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Computational Characterization of Splashplate Atomizers

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Abstract

We have developed a computational model that can be used in the spray characterization of splashplate atomizers. The computer model, called *Simulent*, can accurately simulate the impingement of a liquid jet on the plate of a splashplate nozzle, and the formation of the liquid film and subsequent droplets. To validate the model, we compared simulation results with experimental measurements for the film thickness and velocity distributions in a typical splashplate nozzle. Close agreement between numerical results and measurements validated the model and its underlying assumptions. We also developed correlations between liquid film characteristics at the nozzle exit and the spray mean drop sizes. This was done by running many different numerical simulations on typical splashplate nozzles using the developed computer code. The correlations were obtained by performing a close inspection of the numerical results in order to extract all information regarding the liquid film and spray. The results of the developed code were combined with correlations to get spray drop size distribution in a more practical approach with less computational time and efforts. This capability along with the program module we developed for analyzing the output data have turned the developed code into an efficient and practical tool in the design of splashplate nozzles. This paper presents mathematical formulations, results of model validation, and the spray drop size distribution for a typical ALSTOM splashplate nozzle.

Introduction

In a splashplate atomizer, a flat plate of usually rounded cross-section is attached at an angle to the end of a liquid carrying pipe. The liquid flows through the pipe and when it exits from the end of the pipe it strikes the flat face of the plate at an angle. The flow is turned and flattened into a film of liquid. The film leaves the plate and breaks up into ligaments and droplets.

Splashplate atomizers are widely used in recovery boilers where the use of slurries such as black liquor from wood pulp is utilized in combustion systems as an alternative to oil and gas. Black liquor droplet size is an important parameter for proper combustion in these systems. Splashplate atomizers are designed based on experimental measurements. Because of the complexity of the flows existing in these systems, there is no accurate technique that can relate the nozzle design to the spray droplet size and velocity distributions. To better understand the performance of a particular nozzle, the determination of the droplet size distribution is critical. This particle size distribution is usually determined by physical experimentation in spray booth, using either black liquor or corn syrup. Most spray nozzles are characterized in ambient conditions and may not provide the same results under different conditions. A computer code that could accurately predict black liquor spray flow characteristics and droplet size distribution based on specified operating conditions and nozzle configuration would be invaluable. From a practical point of view, such a computer code can be used:

- to design an improved nozzle by investigating the effects of shape changes on spray characteristics;
- to predict flow and droplet size distribution of a specific nozzle or conversely, to determine the optimum nozzle for the specific operation; and
- to provide input into CFD models that solves the spray combustion to improve predictions of burn out and combustion characteristics.

We have developed a computer code called *Simulent* than can predict the liquid film characteristics and spray droplet size distribution in a splashplate atomizer. We use a 3D numerical model that combines the solution of Navier-Stokes equations with an algorithm for tracking the liquid free surface in presence of an arbitrary obstacle shape in the computational domain. To validate the model, we compared simulation results with experimental measurements for the film thickness and velocity distribution in a typical splashplate nozzle. In this paper we present a description of the numerical techniques, validation of the model with available experimental results and the spray drop size distribution for a typical ALSTOM splashplate atomizer.