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INVESTIGATION OF THE EFFECT OF THE CATALYST ON THE COMPOSITION AND STRUCTURE OF PETROL FRACTION IN OIL UNDER ELECTRIC HYDROPULSE PROCESSING

Satybaldin A.Zh., Aitpaeva Z.K., Ospanova D.A.

Karaganda State University named after E.A. Buketov, Karaganda, Kazakhstan, zamik1981@mail.ru

As a result of the complicated practical implementation of electric hydropulse processing of liquid media, the mechanism of its effect on the properties of the water-organic dispersed system has not yet been fully studied. In some cases, the electric hydropulse processing of a liquid mixture of water and hydrocarbon makes it possible to facilitate the separation of light and middle fractions. The results of the investigation of the impact of electric hydropulse effects on the properties of the obtained fractions are presented in the article. As a result of the study, conditions facilitating the maximum reduction in the kinematic viscosity of the Karazhanbas field oil have been established. The duration of the electric hydropulse processing time during which the yield of light and middle fractions of high-viscosity oil increases is established. The optimal parameters of high-viscosity oil processing are determined. Those are the discharge voltage magnitude of a switching device and the capacitance of a capacitor bank.

Keywords*:* electro-hydro-pulse processing, dispersed product, structure, correlation coefficient, energy spectrum, dynamic equations.

Introduction

The rapid scientific-and-technological advance and high rates of development of various branches of science and world economy in the XIX-XX centuries led to a sharp increase in the consumption of various minerals, a special place among which was occupied by oil.

Growing competition in the oil and gas sector makes it necessary to improve the efficiency of company work. One of the promising directions in achieving this result is the technical and technological improvement of the oil treatment processes, such as oil gathering, water and gas utilization, oil desalting at the oilfield [1, 2]. The parameters and results of the technological procedure specification of oil refining and petroleum chemistry are determined by the quality of raw hydrocarbons in processing, which in turn directly depends on the effectiveness of the methods of its treatment and refining used. The current stage in the development of chemistry and technology of hydrocarbons is characterized by a progressive deterioration in the properties and quality of the processed oils due to increased water content, corrosive aggressiveness, sulfur and salt content, etc. Chemical reagents for various purposes are used in the technological processes of preparing raw materials for oil refining and petroleum chemistry; but in abnormal operating conditions traditional chemical methods and standard technologies are not sufficiently effective in many cases. In the process of oil extraction, transportation and storage, a number of problems arise, the solution of which requires deep understanding of mechanisms of the structure formation [2].

These include the formation of asphaltene sediments in tanks and pipes, high values of viscosity-temperature properties of paraffinic and high-viscosity index oil [2, 3]. One of the foreground tasks of the development of science and technology is the enhancement of chemical and technical processes and increase in efficiency of technical equipment. The basis of improving the quality of products, increasing productivity and reducing energy costs for running chemical technology processes is the development of highly efficient technology equipment with optimal energy density and specific consumption of materials, high level of effects on the processed substance matter.

1. Statement of the problem

Along with chemical methods for processing and improving the physical and chemical characteristics of heavy oils, a number of physical methods are used to impact on oil and water-organic mixtures, including their processing using electric hydropulse (EHP) treatment, which in some cases improves their properties and facilitates separation of light and medium fractions. EHP discharge in a high-molecular hydrocarbon medium causes the destruction of a continuous chain; in this case it breaks the bonds between the different parts of a molecule, and also causes a change in the structural viscosity, that is, a temporary breaking of Van der Waals bonds. Under electro-hydraulic shock waves, which cause a process of cavitation of quite a great intensive rate, during a long period of time, C-C bonds are broken in paraffin molecules. As a result, changes in the physical and chemical composition (reduction in molecular weight, crystallization temperature, etc.) and the properties of the petroleum products (viscosity, density, flash temperature, etc.). In the process of impulsive cavitation treatment of oil and petroleum products, the energy released at cavitation bubble collapse is used to break chemical bonds between the atoms of large molecules of hydrocarbon compounds.

The C-H dissociation energy changes dependening on the molecular weight and the molecule structure within the range of 322 ... 435 kJ/mole, and the C-C dissociation energy is in the range of 250 ... 348 kJ/mole. When the C-H bond is broken, monoatomic hydrogen rebounds from the hydrocarbon molecule, and when the C-C bond is broken, the hydrocarbon molecule breaks into two uneven parts. At electric hydro-pulse oil treatment, the destruction of the molecules takes place, which was caused by micro-cracking of the molecules and the processes of ionization. As the result of these processes, the "activated" particles, such as ions, radicals, ionic-radicals, etc. are accumulated in the system.

In this regard, the study of EHP processing as a method of preparing hydrocarbon raw materials for further processing seems relevant. The results of analyses presented in the articles [5, 6] and the development of this technology show that the EHP discharge in oil increases the rate of hydrogenation and hydrogenolysis reaction. This makes for improvement of facilities for electric hydro-pulse processing and the feasibility study and prospects of its further development [4].

2. The results of experimental studies

In the laboratory of hydrodynamics and heat transfer of the Department of Engineering Thermophysics named after Prof. Zh.S. Akylbaev and in the laboratory of chemical technology and ecology of the chemical faculty, a number of experimental works on distillation and study of the impact of the EHP discharge effect and the amount of catalyst on the individual hydrocarbon composition of a gasoline fraction of HV oil from the Karazhanbas field [5-7] were carried out.

2.1 Change in the rheological properties of oil

Karazhanbas oil is the most viscous one among the known oils of Western Kazakhstan; the elemental composition of oil is the following (mass%): C – 84.09; H – 12.5; N – 2.14; O – 0,88; S – 0.39. The oil is highly resinous, sour, and it is characterized by a low yield of light fractions.

Presented in this paper, the results of study on the effect of the discrete EHP treatment on the rheological properties of a number of paraffin oils make for a more detailed assessment of the dynamics of structural and mechanical changes in oil dispersed systems after external action. Figure 1 shows the effect of EHP treatment on the kinematic viscosity of oil before and after processing. Numerous experiments show that at an interelectrode distance of 4 to 8 mm EHP discharges act on the physicochemical structure of oil causing change in the rheological properties of the suspension. Before the EHP processing, the kinematic viscosity of the oil at a temperature of 30°C was 550 mm^2/s (Fig. 1), after EHP processing its viscosity at the same temperature decreased to 400 mm^2/s.

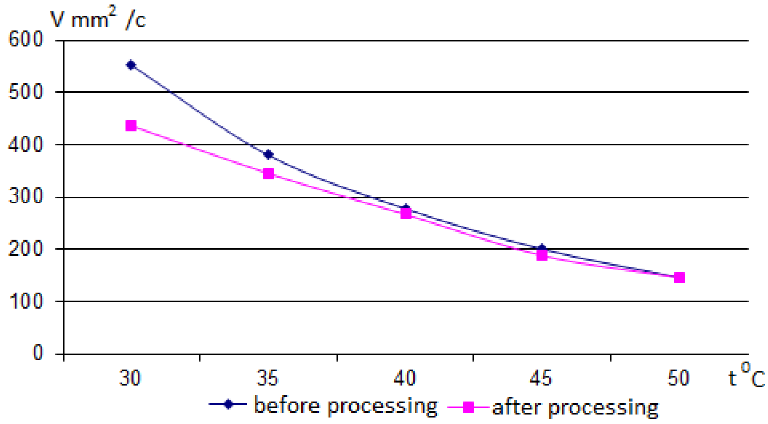
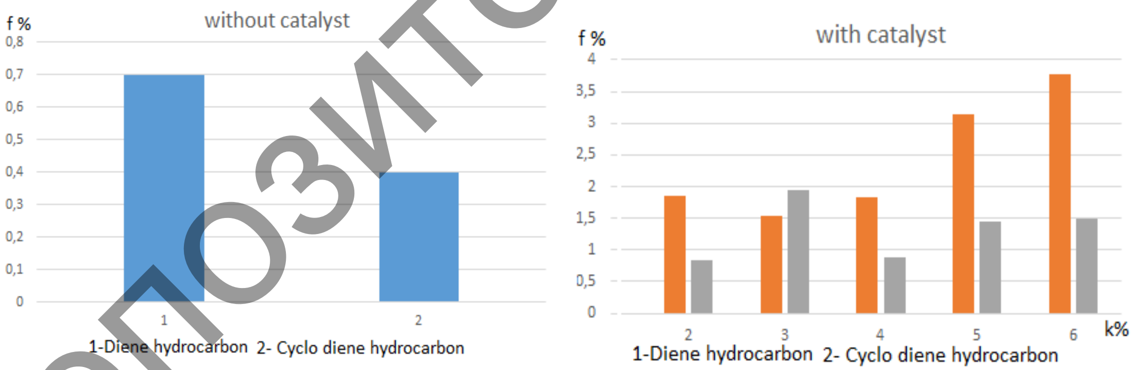


Fig.1. Effect of temperature on the kinematic viscosity of oil before and after processing by electric hydropulse treatment

Thus, the obtained results of the study show that decrease in the kinematic viscosity value of high-viscosity oil (HVO) of the Karazhanbas field takes place when the distance between the discharger and the electrode in the processing cell is from 4 to 8 mm. The duration of the processing time by EHP treatment increases the yield of light and medium HVO fractions for an exposure time in the range of 4 to 8 minutes. Then discharge voltage of the switching device is 10 kV, the capacity of the capacitor bank is 0.1 μF.

Later, the effect of catalyst additions on the individual hydrocarbon composition of the gasoline fraction of HVO before and after electric hydropulse processing was determined. Figures 2 (a, b) show the effect of the dependence of the addition of the pyrite catalyst from 1% to 5% on the individual hydrogenates of the diene and cyclodiene before and after the electric hydropulse processing.

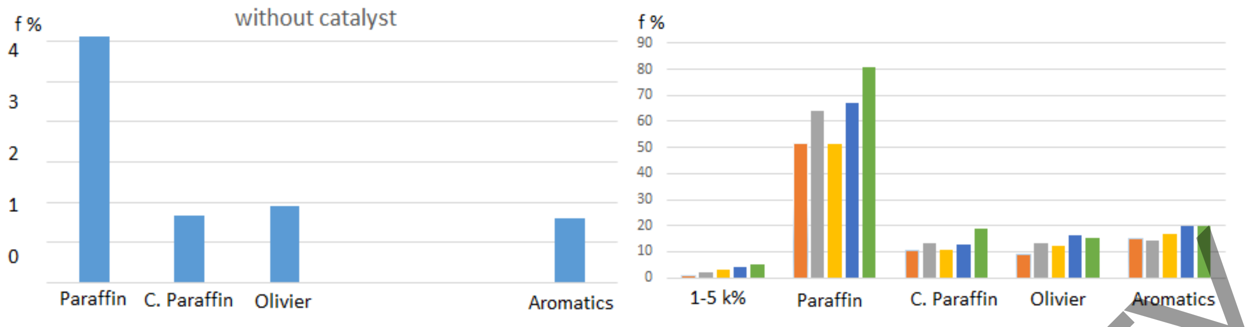


a) *b)*

Fig.2. Diene and cyclodiene composition of oil at different catalyst contents:
a) before and b) after the electric hydropulse processing

It is apparent that before the processing and without the addition of a pyrite catalyst to HVO, the individual hydrogenates included dienes of 0.7% and cyclodiene of 0.4% (Fig. 2a). After addition of the pyrite catalyst (Fig. 2b) and electric hydropulse processing of individual hydrogenators, the dienes increased from 0.7% to 3.8% and cyclodiens from 0.4% to 2%.

Figure 3 shows the dependence of the percental additive of a high-viscosity oil catalyst from 1% to 5% to the group composition of paraffin, cycloparaffin, olefin and to aromatic hydrocarbons before and after electric hydropulse processing.



a) b)

Fig.3. Paraffinic, cycloparaffinic, olefinic, aromatic and hydrocarbon oil compositions with different catalyst contents: a) before and b) after the electric hydropulse processing

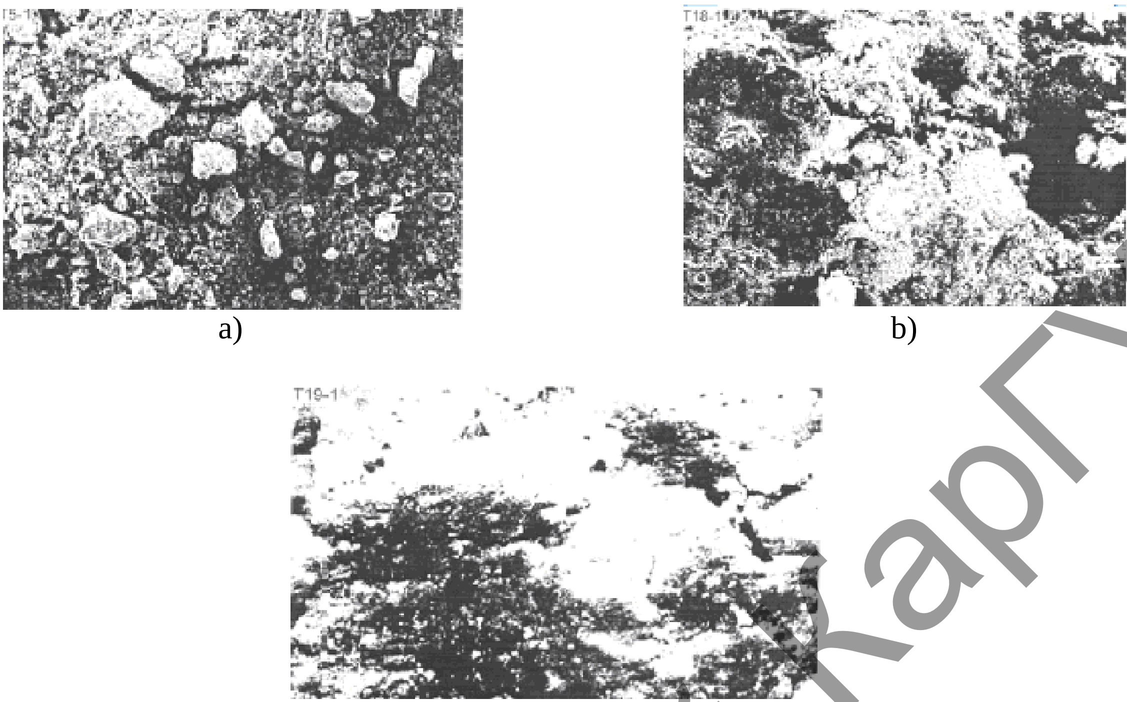
As can be seen in Figure 3a, before processing of the high-viscosity oil by the EHP treatment, the group composition of the hydrogenation showed paraffin of 3%, cycloparaffin of 0.75%, olefin of 0.9% and aromatic hydrocarbon of 0.8%. After the EHP processing of high viscosity oil and addition of a pyrite catalyst up to 5% the individual composition of the hydrogenate changed: paraffin of 80%, cycloparaffin of 20%, olefin of 17%, aromatic hydrocarbons by 20%.

2.2 Change in the structure

Then we studied photographs taken with the help of an electronic scanning microscope BS-340 of the Tesla company. The photographs show changes in the microstructure of the light fraction of high-viscosity oil before and after EHP processing. Figure 4 shows the structure of crude oil from the Karazhanbas field.

Fig.4. The microstructure of Karazhanbas oil before the electric hydropulse processing, magnified by 200 times

It can be seen in the photograph that before the EHP processing and without the addition of the pyrite catalyst, microstructures remain undeformed and possess sharp angles. The experiments aided to determine the effect of the amount of catalyst on the individual hydrocarbon composition of the gasoline fraction of HV oil after EHP processing. Figure 5 shows photographs of the Karazhanbas oil microstructure with different contents of the pyrite catalyst. As can be seen in Figures 5 (a, b, c), after oil processing using EHP treatment with catalytic additives from 1 to 5%, the degree of fineness of the solid phase sharply decreases, and complete dispersion of the catalytic additives is observed.



a) b) c)

Fig.5. Photos of structure of the Karazhanbas oil with various content of the catalyst after electric hydropulse processing: a) 1%; b) 3%; c) 5%.

A phase analysis of solid residues showed that during processing using EHP in a mixture consisting of oil and a catalytic additive of pyrite, the latter generates to pyrrhotine.

Conclusion

The results of the analysis of solid residues obtained by an electron microscope confirm the published data [7] that during the regeneration process of pyrite to pyrrhotine hydrogen sulfide is formed, which in turn begins to disintegrate on the surface of the formed pyrrhotine into two active hydrogenating radicals: hydrogen H and hydrogen sulphide HS.

Thus, the obtained results allowed us to determine the optimal experimental conditions, the effect of the amount of catalyst additive on the group and individual hydrocarbon composition of light and middle fractions obtained from HVO after preliminary processing by EHP treatment. The conducted tests allowed us to establish that the EHP treatment has a number of advantages over the other wave methods. First of all, this is a more economical method, allowing to carry out the process in continuous-flow mode and being the most acceptable under production conditions. In addition, it provides a higher yield of light fractions, a high degree of processing of raw hydrocarbons for their further transportation.

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