Development of Reduction Technology of Unburned Carbon on Pulverized Coal Combustion
− Blended Combustion of Sub-bituminous Coal with Bituminous Coal −

Background

Coal is an important energy resource for meeting the increasing demand for electricity because there are more abundant reserves than other fossil fuels. However, considering the security of fuel supply and fuel cost, it is desirable to use lower rank coal. Although sub-bituminous coal with moisture content higher than 20 % is mined in large amounts throughout the world, ignitability of sub-bituminous coal is worse because of the latent heat of vaporized moisture. If sub-bituminous coal is fired in the conventional boilers designed for bituminous coal combustion, it must be utilized for blended combustion with bituminous coal. We have already clarified that unburned carbon concentration in fly ash during blended combustion is higher than that in non-blended combustion. This reason is that the increase of latent heat of vaporized moisture from sub-bituminous coal tends to reduce the combustion efficiency of bituminous coal. And, fly ash is mainly utilized as cement material. However, such utilization entails considerable treatment cost. To reduce the treatment cost, fly ash has to be utilized as useful material such as cement or concrete admixtures. In the utilization of fly ash as these admixtures, the unburned carbon concentration in fly ash must be reduced to less than 3 %.

Objectives

Reduction technology of unburned carbon concentration in fly ash without the increase of NOx concentration at the exit of furnace is developed during the blended combustion of sub-bituminous coal in the blended ratio of 30 %. Fuel ratio of tested bituminous coal is about 1.5 and moisture content of sub-bituminous coal is about 20 %.

Principal Results

1. Optimization of combustion air injection condition

(1) Air injection condition from burner

When the primary air velocity is reduced to the minimum value, which prevents the sedimentation of pulverized coal in primary air nozzle, oxygen consumption progressed efficiently around the burner outlet. Then, unburned carbon concentration in fly ash decreases, although NOx emission at the exit of furnace increases (Fig.1). Additionally, the optimization of swirl vane angle of secondary air, shape of combustion flame is modified and NOx reduction area before injection point of multi staged air is expanded. These optimizations are able to reduce both NOx emission at the exit of furnace and unburned carbon concentration in fly ash (Fig.2).

(2) Injection condition for multi staged air

The temperature in the furnace during blended combustion of sub-bituminous coal is lower than that on bituminous coal combustion. Therefore, air injection ratio of first stage should be increased to reduce unburned carbon concentration in fly ash (Fig.3). But, NOx concentration after air injection point of first stage becomes high. When air injection point of second stage is shifted toward the exit of furnace, NOx reduction area becomes wide and NOx emission at the exit of furnace is decreased (Fig.4).

2. Optimization of structure of primary air nozzle

The cross section area of primary air is modified wider in order to reduce primary air velocity at the burner outlet without the decrease of primary air flow rate. And the optimization of structure design where pulverized coal is concentrated by swirl force at the burner outlet is proposed to improve oxygen consumption (Fig.5). In these optimizations, NOx is decomposed efficiently before air injection point of first stage. So, both NOx emission at the exit of furnace and unburned carbon concentration in fly ash are reduced to almost the same value as those in bituminous coal combustion (Fig.6).

As a result, by optimizing air injection condition from burner and that for multi staged air, it is clarified that unburned carbon concentration in fly ash is reduced to less than 3 % at 100 ppm of NOx emission at the exit of furnace.

Future Developments

Advanced combustion technology for controlling ash quality (diameter and density, etc.) will be further developed during bituminous coal and blended combustion of sub-bituminous coal with bituminous coal.

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Reference

M. Ikeda, et. al., 2006, “Development of reduction technology of unburned carbon on pulverized coal combustion (Part 2)”, CRIEPI Report M05013 (in Japanese)

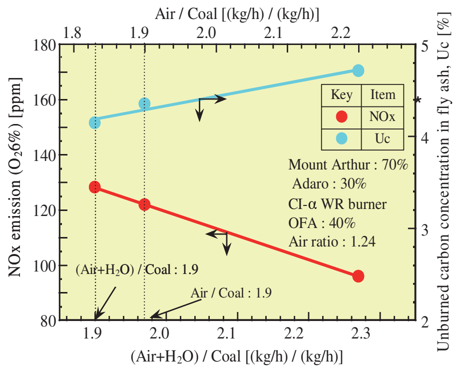

Fig.1 Influence of Air/Coal on NOx emission and unburned carbon concentration in fly ash

As Air/Coal decreases, although NOx emission at the exit of furnace is increased, unburned carbon concentration in fly ash is reduced.

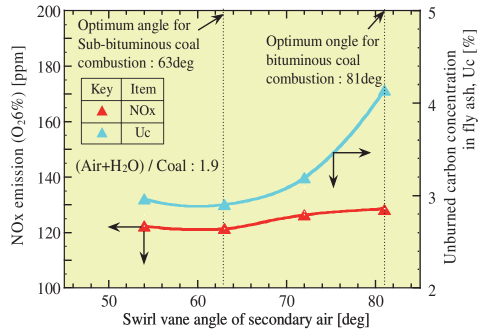

Fig.2 Influence of swirl vane angle of secondary air on NOx emission and unburned carbon concentration in fly ash

The decrease of swirl vane angle makes both NOx emission at the exit of furnace and unburned carbon concentration in fly ash reduce.

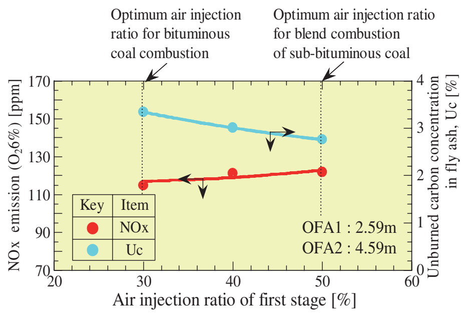

Fig.3 Influence of air injection ratio of first stage on NOx emission and unburned carbon concentration in fly ash

The increase of air injection ratio of first stage makes unburned carbon concentration in fly ash reduce.

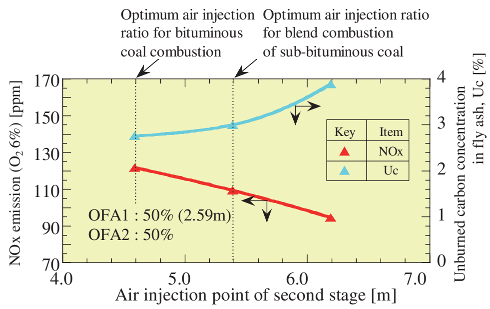

Fig.4 Influence of air injection point of second stage on NOx emission and unburned carbon concentration in fly ash

As air injection position of second stage shifts to downstream, NOx reduction area is expanded and NOx emission at the exit of furnace is reduced.

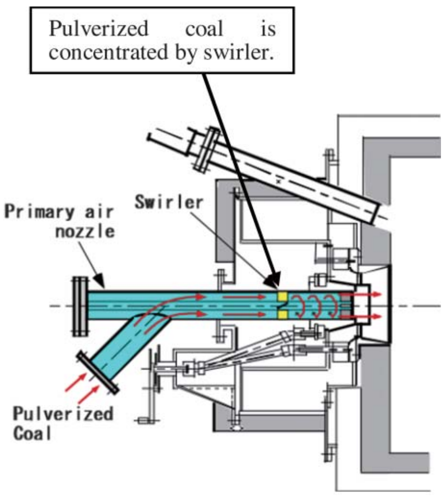

Fig.5 Optimization of structure of primary air nozzle

Cross section area expands and pulverized coal is concentrated by swirler.

Combustion condition	Primary air nozzle	Coal concetration
A	For bituminous coal	-
B	For sub-bituminous coal	-
C	For sub-bituminous coal	Swirler

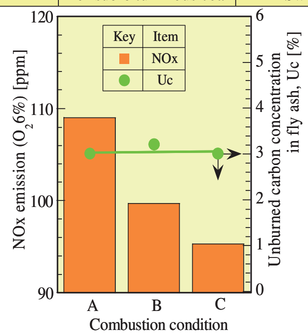

Fig.6 Effect of optimization of structure of primary air nozzle on NOx emission and unburned carbon concentration in fly ash

The optimizing structure of primary air nozzle makes NOx emission at the exit of furnace reduce without the increase of unburned carbon concentration in fly ash.