Off Center Impact of Water Droplets on a Thin Horizontal Wire

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Abstract

The current work focuses on the initial stage of filtering droplets, and explores the influential factors of drops impacting on a thin horizontal dry wire. We investigate the effect of the impact velocity, wire thickness, initial drop size and liquid surface tension along with the impact eccentricity, i.e. the distance between the trajectory of the drop and the axis of the wire, on the amount of liquid trapped on a wire. A large number of experimental sets were performed in order to determine the amount of the liquid remains on a wire after a drop impact. In all cases, the initial velocity was higher than the capture velocity for the centered impact [2]. For each set, 100 droplets were allowed to impact the wire, while measurements were taken for the un-captured droplet fraction. The results were analyzed statistically.

It was found that for high impact velocities (1.36, 1.42 m/s), the amount of liquid that remains on the wire is minimal and is fairly constant. For low and medium velocities (0.46-1.25 m/s), the amount of liquid that remains on the wire increases at a critical eccentricity value (from 0.2 to 2 mg), and from there it decreases. As the velocity increases, the maximum amount of liquid captured on the wire decreases while the corresponding critical eccentricity increases. This behavior was first observed and explained by Lorenceau et al. [5]. For a centered impact, the droplet is divided into two independent fragments, where each volume is bigger than the critical capture volume [5]. These fragments do not remain on the wire, and are detached under the effect of gravity and inertia. Only a small fraction of liquid remains on the wire in this case, following coating theorems. As the eccentricity increases, less equal the two lobes become, till the volume of one of them get smaller than the critical volume, consequently, it remains on the wire under the effects of the capillarity and friction that keep it from falling. An additional increment of the eccentricity above the critical value results a decrease of the captured fragment, till it extinct at e~R.

Thickening the wire was found to increase the max amount of captured liquid because of the larger surface area. The max amount of captured liquid is also increased when increasing the initial drop radius, but the relative amount in this case is significantly decreases. At low surface tension, the max amount of captured liquid is dramatically decreases, though the small amount of coating liquid that remains on the wire before the critical eccentricity is actually increases in agreement with the coating features of surfactant solution.

These findings led to development of a criterion that characterizes the amount of liquid that can be captured by the wire. The criterion is based on a force balance and includes 4 non-dimensional (Re, We, Fr and the wire-drop radii ratio). The critical eccentricity and the max amount of captured liquid have been calculated and compared with the experimental observation, and good agreement has been obtained. Therefore, our equation provides a reliable criterion for capturing liquid by the wire.

References:

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