Jet Trajectory in Tangentially-fired Single Chamber Furnaces with Square Horizontal Cross-sections

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Abstract

In this work, jet trajectory in the flow field of tangentially-fired furnaces (TFF) with square horizontal cross-sections is studied using three-dimensional computational fluid dynamics (CFD) simulations. A least-squares correlation for the trajectory of the coaxial fuel-air jets is suggested which can be very useful in future analysis of TFF. In order to verify the CFD solution procedure, a turbulent round jet injected into cross-flow is simulated. The calculated jet trajectory and velocity profile are compared with the experimental and numerical data of existing references and good agreement is observed. Results show that the trajectory of the coaxial fuel-air jets is neither affected by the inner (fuel) jet Reynolds number nor by the outer-to-inner jet momentum ratio.

Keywords: Jet trajectory, tangentially-fired furnace, diffusion combustion, CFD

1. Introduction

In most industrial combustion and flame applications, the achievement of high heat transfer rates and low pollutant emissions using diffusion furnaces is a target and is desirable. Uniform heat flux in industrial furnaces is of great importance because local overheating and high thermal stresses result in components failure and shorter furnace lifetime. Taking account of different parameters, engineers have continuously modified furnaces to meet the above-mentioned requirements. Tangentially-fired furnaces (TFF) are one of the modified types of furnaces which have become more attractive in the field of industrial firing systems in the last years. They have been used extensively throughout the world with wide applications in power station boilers. In these furnaces, several coaxial fuel-air jets are directed at an imaginary circle in the middle of the furnace to bring about a vortex motion. Each coaxial jet impinges upon the adjacent jet and deflects it. Thus the initially-free coaxial fuel-air jets no longer remain free after the impingement. Operating characteristics, flow pattern, mixing, heat transfer, and combustion in these furnaces have not yet been adequately studied. Some recent works on TFF are introduced below.

Vagner (2004) experimentally studied a tangentially coal-fired cogeneration plant boiler in order to raise its thermal efficiency and to reduce the harmful emissions. The boiler was reconstructed and stage firing of coal in a U-shaped flame was organized. Habib *et al* (2005) numerically studied the flow field and thermal characteristics in a model of a TFF under different conditions of burner tripping. They showed that tripping one or two burners either adjacent or opposite results in high temperature regions close to the walls. Belosevic *et al* (2006)