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REDUCING VISCOSITY OF PARAFFINIC OILS IN ULTRASONIC FIELD

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Experimental data on treatment of oils from East Zhetybai and Ashchisai fields in ultrasonic field for reducing their dynamic viscosity on a pilot plant are reported.

Oils having densities of 880–980 kg/m^3 and viscosities of 10–100 mPa·sec are generally considered *heavy* and oils having densities close to or above 1000 kg/m^3 and viscosities of 100–10000 mPa·sec, as *superheavy*. Many authors combine heavy and superheavy oils under the general term *heavy oils* or *high-viscosity oils* [1].

Improving technologies of heavy oil extraction is acquiring increasing urgency because reserves of these resources now exceed reserves of the remaining light oil, and with continuing rise in light oil production the share of heavy oil in the hydrocarbon reserve structure will keep on increasing.

In the opinion of domestic and foreign experts, the most promising method of attacking oil is subjecting it to the action of physical fields (magnetic, ultrasonic, vibration, etc.), which cause breakdown of the structures of the oil associates and thereby reduce the viscosity of the oil.

Application of elastic mechanical vibrations in petrochemical technologies ensures in many cases exceptionally high intensity of the technological process, which cannot be achieved by other methods. Analysis of investigations on application of cavitation for intensifying various technological processes shows good potential for this method [2, 3].

The goal of this work was to study the impact of cavitation and chemical reagents on the viscosity of oils from East Zhetybai and Ashchisai fields.

The tests were carried out on paraffinic oils from East Zhetybai and Ashchisai fields, the properties and group composition of which are cited in Table 1.

Based on the experiments performed earlier, the pilot plant GPR-2 with a throughput of 3 m^3/h, the core of which is a hydrodynamic flow-type reactor (HFR), was developed. The flow diagram of the plant is shown in Fig. 1 and its general view, in Fig. 2.

From the feed (starting) tank *1* (Fig. 1) the oil being treated is fed by the pump *2* under pressure 8.0–12.0 MPa into the HFR where in the housing of the intake section occur acceleration of the oil flow and rise in dynamic pressure (kinetic head), accompanied by fall in static pressure below the vapor pressure, and profuse formation of gas bubbles begins. After increase of the flow cross section in the chamber, the flow rate decreases, the static pressure rises, and the gas bubbles burst, which is accompanied by formation of a large number chaotic microbubbles. The concomitant pressure changes in limited

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TABLE 1

Oil field	Dynamic viscosity at 20°C, mPa·sec	Content, wt.%		
		of paraffins	of resins	of asphaltenes
East Zhetybai	575	28.3	19.3	3.8
Ashchisai	360	18.9	15.2	4.0

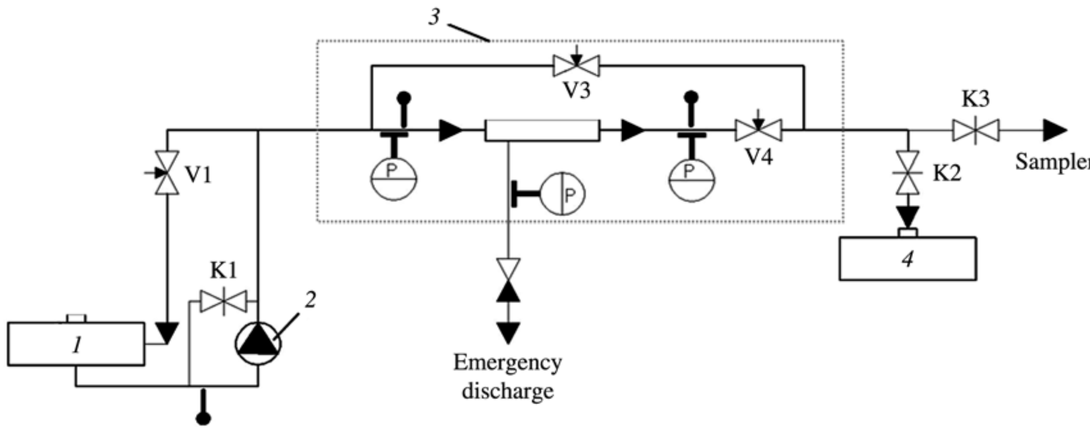
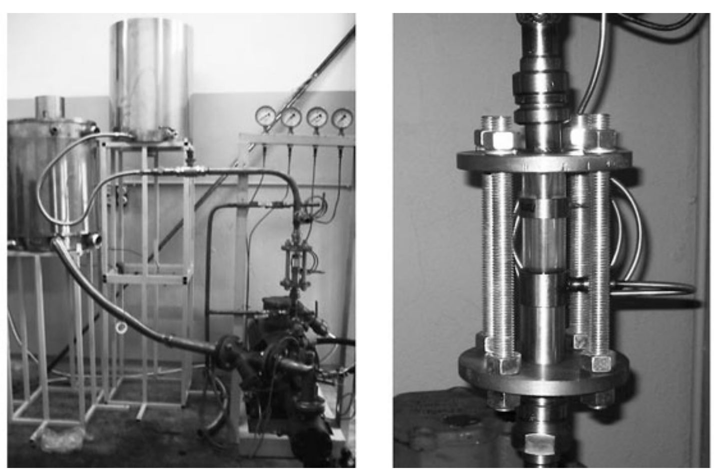


Fig. 1. Flow diagram of the pilot plant: *1*) feed (starting) tank; *2*) pump; *3*) working section; *4*) receiving tank.

a



b

Fig. 2. Pilot plant GPR-2: *a*) general view; *b*) hydrodynamic flow reactor.

parts of the liquid mass or high pressure gradients break up the intermolecular bonds in the oil, which leads to disintegration of the paraffins and breaking up of the oil associates, reducing thereby the viscosity of the oil.

The pressure in the system is controlled by valves V1, V3, and V4 and is measured by pressure gages. After the treatment, the oil flows into the receiving tank *4*. A sampler is used to collect samples. The plant also provides for emergency discharge.

The dynamic viscosity was determined on an INPN SX 850 instrument developed by the Institute of Petroleum Chemistry, Siberian Branch, Russian Academy of Sciences (IKhN SO RAN), for measuring low-temperature parameters of

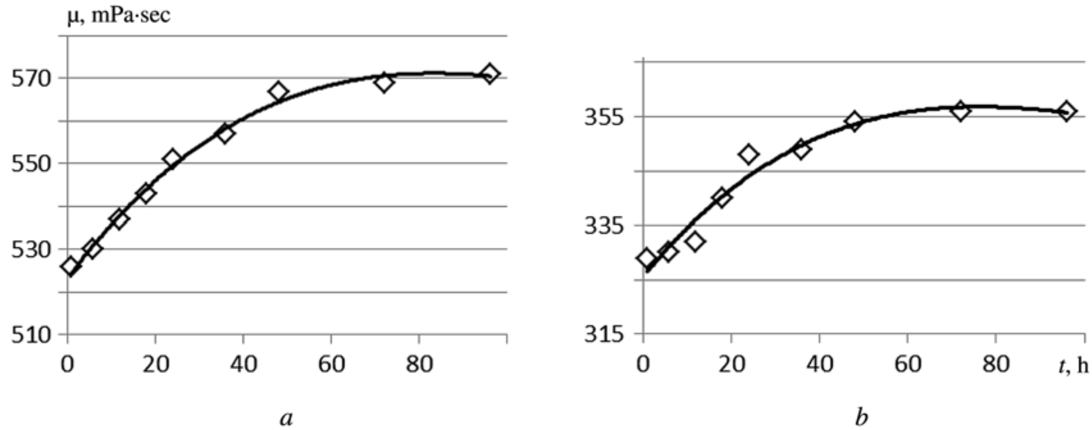


Fig. 3. Dynamic viscosity of oil versus time of sample storage after cavitation treatment in GPR-2: *a*) East Zhetybai field; *b*) Ashchisai field.

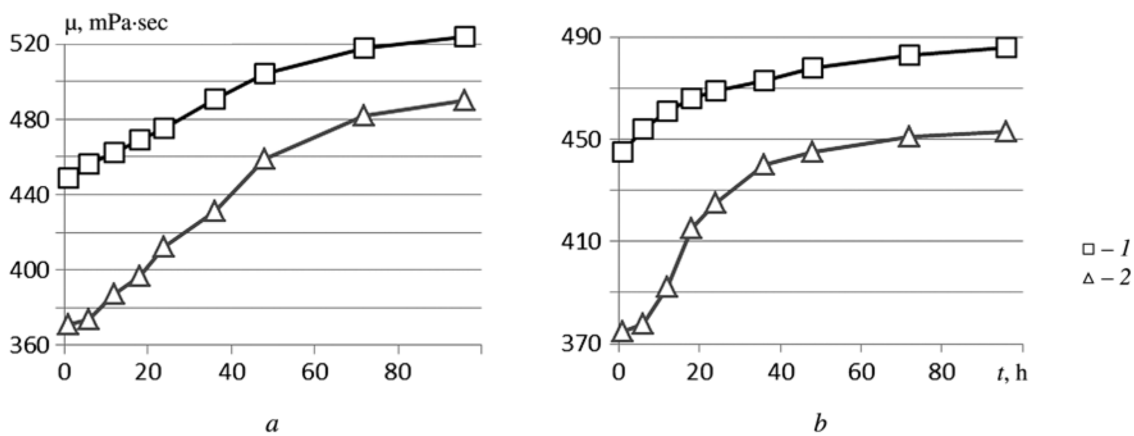


Fig. 4. Dynamic viscosity of oil from East Zhetybai field versus sample storage time: *a*) 2 wt.% of toluene; *b*) 2 wt.% of butyl acetate; *1*) after dilution with reagent; *2*) after combined action of reagent and treatment in GPR-2.

oil products, which is a rotary viscometer that measures the torque at a constant sliding velocity of 250 rad/sec. The precision of measurement of the sample temperature is ± 0.2°C and the precision of determination of the dynamic viscosity is 2 %.

Before measuring the viscosity, the temperature of the oil sample was kept at 20°C for 30 min.

The measurement procedure takes account of the requirements of the international standards ASTM D2602 and ASTM D4684 and the Russian standard GOST 1747–91. The arithmetic mean of two parallel determinations was used as the test result. The obtained result was rounder up to a whole number.

The laboratory experimental procedure provides for treatment of 50 liters of oil poured into the feed (starting) tank. The oil temperature in the tank was kept constant by an automatic electric heater. A fixed quantity of a reagent was mixed with the oil using a mechanical stirrer. Thereafter, the mixture was fed into the working section and then into the receiving tank.

Toluene and butyl acetate were used in the experiments as the reagents.

In the *first series* of the experiments, the change in the moisture content of the oil upon cavitation treatment was determined. The experiments revealed that upon cavitation treatment the dynamic viscosity of the oil from East Zhetybai field

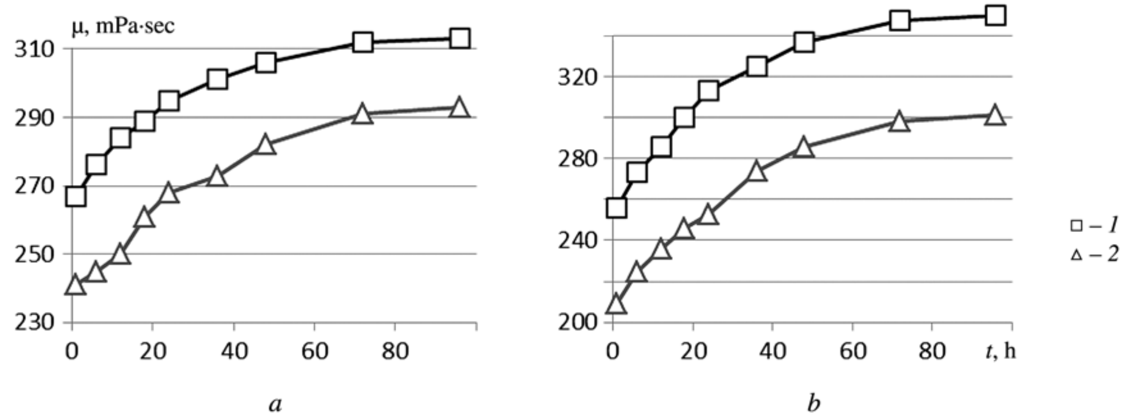


Fig. 5. Dynamic viscosity of oil from Ashchisai field versus sample storage time: *a*) 2 wt.% of toluene; *b*) 2 wt.% of butyl acetate; *1*) after dilution with reagent; *2*) after combined action of reagent and treatment in GPR-2.

diminishes by 7–8% and from the Ashchisai field, by 10–11%. A typical feature of both oils is relaxation of their properties with time; for instance, in two days the viscosity is found to return to the initial value (Fig. 3).

Cavitation treatment causes disintegration of paraffins and supramolecular structures (associates, micelle, etc.) and diminution of their size, which facilitates reduction of oil viscosity. With passage of time after the treatment, the disintegrated particles restore intermolecular bonds, causing relaxation of dynamic viscosity of the oil.

It is well known that addition of aromatic hydrocarbons alters molecular mobility of group components of disperse oil systems (DOS), which causes diminution of viscosity and aggregate stability of DOS [4].

In the *second series* of experiments, the viscosity of the oils after addition of the reagents was determined. Earlier experiments showed use of toluene (2 wt.%) and butyl acetate (2 wt.%) to be effective for reducing viscosity of the test oils. The results of the second experiment series are plotted in Figs. 4 and 5. Upon addition of 2 wt.% of the reagents, the viscosity of the East Zhetybail oil fell by 22% and of the Ashchisai oil, by 28%. Subsequent viscosity measurements showed that with sample storage time the viscosities of the oils go up by 7–9%. The experiments demonstrated that addition of reagents impedes restoration of intermolecular bonds and formation of supramolecular structures.

The most remarkable results on reduction of dynamic viscosity of the test oils were obtained in the *first series* of experiments with addition of 2 wt.% of toluene and butyl acetate, followed by cavitation treatment in GPR-2. For instance, the viscosity of the East Zhetybail oil fell by 35% (Fig. 4) and of the Ashchisai oil by 42% (Fig. 5).

Unlike dilution with reagent alone, dilution of the oil with the reagent, followed by cavitation treatment in the GPR-2, causes the viscosity to diminish further by18–19%. Measurements of oil viscosity after the *third series* of experiments showed that the viscosity of the oils rose in four days, but the combined effect of reagent and cavitation action was greater than the effect achieved by action of cavitation or reagent individually: it was 8% for the East Zhetybai oil and 14% for the Ashchisai oil.

Conclusions

1. The studies conducted demonstrated that the dynamic viscosity of the oil from the East Zhetybai field diminished:
   - by 8% upon cavitation treatment of the oil;
   - by 22% upon dilution of the oil with 2 wt.% of butyl acetate;
   - by 35% upon dilution of the oil with 2 wt.% of butyl acetate, followed by cavitation treatment.
2. The viscosity of the oil from the Ashchisai field diminished:
   - by 10% upon cavitation treatment;
   - by 28% upon dilution of the oil with 2 wt.% of butyl acetate;
   - by 42% upon dilution of the oil with 2 wt.% of butyl acetate, followed by cavitation treatment.

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