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Two component droplet wall-film interactions: impact dynamics on very thin films

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Introduction

The flow domain generated by a single drop with diameter D impacting onto a thin liquid film is faced in a variety of industrial applications, including combustion processes, ink-jet printing, pesticide spraying, and others. Therefore, a considerable amount of research has been focused on the morphology and the splashing-deposition limit, mainly, for one-component droplet wall-film interactions, e.g. Cossali et al. [1]. A detailed review that includes experimental, theoretical and numerical aspects of one-component drop impacts can be found in Yarin [2]. However, for two-component droplet wall-film interactions the underlying flow mechanisms that lead to deposition or splashing impact morphologies is still a fundamental aspect that is not yet fully understood. Recently, Geppert et al. [3-4] investigated the morphology and the splashing/deposition limit for two-component interactions over a range of Weber numbers (We = $\rho D v^2/\sigma$) and wall-film thicknesses (H). The results were correlated for the critical We number in the splashing/deposition limit as a function of the normalized wall-film thickness ($\delta = H/D$), in the range of $0.1 < \delta < 0.5$.
In this paper, we additionally show for two-component droplet wall-film interactions that the droplet impact onto very thin liquid films may result in the ejection of secondary droplets, even if no crown-type splashing is observed.
These secondary droplets are generated during a crown breakdown starting from the wall-film surface. In Figure 1 this phenomenon is shown for the impact of a hexadecane droplet at We = *840* onto a hyspin wall-film of $\delta = 0.05$. A few moments after drop impingement ($\tau = tv/D = 3.96$), a uniform, smooth and conical crown formation is observed approaching a typical deposition case. However, at $\tau = 4.75$ a crown breakdown can be noticed starting from the liquid

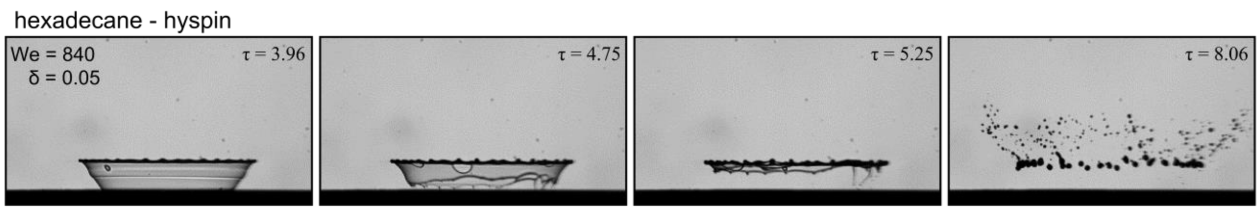

Figure 1. Image sequence of a drop impact on a very thin film: two-component interaction of hexadecane droplet with hyspin wall-film.

surface. As the breakdown propagates rapidly to the top of the crown, the fluid of the crown flings in the radial direction and hundreds of droplets are ejecting upwards ($\tau = 8.06$).

Results and Discussion

This additional mechanism for the generation of secondary droplets is of particular relevance for internal-combustion engines. During post-injections in diesel engines, for example, the diesel spray impacts onto a very thin film of lubricating oil, causing the ejection of secondary droplets consisting of only ~10-16% diesel [5]. This represents an undesired effect, since the combustion of secondary droplets containing fuel and lubricating oil leads to a significant increase in engine emission. So far, only splashing was considered as possible mechanism for secondary drop generation, thus leading to an underestimation of oil contamination effects.
The objectives of this paper are to investigate the dynamics of this additional mechanism for secondary droplet formation and to extend the prediction of secondary droplet distributions to very thin films and low Weber numbers. Furthermore, in order to gain a better understanding of the process, also the associated one-component interactions are considered. Finally, the number and size of the secondary droplets is determined and compared to those resulting from crown-type splashing.
For this purpose, experiments are carried out including two- and one-component interactions of hexadecane and hyspin over a range of Weber numbers and normalized film thicknesses between $0.04 < \delta < 0.1$.

References

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