INFLUENCE OF TWO-LIQUID DROPLET TEMPERATURE ON THE CHARACTERISTICS OF CHILD DROPLETS DURING MICROEXPLOSION AND PUFFING

R. M. Fedorenko, D. V. Antonov, and P. A. Strizhak

National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk 634050, Russian Federation

Abstract: The results of experimental studies of the influence of the temperature of two-liquid drops on the characteristics of child droplets during puffing/microexplosion are presented. The components of the parent two-liquid drops were: diesel fuel; kerosene; rapeseed oil; and water. The volumetric concentration of the flammable component during the experiments was 90%. The temperature of the two-liquid droplets was recorded using a National Instruments data acquisition complex and low-inertia thermocouples. The temperature of the gas–air environment in the experiments varied from 630 to 750 K. The characteristics of the processes of microexplosive breakup of two-liquid droplets were recorded using the shadow photography method. Processing of the received video frames was carried out using the author's program codes in MATLAB. The main recorded characteristics are: the sizes of the initial drops during the heating process, the number and radii of child droplets, the delay times of microexplosive breakup, and the times of breakup of the two-liquid drop into child droplets. A transition boundary has been established for the temperature of two-liquid droplets before puffing and microexplosion. A dimensionless criterion F_{cd} is proposed which makes it possible to take into account the simultaneous contribution of the time required to warm up a two-liquid drop to the conditions of microexplosive breakup, the time required for the formation of child droplets, and the ratio of the surface areas of the liquid after and before breakup. Using the proposed criterion, areas characteristic of different breakup modes were identified.

Keywords: microexplosive breakup; two-liquid droplets; kerosene; Diesel fuel; rapeseed oil; child droplets; shadow photography

DOI: 10.30826/CE24170206 **EDN:** XRSJTH

Figure Captions

Figure 1 Scheme of the experimental setup for registration of fragmentation characteristics of two-liquid droplets: *1* — tubular muffle furnace; *2* — heat-insulated cylinder; *3* — two-liquid droplet; *4* — holder; *5* — National Instruments temperature registration system; *6* — light source; *7* — high-speed camera; and *8* — motorized manipulator

Figure 2 Typical video frames of child droplets resulting from microexplosive breakup of two-liquid droplets (*a*) and binarized image of the same frame (*b*)

Figure 3 Typical intensity profiles (*a*) and derivatives $dI(x)/dx$ (*b*) for focused (*1*) and unfocused droplets (*2*)

Figure 4 Typical video frames of microexplosive breakup regimes of two-liquid droplets: (*a*) puffing (kerosene 90% / water 10%; $T_{\text{gas}} = 630 \pm 10$ K; and $R_{d0} = 0.95 \pm 0.02$ mm); (*b*) microexplosion (Diesel fuel 90% / water 10%; $T_{\text{gas}} = 705 \pm 10$ K; and $R_{d0} = 0.99 \pm 0.03$ mm)

Figure 5 Dynamics of radii (grey curves) and temperature (black curves) changes of two-liquid droplets during heating for different regimes of microexplosive breakup (*1* — microexplosion; and *2* — puffing) for droplets of rapeseed oil 90% / water 10% (*a*), Diesel fuel 90% / water 10% (*b*), and kerosene 90% / water 10% (*c*). Parameters of the experiment: $T_{\text{gas}} = 700 \pm 10$ K and $R_{d0} = 0.98 \pm 0.02$ mm

Figure 6 Dynamics of radii (grey curves) and temperature (black curves) changes of homogeneous drops of water (*1*), rapeseed oil (*2*), Diesel fuel (*3*), and kerosene (*4*). Parameters of the experiment: $T_{\text{gas}} = 700 \pm 10$ K and $R_{d0} = 0.98 \pm 0.02$ mm

Figure 7 The values of the dimensionless criterion F_{cd} vs. the ratio of the average temperature of a two-liquid droplet before microexplosive breakup to the temperature of the gas medium (T_d/T_{gas}) obtained by generalizing experimental data for droplets based on rapeseed oil, Diesel fuel, and kerosene ($T_a = 630$–750 K and $R_{d0} = 0.8$–1.1 mm): *1* — rapeseed oil 90% / water 10%; *2* — Diesel fuel 90% / water 10%; *3* — kerosene 90% / water 10%; empty signs — microexplosion; and filled signs — puffing

Table Caption

Main properties of liquids (based on data from [16]) used in the experiments at their starting temperature of about 300 K

Acknowledgments

This research project was supported by the Russian Science Foundation (Project No. 21-71-10008, https://rscf.ru/project/21-71-10008/).

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Received December 4, 2023

Contributors

Fedorenko Roman M. (b. 1997) — research engineer, School of Energy Engineering, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk 634050, Russian Federation; vfedrm@gmail.com

Antonov Dmitrii V. (b. 1996) — Candidate of Science in physics and mathematics, associate professor, Research School of Physics of High-Energy Processes, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk 634050, Russian Federation; antonovdv132@gmail.com

Strizhak Pavel A. (b. 1985) – Doctor of Science in physics and mathematics, professor, School of Energy Engineering, National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk 634050, Russian Federation; pavelspa@tpu.ru