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COMPARISON OF OIL PRODUCTS AS COMPONENTS OF GRANULITS FOR SIBERIA, EXTREME NORTH AND THE ARCTIC AREAS

The article discusses the properties of oil products in the chain of manufacture and application of industrial explosives–granulits in the conditions of the northern and arctic zones of Russia in dislocation of its resource potential in the European and Asian parts of the country. It is shown that in manufacture of granulits in operation flows in the northern and arctic conditions (pumping, filtration, nozzle spraying, mixing, etc.), it is expedient to use diesel fuels and mineral oils of such grades, classes and groups that possess high flowability under negative temperatures. The evaluation involves the analysis of the trends of the oil product properties under low temperatures using the quality criterion–temperature gradation of climatic conditions of application (summer, interseasonal, winter, arctic, etc.) and the quantity criteria–values of filterability temperature limit, cloud point and pour point per grades, classes and types of fuels and oils. In the viscosity evaluation of the oil products used in manufacture of granulits, the quality criteria remain the same, and the quantity criteria include the value and range of viscosity under different conditions of application. Using the indicators of the flash point, self-ignition point and the limit combustion point, the fire and explosion hazards of the test oil products is evaluated.

Keywords: *northern and arctic regions, physicotechnical geotechnologies, industrial explosives, granulits, oil products, diesel fuel, mineral oil, viscosity, oil product properties under low temperatures, flash point, evaluation criteria*
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Introduction

The northern and arctic environment has a material effect on production processes of mineral mining in Russia. Blasting operations as a component of a physicotechnical geotechnology are conditioned by the class, methods and parameters of explosions, and by the characteristics of explosives (physical and mechanical, detonating, functional). The manufacture and use of the cheap explosives is affected by some complicating factors, including geology, nature, climate, economic geography, ecology, technology and equipment [1]. Considering these complexities, it is proposed to estimate the properties of the components of the cheap explosives within the framework of a geotechnical paradigm with a view to improving blasting technologies.

As the explosive market analyses (both global and domestic) show [2–6], the main tool used in strong rock breaking in a mining technology is explosives. The properties of explosives govern in many ways the choice of a blasting technology and blasting equipment. The domestic granulated explosives of the simplest composition are united under a common name—granulits. The main oxidizer for granulits is granulated ammonium nitrate. It can have different fractional makeups, absortivity and retentivity indicators, gravity, density, etc. The composition analysis [7] and the properties research [8] show that the formula of granulits contains oil products in the capacity of a fuel: diesel fuel, instrument and absorption oils, exhausted oil products, as well as fuel emulsions and mixtures. The listed oil products are obtained from different raw materials and using different technologies, and, thus, have different application characteristics. All these being taken into account, we have that in the North and in the Arctic zone of Russia, the properties of oil products, alongside with the criteria of manufacture and application of granulits, should meet the objectives of logistics, transportation and layout of mines.

Methods of research

Evaluation of the mineral resource potential and natural climate in Siberia, Extreme North and in the Arctic Zone of Russia. The geotechnical paradigm of integrated subsoil management in the Russian Arctic Zone developed by IPKON RAS [9] assumes creation of theoretical and methodological provisions for the "…promotion of cardinally new ideas both in the field of integrated subsoil use and in the sphere of innovative mining technologies for different minerals". The Arctic inland minerals include copper–nickel ore, platinoids, rare metals and rare earths, gold, diamonds, tungsten, mercury, tin, ferrous metal ores, crude fertilizers and other resources [10]. A distinctive feature of the local resource potential is its spatial distribution nonuniformity. For instance, Pavlovskoe silver-bearing lead and zinc deposit lies on the southern Yuzhny island of Novaya Zemlya archipelago, Tomtor rare earth deposit occurs in the Olenek national region in Yakutia, Afrikanda REE deposit occurs in the Murmansk Region, Fedorova Tundra platinum deposit lies in the center of the Kola Peninsula, Pykvar tin-and-tungsten ore fold is located in the north of Chukotka, while diamond placers occur in Yakutia's Arctic area [11, 12]. The natural climate in the north of Siberia features a long winter period (from half a year to 300 days) with the temperatures of –40 °C and below [13].

Selection of standard indicators for oil products. Oil products as the components of granulits meant for the use in Siberia, Extreme North and in the Arctic zone in Russia are placed in two groups: the first group is mineral lubricants for machines and mechanisms, and the second groups is diesel oil for diesel motors. In both groups, the products possess the common and individual standard indicators aimed to ensure longevity, fire and explosion safety, reliability, corrosion resistance, eco-friendliness, as well as operational and economic efficiency of parts of machines and mechanisms during production, transportation, application and storage of oil products. Since manufacture and application of granulits, including process steps connected with oil products (pumping, filtration, nozzle delivery, mixing, etc.) is unconnected with heat regimes, or with maintenance of high-temperature corrosion resistance of IC-engine parts, the number of the study parameters is reduced. For the evaluation of oil products employed as fuels in formulas of granulits to be used in Siberia, Extreme North and in the Arctic Zone in Russia, we selected the standard indicators independent of the climatic conditions (ambient temperature). Considering fractional makeup and structural conversions in oil products under low temperature, we discriminate such indicators as limit filterability temperature, cloud point, pour point, toughness factor, self-ignition point, self-ignition temperature range and flash point.

Selection and justification of evaluation criteria for oil products. Oil products in the group of mineral oils include industrial, instrument and secondary machine oils. The diesel fuel group includes four types distinguished by grades, classes and quality categories. The comparison of the main parameters of oil products included in the composition of granulits meant for the application under long-term negative temperatures uses the quality and quantity criteria [14].

The comparison of the temperature parameters of oil products—such as limit filterability temperature, cloud point and pour point—used a quality criterion which takes into account climatic conditions of application with regard to grades, classes, sorts and types of fuels produced by different manufacturers. In this context, a grade is reflective of a season of application of a fuel (or its application in the cold and arctic climate), a class describes the operational characteristics of the winter and arctic fuels, a sort indicates the limit filterability temperature of seasonal fuels, and a type presents the ecological characteristics of a fuel. For the regions of Siberia, Extreme North and the Arctic, when considering the issue of adding granulits with the summer, interseasonal, winter and arctic fuels manufactured under different standards and having different recommended values of ambient temperature, it is proposed to use the criterion of temperature-based ranking of climatic conditions of fuel application. Alongside with the verbal meaning (summer, interseasonal, winter, arctic), the proposed term includes the quantity characteristics (value of an indicator, its trend, temperature interval between the values of different gradations). In this manner, it becomes possible to evolve a unified criterial and terminological approach, to avoid reduplication, and to abridge presentation of low-temperature properties, viscosity and fire/explosion hazard of both fuels and oil products. When comparing viscosity and visco-temperature properties of oil products, the quality criteria may also be the climatic conditions of application with regard to grade, class, sort or type of fuel or mineral oil.

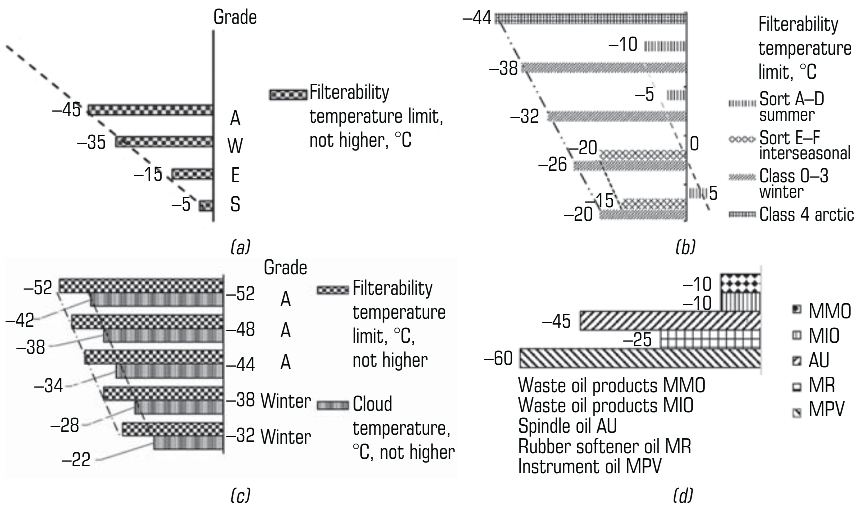


Fig. 1. Indicators of properties of diesel fuel and mineral oil under low temperatures: *a* – DF GOST 305–2013; *b* – DF GOST R 32511–2013; *c* – DF GOST R 55475–2013; d – Pour point of mineral oil, °C

The quantity criteria in comparison of fuels include the indicator of the low-temperature properties, the difference in temperature gradation of application conditions of different fuel grades, and the number of temperature gradations within the same fuel grade. The quantity criterion of the low-temperature parameters of mineral oils is chosen to be the pour point. The quantity criteria of the viscosity characteristics are the range of variation in the viscosity index and the spread of values within this range.

The selected quality criteria for the fire/explosion hazards of oil products are the self-ignition point, temperature range of flame spreading and the flash point. The flash point as a criterion is presented with regard to the fuel objective, climatic conditions of application per grades, classes and types (summer, interseasonal, winter, arctic). The quality criterion of mineral oils is the oil type. The quantity characteristics of the criteria are the ranges of the flash points per grades, classes and types, or the absolute value of an index.

Thus, the methodological comparison of oil products used in the formulas of granulits meant for the application in Siberia, Extreme North and in the Arctic zone in Russia is based on the: difference in the low-temperature properties per gradation of application conditions subject to a type, a grade and a class of a fuel; comparison of the largest and least viscosity indexes of oil products and viscosity ranges with regard to the climatic conditions of application; differentiation of self-ignition point, temperature range of flame spreading and the flash point.

Results

Blasting is the key component of a mineral mining technology. Blasting aims to provide the wanted quality of rock fragmentation to enhance efficiency of mineral mining and pretreatment. In this respect, the territorial location of Russian mines should be taken into account with regard to the local features of nature, climate, geography, industry, transport and power supply. The correctly selected formula of granulits ensures efficient blasting operations in the Arctic zone, in connection with the technical and technological processes of mineral mining, with the transportation and logistics, as well as with the power and material resources supply. In the capacity of fuels in granulits, it is possible to use various-nature organic liquids capable to saturate nitrate grains (oxidizer in granulit formula). Flammable organic liquids, subject to their nature and physical properties, can differently imbibe and hang on an oxidizer [15]. Nitrate can accept hydrocarbons (diesel fuel)—13.3% and motor oil (analog of oil M8G)—8%; polymers (pylosiloxane-based liquid)—10.2%; alcohols (glycyl alcohol)—11.9%; aspic oils (turpentine)—18%. However, in the overwhelming number of cases, liquid oil products are used as fuels [1–8, 15]. Let us analyze the standard low-temperature parameters of oil products with regard to the conditions of manufacture and application of granulits in the regions with a long period of negative temperatures. **Figure 1** gives the values of the filterability temperature limit (FTL) and the cloud point for diesel fuel (standard GOST 305-2013), EURO diesel fuels (GOST 32511-2013 (EN 590:2009) and R52368-2005 (EH590:2004)) and for winter and arctic dewaxed diesel fuel (GOST R 55475-2013), as well as the pour points of mineral oils. The diesel fuel is abbreviated as DF GOST … in the diagrams. Below in this article, we will use a short term "fuel" for the diesel fuel. The symbols used for grades, classes, sorts and types of fuels in the figures below in this article comply with the specification documents in Russia.

The indicators (FTL and pour point) are the control parameters of the oil product mobility under low temperatures, and also they define the bottom temperature for the usability of oil products in the technologies of manufacture and application of granulits. These indicators of oil products influence the operational performance of mixing and charging equipment. The decrease in the oil product mobility complicates all processes (pumping, filtration, nozzle delivery, mixing, etc.). Viscosity characterizes mobility and flowability of oil products.

Viscosity and other properties (under low temperature) of oil products as hydrocarbon systems depend on the chemical composition and are governed by the intermolecular interaction forces [16]. Practically, it is interesting to evaluate the change in the viscosity of oil products with the decreasing temperature, and the viscosity–negative temperature dependence. Regarding the manufacture and application of granulits in Siberia, Extreme North and in the Arctic zone of Russia, this enables characterizing the flowability of oil products, their thickening time and the increase in resistance in parts and assemblies of mechanisms. The standard viscosities per grades and classes of the test fuels and mineral oils are given in **Fig. 2**. The fuels defined by GOST 52368-2005 (EH 590:2004) и GOST 32511-2013

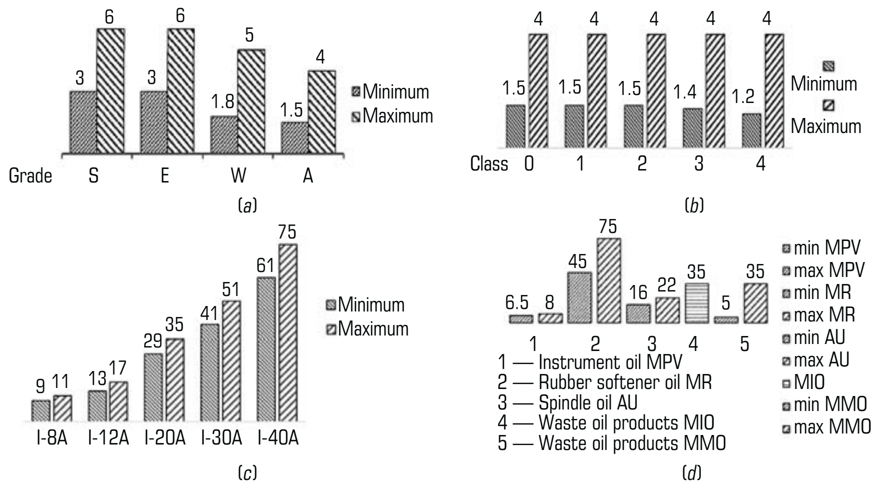


Fig. 2. Viscosity of diesel fuel (per grades and classes) and mineral oils:
a – Viscosity DF GOST 305–2013, cSt (at the temperature of 20 °C); *b* – Viscosity DF GOST R52368–2005 (EH 590:2004), DF GOST R 32511–2013, cSt (at the temperature of 40 °C); *c* – Industrial oil viscosity, cSt; *d* – Oil viscosity, cSt

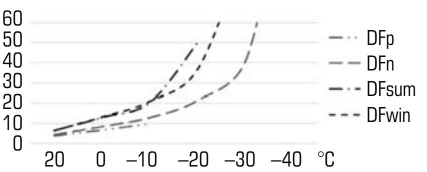


Fig. 3. Temperature–viscosity curves of summer and winter diesel fuels, Kinematic viscosity of diesel fuel, cSt

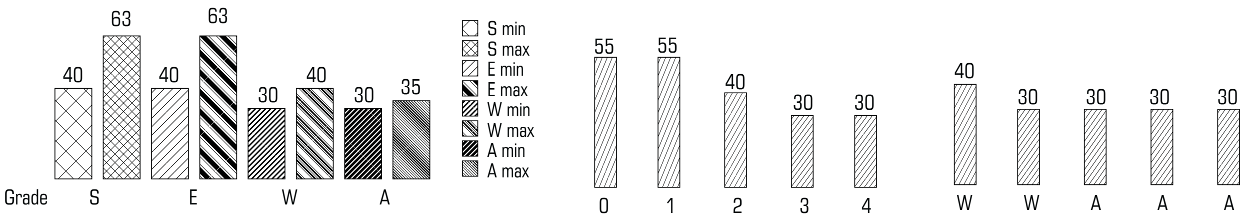
(EN 590:2009) are depicted in the same diagram (see fig. 2b). The fuel defined by GOST R 55475-2013 is omitted in the viscosity diagrams. For different climatic conditions, the values of the test viscosity indicators should fit the ranges of 1.5–4.5 cSt and 1.2–4.0 cSt for the winter and arctic fuels, respectively.

The temperature dependence of the fuel viscosity was characterized using the information from the literature and open sources [17–21]. Based on the data from [17], the trends of the temperature–viscosity curves are presented for the summer and winter diesel fuels. The temperature–viscosity curves (**Fig. 3**) are plotted for the paraffinic catalytic gas oil (DF_p), naphthenic aromatic catalytic gas oil (DF_n), as well as for the summer and winter diesel fuels (DF_{sum} and DF_{win}, respectively).

Regarding the fire/explosion hazards of oil products in the technologies of manufacture and application of granulits in the areas of Siberia, Extreme North and Arctic, the data on the self-ignition point, temperature range of flame spreading and on the flash point of the materials are taken from the regulatory documents [22]. The self-ignition point subject to the grade, class and type of a fuel ranges as 280–330 °C. The winter and arctic fuels have a narrower range of 310–330 °C. For the mineral oil, the standard value is limited, for instance, the self-ignition point of the instrument oil MPV is 300 °C. The differentiation of the temperature ranges of flame spreading by grades, classes and types is generalized in the technical documents. These ranges are 62–105 °C, 57–100 °C and 109–140 °C for the winter fuel, artic fuel and instrument oil MPV, respectively.

The most representative and a fuller-scale information on the characteristics of grades, classes and types of oil products is offered by the indicator of the flash point. The flash point is determined by flashing of vapor when approached by flame in a closed firepot. For the fuels GOST 305-2013, GOST 32511-2013 (EN 590:2009), GOST R 55475-2013 and GOST R 52368-2005 (EH 590:2004), the values of the flash point are given in accordance with [23, 24]. **Figure 4 *a–c*** presents the flash points for the test fuels. The fuel GOST R 52368-2005 (EH 590:2004) has the flash point of 55° C (omitted in the figure). The values of the flash points in fig. 4*a* are differentiated by the fuel objective. The smaller values of the indicator describe the general-purpose fuel, the higher values characterize the fuels for the locomotive-type and marine diesel engines, and for the gas turbines.

The flash point of mineral oils is mostly determined in open firepots by flashing of the air and heated oil vapor mix under the action of fire, which dies out quickly owing to low intensity of evaporation [25]. For the test mineral oils (industrial, instrument, rubber softener, spindle, and waste oils MIO and MMO), the discussed indicator is shown in **Figs. 4 *d* and 4 *e***.



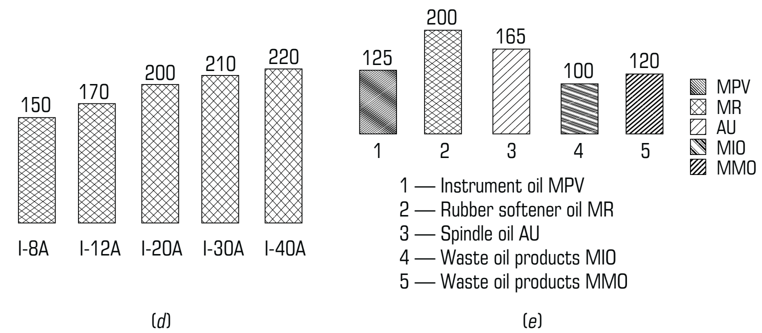


Fig. 4. Flash points of diesel fuels and mineral oils:
a – Flash points DF GOST 305–2013, °C; *b* – Flash points per classes DF GOST R 32511–2013, °C; *c* – Flash points per grades DF GOST R 55475–2013, °C; *d* – Flash point of industrial oil, °C; *e* – Flash points of oils, °C

Results and discussion

The Russian areas exposed for the long-term negative air temperatures need low cold-test diesel fuels. Subject to the required production data and the manufacture technology, the winter and arctic diesel fuels may contain hydrocarbon fractions which have end points approximately the same as the kerosene fractions have, which, intrinsically, agrees with production of high-density kerosene [26]. According to [27], retention of kerosene by ammonium nitrate is much weaker than by diesel fuel. In this connection, it is necessary to estimate carefully physical stability of simplest explosives. Diesel fuels with satisfactory properties under low temperatures are obtained from middle-distillate oil fractions containing up to 10–20% of alkanes with the dominant normal structure and high pour point, produced by the method of deparaffination. High-molecular paraffin hydrocarbons in the composition of diesel fuels pass to the solid state when cooled, and form crystal lattices, which promotes the loss of the flowability of a fuel [26]. This constitutes a hazard of deactivation of atomizers of granulits under low temperatures when such granulits are produced immediately at the blasting sites.

Regarding the manufacture and application technologies, granulits produced according to different standards can be characterized by the values of FTL, by the trends of FTL and cloud point [14], and by the ranges of the climatic conditions of application for different temperature gradations. The methods to improve fuel properties under low temperatures are based on the removal of high-melting normal paraffin hydrocarbons from the fuel composition (fuel GOST 54475-2013), on the compounding of virgin and hydrofined fractions (fuel GOST 305-2013), and on the addition [28] of depressants–dispersants (fuels GOST R 52368 and GOST 32511-2013). The rated values of FTL are –44 °C, 45 °C and –52 °C for the arctic fuels GOST 32511-2013, GOST 305-2013 and GOST 55475-2013, respectively.

The decrease in the boiling point of the diesel fraction to 300–320 °C and to 280 °C allows producing fuels with the cloud points of –25 °C and –35 °C, respectively [29]. For the fuel GOST 305-2013, Fig. 1*a* shows the trends of the FTL minimums of –35 °C (winter grade) and –45 °C (arctic grade) at a span of 10 °C. Thus, the winter and arctic fuels include more kerosene fractions which have better properties under low temperatures. However, under the studied conditions of manufacture of granulits, this can worsen retention of fuels by niter grains, which degrades physical stability of the fuel.

Improvement of fuel properties under low temperatures by means of adding depressants–dispersants is based on the prevention of association and growth of paraffin crystals when a depressant gets adsorbed at the surface of an incipient crystal. The crystals of paraffin in the presence of a depressant have sizes in the range of a few tens of micrometers, and the addition of a dispersant enables reduction of the size by an order of magnitude. The winter and arctic grades of the fuels GOST 32511-2013 and GOST R 52368 are manufactured with addition of depressants–dispersants. The FTL minimums lie in the ranges from –20 °C to –38 °C (for the winter fuels) and to –44 °C (for the arctic fuels) at a span of 6 °C in the trend line (see fig. 1*b*). The application of these types of fuels in manufacture of granulits is limited by the fact that in cold storage, depressants contribute to microcrystallization but the fuel experiences layering (sedimentation) with the formation of moving beds. The fuel layering may be prevented using a dispersant at an optimized concentration. The choice of a winter or arctic fuel for granulit manufacture and application, given the long-term storage is involved at the underdeveloped transport and logistic infrastructure, is complicated by the uncertain duration of the negative temperature periods.

The fuel GOST 55475-2013 is produced by deparaffination. The required depression of FTL [30] is achieved through the optimization of refining (optimized range of fractions when different raw materials are used, etc.). The FTL minimums of –32 °C and –52 °C are shown for the winter and arctic fuels, respectively, in the FTL trend line at a span of –6 °C in Fig. 1*c*. The FTL minimums of –22 °C and –42 °C are shown for the winter and arctic fuels in the trend line of the cloud point at the spans of –6 °C and –4 °C, respectively (see fig. 1*c*). Removal of normal paraffin hydrocarbons to improve fuel properties under low temperatures results in the decreased flash point, which should be considered as a fire/explosion hazard when employing granulits manufactured using such fuels.

In practice, the fuel properties under low temperatures are improved using a rule of thumb, by reducing concentrations of paraffin (mixing with light fractions of hydrocarbons, adding of depressants).

The chemical composition of base oils in production of commercial oils represents a mixture of hydrocarbons from paraffin, naphthene and aromatic groups. The average values of these groups in the composition of oil products are: 10–40% of paraffin hydrocarbons, 20–60% of naphthene hydrocarbons, 14–30% of aromatic hydrocarbons [31]. Under lower temperatures, hydrocarbons become more viscose and non-mobile. The indicator of mineral oil properties under low temperatures is the pour point. Hydrocarbon oils are the oil-processing products representing liquid mixtures of high-boiling, mostly alkyl-naphthene and alkyl-aromatic hydrocarbons [32]. The most wide-spread oils are lubrication oils, including industrial and instrument oils. The service properties of a commercial oil depend on the chemical composition of a base oil.

The values of the pour points of some mineral oils used in granulits are shown in Fig. 1*d*. The pour point of industrial oils I-8A, I-12A, I-20A, I-30A and I-40A is –15 °C. The pour points of oils depend on the presence of high-molecular hydrocarbons in the base oils, first of all, paraffins and ceresines. Depending on the melting and solution temperatures of solid paraffins and ceresines in a base oil, they pass into solid state under lower temperatures, and form crystal lattices which retain liquid hydrocarbons inside [25].

When cheap explosives are manufactured at blasting sites under low temperatures, there is a hazard of failure of mixers and atomizers. The instrument oil MPV has the lowest pour point (–60 °C), and the spindle oil is less frost-resistant (–45 °C). The waste oil products from MMO and MIO groups, and the softener for rubber regeneration are less frost-resistant—the pour points are –10 °C and –25 °C, respectively. For manufacturing granulits at blasting sites under low temperatures, it is allowed to use the instrument oil MPV in the arctic conditions of application and the spindle oil AU for the winter conditions of application. When using the waste oil products MMO and MIO, and the rubber softener oil, it is possible that mixing and spraying facilities may fail to operate, which requires certain seasoning of the oil properties to operate under low temperatures. The wanted properties of oils under low temperatures are achieved by removal of solid alkanes, polycyclic arenes and cycloalkanes–arenes with short chains [33].

Mobility of the oil products used in manufacture of granulits influences operating efficiency of mixing and charging equipment. The decrease in the oil product flowability complicates operations (pumping, filtration, spraying of oil product mixed with oxidizers, mixing, etc.). The degree of mobility governs viscosity of oil products. In the studied conditions of manufacture and application of granulits, the viscosity of oil products was evaluated with the determination of the maximum and minimum values, and the ranges of values with regard to the temperature gradations of climatic conditions of application.

Lightening of fraction composition promotes reduction in fuel viscosity. With the addition of kerosene fractions, the fuel GOST 305-2013 becomes less viscous (see fig. 2*a*). The ranges of viscosity for the temperature gradations of climatic conditions of application are: 3–6 cSt for the summer conditions, 1.5–5 cSt for the winter conditions and 1.5–4 cSt for the arctic conditions.

In cooling of fuels produced using depressants–dispersants, crystallization of normal paraffin hydrocarbons takes place without structurization. In terms of the fuels GOST 52368-2005 and GOST 32511-2013 (EN 590:2009), it is seen that in different temperature gradations of the climatic conditions of application (classes 0–4), the maximum value of viscosity is the same and is 4 cSt, and the minimum values change from 1.5 cSt to 1.2 cSt for the classes from 0 to 4 (see fig. 2*b*).

The change in the mobility of the components in cooling of a fuel with partly removed normal paraffin hydrocarbons (deparaffination) takes place because of viscous gelation. For the fuel GOST 55475-2013, the highest viscosity value is 4.5 cSt, and the least values vary from 1.5 cSt to 1.2 cSt in the winter and arctic fuels, respectively.

The analysis of the temperature–viscosity curves of DF_p, DF_n, DF_{sum} and DF_{win} (see fig. 4) shows that in the summer-grade diesel fuel, the viscosity curve changes its steepness starting from the temperature of 3–7 °C. At the temperature below 0 °C, the temperature-dependent gradient grows noticeably [28], and at the temperature of –6–8 °C, the curve exhibits an exponential upsurge. The winter-grade diesel fuel has a gentler curve of viscosity under negative temperatures (see fig. 4). Under negative temperatures, no significant change is observed in the temperature-related gradient and, accordingly, in the steepness of the viscosity curve down to the temperature of –15–17 °C. The exponential upsurge takes places in the viscosity curve at the temperatures below –30 °C. The described trends of the temperature–viscosity curves agree well with the data on the temperature effect on the viscosity of different-type diesel fuels [17–20, 32].

The analysis of the mineral oils used in manufacture of granulits shows that for the industrial oils (see fig. 2*c*), in the ranges of viscosity, it is possible to distinguish the highest values (11–75 cSt) and the least values (9–61 cSt) at a scatter of 2–14 cSt. The ranges of viscosity for the other mineral oils are sizable (see fig. 2*d*): 6.5–8 cSt for the instrument oil MPV, 16–22 cSt for the spindle oil, 5–35 cSt for the waste oil products and 45–75 cSt for the rubber softener oil. The temperature-dependent gradients of viscosity in different oils under positive temperatures are not higher than 1 cSt per 1 °C but grow appreciably after transition to the domain of negative temperatures. The temperature gradients of viscosity range differently in different ranges of temperature [21]: 60–70 (–20 °C ... –30 °C), 90–370 (–30 °C ... –40 °C), 800–6000 (–40 °C ... –50 °C), 50000 and more (–50 °C ... –60 °C).

The self-ignition points of oil products are much higher than the temperatures involved in production of granulits. The limited information on the ranges of temperature of flame spreading disables a rigorous study into the influence of this indicator on the technologies of manufacture and application of granulits.

The flash point of diesel fuels is an important parameter. First, it characterizes the hazard of a fuel when transported and stored. Second, it defines usability of a fuel in manufacture of granulits. Third, the flash point allows judging on the fractional composition of a fuel and its serviceability if granulits are meant for the application under negative temperatures.

Conclusions

The low-temperature indicators (FTL, cloud point, pour point) are the parameters which govern mobility of oil products under negative temperatureы and condition the lower temperature boundary of usability in the technologies of manufacture and application of granulits.

The comparison of oil products as components of granulits to be used in the regions exposed to long-term negative temperatures used the quantity and quality criteria. For the comparison of oil products (in particular, fuels) produced under standards and having different recommended ambient temperatures (seasonality), the proposed quantity criterion assumes the temperature gradation of climatic conditions of application. The quantity criteria are the values of different indicators, their trends and ranges which represent the main parameters of the test oil products.

When comparing the critical parameters of the test groups, classes, grades and types of fuels for different gradations of climatic conditions of application, the proposed approach allows additional characterization of the fuel properties under low temperatures of manufacture and use of granulits, namely:

—for the fuel GOST 305-2013, there is one temperature interval between the winter and arctic types, which makes 10 °C;

—for the fuel GOST 32511-2013 (EN 590:2009), there are three temperature intervals for the winter type and one temperature interval for the arctic type, which is 6 °C;

—for the fuel GOST 55475-2013 there are two temperature intervals for the winter type and three intervals for the arctic type, which equal 6 °C and 4 °C, respectively.

In the test conditions of application of granulits, it is necessary to take into account the connection of the fuel properties with the quality of the initial feedstock and its processing technology.

It follows from the comparison of the mineral oil properties under low temperatures that the instrument oil MPV (pour point –60 °C) is tolerable for the service in the arctic conditions, while the less frost-resistant spindle oil AU (pour temperature –45 °C) is serviceable in the winter conditions. Congelation of such oils occurs owing to the change in their viscosity. When using the waste oil products MMO and MIO (pour point –10 °C), it is required to undertake certain measures aimed at conditioning their properties under low temperatures. Such measures may be the use of depressants which improve movability of oils under low temperatures and weaken tendency for structurization of normal paraffin hydrocarbons.

The temperature dependence of viscosity of oil products is a function of their fractional composition, content of paraffin hydrocarbons, temperature conditions of application and of other factors. In the domain of negative temperatures, the naphthenic aromatic catalytic gas oil has two–three times lower viscosity than the diesel oil of the winter type. The arctic-type fuels have originally lower viscosity owing to the decreased concentration of paraffin hydrocarbons.

The same behavior is typical of the mineral oils. On the other hand, rather high viscosity of the mineral oils (industrial oil, rubber softener, waste oil products) promotes quick thickening and reduced flowability under low temperatures.

The low flash point of the diesel fuel limits its indoor application and can be a constraint for using the fuel in manufacture of granulits. As per specifications, all diesel fuels belong to the flammable liquids. The flash point of the mineral oils ranges from 100 °C to 220 °C, which is much higher than the temperature of their possible heating in the technologies of manufacture and application of granulits. The test group of the mineral oils belongs in the category of combustible products according to specifications.

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SCIENTIFIC AND TECHNICAL FUNDAMENTALS OF CHANGING THE PROPERTIES OF HYDROCARBONS IN CONDITIONS OF OPTIMAL SUBSOIL USE

The article provides a rationale for the development of a new geotechnology of subsoil use. It is shown that in order to change the viscosity of formation waters it is necessary to study the phenomena occurring at the interface between the phases "water-oil-quartz" fluid system in order to solve the problem of managing the properties of hydrocarbons in the conditions of natural occurrence.
The results of the experimental work on physical and chemical modeling of the processes of synthesis and decomposition of hydrocarbons (HC) at the interface under conditions as close as possible to the reservoir state are presented. The obtained data indicate that under natural conditions the oil field is in a dynamic state, which responds to any external influence by changing the chemical composition of the components of the system "quartz-oil-water" [1].
The aggregate of the obtained data allows us to make the following predictions:
–the main geological feature in physical modeling of HC synthesis and decomposition processes in the "quartz-oil-water" system is the resonance correspondence of sound velocities of quartz and associated components of the interface. This is evidenced by the fact of the harmonic series of responses to an external pulse action at the frequency of water decomposition;
–the change of chemical composition in the three-component system manifests itself by the appearance of low-amplitude responses located between the frequencies of the harmonic series from the quartz particles of the three-component surface.

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