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TECHNOLOGIES OF SYNTHESIS OF MATERIALS WITH PREDEFINED PROPERTIES

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ТЕХНОЛОГІЇ СИНТЕЗУ МАТЕРІАЛІВ З НАПЕРЕД ВИЗНАЧЕНИМИ ВЛАСТИВОСТЯМИ

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This work is devoted to the decision of scientific and technical problems of the day, namely to the development of scientific and methodological bases of forming of structural and phase composition of alloys synthesized by the combined processes which consist of the metallothermic stage and SHS (self-propagating high-temperature synthesis). Alloys, synthesized metallotermy and SHS, theoretical bases of synthesis are developed relations are set between the structure of alloys, properties and descriptions of metallothermic reactions. Besides scientific bases of adjusting of properties of alloys synthesized are developed by exothermic processes with the use of metallotermic and SHS. On the basis of research the influence and terms of synthesis of different technological factors, the methods of synthesis, which allow acquiring better properties of materials are considered, compared with materials made by industrial technologies. Conformities to the law of forming of phase structure of alloys, got by the combined processes are carried out. The search of optimal structures of alloys which satisfy the preliminary set special and technological properties of materials and found out the features of the synthesized alloys is conducted. Conformities to the law of gelation are set in the poured alloys synthesized by exothermic processes depending on chemical composition, method of melting and dispersion of ingredients.

Key words: *properties, exothermic processes, metallotermy, SHS, combined processes, thermite alloys.*

Дана робота присвячена вирішенню науково-технічних проблем сучасності, а саме розробленню науково-методичних основ формування структурно-фазового складу сплавів, синтезованих комбінованими процесами, що складаються з металотермічної стадії та СВС (само поширюваного високотемпературного синтезу). Для сплавів, синтезованих металотермією та СВС, розроблені теоретичні основи синтезу, встановлені співвідношення між структурою сплавів, властивостями та змістом металотермічних реакцій. Крім того, розроблені наукові основи регулювання властивостей синтезованих сплавів екзотермічними процесами з використанням металотермії та СВС. На основі дослідження розглянуто вплив різних технологічних факторів на методи синтезу, які дають змогу набувати кращих властивостей матеріалів порівняно з матеріалами, виготовленими за промисловими технологіями. Здійснено дослідження основних закономірностей формування фазової структури сплавів, отриманих комбінованими процесами, а також проведено пошук оптимальних структур сплавів, які задовольняють попередньо завданим спеціальним і технологічним властивостям матеріалів та з'ясовані особливості синтезованих сплавів. У литих сплавах, синтезованих екзотермічними процесами залежно від хімічного складу, способу плавлення та диспергування інгредієнтів.

Ключові слова: *властивості, екзотермічні процеси, металотермія, СВС, комбіновані процеси, термітні сплави.*

Progress in mechanical engineering, advancing the development of new forms of production,

conditions of single and small-scale production, modern repair and recovery technologies require the use of alloys with the necessary set of physical and mechanical, and operational characteristics and advanced technologies for their production. This is especially acute in Ukraine due to the shortage of many alloying elements.

Analysis of the problem showed that one of the promising ways to improve the technological and service properties of materials, expanding their functional purpose is to create materials with a composite structure obtained by combined processes that combine metallothermic and self-propagating high-temperature synthesis (SHS).

The general foundations of metallothermic and SHS processes have been laid for a long time, but only recently have the conditions emerged to solve the problem of forming the structure and phase composition of alloys with improved properties synthesized by new advanced combined (SHS+metallothermy) technologies. In addition, the influence of combined processes on the structure, phase, and chemical composition of synthesized materials and their properties have not been studied enough, and there is no data on the patterns of connection between the indicators of different properties of these materials [1-4].

The absence of this set of patterns and data does not allow to purposefully influence the structure and phase composition of synthesized alloys, which provide improved properties compared to industrial technologies and to develop technologies for creating advanced materials.

Given the above, the use of new materials and technologies that do not require significant changes in existing technological processes becomes especially relevant.

The problem of research is the regularities of the formation of the structure and phase composition of alloys synthesized by combined processes (SHS+metallothermic), which have improved properties compared to alloys obtained by industrial technologies.

The aim of the work is to create a scientific basis for the formation of the structure and phase composition of cast alloys with improved mechanical, service and technological properties, and the development of competitive technologies by combining metallothermic and SHS processes.

The authors considered the practical application of surface alloying and strengthening of iron-carbon castings using SHS mixtures.

To reduce temperature fluctuations in the surface layer and eliminate the influence of changes in external factors, it was proposed to add exothermic additives to this layer. Then the internal chemical heat of the exothermic reaction and the quality of sintering (or melting) of the layer is less dependent on external factors, and when this layer is heated to the liquidus-solidus temperature range, it is additionally impregnated with molded melt and has almost no pores characteristic of sintered powder materials. But this method has a disadvantage - the formation of a non-metallic phase (alumina) as a result of metallothermic reactions, which contaminates the surface alloy layer [5].

Surface hardening was decided to be performed when applying carbide coatings synthesized by the SHS method. These mixtures consist of free carbon and other powder materials (Ti, Cr, and V). The best results were obtained when applying to the base of materials containing carbon. In this case, carbon as a product of carbonization is involved in the reaction of carbide formation.

Subsequently, a technology was developed that combines laser surface hardening (LSH) and SHS. In laser surface hardening, almost all Ti interacts due to oxygen-free combustion with carbon, forming TiC carbide. Excess carbon and a very small amount of titanium dope iron, forming liquid steel of eutectoid composition, which under conditions of rapid cooling turns into a cane in layers up to 500 μm thick.

In fig. 1 shows a typical microstructure of metal in the cross-section of a reinforced layer. The thickness of the doped layer is ~ 500 μm. This layer consists of ~ 50% TiC particles and ~ 50% (by volume) of metal bond (type high-carbon tool steel with a carbon content of 0.8%). The same figure shows that in the zone of intense thermal influence the microstructure of steel acquired a very small columnar structure with a slight slope of thin dendrites (which have almost no branches) in the direction opposite to the direction of scanning by the laser beam.

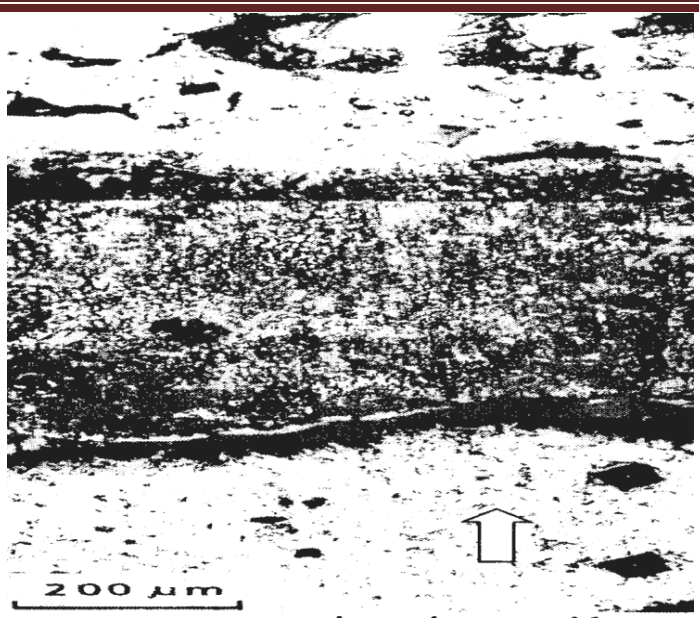

Fig. 1. **Microstructure of the reinforced layer with semi-molten TiC particles**

Highly solid (~ 2000 HV) TiC carbides can be seen in the semi-fused zone, which occupies up to 50% of the volume of the entire carbide layer. Studies have shown that the microhardness of TiC carbides is almost ten times higher than the hardness of steel. Thus, it was possible to organize the SHS process in a relatively thin layer by using LSH technology simultaneously to solve the following tasks: for heating, melting, and carburization of iron; for melting Ti particles and its "combustion" in carbon with the formation of TiC carbides.

It is important to note that at the specified oxygen-free combustion any non-metallic phases and their inclusions are not formed. Welding of the reinforced layer with the base metal is obtained "metallurgical", excluding the need for soldering or other methods of connecting one alloy (eg, tool) with others (eg with the base of the cutter).

The combination of LSH and SHS in one operation allows solving a set of technical problems for obtaining high-hard materials such as carbide and hard alloys on the metal surface. The release of internal chemical heat in SHS mixtures reduces the power of laser radiation, the role of which is to initiate SHS reactions and maintain it in thin layers of material. The new complex technological process allows increasing the worn surfaces of parts of machines, and devices with materials with high mechanical, service, and technological properties.

1. Regularities of formation of structure and phase composition of alloys synthesized by combined processes (SHS + metallothermy) having improved properties in relation to alloys obtained by industrial technologies are established. At the same time, the optimal conditions for their receipt and the areas of the most effective application, namely non-specialized, repair, and individual production.

2. Regularities of surface hardening by means of SHS and the influence of TiC carbides on the received surfaces are established. The combination of SHS and laser surface hardening forms high-hard TiC carbides in the semi-molten zone, which occupy up to 50% of the volume of the entire carbide layer. The hardness of this carbide reaches HV 1400. The combination of LSH and SHS in one operation allows to obtain high-strength materials such as carbide and hard alloys on the metal surface and increase the worn surfaces of machine parts to a depth of 500 μm.

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SECTOR OF MOUNTAIN SETTLEMENTS USE OF INNOVATIVE FOREIGN EXPERIENCE IN THE TOURISM

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ВИКОРИСТАННЯ ІННОВАЦІЙНОГО ЗАКОРДОННОГО ДОСВІДУ У ТУРИСТИЧНІЙ СФЕРІ ГІРСЬКИХ НАСЕЛЕНИХ ПУНКТІВ

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Recreational tourism is becoming more and more popular and popular every year in the vast majority of countries around the world, especially those countries that have significant recreational resources. The development of society causes environmental, demographic, and economic problems,

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