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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ СТРОИТЕЛЬНО-ДОРОЖНЫХ МАШИН ПРИ ВЗАИМОДЕЙСТВИИ С АДГЕЗИВНЫМИ МАТЕРИАЛАМИ ПРИ ОТРИЦАТЕЛЬНЫХ ТЕМПЕРАТУРАХ

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Ключевые слова: адгезия, коэффициент пропорциональности, MAXFLIGHT 04, уравнение регрессии.

Аннотация. В данной статье объектом исследования является строительно-дорожная машина, взаимодействующая со связным грунтом. В статье анализируется использование противообледенительной жидкости «MAXFLIGHT 04» в качестве материала для устранения адгезии системы «грунт-металл», которая возникает в работе строительно-дорожных машин при разработке влажных связных грунтов в условиях отрицательных температур. Основная цель данного исследования – повышение производительности и более эффективной работы строительно-дорожных машин при работе с влажным связным грунтом в условиях отрицательных температур посредством уменьшения адгезии влажного связного грунта, контактирующего с рабочим органом строительно-дорожной машины.

IMPROVING THE EFFICIENCY OF CONSTRUCTION ROAD MACHINES IN THE INTERACTION WITH ADHESIVE MATERIALS UNDER NEGATIVE TEMPERATURES

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Keywords: adhesion, proportionality coefficient, MAXFLIGHT 04, regression equation.

Abstract. In this paper, the object of study is a construction road machine that develops the cohesive ground. The article analyzes the use of the MAXFLIGHT 04 anti-icing fluid as a material to eliminate the adhesion of the “soil-to-metal” system, which is used in the operation of construction road machines in the development of wet cohesive soils at negative temperatures. The main objective of this study is to achieve higher productivity and more efficient operation of construction road machines when working with wet cohesive soil at negative temperatures by reducing the adhesion of wet cohesive soil in contact with the working body of the earthmoving machine.

Introduction. One of the main reasons resulting in a the productivity decreaseof technological machines is adhesion and friction an increase during the development of wet cohesive soils under negative ambient temperatures.

There are four methods to control sticking and freezing of the soil to the working bodies of technological machines. The first method is the formation of an intermediate layer the the “soil-to-metal” interface. The second group includes methods function is to reduce soil-to-metal adhesiveness by external action. The third group includes technological and mechanical methods to control adhesion. The fourth group combines two or more approches to reduce the soiladhesion and friction described above [1].

One of the most common and promising methodic prophylactic [1], which involves the creation of an intermediate layer under interface between the surface of the working organ and the moist soil. The intermediate layer serves as a protective shield for intermolecular interaction, providing free movement of phase surfaces. The intermediate layer is divided into liquid, solid and gaseous.

Results and discussion. Prophylactic agent "MAXFLIGHT 04" and "OCTAFLO EG" are propylene glycol anti-icing fluids and are intended for ground anti-icing aircraft treating. The liquids have a very good anti-icing performance when heated up to +70ºC without any operational restrictions. The anti-icing liquid must be kept on the wings (Holdvertime) for the from 3 minutes to 12 hoursperiod.It has the lowest limits of viscosity of all SAE Type IV fluids, in some cases even lower than those of the SAE type II [1] liquids.

During the experimental studies, soil was used of category IV - loam, as the most common in the northern areas of the Irkutsk region. The soil moisture was 7.5, 12.5 and 17.5%, the time of “soil-to-metal” system contact metal surface was 3, 5 and 7 minutes. This corresponds to the operating parameters of technological machines. The plan and the results of the experiment are shown in table 1.

Tab. 1. The plan and results of the experiment

The experimental plan in natural values				
Ambient temperature T_{at}, °C	Soil moisture W, %	The contact time of the soil-to-metal system t, min	Without impact	With impact MAXFLIGHT 04
-35	7.5	3	92.73	30.4
	7.5	7	174.2	62.74
	12,5	5	186.54	78.91
	17,5	3	218.54	134.2
	17,5	7	400	159.89
-15	7,5	5	63.74	38.25
	12,5	3	78.45	50.01
	12,5	5	144.2	56.88
	12,5	7	240.3	58.84
	17,5	5	228.5	94.14
5	7.5	3	11.6	4.2
	7.5	7	15.2	5.1
	12,5	5	17.9	8.3
	17,5	3	24.3	14.8
	17,5	7	31.7	17.4

Mathematical processing of the obtained results was carried out by using the MODEL program for multifactor according to dependencies the latest square method. As a result of experimental datathe processing of resulted in obtaining regression equations without the effect of the lubricant and theanti-icing fluid "MAXFLIGHT 04" applying.

Without impact:

$$\tau_{БВ} = 134.3 + 1.026 \cdot T_{cp} - 4.3 \cdot W - 46.08 \cdot t - 0.1 \cdot T_{cp}^{2} + 0.1074 \cdot W^{2} + 3.985 \cdot t^{2} - 0.4 \cdot T_{cp} \cdot W - 0.8 \cdot T_{cp} \cdot t + 1.3 \cdot W \cdot t \quad (1)$$

With impact «MAXFLIGHT 04»:

$$\tau_{Maxflight} = 41.22 + 0.66 \cdot T_{cp} - 8.14 \cdot W + 4.4 \cdot t - 0.03 \cdot T_{cp}^{2} + 0.43 \cdot W^{2} - 0.27 \cdot t^{2} - 0.22 \cdot T_{cp} \cdot W - 0.17 \cdot T_{cp} \cdot t - 0.062 \cdot W \cdot t \quad (2)$$

Calculation of the proportionality coefficient. The resistance (voltage) to the displacement of the soil over the metal surface consists of the deformation (*fP*) and adhesive (f, ρ_n, S) components and depends on the pressure and area of contact, the properties of the shear surfaces, the speed of movement of the sample [1].

The proportionality coefficient is determined by the expression [1]:

$$f = \frac{rS}{P} = f + f_1 \cdot \rho_n \frac{S}{P}. \quad (3)$$

The proportionality coefficient or the given friction coefficient *f* takes into account the shear characteristic when determining the force of the soil-to-metal surface friction, and its value includes the deformation and adhesive values and depends on the same parameters as the shear resistance, namely: time *t* and contact pressure *P* , moisture *W* and disparity *D* of the soil, temperature in the shear plane *T*, the metal surface state.

That formula is considered (3) to determine the resistance to shear under the soil freezing to the sliding surface also. And the proportionality coefficient *f* will reflect the effect of adhesion under negative temperature and be determined by equating the analytical dependence (3) and dependences experimentally obtained on the special shear stand (1,2), where $\tau = f(D, F, P, W, T, t)$.

The shear stress τ, area *S* and contact pressure *P* are measurable, this fact allow to determine experimentally the friction coefficient *f* under the soil-to-metal surface freezing of the working body.

Without the effects of intensifiers, taking into account the dependence (1):

$$f = (134.3 + 1.026 \cdot T_{cp} - 4.3 \cdot W - 46.08 \cdot t - 0.1 \cdot T_{cp}^{2} + 0.1074 \cdot W^{2} + 3.985 \cdot t^{2} - 0.4 \cdot T_{cp} \cdot W - 0.8 \cdot T_{cp} \cdot t + 1.3 \cdot W \cdot t) \cdot \frac{S}{P}. \quad (4)$$

When using a liquid intermediate layer, taking into account the dependence (2):

$$f = (41.22 + 0.66 \cdot T_{cp} - 8.14 \cdot W + 4.4 \cdot t - 0.03 \cdot T_{cp}^{2} + 0.43 \cdot W^{2} - 0.27 \cdot t^{2} - 0.22 \cdot T_{cp} \cdot W - 0.17 \cdot T_{cp} \cdot t - 0.062 \cdot W \cdot t) \cdot \frac{S}{P}. \quad (5)$$

The results of the calculation of the proportionality coefficient dependence on the temperature are presented in tables 2.

Tab. 2. Controlled values of the proportionality coefficient f depending on the temperature in the shear plane

Ambient temperature T_{at}, °C	+5	- 5	-15	-25	-35
Without impact	0,39	1,1	1,7	2,16	2,5
«MAXFLIGHT 04»	0,11	0,38	0,61	0,81	0,97

Conclusion. Analysis of the obtained values of the proportionality coefficient *f* allows to conclude that if the temperature of the contacting surfaces decreases in the range of + 5°C ...-35°C, the coefficient of proportionality *f* increases if used anti-icing fluid brand "MAXFLIGHT 04", but its value is 2…3.5 times lower proportionality values without using prophylactic agents to reduce the adhesion the soil.

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