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Clean and energy-efficient mass production of biochar by process integration: Evaluation of process concept

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Abstract

Biochar from biomass pyrolysis is gaining greater attention for various energy and environmental applications. To realize its potential in industry, it is essential to produce biochar in an economical, clean, and energy-efficient process. This study proposes a new process integrating pyrolysis reactor with a large host boiler, in which the flue gas from the boiler is extracted as heat source for pyrolysis while pyrolytic vapor (PV) is burnt in the boiler. It has many potential advantages, including compact reactor design by direct heat exchange between biomass and extracted flue gas (EFG), minimization of PAH condensation onto biochar, and efficient combustion of PV. Key characteristics and requirement of this process were analyzed for major design and operating parameters such as biomass type, moisture content, pyrolysis temperature, flue gas temperature, and reactor configuration. Results showed that the host boiler had a net thermal gain mainly by energy content of PV even at 350 °C of pyrolysis despite temperature decrease in EFG recirculated back to the boiler. At 100 ton/day of biomass throughput with 10% moisture content, net thermal gain ranged from 4 to 11 MW_{th} depending on biomass type and pyrolysis temperature. Lowering moisture content in the biomass fed was crucial not only to increase biochar yield, but also to reduce EFG required. To minimize the EFG flow rate, using counter-current flow configuration between the biomass and EFG in the pyrolysis reactor was favorable.

***Keywords**:* biomass; biochar; boiler; slow pyrolysis; process integration