DYNAMIC BLOCKING AT THE FLOW OF INVERT WATER-OIL EMULSIONS

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Properties of selected multiphase fluids

Experimental investigations were done with the multiphase systems – highly concentrated invert water-in-oil emulsions (HCIWOE), stabilized by the emulsifier Neftenol (produced by the Khimeko-GANG Stock Company) and without it.
Structure of invert disperse systems was studied on the microvideoimages of used HCIWOE. The disperse analysis of structure of the non-stabilized emulsion showed that most microdrops have the size of approximately 2 μm, maximal size is about 5 μm. Stabilized emulsion consists of microdrops of the size 0,2-1 μm.
Rheological properties, obtained on the rotational viscosimeter RheoTest 2.1 using the method cone-plate in the range of shearing strain rate from 1 to 3000 s^{-1} are satisfactory described by the model of Ostwald-de Waale $\tau = k\dot{\gamma}^n$. It should be noted that parameters obtained during the measurement are only estimation, as mechanical rotation of the cone causes microdrops of the emulsion to coalesce and thus exude of the water phase from the emulsion. Emulsion stabilized by Neftenol in similar measurements of rheological properties doesn't suffer destruction (dynamically stable), and displays rheopectic properties [2].

Flow of the stabilized HCIWOE in plane structures

For the research of processes occurring in plain channels, the cell of Hele-Show was used. It consists of two plane-parallel glass optical plates with a gap of 17, 20 or 35 microns and the size 4 x 2 cm, restricted by the foil. Fluid passed through the tube to the hole in the upper glass at the constant pressure on the entrance. The pressure on the exit was equal to atmospheric. For measurement of the liquid flow rate the scales HM-200 with the scale interval 0,1 mg were used, the data was fixed on the computer. The fluid, flowing out of the model, displaced the distilled water from the tube, which moved by the small pipe into the glass with water, placed on the scales. Thus, the weight of the distilled water was re-counted into a volume of the liquid, passing through the model. To avoid the influence of capillary effects, the end of tube was put in a liquid. With the purpose of the errors reduction, due to vaporization of water, it was covered by thin layer of the spindle oil. Microvideoimages and pictures of flow was recorded on digital camera.
Behavior of the emulsion with and without emulsifier flowing in the slot structure differs considerably. In the cell of Hele-Show at large shearing strain rates an ordinary emulsion transforms significantly: microdrops (1-5 μm) of the emulsion coalesce, water drops segregate, and in process of moving they also coalesce with each other. As the time passes the deadlock zones appears in the slot, where a complex emulsion is formed from the initial. It can be seen under the microscope that flow in the slot goes not like a solid flow, but through "beds", where formation and moving of water phase also occurs [1].. Integral measurements of the fluid flow rate showed that in the cell with gap of 20 μm at the constant pressure drop of 0,2 MPa showed the gradual reduction of flow rate, and after 55 minutes according to data from the scales the flow stopped (fig.1).
During injection of the stabilized by Neftenol HCIWOE into the cell of Hele-Show there was also found an effect of blocking after some time. Changing of structure of the flow with time is principally different from those of described above non-stabilized emulsion, though dependence of volume of displaced emulsion from time [3] are similar.
The complete blocking, found out by the scales readings, at more careful study with the microscope, it was found a small flow of fluid at the inlet and outlet (fig. 2). The value of a flow is four orders less than the initial flow rate and does not increase with time, though the structure of the emulsion in the cell and in the micromodel considerably transformed after long time (day and more). As the microflow of the emulsion is always present, the found effect of "blocking" we have called **"the effect of dynamic blocking"**.

Flow of the stabilized HCIWOE in the cylinder tubes

Study of the stabilized HCIWOE in axisymmetrical flows was conducted using the capillary with diameter 100 μm. Like in the case with the cell of Hele-Show, electronic scales were used to measure the volume of the flowing emulsion and computer to register received data automatically.
In the experiment were used the 4-cm piece of the capillary, cut out from the long capillary, preliminarily washed out by alcohol and water. Diameter of the capillary was 100 μm, pressure drop was 0,2 MPa. Transition into the state of blocking, compared with the slot model (the cell of Hele-Show) and capillary structure (micromodel), have gone more intensively, as it can be seen on fig.3, the time was nearly 2 minutes, though diameter of the capillary significantly exceeded the gap of the slot model (17 and 35 μm) and depth of the channels (15 μm) of the micromodel [3]. Some incoherence should be noted in times and volumes flowed through the capillary, in spite of using in all 5 experiments parts of the same capillary. Value of the flow rate in transient state was approximately the same.
Careful study of the blocked system under the microscope found that really in state of blocking exists a small creeping flow (fig.2). Transition into the state of blocking occurs quickly, flow rate becomes three orders lower, hydrodynamic flow turns into creeping motion. Then begins slowing of the flow in the creeping regime: after 20 minutes speed

becomes 1,5 orders lower and after that practically doesn't change. Presence of the very slow motion in the capillary allows us to call this effect dynamic blocking.

The discovered effect of dynamic blocking in plane and axisymmetrical flows for the disperse liquid-in-liquid systems at first sight can't be explained. The only assumption that can explain the observed blocking, is that microdrops of water, bristled like the hedgehog, by the molecules of surface-active agents, acts in a stabilized emulsion like the grain in suspension. Originating from this assumption, an attempt was made to describe the effect of dynamic blocking on the base of visco-friable medium, in some case the result is satisfactory.

Conclusions

An effect of dynamic blocking was found experimentally at the flow of both stabilized and non-stabilized highly concentrated invert water-in-oil emulsions in the cell of Hele-Show at the constant pressure drop.

In axisymmetrical flow the effect of dynamic blocking was also discovered; compared with the plain flow in this case occurs a sudden transition from the flow with constant flow rate to the state of dynamic blocking, hydrodynamic flow turns into creeping motion.

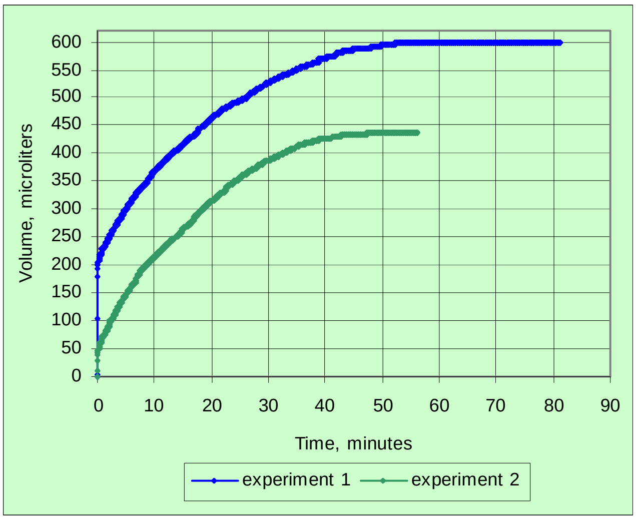

Fig.1. Dynamic blocking at the flow of non-stabilized HCIWOE in the cell of Hele-Show

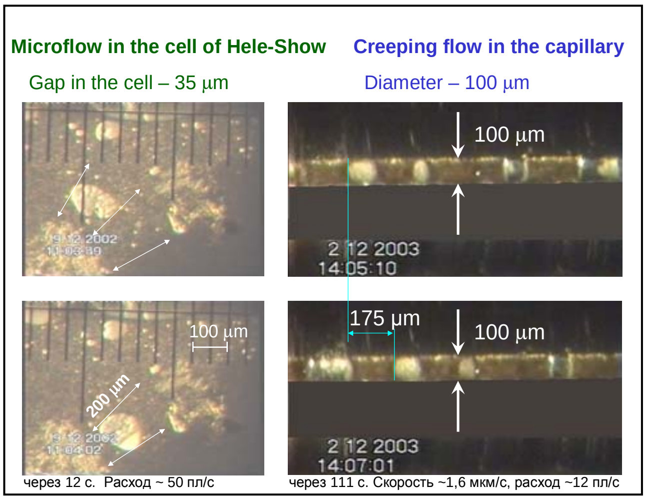

Fig. 2. Microflows in the cell of Hele-Show (left) and creeping flow in the capillary (right)

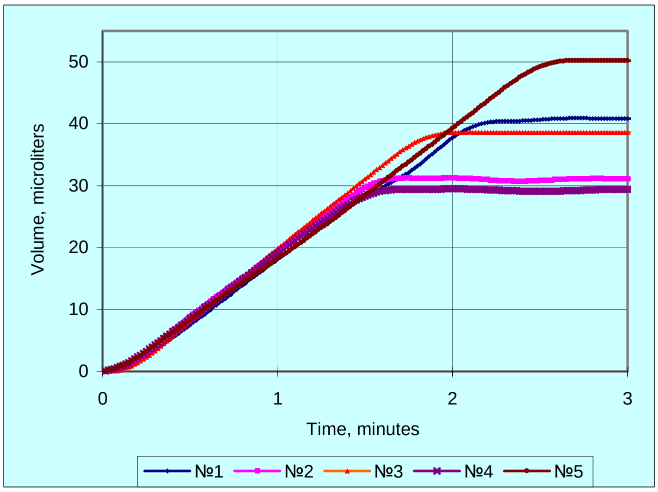

Fig. 3. Dependence of volume of the emulsion flowed through the capillary from time at constant pressure drop (100 μm, length 4 cm, ∇p =5 MPa/m).

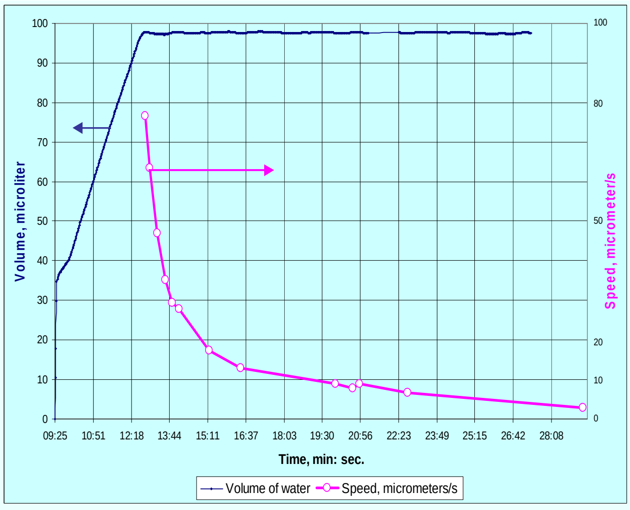

Fig.4. Dependence of volume (left) and speed in state of blocking (right) of the emulsion flowed through the capillary from time at constant pressure drop (∇p =5 MPa/m). X axis presents time in form mm:ss

Literature

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