Biomass Cofiring and Its Effects on the Combustion Process

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Problem Statement

Biomass cofiring, a process where a modest amount of renewable fuel (e.g., wood waste from sawmills) is combusted along with coal in a utility boiler, is an integral part of an effort to reduce emissions to mitigate the contribution of greenhouse gases (GHG) to the environment. Biomass cofiring has been demonstrated to be successful in both small and large boilers, including Seward Generating Station (32 MW Pulverized coal boiler), Ottumwa (700 MW – T-fired boiler), and many others. The knowledge of combustion effects when introducing 10 – 20% highly reactive renewable fuel with coal is not completely understood. Burning profiles and interactions between biomass and coal merit further investigation.

Problem Objectives

This project looks at cofiring of several biomasses (e.g. woody material, corn stover, and switchgrass) with bituminous coal. It entails two phases. The first phase encompasses a thorough literature investigation and review of cofiring and its effects on the combustion process. This includes literature from fundamental papers plus demonstration tests and research studies. The second phase involves laboratory analysis with Thermogravimetric Analysis (TGA) looking at the burning profiles of parent fuels and blended, cofired fuels. In addition to the burning profiles, the TGA data is used to evaluate the influences of cofiring on fuel reactivity and performance. This is accomplished for three types of biomass and Central Appalachian bituminous coal.

Methodology

The methodology included two sections: a detailed literature review and a series of laboratory experiments, using thermogravimetric analysis to evaluate reactivity.

Literature Review

Over the last two decades, there have been many cofiring demonstrations and the experience has been vast. In general, the combustion of biomass with coal is understood. However, understanding of the process by which combustion takes place and the interaction between coal and biomass is limited. The understanding of the fundamental chemistry and the process by which combustion occurs must be strengthened. This work attempts to deepen this knowledge by studying the burning profiles through Thermogravimetric Analysis (TGA).

This work focuses on the combustion of a less reactive Eastern Bituminous coal with highly reactive biomass fuels. This first phase involves a literature review while the second phase of this work involves laboratory analysis. This work investigates over 90 papers and articles, looking at fundamental papers, demonstration tests, and research studies. It is a comprehensive but not an exhaustive review of the literature of cofiring experiences to date. If the energy industry is going to optimize the blending and cofiring of coals or coal with biomass, then it must understand the fundamentals dictating the combustion process.

Experimental Section

Some laboratory studies have shown that there is an interaction between the parent fuels while others claim that there is no apparent interaction. Thus, the experimental study focuses on looking at both the parent fuels and blends of a lower reactive coal with highly reactive biomass to determine if there are interactions between the parent fuels. This interaction would be promoted by the highly reactive fuel and thus increasing the reactivity of the total fuel mass. Experimental tests use predominantly Thermogravimetric analysis to look at the burning profile of the parent fuels and blends. The fuels of choice focus on those typically encountered in the U.S market. These parent fuels include an Eastern bituminous coal and three biomass fuels: sawdust, switchgrass, and corn stover.

Results

TGA and DTG for 100% Wood

Since biomass fuels have significantly higher volatile matter concentration when compared to coal, as the biomass concentration in the blend increased, volatile evolution also increased. The observed blending effects exceeded the weighted average of the blends. This suggested that there may be interactions between the coal and biomass fuels during the pyrolysis stage. Upon completion of volatile evolution, char oxidation followed and thus was dominated by the coal behavior.

In this study, the differences in ramping rates were also explored (10, 20, and 50 °C/min). If the ramping rate is too low, it is not representative of the firing behavior in full scale boilers. Conversely, too high of a ramping rate can potentially mask the intermediate reactions. The ramping rate of 20 °C/min was utilized for two reasons: it is the most commonly studied value and it provided fundamentally supported results.

In conclusion, TGA burning profiles are a useful tool in studying parent fuels and their blends. If used on a relative basis, the fuel and fuel blend behaviors can provide insight into the combustion behavior and subsequently any interaction between the parent fuels.

Discussions

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