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Research for conducting experiments to determine the appearance, corrosiveness, pH and stability of release coatings for die casting molds of aluminum alloys

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The appearance test consisted of the following: the prepared and selected sample of the water-based release coating was poured into a cylinder with a capacity of 50 cm^3 and examined in transmitted light, while the consistency, uniformity, color and transparency of the tested release coating compositions were evaluated visually. When determining the appearance of the separating coating, the latter was applied with a brush on a glass slide with a layer of about 1 mm and examined in transmitted light.

The study of the corrosion aggressiveness of the developed composition of the water-based coating prepared on hard water in comparison with other lubricants was carried out by the drop method. For research, formulations were prepared in the form of an emulsion in a volume of 50 ml. The emulsion was obtained by diluting the pre-prepared release coating concentrate with water in a ratio of 1:20. Corrosion tests were carried out on metal cylindrical samples of steels 45 and 40X with a diameter of 50 mm. The choice of sample material is due to their demand in the manufacture of mold elements for die casting aluminum alloys (pushers, plates, guide bushings, etc.). The working surface of the samples was preliminarily subjected to grinding to create a uniform surface profile before the study. The samples after grinding were not subjected to passivation to preserve the reactivity of the surface layer. The studied samples for testing were prepared in accordance with GOST 6243–75 "Emulsols and pastes. Appearance method. Determination of the corrosive aggressiveness of an emulsion. Determination of emulsol stability. Determination of emulsol stability at low temperatures. Determination of storage stability. Determination of the influence of hard water on the quality of emulsols".

A separating coating was applied to the metal surface of the prepared samples in a volume of 1 ml. To obtain reliable statistical data, a separating coating was applied to each sample on the working metal surface at five points. Next, the samples with a separating coating applied to them were kept at room temperature (20 °C), corresponding to the mold storage conditions, and at an elevated temperature (150 °C), simulating the operating conditions of the above mold structural elements in the production of aluminum alloys. The holding time of samples during testing at a temperature of 20 °C was 250 hours, and under thermal exposure at a temperature of 150 °C – 8 hours. The influence of the components of the technological lubricant on the steel metal surface was evaluated by studying the morphology of the contact patches of the separating coating and the roughness indices of the steel substrates.

The study of the pH of the developed water-based release coating and the selected compositions was carried out using a universal indicator paper designed to determine the pH from 0 to 12 units. Figure 1.1 shows the appearance of a container with universal indicator paper for determining the pH of the test separating coatings.

Figure 1.1 – External view of the container with universal indicator paper for determining the pH of the test separating coatings

Before measuring the pH value, the separating composition prepared and poured into a beaker in a volume of 100 cm^3 was closed with a cork, after which it was intensively shaken with vertical movements for 1 min, and then the contents were poured into a separating funnel, followed by holding at rest at a temperature of (20 ± 5) °C for 30 min. A sample of the prepared separating coating composition for research was taken from the bottom of the separating funnel through a tap. The arithmetic mean of the results of two parallel measurements was taken as the test result. The results of the pH study of the compositions of the studied water-based release coatings are presented in Table 1.2.

The stability of the emulsion during long-term storage was determined by taking two samples of the developed and studied compositions and pouring them into glass test tubes. The sample volume of the lubricant composition for research is 25 cm^3. After taking a given amount of lubricant, the samples were closed with stoppers and subjected to heat treatment (sample exposure at (40 ±2)°C for 24 hours), and then the samples were stirred at a frequency of 1 500 min^{-1} for 1 min. The composition of the separating coating was considered to have passed the test in the absence of isolated solids and the appearance of liquid layers of different density in the volume of the test sample.

The results of studies to determine the appearance of the studied separating coatings are presented in Table 1.1.

Table 1.1 – Results of studies to determine the appearance of the studied separating coatings

Release number	Separating coatings based on:	Appearance of the emulsion
1	Mineral Oil Vapor	Homogeneous emulsion, light yellow color
2	Mountain wax B40, Belarus	Homogeneous emulsion, light yellow color
3	Firm "Petrofer", Germany	Homogeneous emulsion, white color
4	Firms "Eutektika", Belarus	Homogeneous emulsion, white color
5*	Fuse-based lubricant	Homogeneous emulsion, white color

Visual inspection of the studied samples showed that after 100 hours of contact of the developed emulsion at 20 °C, no traces of corrosion damage were observed.

It has been established that in the process of interaction of the components that make up the emulsion with the metal surface of steel samples at an ambient temperature of 20 °C, a test time of 250 hours and a relative air humidity of 70%, foci of corrosion damage are observed on the contact spots. Moreover, when using a sample of steel 45, traces of surface damage are present on all contact spots, while on a sample of steel 40X, in one case, traces of damage are hardly noticeable. Increasing the test temperature to 150 °C in the study of the corrosive activity of the emulsion, obviously, led to the evaporation of water from the lubricating layer on the surface of the sample. The fatty components of the emulsion, apparently, did not have any effect on the tested steel samples, but, on the contrary, covering the surface of the sample with a lubricant film, prevented the access of oxygen to the metal base of the sample, and thereby slowed down the corrosion process.

A detailed analysis of the centers of corrosion damage of steel substrates on the contact patches of the lubricant composition was carried out on a metallographic microscope at a 40x optical magnification. Obviously, as a result of prolonged contact of the emulsion, which initially contains 65 wt.% water, corrosion processes occur on the surface of the steel substrate. Corrosion damage was recorded on steel specimens made of steel 45 and steel 40X. The studied composition of the technological lubricant does not exhibit corrosive activity with a rapid loss of the water base due to heating of the substrates (150 °C). It should also be noted that the fatty components of the lubricant are stable, i.e. the lubricating layer is not destroyed, and retain their lubricating and preservation properties after 100 hours of testing at a temperature of 150 °C.

The results of the study of the pH compositions of the studied water-based release coatings are presented in Table 1.2.

Table 1.2 – The results of the study of the pH compositions of the investigated water-based release coatings

Release number	Separating coatings based on:	Meaning pH
1	Mineral Oil Vapor	7,6
2	Mountain wax B40, Belarus	7,3
3	Firm "Petrofer", Germany	7,2
4	Firms "Eutektika", Belarus	7,4
5*	Fuse-based lubricant	7,5

It can be seen (Table 1.2) that the pH value of all the studied compositions of separating coatings is in the range of values from 7.2 to 7.6 units, which corresponds to a neutral environment, and, therefore, these compositions do not have a high corrosion property.

The results of the study of the stability of the investigated lubricant compositions for die casting molds of aluminum alloys are presented in Table 1.3.

Table 1.3 – The results of the study of the stability of the studied lubricant compositions for die casting molds of aluminum alloys

Release number	Separating coatings based on:	Stability emulsions, %
1	Mineral Oil Vapor	86
2	Mountain wax B40, Belarus	92
3	Firm "Petrofer", Germany	98
4	Firms "Eutektika", Belarus	95
5*	Fuse-based lubricant	95

It can be seen (Table 1.3) that the developed composition of the fuse-based release coating has a sufficiently high stability (95%) in comparison with other studied compositions. It is shown (table 3) that the stability of the imported separating coating of the company "Petrofer" has a value of 98%. The lowest value of emulsion stability is for a release coating based on Vapor mineral oil and B40 grease.