EFFECTS OF OPTIMAL CONCENTRATIONS OF ASPHALT—TAR SUBSTANCES AND WAX ON THE RHEOLOGICAL CHARACTERISTICS OF HIGH-VISCOSITY PETROLEUM DURING TRANSPORT IN LARGE PIPELINES

A. M. Shammazov

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It is shown that the optimum ratio of asphalt—tar substances to wax is independent of temperature and pressure in transport of high-viscosity petroleum through pipelines.

One way of improving the performance in the transport of a non-Newtonian oil is to adjust the rheological parameters by introducing depressor additives. Very often, the oil itself contains considerable amounts of asphalt—tar substances (ATS), which at certain concentrations increase the pipeline capacity. The contents of these substances in certain oils may be as high as 50% [1, 2].

We have examined the optimum wax and asphalt—tar contents, at which there is the largest improvement in the rheological parameters of high-viscosity petroleum, together with the effects of temperature and pressure on the optimum ratio of ATS to wax. We used solutions of diesel fuel and industrial oil, in which the wax and asphaltenes were dissolved. The wax concentrations varied from 10 to 25%, and the ATS from 1 to 12%. These substances were added to a closed vessel at 80°C. The solutions were kept for 5 days to eliminate the effects of the heat treatment and then were used with a Reotest-2 rotational viscometer at velocity gradients of 40-729 1/sec.

There is a characteristic minimum on the graph relating the tangential stress to the ATS content.

It seems clear that there is a ratio of asphalt—tar substances to wax in a high-wax oil at which one gets the best transport behavior in a pipeline (Fig. 1). The optimum ratio of ATS to wax in the experiments was 0.3.

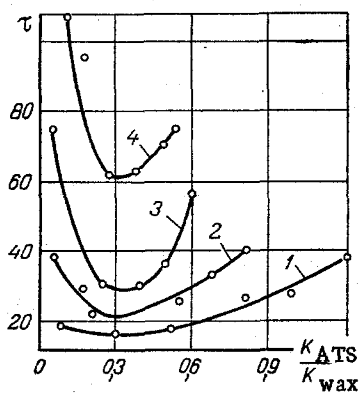

Fig. 1

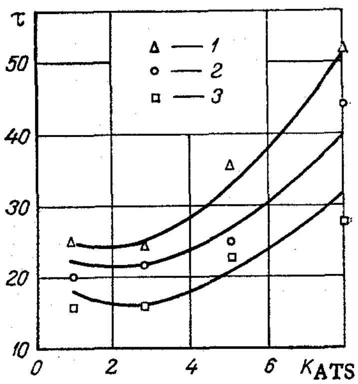

Fig. 2

Fig. 1. Variation in tangential stress τ with K_{ATS}/K_{wax} (solvent diesel oil D_r = 437.4 1/sec, t = 20°C: 1) 10% wax; 2) 15; 3) 20; 4) 25; τ in dyn/cm^2.

Fig. 2. Dependence of τ on K_{ATS} (10% wax, solvent diesel oil): 1) t = 10°C; 2) 15; 3) 20.

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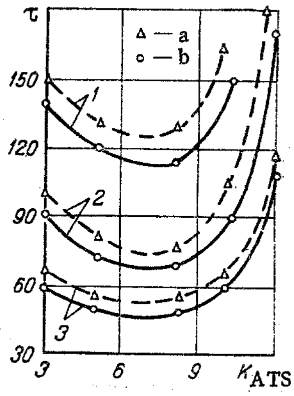

Fig. 3. Dependence of τ on K_{ATS} (30% wax, solvent diesel fuel, t = 20°C): a) initial system at an excess pressure of 0 atm; b) pressure-treated system at an excess pressure of 50 atm: 1) D_r = 729 1/sec; 2) 437.4; 3) 243; K_{ATS} in %.

In the second series, we examined the effects of temperature on the optimum ratio of ATS and wax. It was not evident that temperature affects this ratio (Fig. 2).

One of the factors enabling one to control the rheological parameters in a non-Newtonian system is pressure treatment [3]. A non-Newtonian liquid after hydrostatic compression (pressure treatment) may show a fall in viscosity [4].

A series of experiments was performed on the effects of pressure treatment on the properties of non-Newtonian systems and on the optimum ratio of wax to ATS. The excess pressure varied from 0 to 50 atm. The upper limit was set by the permissible working pressure in pipelines.

Figure 3 shows the variation in τ with content of asphalt—tar substances before and after pressure treatment. It was not evident that there was any change in the optimum ratio between wax and ATS. It was also found that a non-newtonian system after pressure treatment tends to recover its rheological parameters as time passes.

NOTATION

τ, shear stress; D, velocity gradient; K_{ATS}, concentration of asphalt—tar substances; K_{wax}, wax concentration; t, oil temperature.

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