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Puffing/Micro-explosion in Composite Droplets in Tandem: Experimental Results and Modelling

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Extended Abstract

Results are presented of the experimental and theoretical investigation of the mutual effect on their puffing and micro-explosion of two closely spaced rapeseed oil/water droplets. It is shown that the time to puffing/micro-explosion of the lead droplet is always shorter than that of the downstream droplet, and the difference between them decreases with increasing distance between droplets divided by their initial diameters. It is shown that the time to puffing/micro-explosion of both droplets increases with increasing initial droplet diameters. The experimental results are interpreted in terms of the previously developed model for fuel/water droplet puffing/micro-explosion [1] and its non-self-consistent generalisation [2]. The model described in [1] is based on the assumptions that the water sub-droplet is located in the centre of the fuel droplet and that puffing, possibly leading to micro-explosion, is triggered when the temperature at the water/fuel interface reaches the water nucleation temperature. The generalisation of the model described in [2] took into account the modifications of the Nusselt and Sherwood numbers due to the relative motion between gas and droplets, ignoring the effect of this motion on the processes in the liquid phase. The effect of interaction between the lead and downstream droplets is considered via further modifications to the Nusselt and Sherwood numbers for these droplets using the results of numerical calculations. These modifications were obtained based on numerical calculations of the flow and heat/mass transfer processes around two droplets in tandem. Using the results of these calculations new correlations for these numbers for the lead and downstream droplets were obtained. In these correlations it was assumed that Pr=0.775 and Sc=3.676, respectively. These values of Pr and Sc were taken from the conditions under which the experiments were performed. Both experimentally observed and predicted values of time to puffing/micro-explosion are shown to increase with increasing initial droplet diameters. They are shown to be longer for the downstream droplets than for the lead droplets. The experimentally observed differences in time to puffing/micro-explosion for the lead and downstream droplets are shown to be close to the predicted differences [3]. Preliminary results of experimental and theoretical analysis of puffing and micro-explosion in three Diesel fuel/water droplets in tandem are presented. Work on this extended abstract was supported by the National Research Tomsk Polytechnic University (project VIU-ISHFVP-60/2019) (P. Strizhak; planning of the experiments), Scholarships from the President of the Russian Federation (Grants SP-447.2021.1 and MN-7/2260) (D. Antonov and R. Fedorenko; performing the experiment, and applications of the models), and the Royal Society (UK) (Grant No. IEC 192007) (S. Sazhin; development of the models).

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