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ANALYSIS AND CHOICE OF COATINGS FOR INCREASING THE DURABILITY OF PARTS OF DIFFUSION UNITS OF SUGAR PLANTS

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Досліджено електрохімічні властивості зносо- і корозійностійких покриттів та їх вплив на процеси тертя та зношування деталей дифузійних апаратів цукрових заводів. Встановлено вплив температури і складу технологічного середовища, електрохімічних характеристик захисних покриттів на опір деталей спрацюванню в умовах корозійно-механічного зношування. Визначено основні закономірності зношування та корозії деталей в технологічних середовищах

Ключові слова: захисні покриття, дифузійний сік, електрохімічні властивості, корозійно-механічне зношування

Исследованы электрохимические свойства износо- и коррозионностойких покрытий и их влияние на процессы трения и изнашивания деталей диффузионных аппаратов сахарных заводов. Установлено влияние температуры и состава технологической среды, электрохимических характеристик защитных покрытий на сопротивление деталей разрушению в условиях коррозионно-механического изнашивания. Определены основные закономерности изнашивания и коррозии деталей в технологических средах

Ключевые слова: защитные покрытия, диффузный сок, электрохимические свойства, коррозионно-механическое изнашивание

1. Introduction

Aggressive technological liquids affect large quantity of metal parts of sugar plants equipment. Their influence causes intense corrosion and mechanical wear. In some cases, intensity of wear is so high that parts of equipment cannot hold out a work season of a sugar factory. This happens because of especially difficult operating conditions in aggressive media directly, in particular in diffusion juice, washing and disinfecting solutions, etc.

Friction of metals in active liquid media has specific features. Namely, deformation process and destruction of conjugate surfaces affect electrochemical factors significantly [1]. The tribocorrosion covers a science of surface transformations and combines mechanical and chemical interactions between a body, a counter body, interphase medium and medium, which includes friction, greasing, wear and tribological activated chemical and electrochemical reactions [2].

Friction in aggressive media accelerates corrosion processes significantly. Acid, alkaline and neutral technological media-electrolytes differ in the influence on the corrosion process and mechanical wear of parts. Anode dissolution of metals and coatings predominates in acidic media [3]. Alkaline media can form protective films on metal surfaces and reduce a role of corrosion factor during wear process [4]. Neutral environments – electrolytes can reduce corrosion resistance of parts (eg, weak solutions of kitchen salt) [2, 5]. If there is an excess in oxygen solutions, protective films may form on friction surfaces of parts. Such films protect parts from corrosion and mechanical wear [6]. Two factors determine a rate of corrosion and mechanical wear of metal coatings – mechanical wear and anodic dissolution of surfaces. Fraction of dissolution of surfaces of metal parts due to corrosion processes exceeds fraction of mechanical wear in many cases. This is typical for parts of equipment used in weak acidic media of sugar factories [5] and meat processing enterprises [6]. Intercrystallite corrosion affects even rust-resistant steels under friction in acidic media [7].

There are many technological methods of influence and control of a composition, structure and properties of surface layers of parts. However, lack of scientifically substantiated recommendations for a rational choice of materials and ways to strengthen surfaces of parts, depending on a type of wear, its nature, intensity, characteristics of an operation environment, etc. hampers introduction of such means into production.

The manufacture and repair of parts of a technological equipment of sugar factories implies a use of various materials and protective coatings.

Data on wear and corrosion resistance of a processing equipment of sugar factories obtained during their inspection indicate that the repair of evaporators and diffusion plants takes the largest amount of material expenses.

One of the main technological media of sugar production is diffusion juice. This is a multicomponent solution, which contains about 12–15 percent of sucrose, a series of compounds in the dissolved state and fraction of the insoluble matter. The presence of organic acids (oxalic, citric, succinic, etc.) in its composition gives it a weak acidic reaction (pH 6.1–6.6). Along with other admixtures, it contains a number of surfactants (SASs) – saponin, proteins, pectins. The composition of diffusion juice depends on a region, where raw material grows. The diversity of the composition and properties of diffusion juice determines peculiarities and complexity of studying processes of corrosion and mechanical wear (CMW) of surfaces of parts of diffusion apparatus and causes difficulty in development of effective recommendations for increase in durability.

The least durable parts of diffusion apparatus are slide bearings and screws of a transport system. They need protection against corrosion and mechanical wear.

One of the promising ways to protect mentioned parts from wear is the application of self-fluxed plasma coatings. Such coatings are able to protect parts from wear and corrosion. At the same time, there are no definitions of electrochemical and tribotechnical properties of such coatings in diffusion juice of sugar beets. The study of these factors is an urgent task.

2. Literature review and problem statement

Investigation on the corrosion resistance of metals in diffusion juice [1] made possible to establish that stainless steel of the austenitic class is best suited for the manufacture of parts of diffusion apparatus. But such steels are prone to intercrystallite corrosion [8, 9]. They are also highly deficient, expensive and non-technological.

The choice of materials for details of processing equipment for sugar factories is complicated due to the lack of a unified methodology for the study of CMW process, and sometimes because of the inability to compare results obtained by different researchers. Authors of paper [10] established that the corrosion factor determines wear intensity at low pressures only.

Recently, studies of corrosion and mechanical wear of parts of equipment take into account electrochemical characteristics of technological medium, metals and alloys [9]. An author [11] considers tribocorrosion as the interaction between chemical, electrochemical and mechanical processes, which leads to degradation of materials immersed into a corrosive medium. Modification of surface characteristics occurs as a result of the combined periodic mechanical removal of a surface film during the interaction of friction pairs and subsequent (electro) chemical growth of this surface film [12]. Some researchers predict a level of wear resistance by electrode potentials of structural materials in media-electrolytes. Sometimes researchers evaluate the resistance of metals to corrosion damage by corrosion current [13].

Of course, electrode potentials of surfaces of parts in the medium and emerging currents of electrochemical corrosion have a decisive influence on processes of formation of passivating films on surfaces of parts and intensity of wear [14]. There are no general guidelines for protection of parts from being worn out for any medium. It is possible to estimate the resistance of materials to corrosion and mechanical wear only taking into account electrochemical characteristics of materials in a specific medium by a special method [15].

Therefore, a return to the problem of increasing durability of parts of diffusion apparatus on the basis of modern understanding of processes of corrosion and mechanical wear is a promising task.

3. The aim and objectives of the study

The objective of the study is to increase durability of parts of diffusion apparatus for sugar factories taking into account electrochemical properties of materials and technological medium.

The following tasks were solved to achieve the objective:

– determination of the influence of diffusion juice, its temperature, concentration of sucrose in it, electrochemical properties of surfaces of parts of diffusion apparatus on processes of friction and wear;

– determination of the corrosion resistance and tribotechnical characteristics of coatings under study in diffusion juice;

– selection of advanced plasma coatings that will provide high resistance to the wear of operation of parts of diffusion apparatus.

4. Materials and methods of the study

4. 1. Explored materials and equipment used in the experiment

Based on the worked out literary sources [4, 7–10], we selected and tested plasma coatings made of powder alloys for the purpose of increasing durability of parts of diffusion apparatus. PN85U15, PN55T45, PR-N70KhI7S4R4 powders of alloys are produced by PJSC «Tulachermet» (Russia). Table 1 shows the composition and properties of alloys.

We investigated the corrosion resistance of the selected coatings in aqueous solution of 150 g/l of sucrose, 20 g/l of Na_2HPO_4, 5 g/l of citric acid [1, 5]. The solution simulated diffusion juice made of sugar beet. We controlled the acidity of the solution with a universal EB-74 ionometer. The buffer capacity of the solution allowed to maintain pH of the medium within ±0.2 pH during the experiment.

We determined the corrosion resistance of coatings under investigation by registration of polarization potential-dynamic curves in static and when stirring in an electrochemical jar using potentiostat of the type P-5827M [15].

Table 1

Composition and properties of powder alloys

No.	Coating	Massive fractions of components, %	Fraction, μm	Hardness of a coating, HRC
1	PN85U15	85 Ni, 15 Al, 0.07 C, 0.2 Fe	40–100	30–40
2	PN55T45	55 Ni, 45 Ti, 0.07 C, 0.2 Fe	40–100	55–60
3	PR-N70KhI7S4R4	70 Ni, 17 Cr, 4,1 Si, 3.6 B, 1.0 C, >5.0 Fe	63–100	55–59

We used SMTs-2 friction machines, as well as special plants, to determine the wear resistance of materials under friction in diffusion juice of sugar production. We carried out electrochemical investigations at the plant (Fig. 1), which gives possibility to measure potentials of friction surfaces and corrosion currents.

We carried out tests for wear in technological media on the end friction device (Fig. 2). We cleaned the surface of the coating to remove passivating films with 24A25NSM16K5B abrasive disc.

The study of wear resistance of selected coatings went also in friction pairs with SCh-15 cast iron and BrOTsS-5-5-5 bronze, which are used in sliding bearings diffusion apparatus. The friction occurred according to the chart of end friction at sliding rates of 0.15; 0.35; 0.74 m/s and pressure on a friction contact of 1, 2 and 3 N/m^2 (Fig. 3).

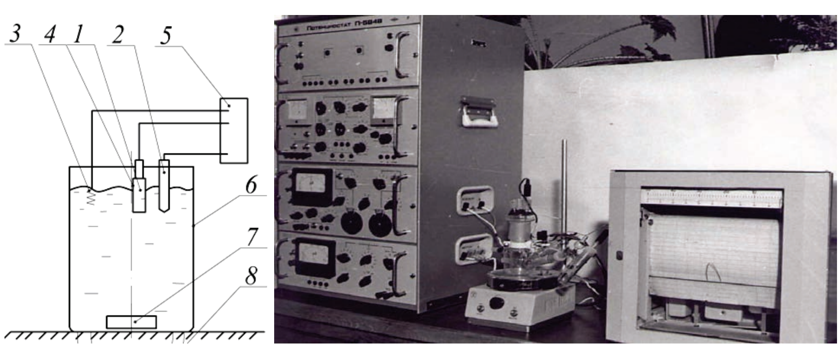

Fig. 1. A chart and general view of the device for measurement of electrode potentials and obtaining polarization curves in technological media: 1 — a sample with a coating; 2 — a comparison electrode; 3 — an auxiliary electrode; 4 — a layer of insulating varnish; 5 — P5827M potentiostat; 6 — a glass jar for medium; 7, 8 — a magnetic stirrer

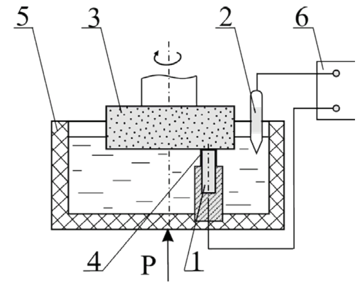

Fig. 2. A chart of the end friction plant: 1 — a sample; 2 — a comparison electrode; 3 — a counterpart; 4 — a layer of protective lacquer; 5 — a plastic case; 6 — a potentiostat

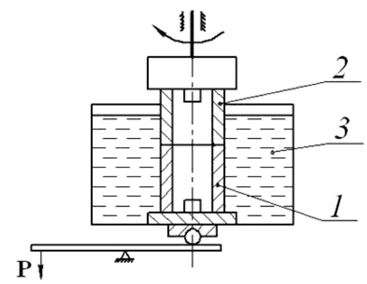

Fig. 3. A diagram of tests on friction and wear: 1 — a sample; 2 — a counterpart; 3 — technological medium

The developed and applied experimental plants made possible to conduct research in various media.

4. 2. Methods of the study on electrochemical properties of protective coatings

We used the galvanostatic method based on the recording of polarization curves in the electrochemical jar for the study of electrochemical processes [5, 6, 15]. We carried out potentiostatic studies at the plant. Fig. 1 presents its chart and general view.

We performed electrochemical measurements in a three-electrode scheme, which includes a test sample 1, a lateral surface of which is insulated with a protective lacquer, a comparison electrode 2, and an auxiliary platinum electrode 3 [15]. We took a standard EVL-IMI chlorine silver electrode as a comparison electrode. We sent a constant polarization current through the sample and fixed the potential as its function. We carried out the studies under room temperature for 720–1,140 hours.

A value of the electrode potential characterized the state of surface metal layers in the technological medium. We observed a potential jump between metal and solution at the formation of a double electric layer and films on the surface of the metal [9, 15].

A voltmeter of the potentiostat measured the standard potential of the metal sample after checking the efficiency of the electrical circuit of the device. Subsequently, we were supplying a current to the test sample until hydrogen bubbles appeared on it and recorded the potential of a hydrogen release on the surface.

We turned on the recording device and registered the polarization curve of the electrode.

We obtained an anodic polarization curve by biasing the potential to the positive region from the stationary potential of the investigated electrode (sample), and a cathode polarization curve by biasing the potential to the negative region. The shape of the curves and the nature of the dependence on different parameters give information on the nature of the electrode process.

We disconnected and washed the sample after registration of the curve. We got potential dynamical polarization curves at the same rate of the potential expansion – 0.5 MV/s. We constructed dependences of the polarization current density on **j** electrode potential in semi-logarithmic coordinates.

The presence on a surface of a cathode depolarizer – oxygen, determines the corrosion rate in technological media. Stirring of the solution, which always accompanies friction, also greatly facilitates access of oxygen and eliminates the inhibition of stages of the corrosion process associated with the diffusion of the depolarizer. Therefore, we carried out tests in a calm medium and under conditions of its intense stirring.

We determined dependences between φ electrode's potential and I polarizing current density during the study of kinetics of electrochemical reactions. That is, we constructed polarization and i–φ curves. Extrapolation of rectilinear (Tafelian) sections of polarization curves makes possible to obtain a comparative estimation of the corrosion rate of the investigated materials [15].

4. 3. Methods of determination of the wear resistance of protective coatings

We carried out tests of materials for wear resistance according to the chart of end friction (Fig. 2, 3). We investigated the process of friction in a wide range of rates and specific loads on a contact of bodies.

We performed the wearing of the metal with abrasive disc 24A25NSM16K5B (Fig. 2) in the solution of the electrolyte for realization of the method of stripping of metal surfaces under the solution [15] and comparison of friction and stripping potentials. This made possible to obtain information on the electrochemical behavior of metal or protective coating and to determine their wear resistance under corrosion-abrasive wear. We carried out tests for wear on a serial SMTs-2 friction machine and an end friction plant (Fig. 3).

We carried out the wear of a fixed metallic sample 1 with a protective coating with a use of abrasive wheel (or metallic counterfilter) 3 (Fig. 2). P force pressed the sample fixed in plastic case to the abrasive wheel. We measured the moment of friction with a dynamometer (it is absent in the figure).

We poured the technological medium into a jar 5 of organic glass. We carried out measurement of the electrode potential at the wearing of the end surface of the sample relative to the chloride silver comparison electrode with potentiostat 6. Experiments went at a sliding rate of 0.8 m/s and a specific load of 0.3 MPa.

Preparation of working surfaces of samples, which were reinforced with protective coatings, before the experiment consisted of running-in of the end surface to a homogeneous state, which was determined visually and from the stabilization of the friction moment.

We determined the value of wear of a coating by the weight method and the method of linear measurements.

5. Results of studies of properties of investigated coatings

Investigation on kinetics of electrode potentials of the selected coatings made possible to establish that values of the electrode potential stabilize after 15...40 minutes when stirring a model solution of diffusion juice and after 60...240 minutes without stirring.

We observed the most positive potential in the coating 2 (–390 mV). In coatings 3 and 1, it was more negative (–460 and –490 mV, respectively) (Table 2). The indicated difference in the values of φ_{st} stationary electrode potential existed due to the difference in the chemical composition of the coatings studied. Conditions for application of protective coatings may also be affected.

Table 2

Values of electrochemical characteristics and rates of corrosion of investigated coatings

Coating number	Coating	Stationary electrode potential, φ, V	Density of corrosion current, $_c$, A/m^2	Corrosion rate, V_c, g/m^2·h
1	PN85UI5	–0.49	0.0275	0.0278
2	PN55T45	–0.39	0.0199	0.0208
3	PR-N70KhI7S4R4	–0.46	0.0513	0.0535

We carried out registration of polarization anode and cathode curves in potential-dynamic mode. Analysis of the curves obtained (Fig. 4, curves 1–3) showed that the nature of the corrosion behavior of the coatings 1 and 3 was approximately the same, while there was a pronounced passive region in the coating 2. Comparison of corrosion currents (Table 2), which were determined by extrapolation of Tafelian sections of polarization curves, showed that the coating 2 had a minimum current density and, accordingly, its corrosion resistance was higher.

In accordance with the mechanism of diffusion kinetics of electrochemical processes occurring with oxygen depolarization, a rate of corrosion is proportional to a concentration of dissolved oxygen in a corrosive medium. Stirring of the solution contributes to increase in the concentration of oxygen in a near-electrode layer, which leads to an increase in a rate of corrosion. The same explains a faster establishment of φ_{st} at increase in a stirring rate. We can observe linear dependence of the corrosion rate on the stirring rate at the range of stirring rates from 0.5 to 1 m/s. That is, when there is a rather high concentration of oxygen on a surface of a sample, then it begins to passivate (see Fig. 4, curve 2). However, even at the intense stirring sparingly soluble compounds screen corrosion nuclei, which are localized in pores of a coating, resulting in a reduction in the rate of corrosion over time.

Electrochemical studies established (Table 2) that the smallest corrosion rate was inherent in PN55T45 coating, which can be used as corrosion resistant in acid solutions of sucrose, for example, to strengthen screws of diffusion apparatus.

It is known that the intensity of corrosion of metals depends on temperature of a medium essentially [1, 5]. The operating temperature of diffusion juice of sugar beet production varies from 30 to 80 °C. An increase in the temperature of friction surfaces leads to a reduction in energy costs for processes of deterioration and destruction [5, 8].

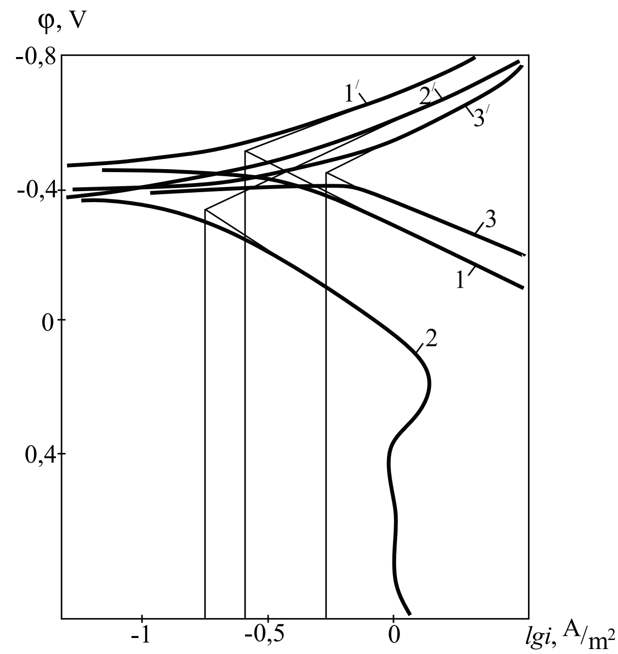

Fig. 4. Potential-dynamic polarization curves of coatings 1, 2, 3 (coating numbers correspond to Table 1)

As the temperature of the acidic medium increased, the electrode potential of the surface of the samples was displaced in the negative side and increased corrosion currents. This indicated an increase in the corrosion rate. Characteristically, at 40 °C, an anode polarization curve 2 did not have a passive region (Fig. 4, curve 2).

As diffusion juice is a multi-component corrosion-active agent, the study of the influence of sucrose concentration on the corrosion resistance of metal is a matter of considerable interest. Sucrose, which is the main component of diffusion juice, can affect its electrochemical characteristics significantly. In particular, sucrose affects pH of juice, electrical conductivity and solubility of oxygen in it.

Taking into account the increased corrosion resistance of coatings studied and the small difference between electrochemical parameters under the influence of the concentration of dissolved sucrose, we took St5 carbon construction structural steel as the research object.

The results of the studies presented in Fig. 5 show that we can observe a significant influence on the course of a potentiometric curve at concentrations of sucrose more than 10 percent only. At the same time, the value of the electrode potential is stabilized. An increase in the concentration of sucrose caused passivation of the steel, even when potentials were displaced to the region of negative values.

Comparison of values of the corrosion rate of St5 steel in the model solution of diffusion juice at various concentrations of sucrose showed that there was a decrease in the corrosion rate due, obviously, to a decrease in the oxygen content in the solution, while oxygen is the main depolarizer of the cathode process (Table 3).

During experiments on the influence of sucrose concentration on the electrical conductivity of the solution, we established that the specific electrical conductivity of the solution decreases with an increase in concentration. We observed the maximum electrical conductivity in a solution of refined sugar with a concentration of about 20 percent. The maximum electrical conductivity for solutions containing sucrose may vary in a wide range of solution densities and depends on the presence of organic admixtures.

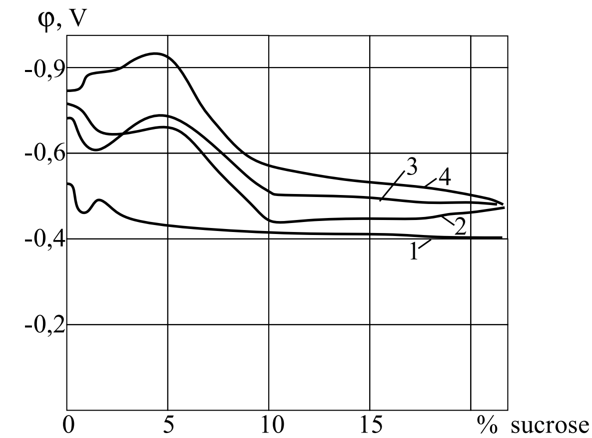

Fig. 5. Influence of concentration of sucrose on φ electrode potential of St5 steel at exposure in solutions:
1 — after immersion; 2 — after 1 day of exposure;
3 — after 2 days of exposure; 4 — after 4 days of exposure

Table 3

The value of the corrosion rate V_c of ST5 steel after 96 h of exposure in the model solution of diffusion juice

Sample number	V_c, g/m^2·h at sucrose concentration, %				
	0	5	10	15	20
1	0.044	0.041	0.037	0.027	0.026
2	0.047	0.039	0.036	0.022	0.024
3	0.042	0.039	0.038	0.025	0.021

In addition, sucrose increases load carrying capacity of a friction pair due to its high lubricating properties significantly [5]. Therefore, the presence of sucrose in a liquid medium reduces the wear rate and the coefficient of friction of materials and increases the resistance of the coupling of friction pairs. Results of determination of the corrosion rate at friction confirmed the conclusion: the proportion of a corrosion factor, which is determined by the density of corrosion current, decreases in general wear of investigated coatings.

We established that after 96 hours of exposure in the model solution of diffusion juice, a layer of corrosion products of gray-green color, which had a rather strong shielding effect and prevented further development of corrosion processes, covered the surface of the samples. The film on the surface is dissolved with hydrochloric acid and is probably phosphoric acid. The screening properties of the formed film indicated that when the film was removed periodically from the surface of the samples, the corrosion rate increased and approached the rate of dissolution of the metal in the active state.

At friction of metals in an electrolyte, the coefficients of friction and wear depend on the presence (or absence) of adsorption or oxide films, the formation of which is determined by the value of the electrode potential. However, the electrode potential, being an integral characteristic, reflects not only a change in the relative area of such films, but also qualitative changes in electrochemical processes that determine the nature of contact phenomena arising from the interaction of two bodies.

The study on wear resistance of the selected coatings in the friction pair with SCh15 cast9 iron (GOST 1412-85) showed (Fig. 6) that, an increase in pressure on the contact leads to reduce in the intensity of wear of a coating. The exception is the coating 1. For the coating 1, when the load increased from 1 to 2 Pa, the intensity of wear increased slightly (Fig. 6, *a*, curve 1).

This happens due to an increase in the role of a mechanical factor in the process of friction and delayed manifestations of the hydrodynamic effect.

We established that with an increase in sliding rate from 0.15 to 0.35 m/s, the intensity of deterioration of all investigated coatings reduces. This occurs due to the reduction in duration of the interaction of individual areas of a surface contact. The time of the interaction of the corrosive medium with juvenile sections of surfaces also diminish. We observed partial hydrodynamic effect. With the increase of sliding rate to 0.74 m/s the term of interaction between juvenile sections decreases, which leads to further decrease in the intensity of wear. It is characteristic that at the maximum sliding rate, the intensity of wear of all investigated coatings remains approximately the same (Fig. 6, *b*, curves 1–3). Obviously, the corrosion resistance, which exists due to different chemical composition, determines differences in the wear resistance.

For all studied coatings at the sliding rate of 0.15 m/s, the friction coefficient at the range of the considered loads remained practically constant, which indicated plastic deformation of unevenness in contact areas. The process of friction of samples at V_{sl}=0.35 and 0.74 m/s occurred under plastic deformation. Deformation of friction surfaces promoted an increase of the area of actual contact and the development of adhesion processes. As the load increases, the coefficient of friction increased.

We also tested shafts with coatings in pairs with bushes made of BrOTsC-5-5-5 bronze (Fig. 7) for wear resistance in a model solution of diffusion juice. With the increase of the load on a friction contact, the wear intensity of the coating 1 increased, while the wear intensity of the coatings 2 and 3 almost did not change.

With the increase in the sliding rate from 0.74 to 1.0 m/s, the intensity of wear of coatings 1 and 2 increased. At small loads and sliding rates, the most wear resistance had the coating 1. But at the increase in load and rate, wear also increased dramatically. Its wear exceeded the wear of the coating 3 at maximum loads and rates.

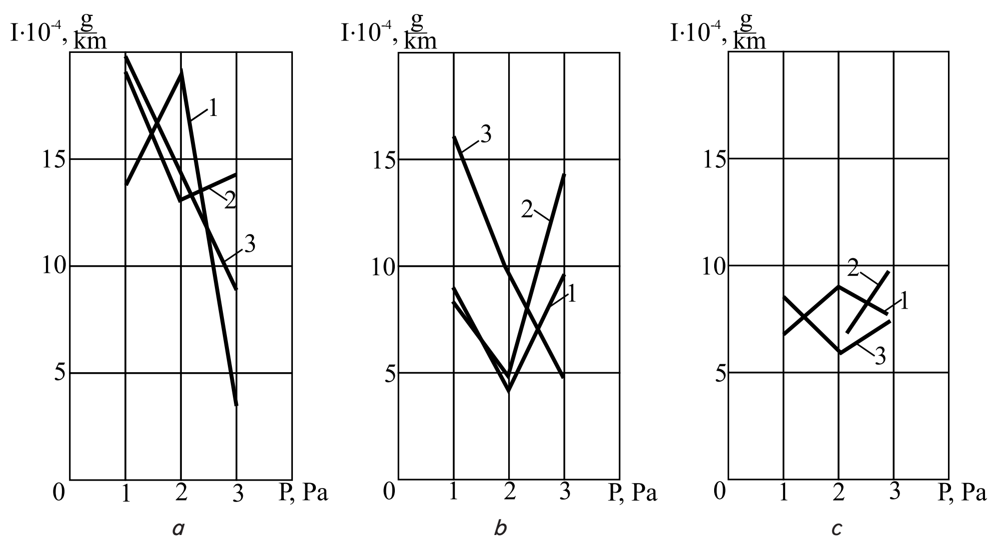

Fig. 6. Dependence of the intensity of wear of protective coatings in the model solution of diffusion juice on the load on a contact in a friction pair with SCh-15 cast iron at friction and sliding speed: *a* – 0.15 m/s; *b* – 0.35 m/s; *c* – 0.74 m/s (numbers of coating correspond to Table 1)

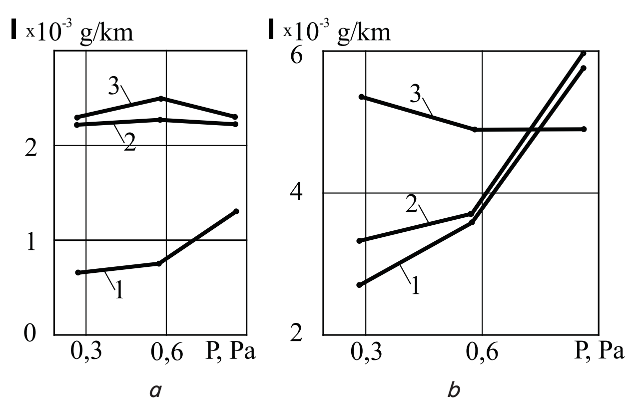

Fig. 7. Dependence of the wear intensity of protective coatings in the model solution of diffusion juice on the load on a contact in the friction pair with BrOTsS-5-5-5 bronze at the sliding rate: *a* – 0.74; *b* – 1.0 m/s

6. Discussion of results of the study of corrosion and mechanical wear of materials

We established the main factors, which influence the stability of materials and coatings. We can use the study findings as a basis for the development of forecasting methods and for ensuring the durability of parts of diffusion apparatus operating in aggressive technological media of sugar beet production.

Studies (Table 2 and Fig. 4) showed that all the coatings covered in the model solution of diffusion juice of sugar beet production have rather high corrosion resistance. The low density of polarization currents near stationary potentials at the range of ±0.4 V evidences this.

There are differences in the electrochemical behavior of coatings. The smallest corrosion current density at anode polarization was in the protective coating 2 (Table 2), and the largest in the coating 3. Composition of metals and protective coatings and the rate of flow on friction surfaces of electrochemical processes affecting formation and destruction of protective films determine the intensity of the corrosion and mechanical wear.

Physical and chemical properties of secondary structures determine the destruction of surfaces of metals and coatings at friction in liquid corrosive-active media largely. Secondary structures form and screen surfaces of friction and protect against damage, they also perform a function of lubrication. When sliding along the oxide of destruction, as a rule, it is localized inside it and the more a film inhibits the anode process, the higher its lubrication. We should note that along with the importance of mechanical properties of oxide films, the role of the rate of their formation and removal during the corrosion and mechanical wear is equally important.

Sucrose also reduces coefficients of friction of the materials studied. We should note that sucrose is a weak monosaccharide with an electrolytic dissociation constant at 25 °C of $3 \cdot 10^{-13}$. Therefore, we can assume that one of the reasons for slowing down the intensity of wear of materials in a solution of sucrose is deceleration of electrochemical processes, which, under friction and wear, plays a decisive role. Good lubricating properties are characteristic for solutions of sucrose, which makes possible to load a friction pair additionally.

Thus, the following set of factors influences the intensity of corrosion and mechanical wear of surfaces of parts in solutions of diffusion juice: specific electrical conductivity of a solution, presence of dissolved oxygen and concentration of sucrose.

Diffusion juice and sucrose are the main substances of beet and sugar production. Therefore, certain promising coatings for protection of parts from corrosion and mechanical wear will enable to increase durability of a large range of equipment for sugar factories. Such equipment includes, in particular, diffusion apparatus, pumps, evaporators, beet-cutting machines, etc.

The performed study is a continuation of earlier studies [9, 15], which concerned the influence of technological media of food industries on processes of corrosion and mechanical wear of equipment.

We will continue the study in the direction of application of industrial coatings for protection against corrosion and mechanical wear of equipment of sugar factories.

The benefits of the study are consideration of the interaction of technological medium and protective coatings and recreation of real conditions of a friction process during the experiment. This made possible to choose the right coatings for screws and sliding bearings, which wear out with great intensity and determine the level of durability of diffusion apparatus.

Manufacturers use a large number of acidic process media in the food industry. We can apply obtained pH results to them.

At the same time, the industry produces a wide range of powders, for example, known non-nickel powders, which are also used to protect parts from corrosion and mechanical wear, with increase in the durability of these parts. It is advisable to expand the scope of the study to evaluate corrosion and mechanical resistance of mentioned materials.

7. Conclusions

1. We established that the value and sign of the electrode potential of the surfaces and temperature of the electrolyte determine possibility of passivation of surfaces of friction and the intensity of corrosion and mechanical action. With the increase in temperature of diffusion juice, the ability of surfaces of friction materials and coatings to passivation reduces. An increase in the concentration of sucrose in diffusion juice leads to the passivation of surfaces of friction of parts, it increases the load capacity of sliding bearings and reduces the intensity of corrosion and mechanical wear.

2. We defined tribotechnical characteristics and estimated corrosion resistance of protective plasma coatings for parts of diffusion apparatus. We proved that electrochemical processes in the friction zone determine wear resistance of metals and coatings largely. We showed that all tested coatings can be used to work in pairs with cast iron screws SCh15 (GOST 1412-85) and BrOSTs-5-5-5 bronze (GOST 613-79). PN55T45 coating has the highest corrosion resistance according to the values of electrochemical characteristics and corrosion rates under conditions of corrosion and mechanical wear. The highest wear resistance at low loads and sliding rates shows PN85U15 coating.

3. We can recommend all tested coatings for a work in acidic process media of diffusion apparatus. In particular, PN55T45 coating can be used to protect cases and screws, and PN85U15 coating - to strengthen sliding bearings of diffusion apparatus.

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