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STRUCTURAL FEATURES OF INDUSTRIAL WATER-CRUDE OIL EMULSIONS. MICROWAVE STUDIES

I. N. Evdokimov and M. A. Novikov

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The thermal properties and structural features of industrial water-oil emulsions were investigated with microwave treatment. The critical concentrations of water at which abrupt structural changes take place were determined. The effect of the mass fraction of water in the emulsion on its heating rate and the efficiency of demulsification was studied. A 15-20 or 60-65% water content is recommended for breaking down emulsions. Demulsification takes place with minimum power consumption and with the highest efficiency.

The performance and user properties of crude oils and many petroleum products – fuel, viscous oils, and greases – are to a great degree determined by the presence of water in them [1, 2]. The formation of emulsions of water with fuel can cause engines to break down, and formation of emulsions with lube oil in the crankcase ventilation system can diminish the protective properties of the lube oil. One negative factor in crude production is its flooding, which causes problems related to formation of stable water–crude oil emulsions. Water also enters crude oil when steam is pumped into the stratum and during desalting in electric desalting units (EDU).

Petroleum emulsions are easily formed in turbulent streams of a water-crude mixture when the pressure in the pore channels changes and during movement through throttle plugs and different valves in pipeline systems. An increase in the viscosity of the crude can increase the pumping costs due to higher power consumption. The presence of emulsions intensifies corrosive wear of the equipment.

Typical natural emulsions are water in crude oil [3]. Crude oil contains surfactants (SF) such as asphaltenes, naphthenic acids, and solid organic and inorganic particles. According to the Bancroft rule, a liquid containing SF becomes a continuous phase [4]. In migrating to the phase boundary, SF form elastic protective films around drops of water [1].

Modern methods of breaking down water–crude emulsions are based on using contact heating methods or chemical additives (demulsifiers). Excessively high power consumption is characteristic of the first, and

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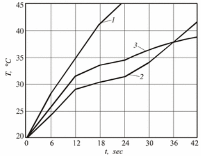

Fig. 1. Sample temperature T vs. microwave exposure time t : 1) pure water; 2) pure crude ; 3) water–crude emulsion with 30% water.

contamination of wastewaters and oil refining products is characteristic of the second method. Contactless microwave demulsification, patented more than two decades ago, is an alternative to these methods [5].

Microwaves have high penetrating power and act selectively on water, crude, and interfacial films, ensuring separate energy input. As a result, the phase separation rate increases significantly in comparison to ordinary heating methods and power consumption decreases [6-9].

Detailed information on the structural properties of the emulsions are necessary for controlling and increasing the efficiency of demulsification [10]. Our studies provided new information on the character of the structural changes in natural water–crude emulsions and revealed the features of their breakdown by microwave treatment.

Emulsions based on crude oil taken from well No. 624 (Bobrikov stratum) in the Kuroki field in Volgograd oblast were investigated. The degassed crude had a density of 832 kg/m^3 at 20°C and a solid point below –18°C, and1% asphaltene, 8% resin, and 2% paraffin content. The aqueous phase was a double distillate (pH=5.5) obtained according to GOST 6709–92 and stored in air.

All preliminary procedures were conducted in a thermally controlled cabinet at a temperature of 20°C. Water in proportions of 0 to 100 wt. % (with a 5% step) was mixed with the crude oil with a mixer (~2000 ppm) for 8-10 min. Samples of the emulsions weighing 70±0.5 g were placed in 100-ml glass vessels for microwave treatment. The type of emulsion (water in crude or crude in water) was determined by the drop test method [9]. All emulsions with a water content of up to 80% (inclusively) were of the water in crude type.

An Elenberg Microwave Oven MS-1700M (2.45 GHz, 700 W) operating in the minimum (17%) output power range was used as the microwave source in the experiments. In each experiment, the vessel with the emulsion (initial temperature of 20±0.1°C) was placed in the center of the microwave oven and exposed to microwave treatment for the assigned time (accuracy of determination of ±0.5 sec).

The temperature of the emulsion was measured with a calibrated thermocouple placed on the axis of the sample at a depth of 10 mm from the surface of the emulsion. In addition, the heating time t_d at which the beginning of demulsification was visually observed was recorded: appearance of the first drops of water on the bottom/walls of the vessel containing the emulsion or formation of a layer of pure crude on the surface. The effectiveness of demulsification was defined as $1/t_d$.