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Gas bubble trajectory in nanofluid

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Abstract: Nanoliquids are gaining in popularity in a relatively short period of time in various industrial applications. This work concerns an attempt to control the two-phase flow process due to the addition of nanofluid to the well-known phenomenon of gas bubble movement in liquid. The analysis of the obtained results based on the registration of individual bubble will be mainly based on a non-linear analysis, which is the multifractal analysis.

Keywords: trajectory, nanofluid, multifractal, image analysis

1. Introduction

The growing industry demand for optimization, accuracy and pollution reduction is driving the re-examination of fundamental process problems. One of the main such issues concerns two-phase flows, and in particular the free movement of gas bubbles in a liquid. Over the past decades, countless experimental studies have been carried out, the results of which have allowed us to understand the observed phenomenon to a large extent. Nevertheless, there is still a lot of room to improve both the understanding of the phenomenon itself and its optimization. This paper deals with the analysis of the trajectory of gas bubbles in water with the addition of silica nanopowder. The influence of nanofluid addition to distilled water is investigated in terms of the movement of individual gas bubbles and their repeatability, as well as the process of periodic detachment from the nozzle front.

2. Results and Discussion

The tests were carried out in a glass tank filled with distilled water, to which a solution of distilled water with silica nanopowder at a concentration of 0.5%, 0.8% and 1.0% was then added. The scheme of the setup is shown in Fig. 1 In the conducted experiment, the air flow rate, the diameter of the nozzle generating bubbles and the height of the liquid column in the tank will be controlled.
The nano liquid was prepared in distilled water into which diatom powder was introduced. The solution was then broken into smaller particles using an ultrasonic cleaner. The liquid prepared in this way was added to a tank filled with distilled water at a temperature of about 21 degrees Celsius . The result of the obtained liquid is shown in Fig. 2. It is worth mentioning that it is an SEM photo of a liquid sample that was put on the table and allowed to evaporate freely.
Then, using the image processing algorithm [1], it becomes possible to create three-dimensional trajectories of the movement of individual gas bubbles. Each trajectory will be subjected to non-linear data analysis [2,3], as a result of which a graph will be obtained showing the spectrum of singularities with information on the two-phase flow process itself, the movement of a single bubble and the long-term memory phenomenon of the entire system.

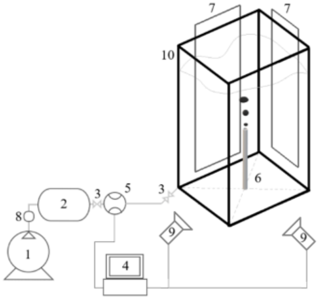

Fig. 1. Experimental setup: 1 - compressor, 2 - air tank, 3 - ball valves, 4 - computer, 5 - mass flow meter, 6 - brass nozzle, 7 - led panels, 8 - proportional valve, 9 – double camera system, 10 – glass tank.

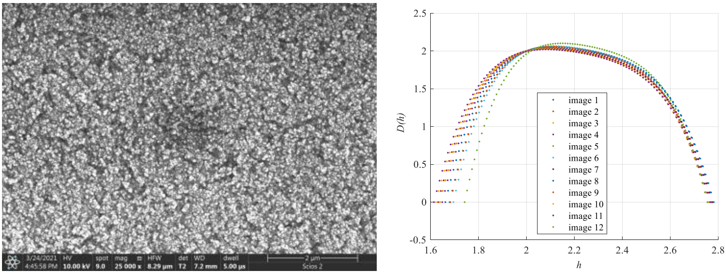

Fig. 2. SEM image of the prepared nanofluid sample and exemplary multifractal spectra.

3. Concluding Remarks

As a result of the research, singularity spectra will be obtained, which will provide information on the three characteristic points, the width of the multifractal spectrum and the placement in the singularity domain. Thanks to such an analysis, it will be possible to draw conclusions about the two-phase flow process itself and the quality of the obtained nanofluid.

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