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Research of Affection of Iron Nanoparticles on Chemical Indicators and Rheological Parameters of Waxy Crude Oil

E. M. Gojaev[1*], E. A. Mammadov[1] and A. Sh. Aliyeva[2]

[1]Department of Physics, Azerbaijan Technical University, Azerbaijan.
[2]Department of Environment and Nature, Sumgait State University, Azerbaijan.

Authors' contributions

This work was carried out in collaboration between all authors. Author EAM formulation of the problem, assembly and adjustment of the measuring device, discussion of the experimental results, author ASA participate in the discussion of the results and the preparation of this article. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

The study presented dependence of densities, dynamic and kinematic viscosity coefficients, surface tension and thermal expansion coefficients of paraffin oil from operating oil wells on temperature range 290-350 K and and concentration of the iron nanoparticle- 100 nm.

It was found that the addition of paraffin oil production of 0.01% when the dynamic and kinematic viscosity ratios of iron nanoparticle and surface tension coefficient decreases sharply and at the further increase the amount of nanoparticle these parameters remain unchanged.

The study will be prepared for paraffin oil using magnetic mixer mechanically mixed for half an hour, an hour and then washed them largely for research nanoparticle 100 nm sized iron is added in the same manner mix half an hour, gets ready for the sample after being 4 hrs.

**Corresponding author: E-mail: geldar-04@mail.ru, Breathe-no-more@list.ru;*

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1. INTRODUCTION

As it is known, the pressure gradient across the layer of oil field development process can vary widely. It means, that the dynamic pressure gradient is various in different parts of layer. That is one of the consequences of the high amount of asphalt-tar-wax mixture in crude oil from the oil fields. It was found that, in the case of decrease of the temperature dispersed compounds lead to the non-Newtonian properties of the oil. In other words, existence of tar gives the oil elasticity, while presence of wax leads to its nonlinearity [1,2].

The formation of asphalt-resin-paraffin sediments sharply influence to the work of technology installations and the prime cost of extracted oil. There are different methods to research these sediments: it is achieved by the addition different reagents into the oil chinks, local warming of the zone, where the sediment exists, or by the prevention them by mechanical methods. Factually, these technologies service to the prevention of yet formed sediments. There are many ways, when for examples, the increase of the pressure and the temperature has certain negative impacts: by the increase of the pressure the harvest decreases, but for the increase of the temperature there are demanded additional energy and additional expenses.

There exists other method. Over the length of the delivery pipe the consistence of paraffin-resin-asphalt sediment changes, and in very extremely cases in the consistence of the sediment the paraffin becomes high than 50%. So as aliphatic carbohydrates are selective solutions of the paraffin, taking over the oil in aliphatic, naphthenic and aromatic carbohydrates there have been researched the formation possibilities of paraffin sediments in conditional “Oil-paraffin” solution. In this method there have been accepted that on increasing of the depth of the chink the thermodynamic condition of the system changes and therefore undergoes to the changes in paraffin. The decrease of the pressure, the gazing of definite part of slight aliphatic change the balance of “Oil-paraffin” system and then the temperature of the system decrease for the encouragement of the gas form of the oil. The practice of the oil industry show that stopped and little harvest, also sediments by paraffin origin with high harvest practically don’t create; they begin to form from certain depth and then gradually decrease on reaching the maximal value. Sediments usually form after decrease of the pressure in the system in chinks, which harvest consists of 20-60 m3/day. In stopped and little debit chinks the flow is laminar; therefore the delivery of the mass is connected with the diffusion process, expressing with Feke law. Regarding to this law for the standard replacement the proportion coefficient consists of 10^{-5}, therefore there isn’t observed the formation of crystals. On increasing of the loss the linear speed increase, and it results in the mass delivery to the pipe wall, and delivering substance small stick reaches its maximal value after turbulent flow. At the same time the layer, which provide the delivery of molecules to the wall of the pipe is saved. Over the stronger turbulent flow the general substance is delivered by the center of the pipe and the laminar layer, which exists between the central turbulent core and the pipe’s wall. The thickness of the laminar layer is inverse proportion with Reynolds number and when its size is included into the size of shoots of pipe’s wall the substance, which deliveries from the flow to the pipe’s wall, is decreased. This condition is provided when Reynolds number is 20000. Over the increase of the liquid the speed characteristic of flood increase gradually and in this time the delivery of paraffin molecules from the oil production to the pipe’s wall decreases. For crystallizing theory it is possible to realize the decreasing of the formation of asphalt-resin-paraffin sediment by: 1. Including additional crystallizing centers into the structure; 2. To create imitation crystallizing centers by the changing of thermodynamic parameters of the lifting liquid.

Results of research works, held in this direction, have been comprehensively resumed in [1-7] works. Taking into the attention the all of above noted in presented work the aim is to improve and manage paraffin damp oil parameters on using gland nano-particles.

As is well known, decrease of extracted oil flow temperature is the cause of wax sediments in inner surface and discharge lines of lifting pipes. Usually when productivity of wells is high, speed of oil flow in a pipe and productivity are also high. However, a gradual decrease of the temperature leads to the formation of wax sediments at great depths. That decreases the viscosity of crude oil, and oil extraction process becomes difficult [3,4]. To prevent this process it is important to develop new technology for treatment of wax oil. Taking this into account, it has been tried to manage and improve the parameters of waxy crude oil using iron nanoparticles.

2. METHODS OF PRACTICE

“Material iron powder wetted hexane (Fe 100 nm)” nanoparticle was used in research work. Samples for the research are prepared as mentioned below:

Firstly wax oil sample is mixed for half an hour by magnit mixer. After an hour, 100 nm iron nanoparticles in ratio destined for the research is added to the mixture and it is mixed for another half an hour. The sample for the research is ready after precipitation of mixture for 4 hours. This mode of oil-nanoparticle system is defined by stability of conversion of parameters to be researched.

The dynamic viscosity (η) of oil has been determined in a rotary viscometer "Reotest 2" [8,9] and a density has been determined in hydrometer according to the procedure described in [10]. Kinematic viscosity has been determined by the formula

$$\nu = \frac{\eta}{\rho}.$$

Measurement of wax crude oil parameters were done firstly without any exposure. The research was done on wax oil product extracted from oil well. Temperature differences of rheologial parameters of crude oil, surface stress factor, density, kinematic and dynamic viscosity factors were researched in 290-350 K temperature interval under atmosphere pressure.

3. EXPERIMENTAL RESULTS AND THEIR DISCUSSION

Dependence of temperature from the surface stress is shown on Fig. 1. As it is shown in the Fig. 1, by increase of temperature from 290 K to 350 K surface stress coefficient of wax oil comes down from 29, 6mN/m – to 25, 3 mN/m, that is 15% decrease.

In the same temperature range of wax oil density decreases from 864 to 828 kg/m^3, that is about 4%. It should be mentioned, that during the research decrease and increase of the temperature of both parameters was the same. The result of kinematic and dynamic ratio of wax oil research in 290 – 350 K range of temperature is shown on Fig. 2.

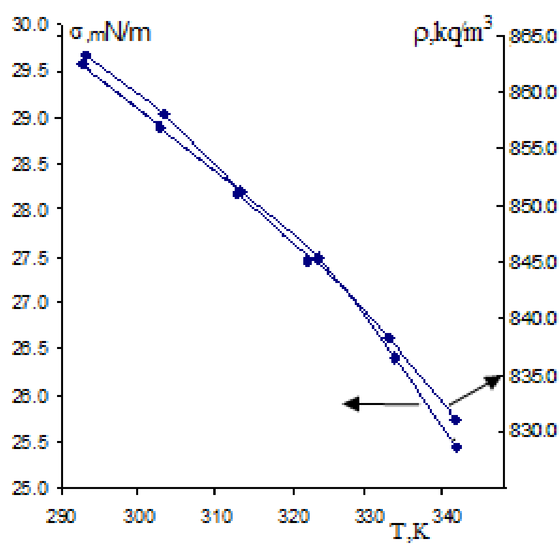

Fig. 1. Temperature dependences of surface stress factors (σ) and density (ρ) of wax oil

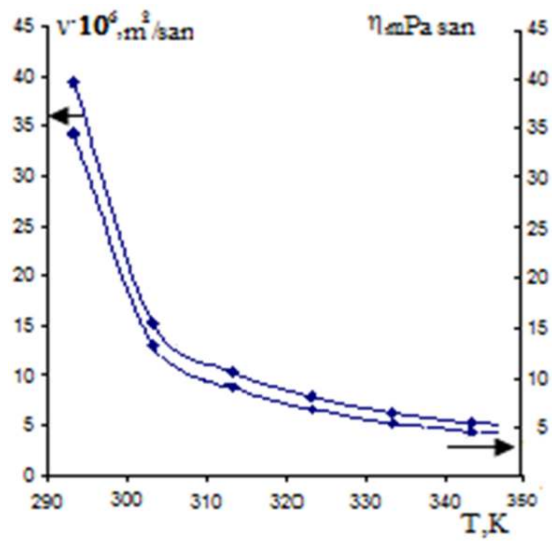

Fig. 2. Temperature dependences of kinematic (ν) and dynamic (η) viscosity coefficients of wax oil

Apparently, increase of temperature to 300 K leads to decrease of kinematic viscosity coefficient from 39 $10^6 m^2$/sec to 15 $10^6 m^2$/sec, which is 61%, while the temperature rise from 300 to 350 K leads to decrease of viscosity coefficient from 15 $10^6 m^2$/sec to 5 $10^6 m^2$/sec that is 33% decrease. So, the change of temperature at low temperatures decrease of viscosity becomes sharper. It should be mentioned that nature of change of dynamic viscosity of wax oil depends on temperature is almost identical. (Fig. 2), the increase in temperature to 290-300 K brings decrease of viscosity to 34 – 13 MPas sec, which is 61% decrease. But following rise of the temperature up to 50 K, there is a fall from 15 MPas·sec to 5 MPas·sec is traced, that is 33%.

According to experimental estimates of density of temperature dependence of wax oil, following formula is used

$$\alpha_p = -\frac{1}{\rho}\left(\frac{\partial \rho}{\partial T}\right)_p = -\frac{1}{\rho}(1.853 - 0.0078T)$$

where the thermal expansion coefficient of wax oil is calculated.

The result of calculation is shown in Fig. 3. As shown in the Fig. 3, the research is carried out in 290-350K temperature range, thermal expansion coefficient increases from $500 \cdot 10^{-6} K^{-1}$ to $1000 \cdot 10^{-6} K^{-1}$, that is 50% rise.

Influence of geometrical dimensions and amount of materials of nanoparticles upon rheological parameter of wax crude oil was investigated. The research was carried out in room temperature (20℃). Initially, 100 nm iron nanoparticles were added to wax oil samples, properties of which were analysed. It has been determined that the rise of amount of iron nanoparticles to 0.0015 percent, leads to reduction of kinematic viscosity by 31%, from $39 \cdot 10^{-6} m^2$/sec up to $27 \cdot 10^{-6} m^2$/sec. Monitored decrease of kinematic viscosity entailed by following reduction of concentration of nanoparticles is not observed (Fig. 4). Similar results were obtained for the dynamic viscosity coefficient. Thus, change of η coefficient followed by rise of amount of nanoparticles to 0.012 percent while amount of iron nanoparticles increases to 0.004 percent, that leads to reduction of kinematic viscosity by 36%, from 36 mPa·sec up to 23 mPa·sec, was not observed.

The results of research on determination of interaction between surface stress coefficient of wax oil and amount of iron nanoparticles in percents are listed in Fig. 5. As it is shown in the figure, change of σ coefficient followed by

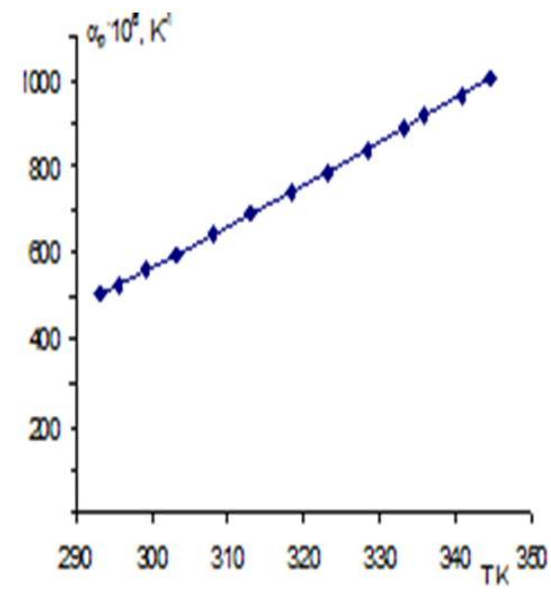

Fig. 3. Dependence of thermal expansion coefficient from the temperature for wax oil

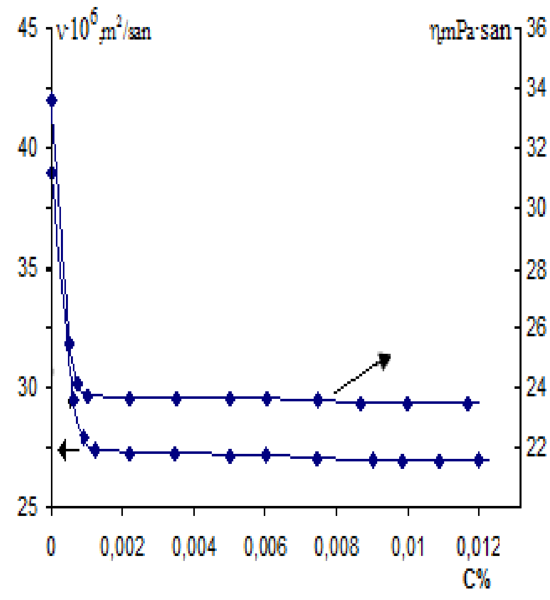

Fig. 4. Dependence of variety of kinematic (ν) and dynamic (η) viscosity coefficients from +100 nm wax oil iron nanoparticles system

consequent rise of concenration of nanoparticles to 0.004 percent, that leads to decrease of σ by 9%, from 29,7 mN/m up to 27 mN/m, practically was not observed. The results of research on determination of interaction between density of wax oil and amount of iron nanoparticles are reflected in Fig. 4. As it is shown in the Figure this interaction is very weak.

As we know in available chink after the decreasing of the pressure the formation of sediments occurs in the condition of great kinetic energy of molecules in hydrogen connection energy and Van-der-Vaals. It occurs when the metallic pipe's wall accords to the crystalline structures of the crystal, which forms in there. As we know from the colloid chemistry courses the glade and paraffin, which form in result of the splitting of the glade hydroxide (Fe2O3.n.H2O) over short time, crystallize in same rhombic syngony. For this reason paraffin sediments form on the surface of the metallic pipe.

In order to explain the high viscosity of wax oil, this type of oil products should be observed as colloidal systems [5]. There occurs weak interaction between colloid particles of low concentration of wax in oil, according to their location away from one another (Fig. 6). Viscosity of such system is also low. By increase of wax concentration, the space between these particles becomes smaller and arised weak interaction leads them to team up and develop associations (Fig. 6b). At this time, a slight increase in viscosity can be remarked. Greater concentrations of wax brings to convergence of associates and emergence of unit spatial cage, which leads to a sharp increase in index of viscosity (Fig. 6c).

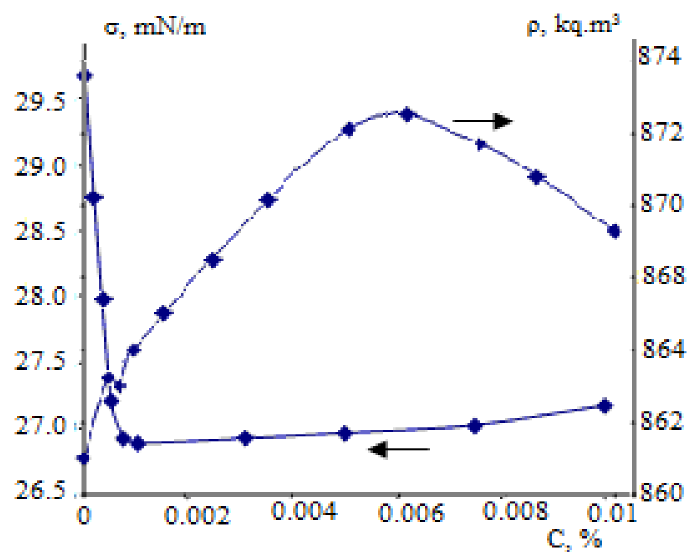

Fig. 5. Dependence of surface stress coefficient (σ) and density (ρ) concentration from+100 nm Aluminum nanoparticle of wax oil

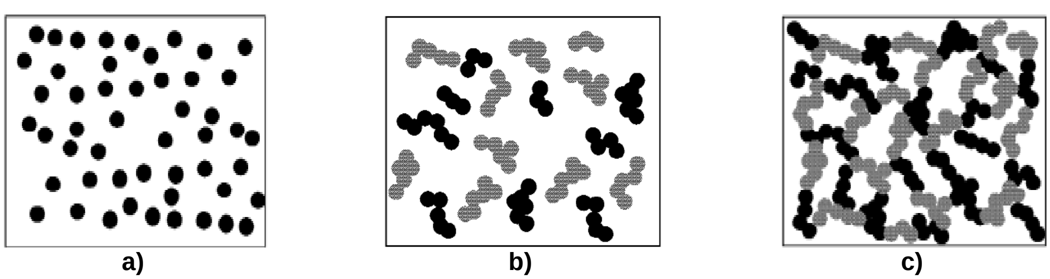

Fig. 6. Variety of microstructures in accordance with concentration of particles of colloid system

Analysis of the results testifies that heating of the temperature up to 303 K and 100 nm sized iron nanoparticles substance of wax oil correspond with its optimal values by increase of kinematic and dynamic viscosity factors and surface stress factors. It means that, it is allowable to use practice of experimental determination of geometrical dimensions, nanoparticles materials selection and their amount in percentage, for cleansing of wax crude oil extracted from oil wells.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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