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# The Influence of Infrasonic Impacts on the Crude Oil Viscosity Reduction

***Abstract**. The article provides an overview analysis of the background literature with the description of the characteristics of Kazakhstan's crude oil and methods for reducing paraffin content in oil. The results of experimental studies on the effect of low-frequency sounds on crude oil samples are given to determine the dependence of the paraffin content on the input characteristics of the experiment.*

***Streszczenie.** W artykule przedstawiono ogólną analizę literatury z opisem charakterystyki ropy naftowej w Kazachstanie oraz metod zmniejszania zawartości parafiny w oleju. Wyniki badań eksperymentalnych wpływu dźwięków o niskiej częstotliwości na próbki ropy naftowej są przedstawione w celu określenia zależności zawartości parafiny na wejściowych charakterystykach eksperymentu. (**Wpływ dźwięków o niskiej częstotliwości na próbki ropy naftowej**).*

**Keywords:** crude oil, low frequency sound, kinematic viscosity
**Słowa kluczowe:** ropa naftowa, dźwięk o niskiej częstotliwości, lepkość kinematyczna

## Introduction

Oil is a complex mixture of organic compounds based on hydrocarbons of different structure. Oils from different fields have different physical and chemical composition, contain many impurities, as well as dissolved gas, mineral salts and water. Oil is the main raw material for the production of gasoline, kerosene, diesel fuel, fuel oil, lubricating oils and other products used by various industries.

Oils from different fields often differ significantly in composition, since the components of oil are a mixture of different hydrocarbons. Oil contains molecules of different structure; and the number of carbon atoms and hydrogen atoms in each molecule differs.

In the process of extraction and transportation oil is exposed to various influences that can result in the concentrating of paraffins, asphaltenes and resins. This increases the density and viscosity of oil, changes its structure and characteristics; so oil gets into the category of hard-to -extract resources.

Because of the active world oil production the reserves of light oils are depleted. The increasing demand for oil and products of its processing forces to look for new ways of production and processing of oil that is categorized as hard-to-extract, highly viscous, and containing an increased percentage of paraffin in its composition.

If oil contains more than 6% paraffin it is classified as paraffin base oil. 19,200 oil samples from various fields of the Earth were investigated in Russian Academy of Sciences. On the basis of the obtained results was compiled a database that stores information about the physical and chemical properties of oils. The study allowed to compile a scheme for the distribution of oil and gas basins whose oil contains a high percentage of paraffin. The analysis showed that the leader in the reserves of paraffin base oil is Russia, Kazakhstan occupies the second place, and China the third.

Oil of newly discovered fields contains paraffin hydrocarbons, mercaptan sulfur compounds, metalloporphyrins thus making scientists face the task of looking for unconventional approaches to processing oil of these fields [1].

## Crude oil dewaxing methods

The following scientists and researchers studied the properties of Kazakh oil fields developed in the late XX century Kaldygozov A. E., Nadirov N. K., Omaraliev T. O., Kaldygozov E. K, Erkebayeva G. Sh., Pivovarova N. A. Kirillova L. B., Takaeva M. A., Musaeva M. A., Mukhambetova Zh. A., Shugorev V. D.. During the existence of Kazakhstan as an independent state, several new fields were discovered in the East and South of the country. The properties and characteristics of Kazakhstan oils have been studied and described in the works of well-known and authoritative Kazakh scientists and their young successors [1-7].

Kazakhstan fields' oils are considered to be viscous, highly paraffinic, low-sulfur, resinous, and low-asphaltene. Baideldina O. Zh., Daribaeva N. G., and Nuranbayeva M. B. studied and described the characteristics of the structure and properties of paraffinic oils of Kazakhstan.

The oldest field in Kazakhstan is the Zhanazhol gas condensate field in the Mugalzhar district of Aktobe region of Kazakhstan, which was discovered in 1978. The characteristics of the Zhanazhol oil were studied and described in the works of Russian scientists and their Kazakh colleagues [8-11].

The ability of oil to flow and deform is described by its rheological properties. The pour point of oil is one of its most important physical characteristics. When the oil temperature approaches the pour point, paraffin crystals begin to grow in its composition. With a greater convergence of the temperature values the paraffins form a crystal lattice which complicates the rheology of the liquid phases of oil [3].

Today, the market demand for the production of high-quality diesel fuel is increasing due to the large number of vehicles running on it.

The main low-temperature characteristics of diesel fuels are the turbidity and pour points. The turbidity point characterizes the moment of precipitation of solid fractions [12]. If diesel fuel is poured into the test tube, and the test tube is cooled in the laboratory, and then the test tube is tilted at an angle of 45 degrees and kept in this position for one minute, the temperature at which the position of the meniscus remains unchanged is called the pour point [13].

In order to improve the quality of crude oil and its products it is required to search for methods for its dewaxing. For most regions of Kazakhstan the problem of diesel engines operation in the period of the low temperature is a very challenging issue. The paraffin crystals formed at low ambient temperatures over time create technical problems in the operation of diesel engines. One way to clean oil from excess paraffin is urea dewaxing. The main purpose of this way of dewaxing is the formation of an urea complex, with its subsequent separation, washing and destruction.

Another way to solve this problem may be the use of winter diesel additives [14-15].

At the refinery, in a full production cycle, the processing of oil with a high content of paraffin may be accompanied by the use of modern high-performance additives that reduce the temperature of paraffin solidification. In the authors concluded that the quality of the base fuel significantly affects the efficiency of using additives. Selection of the type and concentration of additives to be added to the fuel must be carried out anew in each case. This process does not allow optimizing the process of oil refining.

The use of additives does not always improve the quality of diesel fuel to the required regulatory indicators. The effectiveness of using additives is often low, since the hydrocarbon composition of the fuel has a significant impact on the dewaxing process. Therefore, scientists continue to search for new ways of dewaxing.

**Infrasonic method for oil viscosity reducing**

One of such methods can be considered the use of low-frequency sounds to influence the samples of Kazakhstan crude oil in order to determine the effect of infrasound on the process of separation of solid hydrocarbons from oil fractions.

If we assume that under the influence of low-frequency sounds chemical bonds break in hydrocarbon molecules, the chemical-physical properties of oil after infrasonic treatment will differ from the chemical-physical properties before treatment.

There is a range of infrasonic devices used for the "acceleration" of technological processes in liquid media. Fluctuations can be created directly in the processed environment, or the processed environment is exposed to infrasonic influence remotely. Owing to the fact that infrasonic waves are absorbed by the processed medium to an insignificant extent, it allows to extend the waves arising from the infrasonic effects to significant technological volumes. Infrasonic devices can implement such physical effects as cavitation, acoustic currents (sound wind), liquid degassing and others. These effects allow intensifying industrial processes of mixing, filtering, and dissolution.

**Results and discussion**

The authors of the study conducted an experiment on the effects of low-frequency sounds on crude oil samples. Experimental studies were based on the theory of experiment. Experimental studies on the impact of low-frequency sounds on the oil of Kazakhstan fields were conducted using samples obtained from the "Zhanazhol – Kenkiyak" field, the Republic of Kazakhstan. The experiment was carried out in the laboratory premises using the device IFS-1.

The procedure for experimental studies was as follows.

1. Crude oil samples were bottled in the containers of the same volume.
2. Each container was marked with relevant data (sample number, sample volume, oil sampling location).
3. The container with a control sample of crude oil which was not subjected to infrasonic effects was prepared separately.
4. The tanks with oil samples were put under the low-frequency emitter.
5. The required parameters of infrasound were set on the generator of the emitter.
6. After setting all the parameters the unit was switched on and the low frequency sound was applied to an experimental sample.
7. When the exposure time was over, the unit was switched off.

The container with the processed sample was replaced with the following one, and the experiment was repeated. The duration of the unit operation was in the range from 10 minutes to 30 minutes.

Fig.1. External view of the IFS – 1 unit

Infrasonic irradiator is a device with a mass in a complete set less than 5 kg. It operates from AC mains with a frequency of 50Hz with a nominal voltage of 220V. The power consumed by the installation does not exceed 160W.

After the experiments were over, the processed crude oil samples were examined in the laboratory of the center for certification tests of automotive fuels and technical oils "SATYM" SPC at D.Serikbayev EKSTU to determine the viscosity and the pour point of the oil.

Table 1. The parameters of the sensor

| Sample No. | Frequency, Hz | Exposure time, min | Sample volume, l |
|---|---|---|---|
| 1. | 10 | 15 | 0.5 |
| 2. | 10 | 30 | 0.5 |
| 3. | 10 | 60 | 0.5 |
| 4. | 20 | 15 | 0.5 |
| 5. | 20 | 30 | 0.5 |
| 6. | 20 | 60 | 0.5 |
| 7. | 26 | 15 | 0.5 |
| 8. | 26 | 30 | 0.5 |
| 9. | 26 | 60 | 0.5 |

The control sample of 0.5 l was not exposed to low frequency impact.

The changes in the values of oil pour point in relation to the exposure time and the frequency of infrasound were established in the laboratory studies of oil processed by the low frequency sounds. The results are presented in Figures 2-3.

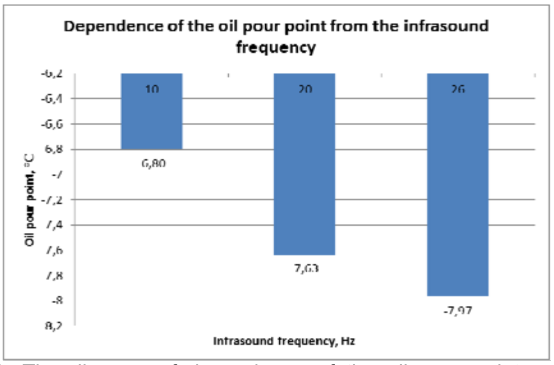


Fig.2. The diagram of dependence of the oil pour point on the infrasound frequency

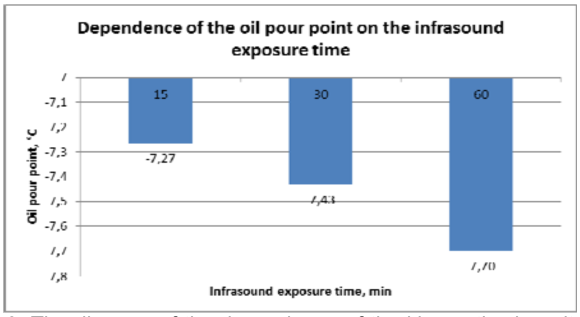


Fig.3. The diagram of the dependence of the kinematic viscosity of oil at 100 °C and 20 °C on the infrasound frequency

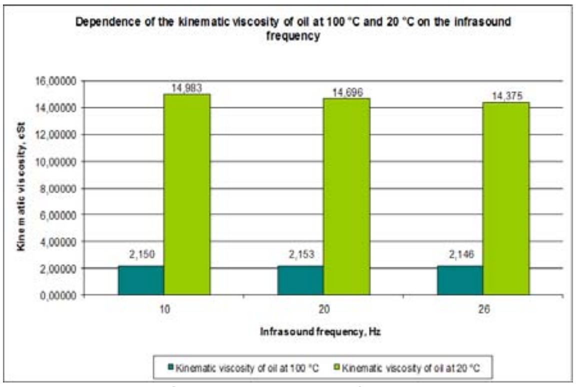


Fig.4. The diagram of the dependence of the kinematic viscosity of oil at 100 °C and 20 °C on the infrasound frequency

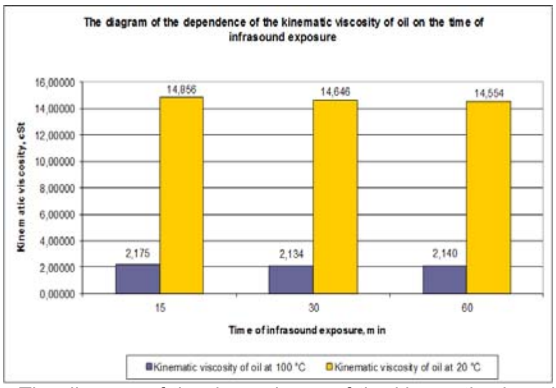


Fig.5. The diagram of the dependence of the kinematic viscosity of oil on the time of infrasound exposure

The kinematic viscosity of the oil control sample at 100°C was 2.16 cSt.
The kinematic viscosity of the oil control sample at 20°C was 14.9356 cSt.
The results of the experiment allow us to draw conclusions about the decreasing of the oil pour point under the influence of low-frequency sounds, as well as the improvement of fluidity at the expense of reducing the kinematic viscosity of oil at low temperatures.

**Conclusion**

The results of the experiments showed that the crystallization of paraffin in crude oil reduces when the former is exposed to low-frequency sounds in the range from 10 to 26 Hz in the time interval from 10 to 30 minutes. Thus, this method can be used to produce low pour point fuels and oils.

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REFERENCES

[1] Kaldygozov A.E., Investigation of physicochemical properties of paraffinic Kumkol oil and petroleum mixtures of the Republic of Kazakhstan and development of effective technology for their processing, Thesis for a Doctor of Philosophy (PhD) 6D072100, (2015)
[2] Pivovarova N.A., Kirillova L.B., Takaeva M.A., Musaeva M.A., Mukhambetova Zh.A., Shugorev V.D., On the properties and structure of oil dispersed systems, *Vestnik of astrakhan state technical university*, 47 (2008), No. 6, 138–143
[3] Polishchuk Yu.M., Yashchenko I.G., Regularities in the variability of tar and asphaltene content in Eurasian oils, *Geology and Geophysics*, 44 (2003), No. 7, 695-701
[4] Baydeldina O.Zh., Daribaeva N.G., Nuranbaeva B.M., Features of the structure and properties of crude oils of kazakhstan influencing the effectiveness of interventions in the fight against partynational, Scientific journal Modern high technologies, (2015), No. 4, 100-106
[5] Kaldygozov A.E., Ensuring Kazakhstan's demand for high-octane gasoline, *The journal Oil and Gas*, (2012), No.1, 138
[6] GOST 305-82, State Standard 305-82. Fuel diesel. Specifications, (2007), 10
[7] Kaldygozov E., Erkebaeva G.Sh. et. al., Ways to improve the operational properties of diesel fuel from paraffin petroleum, Collection of reports of the International Conference on Chemical Technology KT.5 Regional Central Asian International Scientific Conference on Chemical Technologies, 2007, 240-242
[8] Kaldygozov A. E., Klokova T.P., Production of diesel fuels from paraffinic petroleum using depressant additives, *Abstracts of the IX All-Russian scientific and technical conference Actual problems of development of the Russian oil and gas complex*, (2012), 205-207
[9] Ovchinikova T.F., Khvostenko T.F., Mitusova T.N., Experience in mastering the production of diesel fuels with depressant additives, *The journal Oil refining and petrochemistry*, (2002), 6
[10] Dolgopolova A.V., Kushnarev D.F., Kin Yonghwa, Investigation of water structure formation in the water-oil product system, Petrochemistry, 36 (2004), No. 4, 371-375
[11] Blinaeva E.V., Automation of the process of infrasound dust and gas purification, *Monograph Publisher LAP LAMBERT Academic Publishing GmbH & Co. KG.,* (2012), 151
[12] Baskin Yu.G., Suslenkova E.B., Technique of carrying out a natural - virtual laboratory experiment, *Scientific and theoretical journal Accounts*, 55 (2009), No. 9
[13] Smolarz, A.; Wojcik, W.; Gromaszek, K.; et al., Artificial intelligence methods in diagnostics of coal-biomass blends co-combustion in pulverised coal burners, *Environmental Engineering V*, (2017), 311-317.
[14] Azzopardi B.J., Pioli L., Abdulkareem L.A., The properties of large bubbles rising in very viscous liquids in vertical columns, *International Journal of Multiphase Flow*, (2014), 160-173
[15] Kisil I., Bilischuk V., Kuchirka Y., Barna O., Device for study of dynamic surface tension of aqueous surfactant solutions, *Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Środowiska – IAPGOŚ*, 4 (2014), No. 2, 28-30