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SYNTHESIS OF LOW-VISCOSITY PARTING LUBRICANTS BASED ON DOMESTICALLY-MADE SOLVENTS AND OILS WITH IMPROVED ORGANOLEPTIC CHARACTERISTICS

СИНТЕЗ НИЗКОВЯЗКИХ РАЗДЕЛИТЕЛЬНЫХ СМАЗОК НА ОСНОВЕ ОТЕЧЕСТВЕННЫХ РАСТВОРИТЕЛЕЙ И МАСЕЛ С УЛУЧШЕННЫМИ ОРГАНОЛЕПТИЧЕСКИМИ ПОКАЗАТЕЛЯМИ

ABSTRACT

The article describes the results of studies carried out in Institute BelNIIS Republican Unitary Enterprise (RUE) in synthesis of especially low-viscosity parting lubricants with the kinematic viscosity about 2 mm²/s at 20 °C; the need for these lubricants arose at several enterprises in the Republic of Belarus as a result of commissioning of several imported process lines for making reinforced-concrete articles on horizontal trays with movable sidewalls. As a result of these studies, the method has been designed for physicochemical treatment of low-viscosity hydrocarbon

solvent, Nefras-C4–150/200, made by Naftan OJSC, making it possible to eliminate bad odour of the initial solvent and provide it with properties necessary for its application as a component in lubricants. The product resulting from physicochemical treatment of the aforementioned solvent makes homogeneous solutions with mineral oils, with a wide range of viscosities typical for them, depending on the composition and suitable for application as a hydrophobic component in low-viscosity parting lubricants meeting modern requirements in terms of viscosity, sanitary and hygienic characteristics and other properties.

Isoparaffin oil from Rosneftekhim Innovative Industrial Company CJSC, industrial oil from Naftan OJSC and the product of physicochemical treatment of Nefras-C4–150/200 solvent from Naftan OJSC were used as basic materials for synthetizing low-viscosity parting lubricants with kinematic viscosities 2.7 and 5.3 mm²/s meeting modern requirements including the requirements in sanitary and hygienic terms and making it possible to produce articles with high quality of concrete surface meeting the category A2. The designed parting lubricants are similar, in terms of their operational characteristics, to imported lubricants, Formenal FT-SV and Divinol, being in use now at Gomel Integrated House-building Works OJSC, and surpass them in sanitary and hygienic terms.

АННОТАЦИЯ

В статье изложены результаты выполненных в РУП «Институт БелНИИС» исследований по синтезу особо низковязких разделительных смазок с кинематической вязкостью около 2 мм²/с при 20 °С, потребность в которых появилась на ряде предприятий Республики Беларусь в связи с запуском импортных технологических линий по производству железобетонных изделий на горизонтальных поддонах с передвижными бортами. В итоге исследований разработан способ физико-химической обработки низковязкого углеводородного растворителя Нефрас–С4–150/200 производства ОАО «Нафтан», – позволяющий устранить неприятный запах исходного растворителя и придать ему свойства, необходимые для его использования в качестве компонента смазок. Полученный продукт физико-химической обработки указанного растворителя образует однородные растворы

с минеральными маслами, характеризующиеся широким диапазоном вязкости в зависимости от состава и пригодные для использования в качестве гидрофобного компонента низковязких разделительных смазок, отвечающих современным требованиям в отношении вязкости, санитарно-гигиенических показателей и других свойств.

На базе изопарафинового масла ЗАО ИПК «Роснефтехим», индустриального масла ОАО «Нафтан» и продукта физико-химической обработки растворителя Нефрас-С4–150/200 ОАО «Нафтан» синтезированы низковязкие разделительные смазки с кинематической вязкостью 2,7 и 5,3 мм²/с, отвечающие современным требованиям, в том числе в санитарно-гигиеническом отношении, и позволяющие получить изделия с высоким качеством поверхности бетона, отвечающей категории А2. Разработанные разделительные смазки по эксплуатационным параметрам аналогичны используемым ныне на ОАО «Гомельский ДСК» импортным смазкам Formenal FT-SV и Divinol и превосходят их в санитарно-гигиеническом отношении.

Keywords: kinematic viscosity, lubricant for formwork, petroleum solvent, mineral oils, surface quality.

Ключевые слова: кинематическая вязкость, смазка для опалубки, нефтяной растворитель, минеральные масла, качество поверхности.

Recently, the need arose in our country for especially low-viscosity parting lubricants, with their kinematic viscosity as low as 2–5 mm²/s at 20 °C. However, the best lubricants been in use earlier had the viscosity at least 12–20 mm²/s at 20 °C. The aforementioned need arose due to installation and commissioning of up-to-date imported process lines at several Belarusian enterprises, similar to lines from *Vollert Weckenmann* (Germany) and *Plan* (Italy) companies, for making reinforced-concrete articles on horizontal steel trays with movable sidewalls fastened by magnets. Equipment installed on these lines for application of the parting lubricant on trays is operable only when quite low-viscosity (5 mm²/s or less) lubricants are used.

Manufacturers of aforementioned process lines recommend imported low-viscosity lubricants to be used. In particular, *Gomel Integrated House-building Works* OJSC uses German lubricants, Formenal FT-SV and Divinol [1,2]. Attempts to replace imported lubricants by domestically-made commercially available lubricants are still unsuccessful at this enterprise.

These lubricants, Formenal FT-SV and Divinol, provide easy separation of manufactured reinforced-concrete articles from steel trays and sidewalls and quite high quality of concrete surface approaching the requirements of category A2 according to [3]. However, they not always provide protection of steel moulds against corrosion during concrete hardening at higher temperatures in high-moisture environment. The serious shortcoming of these lubricants is bad odour of highly-volatile solvent adversely affecting the operating personnel's health. Also, these lubricants are quite costly.

The specific characteristic of Formenal FT-SV and Divinol lubricants is high content of low-viscosity highly-volatile solvent (about 70% by weight). The percentage of the active substance effectively providing the parting effect is less than 30%. The viscosity of the composition of components acting as the active substance is much higher than the viscosity of solvent. The solvent function is to impart the required low viscosity (2–3 mm^2/s at 20 °C) to the whole composition (i.e. lubricant), making it suitable for application on mould surfaces by spraying through the nozzles and for uniform distribution on the aforementioned surface as a continuous thin layer. Due to solvent's high volatility, it is evaporated soon (15–30 minutes) after the lubricant application on a mould, and the very thin layer of the active substance (7–10 g/m^2) remains on the mould surface, consisting of mineral oil and targeted additives providing easy separation of hardened concrete articles and high quality of concrete surface.

It should be noted that the principle taken as a basis for the design of the composition and the technology of application of Formenal FT-SV and Divinol lubricants deserves most serious consideration. This principle involves deposition of the minimal amount of parting lubricant's active substance on the mould surface, as required to provide minimal adhesion between the hardened concrete and the mould material as well as defect-free quality of concrete surfaces and

mould surfaces. This principle is confirmed by the results of studies carried out in *Institute BelNIIS* RUE with regard to the properties of lubricants based on the «I20A industrial oil–targeted additives» system. For optimal compositions, the concrete adhesion to steel was only 0.2–1.0 kPa, with the lubricant layer thickness corresponding to the consumption of 6–10 g/m^2. The concrete surface quality in such a case met the requirements for the category A2 according to [3]. With the lubricant layer increased to 20–50 g/m^2, the concrete adhesion to steel remained almost unchanged, while the quality of surface of concrete and steel substrate worsened: pits arose on concrete, up to 2 mm, and friable substance layer arose on steel.

Thus, lubricant layer thickness on a mould surface in terms of the active substance corresponding to the consumption of 6–10 g/m^2 is sufficient to ensure high-quality article formwork removal. However, when lubricants based on most of industrial mineral oils (including I-20A) are used, such thin layer cannot be made in industrial environment by available application tools due to high viscosity of lubricants. As a rule, the quantity of lubricant applied is 4–6 times higher than the required amount. Among the methods for application of lubricants on mould surfaces with the minimal lubricant quantity in terms of the active substance is the active substance dilution by volatile solvent followed by the solvent removal resulting from evaporation.

The goal of this study is the design of the receipt and technology for preparation of domestically-made low-viscosity lubricants with the kinematic viscosity 2–5mm^2/s at 20 °C, based on hydrocarbon oils and solvents made in Belarus or Russia.

Hydrocarbon oils are produced in the Republic of Belarus and the Russian Federation, meeting the requirements in terms of their properties, except for viscosity, for their application as hydrophobic components of low-viscosity parting lubricants. Among these oils are, in particular, industrial oil I-20A (*Naftan* OJSC, the Republic of Belarus) and basic isoparaffin oil (*Rosneftekhim* Innovative Industrial Company CJSC, the Russian Federation). Commercially available hydrocarbon solvents have low viscosity and, when mixed with aforementioned oils, provide combinations with the required viscosity. In terms of their properties, the most suitable are Nefras-C4–150/200 solvents made by *Naftan* OJSC in accordance with [4]. The kinematic

viscosity of this solvent at 20 °C is 1.4 mm^2/s, and the flash point is at least 31 °C. However, as for application as a component in lubricants, this solvent has a significant shortcoming – the specific odour making the especially low-viscosity lubricants less attractive in sanitary and hygienic terms.

In *Institute BelNIIS* RUE, the method has been developed for elimination of bad odour of the aforementioned solvent, Nefras-C4–150/200, by special physicochemical treatment focused on removal of odour-producing compounds from the solvent composition. The result is a low-viscosity product free of the aforementioned shortcoming and suitable to make homogeneous solutions with hydrocarbon oils, meeting the sanitary and hygienic requirements.

The viscosity of solvents made of the product resulting from the physicochemical treatment of Nefras-C4–150/200 and hydrocarbon oils varies in wide range depending on the ratio of components. For example, see Figure 1 for the resulting «composition vs. viscosity» relationship.

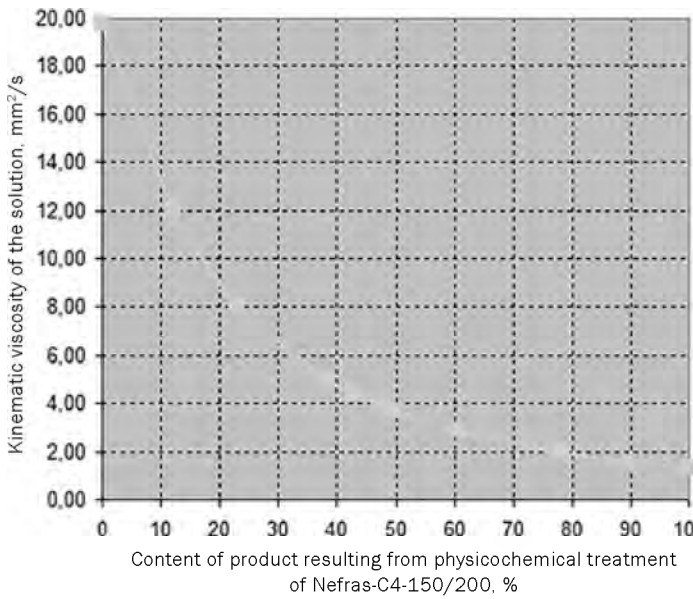

Figure 1. Kinematic viscosity relationship for compositions based on the product resulting from physicochemical treatment of Nefras-C4–150/200 and the basic isoparaffin oil made by Rosneftekhim Innovative Industrial Company CJSC

The compositions of the aforementioned product with the industrial oil I-20A from *Naftan* OJSC and the basic isoparaffin oil from *Rosneftekhim* Innovative Industrial Company CJSC were used as basic materials to make low-viscosity parting lubricants with the kinematic viscosity 2.7 and 5.3 mm^2/s at 20 °C.

The technology for making these lubricants consists of mixing the solutions of the product resulting from Nefras-C4–150/200 treatment and mineral oils with targeted additives to impart the required functional properties – high lubricant adhesion to the material of moulds and low concrete adhesion to this material, capability to provide high quality of surfaces of concrete articles and protection against corrosion of steel moulds during the concrete hardening process. The specific feature exists in application of resulting lubricants: a mould with the lubricant applied must be kept for some time (30–60 minutes) before filling it with concrete mix. This delay is necessary for evaporation of solvent from the lubricant composition and for formation of continuous thin layer of the active substance from the lubricant on the mould surface. See Figure 2 for the solvent evaporation kinetics.

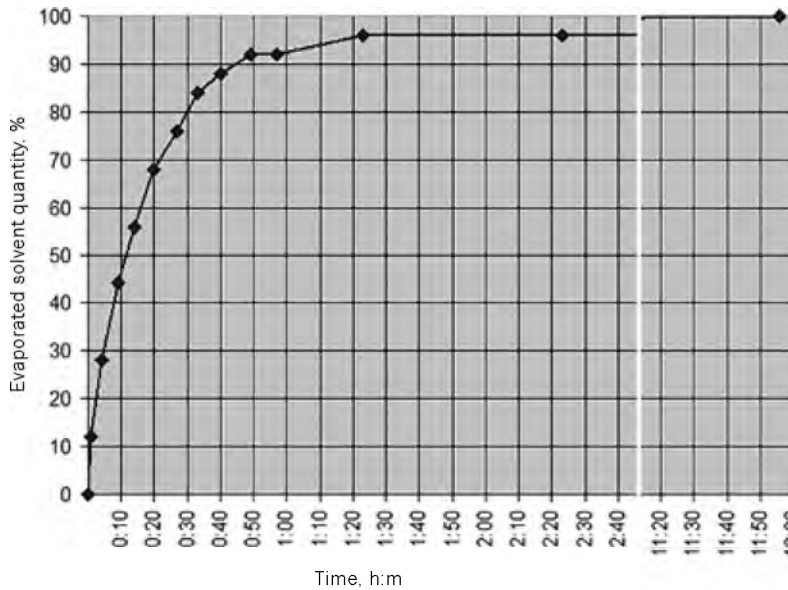

Figure 2. The plot of solvent evaporation from DSK-29 lubricant

The plot demonstrates that the solvent evacuation is especially rapid during the initial time interval (80% is evacuated during the first 30 minutes); then, it becomes much slower.

See Tables 1 and 2 for the composition and physicochemical characteristics of the resulting lubricants.

Table1

Composition of experimental lubricants

Lubricant components' description	Lubricants' laboratory index, raw material component content (% by weight)	
	DSK-29	DSK-30
Industrial oil I-20A (*Naftan* OJSC)	–	47.63
Basic isoparaffinic oil (*Rosneftekhim* Innovative Industrial Company CJSC)	28.95	–
Product resulting from physicochemical treatment of Nefras-C4–150/200 lubricant (*Naftan* OJSC)	69.81	50.39
Component for improvement of mould material moistening by the lubricant	0.80	1.33
Modifier for improvement of lubricant adhesion to the mould material	0.07	0.08
Lubricant surface tension modifier	0.04	0.10
Component for protection of steel surfaces against corrosion	0.34	0.48

Table 2

Physicochemical characteristics of experimental lubricants

Characteristic description and unit of measurement	Lubricants' laboratory index and characteristic value	
	DSK-29	DSK-30
State of matter at 20 °C and atmospheric pressure	Homogeneous transparent liquid	Homogeneous transparent liquid
Odour	Neutral	Neutral
Density at 20 °C, kg/m^3	790	820
Kinematic viscosity at 20 °C, mm^2/s	2.7	5.3
Weight of lubricant applied on a steel plate, calculated per 1 m^2 of surface, g/m^2	18	18

Table 2 (continued)

Characteristic description and unit of measurement	Lubricants' laboratory index and characteristic value	
	DSK-29	DSK-30
Time for evaporation of 90% of solvent from the layer of applied lubricant at ambient air temperature 20 °C and relative humidity 60%, min	45	60
Weight of lubricant that remains on the steel plate surface, calculated per 1 m^2, g/m^2	5.4	8.9
Concrete adhesion to steel after hardening under the temperature and moisture conditions in accordance with the mode [5], kPa	0.6	0.5
Concrete surface condition according to [5]	Clean, free of visible defects	Clean, free of visible defects
Corrosive effect for concrete according to [5]	No effect	No effect
Corrosive effect for steel according to [5,6]	No effect	No effect
Concrete surface category according to [3]	A2	A2

According to the results of laboratory tests, both lubricants provide easy separation of concrete specimens from steel moulds, defect-free concrete surface, protection of steel mould surfaces against corrosion. The concrete adhesion to steel is only 0.5–0.6 kPa. The concrete surface meets the requirements for the category A2 according to [3].

In terms of their functional physicochemical characteristics, the resulting lubricants, DSK-29 and DSK-30, are equivalent to imported lubricants, Formenal FT-SV and Divinol, used at *Gomel Integrated House-building Works* OJSC uses; however, they significantly surpass the imported lubricant in sanitary and hygienic terms. Lubricants Formenal FT-SV and Divinol have bad odour and not safe for the operating personnel's health. Synthetized lubricants, DSK-29 and DSK-30, are almost odourless, and there is no need to install the high-power exhausting system when they are in use.

Thus, the method has been developed in *Institute BelNIIS* RUE for improvement of quality of especially low-viscosity lubricants by physicochemical treatment of Nefras-C4–150/200, the domestically-made lubricant being in use. As a result of works carried out, the lubricants DSK-29 and DSK-30 are made, providing high quality of

surfaces of manufactured concrete and reinforced-concrete articles, meeting the raised requirements in terms of sanitary and hygienic safety of the operating personnel and the requirements of modern equipment in terms of application of lubricants on surfaces of moulds.

REFERENCES

1. [Electronic resource].–Mode of access: http://elaskon.de\formenal-ft-sv-250.html.–Date of access: 15.09.2017.
2. [Electronic resource].–Mode of access: http://www.Divinol.biz/stroitelnaya-himia/otdelyaushhie-agenty-dlya-betona.–Date of access: 15.09.2017.
3. *Konstruktsii i izdeliya betonnye i zhelezobetonnye sbornye. Obshchiye tekhnicheskiye trebovaniya* [Prefabricated concrete and reinforced concrete constructions and products. General technical requirements]: GOST 13015.0–83 (rev. № 3 01.08.2004) – Moscow: Izdatel'stvo standartov, 1991. 16p.
4. *Nefras-C4–150/200 (zamenitel' wite-spirita)* [Petroleum solvent-C4–150/200 (white spirit substitute). Specifications]: BY100006485.147–2002 – Minsk: Progress RUE, 2002. 18 p.
5. *Smazki dlya form i opalubok. Obshchie tekhnicheskiye usloviya* [Oil for moulds and forms. General specifications]: STB1707–2006: Brought into force: 01.06.2007. Minsk: The State Committee for Standardization of the Republic of Belarus (Gosstandart), 2007. 13p.
6. *Masla i prisadki. Metod korrozionnogo vozdeistviya na metally* [Oils and additives. Method of test for corrosion influence on metals]: GOST 2917–76. Brought into force: 01.01.1979 (amendments No.1,2 06.1988) (the validity period limitation was cancelled in 1993). Moscow: Ministry of petroleum processing and petrochemical industry of USSR, 1988. 5 p.

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