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Influence of pulverized coal properties on heat release region in turbulent jet pulverized coal flames

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A B S T R A C T

The effects of pulverized coal properties, volatile matter, particle size and moisture content, on the heat release region in turbulent jet pulverized coal flames were investigated experimentally. To understand the accuracy of line of sight measurement in the two-dimensional (2-D) visualization, point measurements of chemiluminescence intensity by cassegrain optics were also conducted. The heat release region for the structure of pulverized coal flame was observed through visualization by CH* chemiluminescence image with an intensified high-speed camera, and by CH* chemiluminescence intensity for local point measurements. The streamwise length of the heat release region based on 2-D visualizations was about 11.4% longer than that of point measurements and increased proportionally to the volatile matter content. The temperature rise for 35–45 μm coal particles was faster than that for 75–90 μm particles, which resulted in a shift of reaction region toward upstream direction. The length of heat release region depends upon the particle size and the volatile matter. However, the coal moisture content less than 15% shows minor effect on the heat release region comparison to volatile matter and coal size within our experimental conditions.

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1. Introduction

The combustion of pulverized coal is a complex process involving conductive, convective, and radiative heat transfer; turbulent fluid motion; coal particle devolatilization; volatile reaction; char reaction; particle dispersion; ash formation; and other processes, interactively and simultaneously [1]. Thus, the fundamental mechanism of pulverized coal combustion and the structure of pulverized coal flame have not fully understood. To obtain optimal conditions of pulverized coal combustion, the major processes such as ignition, drying, devolatilization, and volatile and char reactions of pulverized coal particles must be understood. All these processes depend on burning condition and coal properties [2]. Coal properties and combusting condition include volatile matter content, particle size, moisture content, coal rank, gas temperature, system pressure and residence time [3–9].

Many studies have been conducted to understand the detail characteristics of pulverized coal combustion [10] such as the structure of pulverized coal flame, pulverized coal particle ignition [11–13], devolatilization [14,15], and volatile and char combustion [16]. The yield of volatile is likely to be fairly high in actual pulverized coal flame, and the volatile reaction is also of great importance for the ignition of coal particles [17]. The interactions of volatile flame and char combustion of coal particles were investigated experimentally and numerically [17]. A surrounding mantle of volatile products was observed during the early stages of combustion when bituminous coal particle are more sensitive to the volatile yield than to the kinetics of devolatilization, and relatively insensitive to the kinetics of char combustion for medium-volatile coal flame [18]. The phenomena of coal combustion can be described by considering three major regions: a particle heatup region, a devolatilization region, and a soot growth region [19].

There is an extensive review for diagnostic techniques for the monitoring and control of practical flames [20]. Burning coal may give luminous (carbon) flames, and at times the base of such flames may show C_2 and CH emission [21]. The OH^* radical seems more suitable for lean flames, which CH^* and C_2^* have a more monotonic behavior and stronger dynamics for richer flames [22]. Thus, luminosity flame structure is observed through CH^* chemiluminescence intensity and is considered to be a good representative of the heat release rate [23]. CH^* chemiluminescence signals also provide a better indicator for the onset of pulverized coal particle ignition and the volatile reaction region than a direct photograph of the pulverized coal flame [24]. The measurement of CH^*

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