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THE LATEST TECHNOLOGY DIFFUSION SATURATION OF TITANIUM SURFACES STEEL

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НОВІ ТЕХНОЛОГІЇ ДИФУЗІЙНОГО НАСИЧЕННЯ ТИТАНОМ ПОВЕРХОНЬ СТАЛЕЙ

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The article is devoted to the study of the influence of combined surface material processing, which combines self-propagating high-temperature synthesis and laser surface hardening. The authors carried out theoretical calculations of the adiabatic temperature of the synthesis reaction. In addition, the authors discovered the microstructure of steel after a combined treatment, which consists of classical carbon steel (base) and carbides of various types. A separate study revealed the properties of phases and the microhardness of the surfaced material and the possible applications of synthesized alloys.

Key words: *metallothermy, mechanical properties, micromelting, technology.*

Стаття присвячена дослідженню впливу комбінованої обробки поверхневого матеріалу, що поєднує самопоширюваний високотемпературний синтез та лазерне поверхневе гартування. Авторами проведено теоретичні розрахунки адіабатичної температури реакції синтезу. Крім того, автори виявили мікроструктуру сталі після комбінованої обробки, яка складається з класичної вуглецевої сталі та карбідів різних типів. Окреме дослідження виявило властивості фаз та мікротвердість наплавленого матеріалу та можливості застосування синтезованих сплавів.

Ключові слова*: металотермія, механічні властивості, мікроплавлення, технологія.*

The laser surface hardening (LSH) of metals was discovered in 1965. It has won strong positions in technology of metals [1]. Nowadays in the whole world hundreds of patents have been awarded to branch inventions including those dealing with combination of LSH with SHS (self-propagating high-temperature synthesis). One of them is dedicated to combining of LSH (Laser Surface Hardening) with SHS (self-propagating high-temperature synthesis) [2-6]. Formerly SHS was combined with other technologies of surface hardening of components [5, 6].

In addition, one of the materials combining strength, reliability and durability is steel. Therefore, it is used for the manufacture of critical products subject to heavy loads. High temperature, static and dynamic loads, aging of steel lead to irreversible changes in its structure. The surface layers of parts and tools are most affected, therefore, the structure and properties of surface layers have a major impact on the performance of products. The establishment and search for new integrated technologies to improve of physical and mechanical properties of alloys is an urgent task of modern materials science. The solution to this problem requires the improvement of existing and the creation of new methods of metal processing to increase their operational stability.

Integrated plasma saturation of the surface of steel with alloying elements is able to create a functionally gradient surface layer with unique mechanical, technological and special properties and make research aimed at creating such surfaces relevant. That is why recently more and more attention has been paid to methods of surface treatment of steels [1, 2, 3].

One of the main, most promising methods of coating is plasma coating in combination with laser initiation of combustion in exothermic mixtures (SHS). In this case, the surface can be saturated with boron, chromium, silicon, and also saturate immediately with two components: titanium, boron chromium and simultaneously several elements chromium and silicon, boron and titanium [2, 3, 6].

Combined processing causes changes in the structure and stress state of steels. The basis of the processes is the study of the kinetics of the transformations occurring in the metal and the factors affecting this kinetics. Knowledge of the laws of diffusion processes of chemical-thermal treatment will significantly increase the efficiency of the search for new materials and optimal methods for their processing. The main efforts of researchers studying the processes of combined processing are focused on establishing the mechanisms and laws of diffusion penetration of various elements into the metal base or on studying the nature of growth and properties of the formed diffusion zones.

The aim of the present work is to study the effect of titanium diffusion on increasing the operational stability of machine parts and tools by changing the phase composition, physical and mechanical properties of diffusion layers when alloying a steel surface as a result of using a complex technological process combining LHS and SHS. Qualitative and quantitative characteristics of the process of surface saturation with titanium are the thickness of the diffusion layer, the distribution of the concentration of the diffusing element over the thickness of the layer, the phase composition and properties of the layer (hardness, wear resistance, corrosion resistance). The structure of layers saturated with titanium substantially depends on the composition of the mixture, on the method of saturation, on the temperature and duration of the process, on the composition of steel. All these factors affect the final result and determine the physical and mechanical properties of the surface layer after saturation.

The impotent problem within the LSH is the decreasing of the losses of beam energy because of its reflection by the surface of metal under machining. In the given investigation, as well as in the invention [1, 2], the mixture of powders Ti (65%), carbon in black state (18%) and Fe (14% by mass) were used in the role of light-absorbing paint. The mixture was damped by solution of 2 % latex in gasoline, and then it was put on the surface of stalls of mark 10 and 20 and was dried in an open air, forming the layer 80, 200 or 500 mkm thick. Thermochemical calculations showed that in such a mixture practically all Ti interacts, thanks to non-oxygen combustion, with carbon, forming the carbide TiC. The seer plus of carbon and very small account of Ti alloy the iron forming liquid steel of condition, which under fast cooling turns into troostite in layers of 80 mkm thick. This reaction is highly exothermic and is accompanied by significant temperatures.

The adiabatic temperature of non-oxygen combustion of equiatomic mixture Ti-C equals to 3200 K. The real temperature of combustion of selected mixture 68% (% in mass particles) is more than 1850 K that provides the formation of hard-liquid dross (TiC-melding) with the large interval liquids solid us. The formation of dross instead of one-phase alloy influences positively on the quality of surface of hardened layer after its full growing hard and cooling as well as on supporting of this layer even on inclined planes.

It is important to note that in the mentioned non oxygen combustion none of nonmetallic phase and its including is formed. Welding of hardened layer with basic metal is obtained automatically „metallurgic ally", excluding the necessity of soldering or other methods of connecting one alloy (e.g. instrumental) with other (e.g. with the basis of cutting tool).

In typical microstructure of metal in cross-cut of harded layer got under density og power 17 $W \cdot m^{-2}$, diameter of „spot" − 0,4 mm, the speed of scanning 12 min/s and expense of argon (for the defense of Ti from air oxidation) − 0,5 l/s is shown. The thickness of alloy is ~500 mkm. This layer consists of ~50% particles TiC and ~50%(by volume) of metal link-instrumental carbon steel of type "У8" (fig. 1). The investigations made have proved that the microhardness of carbides TiC is higher than the hardness of steel almost 10 times. Thus, in the given work we managed to organize the SHS process in comparatively thin layer thanks to using of LSH technology simultaneously for solving of two tasks: for heating, flashing and carbonating of an iron; for flashing Ti particles and its „combustion" in carbon with forming of carbides TiC. The TiC carbides during their synthesis "burnt" steel with high local heat release and deeply rooted in the bond. Wi shown also evident that in the zone of intense thermal influence the microstructure of steel acquired a very shallow columnar structure with a slight inclination of thin dendrites.

The microstructure demonstrated range changed of microhardness by depth of structural components of the surface layer (Fe-C-Ti system) within 1220-1570 HV. The substitution of a part of iron powder by the powder of carbon ferrochrome (e.g. 12%Fe+2%FeCr instead of 14%Fe in the formulae of SHS mixture) allows to get layers of carbidosteel with the link not in the shape of steel “У8” but from alloyed steel “X12” which after fast cooling of these layers thanks to accelerated drain of heat to cold metal of the basis gets austenite-martensite-carbide structure.In the process of work of the instrument such metal link additionally grows hard thanks to pre-transforming of austenite into martensite and getting older of the later one. The hard of such a carbidosteel reaches HV1400 (14000MPa).

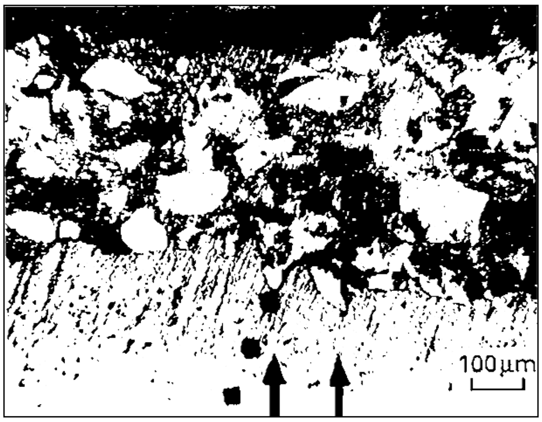

Fig. 1. Microstructure of the strengthened layer with semi-fused TiC particles

The substitution of a part of iron in the SHS-mixture by ferrochrome increases greatly corrosion resistance of carbidosteel and decreases its oxidizing wear in the process of its exploitation. The substitution of carbon in SHS-mixtures by the powder is also long-range. The same effect is obtained also with the substitution in another field of hot machining of metals namely the using of SHS-reactions for inmoulding process (modification within of the form) in casting manufacturing.

The substitution of carbon in SHS-mixtures by the powder of boron is also perspective. In such a case it is possible to reach the liquidus-solidus interval to 1500 K, that in other technologies it is practically impossible to meet. Thus, while the above mentioned method on the one hand high refractory diborides TiB_2 and CrB_2 (with high hardness) are formed and, on the other hand, very easily melted complex eutectics are formed.

Combination of LSH and SHS in one operation allows to solve the whole complex of technical problems connected with producing of materials with high hardness like carbidosteels and hard alloys on metal surface. Evolution of inner chemical heat in SHS-mixtures allows to decrease the power of laser radiation. New complex technological process allows to build up wearied surfaces of parts of machines and devices to the high of 0,5 mm.

References

1. Zhiguts, Yu.Yu., Pokhmursky, V.I. 2005. Materialy, syntezovani metalotermiyeyu i SVS-protsesamy [Materials synthesized by metallothermy and SHS processes]. *Extra NAS of Ukraine. Series: Mathematics, natural sciences, technical sciences* 8: 93 - 99.
2. Zhiguts, Yu.Yu., Lazar, V.F., Khomjak, B.Ya. 2017. Perspective materials and technologies for industry. *Current trends in the development of science and education in the deepening of European integration processes: a collection of abstracts All-Ukr. scientific-practical Conf.*, Mukachevo, May 17-18.
3. Zhiguts, Yu.Yu., Lazar, V.F. 2014. *Tekhnolohiyi otrymannya ta osoblyvosti splaviv syntezovanykh kombinovanymy protsesamy [Production technologies and features of alloys synthesized by combined processes]*. Uzhhorod: Invasor.
4. Zhiguts, Yu.Yu., Kuritnik, I.P., Klyap, N.M. 2016. Methodyka thermochimithnyh

rozrahunkiv dlja vstanovlennja skladu ekzotermithnyh shyht [Methods of thermochemical calculations to determine the composition of exothermic charges]. *Interuniversity collection of Lutsk National Technical University "Scientific Notes"* 54: 125 - 129.

5. Zhiguts, Yu. Yu., Vivtharskuj, O. V. 2015. Using SHS for synthesis of nanostructures in hard alloys and karbidostal's. *Clusters and nanostructured materials (CNM-4'2015): 4 international meeting,* Uzhorod, October 12-16.
6. Zhiguts Yu., Legeta, Ya., Golovka, Yu. 2019. *Development of SHS technology. Prospects of world science – 2019: XV intern. scientific and practical conf.*, Sheffield, 30 July - 7 August 8.

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ПОРІВНЯЛЬНИЙ АНАЛІЗ ПЕРСПЕКТИВ ВИКОРИСТАННЯ СОЛЕЙ МЕТАЛІВ В ТЕХНОЛОГІЇ МІКРОКЛОНАЛЬНОГО РОЗМНОЖЕННЯ РОСЛИН

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COMPARATIVE ANALYSIS OF PROSPECTS OF USING METAL SALTS IN TECHNOLOGY OF PLANT MICROCLONAL PROPAGATION

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У статті проаналізовано перспективи використання солей срібла, міді, заліза, церію для модифікації середовищ для вирощування мікроклінів рослин Solanum lycopersicum. Встановлено, що найефективнішими речовинами, які підвищують активність пігментів в рослинних клітинах та не знижують активності каталази є солі срібла та міді.

Ключові слова: *мікроклональне розмноження, сульфат міді, сульфат заліза, сульфат церію, нітрат срібла, каталаза, перекис водню, хлорофіл.*

The article analyzes the prospects of using salts of silver, copper, iron, cerium to modify the environment for growing microclines of plants Solanum lycopersicum. To study the effect of metal salts on oxidative stress in plants, standard methods were used to determine the content of hydrogen peroxide and catalase activity in plant tissues. To analyze the effect of metal salts on the activity of chlorophyll used photometric method. It was found that iron sulfate and cerium sulfate to varying degrees reduce the activity of catalase and increase the content of hydrogen peroxide in plant tissues. Copper sulfate and silver nitrate are able to increase the activity of pigments in plant cells without reducing the activity of catalase. The results of this study indicate the prospects for the use of salts of silver and copper as trace elements in the culture of plant clones of S. lycopersicum.

Key words: *microclonal propagation, copper sulfate, iron sulfate, cerium sulfate, silver nitrate, catalase, hydrogen peroxide, chlorophyll.*

Надмірне накопичення активних форм кисню (АФК) у клітинах, яке є реакцією рослин на дію абіотичних і біотичних чинників зовнішнього середовища, стимулює процес перекисного окиснення ліпідів, що призводить до розвитку оксидативного стресу, тобто порушення балансу між окислювально-відновлювальними процесами. Це зумовлює пошкодження структурно-функціональної цілісності клітинних мембран і порушення процесів проростання та росту молодих рослин [1]. Але утворення АФК не тільки негативно впливає на організми, а також бере участь у відповіді рослини на інфекцію викликану патогенами. Оксидативний стрес безпосередньо пов'язаний з обмінними процесами, що проходять за участю кисню. Молекула кисню втрачає свій електрон і починає пошкоджувати інші клітини організму, таким чином заповнивши свою втрату і утворивши вільні радикали (ОН та O_2). Ці реактивні проміжні продукти O_2 та ОН потенційно токсичні; вони можуть реагувати з ліпідами, білками, нуклеїновими кислотами, пігментами та іншими важливими