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TO THE QUESTION OF SYNTHESIS OF PARTING GREASES FOR FORMWORKS IN CONCRETE PRODUCTION

ABSTRACT

The article presents the results of the research of composition and preparation technology of the parting greases to be used for smearing on working surfaces of forms and timberings in traditional ways during the manufacture of concrete and reinforced concrete structures. The executed work has been focused on the determination of economically reasonable domestic components that provide parting greases with the demanded functional properties. The basic attention is focused on the research of viscosity of the compositions that consist of industrial oil and solvents – oil solvent and fatty acid methyl esters which are manufactured in the Republic of Belarus. It is established that the specified raw materials being mixed form the true solutions. The viscosity of the solutions, according to the structure, changes in a wide interval (from 1,6 to 170 mm^2/s). A number of compositions with kinematic viscosity in a range from 2 to 20 mm^2/s at a temperature of 20°C are of interest as a basis for synthesis of parting greases. The reason is that except for the low viscosity at introduction of modifying additives the compositions are characterised with the demanded values of other important indicators, in particular, the low adhesion characteristics of concrete to materials of forms and timberings, the ability to protect them from corrosion in heat-damp conditions of a concrete mixture hardening etc. A number of lacks are revealed. The search of the possible ways to eliminate the lacks will be held in further research work.

Keywords: kinematic viscosity, parting greases, adhesion, corrosive attack, solvent, diluent

Modern requirements for the quality of precast concrete and reinforced concrete structures and products have led to a significant change in production technologies and the emergence of special parting greases. The main functional requirement for a modern grease of a similar purpose is to prevent concrete from sticking to the surface of the form due to the formation of a stable grease layer with good adhesion to the surface of the mold, as well as improve the parting the concrete elements from it. In this case, the grease should withstand high loads per area unit, should not drain from the vertical walls, not to leave marks on the concrete surface and shall have improved environmental and operational characteristics. Production technology for reinforced concrete structures impose new mandatory requirements for grease:

- dispersion of air bubbles sucked in at the stage of concrete vibration in order to prevent the formation of cavities in the surface layer of the structure;
- lack of corrosive attack onto the concrete and the material of the forms and formworks;
- lack of undesirable odor;
- maintenance of operating abilities in a wide range of ambient air temperatures, including the low positive ambient temperatures.

In addition to the above-mentioned, one of the main requirements for modern parting greases for forms used in the production of concrete and reinforced concrete products and structures is the low viscosity, which allows them to be applied to the surface by mechanized methods, in particular, by spraying. However, the synthesis of domestic low-viscosity greases is associated with considerable difficulties, since most of the available industrial mineral and vegetable oils, of which the greases are composed and that provide for a separating ability, are characterized by significantly higher viscosity compared with the viscosity required for greases. The low viscosity of some imported greases, for example, the German grease Addinol F10, is achieved through the use of special low-viscosity refined

mineral oils, which are not produced in the Republic of Belarus and, therefore, a different way to obtain low-viscosity greases is required. According to [1, 2, 3, 5], an effective way to reduce the viscosity of mineral and vegetable oils is to dilute them with low-viscosity solvents — methyl and other rapeseed fatty acid esters and low molecular weight oil solvents, which are produced in our country (Grodnoazot OJSC, Khimvolokno OJSC, Naftan OJSC). However, the literature does not contain in-depth information about the viscosity and other properties of the compositions obtained on the basis of the oils produced in our country and the indicated solvents.

Experts of the Institute BelNIIS RUE conducted a significant research work aimed at the study of the following:

- viscosity, density and other properties of the compositions resulting from dilution of industrial oil with fatty acid methyl esters of rapeseed oil (hereinafter - FAMERO) and Nefras C4 150-200 petroleum solvent (hereinafter - PS);
- influence onto the properties of these compositions of some target modifying additives, which give the ability to perform functional purpose to the parting greases. In preparing the experimental compositions, industrial oil with a kinematic viscosity of 170.09 mm²/s, FAMERO with a kinematic viscosity of 6.64 mm²/s and PS with a kinematic viscosity of 1.59 mm²/s at 20 °C were used.

Figure 1 shows the dependence of the viscosity of solutions of industrial oil in FAMERO and PS from their concentration.

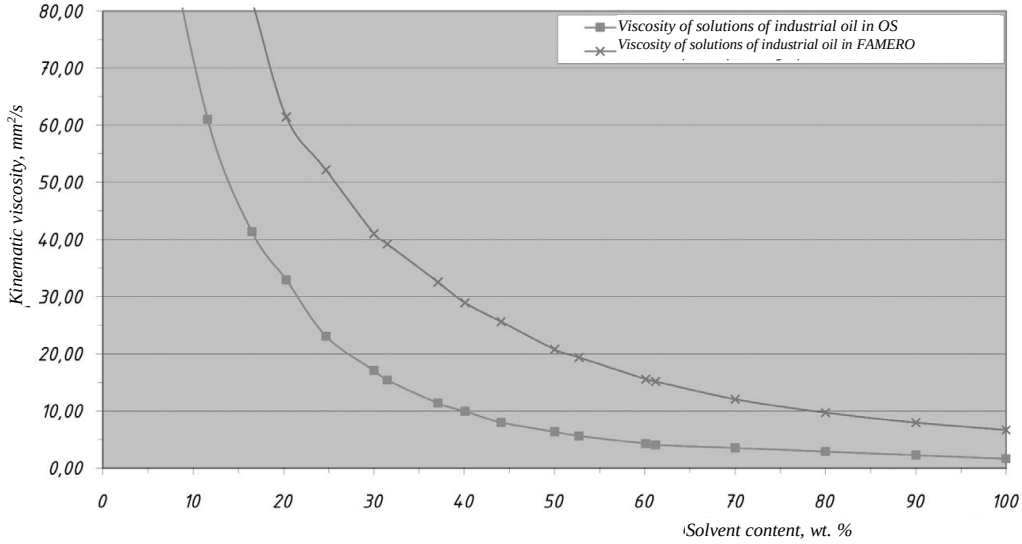

Figure 1. Viscosity of solutions of industrial oil in FAMERO and PS

In addition to studying the viscosity of industrial oil solutions in each of the FAMERO and PS solvents, the viscosity of industrial oil solutions in a mixture of these two solvents was also investigated at different ratios. The results are shown in Figure 2. For visualization of data, the method of construction of isolines was used. The contours shown in Figure 2 correspond to the kinematic viscosity of the investigated compositions in mm²/s at 20 °C.

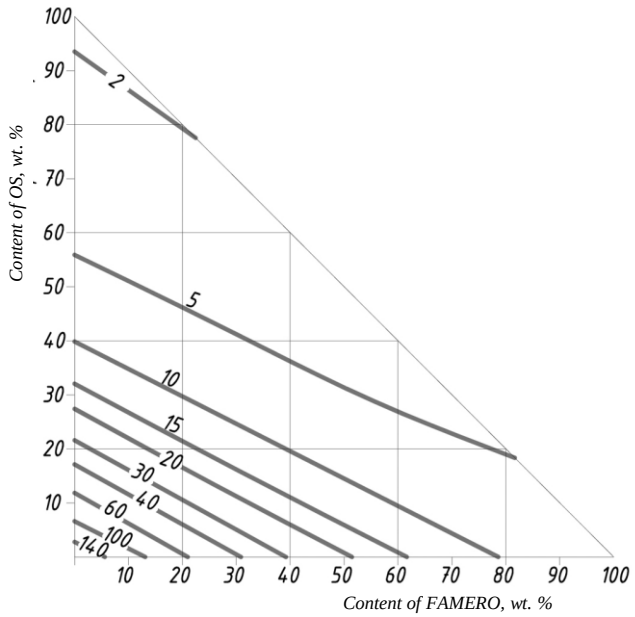

Figure 2. The viscosity of the compositions in the system "industrial oil - FAMERO - PS" at 20 °C

The research results presented in Figures 1 and 2 show that the viscosity of compositions obtained by diluting industrial oil with FAMERO and PS solvents varies over a wide range depending on their formula. The greatest practical interest relates to the compositions based on industrial oil and FAMERO characterized by kinematic viscosity in the range of 10-20 mm²/s at 20 °C, as well as compositions in the system of "industrial oil - FAMERO - PS" with kinematic viscosity in the range of 2-20 mm²/s at a temperature of 20 °C. It is the specified viscosity value that is required for modern parting greases used in the manufacture of concrete products and structures.

The graph presented in figure 2 allows to determine the formula of the compositions with the desired viscosity. The possibility of using a mathematical apparatus for the selection of a composition with the required viscosity was revealed as a result of the analysis of experimental data expressing the dependence of the viscosity of the compositions from their contents. For example, formulae of compositions with a viscosity of 10 mm²/s are described by the following system of equations:

$$\begin{cases} W_1 + W_2 + W_3 = 100 \\ W_2 + 0{,}507 \cdot W_3 = 39{,}87 \end{cases} \quad (1)$$

where W_1 – is the concentration of industrial oil, wt.%;
W_2 – is the concentration of PS, wt.%;
W_3 – is the concentration FAMERO, wt.%.

Compositions with viscosity of 15 mm²/s are described by the following equations:

$$\begin{cases} W_1 + W_2 + W_3 = 100 \\ W_2 + 0{,}520 \cdot W_3 = 31{,}97 \end{cases} \quad (2)$$

In order to obtain a basis for the synthesis of specific parting greases for a number of low-viscosity solutions of industrial oil in FAMERO and PS, as well as solutions complicated by target modifying additives, several other properties besides viscosity that are required for greases were investigated in accordance with [4].

The following substances were used as modifying agent:

– oleic acid (OA), which is the most affordable organic fatty acid and is used in many parting greases;

– substances that can react with oleic acid and prevent steel corrosion (MA-1 agent) and non-ionic surfactant, which favorably affects the quality of concrete surface (MA-2 agent).

The compositions of the investigated compositions and their properties are shown in tables 1 and 2. Determination of physico-mechanical parameters of the compositions was carried out by the methods in accordance with [4].

Table 1

The content of the investigated compositions

Index of compositions	Component composition, wt.%					
	Industrial oil	FAMERO	PS	OA	MA-1	MA-2
B-1	-	100	-	-	-	-
B-3	20	80	-	-	-	-
B-5	40	60	-	-	-	-
B-7	60	40	-	-	-	-
B-3м	19.40	77.60	-	3.00	-	-
B-5м	38.72	58.28	-	3.00	-	-
B-10	75.18	-	24.82	-	-	-
B-11	72.91	-	24.09	3.00	-	-
B-12	71.50	-	25	3.00	0.50	-
B-13	36	40	20	3.00	0.50	0.50

Table 2

Physico-mechanical parameters of the investigated compositions

Physico-mechanical properties of the compositions	The compositions index and the value of indicators									
	B-1	B-3	B-5	B-7	B-10	B-3м	B-5м	B-11	B-12	B-13
Viscosity, mm^2/s	6.64	9.68	15.54	28.70	24.13	9.73	15.57	24.15	23.2	15.1
Density, kg/m^3	873	873	874	875	858	873	874	860	857	856
Absolute value of adhesion of concrete to steel, N/m^2	89	178	178	267	133	89	311	267	120	110
Category of concrete surface according to GOST 13015.0-83	A3	A3	A3	A3	A3	A3	A3	A3	A3	A2
Corrosion effect on concrete	None									
Corrosion protection of steel	does not provide: there are major corrosion spots on the surface					does not provide: completely: there are point corrosion traces			provides: the surface is clean with no signs of corrosion	

The obtained results showed that the compositions in Tables 1 and 2 consisting only of industrial oil and solvents of FAMERO and PS are characterized by low viscosity, imporosity and adhesion of concrete to steel, provide good quality concrete surface, do not have a corrosive attack on concrete; however, they do not protect steel against corrosion. The introduction of oleic acid into the contents of these compositions favorably affects the anticorrosive protection of steel: the large corrosion spots are not being observed, but pinpoints of corrosion are still present. Additional introduction of the MA-1 modifying agent, which enters into chemical interaction with oleic acid, fully protects the steel from corrosion. When adding MA-2 modifying agent to the composition, the quality of the concrete surface significantly increases, the size of the surface sinks decreases to less than 1 mm, corresponding to the surface category of A2.

As a result of research, it was also found that compositions containing FAMERO cause some darkening of the concrete surface when used as greases, while compositions containing PS have a specific undesirable odor.

CONCLUSION

Thus, the results of research show that the properties of solutions of mineral oil in domestic solvents of FAMERO and PS, modified with oleic acid and target agents of MA-1 and MA-2, meet the requirements for parting greases in terms of viscosity, adhesion of concrete to the formworks, quality of the concrete surfaces and anticorrosive protection of the formworks and can serve as the basis for the synthesis of modern greases. Further research will be directed at eliminating the discovered deficiencies of the obtained compositions, in particular, at eliminating the dark background of the surface of concrete formed under the influence of FAMERO and neutralizing the odor from the injection of PS solvent.

REFERENCES

1. *Trennmittel fur retonbauscalungen: pat. AT 398078 B*, Republic Űsterreich, Int.Cl5.:C10M 105/32, B28B 7/38 / Nolz Gesellschaft M.B.H. & Co KG – №1881/90; Anm. 17.9/1990; Beg. 15.1.1994.
2. *Smazka dlya form i opalubok* [Grease for forms and moulds]: pat. 14640 Resp. Belarus, MPK S 10M 101/04, B28B 7 / 38 / N.V. Vorivodskaya, A.A. Silchenko, V.V. Semirskiy, zayaviteli – NPRUP "UNIHIMPROM BGU", Uchrezhdeniye Bel. gos. un-ta "Nauchno-issledovatelskiy institut fisico-khimicheskikh problem" – № a20091895; zayavl. 2009.12.29, opubl. 2011.08.30 // http://bypatents.com/4-14640-smazka-dlya-form-i-opalubok.html (data dostupa: 2015.11.13) (rus)
3. Galiakbirov, A. R., *Razrabotka razdelitel'nykh smazok dlya form betonnykh izdeliy* [Elaboration of parting greases for forms of concrete products]: avtoref. diss.… kand.tekhn.nauk: 05.17.07 / A. R. Galiakbirov; Ufa petroleum state university – Ufa, 2011. 24 p. (rus)
4. *Smazki dlya form i opalubok. Obshchiye tekhnicheskiye usloviya* [Oil for moulds and forms. General specifications]: STB 1707-2006. – Vved. 01.06.07. – Minsk: Gosstandart RB, 2006. 11 p. (rus)
5. Shatov, A. N. *Concrete technologies*. 2011. No 3 – 4. pp. 10 – 13. (rus)
6. *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. – 01.01.84. – Moscow, 1991. 13 p. (rus)

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