EXPERIMENTAL INVESTIGATION OF LIQUID FRAGMENTATION IN HYPERSONIC CROSSFLOW

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Fragmentation of liquid exposed to hypersonic crossflows is investigated within this experimental campaign. For this purpose two wind tunnel models are used. The first one consists of a flat support with a balloon filled with water exposed in a hypersonic flow. The second one is a flat plate from which a liquid jet is being injected into the hypersonic flow. All the experiments are carried out in the test section of the VKI-H3 facility, where a Mach 6 flow is establish with a total pressure of 20 bars and a total temperature of 500 K.
The main objectives are to investigate the flow topology related to the shock-boundary layer interaction, to study the physics of the break-down mechanism of liquid inside a hypersonic air flow through image analysis (Schlieren, Back/Front light high speed movies) and to determine the diameter of the droplets in the atomized zone of the jet employing Phase Doppler Interferometry technique. For the first two objectives, the balloon test model is studied, whereas the liquid jet model is used for the study of the atomization.

Data processing tools for analysing the high speed camera (HSC) movies have been developed, including an improved edge detection technique, implementation of the snake (active) contours and time interpolation for the boundaries tracking. The data processing tools are applied to selected high speed camera movies to study the transient behaviour of the unsteady phenomena, defining the break down mechanism that occurs in interaction with the shock waves. To increase the understanding of the shock wave interaction with the flow topology, two different supports, one with a sharp leading edge and one with a blunt edge have been employed for the balloon tests. A good agreement has been found between the fragmentation mode proposed in the literature and the one observed in the experiments.

An investigation on the atomization of a water jet into the hypersonic crossflow has been carried out by measuring the Sauter mean droplet diameters. Different types of setup configurations are used along with the Phase Doppler instrumentation, to assess the droplet size in the secondary breakup zone of the water jet. The information are then used to verify and discuss the mathematical models for the atomization prediction found in the literature. Has been also investigated also the behavior and level of atomization in the secondary breakup zone as a function of both the liquid mass flow rate injected and the x-distance from the injector.

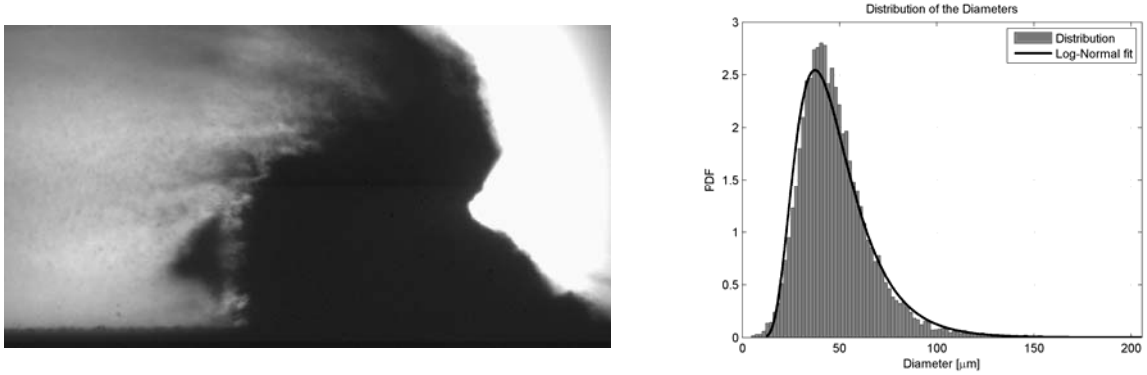

Figure 1: Balloon bursting captured with the back light image technique (left) and log-normal droplet size distribution for Phase Doppler Interferometry technique (right)