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NUMERICAL ANALYSIS OF THE 3-D FLOW FIELD OF PRESSURE ATOMIZERS WITH V-SHAPED CUT AT ORIFICE*

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Abstract: Axisymmetric liquid jets have been studied extensively for more than one century, while non-axisymmetric jets are also very common in engineering applications but attract less concern. Based on Eulerian fluid-fluid model in Fluent software, this article analysizes the 3-D flow fields of pressure atomizers with V-shaped cut at orifice, which will result in a non-axisymmetric liquid jet. Flow rate analysis and jet structure analysis are carried out, the results show that the flow rate can be formulated by adding a correction coefficient to the formula of inviscid axisymmetric jets in atomization regime, when the Weber number is low enough to make the flow fall out of atomization regime, and the jet structure together with the flow rate formula will change. Analysis shows that the evolution of the spray and therefore the structure of the liquid jet are affected much by relative velocity and the local volume fraction of liquid phase.

Key words: flow rate, fraction distribution, gas-liquid interference, non-axisymmetric liquid jet, pressure atomizer

Introduction

Atomizer is a type of device which utilizes the gas-liquid interference to break up the continuous liquid flow into spray. There are many types of atomizers in engineering applications, such as pressure atomizer, air blast atomizer[1,2] etc., but pressure atomizer is the most common type, which usually has a relatively simple structure that always means a lower cost of production. Inside a pressure atomizer, the liquid phase is accelerated by the inlet pressure, and when the liquid is injected into the ambient gas, a spray composed of large amounts of small liquid droplets will form if the Weber number is high enough. It is mainly due to the growth of the Kelvin-Helmholtz instability at the interface between gas and liquid. While the instability grows, the liquid flow will distort, fingering and eventually breaking up into droplets, and droplets can even break up into finer droplets if the aerodynamic force is much larger than the surface tension stress. This process is called atomization[3]. Although atomizers have found many applications in industry, military and agriculture[4], its mechanism is not completely revealed yet[5]. Many work has been done in axisymmetric atomization, especially those of axisymmetric water jets[6]. Lin and Reitz[7] have classified the atomization process into four types according to the range of the Weber number, while non-axisymmetric jet flows still need more studies[8].

The pressure atomizer discussed in this article is designed for industrial painting process. The most concerned factors are the flow rate and distribution pattern of the liquid phase which will determine the thickness of the painting and the operation process. The engineering experience has indicated that the cross section of such a spray will assemble the shape of the orifice, but is changed a little in shape and size when traveling downstream. This article will discuss these two factors, the corresponding numerical techniques and the underlying mechanism.

1. Numerical method

The flow field of a pressure atomizer is a typical two-phase flow field. In case that the density ratio of the gas and liquid is very large, the phase interference

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