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Effect of Mechanical Impurities on Wax Appearance Temperature

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Abstract

Wax precipitation was studied in solutions of wax in concentrations of 10-60% by weight in two hydrocarbon solvents. It is shown that the model solutions prepared with diesel fuel have higher values of saturation temperature compared with the solutions prepared on kerosene. Studies have shown that increasing the concentration of wax in solution leads to an increase of the saturation temperature. Article describes that the addition of impurities to the solutions leads to an increase of the saturation temperature. A comparison was made by processing research data obtained by two independent research methods (visual and rheological). It is shown that the saturation temperature obtained by rheological method is higher on average for 1°C than the saturation temperature obtained by the visual method.

Keywords: Wax precipitation; Wax appearance temperature; Mechanical impurities; Rheological research method; Visual research method

Introduction

Operation of the wells producing heavy oil is inevitably accompanied by a sphaltene-resin-wax deposits in the surface and underground equipment [1-3]. This requires regular monitoring by operating companies of complicated objects, rapid determination of the complications localization in order to avoid costly inactive of production wells. Mechanical impurities (particles of the reservoir, proppant, salt, corrosion products), that are brought from the well by the fluid flow influence the formation process of asphaltene-resin-wax deposits in oil-field equipment. They participate in the creation of difficult to remove deposits of complex composition. The solution to the problems: identifying areas of probable wax precipitation in solid phase during the extraction of the fluid which contains mechanical impurities; and select the best way to prevent this type of complication it is possible to apply the express methods for determining the saturation temperature of oil with wax (wax appearance temperature), one of which may be rheological method [4].

Main part

Laboratory studies of the wax solubility in crude oil and model hydro carbon solutions in a wide range of concentrations have been carried out in the works [5-8]. However, authors have not analyzed the influence of mechanical impurities on the wax appearance temperature. In the current work, we analyzed the effect of wax concentration and mechanical impurities on the saturation temperature (TAS) of model solutions with wax by using visual and rheological methods. We created solutions with various concentrations of wax mark T-1 according to GOST 23683-89 with a melting point of 52-58°C in kerosene; mark TS-1 according to GOST 10227-86 with the crystallization temperature that is not higher than - 50°C and diesel fuel mark H GOST305-82 with a pour point not higher than - 25°C.

Results and Discussion

Determination of saturation wax temperature of the model solutions by visual method was carried out according to GOST 5066-91 [9]. The result was obtained on the basis of two parallel tests. The results of the experiments are presented in Figure 1.

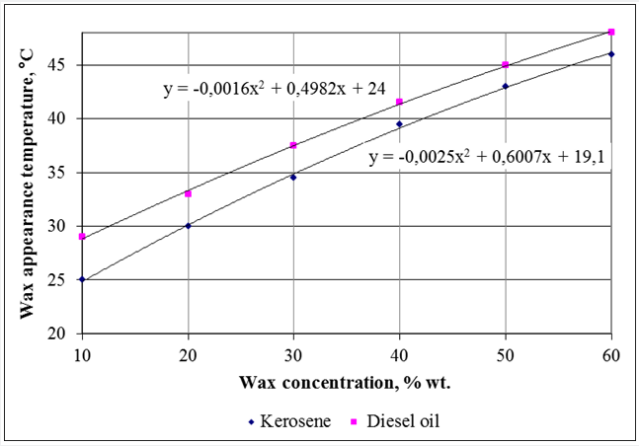

Figure 1: Dependence of the saturation wax temperature of the model solutions vs concentration of wax (visual method).

The saturation wax temperature in two different solvents, depending on the concentration of the wax, varies according to the power law and differs between them are 2-4°C due to the presence of large quantities of high-molecular compounds of the wax series in diesel fuel compared to kerosene [10]. In further experiments we used a wax solution in various concentrations in diesel fuel. To determine the influence of the mechanical impurities presence on saturation wax temperature of model solutions we added kaolinite clay fraction (0.01mm) at concentrations of 0.1, 0.5 and 1g/l, respectively. The test results are shown in Figure 2.

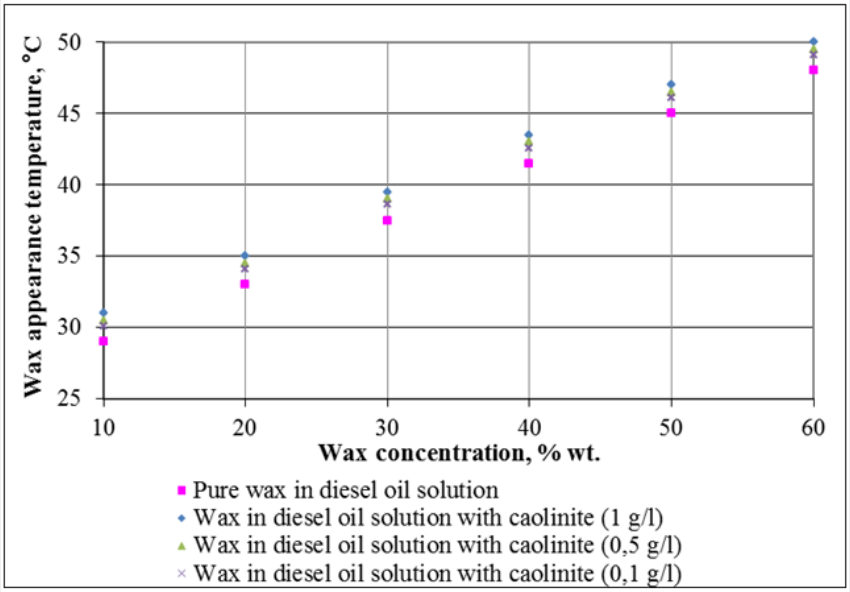

Figure 2: Dependence of the wax saturation temperature of model solutions vs wax concentration for different concentrations of mechanical impurities (visual method).

The above figure shows that the presence of mechanical impurities in the model solution increases the temperature of wax saturation by 1-2°C, determined by the visual method. It does not change the nature of the curve in general. Mechanical impurities act as centers of wax crystallization, between which molecules of the latter are redistributed. Its earlier release into the solid phase when observed temperature decreases.

Determination of saturation temperature of the model solutions by wax at its different concentrations in diesel fuel is made by rheological method with the applying of rotational viscometer Rheo test RN 4.1. The shear rate was set to 2s-1 based on the operation of a well with a diameter of 73/5,5mm and a flow rate of 30m3/day as one of the most dangerous in terms of wax formation. The results of the experiments are shown in Figure 3.

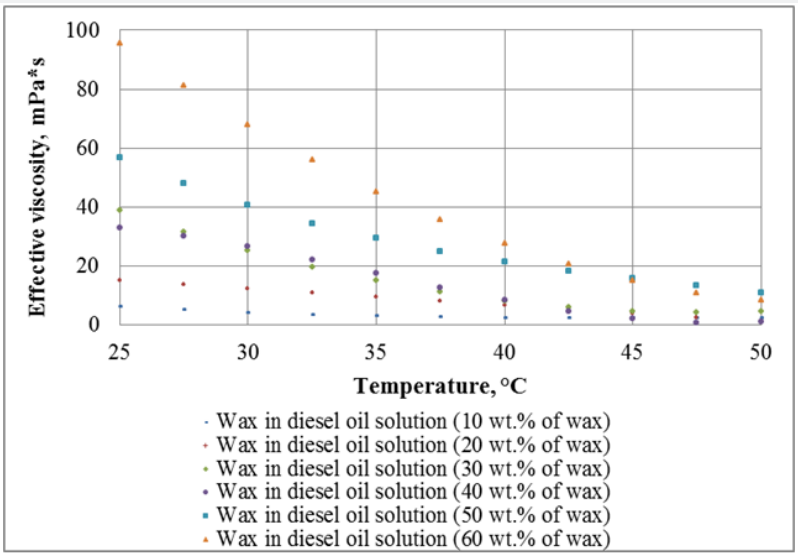

Figure 3: Dependence of effective viscosity of model solutions vs the temperature.

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The bending of the temperature viscosity curve indicates the appearance of a wax solid phase in the model solution (wax appearance temperature), and a further decrease in temperature leads to the formation of a structural network of wax crystals and a concomitant significant increase in the effective viscosity of the solution.

The kinetics of the process is determined by the concentration of wax in the model solution. When wax is crystallized in a solution with a higher concentration, adenser and stronger structural network is formed, the destruction of which requires more energy. The saturation temperature obtained by the rheological method is higher than that obtained by the visual method by approximately 1°C. This is due to the different sensitivity of the research equipment for different research methods and different test conditions. Figure 4 shows the experimental results when added mechanical impurities to a solution of wax in diesel fuel.

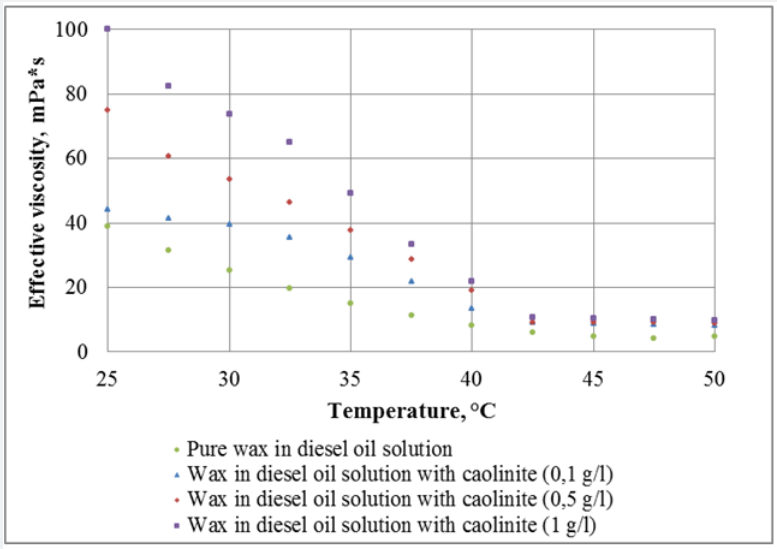

Figure 4: Dependence of the effective viscosity of the wax model solution with the 30%wt. concentration vs temperature for different concentrations of mechanical impurities.

a) The more wax concentration in the model solution the more wax saturation temperature that increases according to the power law.

b) Mechanical impurities increase the saturation temperature of the wax model solution and strengthen the three-dimensional spatial structure formed by the wax crystals.

c) The rheological method is technically simple, inexpensive and can be used as a rapid method for the determination of wax saturation temperature.

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