ORIGINAL ARTICLE
DOI: https://doi.org/10.30932/1992-3252-2022-20-6-2

World of Transport and Transportation, 2022, Vol. 20, Iss. 6 (103), pp. 134–137

Obtaining Arctic Diesel Fuel for Reliable Operation of Vehicles in the Areas of the Far North and the Arctic

Elizaveta L. IOVLEVA

Mikhail P. LEBEDEV

Nadezhda A. FILIPPOVA

Elizaveta L. Iovleva[1], Mikhail P. Lebedev[2], Nadezhda A, Filippova[1, 3]

[1] North-Eastern Federal University in Yakutsk, Yakutsk, Russia.
[2] Yakutsk Scientific Centre of the Siberian Branch of the Russian Academy of Sciences, Yakutsk, Russia.
[3] Moscow Automobile and Road Construction State Technical University (MADI), Russia.
✉ *[3] umen@bk.ru.*

ABSTRACT

In the Republic of Sakha (Yakutia) there are many winter roads for transportation of food and essential goods. As a rule, vehicles are running on a diesel fuel on such roads. Despite the difficulties in operating diesel vehicles under extremely low temperatures, diesel vehicles are much more powerful and economical than gasoline ones. Problems with start and operation of a diesel engine are associated with low-temperature properties of diesel fuel. The process involved in refining oil to create a winter class diesel fuel is expensive and complex because paraffinic hydrocarbons must be removed.

Therefore, today it is important to produce winter classes of diesel fuel by compounding a pour point depressant and a summer class of fuel. When using additives, problems arise with the choice of their concentration. Those limits that the manufacturer recommends in real life show a negative result.

There is no wide range of those additives in Yakutia so the authors chose for experiments Dewaxol additives that diminish sedimentation during fuel transportation. So, during the study of the impact of Dewaxol additive, that contained amides and imides of mono- and dicarboxylic acids on the diesel fuel, it was considered how, at various concentrations of the additive and the heating temperature of fuel, the cloud point decreases, and sedimentation stability improves. The least squares method has allowed describing optimal concentration of pour point depressant. The study resulted in the conclusion that the fuel with a high content of depressant-dispersant additive has the best sedimentation stability.

Keywords: motor transport, diesel engine, winter diesel fuel, depressant-dispersant additives, cloud point, sedimentation stability.

For citation: Iovleva, E. L., Lebedev, M. P., Filippova, N. A. Obtaining Arctic Diesel Fuel for Reliable Operation of Vehicles in the Areas of the Far North and the Arctic. World of Transport and Transportation, 2022, Vol. 20, Iss. 6 (103), pp. 134–137. DOI: https://doi.org/10.30932/1992-3252-2022-20-6-2.

The text of the article originally written in Russian is published in the first part of the issue.
Текст статьи на русском языке публикуется в первой части данного выпуска.

INTRODUCTION

The Republic of Sakha (Yakutia) occupies the vast territory of the North-East of the Russian Federation. Many settlements are located in the Far North area. The complex transport and logistics system of the Republic involves delivery of vital and essential goods in summer by navigation, and in winter by snow-and-ice roads.

Large trucks, special road construction vehicles are equipped with an internal combustion engine running on diesel fuel. Diesel vehicles are used off-road in the Far North due to their powerful and easily controlled traction [1].

The use of low-quality diesel fuel affects performance of equipment in the North, for example, in case of unsatisfactory quality, the fuel complicates the operation of the high-pressure fuel pump and significantly increases fuel consumption. Therefore, the problem arises of improving performance of diesel fuel in the cold period [2].

Starting a diesel engine in winter is complicated by negative temperatures, which affect solidification and turbidity of fuel [3]. The low temperature properties of diesel fuel are characterised by formation and growth of *H*-paraffin crystals, which affects operation of filter elements, fuel line and fuel tank. As world experience shows, the most cost-effective and less energy-consuming is the use of depressant additives, the use of which is reflected in the works of the authors [4–15].

The most important point in the use of additives is to determine optimal concentration of the additive.

The *objective* of the study described in the article was to determine optimal concentration of Dewaxol 7801 pour point depressant converting summer diesel into winter diesel fuel.

RESULTS

Materials and Methodology

Dewaxol 7801 contains copolymers and surface active substances (surfactants, SAS). The concentrations of the Dewaxol 7801 additive for the study were taken in the following volume: 0,05 % wt., 0,1 % wt., 0,2 % wt. The technology of compounding the additive with fuel was as follows: fuel was heated to 40, 50, 60°C, the additive to 30°C, and components were mixed in a mixer with a bowl.

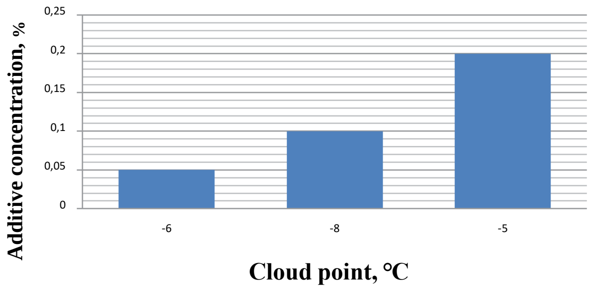
A total of nine samples were prepared:

- Sample № 1. Additive concentration 0,05 % wt., diesel temperature 40°C.
- Sample № 2. Additive concentration 0,1 % wt, diesel temperature 40°C.
- Sample № 3. Additive concentration 0,2 % wt., diesel temperature 40°C.
- Sample № 4. Additive concentration 0,05 % wt., diesel temperature 50°C.
- Sample № 5. Additive concentration 0,1 % wt., diesel temperature 50°C.
- Sample № 6. Additive concentration 0,2 % wt., diesel temperature 50°C.
- Sample № 7. Additive concentration 0,05 % wt., diesel temperature 60°C.
- Sample № 8. Additive concentration 0,1 % wt., diesel temperature 60°C
- Sample № 9. Additive concentration 0,2 % wt., diesel temperature 60°C.

Table 1

Cloud point of diesel fuel with Dewaxol depressant-dispersant additive 7801 at fuel heating temperatures up to 40 °C, 50 °C, 60 °C [performed by the authors]

Additive concentration, % wt.	Temperature of fuel preheating		
	40°C	50°C	60°C
	Cloud point of fuel,°C		
0,05	-6		
0,1	-8		
0,2	-5		
0,05		-9	
0,1		-10	
0,2		-7	
0,05			-10
0,1			-12
0,2			-11



Pic. 1. Graph of the correlation dependence of cloud point on concentration of Dewaxol 7801 of samples 1, 2 and 3 [performed by the authors].

Sedimentation was measured by the method of long-term determination of sedimentation stability.

Experimental Part of the Study

For the experimental part of the study, we took summer diesel fuel, which consisted of 25 % paraffinic, 50 % naphthenic, 15 % aromatic hydrocarbons.

The results of testing samples of diesel fuel with Dewaxol 7801 are shown in Table 1.

The graphs 1–3 show that the maximum cloud point depressant effect is achieved at 0,1 % wt. of Dewaxol 7801 additive in diesel fuel, and it is of interest that such a reaction occurs in all heated samples. But the cloud point was especially reduced when diesel fuel was heated to 60°C.

When determining sedimentation stability during long-term storage, fuel samples with an additive concentration of 0,05 % wt. and 0,1 % wt. showed stratification of fuel. Moreover, the heating temperature of the fuel did not affect the stability. The best sedimentation stability was shown by fuel samples with an additive concentration of 0,2 % wt.

DISCUSSION

Studies have shown that with an increase in concentration of the additive, sedimentation stability improves. The reason for this behaviour is that the dispersant allows the *H*-paraffins to be suspended.

During the study, a regularity was observed: with an increase in heating temperature of fuel, the cloud point temperature decreased as much as possible. This behaviour of the fuel can be explained by the principle of action of the additive. The depressant molecule prevents convergence, crystallisation and increase in the size of *H*-paraffins [6]. In the heated fuel, the paraffins completely dissolved and therefore received the maximum depressant effect.

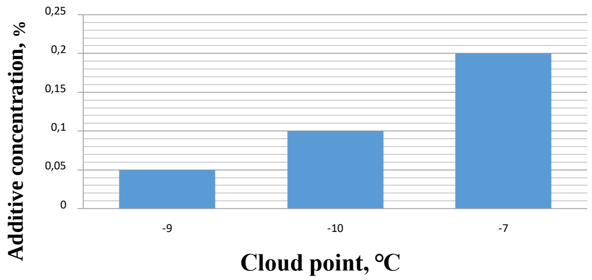
This can also be explained by the fact that high density and viscosity of the depressant-dispersant additive in well-heated fuel decreased even though the additive was also heated to 30°C, and as a result, good compounding of the additive with the fuel was obtained.

Therefore, the cloud point temperature decreased as much as possible at a fuel heating temperature of 60°C, when the paraffins were maximally dissolved.

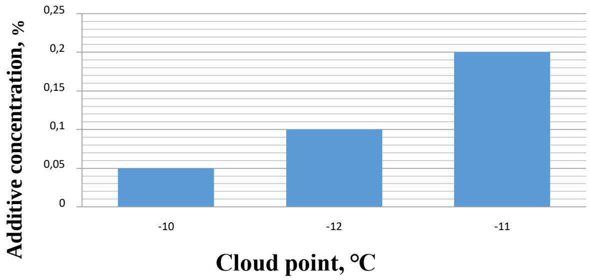
The dispersant molecule contains a long hydrocarbon functional group, which forms an electric charge on the surface of newly formed crystals; subsequently, these molecules repel each other.

CONCLUSIONS

Based on the foregoing, it can be concluded that the maximum depressant effect is achieved



Pic. 2. Graph of the correlation dependence of cloud point on concentration of Dewaxol 7801 of samples 4, 5 and 6 [performed by the authors].



Pic. 3. Graph of the correlation dependence of cloud point on concentration of Dewaxol 7801 of samples 7, 8 and 9 [performed by the authors].

at a fuel heating temperature of 60°C, the concentration of the additive at which it is possible to obtain a decrease in the cloud point is 0,1 % wt., the sedimentation stability of the fuel is achieved at a high additive concentration of 0,2 % wt.

REFERENCES

1. Iovleva, E. L., Kirikova, N. V., Borisov, A. A., Stepanov, P. A. The impact of the quality of diesel fuel on the efficiency of engines. *IOP Conference Series: Materials Science and Engineering,* 2019, Vol. 632 (1), 012002. DOI: 10.1088/1757-899X/632/1/012002.

2. Iovleva, E. L. Use of a depressant-dispersant additive during storage of diesel fuel. *IOP Conference Series: Earth and Environmental Science 990*, 2022, 012003, 6 p. DOI: 10.1088/1755-1315/990/1/012003.

3. Ramazanova, Y. B. Depressor additive for oil pumping. *Chemical Problems,* 2021, Iss. 3 (19), pp. 143–149. DOI: 10.32737/2221-8688-2021-3-143-149.

4. Kondrasheva, N. K., Eremeeva, A. M., Nelkenbaum, K. S. Development of domestic technologies of produsing high quality clean diesel fuel. *ChemChemTech,* 2018, Vol. 61 (9–10), pp. 76–82. DOI: 10.6060/ivkkt.20186109-10.5651.

5. Kondrasheva, N. K., Kondrashev, D. O., Eremeeva, A. M. Obtaining and examining biodiesel fuel based on corn oil and butyl alcohol. Academic Journal of West Siberia*,* 2014, Vol. 10 (251), p. 24. [Electronic resource]: https://s2.siteapi.org/2272b53cc9c3a55/docs/cxsit1q03sgso0gc8oko8s4w00ksog. Last accessed 24.10.2022.

6. Eremeeva, A. M. Development and research of ecologically pure diesel fuel with additives and bioadditives. *Koncept scientific and methodological e-journal,* 2016, Vol. 11, pp. 1861–1865. [Electronic resource]: http://e-koncept.ru/2016/86399. htm. Last accessed 24.10.2022.

7. Litvinets, I. V., Prozorova, I. V., Yudina, N. V., Kazantsev, O. A., Sivokhin, A. P. Effect of ammonium-containing polyalkyl acrylate on the rheological properties of crude oils with different ratio of resins and waxes. *Journal of Petroleum Science and Engineering,* 2016, Vol. 146, pp. 96–102. DOI: 10.1016/j.petrol.2016.04.026.

8. Mustafaev, N. P., Efendieva, K. K., Akchurina, T. K. Synthesis of 2-Sulfanylidene-1,3-thiazolidin-4-one Derivatives. *Russian Journal of Organic Chemistry,* 2017, Vol. 53 (12), pp. 1860–1863. DOI: 10.1134/S1070428017120132.

9. Novotorzhina, N. N., Sujayev, A. R., Gahramanova, G. A., Safarova, M. R., Ismailov, I. P., Musayeva, M. A., Mustafayeva, Y. S. Unsymmetrical disulphides as additives to transmission oils. *Kimya Problemleri,* 2022, Vol. 20 (3), pp. 264–270. DOI: 10.3273/2221-8688-2022-3-264-270. [Electronic resource]: https://www.elibrary.ru/item.asp?id=49367714. Last accessed 20.02.2023.

10. Wahlen, C., Blankenburg, J., Von Tiedemann, P., Ewald, J., Sajkiewicz, P., Müller, A. H., Frey, H. Tapered multiblock copolymers based on farnesene and styrene: impact of biobased polydiene architectures on material properties. *Macromolecules,* 2020, Vol. 53 (23), pp. 10397–10408. DOI: https://doi.org/10.1021/acs.macromol.0c02118.

11. Iovleva, E. L. Reducing Diesel Fuel Depression Using a Depressor-Dispersing Additive. *IOP Conference Series: Earth and Environmental Science*, 2021, Vol. 666 (4), 042019. DOI: 10.1088/1755-1315/666/4/042019.

12. Loizzo, M.R., Tundis, R., Conforti, F., Saab, A. M., Statti, G. A., Menichini, F. Comparative chemical composition, antioxidant and hypoglycaemic activities of Juniperus oxycedrus. *Food Chemistry,* 2007, Vol. 105 (2), pp. 572–578. DOI: 10.1016/j.foodchem.2007.04.015.

13. Zhirnov, B. S., Khairudinov, I. R., Sidracheva, I. I. Selection of catalyst for butanolysis of rapeseed oil triglycerides [*Podbor katalizatorov dlia provedeniya butanoliza triglitseridov rapsovogo masla*]. *Oil refining and petrochemistry [Neftepererabotka i neftekhimiya],* 2009, Iss. 1, pp. 40–42.

14. Iovleva, E. L., Lebedev, M. P. Definition of the depressant concentration in the composition of diesel fuel derived from Talakon oil [*Opredelenie kontsentratsii depressornoi prisadki v sostave dizelnogo topliva, poluchennogo iz talakonskoi nefti*]. *Khimichesaya tekhnologiya*, 2016, Vol. 17, Iss. 6, pp. 251–255. [Electronic resource]: https://elibrary.ru/item.asp?id=26189875 [limited access for subscribers].

15. Iovleva, E. L., Zakharova, S. S., Popova, L. I. The prospects of improving the low-temperature characteristics of diesel fractions. *Vestnik Saratovskogo gosudarstvennogo tekhnicheskogo universiteta*, 2013, Vol. 2, Iss. 2 (71), pp. 116–120. [Electronic resource]: https://elibrary.ru/item.asp?id=20313133. Last accessed 17.10.2022. ●

Information about the authors:

Iovleva, Elizaveta L., *Ph.D. (Eng), Associate Professor, Head of the Department of Machine Engineering of North-Eastern Federal University in Yakutsk, Yakutsk, Russia, elizaveta-iovleva@yandex.ru.*

Lebedev, Mikhail P., *D.Sc. (Eng), Corresponding Member of the Russian Academy of Sciences, General Director of Federal Research Centre «Yakutsk Scientific centre of the Siberian Branch of the Russian Academy of Sciences», Yakutsk, Russia, m.p.lebedev@prez.ysn.ru.*

Filippova, Nadezhda A., *D.Sc. (Eng), Professor of Moscow Automobile and Road Construction State Technical University (MADI), Moscow; Professor of North-Eastern Federal University in Yakutsk, Yakutsk, Russia, umen@bk.ru.*

Article received 24.10.2022, approved 05.12.2022, accepted 12.12.2022.