Differntiated Properties of Metal Products' Surface

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***Abstract* - Analysis of operation of moulded parts of machines and mechanisms that work in the conditions of intense wear indicates that the technologies of their manufacture using bulk doping do not always justify themselves, as small thickness of such parts wears out or is damaged in other way, which leads to unjustified costs of expensive high alloys and complicates the technologies of their casting.**

In order to achieve high surface properties (wear resistance, heat resistance, cavitation resistance) of moulded parts, the promising methods can be methods of manufacturing castings from unalloyed iron-based alloys with surface composite or alloyed layer that is formed during the creation of casting in a casting molding.

The best and cheapest materials to get castings with differentiated surface properties are powders of ferrous-based alloys (FeMn, FeCr, FeTi, FeB), as well as their mechanical mixtures.

The grane size composition of such powders should be within the range of 0,2...0,4 mm.

As an adhesive component to prepare plating, a glass liquid with the density of 1,0 g/cm3 in a quantity of 3...6% depending on powder grading.

Technologies of surface alloying allow obtaining on the surface of casting an alloyed layer without defects with thickness up to 10...12 mm.

For the manufacture of wear-resistant parts, it is necessary to use FeMn, FeCr, FeTi, which make it possible to obtain on the casting surface an alloy, defect-free layer up to 10 mm thick, and Cr-and Al for heat-resistant castings.

The quality of the alloy layer corresponds to the operational requirements for products that work under abrasive or hydroabrasive wear, high temperatures and corrosive environments.

Keywords – Surface alloying, ferromanganese, ferrotitanium, wear resistance, heat resistance, adhesive component, liquid glass, technical lignosulphonate

INTRODUCTION

For moulded details of modern machines and mechanisms that work in extreme conditions (intense wear, high temperatures, aggressive environments), increased requirements for hardness, wear resistance, heat resistance, cavitation resistance etc. are made. Molded parts of machines and mechanisms determine to a large extent their reliability, service life and efficiency[1].

An analysis of operation of a large number of moulded parts of machines and mechanisms working in extreme conditions (thermal power engineering, metallurgy, mining, chemical and other industries) has shown that the technologies of their manufacture using volumetric alloying of the metal do not justify themselves, and in many cases are harmful, because only a small thickness of such parts is worn out, oxidized or can be damaged in other way during operation. This leads to unjustified use of expensive high-alloy alloys. For example, by analyzing the use of metal per unit of electricity produced by the thermal power plants of Ukraine, it has been established that during the year thousands of tons of metal of moulded parts of high cost are lost. It is obvious that in these cases it would be enough to provide high performance characteristicsonly for working surfaces of such parts.

In order to achieve high surface strength and wear resistance of moulded parts, different types of treatment are used in mechanical engineering: thermal, chemical-thermal, laser, etc. Electrochemical coatings and linings on the surface of metal products with special properties are often used. However, many of these methods don't allow to obtain a sphere of metal with the desired properties with thickness more than 0.3 mm. Such thickness is not enough especially for prolonged operation of large parts. According to [2], the thickness of a surface sphere with special properties should be not less than 5...10 mm. With lining on the surface of the part it is possible to obtain a sphere of such thickness, but this process is very labor-intensive, expensive and, moreover, it is practically impossible to make lining of metal on some surfaces of parts.

To solve this problem, the promising methods can be methods of manufacturing castings from unalloyed iron-based alloys with surface alloyed sphere that is formed during the creation of casting in a casting molding.

In this paper, the prospect of obtaining an alloyed sphere of maximum thickness with pre-defined properties by surface alloying with certain chemical elements and their mixtures is investigated. The core of this method is that working surfaces of a foundry mold or core during the manufacture of castings, which work, for example, in conditions of intense wear, are coated with alloying plates in the form of dyes or pastes. The metal poured into the mould interacts with the alloying plating, and as a result the surface of the casting is saturated with the corresponding elements with the formation of a pre-defined structure and properties [3, 4]. Such technology makes it possible to get an alloyed sphere on the surfaces of castings, which is closely connected to the base metal and has a high resistance to wear or resistance to high temperatures and aggressive environments. Compared to other ways to improve properties of products' surface, this process has certain advantages, and the most effective during the manufacture of parts with working surfaces which are not matched [5-8].

However, when making castings with a surface alloy layer of required thickness, many factors must be taken into account: the temperature of alloy, poured into a mould that should be sufficiently high to cause melting and dissolving of alloy plating under the action of heat of a liquid metal, the thickness of the alloy plating which should be determined by the temperature of its melting, the granulometric composition of the filling mass, the properties of adhesive component, etc. [9-11].

Moreover, the necessary condition for the formation of an alloy layer of required thickness, there should be a prolonged contact of the base metal in a liquid state with an alloy plating. The leading processes in the formation of an alloy layer in this case can be melting and dissolving of an alloy plating, as well as filtration of the base metal through the plating. Therefore, on the basis of this understanding, it becomes possible to propose two mechanisms of surface alloying of castings in the mould, which can be occured simultaneously or separately:

- if the melting point of the alloy plating is lower than the temperature of the base metal that is poured into the mould, the formation of an alloy layer is due to the melting of the plating, its mixing with the base metal and further diffusion processes;
- if the melting point of an alloy plating is higher than the temperature of the base metal, the alloy layer can be formed as a result of penetration of a liquid alloy in the pores of the plating with further diffusion processes of transferring the alloy elements from the plating into the base of the metal and partial dissolution of the plating components.

It is obvious that surface alloying of castings should be made with the application of alloy platings on the working surfaces of moulds and cores. The melting point of these alloy platings must be lower than the temperature of a metal poured into the mould. For the production of large thick-wall castings, it is possible to use insert pieces of heat-resistant materials, which are by-products, for example, during the manufacture of hard-metal model [12].

FORMULATION OF THE PROBLEM

The aim of the work is to develop a new method for the production of castings with pre-defined differentiated surface properties. To achieve this goal it is necessary to choose effective ferroalloys for the preparation of alloy platings, to investigate the processes of interaction of a liquid metal with the layer of alloy plating applied to the working surface of a mould or core and to establish the basic principles of obtaining an alloy layer on the surface of a casting and transition zone.

RESEARCH METHODOLOGY

Based on the analysis of geometry and overall dimensions of molded parts of machines and mechanisms that are subjected to intense wear and action of high temperatures and aggressive environments, it has been established that the average thickness of castings'walls is in the range of 30...40 mm. Therefore, to study the processes of surface alloying, samples with dimensions of 85×35×40 mm, which have special cross breaks to facilitate the process of separating them from the general block, were used,. For preparing alloy platings, metals, ferro-alloys and their mechanical mixtures were used. The thickness of alloy plating was changed from 3 to 7 mm, using special frames of the required height. The cores with applied plating had been dried in the air in 24 hours with further heating in the chamber dryer. Mould sections had been dried in a dryer at a temperature of 200...220 ºC for four hours. The joining of moulds was carried out at a temperature of 40...50 ºC just before poured them with metal. The cores also had the same temperature. In experiments, medium carbon foundry steel 30L was used as a metal base.

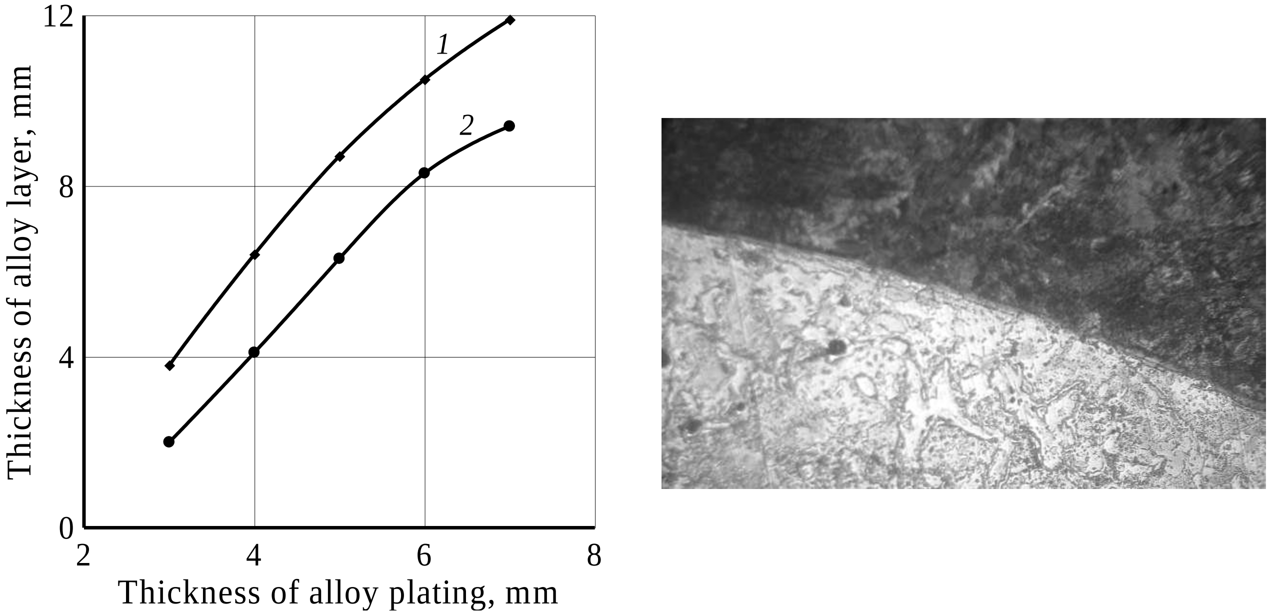
MAIN RESULTS OF RESEARCH

The work has investigated the influence of certain chemical elements in the form of ferroalloys and their mixtures on processes of manufacturing of castings with differentiated properties of a surface using surface alloying in a mould form.

Manganese. The change in the thickness of the alloy layer depending on the thickness of alloy plating, produced with the use of low carbon FeMn1,5 and high carbon FeMn78A with approximately the same content of manganese (fraction 0315) has been studied. The research results are shown in Fig. 1

It was established that the maximum thickness of the alloy layer can be obtained after the use of high carbon FeMn78A as a filler for alloy plating. If the thickness of an alloy plating is 7 mm, the thickness of the alloy layer reaches 12 mm. This is due to the low melting point of the plating, which contributes to its full use, ie, full meltdown and mixing with the surface layer of the metal base.

The same nature of the change in the thickness of the alloy layer in terms of the thickness of the alloy plating is also kept for low carbon FeMn1,5. However, the thickness of the alloy layer decreases slightly, although it remains quite high (9,5 mm for the thickness of the plating 7 mm). The decrease in the thickness of the alloy layer can be explained by some increase in the melting temperature of such FeMn, as a result, not all alloy platings are melted under the action of the melt heat, although the melt temperature before pouring into the mould was the same.



a

b

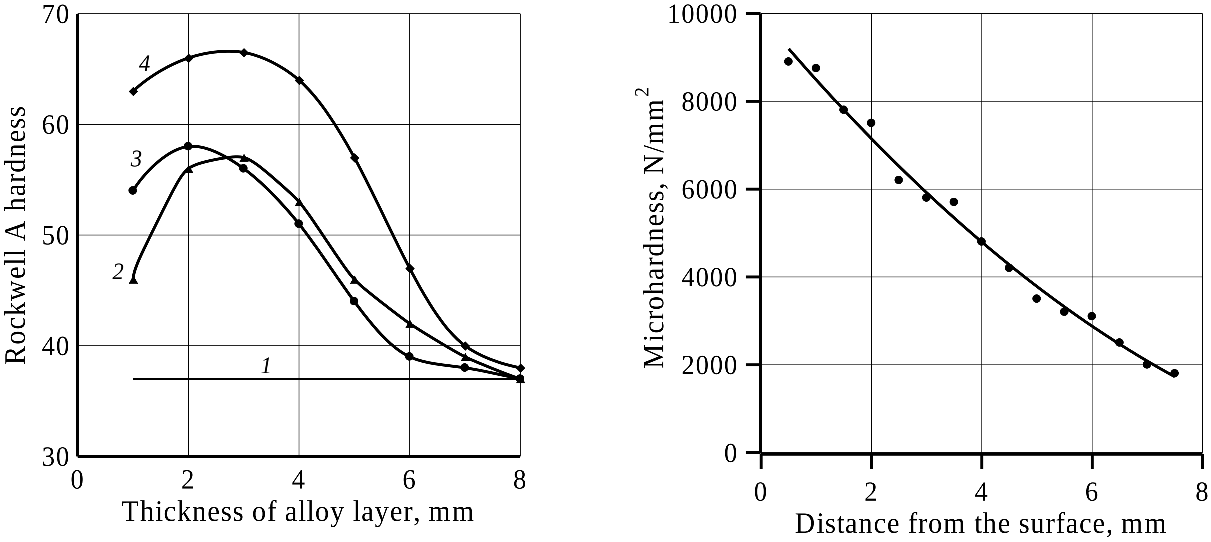
Fig.1. Change in the thickness of the alloy layer depending on the thickness of the alloy plating (1 – FeMn78A; 2 – FeMn1,5) (*a*) and the microstructure of the surface layer (*b*) after the use of FeMn78A with the fraction of 0315 ×200

Consequently, it is possible to draw a conclusion, and at the same time to give a recommendation: for wear-resistant surface alloying, from the economic side, it is better to use cheap high carbon ferromanganese, which ensures the stability of the process of surface alloying and contributes to the formation of a reliable alloy layer of considerable thickness.

Since the crystallization conditions of alloy layer are different (they depend on the dimensions of the plating components with the same its thickness), the practical interest is the change in its hardness by the thickness. The thickness of the alloy layer and its transition zone can be judged from changes in hardness .

The change in the hardness and microhardness of the alloy layer by its thickness, depending on the size of the alloying component, has been studied. The thickness of the alloy plating in all experiments was 3 mm. As an adhesive component here and further a diluted with water liquid glass with the density of 1,0 g/cm^3 was used. The results of studies using ferromanganese FeMn78A are shown in Fig. 2

It was established that an alloy layer acquires the maximum hardness after the use of ferromanganese from the fraction 0315 and reaches 68 HRA at a depth of about 3 mm (see Fig. 2, *a*). It is almost twice as strong as the base. Such effect of ferromanganese on the change in hardness can be explained as follows: the liquid melt, when pouring into the mould, first contacts with the surface of the plating, heats it to the melting point, and as a result solid solution with a small amount of carbides are formed to a large extend.Therefore the hardness is slightly lower than at a depth of 3 mm. At the same time, a liquid melt under metalostatic pressure penetrates into the pores of the plating and heats it to the melting point. Over time, however, the amount of heat decreases, the melting processes come to completion and diffusion processes that occur much more slowly than the melting processes become more predominant. Consequently, during the use of fraction 0315, processes of melting of alloy plating and the penetration of a liquid melt into the porous of an alloy layer, followed by its melting and diffusion processes, are carried out simultaneously. In this case, carbides of manganese (Mn_3C), complex manganese carbides (Fe, Mn_3C) and (Mn, Fe_3C) and a solid solution of manganese with iron are formed, which contributes to the formation of the hardest alloyed metal at a depth of about 3 mm. The ratio of manganese in carbides and in the solid solution for such alloys is 1:3. Further, as a result of only diffusion processes, a solid solution and a smaller number of carbides are formed than at the beginning of the interaction of a liquid melt with the plating, therefore the hardness of the alloy layer decreases till the hardness of the base. Confirmation of this is the change in the microhardness of the alloy layer by its thickness (Fig. 2, *b*) after the use of fraction 0315.



a *b*

Fig. 2. Change in the hardness (*a*) of the alloyed layer by its thickness, depending on the fraction of FeMn78A and its microhardness (fraction 0315) (*b*): 1 – hardness of the base; 2 – fraction 04; 3 – fraction 02; 4 – fraction 0315

After using fraction 02, the hardness of the alloy layer is less (see Fig. 2, *a*), since in this case melting of an alloy plating is occurred starting from its surface (the penetration of a liquid melt in the plating is minimal), and therefore the structure formation shifts toward increasing the solid solution with high content of manganese. To increase the surface hardness the product must be exposed to external action, that is, hammer hardening. When using fraction 04, the process of melting of the plating is to a large extent done by the heat of a liquid melt, which penetrates by capillaries in its depth, and to a lesser extent, from the contact of a liquid melt with the surface of a plating. In this case, the process of formation of a solid solution in the surface part of an alloy layer predominates, therefore, the hardness is the lowest (see Fig. 2, *a*), although a small amount of manganese and iron carbides is formed simultaneously. The highest hardeness an alloy layer in this case also acquires on a depth of 3 mm due to the processes described for fraction 0315.

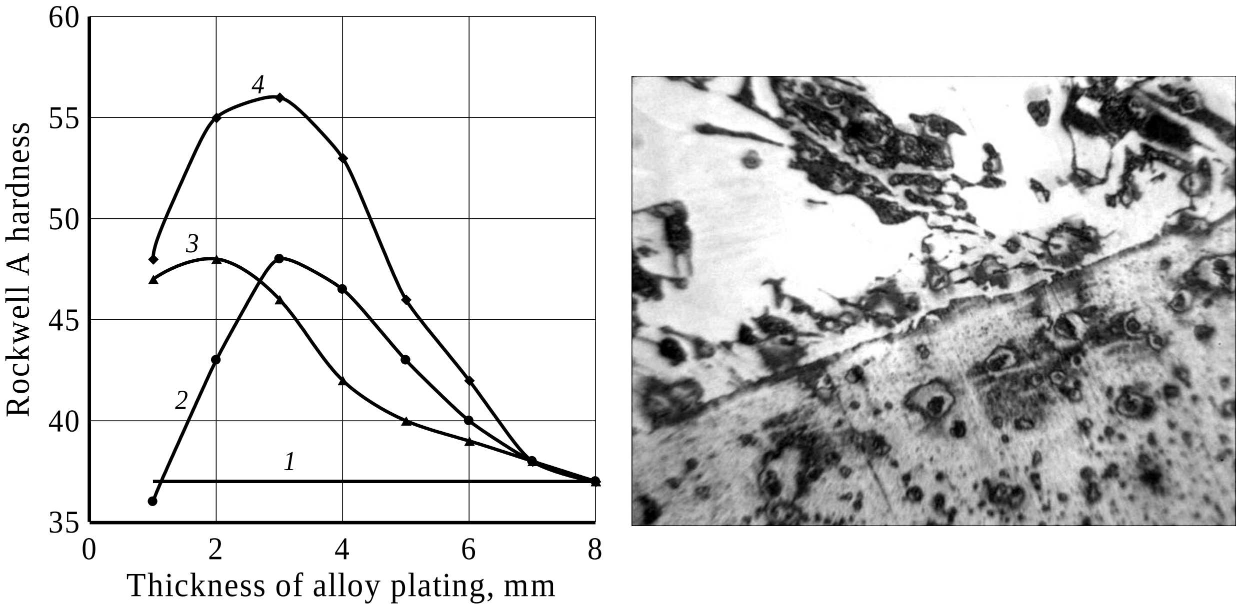
For this reason, to obtain the maximum hardness and thickness of an alloy layer during the use of high carbon ferromanganese FeMn78A as a filler for an alloy plating, fraction 0315 should be used.

Titanium. In iron-carbon alloys, titanium simultaneously can form a solid solution, carbides, nitrides (carbonitrides) and oxides, and contributes to the dispersion hardening of such alloys, that's why its use as a component of an alloy plating is of theoretical and practical interest.

An impact of ferrotitanium FeTi30A in fractions 02, 0315 and 04 on the formation of an alloylayer and its hardness was investigated. The thickness of an alloy plating in all experiments was 3 mm. The research results are shown in Fig. 3

It was established that after the use of ferrotitanium FeTi30A in fraction 0315 an alloy layer with a thickness of about 8 mm with a maximum hardness up to 58 HRA at its depth of 3 mm is formed, which is 1,5 times the hardness of the metal base.

After using fraction 02, the hardness of the surface of the alloy layer is somewhat lower than the hardness of the base, apparently due to the formation of ferrite-titanium alloy. As the thickness of the layer increases, the amount of titanium carbonitrides in the alloy layer increases and its hardness rises. The same dependence remains the same when using ferrotitanium fractions 0315 and 04.



a *б*

Fig. 3. Effect of (FeTi30A) on the hardness of alloy layer (*a*) and microstructure (*b*) – fraction 0315, depth of alcroloy layer is 3 mm (×400): 1 – hardness of the base; 2 – fraction 02; 3 – faction 04; 4 – fraction 0315

Consequently, to obtain the maximum hardness and thickness of an alloy layer formed after the use of ferrotitanium, an alloy plating should be produced on the basis of FeTi30A in fraction 0315.

Chrome. Refers to elements that form with iron continuous series of solutions and complex carbides that significantly increase the hardness of an alloyed metal.

As the industry produces a large number of ferrochromes with different carbon content, and hence with different melting temperatures, in the work high carbon ferrochrome FeCr800A and low carbon – FeCr015A are used as fillers of alloy plating. The thickness of an alloy plating in all experiments was 3 mm. The research results are shown in Fig. 4 and 5.

As for previous alloying elements (manganese and titanium), the change in the hardness of an alloy layer is made according to the same laws. The only difference is that the ferrochrome FeCr800A has a lower melting point, so it is more soluble in the liquid metal of the base and enhances the hardness: for FeCr800A the maximum hardness is 64 HRA, and for FeCr015A – 56 HRA, although for FeCr015A the maximum hardness shifts to the right in comparison with FeCr800A (see Fig. 4 and 5).

Such a slight difference in the hardness and thickness of an alloy layer makes it possible to conclude that as fillers of alloy plating can be used both high-carbon and low-carbon ferrochromes. This is especially true of mechanical mixtures. However, in terms of powder preparation, it would be useful to use high-carbon ferrochromiums, because they are cheaper and easier to reduce.

Thus, based on the results obtained for surface wear-resistant alloying of separate parts of mould parts made from iron-based alloys, it is advisable to use any type of ferrochrome, reduced to a fraction of 0315 mm.

The usefulness of mechanical mixtures of ferroalloys for surface wear-resistant alloying is investigated. The components included in mixtures are presented in Table. 1, and their estimated chemical composition – in Table. 2. The thickness of the plating is 3 mm.

The melting point of mechanical mixes, which are the cheapest, are not scare and more effective, is 1240...1310 ºC. The temperature was determined using the device designed for this purpose, equipped with a PC, while melting of foundry alloy from components shown in Table. 1. The temperature of the metal before pouring into the mould was within 1600 ± 10 ºC.

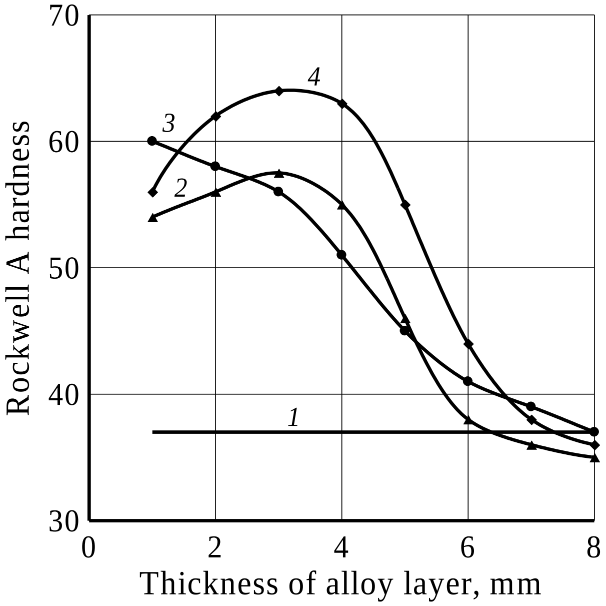


Fig. 4. Influence of FeCr800A on the hardness of alloy layer: 1 – hardness of the base; 2 – fraction 02; 3 – faction 04; 4 – fraction 0315

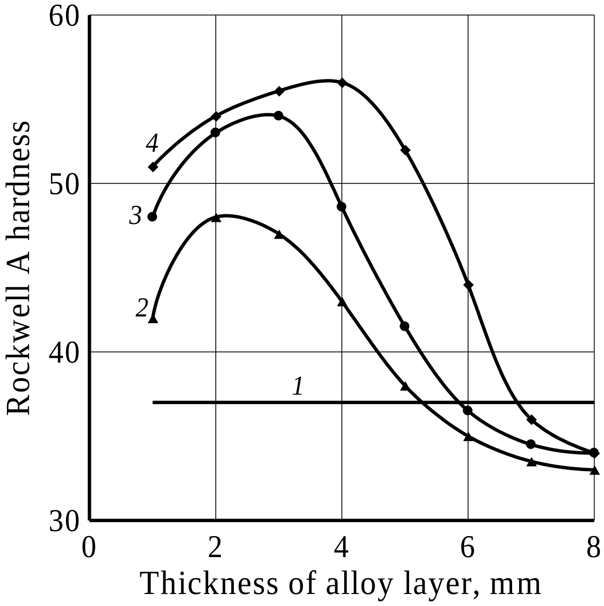


Fig. 5. Influence of chromium FeCr015A on the hardness of alloy layer: 1 – hardness of the base; 2 – faction 04; 3 – fraction 02; 4 – fraction 0315

Table 1. Components for alloy platings and their number

Plating index	Content of components in mechanical mixture, pts. wt.					
	Mn965	FeCr800A	FeTi30A	FeB10	iron powder	broken electrode
1	35	6	15	5	33	4
2	40	6	15	5	27	5
3	45	6	15	5	21	6
4	50	6	15	10	9	8

Table 2. Estimated chemical composition of alloy plating

Plating index	Estimated content of chemical elements in the plating, %					
	manganese	chromium	carbon	titanium	boron	iron
1	33,8	3,5	4,10	5,3	0,5	52,80
2	38,6	3,5	5,08	5,3	0,5	47,02
3	43,4	3,5	6,06	5,3	0,5	41,22
4	48,3	3,5	8,02	5,3	1,0	33,88

The alloying platings differ in the content of manganese, carbon and iron, and therefore their melting points are different: the highest – plating 1, the lowest – plating 4. This explains the best results after using the alloy plating 4, prepared from fine powders (<02 and 02 mm) – the thickness of the alloy layer reaches 10 mm (Fig. 6), and its hardness is 75 HRA, which is 2,3...2,6 times higher than the hardness of the casting base. In these cases, the dominant the processes are processes of melting and dissolution of components of an alloy plating under the action of heat of a liquid metal and the formation of maximum amount of carbides and alloying of the base during the period of interaction of an alloy with an alloy plating.

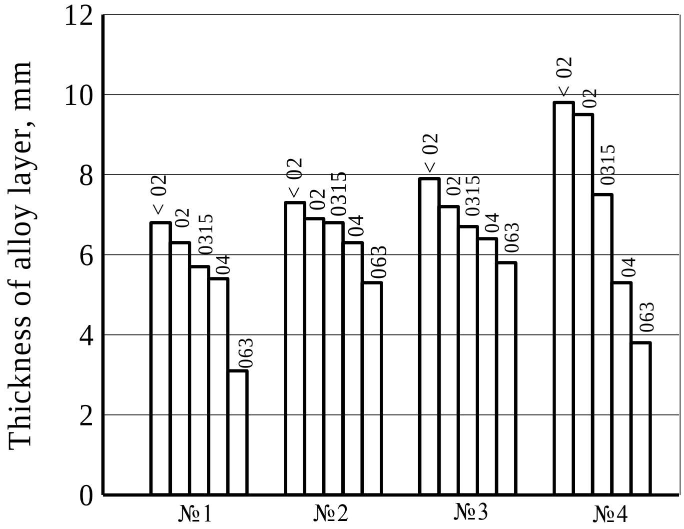


Fig. 6. Influence of alloy platings on the basis of mechanical mixtures and their granulometric composition on the thickness of the alloy layer

Thus, the best way to achieve the maximum thickness and hardness of the alloyed layer is to use a plating 4 in fractions <02 and 02 mm. However, good results were obtained after the use of fraction 0315 from the same mixture, which contains more than 48% of manganese. It can be assumed that in this case, the first will occur the leakage of a liquid metal into a plating, followed by melting and dissolution of plating’s components. The depth of an alloy layer depends, preferably, on the initial depth of penetration of a liquid melt in pores of the plating. Since an alloy plating isa powerful fridge (especially with thickness of 5...7 mm), the depth of penetration of a liquid melt in its pores will depend largely on the temperature of a metal poured into a mould and its liquidity. By this fact the lower thickness of an alloy layer after using all surfaces with fractions 04 and 063 can be explained. In addition, after using these factions capillary effect is being improved compared with the faction 0315, in which the process of metal alloying is more evident and the formation of carbides is less. At the same time it was established that the grain structure does not make much impact on the process of wear-resistant surface alloying as the hardness of alloy layer depends on the composition of an alloy plating and ranges from 68...76 HRA for mixtures being studied.

Consequently, any of studied mixtures can be used for wear-resistant surface alloying. The choice of the mixture depends on the required thickness of an alloy layer on the detail, the presence of an appropriate fraction of a ferroalloy and taking into account the factors listed above.

The influence of thickness (1, 2 and 4 mm) of the allow plating 4 on the thickness of analloy layer using fractions 0315, 04 and 063 was studied. It was established that at the minimum thickness of an alloy plating (1 mm), the thickness of an alloy layer after use of all fractions is almost on the same level – 0,9...1,1 mm. As the thickness of an alloy plating increases, the thickness of the alloy layer rises. Thus, for fraction 0315, the thickness of the alloy layer is maximum and equals to 2.5 mm if the thickness of an alloy plating is 2 mm. For fractions 04 and 063, the thickness of an alloy layer is slightly lower. However, with an increase in the thickness of an alloy plating for these fractions, the thickness of an alloy layer increases more intensively, which is explained by the capillary effect of a liquid metal and better melting and dissolution of tan alloy plating.

Taking into account the complexity of coating a surface of a mould or core with an alloy plating, for operational circumstances, it is recommended to apply an alloy plating with thickness of 3 mm, using a fraction 0315 for plating 4.

By studying the change in the microhardness of an alloy layer, it was established that during the process of filling the casting mould with a liquid metal, not only surface alloying happens, but also extensive one. The main metal of a casting acquires stable microhardness only at a distance of 10...15 mm from the edge of an alloy layer. This is a positive effect during the production of wear-resistant and heat-resistant molded parts.

The operational properties (hardness and wear resistance) of an alloy layer obtained after the use of plating 4 fractions 0315, 04 and 063 were investigated. As a standard for determining wear resistance of an alloyed layer, samples from steel 30L, which is the base of castings during a surface alloying, were used. The thickness of an alloying plating in all experiments was 3 mm.

It has been established that the highest relative wear resistance has an alloy layer formed after the use of fraction 0315. Relative wear resistance of such a layer is 2,7 times higher than the base of casting – steel 30L has got. The hardness of an alloy layer is in the range of 77...79 HRA.

After using fractions 04 and 063, the relative wear resistance of an alloy layer is slightly reduced, but remains at a high level (2,40 and 2,32 respectively), and the hardness is equal to 75...76 HRA.

Therefore, during the manufacture of molded parts operating in conditions of abrasive and, especially, hydroabrasive wear, it is clearly advisable to apply surface alloying using manganese, chromium, titanium and boron based mechanical mixtures.

If in technical literature it is possible to find some information as for the use of surface alloying to increase the wear resistance of molded parts, then there is no information regarding the heat-resistant alloying at all. Consequently, studies of possibilities how to use this process for obtaining on the surface of molded parts a metal layer with high resistance are of particular theoretical and practical interest. To do this, an alloy plating must include chromium, aluminum, silicon or their mechanical mixtures.

To study the processes of heat-resistant surface alloying taking into account the conditions of operation of heat-resistant parts for thermal power plants (nozzles of burners of boiler units, gas burners, stud tubes, etc.) and the influence of alloying elements on heat resistance of products, aluminum powder type lignosulfonates ASD-1 with fraction of 50 microns and high carbon ferrochrome FeCr200 fraction of 0,2 mm with a melting point of about 1530 ºС were used. An alloying plating with a brush was applied to the core several times to a thickness of 7 mm. As an adhesive component, technical lignosulfonate diluted with water in the ratio 1:1 was used. Aluminum powder and ferrochrome were used in different proportions, as well as an alloy plating with different thickness.

It has been established that the change in the aluminum content in an alloy plating significantly affects the thickness of an alloy layer. So when 100% of ferrochrome powder was used in an alloy plating and with thickness of 3 mm, an alloy layer with thickness 1920 microns was formed on the surface of a workpiece. The addition and increase of aluminum content in the plating to 50% led to reduction of thickness of an alloy layer by volume in many times and was only 350 microns. This can be explained by following: with a little amount of aluminum in the plating the base is a relatively high-melting powder of ferrochromium. In this case, the alloying is apparently due to the capillary penetration of a liquid metal in the porous of an alloy plating. However, due to the fact that the coating pores are filled with a fine aluminum powder that does not allow a liquid melt to penetrate into the plating, has a lower melting point than chrome and absorbs a significant amount of heat, the thickness of the alloy layer decreases and reaches a minimum with chromium and aluminum ratio 50:50% by volume.

The investigation of the microhardness of an alloy layer found that the distribution of chromium and its compounds is not the same. The maximum microhardness an alloy layer has on the surface, which makes it possible to confirm the presence of a zone with a high concentration of chromium and its compounds. The microstructure of an alloyed with aluminum and chromium is present. The structure of a surface alloy layer is heterogeneous.

After increasing the content of aluminum in an alloy plating up to 50%, the thickness of the alloy layer increases in volume and reaches a maximum (538 μm) with 65,5% of aluminum content in a plating. In a case where only aluminum is used as an alloy plating filler, the maximum reaches 5500 microns. The mechanism of surface alloying in the first case consists in intense melting of aluminum, mixing it with a liquid metal of a base and coating the particles of ferrochromium while diffusion processes are happening. At the same time the distribution of chromium in a surface layer is more uniform, and the structure is becoming more homogeneous.

Change in the thickness of an alloy layer depending on the thickness of the plating is shown in Fig. 7

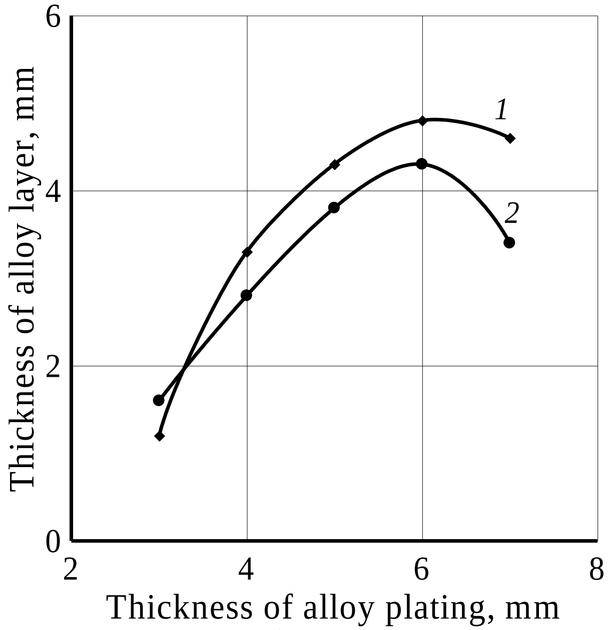


Fig. 7. Change in the thickness of alloy layer depending on the thickness of plating:
1 – ASD-1, fraction of 50 microns; 2 - FeCr200 (80%) fraction 0315 + ASD-1 (20%)

Aluminum, despite the formation of oxide films in the process of interaction of the metal base, that means a liquid melt, with the coating material, has a positive effect on the formation of an alloy layer, the thickness of which has a maximum value with thickness of 6 mm. The thickness of the alloy layer at the same time reaches 5 mm. However, the further increase in the thickness of the alloy plating leads to a decrease in the thickness of the alloy layer, obviously due to the loss of temperature by base metal through time and a sharp decrease in the thermal conductivity of layer alloyed by aluminum.

The same nature of change in the thickness of an alloy layer from the thickness of an alloy plating has a mechanical mixture of ferrochrome and aluminum. Despite the increase in the melting point of an alloy plating, the thickness of the alloy layer exceeds 4 mm, which fully satisfies the requirements for heat-resistant molded parts. For example, burners' nozzles of boiler units at thermal power plants during 52000 hours of operation at a temperature of 1200 °C acquire a corrosion depth of 2,0...2,5 mm.

Since powders with fractions 50 μm and 0315 were used in experiments, it can be assumed that in this case, surface alloying was carried out both as a result of the partial melting of the coating components, and due to the capillary penetration of the liquid metal into the pores of the plating with futher dissolution of ferrochrome and formation of ferrite alloyed with chromium and aluminum, which is the best structure for heat-resistent iron based alloys.

Therefore, in order to achieve the maximum thickness of an alloy layer, it is necessary to use an alloy plating on the basis of aluminum or a mechanical mixture of ferrochromium and aluminum in certain ratios with thickness up to 6 mm, which can be applied on the surface of casting moulds or cores in the form of renderings.

In many cases it is virtually impossible to treat a surface of a mould or core with a thick layer of alloy plating, for example, using a pallet knife. In this case, it is enough to apply an alloy plating 2 to 3 times with a spray device to obtain a sufficient thickness of the alloylayer.

CONCLUSIONS

1 Molded parts, which work in conditions of intense wear, high temperatures and aggressive environment, can be produced using the technological processes of surface alloying, that means to manufacture products with varied properties of the surface or their individual parts. The processes make it possible to significantly save expensive ferroalloys, which are excessively consumed during volumetric alloying of alloys.

2. For the manufacture of wear-resistant parts with varied surface properties it is reasonable to use ferromanganese, ferrotitanium and ferrochrome, which allow with using fraction 0315 to get an alloy layer on a surface of a casting up to 12 mm with hardness up to 68 HRA or mechanical mixes of given ferroalloys.

3. The best combination of properties has a mechanical mixture of fraction 0315 containing about 48% manganese, while the metal structure becomes as homogeneous as possible. The choice of the mixture depends on the required thickness of an alloy layer on a detail, the presence of suitable fraction of ferroalloys and when the factors listed above are taking into account.

4. To achieve the maximum thickness of an alloy layer during the heat-resistant alloying, it is necessary to use an alloy plating on the basis of aluminum or a mechanical mixture of ferrochromium and aluminum with thickness up to 6 mm in certain ratios.

5. To obtain an alloy layer of sufficient thickness, an alloy plating should be applied 2...3 times to the surface of moulds and cores in the form of renderings, for example, using a pallet knife or spray device.

6. The principles of process of surface alloying described in the work fully meet the production requirements and can be used for manufacturing wear-resistant and heat-resistant mold parts.

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