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The influence of the spectrum of jet turbulence on the stability, NO_x emissions and heat release profile of pulverised coal flames

Ph.D. Thesis

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Abstract

The hypothesis investigated in the current study is that, *increasing the scale of, and energy contained in, the larger scales of jet turbulence can beneficially influence the stability of pulverised fuel (PF) flames, their heat release profiles, and* NO_x *emissions.* The hypothesis is investigated using precessing jet nozzles to enlarge the largest scales of turbulence and shift the energy in the spectrum of turbulence away from the fine scales. These effects are referred to as "enhanced large scale mixing" in the text.

Experiments were conducted to measure and compare the effects of a number of types of central jet, located within a co-annular stream, on the turbulent structure of the combined flow. Modelling was performed in water using a planar laser induced fluorescence visualisation technique, and limited to a region corresponding to the pre-ignition region of flames, where reasonable similarity exists. Individual fluid structures were tracked on successive video images. The effects of precession on jet half angles, convection velocities and characteristic strain rates were measured and compared with those of steady jets.

In a separate experiment, glass beads with particle size distributions similar to that of pulverised coal, were visualised in non-reacting air jets at ambient temperature, using a planar laser technique. The effects of large-scale structures, generated by centrally located precessing air flows, on particle motion and preferential concentration of particles in an annular jet were measured. Only the region corresponding to the pre-combustion region of flames was investigated since combustion is known to dramatically alter particle motion.

The effects of enhanced large scale mixing and particle clustering on PF flames were measured in two refractory lined kilns operated at 130 kW and 2.5 MW, respectively. A scaling parameter, which relates the effects of the dominant mechanisms on flame ignition distance was developed, and used to estimate the influence of enhanced large scale mixing at full scale. The dominant mechanisms, by which enhanced large scale mixing and particle clustering influences combustion, were assessed using sensitivity analyses.

It was demonstrated that large-scale particle clustering results from the promotion of the large scales of turbulence. These changes are shown to have potential to provide a means to simultaneously control NO_x emissions, and improve heat release and stability of PF flames in rotary kiln applications.