DOI: 10.31319/2519-8106.2(41)2019.185070
UDC 621.785.5: 621.793.6
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MODELING OBTAINING OF DIFFUSION LAYERS BY USING A COMPOSITE POWDER MATERIALS

The process of modeling the production of alitized, titanium, siliconized, nickeled coatings is an effective method to increase the reliability and durability of machine parts, tools, and tooling due to the creation of protective layers on the surface of the machined parts that have a unique set of physicochemical properties.

One of the most efficient methods of the development covering, possessing high mechanical, physic and chemical characteristics is surface metal diffusion saturation using a composite powder materials.

The alloys based on copper served the source data for study. The diffusion method of the surface saturation from hard phase in active gas ambience on the basis of analysis of the requirements, presented to copper covering and the way of the metal saturation for defensive covering obtaining has been chosen. This method provides for high surface quality and it is the simplest and most suitable one in laboratory practice being well reproduced in production condition and it does not demand for special complex equipment whileь it's realizing.

***Keywords**: composite saturating environment; thermodynamics; modeling; coatings.*

Процес моделювання отримання алюмінієвих, титанових, силіційованих, нікельованих покриттів є ефективним методом підвищення надійності та довговічності машинних деталей, інструментів за рахунок створення захисних шарів на поверхні оброблюваних деталей, які мають унікальний набір фізико-хімічних властивостей.

Одним з найбільш ефективних методів розробки захисних шарів, що володіють високими механічними, фізичними та хімічними характеристиками, є дифузійне насичення поверхні шарів із застосуванням композиційних порошкових матеріалів.

Сплави на основі міді слугували вихідними даними для вивчення. Метод дифузійного насичення поверхні із твердої фази в активному газовому середовищі на основі аналізу вимог, що пред'являються до дифузійного шару, та обрано спосіб насичення металу. Цей метод забезпечує високу якість поверхні, він є найпростішим і найбільш використовуваним у лабораторній практиці, добре відтворюється у виробничих умовах, і не потребує спеціального складного обладнання, реалізуючи його.

***Ключові слова**: композиційні насичуючі середовища; термодинаміка; моделювання; покриття.*

Introduction

The choice of node construction material details development of friction while trying to get high performance characteristics is one of the base problems in machine building. The main aim is a selecting known and creating new materials, possessing optimum characteristics, providing necessary resources for a given node development of friction. Alongside with getting necessary working characteristics it is required to take into account the economic considerations minding market conditions.

In this connection it's important that for node material development of friction to be obtained from available undeficit components using technology, requiring standard equipment, high vacuum, cryogenic temperatures and expensive technologies.

While selecting node material development of friction it must be taken account their compatibility, especially it's property of dripping and the following edge fin those are connected with chemical affinity, proximity to constitution and value of parameter of crystal lattices. In more general form compatibility is understood as the ability of materials to provide the optimum parameters of the node of friction at continuous exploitation, quickly adaptation to abrupt changes of the load, velocity and temperature under adverse conditions of lubricant.

Analysis of recent research and publications

In the article Kukhareva N.G., Galynska N.A., Petrovich S.N. [1], when considering the process of forming diffusion layers, usually attempt to trace this process using alloy state diagrams. At the same time, they proceed from the position that has become almost the rule that the formation of a layer on the diffusion isotherm follows an increase in the concentration of the diffusing element in the alloy system and obeys the laws of phase transformations. In this case, first the phases of the lower composition must occur, then the middle and finally the higher (pure or atomic diffusion theory) [1]. According to another theory (reaction diffusion theory), the formation of a diffusion layer can begin with the formation of a phase of higher or medium composition, past the stage of formation of a phase of the lower composition, if the thermodynamic conditions for the formation of these phases are more favorable than for the phases of the lower composition [1].

The large theoretical and experimental material available [2—8], which is based on the application of precision methods for the study of the phase and chemical compositions of the diffusion layer, convinces us that in many cases the practice of chemical-thermal treatment of the formation of the diffusion layer does not obey equilibrium conditions, intermittent and may begin with the formation of the phase of higher or middle composition. In this case, the structure of the diffusion layer is not equilibrium. Among the various factors affecting the mechanism of formation of a diffusion layer with non-equilibrium structure, the main ones are the initial conditions preceding the process of diffusion of elements into metal, which directly or indirectly depend on a number of physicochemical and kinetic saturation factors, especially significant when it comes to a multicomponent system the saturation presented in this study.

With the emergence of the theory of nonequilibrium systems, it became possible to influence the structure and properties of diffusion layers by changing the dynamics of the saturation process itself. By changing the composition of the saturating medium and the ratio of its components, it is possible to influence the system and thereby change the kinetics of the diffusion processes.

Presenting main material

In diffusion saturation, it is important to transfer the components to the surface through the saturated gas phase. Obtaining protective coatings is carried out under non-stationary temperature conditions, so chemical transport reactions are important.

Mechanical compression tests show that the role of the diffusion layer is not only limited by the surface protection functions of the specimens, but also has a significant effect on its bulk properties. Diffusion saturation of titanium and aluminum alloys increases the compressive strength by 52%.

The high propagation velocities of the combustion wave, together with the high temperature, determine the short synthesis times and high process performance. Typical linear combustion velocities are 0.5–5 cm/sec., and in some cases they can reach large values (up to 20 cm/sec.). Often, the synthesis reaction does not have time to complete in the wave itself, and a volumetric reaction and formation of the final structure of products behind the combustion front take place. But also such process proceeds quickly enough because of high combustion temperatures.

Copper alloys protection with their chemist-thermal processing appears to be not only perspective, but sometimes and the only possible way of the obtaining product having necessary complex working characteristics, with enlarged mechanical toughness, corrosion to stability, resistances to detritions and oxidation under high temperature while keeping main copper alloy quality that is high electrical and thermal conductivity. Saturation to surfaces alloys simultaneously with several elements has main the advantage it allows to obtain, as a rule, more essential improvement of characteristic surface layer [9].

On analysis reaction observation, taking place while chemical-thermal processing in mode of the heat spontaneous combustion of powdered mixture, as well as the results of experiments and metallographic examination, there has been got the scheme of the formation hardened layers on copper alloys. It is possible to divide this process into several stages conditionally. First, the reactionary mixture is warmed in a stove up to the temperature of ignition that is it passes so called stage of the inert heating. Then occurs the interaction between powder oxides chromium, aluminum, as well as molybdenum, aluminum and silicon, occurs at the same time temperature in a reactor increases up to a maximum value. It is a stage of the heat spontaneous combustion.

On the third stage ─ the stage of heating product if occurs leveling the temperature over the volume of the reactor. At this chase active atoms of silicon, molybdenum and the other elements begin diffuse into a substrate. On the following stage, the stage of isothermal endurances ─ further diffusion a growing of the covering occurs.

As a result of diffusion surface saturation in condition of self-propagation high-temperature synthesis alumina-silicon, titanium-silicon and alumina-molybdenum-silicon covering on copper alloy were obtained. Herewith, the maximum thickness covering was 10—65 мм. The measurement of the geometric sizes of samples were conducted before and after the chemicalthermal processing.

The differences in quality of surfaces, as structure, phase, composition, micro hardness and contents doping elements in diffusion layer on alloys are defined by the temperature of the process, the time of the endurance and the composite saturating environment. The mode of the heat spontaneous combustion, characterized by small duration, is recommended to use instead of traditional ways of chemical-thermal processing alloys (nitration, chrome plating and others.).

Structure x-rays analysis has shown that except б-hard solution aluminum and nickel in alloy on base copper in diffusion layer there are following phases Cu_9Al_4, NiAl, Ni_3Al. Stabildross of samples saturated with aluminum, silicon and nickel simultaneously, in many times exceeds the resistance to oxidation of the uncovered alloy. So, when testing during 12 ch weight up of diffusion-saturated samples is 6 times less. Microstructure of a diffusion layer after testing keeps column extended grain б-phases and a number of mechanical mixture phases, but the general depth of a layer is somewhat bigger. Presence refractory chemical compounds in diffusion layer such as NiAl, must promote increasing hot-resistance sample [10].

The influence of diffusion saturation aluminum, silicon and nickel on wear capability copper alloy was defined on a universal machine MI-1M in condition of dry friction and the swing under load 25 kg [11]. The following conditions of friction were accepted, meeting the usage terms of the nodes: V = 1,5 m/s, P = 0,8 MPa. The behavior of diffusion-saturated sample in condition of the wear-out test has shown perspectives of dopins surface as a method of increasing alloy wear capability. It gave possibility for normal working conditions of mechanism optimum thickness of the defensive covering on details, being subjected to wearing out is 0,02—0,09 mm. Using of mechanical tests on compression it is proved that the role of diffusion layer is not limited only a function of surfaces sample protection, but it influences essentially threedimensional characteristics. Diffusion saturation of alloy aluminum and nickel raises the limit to toughness at compression of 52 %.

Consequently, diffusion saturation alloy aluminum and nickel raises such characteristics of bronze and brasses, as stabildross, wear-out resistance and mechanical toughness, and can beused in the industry aiming increase of reliability and longevity of a copper product.

Research of reliability of mechanisms is proved in most cases quick wear-out of the details, made from bronze C62300 (the bushings, anything numbered six), occurs because of roughness of the associate detail. Most wear-out of the bronze details occurs at period of the wear-in, during which value break-in wear-out can form 60─70 % general tolerance for wear-out.

Research of the influence of the nickel covering on a wear-out sample (V = 2,5 m/s, P = 1,0 MPa) were made on installation for test material on detritions. As rear body was used the bar from fast-cut steel R6M5, hardened to hardness HRC 62—65. To two parties samples of 10 pieces each were subsected to the test: the first party was without covering, the second was with nickel and silicon covering by thickness 10—65 мм. It was accepted that for criterion of the wear-out the ability process surfaces to exercised sample to resist to detrition, which was valued with a gap of time from the beginning of test before appearance of hits on diagram tape grapher, caused by process of grasp a material sample and rear body.

Conclusions

As a result of physico-chemical modeling, it is established that the process of obtaining protective coatings is possible only if the solubility of the diffusing element in the metal and a sufficiently high temperature that provides the necessary energy to the atoms. The possibility of chemical transport in the combustion wave is based on the fact that in the combustion process there is a consistent change of temperature modes and the temperature at each point of the mixture runs a series of continuous values from T_0 to Tg. Thus, a non-stationary temperature process combined with chemical transport reactions can be used to obtain coatings.

Using nickel saturation of allows in 1,4—1,8 times raises wear capability a sample in consequence of reduction of the factor of friction. Herewith improve the steady-state factors to resistivity of the surfaces sample to detritions. The Analysis shows that using on sample of the nickel covering promotes increasing to reliability of the product as a whole. Thereby, executed studies point to perspective using silicon saturation and nickel saturation as a efficient tribotechnical covering. Herewith in process of the mechanical processing the details of the nodes of friction it is necessary to provide allow to come near for thickness of the inflicted covering.

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МОДЕЛЮВАННЯ ОТРИМАННЯ ДИФУЗІЙНИХ ШАРІВ З ВИКОРИСТАННЯМ КОМПОЗИЦІЙНИХ ПОРОШКОВИХ МАТЕРІАЛІВ

Кругляк І.В.

Реферат

Процес моделювання виробництва алюмінієвих, титанових, силіційованих, нікельованих покриттів є ефективним методом підвищення надійності та довговічності машинних деталей, інструментів за рахунок створення захисних шарів на поверхні оброблюваних деталей, які мають унікальний набір фізико-хімічних властивостей. Одним з найбільш ефективних методів розробки захисних шарів, що володіють високими механічними, фізичними та хімічними характеристиками, є дифузійне насичення поверхні шарів із застосуванням композиційних порошкових матеріалів.

Наявний великий теоретичний і експериментальний матеріал, який ґрунтується на застосуванні прецизійних методів дослідження фазового і хімічного складів дифузійного шару, переконує нас в тому, що у багатьох випадках практики хіміко-термічної обробки утворення дифузійного шару не підкоряється рівноважним умовам, а протікає переривчасто і може розпочатися з утворення фази вищого або середнього складу. Структура дифузійного шару в цьому випадку не є рівноважною. Серед різних чинників, що впливають на механізм формування дифузійного шару з нерівномірною структурою, головними є початкові умови, передуючі процесу дифузії елементів у метал, які прямо або побічно залежать від ряду фізико-хімічних і кінетичних чинників насичення, особливо значимих, якщо йдеться про багатокомпонентну систему насичення, представлену в цьому дослідженні.

Сплави на основі міді служили вихідними даними для вивчення. На основі аналізу вимог до дифузійного шару та обраного способу насичення металу обрано метод дифузії насичення поверхні від твердої фази в активному газовому середовищі. Цей метод забезпечує високу якість поверхні, і він є найпростішим і найбільш використовуваним у лабораторній практиці, добре відтворюється у виробничих умовах, і він не вимагає спеціального складного обладнання, реалізуючи його.

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