On the Dynamics of Liquid Jet Breakup in an Annular Cross flow

Deepak Kumar[1a] and Abhijit kushari[1b]

[a] Indian Institute of Technology Kanpur, Dept. of Aerospace Engineering, Kanpur, India
[b] Indian Institute of Technology Kanpur, Dept. of Aerospace Engineering, Kanpur, India

1. INTRODUCTION & OBJECTIVE

The phenomenon of primary breakup in a liquid jet encountering crossflow is pervasive across various applications, including air-breathing propulsion systems, liquid rocket engines, diesel and gasoline engines, spark ignition, and agricultural sprays. Engines like rockets, gas turbines, and internal combustion engines rely on efficient combustion of liquid fuels, which necessitates injecting them as fine droplets to enhance the surface area for vaporization. The combustion efficiency and emissions, particularly NOx, are intricately linked to factors like air-to-fuel mixing, spatial arrangement of liquid droplets, and droplet vaporization rate.

In the realm of spray formation studies, it becomes crucial to decipher the mechanisms governing liquid jet breakup, resulting droplet penetration height, length, and droplet's distribution. In the present times, the imperative to curtail nitrogen oxide emissions from aircraft engines underscores the need to minimize combustor hotspots by establishing lean, homogeneous fuel-air mixtures upstream of the combustor inlet. A profound comprehension of atomization not only aids in emission reduction and maximizing efficiency but also serves as a pivotal component for validating Computational Fluid Dynamics codes that are to be subsequently integrated. Furthermore, achieving meticulous fuel atomization and strategic placement for effective mixing is paramount. The phenomenon of liquid in crossflow emerges as a solution meeting these multifaceted requirements. Hence, a comprehensive understanding of primary breakup and resultant droplet distribution within sprays assumes paramount significance.

The present investigation sheds illuminating insights into the intricate dynamics of liquid jet breakup within the context of air cross-flow in an annular geometric configuration.

.

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

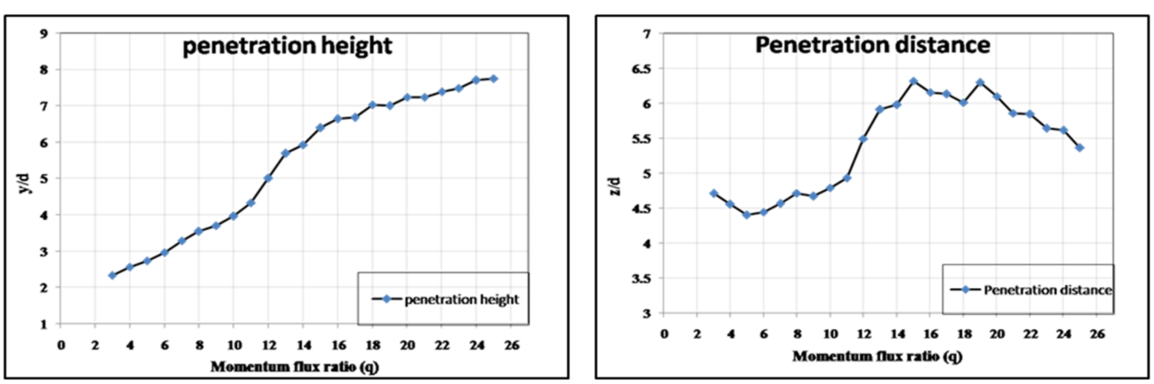

Figure 1: variation of Penetration height and distance with q.

Figure 2: Instantaneous images at q=18.

The penetration height of the liquid jet increases gradually with an increase in liquid-to-air momentum flux ratios. These small deviations may be the results of nature of fluttering of liquid jet spray. Sizes of droplets decrease gradually in axial direction and become almost constant at higher axial locations.

REFERENCES

1. K. A. Sallam, C. Aalburg, and G. M. Faeth, "Breakup of round nonturbulent liquid jets in gaseous crossflow," AIAA J., vol. 42, no. 12, pp. 2529–2540, 2004.
2. D. Kumar, A. Kushari, J. A. Lovett, and S. Syed, "Primary breakup of liquid jet in an annular passage in crossflow of air," ASME 2015 Gas Turbine India Conf. GTINDIA 2015, pp. 1–8, 2015.
3. T. Sikroria and A. Kushari, "Effect of Crossflow Swirl on the Trajectory of Spray in an Annular Passage," J. Eng. Gas Turbines Power, vol. 143, no. 5, pp. 1–10, 2021.
4. Eslamian, A. Amighi, and N. Ashgriz, "Atomization of liquid jet in high-pressure and high temperature subsonic crossflow," AIAA J., vol. 52, no. 7, pp. 1374–1385, 2014.
5. Becker and C. Hassa, "Breakup and atomization of a kerosene jet in crossflow at elevated pressure," Atomization and Sprays, vol. 12, no.1-3. pp. 49–67, 2002.
6. A. Bellofiore, A. Cavaliere, and R. Ragucci, "Air density effect on the atomization of liquid jets in crossflow," Combust. Sci. Technol., vol. 179, no. 1–2, pp. 319–342, 2007.