Fan-Shaped Air Blast Atomizer: A Performance Analysis with Glycerol Mixtures

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1. INTRODUCTION & OBJECTIVE

The atomization of highly viscous liquids with high flow rates plays a pivotal role in diverse industrial processes, encompassing fluidized bed catalytic cracking within petroleum applications, fluid coking, and large-scale burners that employ residual oil as a fuel source. Within the petroleum sector, the transformation of lower-grade, heavy hydrocarbons into valuable light hydrocarbons necessitates the atomization of heavy fuels using atomizers, notably in the context of Fluidized Bed Catalytic Cracking (FCC). Over time, notable progress has been achieved in FCC operations. A critical component in this context is the riser reactor, which serves to facilitate the interaction between high-temperature regenerated catalyst particles and liquid vacuum gas oil. This interaction precipitates the processes of evaporation and conversion into lighter fractions. The scientific community has dedicated significant effort to delving into FCC vaporization mechanisms through meticulous modeling and simulation endeavors. The overarching objective of such endeavors is the enhancement of selectivity about desired products, achieved by minimizing the initial droplet diameter during atomization. Fine atomization holds the key to expediting vaporization, often taking place within mere seconds.

The study is centered around a thorough exploration of the current injector's atomization capabilities. This involves testing 20% and 40% glycerol mixtures, adjusting air and mixture flow rates to optimize operations. The foundation of data collection relies on the Phase Doppler Particle Analyzer and high-speed imaging techniques, offering both quantitative and qualitative insights. Notably, we analyze the intricate characteristics of droplets – their sizes and velocities – at specific downstream points. This analysis reveals a comprehensive distribution of droplet sizes and velocities as the progress of the measurement along and across the flow path.

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

In the initial set of experiments, the mixture flow rate remained constant while the airflow was systematically varied. In the subsequent set of experiments, the mixture flow rates were adjusted within the range of 3 lpm to 7 lpm, corresponding to different air flow rates to maintain an Air-to-Liquid Ratio (ALR) between 0.015 and 0.09. The current study provides a comprehensive analysis of spray parameters and injector performance characteristics. The intricate mechanisms and physics underlying the atomization process of the present injector are explored through high-speed imaging techniques.

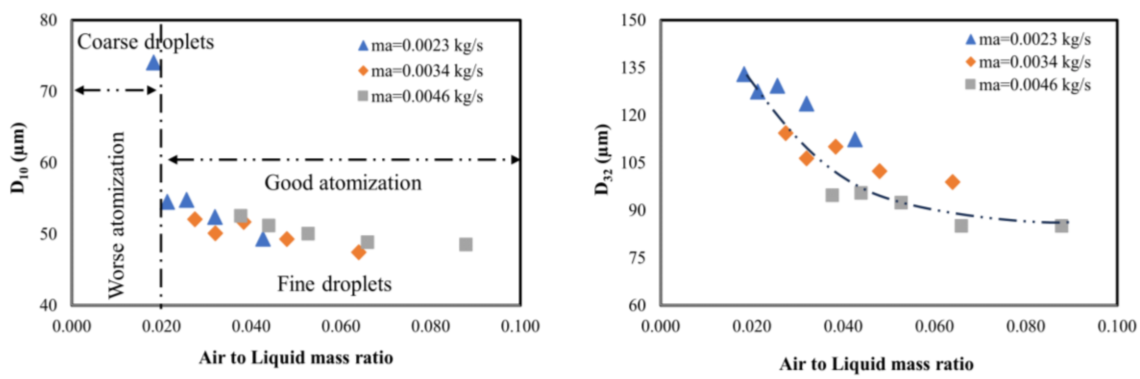

Figure 1:Vvariation of droplet size with Air to liquid mass ratio.

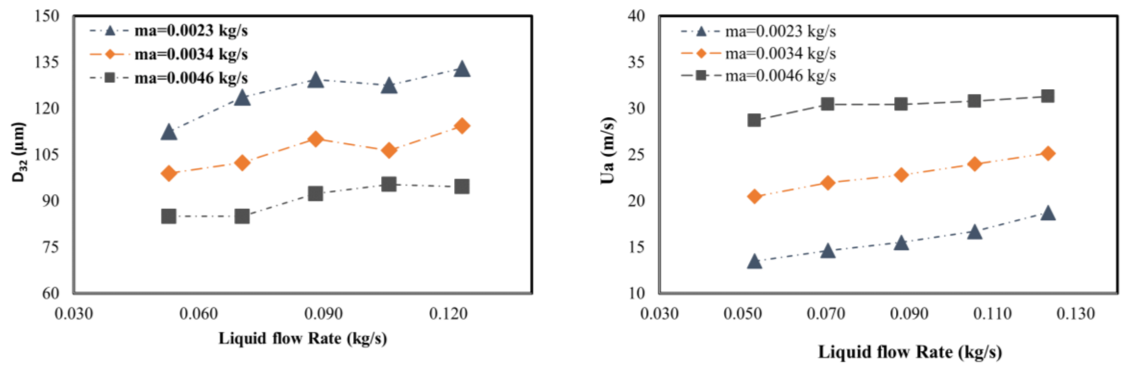

Figure 2: variation in droplet size and velocity with water flow rates.

The findings from the results indicate a gradual reduction in both the Sauter mean diameter and mean diameters as the Air-to-Liquid Ratio is increased at each specific air flow rate. Furthermore, an increase in the mixture flow rate corresponds to an augmentation in droplet size. Alongside this, the axial mean velocity (Ua) demonstrates a gradual rise in response to an escalation in liquid flow rates, attributed to the increase in mixture jet velocity and subsequently, the elevated Jet Reynolds number.

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