Methods for experimental investigation of surface wave phenomena on free liquid films

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Abstract

Prefilming airblast and hollow-cone pressure-swirl atomizers are common types of atomizers. Here, the dominant mechanism of atomization is the aerodynamic breakup of the liquid phase. To improve our understanding of the physical processes that lead to breakup in these atomizers, it is necessary to a) measure the thickness of the film and b) observe the entirety of the film surface or film cone. This work investigates measurement techniques with high spatial and temporal resolution to study the thickness of free liquid films in order to gain information about wave phenomena such as wave growth, wave propagation and wave interaction. The first method is based on two ultrasonic distance sensors placed oppositely on two sides of a liquid film. With the known distance between the two sensors and the measured distance to each surface of the film, film thickness can be calculated. The second method uses a Laser Focus Displacement (LFD) Meter. This instrument consists of a highly accurate distance sensor that is able to detect several surfaces or interfaces within one measurement. Therefore, it is possible to obtain the distance between sensor and air-liquid-interface (front side of the film) and at the same time the distance between sensor and the opposed liquid-air-interface (back side of the film). Accordingly, liquid film thickness can be obtained directly with only one sensor using LFD. In order to validate this method, several investigations on wall-bound films were carried out followed by measurements on free falling films. To observe the characteristics of three-dimensionally deforming conical liquid films, a panoramic optical imaging method was used. The inside of the liquid cone of a hollow-cone pressure-swirl atomizer is photographed with a 360◦ optical lens. The employed shadowgraph method then allows to identify wave patterns on the entire film cone, both in axial and circumferential direction.

Keywords: liquid films, experimental methods, laser focus displacement, film thickness, atomization

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