FUEL DROP SPLASHING ON HEATED SOLID SURFACES

Thesis Synopsis

Droplet-wall interactions on heated surfaces are significantly encountered in applications such as fuel spray impingement in combustors and spray cooling. The present thesis is focused on splashing of fuel drops on heated solid surfaces, and aims to understand the effect of surface temperature in altering the morphology of splash outcome. High-speed imaging is employed as part of the experimental investigation to understand the regimes of splashing impact by varying the impact Weber number (We) and surface temperature (T_S), for the three test fuels (ethanol, n-butanol, diesel) considered. Splash focused experiments conducted at constant We and increasing T_S from ambient to below the Leidenfrost point of respective fuel, reveal that the effect of surface temperature is to suppress corona splashing, as evidenced by the shift of impact morphology from thin-sheet corona splashing to pure spreading via a transition regime. Splash threshold experiments are also conducted to estimate the threshold We for different T_S , which further show that the threshold We increases with the surface temperature for all fuels considered. It is reasoned that the variation of gas viscous stresses or a reduction in the localized gas phase density close to the heated surface could be responsible for the observed transitions.

The experimental data from the threshold and constant We experiments are correlated with corresponding theoretical predictions of splash threshold parameters reported by Xu et al. (2005) and Riboux and Gordillo (2014), by incorporating the temperature parameter into these models. The analytical predictions so derived also point towards the experimentally observed suppression effect. The transition regime is characterized by the tendency of the ejected liquid sheet to re-contact the spreading lamella and is quantified in terms of the re-contact time and the transition surface temperatures, experimentally. Interestingly, the experimental transition surface temperature data between splashing and re-contacting regimes matches fairly well with the predictions made using the air film instability model proposed by Liu et al. (2015). The so derived comparisons hint at the role of low wavelength Kelvin - Helmholtz instabilities acting in the thin gas layer close to the surface in altering the splash outcome with surface temperature.

To gain further insights into the actual mechanisms responsible for the observed splash suppression with temperature, direct numerical simulations are carried out using Basilisk, to ascertain how much the variations in the density and viscosity ratios of the two phases with temperature, contribute to the observed splash outcomes. Variation of density ratio with gas phase temperature reduces the spatial growth of the liquid sheet. Variation of the gas phase viscosity with temperature through Sutherland's law, delays the liquid-solid contact and hence aids in splash suppression. The direct numerical simulations carried out thus hint at possible roles of gas phase density and viscosity variations in altering the thin sheet behavior, and thereby the overall splash outcome.

References

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