# Experimental study of a horizontal shear-driven liquid film approaching a sharp corner. Critical conditions.

E. Bacharoudis[*12], H. Bratec[3], L. Keirsbulck[1], J-M. Buchlin[2], L. Labraga[1]
1: Univ. Lille Nord de France, 59000 Lille, France
UVHC, TEMPO, 59313 Valenciennes, France
2: von Karman Institute for Fluid Dynamics, Rhode-St-Genése, Belgium
3: Robert Bosch Produktie N.V., Tienen, Belgium
bacharoudis@vki.ac.be, herve.bratec@be.bosch.com,
laurent.keirsbulck@univ-valenciennes.fr, buchlin@vki.ac.be and
larbi.labraga@univ-valenciennes.fr

**Abstract**

The present work concerns the experimental study of a horizontal liquid film (order of 1-2 mm thickness) driven by an external turbulent air flow and its separation due to the presence of a convex sharp corner. The liquid film is distilled water ($\sigma = 72$ mN/m) flowing over a polycarbonate surface with critical surface energy of $\sigma_c = 31$ mN/m which implies conditions of the partial wetting regime. The liquid film is formed free on the wall surface without side wall borders which would restrict the expansion towards the spanwise direction. Besides the characterization of the liquid film, main objective of this study is the experimental investigation of the critical conditions dictating the onset of the atomization phenomena at the edge of the corner.

The experimental facility designed and constructed for the purpose of the film separation study is consisted of three main parts, namely, the wind tunnel, the liquid supply system and the test section. The test section is a semi-open configuration of a corner with an angle of $90^\circ$ made by polycarbonate. Qualitative results of the film behavior have been extracted from high speed recording. Planar laser induced fluorescence (PLIF) has been used in order to visualize the cross section of the liquid film in the spanwise direction at the edge of the corner. A Matlab code has been developed to process the images and collect information for the interface of the liquid film. The mean film thickness at the edge of the corner has been obtained. The mean width of the liquid film at the edge of the corner has been measured from single images taken by a digital SLR camera and the mean film velocity has been calculated by measuring the flow rate of the liquid film. The droplets generated downstream the corner have been collected with a flat collector and weighed by means of a digital balance with accuracy of 1 mg. Critical conditions are considered the flow conditions on which the liquid film begins to be atomized at the sharp corner and the resulting atomized mass presents an intermittent layout.

The liquid film formed on the horizontal flat plate and the mass of the droplets produced after the corner have been studied for different flow conditions. The experiments show that there is a weak dependency of the film width on time. Depending on the flow conditions, the liquid film depicts two different trends. Far above the critical conditions, the film is atomized continuously but its rate is slowly reduced due to the slow variation (expansion) of the film width, while at the critical conditions, the atomization presents an intermittent behavior and the effect of the width is vanished.

The main objective of this project is the identification of the critical conditions for the onset of the liquid film atomization at the corner. Measurements of the local characteristics of the shear-driven liquid film have been conducted under critical conditions and presented here. Generally, the critical mean film thickness and the critical mean film velocity drop as the external air flow is increased and the liquid flow rate is reduced. The dimensionless RMS of the film thickness which comprises a mean to measure the interface fluctuations seems to be reduced. The role of the film width on the onset of the film atomization has been investigated by developing and comparing two different films coming from slits with different lengths ($w_{slit} = 100mm$ and $w_{slit} = 45mm$). The results show that the onset of the film breakup depends primarily on the wavy interface but it is independent on the film width. The mean local characteristics of the film have been correlated using two dimensionless numbers, the film Reynolds number (based on the mean film thickness and velocity) and the aerodynamic Weber number (based on the velocity difference of the external air flow with the film and the mean film thickness). An empirical formula has been derived from the experimental data. A first comparison of the experimental data under critical conditions with proposed analytical models in literature showed that further theoretical development is required to predict accurately the onset of the critical conditions.

*Corresponding author: bacharoudis@vki.ac.be