Experimental investigation of fuel drop impact on unheated and heated solid surfaces

Abstract

The modelling of spray-wall interaction encountered in engine combustors relies heavily on studies of single drop impact on heated solid surfaces. In the present thesis, the impact of a single fuel drop on a hot, smooth stainless-steel surface is experimentally examined using high speed visualization. Four different fuels of significantly varying physical properties (heptane, decane, Jet A-1 and diesel) are considered. The condition of impacting fuel drop, characterized in terms of Weber number (*We*), is varied in the range 27-903. The temperature of the solid surface (T_s) is varied in the range 25-410 ^{o}C encompassing all heat transfer regimes from convection to film boiling. The analysis of fuel drop impact on an unheated surface (T_s = 25 ^{o}C) reveals that the lamella spreads sluggishly even beyond the end-point of the inertia driven primary spreading phase. This new phase of fuel impact dynamics is termed in the present study as 'post-spreading'. The spreading rate of the fuel drops in the post-spreading phase is dependent on *We* and is much lower than that dictated by Tanner's Law for spontaneous drop spreading. For the impact of fuel drops on hot stainless-steel surfaces, regime maps with *We* on the X-axis and T_s on the Y-axis, highlighting various heat transfer regimes and morphological outcomes are constructed. Quantitative trends on the variation of maximum spread factor (β_{max}) for the fuel drops on the hot surface are presented. With the help of existing theoretical models for predicting β_{max}, it is concluded that viscosity of the fuel plays a major role in the determination of temperature dependency of β_{max}. For drop impact in film evaporation regime, an empirical model for β_{max} involving an explicit surface temperature term in the form of normalized value T^* is formulated from the experimental data and is found to agree well with similar data from literature. Further details of fuel drop impact dynamics on the hot surface in other heat transfer regimes including contact boiling and Leidenfrost regimes are presented.