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EXPERIMENTAL INVESTIGATIONS OF A LOW WEBER LIQUID SPRAY IN AIR CROSS FLOW

Pontus Eriksson [1] **Raik Orbay [2]** **Jens Klingmann [3]**

[1] Senior Engineer, Volvo Aero Corporation, pontus.eriksson@volvo.com
[2] Graduate Student, Department of Energy Sciences, Lund University, Sweden, raik.orbay@vok.lth.se
[3] Associate Professor, Department of Energy Sciences, Lund University, Sweden, jens.klingmann@vok.lth.

ABSTRACT A Low Weber water spray subjected to an air cross flow has been investigated. The spray is characterized by low liquid injection velocity, producing a column that is broken up by aerodynamic forces from the oncoming air. PIV and PDA have been used to quantify both the continuous and dispersed phases. Long range microscopy has been used to characterize the column breakup process. It has been shown that bubbles (akin to droplet bag breakup) may form already in the column.

Keywords: Liquid Atomization, Droplet, Liquid Jet in Cross Flow, Low Weber Number, We, Bag Breakup, Bubble

1. INTRODUCTION

This paper reports quantification and visualization of the breakup process and droplet characteristics for a We=15 spray with low liquid injection pressure and no nozzle atomization. This kind of spray is not usually found in technical applications where a well distributed and finely dispersed spray is often desired. Injectors will however, in some cases outside the design envelope, operate under such conditions.

2. MATERIALS AND METHODS

A quartz test-section is manufactured. The rig provides air at pressures up to 1250 kPa and temperatures up to 420°C at the inlet. At the injection point the We number was kept at 14.6 and the liquid to air momentum ratio was 21. Air and spray flow field velocity characterizations were performed with a PIV system. One of the PIV system lasers was used as an illumination source for the photographic imaging of the spray. The spray flow field was characterized with the PDA system.

3. RESULTS

In Figure 1 shown an example of column bubble formation and disintegration can be seen. Very small droplets (in the order of 10 μm) are formed from the disrupted membrane.

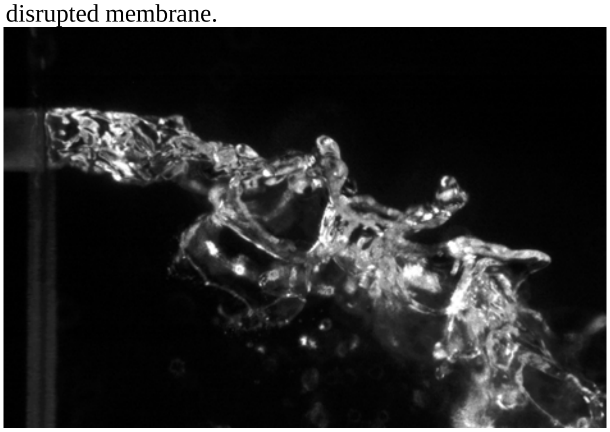

Figure 1: Bursting bubble

As seen in Figure 2, the general trend for mean droplet diameter is an increase in the positive Y direction, i.e., larger structures penetrate further. The planewise averaged D[1,0] and D[3,2] are not changing through planes. It is concluded that the entire break up process therefore has already occurred before plane 1.

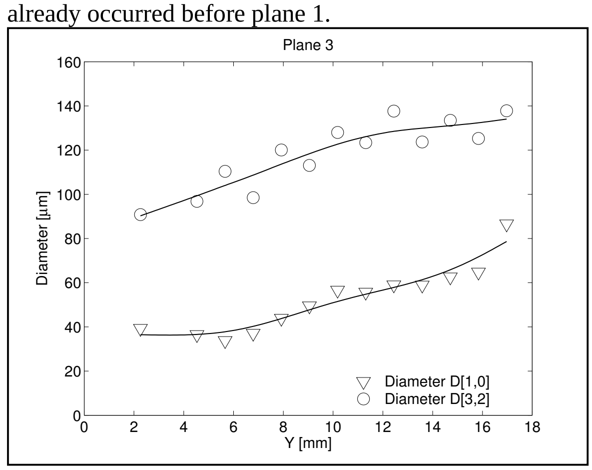

Figure 2: PDA Mean droplet diameters, Z=0

Figure 3 shows the development of U velocity and its fluctuations as the spray progresses through the test section. The spray velocity is seen to be approaching the bulk velocity asymptotically while the RMS velocity is largely unaffected.

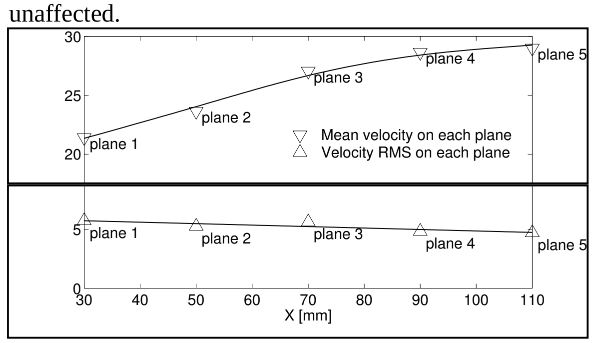

Figure 3: PDA droplet mean and RMS velocities, Z=0

4. CONCLUSION

A complex mix of different breakup mechanisms leads to the formation of a spray. Surface buckling due to internal turbulence and aerodynamic forces, surface tension, wave structures, ligament formation and bursting bubbles all contribute to the breakup process.