CFD Simulation of the Primary Break up of a Vertical Laminar and Turbulent Water Jet

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ABSTRACT

The stability analysis of a liquid jet constitutes a crucial matter for several technological applications. In particular, a good understanding of the jet break-up mechanisms is fundamental for the development of enhanced injection systems. The fundamental mechanism responsible for the breakup of a liquid jet is the instability induced by the surface tension. Other mechanisms, however, can modify the breakup process and alter both the continuous jet length and the size distribution of the drops. These mechanisms include the aerodynamic forces on the jet surface, heat or mass transfer at the jet surface, the relaxation of the velocity profile and the turbulence intensity.

In order to delineate some breakup regimes under the influence of the velocity relaxation profile, a set of four different nozzle geometries is tested in this work. The nozzles are constricted to a conical shape. The angle formed between the jet axis and the nozzle wall are 0°, 2°, 5° and 8°, respectively. The jet diameter at the nozzle exit is about 0.5mm.

The breakup process of the water jet is simulated based on a mathematical model implemented in FLUENT. Finite volume formulations are employed to solve the Navier-Stokes and continuity equations in axisymmetrical geometry. The Volume Of Fluid method (VOF) is used to track the free surface of the water jet. The k-epsilon turbulence model is applied to simulate the turbulent jet. In order to analyze only the first breakup regime, the jet velocity is relatively low (in the range of 1m/s to 3m/s), while the maximum intensity considered is about 10%.

The results show equidistant and uniform drops close to the jet exit, whereas the distance between two successive droplets increases and becomes non uniform as the jet moves away. When the jet exits from a conical nozzle with large angle (5° and 8°), the jet instabilities grow rapidly and the resulting drop size is smaller than the jet diameter. However, the continuous jet length is bigger in comparison to jets issuing from nozzles with small inclination.

The flow turbulence and the gravity influence on the flow pattern are also investigated and some differences to laminar and non gravity cases are pointed out. It is noticed that the flow turbulence and the presence of gravity favor the jet breakup at the end of the trickle of water and increase substantially the continuous jet length in the region close to the jet exit.

Key word: Water jet - Break-up - Volume of Fluid – Polydispersion Droplet Size.

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