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HEAT TREATMENT OF WEAR RESISTANT HARDALLOYED COATING OF THE DETAILS OBTAINED BY CASTING ON GASIFIED MODELS

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Abstract

The followings were studied, the structure, phase composition, microhardness and depth of hardalloyed coating on the samples and details, obtained by polystyrene foam casting by gasified models, on a work surface which is applied with powdered solid carbide. It was established that the heat treatment of such products with dual phase recrystallization increases abrasive wear resistance 1,7 ÷ 1,8 times greater.

Keywords: Hardalloyed coating, casting on gasified models, powdered solid carbide with a binder, heat treatment with a double phase recrystallization, fine structure, residual austenite, abrasive wear resistance.

1. PREFACE

Many parts of agricultural machinery and mine-metallurgical equipment operate in conditions of abrasive environment. Therefore, working surfaces of such products are subjected surface hardening by applying solid cast alloys. Application of hardalloyed coating is performed by melting the metal coating on the surface of the part.

The structural state of the hardalloyed coating is formed during the solidification and cooling of the products. The abatement is the final operation in most cases [1].

The use of parts with hardalloyed coatings without special heat treatment is not effective enough since the capacities to increase the abrasive wear resistance is not completely realized due to insufficient hardness and instability of the structure.

It is advisable to get the small parts with hardalloyed coatings on the working surfaces simultaneously while molding on foamed polystyrene gas models [2]. In this case the powdered hard alloy together with a binder, in the form of a paste, applied to the working surface of froth-model of the product. The froth-model is formed into the casting flask container with dry quartz sand. When pouring liquid metal through the runner system the froth-model burns out, the resulting cavity is filled with liquid metal [3]. When you contact the liquid metal with the cold mold walls a solid crust is produced on which the powdered hard alloy is melted and connected to a solid crust solidifying casting.

There is a large amount of cast hard compositions of the alloys, which are used as wear resistant coatings. This is mostly high carbon and high chromium alloys, eutectic or hypereutectic compositions, which may additionally be doped with nickel, manganese, silicon, tungsten, vanadium and titanium. [4] These alloys during the crystallization forms hardening structure with a significant amount of stable retained austenite. Cast hard alloy with such a structure poorly processed by cutting (when it is necessary) and has insufficient wear resistance due to reduced hardness. In this paper we solve the problem of increasing the abrasive wear resistance of hardalloyed coating produced by casting on gasified models, by using different heat treatment regimes.

2. METHODOLOGY OF THE RESEARCH

For the research the followings were selected: composition of the hard alloy, that does not have a large amount of deficient alloying elements, ensures the completeness of phase transformations during the heat treatment (during annealing for reducing the hardness, during quenching for getting the highest hardness). Table 1 shows the chemical composition of the powdered hard alloy.

Table 1

The chemical composition of hard alloy

Content of elements in % (according to the mass)								
C	Si	Mn	S	P	Cr	Ni	W	M_o
3,0	1,5	0,8	0,04	0,04	22,0	1,2	0,2	0,08

The research included samples obtained by casting steel 35GL on gasified models. On the working surface of the model pasty paint containing hard alloy powder with a binder of the composition - 4% solution of polyvinyl butyral in alcohol was applied. Paste thickness was 2,0 mm. After drying pasty paint the froth-model we formed it

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with dry quartz sand. After installation of the runner system pouring of molten metal was performed. The working surface of powdered hard alloy melted, and when cooling of the entire cast was crystallized to form a cast hardalloyed coating.

Prepared samples were cut across the coating and examined the macro and microstructure, changes in the microhardness was determined by the depth of the coating. Phase composition and state of the fine structure metal base coating was studied by X-ray [5].

The heat treatment of the samples included followings:

- low annealing at 700-720^{0}S;
- hardening with heating temperatures 900-920^0, 1000^0, 1100^0, 1150^{0}S;
- tempering at temperatures of 200-250^{0}S.

Some samples were thermally treated with a double phase recrystallization - first quenching from the various heating temperatures, an intermediate annealing at 600-650^{0}S, - the second hardening 900-920^{0}S, tempering 200-250^{0}S. According to researches [6,7] such heat treatment strengthens the metal base alloy due to the additional growth of the dislocation density.

Abrasive wear tests were performed on a PV-7 by friction by dragging of polyurethane auger on the surface of the sample in the presence of silica sand [8].

3. THE RESULTS OF THE RESEARCH AND DISCUSSIONS

Microanalysis showed that obtained wear-resistant coating on depth has a different composition and structure (fig.1). On the surface coating hypereutectic structure with excessive carbides and hexagonal prismatic shape is formed. Next on the depth of the layer there is the eutectic zone and hypoeutectic compositions with sharp transitions to the structure of hypereutectoid eutectoid steel and metal base.

The formation of high-carbon sublayer under hard-alloyed coating is related to the diffusion of carbon from the powder covering to the crust of solidified metal and the carbonization of the products by froth-model combustion.

The total thickness of hard-alloyed coating is 0,6 mm including the thickness of 0,3 mm. Hypereutectic zones. thickness of high-carbon sublayer is 0,8-0,9 mm.

The phase X-ray analysis of the samples showed the presence of surface-type carbides M_7C_3, $M_{23}C_6$ and the presence of α-γ phase of iron. The microhardness of the layer in depth from the surface varies widely, which is associated with the presence of various structural components (fig.2).

During quenching of the samples at a heating temperature of 900-920^{0}S the location and shape of primary carbides is not changed, however, the lower microhardness values are increased significantly in the spread band from HV 720·10^{-1} MPa and up to HV 840-1100·10¯1 MPa. At higher temperatures heating for hardening, dissolution of secondary carbides in the austenite occurs.

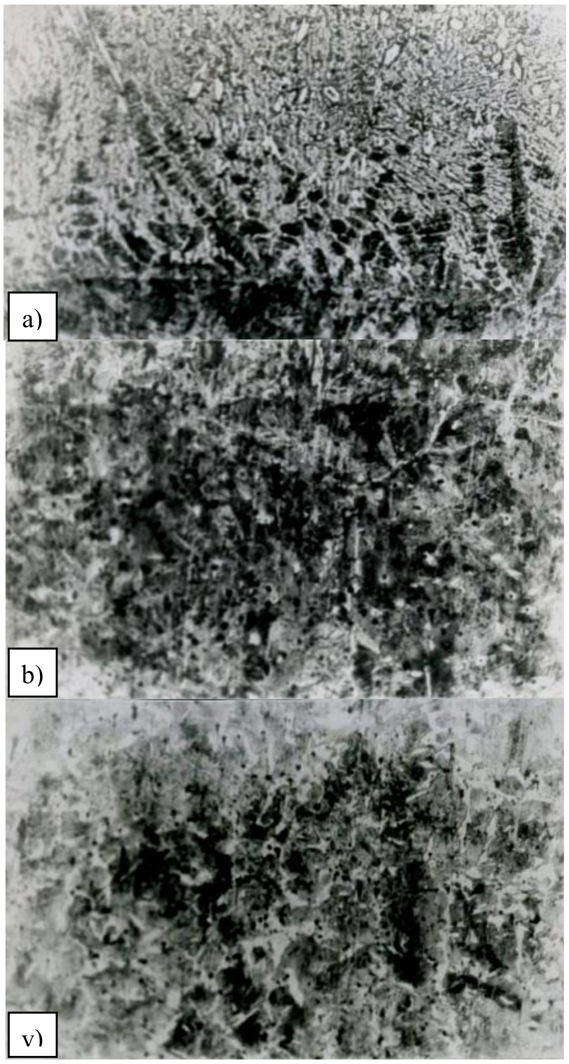


Fig. 1. *The microstructure of hard-alloyed coating obtained by casting parts from steel 35GL on gasified models:* ***a****-hard-alloyed coating with the transition to high carbon sublayer;* ***b****-hypereutectoid structure of the sublayer;* ***v****-the base metal.*

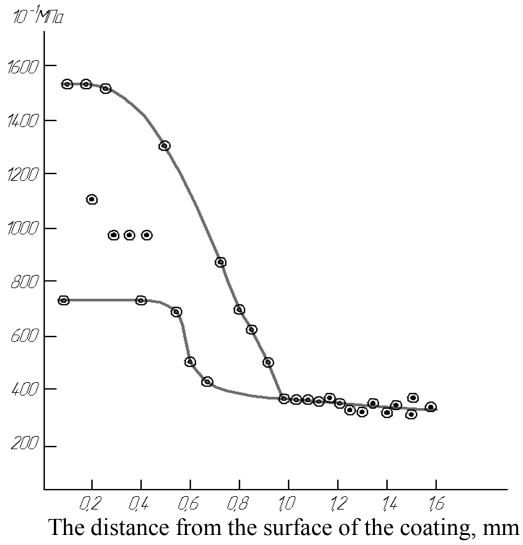
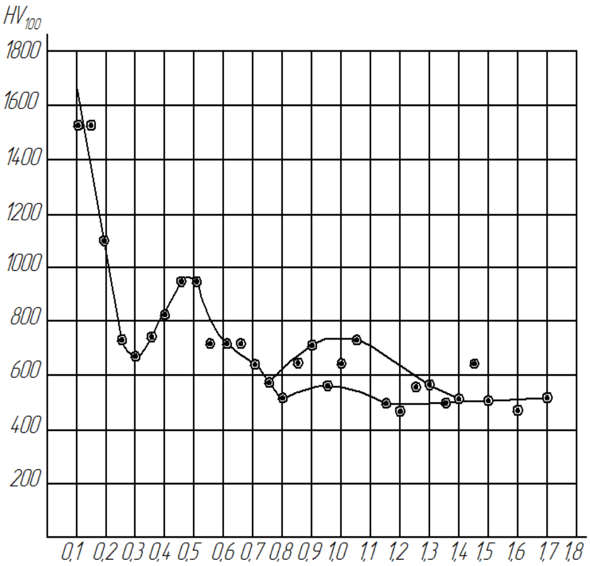


Fig. 2. *Changes in the microhardness of hard-allowed coating in depth from the surface of samples made of steel 35GL obtained by casting the gasified model.*

Because of the high alloying degree of the solid solution in the area of 0,3-0,4 mm depth an increased amount of retained austenite is found and microhardness decreases (fig.3). At the depth 0,6-0,65 mm from the surface of the coating metal base alloy has only martensitic structure, microhardness increases again. Further in depth of high-sublayer a monotonic decrease in microhardness is observed. The total depth of the layer with a hardness of not less than NV_{100} $500 \cdot 10^{-1}$ MPa (hardness of martensite of medium carbon steel) reaches 0,9-1,0 mm.



The distance from the surface of the coating, mm

Fig. 3. *The microhardness values in depth of hard-alloyed coating obtained by molding with the insert in the model of thickness 2,0 mm, after quenching at a heating temperature of 1150^{0}S and tempering 200^{0}S.*

It is obvious that the wear-resistance of high-chromium alloys depends on the state of the thin structure and metal substrate. On the level of defects in the crystal structure according to the dislocation density, which is located at the physical width of the X-ray line (211) α-phase [5], the results of the experiments are given in table 2.

Table 2

The density of dislocations in the crystal lattice of the metal substrate (α-phase) of hard-alloyed coating from the tempering temperature, $\rho \cdot 10^{11}$ 1/sm^2

Tempering temperature, ^{0}C	900-920	1000	1100	1150
Dislocation density	0,35	3,49	4,82	1,98

Table 2 shows that, the level of the dislocation density depends on the temperature and tempering and has an extremum at 1100^{0}S. However, during the tempering from high heating temperatures the amount of stable retained austeniteincreases, which reduces the wear resistance. Use of heat treatment with a double phase recrystallization eliminates this drawback.

The first phase recrystallization goes with heating to extreme temperature. Tempering ensures the formation of structures with a high density of dislocations. An intermediate abatement stabilizes the dislocation structure. Repeated phase recrystallization (in this case with heating 900-920^{0}C) goes in the conditions of inheritance under the initial substructure elements [6], but with minimal amount of residual austenite. The results are shown in table 3.

Table 3

Density of dislocations in the crystal structure (α-phase) of the metal hardalloyed coating bases depending on the temperature of the preliminary hardening, $\rho \cdot 10^{11}$ 1/sm^2

Low pre-hardening temperature, ^{0}C	900-920	1000	1100	1150
Dislocation density	2,24	2,33	3,63	2,33

The microstructure of all samples after re-crystallization of the phase at 900-920^{0}S - is coagulated primary and fine-dyspersated secondary carbides in fine-needled martensite basis with a minor amount of residual austenite.

The Introduction of thermal processing in technology of creation of hardalloyed coatings significantly increases their durability. Laboratory tests show that the abrasion resistance is in good agreement with the structural state of coatings. The laboratory results are shown in table 4.

Table 4

The size of wear of hardalloyed coatings with abrasive wear, depending on the heat treatment

Heat treatment, ^{0}S	Abrasive wear, g	Relative wear resistance, E	Parameters of the structure	
			Dislocation density, $\rho \cdot 10^{11}$ 1/cm^2	The amount of residual austenite in the metallic base,%
Without heat treatment	0,0064	1	-	-
Tempering 900^{0}S	0,0045	1,44	0,35	6,0
Tempering 1000^{0}S	0,0051	1,25	3,49	10,0
Tempering 1100^{0}S	0,0056	1,14	4,82	20,0
Tempering 1150^{0}S	0,0060	1,06	1,98	30,0
Tempering 1100^{0}S Abatement 650^{0}S Tempering 900^{0}S	0,0035	1,82	3,63	<10
Tempering 1150^{0}S Abatement 650^{0}S Tempering 900^{0}S	0,0038	1,68	2,33	<10
Note: Final abatement of all samples 250^{0}S				

As we can see from the results of research on the value of the abrasive wear resistance affects simultaneously on the amount of residual austenite and a fine-structure of the metal substrate. By adjusting the structural parameters hardalloyed coating (in this case, obtained by molding of gasified models) by heat treatment it is possible to improve the wear resistance. Only an introduction to the technology of manufacturing molded parts with hardalloyed coating hardening at 900-920^{0}S improves the durability by almost 1,5 times, and the use of heat treatment of double phase recrystallization increases the wear resistance by 1,82 times.

These results are in accordance with the results of trial field legs , and the point of the cultivator when it was found that heat treatment of workpieces with a wear-resistant hardalloyed coating increases the working time by 1,5 times, after the heat treatment aft with double recrystallization phase of 1,7.

4. CONCLUSION

1. Hardalloyed wear resistant coating of hypereutectic and eutectic compositions formed on the surface of the molded part which is obtained by casting on gasified froth-model, on a work surface which is applied carbide powder with a binder and a thickness of 2,0 mm.

2. When making molded parts with hardalloyed coating by casting on gasified models, on a work surface which is applied paste with powdered hardalloyed paste which is 2,0 mm thick, and 0,6 mm thick hardalloyed coating and and 0,8-0,9 mm thick high carbon sublayer is formed mm.

3. The wear resistance of hardalloyed coating which is obtained by casting of gasified model without heat treatment is not sufficient. Heat treatment of cast parts with wear-resistant hardalloyed coating by using a dual phase recrystallization increases abrasive wear resistance in 1,7 ÷ 1,8 or more times. This technology is implemented into production XK «Metallmexqurilish» with good actual economic effect.

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