- характера распределения плотности дислокаций (градиенты по плотности дислокаций (в 1,8…2 раза) $\Delta\rho$: от $\rho \sim (7…8)\times10^{10}$ см$^{-2}$ до $\rho \sim (3…4)\times10^{10}$ см$^{-2}$).

Аналитическими оценками свойств формирующихся поверхностей установлен конкретный вклад всех структурных параметров в изменение прочности и трещиностойкости исследуемых покрытий. Показано, что наибольший вклад в интегральное упрочнение покрытий вносят: дисперсные частицы фазовых выделений (дисперсионное упрочнение по Оровану до 60%) в матрице покрытий; формирование субструктуры (субзеренное упрочнение до 20%) при равномерном распределении плотности дислокаций (дислокационное упрочнение до 15%).

Установлено, что высокий уровень механических свойств и трещиностойкость новых покрытий обеспечиваются за счет оптимального структурно-фазового состава: мелкозернистой зеренной и субзеренной структуры при равномерном распределении упрочняющих фаз и дислокационной плотности. При этом повышению трещиностойкости покрытий способствует отсутствие протяженных структурных зон дислокационных скоплений - концентраторов локальных внутренних напряжений.

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UDK 621.793.6

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TECHNOLOGY FOR THE PRODUCTION OF CHROME DIFFUSION COATINGS IN COMPOSITE MEDIA

Introduction The operational characteristics of many products - wear resistance, corrosion resistance, reflectivity, heat resistance and others - are determined by the surface properties. To obtain high structural strength characteristics of surface layers, various coating methods are often used to protect the base material from external influences, increase the service life of parts and reduce the cost of repairing worn equipment. The chromium plating process is an effective method of increasing the reliability and durability of machine parts, tools and technological equipment due to the creation of chrome layers on the surface of the machined parts having a unique set of physicochemical properties.

In this paper, we consider the technology of the formation of functional coatings on structural materials using composite saturating media.

However, all known powder methods are energy intensive and time consuming. In this regard, the development of new composite saturating media is an urgent development of new technologies that allow you to adjust the composition and structure of coatings, provide the necessary performance characteristics with a minimum time of their formation.

The aim of this work is to obtain diffusion coatings from composite powders based on chromium and refractory metals with high saturation ability.

Research materials. Chemical-thermal treatment of carbon steels was carried out in an open type reactor in the operating temperature range of 950 – 1050 ºC with an isothermal exposure time of 30 – 60 minutes.

The thickness of the hardened layers was studied using a Neophot – 21 and Neophot – 32 light microscope with an increase of ×150 – ×500. The microstructure was detected by etching in a 3 % alcoholic solution of picric acid (TU 6-09-08-317-80). To identify the grain boundaries of ferrite, a 4% alcohol solution of nitric acid was used.

The elemental composition was studied by X-ray microanalysis using a JEOL Superprob-733 microanalyzer. To calculate the equilibrium composition of the system products, the applied software packages "ASTRA 4" and "TERRA" were used [1].

Research results and discussion. During diffusion chromium plating using ammonium chloride, a layer of carbonitrides of the composition $Fe_2(N,C)$ and Fe_4 (N,C) is also formed on the surface [2]. On medium-carbon steels, mainly, complex coatings are formed with a carbide phase, under which there is a layer of a solid solution of chromium in iron with inclusions of chromium carbides and a decarburized zone (a zone with a low concentration of chromium and carbon). On low-carbon steels, a coating is formed, which is a solution of chromium in iron, under which there is a carbon-free zone [3].

The dimensions of coatings on steels, their structure and phase composition are determined by the conditions for the formation of coatings under the influence of constantly changing factors. In this case, the decisive role is played by the ratio of the counter mass fluxes of chromium (from the outside) and carbon and iron (from the saturated matrix) to strictly specific temperature-time intervals of the diffusion chromium plating process. The characteristics of the counter mass flows of carbon and chromium in the matrix are their diffusion coefficients, and in the near-surface zone, mass transfer coefficients.

The formation of coatings on low carbon steel in composite saturating media including chromium provides the implementation of the chromium plating process, which allows to obtain chromium carbide.

Coatings obtained under non-stationary temperature conditions consist of a diffusion zone [4–5]. It has been established that on the surface of steels, when silicon is introduced into the charge $(Fe, Al)_5Si_3$, silicide is formed, under which α -is a solid solution of titanium, chromium and silicon in iron, a columnar structure.

On steels 45 and U8A, carbide $Cr_{23}C_6$ и Cr_7C_3 are observed on the surface. The tests of coatings for corrosion resistance showed an increase in this indicator by 1,5 – 1,7 times in comparison with diffusion coatings obtained in isothermal conditions.

Conclusions. The use of composite saturating media increases the chemical potential of the carbon saturating medium, which leads to the production of carbides $Cr_{23}C_6$ and Cr_7C_3.

The tests of coatings for corrosion resistance in 20% aqueous solutions of HNO_3, H_2SO_4, HCl showed an increase in this indicator by 1,5 – 1,7 times, compared with diffusion coatings obtained under isothermal conditions.

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UDK 621.793.6

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OBTAINING CHROMO-TITANIUM COATINGS UNDER CONDITIONS OF SELF-PROPAGATING HIGH-TEMPERATURE SYNTHESIS

Introduction The development of modern technology requires the creation of new structural materials with a set of properties such as high strength, corrosion resistance, wear resistance, etc. However, the use of expensive metals and alloys with such properties is not always economically feasible. Given this, one of the urgent problems is to improve the physicochemical properties of chromium-based materials. The chromo-titanium process is an effective method of increasing the reliability and durability of machine parts, tools and process equipment by creating chromium layers on the surface of machined parts that have a unique set of physicochemical properties. [1-2]

In this work the technology of chemical-thermal processing of steels in the conditions of high-temperature synthesis (SHS), combined with chemical gas transport reactions is considered. SHS is a high-intensity exothermic interaction of chemical elements in the condensed phase, capable of involuntary propagation in the form of a combustion wave.

The aim of this work was to develop compositions of powder SHS mixtures for the application of multicomponent coatings based on titanium in thermal spontaneous combustion, study of physicochemical processes of coating formation, determination of optimal technological parameters of SHS process at complex saturation, study of their influence on layer growth kinetics and evaluation quality.

Research materials. Chemical-thermal treatment of carbon steels was carried out in an open type reactor in the operating temperature range of 950 – 1050 ºC with an isothermal exposure time of 30 – 60 minutes.

The thickness of the hardened layers was studied using a Neophot – 21 and Neophot – 32 light microscope with an increase of ×150 – ×500. The microstructure was detected by etching in a 3 % alcoholic solution of picric acid (TU 6-09-08-317-80). To identify the grain boundaries of ferrite, a 4% alcohol solution of nitric acid was used.

The elemental composition was studied by X-ray microanalysis using a JEOL Superprob-733 microanalyzer. To calculate the equilibrium composition of the system products, the applied software packages “ASTRA 4” and “TERRA” were used [3].

Research results and discussion. Analysis of the reactions occurring during thermal spontaneous combustion of SHS-charges, the results of metallographic studies of the phase composition of the layers allowed to determine the scheme of formation of coatings. The process can be divided into several stages: inert heating of the reaction mixture to the ignition temperature; thermal spontaneous combustion; heating of products; isothermal exposure; cooling. Obtaining coatings under conditions of high-temperature synthesis occurs under non-stationary conditions, when neither thermal nor chemical equilibrium until the complete