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Co-combustion characteristics of PCI coal and alternative carbonaceous fuel for blast furnace operation

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This study experimentally analyzed the combustion characteristics of Biocarbon and Carbon Black as potential substitutes for PCI coal in the blast furnace process. Thermogravimetric analysis was employed to determine the basic combustion properties of each sample, while drop tube furnace and laminar flow reactor were used to evaluate combustion performance and visualize single-particle behavior. Based on these results, the limit injection rate for each fuel was derived. Four types of Biocarbon (BC300, BC400, BC500, BC800, classified by carbonization temperature), two types of Carbon Black (CB-I with high purity and CB-II with higher ash content), and one PCI coal as a reference. All Biocarbon samples exhibited higher reactivity than PCI coal, with reactivity decreasing as carbonization temperature increased. In contrast, both Carbon Black samples showed lower reactivity than PCI coal. DTF single-particle combustion tests indicated that BC500 and BC800 had the best combustion performance, while CB-I performed the worst. In co-firing experiments, BC400 and BC500 showed improved combustion from a 5% co-firing ratio, whereas CB-I exhibited reduced combustion performance with increasing co-firing ratio. LFR visualization revealed that BC300 produced a flame cloud typical of biomass combustion, while other Biocarbon samples exhibited fragmentation similar to coal, promoting combustion. CB-I and CB-II, with nano-sized particles, formed bulkier char particles due to strong electrostatic attraction. CB-II also showed extended combustion length due to its high ash content. In co-firing cases, all Biocarbon samples except BC300 exhibited increased combustion length, while Carbon Black samples showed reduced combustion length at 3% co-firing ratio, followed by an increase from 5%. To determine the limit injection rate for PCI application, three factors were considered: (1) combustibility, (2) heating value (HHV), and (3) ash content. The combustibility-based limit injection rate was found to be more restrictive than those based on HHV or ash content, indicating that combustibility is a critical factor in determining the feasible injection rate for alternative fuels in BF PCI operations. These findings provide essential insights into the operational feasibility of Biocarbon and Carbon Black as PCI coal substitutes, highlighting the importance of combustion performance evaluation in setting injection limits.

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