# Current Understanding of Primary Liquid Breakup in Atomisers

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The atomisation process converts bulk liquid into fine droplets to form sprays. This is achieved by injecting a continuous liquid through different atomiser designs. The atomisation starts through the primary breakup of the continuous liquid into small (possibly spherical and stable) droplets and large unstable non-spherical liquid fragments that carry most of the liquid mass, which then undergo secondary breakup to form smaller stable spherical droplets that form the final spray. Two types of atomisers are most commonly used, namely pressure and air-assist/blast atomisers, and many different designs exist. Pressure atomisers inject only high momentum liquid flow from the nozzle. Air-assist/blast atomisers inject a high speed air flow over a lower speed liquid flow. The interaction between the liquid and air flows for both types of atomisers generates instabilities on the liquid interface, which lead to wavy structures of different scales with growing amplitudes. These structures lead to full disintegration of the continuous liquid core into fragments after a distance from the nozzle exit, defined as the breakup length, which varies with operating conditions. Different scaling approaches, based on the boundary conditions at the nozzle exit, have been developed for many years, but the available correlations tend to be applicable to specific atomisers and do not have general applicability.

The talk will address the primary break process in the near nozzle region of atomisers, which is responsible for the speed of the liquid disintegration and the determination of the characteristics of the downstream sprays. It will discuss the origin of the limited validity of the scaling approaches and provide some new measurements that demonstrate these thoughts. The emphasis will be mainly on experimental studies using optical techniques, although links to computational and theoretical efforts will be provided.

The different methods for measurements in the near nozzle region will be initially explained and outline the limitations that they have in obtaining measurements in this droplet dense region. Then, it will describe image processing methods that allow the measurement of physical quantities of the liquid interface.

Primary breakup results will be presented for two geometries, representing pressure and air-blast atomization. This part will report information related to:

(a) the rate of change of the liquid interface velocity with distance from the nozzle exit and explain why this affects the primary breakup process of liquids with different properties.
(b) the range of lengthscales and timescales that develop on the liquid interface during primary atomisation, obtained by applying Proper Orthogonal Decomposition approaches on the recorded images. This information will be linked to theories for the development of instabilities along the liquid interface.

A second part will consider the secondary breakup of non-spherical droplets, which simulate the unstable, non-spherical liquid fragments formed during the primary liquid atomisation. It will demonstrate alternative scaling for the breakup of non-spherical fragments, which is not represented from existing correlations for fragmentation of spherical droplets.

The need for additional information, necessary for the improved physical understanding of the primary breakup process, will be discussed and attempts to measure such information presented.

If time allows, our recent efforts to modify the influence of the primary breakup process on the generation of aerosols from medical procedures will be presented in the context of the Covid-19 pandemic.