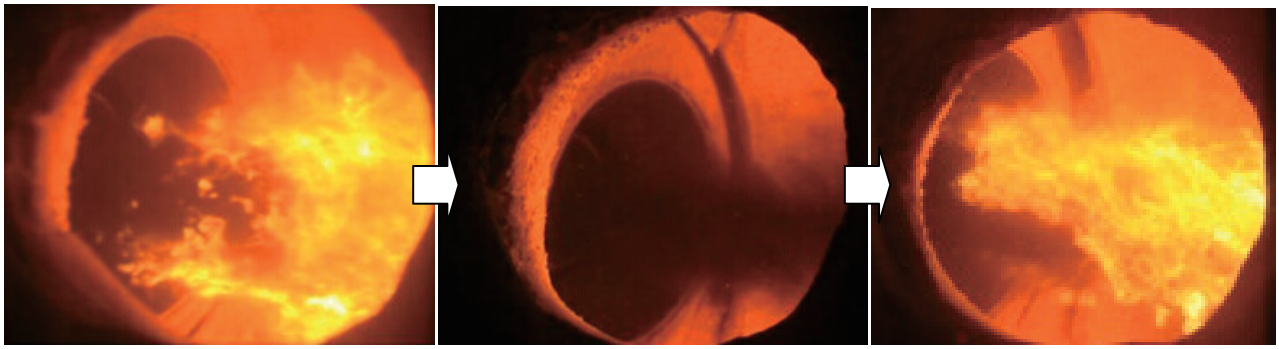
(2) Clarification of fouling and slugging characteristic in coal fired boilers

Coal ash adhesion tests in a CRIEPI's coal combustion test facility revealed that a small difference of combustion gas temperature could cause a significant change in the coal ash adhesion condition (Fig. 4). This suggests that not only ash properties but also gas temperatures are necessary to evaluate the ash adhesion characteristics in commercial boilers.

3. Improvement of environmental preservation of coal fired power plants

The behavior of trace elements in power plants and influential factors of their behavior were investigated. As to selenium, which is a concern in a waste water treatment, the behavior in coal combustion process, the oxidation reaction in FGD (Flue Gas Desulfurization) slurry, and the effect of reagent on the reaction were investigated.

*1: Slugging is a phenomenon that forms ash adhesion on the furnace walls. Fouling is a phenomenon that forms ash adhesion on the surfaces of the heat exchanger tubes. Each phenomenon causes trouble in coal fired boilers.



Ordinary flame of bituminous　　Sub-bituminous was mixed at 50%　　After combustion conditioning

Fig. 1　Change of flame due to the increase of blend ratio of sub-bituminous coal

To raise the blend ratio of sub-bituminous coal, the primary air flow was increased to dry the coal in the mill. However, the increase of the primary air flow caused ignition delay. Adjustment of combustion air around burner and two-stage combustion air enabled stable combustion at 50% blend ratio, and revealed the possibility of stable combustion at 75% blend ratio.

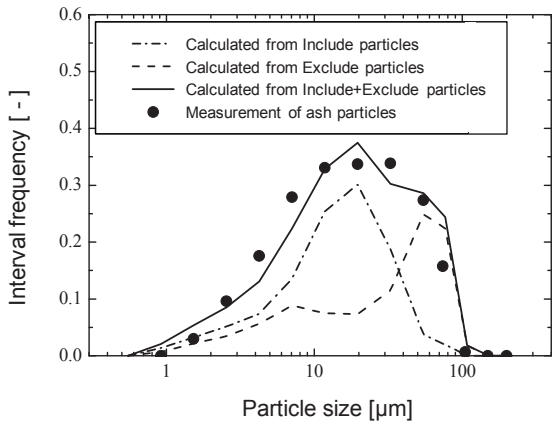


Fig. 2　Comparison between actual ash size distribution and estimated ash size distribution

The mineral in pulverized coal particles consists of the mineral particles associated with the carbon matrix (included mineral) and the mineral particles excluded from the carbonaceous materials (excluded mineral). The particle size distribution of ash can be estimated from the fragmentation of excluded mineral particles and the coalescence of included mineral particles.

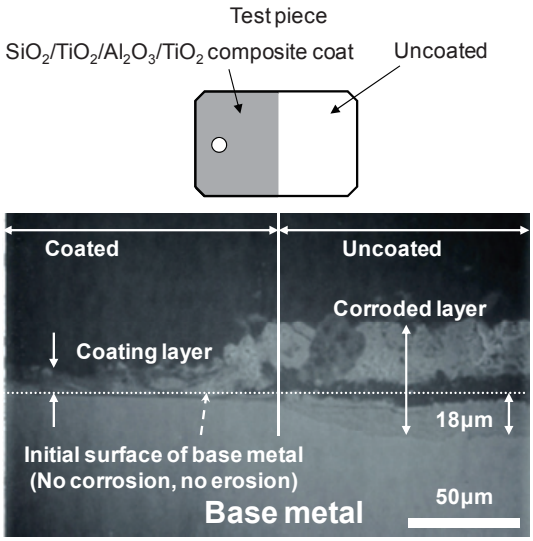


Fig. 3　Effectiveness of developed coating for preventing sulfide corrosion

A specimen was applied to an erosion test under the sulfidation corrosion environment. On the uncoated surface, a corroded layer was formed, then removed by ash erosion. On the coated surface, however, sulfidation and erosion were not observed.

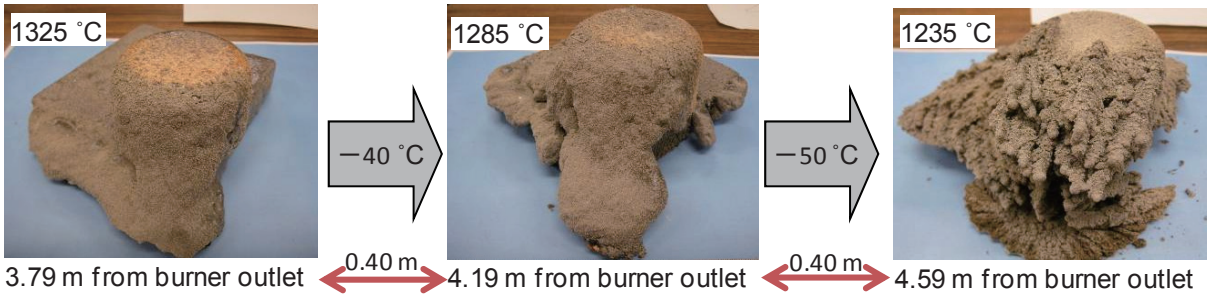


Fig. 4　Relationship between ash adhesion and gas temperature in coal combustion test facility

Melting conditions of ash particles are deeply related to the local temperature where ash deposits. Even a temperature difference of 50 K showed a big difference in ash morphology. In actual boilers, the local temperature can vary about 100 K as a function of coal types and combustion conditions. Therefore, the evaluation of ash adhesion requires an investigation of both ash properties and local temperatures.