Turbulent secondary atomization of non-evaporating dilute spray jets

A. Kourmatzis*, A. R. Masri
Aerospace Mechanical and Mechatronic Engineering, The University of Sydney, NSW 2006, Australia
akourmatzis@sydney.edu.au and assaad.masri@sydney.edu.au

Abstract

The secondary atomization characteristics of dilute spray jets of mineral turpentine with varying levels of turbulence are investigated using phase Doppler anemometry (PDA). The choice of mineral turpentine as the injected liquid ensures no evaporation at room temperature and a dilute spray is utilized to avoid droplet-droplet interactions. The spray is formed upstream of a pipe and is carried with air to the jet exit plane. The influence of turbulence on secondary atomization is studied in this paper via presentation of the Sauter mean diameter (SMD), droplet diameter probability density functions (PDFs), and scatter plots of the droplet Weber (We_d) vs. Ohnesorge (Oh_d) number. A range of Reynolds numbers from ∼12,000-37,000 are tested with tube lengths varying from 4.7 to 43 jet diameters. The focus is on data from measurements taken at the tube exit planes where the effects of dispersion are minimal. All of the aforementioned simplifications allow for the authors to attribute changes in droplet diameter predominantly to secondary atomization. Scatter plots of the droplet We_d vs. Oh_d reveal that in the investigated geometry, $We_d << 10$ for $Oh_d < 0.1$ due to the low droplet slip velocity, indicating that only droplet deformation would be occuring in an analogous non-turbulent gas flow. However, it is found that the SMD decreases by as much as $20\mu m$ with increasing Reynolds number and by $10\mu m$ with increasing tube length. Increasing the tube length from 4.7 to 43 diameters whilst keeping the Reynolds number constant results in a different flow profile at the exit plane, varying from under-developed, to transitional, and finally to a fully developed turbulent flow. This increase in tube length leads to a consistent decrease in the SMD of the dilute spray, acting as evidence of turbulence enhanced secondary atomization.

Keywords: Secondary atomization, Turbulent Atomization, Dilute Spray, PDA

*Corresponding author: akourmatzis@sydney.edu.au