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C3Po1E-02: Development of test rig for optical diagnostics of cryogenic spray.

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Spray cooling is the primary method for conducting chilldown and fill of cryogenic propellant tanks. In a typical spray injection process, a liquid sheet/jet that exits the spray nozzle undergoes primary breakup by the development of surface instabilities. Droplets and ligaments generated after the primary breakup undergo secondary breakup to create a dispersion of droplets, which extract heat on impact with the tank walls. In the existing literature, there is limited data on the primary breakup of cryogenic sprays and their detailed visualization. Moreover, an insight into the spray characteristics such as primary breakup length and cone angle is vital to the development of computational models. In this investigation, optical diagnostics of cryogenic spray breakup and measurement of spray characteristics have been conducted. Liquid nitrogen is the selected cryogen for the analysis. To capture the transient nature of spray breakup after the injection, a novel shadowgraph diagnostics technique is developed to photographically freeze the spray motion. Spray characteristics such as cone angle and primary break-up length are obtained from the shadowgraph. A brief discussion is presented on droplet velocity measurement using particle image velocimetry. The comprehensive experimental dataset obtained not only provides insights into the mechanism of spray formation for cryogenic fluids but also helps in designing of spray cooling system for tank chilldown.

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