Chemistry and Technology of Fuels and Oils, Vol. 45, No. 5, 2009

MAKING A STABLE DISPERSED SYSTEM FOR HIGH-TECHNOLOGY LUBRICANTS BY WAVE TECHNOLOGY

A. G. Chukaev, O. R. Ganiev, S. R. Ganiev, and Yu. A. Belyaev

Adhesion of the concrete is important in the production of large concrete components, since this largely determines the quality of the product: the surface finish, the external form, and often the integrity of the component.

Various lubricants are used to reduce adhesion. One of these is a dispersed system (DS) made by mixing

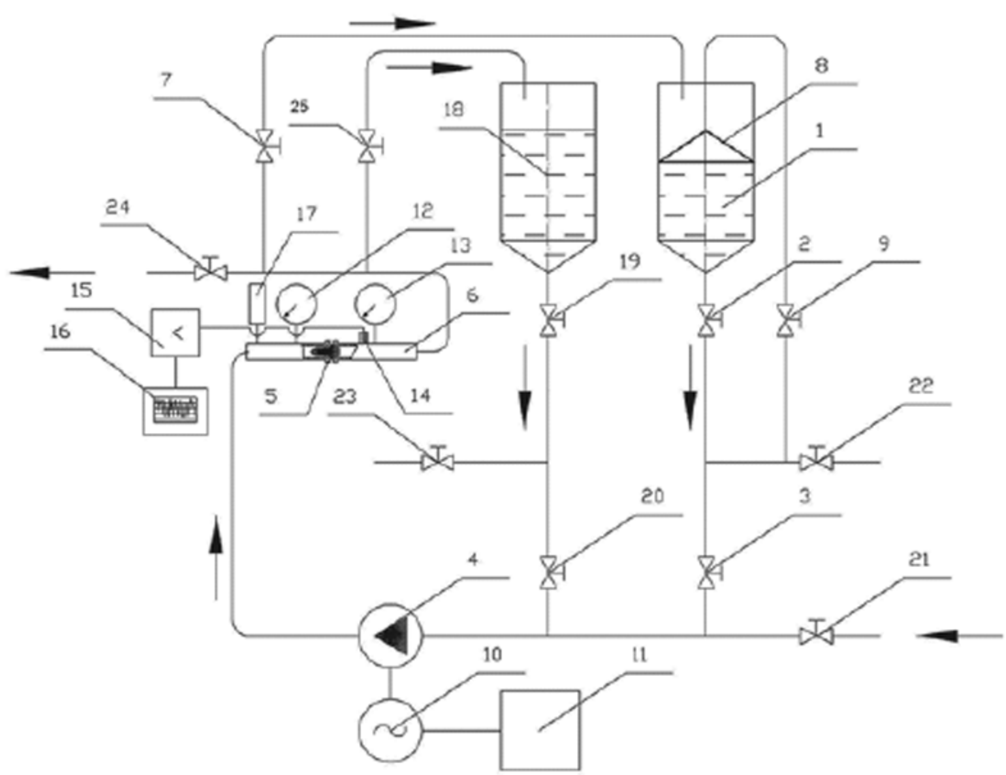

Fig. 1. Technological scheme for the experimental wave equipment: 1, 18) receiving vessels; 2, 3, 7, 9, 19-25) ball valves; 4) pump; 5) wave generator; 6) working chamber; 8) skimmer; 10) electric pump; 11) frequency converter; 12, 13) manometers; 14) pressure sensor; 15) frequency amplifier; 16) oscilloscope; 17) oscillation damper.

Nonlinear Wave Mechanics and Technology Scientific Center, RAS. Translated from *Khimiya i Tekhnologiya Topliv i Masel*, No.5, pp. 37 – 40, September – October, 2009.

0009-3092/09/4505–0359

Table 1

Working time, min	Amount of slaked lime in the form of solution, wt.%	Temperature, °C	Recording* of amplitude-frequency characteristics	Photography*
		Run 1		
5	0	25	+	+
15	0.15	44	+	+
		Run 2		
5	0.2	35	–	–
10	0.2	40	–	–
15	0.2	45	+	+
		Run 3*		
5	0.2	26	–	–
10	0.2	27	+	+
		Run 4*		
3	0.15	27	–	–
5	0.15	30	+	+

Notes. *A plus sign means that the action was performed. and a minus sign that it was not.;
** In runs 3 and 4 the amount of oil was reduced by a factor 2 relative to runs 1 and 2.

water and a mineral oil with the addition of a small amount of milk of lime as stabilizer. Under existing production conditions, much effort is devoted to these, since the plant does not provide a stable composition.

Figure 1 shows the equipment used to make a finely divided highly stable DS with various immiscible liquids for preparing high-technology lubricants, where a basic element is the wave generator developed at this center [1, 2]. The working pressure in the system was 5 MPa.

The dispersion medium is water, a polar liquid of density 1000 kg/m^3, while the dispersed phase is W40 mineral oil, a nonpolar liquid of density 876 kg/m^3. The DS is stabilized by the use of quenched lime in the form of milk of lime. The quality of the resulting DS is determined by the dispersion and stability against unmixing.

To generate the emulsion, the components from the vessel 1 (Fig. 1) are passed by the pump 4 to the wave generator 5, which excites oscillations in the liquid in the working chamber 6. The emulsion formed by the wave action passes through the ball valve 7 to the receiving vessel 1. The mineral oil floating in that vessel is removed by the skimmer 8 on account of the negative pressure generated by the pump and passes through the ball valve 9 to the pump line.

The flow rate and pressure are regulated by adjusting the speed of the electric motor 10 by means of the frequency converter 11. The pressure before the generator is recorded by the manometer 12, and that after the working chamber by the manometer 13. The pressure pulsation in the working chamber is recorded by the pressure sensor 14, whose signal is passed to the amplifier 15 and onward to the oscilloscope 16 for recording. To reduce the pressure pulsations in the working line there is the oscillation damper 17.

The scheme also includes the receiving vessel 18 analogous to the vessel 1. It may be used independently or work in parallel with the vessel 1. The ball valves 19 and 20 serve to transmit the liquid from the

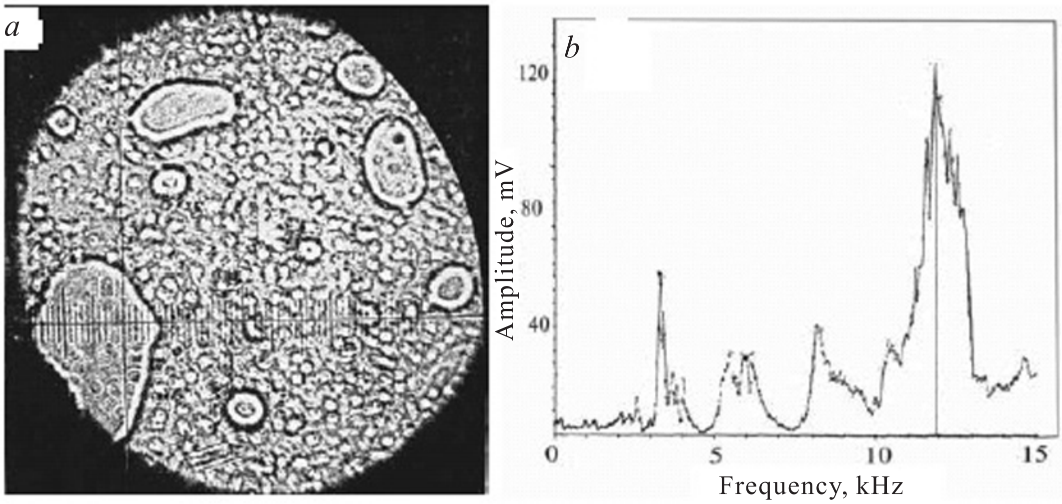

Fig. 2. Oil-water system without stabilizer: a) view of emulsion; b) amplitude-frequency characteristic of wave process.

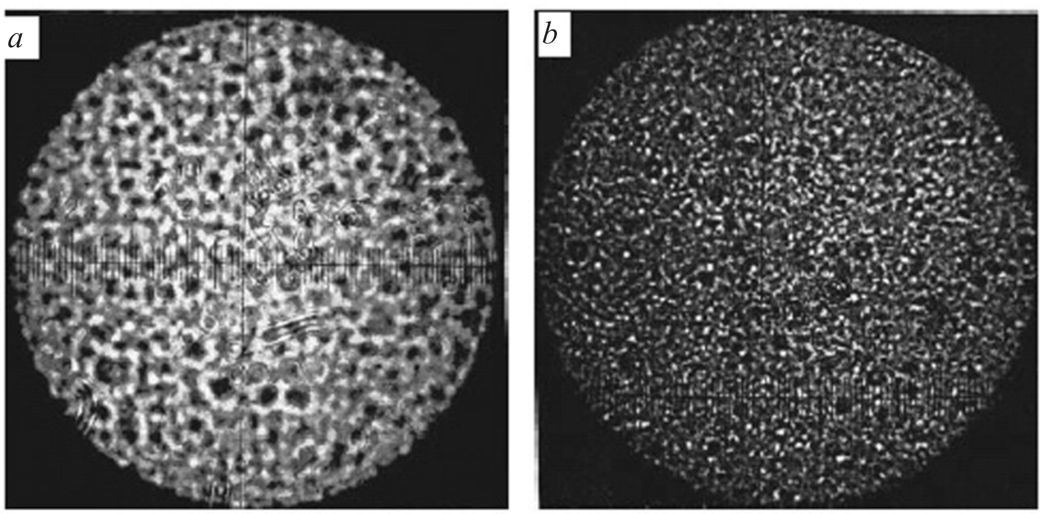

Fig. 3. Oil-water system (a) and water-oil system (b) with the addition of 0.15 wt.% stabilizer (wave generator working for 15 min).

vessel 18 to the pump, while valve 21 is intended to pass the components to the pump line from outside, and valves 22, 23, and 24 are used to sample respectively the receiving vessels and the working line. The ball valve 25 is intended for supplying the working liquid from the system to the vessel 18.

The pressure pulsations are recorded with the pressure sensor, amplifier type 5011 made by Kistler (Switzerland), and the oscillograph type 2034 made by Bruel and Kjaer (Denmark). The dispersion is determined with a microscope made by LOMO Mikomed-2 (Russia) with a magnification of 1500. That magnification allows one to examine the droplet structure and the shells. The DS is photographed with an OLUMPUS (Russia) digital camera. One scale division on the photographs corresponds to 1 ìm.

The DS physical characteristics are determined by standard methods: density in accordance with GOST 18481-81; volume by means of cylinders in accordance with GOST 1770-74; temperature with a standard glass thermometer; and viscosity by means of an MT 202 rotation viscometer.

Table 1 shows the experiments. In runs 1 and 2, we made the DS with 16 liter of water, 4 liter of oil, and correspondingly 0.15 and 0.2 wt.% stabilizer. In the later runs (3 and 4) with the same amount of water (16 liter) the amount of oil was halved, and the amounts of stabilizer were respectively 0.2 and 0.15 wt.%. Samples were taken and analyzed after the equipment had reached the steady state. The operation of the wave generator was accompanied by a rise in temperature. The Reynolds number calculated for the working part was about 1400.

Figure 2a shows a photograph of the DS obtained without the use of stabilizer after the plant had reached the working state. The structure of the DS is not dense, and is inhomogeneous, with the diameters of the droplets 2-20 ìm. Individual small droplets with shells are combined into large groups and coated with a binary protective layer, which shows that flocculation is occurring (formation of aggregates). Similar phenomena have been observed in [3].

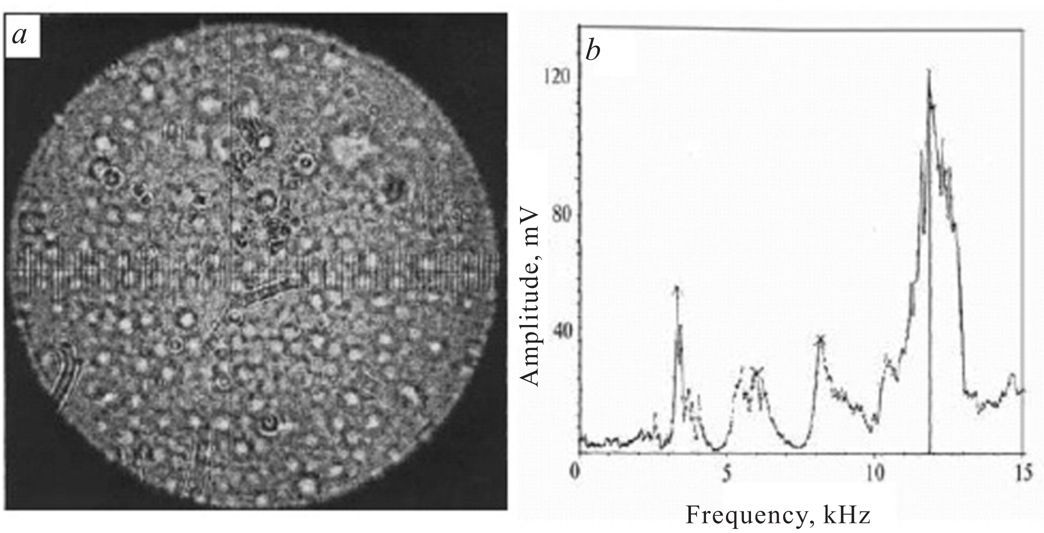

Fig. 4. Oil-water dispersed system with addition of 0.2 wt.% stabilizer: a) view of emulsion; b) amplitude-frequency characteristic of wave process.

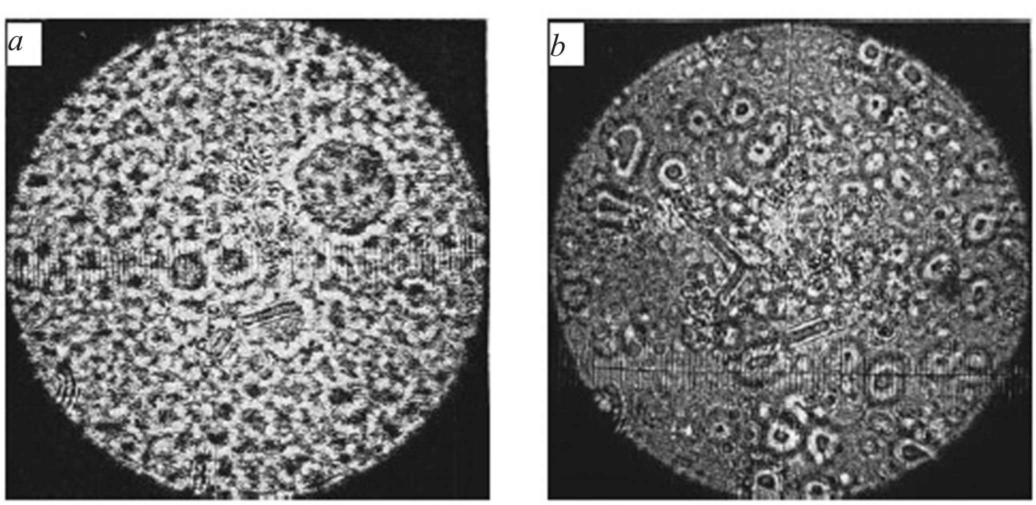

Fig. 5. Oil-water dispersed system with the addition of stabilizer: a) 0.2 wt.% (wave generator working for 10 min); b) 0.15 wt.% (5 min).

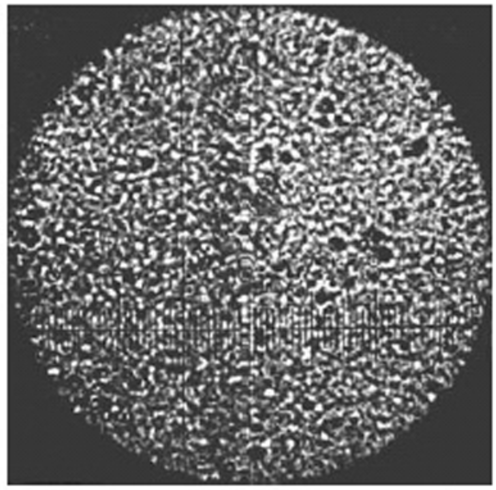

Fig. 6. Mean sample of dispersed water-oil system (foam) after 30 days of standing.

The amplitude-frequency characteristic of the wave process in that experiment (Fig. 2b) in intensity was close to that obtained previously with water: the amplitude of the wave process in the working chamber was given by the electrical signal as correspondingly 122 and 133 mV.

After the plant had been working for 10 min, we added 0.15 wt.% stabilizer. The wave generator produced not only a direct emulsion (oil in water), but also an inverted one (water in oil), i.e., the DS showed inversion. The direct DS after 15 min of operation for the wave generator (Fig. 3a) constituted a dense homogeneous mass of droplets with diameter 2-4 ìm protected by double and even triple shells. Also, there were large spheroid droplets, coated with two or three protective shells. Drops of that form are produced only when the composition is mixed at a very high rate [4].

The inverted DS after 15 min of wave generator operation (Fig. 3b) was a dense finely divided set of droplets of diameter 1-2 ìm. The direct and inverted DS differed considerably in density (973 and 951 kg/m^3) and considerably (by a factor 500) in dynamic viscosity (0.001 and 0.5 Pa.sec). The water-oil DS differed from the oil-water DS in being formed by a different mechanism via other stages, and as a result, no spheroids were produced.

Run 2 was performed with the same technological parameters as run 1 but with the addition of 0.2 wt.% stabilizer.

Figure 4a showed the dense homogeneous consistency of the DS of oil-water type with the inclusion of spheroids. The droplets and the spheroids are enclosed in single, double, or triple shielding sheaths. The droplet diameter is 2-4 ìm. The amplitude-frequency characteristic (Fig. 4b) recorded under the working condition shows that the amplitude of the oscillations in the working chamber indicated by the electrical signal was 124 mV.

Runs 3 and 4 were with the amount of oil reduced by a factor 2, and this resulted in up to 40% of inverted DS. The direct (oil-water) DS obtained in run 3 (Fig. 5a) was similar in form to that obtained in run 1. A difference was that the photographic field had a large aggregate of associated droplets, which may have been formed by flocculation on disruption of the pump mode (flow continuity).

In run 4, the formation of the inverted DS destabilized the work of the plunger pump. The photograph of the direct DS (Fig. 5b) shows that by comparison with the previous analogous system the composition was less dense and less dispersed. The photograph for this DS contained spheroids. The mean droplet diameter was 3-7 ìm.

Halving the amount of oil did not substantially influence the DS structure, but adding the stabilizer substantially altered the stability. For example, the separation of the unstabilized direct DS occurred within 3 days, while the addition of 0.15 wt.% stabilizer increased survival time of the system to 9 days.

We examined the stability of the inverted DS in the first 20 days and found that the unmixing occurred with the segregation of oil constituting 20% of the amount in the material. In the subsequent 18 days, water also segregated at the level of 10%.

Figure 6 shows an average sample from runs 3 and 4 with inverted DS taken after 30 days, where there is a dense uniform dispersed system with droplet diameter 1-3 ìm. This is a viscous oily liquid difficult to wash off. Subsequent samples of the inverted DS taken at 240 days hardly differed from the 30-day ones, which shows that it is possible to make stable finely divided systems as effective lubricants.

It is thus possible to use wave technology to make a direct dispersed system from immiscible liquids that is stable for not less than 9 days.

The lifetime of the inverted dispersed system (foam) of more than 240 days indicates that it is possible to make stable lubricants by the new technology containing 20-30% of mineral oil.

REFERENCES

1. R. F. Ganiev and L. E. Ukrainskii, Nonlinear Wave Mechanics and Technology [in Russian], Dynamics, Moscow (2008), p. 54.
2. R. F. Ganiev, L. E. Ukrainskii, V. E. Andreev, et al., Problems and Prospects of Wave Technology in Multiphase Systems in the Oil and Gas Industries [in Russian], Nedra, St. Petersburg (2008), p. 38.
3. M. P. Volarovich and N. Ya. Avdeev, Kolloidnyi Zhurnal, No. 1, 32-34 (1970).
4. F. D. Rumsheidt and C. Massan, J. Colloid Sci., No. 16, 238-241 (1961).