EGU2020-7775
https://doi.org/10.5194/egusphere-egu2020-7775
EGU General Assembly 2020

Direct numerical simulation of the droplet deformation in the external flow at various Reynolds and Weber numbers

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A lot of experimental works is devoted to studying behaviour of a droplet in the flow of the external medium. It is shown in [1] that mode of the deformation of droplet in the stationary flow is affected by the Weber number and the Reynolds number. The authors distinguish two types of the droplet deformation in the external flow: the dome-shaped deformation and the bowl-shaped one.

Using the Basilisk software package, direct numerical simulation of the process of deformation of liquid drop in the gas stream was carried out. We examined the problem of the following geometry: a drop of liquid with diameter of 5 mm was placed in the gas stream at the speed of 30 m/s. The density of liquid and gas correspond to the density of water and air, the viscosity of liquid is equal to the viscosity of water. The viscosity of gas and the surface tension at the interface between liquid and gas are determined by the set values of the Reynolds (50 - 3000) and the Weber (2 - 30) numbers. Two main modes of the drop deformation were observed: the dome-shaped deformation and the bowl-shaped one, there is a transitional deformation mode between them. The map of deformation modes is constructed for comparison with the experimental data available in the literature. It was found that the dependence of the Weber number corresponding to the transition from one deformation mode to another on the Reynolds number is well described by the power law proposed in the literature.

This work was supported by the RFBR projects 19-05-00249, 18-35-20068, 18-55-50005, 18-05-60299, 20-05-00322 (familiarization with the Basilisk software package) and the Grant of the President No. MK-3184.2019.5, work on comparison with experimental data was supported by the RSF project No. 18-77-00074, carrying out numerical experiment was supported by the RSF project No. 19-17-00209, A.N. Zotova is additionally supported by the Ministry of Education and Science of the Russian Federation (Government Task No. 0030-2019-0020). The authors are grateful to the FCEIA employee: UNR - CONICET (Rosario, Rep. Argentina) Dr. Ing. César Pairetti.

[1] Hsiang, L.-P., Faeth, G. M., Int. J. Multiphase Flow 21(4), 545-560 (1995).

How to cite: Zotova, A., Troitskaya, Y., Sergeev, D., and Kandaurov, A.: Direct numerical

simulation of the droplet deformation in the external flow at various Reynolds and Weber numbers, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-7775, https://doi.org/10.5194/egusphere-egu2020-7775, 2020