Biomass Application for Ironmaking process:

A Study on Biomass blended PCI Combustion

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ABSTRACT

Biomass is used as a partial and fully substitute for coal in thermal power plants or with blast furnaces (BFs) because it is a carbon-neutral fuel and is therefore advantageous, in reducing CO₂ emissions. To investigate the effect of co-firing on pulverized coal injection (PCI) in BFs, two coals of different ranks were blended with biomass in different proportions, respectively, and their combustion behaviors were studied using a laminar flow reactor (LFR). To create an environment similar to that of PCI combustion, the LFR burner generates a diffusion flat flame with 26% oxygen concentration and a flame temperature of approximately 2000–2250 K at a heating rate of 105 K/s. The combustion characteristics, including the flame structure, burning-coal-particle temperature, unburned carbon (UBC) and CO, and the CO₂ emissions were measured for evaluating the effect of the biomass ratio and coal rank on PCI combustion.

Key Words : Laminar Flow Reactor (LFR), Blast Furnace (BF), Pulverized Coal Injection (PCI), Co-firing, Fragmentation

The purpose of this study is to examine the effect of coal and biomass blends, and the char–CO₂ gasification reactivity in PCI-system environments. In this study, the pulverized coal combustion environment within a BF was simulated in terms of the reaction temperature and oxygen concentration. The coal-particle combustion characteristics, with respect to the change in residence time, were analyzed in LFR (Fig. 1). The experimental conditions for this study included 26% oxygen and a flame temper. of 2000–2250 K. Coal and biomass particles with sizes ranging from 75–90 µm were injected, and the changes in the residence time, particle temperature, and CO and CO₂ gas production were measured. Cases, where two different ranks of coal were blended with biomass, were examined, along with the effect of co-firing in a BF.

The fuel samples used in this experiment consisted of two different types of coals, coal A and coal B, and biomass. A vibrator was attached to the urethane rubber cap to exert vibrations on the syringe. The particles floating in N₂ gas were then entrained through the feeding tube by the carrier gas. The coal feed mass flow rate was checked by weighing the mass. With the same fuel-particle sizes (75–90 µm) and flow rates, all the fuel were supplied within an equivalent supply time. The feed rate of the fuel particles, according to the plunger in the syringe pump, was set to be equivalent to a supply rate of 7 mg/min. The total fuel feed was approximately 140 mg. Even when the biomass blending ratio was increased, the total supplied fuel weight was maintained constantly. The structure of the burning fuel-particle flame image, the burning coal-particle surface temperature, and the CO and CO₂ emission gases were analyzed.

The coal and biomass blend fuel-particle flame images were captured by a Canon 600D digital camera during combustion and are depicted in Fig. 2. Volatile matter was released after burning, in the initial stage; a large volume of volatile material was emitted with the rapid heating of the fuel particles. In the volatile combustion region, it is assumed

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Fig. 1 Schematic of the laminar flow reactor that the combustion of volatile matter begins at the burner surface and is completed, when the volatile matter cloud is at its widest. The volatile-matter content determines the length, thickness, and brightness of the volatile-matter cloud. Coal-A exhibited an ordinary coal flame structure, and had high volatile-matter content, forming a wide and long volatile-matter cloud. However, when coal-B particles were injected onto the burner, the coal broke into small particles, resulting in fragmentation phenomenon. Coal-A had sufficient volatile-matter content; however, it was difficult to observe a volatile matter cloud for coal-B due to the fragmentation phenomenon. Although coal-B had low volatility and high fixed-carbon content, it had a similar flame length as that of coal-A due to the effect of fragmentation. The fragmentation phenomenon produced small particles and affected the combustion rate.

Radiocarbon dating results were obtained through AMS (Acceleration Mass Spectrometry) analysis from UBCs, to understand the way biomass actually affects coal combustion. As a result, the biomass blending ratio could be properly considered when using coal that has fragmentation phenomenon as a PCI fuel.

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References