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R. J. Bashirov

*Azerbaijan Technical University ,Azerbaijan*

F. R. Rasulov

*Azerbaijan Technical University ,Azerbaijan ,*

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# Formation of high strength and corrosion resistance composition cover on the surface of casting

R.J. Bashirov, F.R. Rasulov\*

Azerbaijan Technical University, Baku, Azerbaijan

E-mail: resulovfr@gmail.com

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The article is devoted in the casting process of alloying the surface of castings by impregnating the powder composition with liquid iron when pouring the last casting mold. It is established that the impregnability of powder with liquid iron depends on the temperature of the metal, the thickness of the coatings and the particle size composition of the powders.

**Keywords:** casting; composite coating; powder composite; spreading; the liquid glass; gray cast iron

## Introduction

In the modern time, due to the hardening of operating conditions in all aspects of mechanical engineering, as well as in the production of oil and ship equipment, strict requirements are put to increase the surface strength, corrosion and resistance to some external influences. When constructing machines, mechanisms and devices, in most cases such materials require that they have different complex properties. However, theoretical researches and the practice of metallurgical technology show that, in some cases, it is impossible to obtain any complex properties together. In most cases, the creation of such complex properties should be ensured on the working surfaces of the casting. Problems with this aspect can be solved by obtaining more bimetallic problems.

There are several methods are used for obtaining a coated cast iron: metallization with galvanic coating, formation of secondary layer with melting, chemical

recovery, diffused absorption, joining two metal together, mechanical force, discharging of liquid alloy on the working surface of casting which coated with powder, application of coatings on the surface by various methods, application of polymeric material on the surface etc. [1–4].

The latter method of obtaining coated casting is simple and economically profitable. With this method, it is technically feasible to obtain coating that meet different requirements, including corrosion resistance. From this point of view, the development of new technologies in the preparation of low-density steel and cast iron with chromium-nickel is one of the important issues of the day. With the application of new technologies, significant economic benefits can be achieved by increasing the operating life of oil, especially in shipbuilding and mining and other industrial equipments by reducing the corrosion rate of surface alloyed equipment.

Improving the surface of the details used in different areas of mechanical engineering, restoration of the wearing details and their high technical and economic performance are one of the main problems in the repair and technology. Development of science and technology allows to improve the existing technological process and create new ones. For example, it is possible to achieve the restoration of the dimensions and improve their properties along with the addition of various metals and alloys to the surface of them [5].

Corrosion of metals as a result of chemical and electrochemical effects of the environment, destruction of worked parts damage the national economy. As a result of corrosion, 35% of the total metal recycled is broken every year. According to the calculations, 60% of the corrosion metal is recycled in the metallurgical industry. Therefore, non-recurring losses is 10% of the total metal [1].

The effective way is using various types of protective coatings which sustainable for wearing, corrosion, a high strength, for reducing a metal losses and protection of parts. Destruction and damage of parts during the operation causes partial loss of work properties. Wearing, destruction occurs mainly on the surface of the material and causes to fail performed the function. Harmful processes, such as wearing of the worked surface which result of friction, chemical and electrochemical corrosion which result of the active chemical environment, deformation, heat and electro-erosion, diffusion, cracking, metal wear and etc. which result of different impactation, decrease exploitation period and durability of parts of equipment. One of the most important methods is to cover the coat on the worked surface.

Covered seals allow for the following advantages: not only ensuring equal strength, but also increasing the corrosion and wearing durability of separate parts of the casting; the casting giving different physical properties to separate parts of the casting; the possibility of obtaining high mechanical property and economically profitable casting via coating the working surface of sand casting mold and stuffies; it is possible to reduce consumption of expensive and rare material [5].

Depending on the thermodynamics and physical-chemical conditions, making the connection between casting and surface layers can be consist of the below stages which manufacturing with using powders: linkage between surface of

coating and liquid alloy in powders; solubility and mutual diffusion of the coating and liquid melt in boundary of separation; crystallization of the alloy with coating.

Thus, it can be concluded that the properties of coatings relative to conventional disintegrates vary widely, and its wide application can play a significant role in the development of casting technology. Coated casting increases the working capacity and longevity of the installed machines, mechanisms and equipment. Obtained coated casting have high corrosion resistance, wearing tolerance, durability, longevity, and demonstrate good results compared to conventionally produced details in the workflow. Increasing of property of exploitation develop the application of the coated casting in field as mechanical engineering, ship-building, instrumentation [5]. Therefore, production of the coated casting is an actual scientific-technical issue because of the development of exploitation capacity, economically profit, saving expensive alloying.

## **Purpose of the study, statement of matter**

Liquid-metal casting method involves the development of theoretical and practical provisions of the coating process with the participation of liquid and solid phases and, consequently, the improvement of the properties of the surface of the castings, and the restoration of the dimensions of the weared, undisturbed details.

To achieve the goal, the following scientific and experimental tasks have been identified: the analysis of the methods of obtaining coated cast iron in the casting process; studying the possibility of increasing the strength of the surface equipment which is obtained by absorption of the nickel-based powder; studying the mechanism of appearance of connection strength between the alloy and the coating material; development of theoretical provisions of the corrosion and wearing resisted covering process in the casting process; studying of diffusion process in interaction between alloy and coating material; studying of physical-chemical processes of crystallization and structure formation of casting; building a model of thermal conditions in the structure formation in the casting in the coating process; development of the mathematical model of the formation of coated casting; studying the kinetics of the interaction between material of the coating layer and the liquid alloy applied to the working surface of the mold; studying of the impact of the coating material on the formation process of the working layer metal; the effects of physical properties of the temperature and the material on the interaction between the liquid alloy and the coating material; studying of structure, physical-mechanical properties of casting after the complex alloying; studying of the phase composition of the produced diffused layer; establishment of analytical dependence between the properties of casting and the chemical composition of connective mixture which absorbed after absorbing with nickel-based powders; development of technological modes of bimetallic cast iron production, testing-industrial checking of the coating technological process, application of research into production and calculation of technical-economic efficiency.

## Solution methods and approbation of issue

The goal of the process is that 5–6% of the liquid glass is mixed with a powder, and produced porous powder sponge is drawn to working surface of cast mold or stuffing, mold is drained, is packed and filled with liquid metal [6]. As a result of the interaction between the liquid metal and the composite powder mold coating, surface alloyed high qualitical and high propertied coated cast is produced [7]. This method saves considerably more expensive alloying material compared to the volumetric alloying.

Nickel based PG–CrNi<sub>80</sub>SiB<sub>3</sub> brand powder (chemical composition 78–80 wt.% Ni, 15–17 wt.% Cr, 3 wt.% B, 0.2–0.3 wt.% C, 0.7–1.2 wt.% Mn, 1 wt.% Si, 0.75 wt.% P and 4.5 wt.% Fe) and CLASS 15 brand cast iron (chemical composition 3.3–3.5 wt.% C; 2.1–2.2 wt.% Si; 0.6 wt.% Mn; 0.15 wt.% S and 0.2 wt.% P) are taken for research [8].

PG–CrNi<sub>80</sub>SiB<sub>3</sub> brand powder is mainly in spherical form. The grain size of the powder is 50–200 μm. The powder material 5–6%, is mixed with liquid glass which density is  $\rho = 1.35\text{--}1.37 \text{ g/cm}^3$  density [9], 5, 10, 15 mm thick coat covers on the working surface of cast mold or stuffing [10]. The drained mold is dried in air for 8 hours after the coating is applied to the working surface of mold. The liquid cast is poured to prepared mold at a temperature of 1360–1440 °C, as the result of crystallization, surface alloyed high mechanical, physical-chemical propertied composition coated cast iron is produced.

The composition coating plays a unifying role between the powder layer and the casting. The powder layer is melt and is solved on connective surface because of the influence of the heated metal. As a result of melting of the porous powder layer, composition coating, alloyed cover layer is form on the connective surface of the two metals. The properties of the composition coating and the transition zone depend on the chemical composition of the combined metals, the degree of solubility of the jointly metals, the diffusion of one another, the formed chemical composition, and the crystallization of the heat and coat metal. The combination of two metals occurs either by atomic or reactive diffusion. In the case of atomic diffusion, a new phase, solid mixture occurs in the contact zone of metals. The transition layer forms in the tensile zone of the reactive diffusion zone of metal as a new phase, for example nickel and iron diffusion occurs at a temperature above 800 °C [11, 12]. During the formation of the alloyed layer, the casting method changes significantly the absorbing condition of liquid metal to the porous powder layer. In this regard, the absorbing conditions of powder layer researched in both centrifugal and sand-clay molding.

In the centrifugal casting method, mainly carving type cylindrical mold is made. In this connection, the properties of structural formation of carving type surface alloyed composite coated centrifugal cast iron are studied [13].

The technological process of the preparation of the surface alloyed composite coating casting consist of the formation of sponge of the liquid glass powder, its drawing on working surface of metal mold, drying of powder layer, collection of mold and pouring the liquit cast iron from special rabbet to rotated mold, the storing of liquid metal for absorbing by the porous powder layer, partly cooling,

removing of casting from suspended mold, its cooling in the air and control. The granular size of the PG-CrNi<sub>80</sub>SiB<sub>3</sub> powder particles we use is 0.2–0.063 mm. 5–6% of liquid glass is added to the powder and mixed [14]. The 3–15 mm thicker powder layer cover the working surface of the centrifugal mold [15]. For sample casting: cast iron which chemical composition contains 3.3–3.5 wt.% C; 2.1–2.2 wt.% Si; 0.6 wt.% Mn; 0.15 wt.% S and 0.2 wt.% P is melt in the ICT-1 branded induction furnace. Liquid cast iron is modified with amount of 0.3% powdered Al-Si-Ca ligatur in a 100 kg kilogram capacious scoop [16, 17]. After modification, the temperature of the liquid cast iron is  $1440 \pm 20^\circ \text{C}$ . The pouring temperature of cast iron to mold is 1340, 1380 and  $1420^\circ \text{C}$ . It is determined that composite coat is formed by absorption the liquid alloy to the pores of the powder layer and partial and complete melting of the powder particles of CrNi<sub>80</sub>SiB<sub>3</sub>. The effect of the cast iron temperature to the hopping depth and to the structure of the transition zone was investigated in the combined molding [18].

In order to investigate the structure of the transition zone, experimental sample were cutten from casting with a diameter of 102 mm, a diameter of 160 mm and a wall thickness of 43 mm, microscopes were made, and after carving they were looken with microscope. The size of the transition zone was determined by the change in the ratio of the structural organizer of the cast and composite coating and also by measuring the microcal hardness.

The result of the study shows that when pouring temperature of the liquid cast iron is  $1340\text{--}1360^\circ \text{C}$ , the depth of the absorbing layer varies from 1.5 to 2.6 mm, depending on ratio of the thickness of casting to thickness of the powder layer. The structure of the alloying metal consists of perlite and 5–7% thin-walled graphite ferrite. The width of the transition zone is 2.0–2.5  $\mu\text{m}$ . During casting process, the absorption depth increases at  $1390^\circ \text{C}$ . When temperature increases up to  $1420^\circ \text{C}$ , the condition of penetration of alloy to powder layer is improving, the particle frame ( $l=10\text{--}12 \text{ mm}$ ) disperses at depth, and the composition layer increases in the structural organizer as iron casting.

The amount of cementite in the contact zone of coating decreases and the perlite (austenite) grains enter into the molten zone of the metal coating under hydrodynamic effects of the centrifugal force. Hydrodynamics and hydrostatic events occur on the working surface under the influence of centrifugal forces, which determine the main condition for the filling of liquid metal to the powdered coated mold. Thus, the condition of absorption by powder layer, feeding, cooling and hardening of the composition coating change in liquid phase. Quality control of the surface alloyed composition coated casting indicates that during the rotation of more than 600 rpm and the thickness of the coating layer up to 5 mm, there is a local wash on covering layer of the working surface of the mold (probably from the hydraulic effect of poured liquid metal). When the thickness of the covering layer is 10–15 mm, this defect is completely eliminated and the quality of the formation of the composition coating is improved. The average pouring velocity of the liquid metal to mold is 2.0 kg/s.

The properties of the metal of the composition coating of the cast iron casting and structure change cause of partially melting of the powdered particles in liquid casting and the transition zone is formed between the powdered particles with

the powdered particles of component of the mutual diffusion the liquid solution of the casting and vice versa hardened cast iron casting in the contact zone and the "white composed" cast iron  $Fe_2(C,B)$ . It consists of a alloyed diffused complex carbide  $(Fe,Cr)_2C$ ,  $Cr_3C_7$ ,  $Fe_\gamma Ni(C)$  and the austenite, the diffusion of rich composed particles which formed in the casting composition [19, 20].

The composition coated gray cast iron casting is taken out from the mold in centrifugal machine at a temperature of 700–800 °C. The void space creates cause of sitting between the mold and the casting and the casting easily takes out from the mold. Before settling expanding occurs in composition coated engraved type casting at the same temperature, however compensation of expanding with settling ends at the temperature of 960–1100 °C. During the extraction, the gap between the composition cover and the mold is slightly less than that of ordinary gray cast iron.

## Investigation of obtained results

The metallographic study of composition coated metal which width and length cutted from sample was carried out in the grind. The Mim8 metallographic microscope is used for studying structure of the surface alloyed composition coated casting, cast iron and various reagents is used for the tanning of the samplings. 10 ml nitric acid (specific weight 1.42); 25 ml of chloride acid (specific weight 1.19); 20–30 ml glycerine contained reactive composition was used for tanning of the composition coated gray cast iron metal sample. Before tanning, the samples were heated for 10–12 sec in water, is undergone to tanning. 150 × 150 × 250 mm paralelipiped shaped casting is prepared for the testing. Examples were polished, washed in water, dried and oillessed in filter paper.

Absorbing quality was studied by using optical microscopy and strength measurement in tanned grind (samples). The absorbing quality in the composition coating is sufficiently high at a casting temperature when the temperature is higher than 1370 °C.

The centrifugal "CrNi<sub>80</sub>SiB<sub>3</sub>-gray cast iron" consists of two zones – the surrounding and the transition. The surrounding of the 2.4–4.2 mm layer of composition coating is formed from 9 to 11% cementit-ledeburit phase compacted powder particles. The distribution of chromites is irregular and its microbial resistance is 1250–1450 MPa. At high casting temperatures [21], chromium carbide and boride are observed in the borderline.

During absorption of the powder layer by liquid iron casting in the sand-clay molding process, the effect of the temperature of pouring of the iron casting and the thickness of the powder layer to structural emergency of is learned. The majority of the powder particles is seen as the initial formation in the structure of the surface zone of the composite coating of the CrNi<sub>80</sub>SiB<sub>3</sub>-gray cast iron with increasing thickness of the porous powder layer from CrNi<sub>80</sub>SiB<sub>3</sub> branded alloy.

During the metallographic study of composition coating of metal, its internal and external zones have been significantly differentiated, which increases with its thickness. Thus, when the thickness of the composition cover is 10 mm and

the casting temperature of the cast iron is  $1420^{\circ}\text{C}$ , 60–66% of the structure of the outer zone of the sample consists of the blended block and has been maintained in the original form in separate parts of the tail. However, the structure of the iron casting which enters the intercellular pores of the powder fraction, consists of thin sorbitrated perlite, ledeburite and little grain sized graphite [22, 23] (Figure 1 b,  $\times 500$ ).

In the middle section, 46–54% of the structure of the composition consists of molten or partially molten powdered particles, austenitic-carbide large grains perlite, and also relationships with separate vermicular graphite [22], (Figure 1 b,  $\times 500$ ).

The structure of the transition zone of the cast iron-composite coating consist of decreasing of the holding space of the powder particles and increased similar alloyed cast iron structure composition that consists of perlite and partially melted powder particles ( $\approx 17$ – $21\%$  of the observed shaft) involved austenite chain and little plated graphite (Figure 1 b,  $\times 500$ ). Due to the dissolution of particles in the liquid cast iron and its alloying with certain amount of nickel, chromium, and boron, the distribution of the zones on the thickness of the transition zone and the formation of the structure of the nirezist type of cast iron.

The result of the study shows that the structure of the composite coating is dependent on the pouring temperature of the liquid metal and the thickness of the powder coating. In contrast to the structure of the composition coating formed at pouring temperature of  $1380$ – $1400^{\circ}\text{C}$ , elevation of the pouring temperature by  $60$ – $80^{\circ}\text{C}$  helps to melt the particles in "coating-iron casting" sides and the central zone partly and in the contact zone intensively.

Reducing the thickness of the oven up to 5 mm thickens the amount of un-molten powder particles dramatically decreases, powder blocks meets gradually, their dimensions decrease by 2.6–3.6 times and are move away from each other (Figure 1 a and c,  $\times 500$ ).

The structure of the composition coating, which its thickness is 10 mm, is similar to the structure which its thickness is 5 mm. However, when the thickness of the coating is 5 mm, the composition coating has a large number of austenite, the expansion of separate areas occupying the austenite relative to the thickness of 10 mm is observed, the amount of graphite compounds is greater and the size is greater.

The separation of the austenite around the partially dissolved powder particles affect the  $\gamma$ -phase of alloyed nickel: the porous powder coating absorbs the liquid cast iron is initially chemical reaction on the contact surface between the particle and the alloy in the liquid phase. The cast iron is absorbed mainly with nickel.

It should be noted that all experiments for absorbing to a porous powder composite coating were carried out more than  $180$ – $260^{\circ}\text{C}$  from the likvidus temperature of alloy that is  $1420$ – $1480^{\circ}\text{C}$  for cast iron. Decreasing of dissimilarity in the structure can be achieved by increasing the casting temperature or by reducing the thickness of the powder coating and by reducing the cooling speed of the outer surface area of the composite coating metal. To do this, it is necessary to reduce the heat transfer from the composite coated cast iron to mold, using the exothermic heat protection coating on the working surface of the mold.

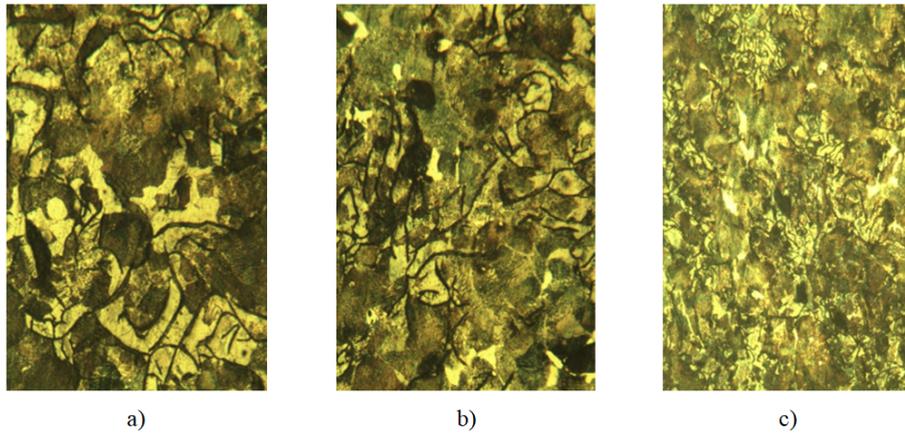


Figure 1.  $\text{CrNi}_{80}\text{SiB}_3$  – microstructure of composite coating of gray cast iron.  $\times 500$ : a – outer surface; b – center of the cover; c – contact zone. Wall thickness – 43 mm; thickness of cover – 10 mm. Casting temperature  $1460^\circ\text{C}$ .

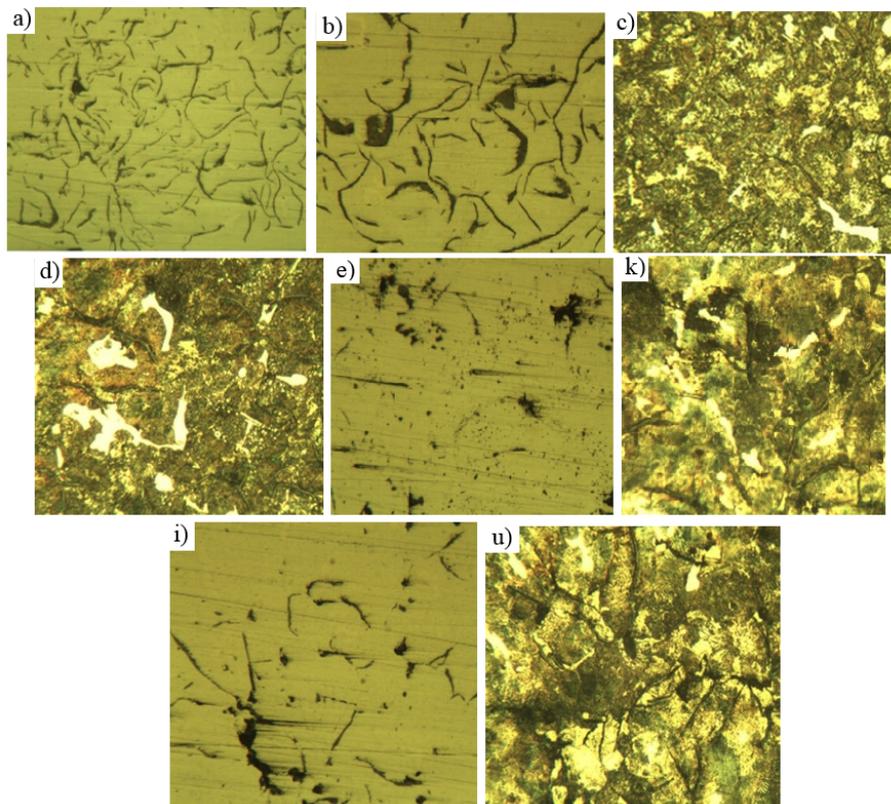


Figure 2. Microstructure of uncoated cast iron casting (a, b, c and d) with a wall thickness of 43 mm and microstructure of  $\text{CrNi}_{80}\text{SiB}_3$  gray cast iron (e, k, i, u) with 5mm thicker composite coating layer,  $\times 500$ : a, c – microstructure of uncoated cast iron casting on the free outside surface; b, d – microstructure of uncoated cast iron casting in the middle of the casting; e, k – microstructure of composite coated cast iron casting on the free outside surface; i, u – microstructure of composite coated cast iron casting in the middle of casting.

Analysis of the research of the structure of the " $\text{CrNi}_{80}\text{SiB}_3$ -gray cast iron" in the composite coated casting indicates the decline in the total amount of graphite. The dimensions of the compounds are reduced from  $300\text{--}320\ \mu\text{m}$  to  $160\text{--}180\ \mu\text{m}$  by increasing own thickness (without composite cover). Pearlite content in composite coated cast iron samples grows considerably and reaches  $83\text{--}90\%$  (Figure 2 e, k,  $\times 500$ ). Its quantity is  $55\text{--}60\%$  in primary composite uncoated cast iron. (Figure 2 c, d,  $\times 500$ ). The microstructure of thickness layer of the composite coated " $\text{CrNi}_{80}\text{SiB}_3$ -gray cast iron" with a thickness of 5 and 10 mm is

almost identical. Surface is dissimilar, mainly visible in the surrounding zone. There are plenty of unmelted powder particles in the surrounding zone of 10 mm thick coating and their dimensions are almost the same with initial condition ( $\approx 50\text{--}100\ \mu\text{m}$ ). In a 5 mm thick coating sample, their dimensions are reduced 4–8 times and range from 13 to 23  $\mu\text{m}$ . The thickness of the austenite segments increases around the melted powder particles.

It has been found that during casting of the cast iron at a relatively low temperature, casting at about  $70\text{--}80^\circ\text{C}$  lower than the casting temperature, does not allow an increase of the depth (1.5–2 mm) of absorption between powder liquid coating and cast iron. Raising cast iron casting temperatures up to  $120\text{--}150^\circ\text{C}$  allows the time interval between the start and final hardening to be increased to 5–7 seconds, it provides a dense composite coating up to 11–13 mm [24].

As a result of the tests, the mechanical properties of the cast iron (wall thickness is 40 mm) with 11–13 mm thick composite coating are much superior than the hardened cast iron without composite coating. It has been established that composition and dispersion of the powder coating do not affect to strength of the cast iron however basically the amount of graphite compounds affects. It has been observed that the limit of the tensile strength of the composite coating cast iron casting is higher than that of the uncoated casting.

As a result of tests of the composite coating material of casting, mechanical properties of nickel-based powder coated gray cast iron ( $\sigma_B$  and HB) are much higher than that of cast iron casting. The difference of mechanical properties of cast iron and surface alloyed composite coated casting is shown in Figure 3.

The stretching limit of strength ( $\sigma_B$ ) and hardness (HB) of nickel-based powder coated gray cast iron increase by 1.90–1.96 and 1.25–1.28 times, compared that to cast iron casting.

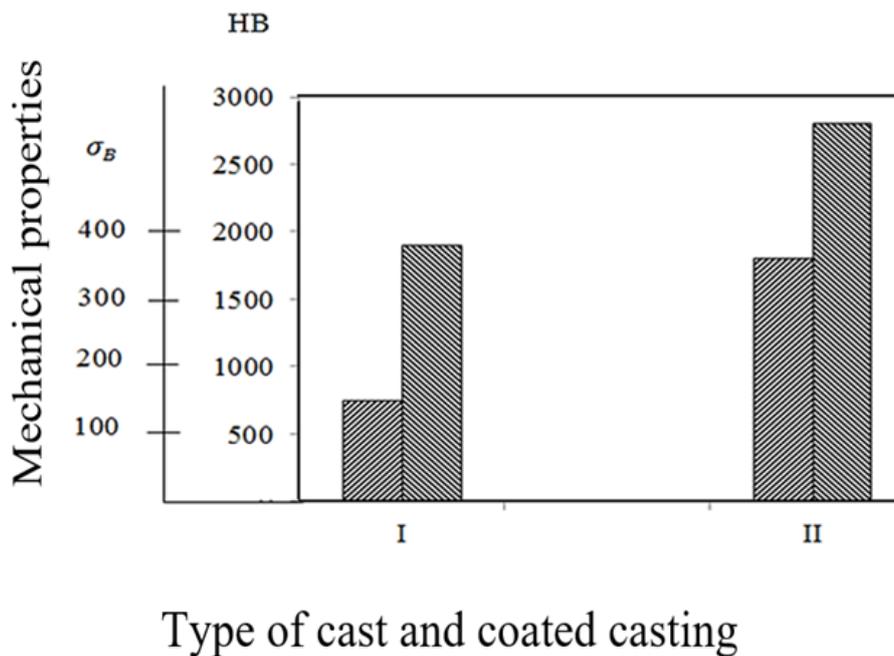


Figure 3. Comparison of mechanical properties of casting and surface alloyed composite coated casting: I – uncoated CLASS 15 brand gray cast iron; II – of nickel-based powder coated CLASS 15 brand gray cast iron.

The possibility of increasing the corrosion resistance of the cast iron casting on the working surface by surface alloying in the casting mold was investigated.

It is known that in the chromium nickel-base alloy powder, the chromium is main alloyed element in the nickel. So, nickel like iron and silicon is capable of solving a large number of elements. The main advantage of nickel in chromium alloy is its high corrosion resistance. The properties of chromium nickel-based alloys depend on the amount of carbon, sulfur, phosphorus like compounds contain in it.

In the electrochemical range, the nickel takes intermediate position  $E_{Ni^{2+}/Ni}^2 = -0.25B$ , therefore, it is more important than iron, and less important than chroma.

Nickel's passivation is increased by chromium and silica. Iron takes part with chromium has a positive effect. Nickel alloys with more passive element-chromium provide increasing of the corrosion resistance of the alloy due to preserving anode process.

The amount of the  $(Fe, Cr)_3C$  type carbide phase is increasing in the surface layer when the thickness of the powder layer for absorption is too less.

Reducing the thickness up to 5 mm at the optimum casting temperature of the cast iron ( $1420^\circ C$ ) helps to form a chain of interconnections on a layer between the insoluble powder particles and alloyed grains on the border of the cementite-ledeburit calony. This structure reduces the growing and expanding of the corrosion loss in a 5 mm thick composite coating sample.

The corrosion destruction spread equally around surface of sample which is 5 and 10 mm thick alloyed coated chromium nickel-based coating PG-CrNi<sub>80</sub>SiB<sub>3</sub>-gray cast iron composite coated casting. Corrosion shows local nature in the 5 mm thick composite coating sample and localized on surface of contact area with the thin ledeburit-cementite phase of the casting.

Thus corrosion destruction always starts from the surface and there is no need to increase the thickness of the composite coating.

In the example, the corrosion resistance test was carried out at room temperature with a commonly accepted method. The trial period was 5 to 100 hours. An example of corrosion resistance sample was assessed by mass loss in the initial surface area.

It is known that iron-carbon alloy is unstable in the mixture of chloride and sulfuric acid added water.

The corrosion resistance of metal of the composite coating of the differend thick "chrome-nickel based gray cast iron" composite coated casting in the chloride and sulfuric acid added solution is shown in the table. Corrosion resistance test results in the "Chrome-nickel based coated gray cast iron casting" composite coating material indicate that it is economically feasible to get a  $\approx 5$  mm thick composite coated casting, which helps to reduce the usage of rare chrome-nickel based alloy-powder in the section. Thus, it can be assumed that the amount of cementite-ledeburide in the composition coating increases with decreasing thickness of the powder layer in the material. On the surface of the sample, the concentration of nickel and chromium reach 50–52 and 8.0–10.5% respectively. This is more than the amount of nickel and chromium content of the corrosion resistance nirezist-cast iron (34–36% Ni, 2.5–4.0% Cr, 3% Cu). Therefore, the

"chrome nickel based coating-CLASS 15" composition material suspends the next step of corrosion in the aqueous solution of sulfate and chloride acid.

Table 1.

Dependence of the corrosion resistance depending on the thickness of the coat on the chrome nickel based coated-CLASS 15 the gray cast iron casting.

Material	Coating thickness, mm	Corrosion rate, g/(m <sup>2</sup> h)					
		The concentration of sulfuric acid at 20° C, %					
		1.0	3.0	5.0	10.0	15	20
CLASS 15	-	47.8	105.8	121.8	98.98	71.97	42.9
CLASS 15	3	0.030	0.103	0.171	0.215	0.109	0.082
CLASS 15	5	0.001	0.024	0.032	0.091	0.005	0.004
CLASS 15	10	0.006	0.030	0.082	0.105	0.002	0.007
The concentration of hydrochloric acid at 80°, %							
CLASS 15	-	81.989	498.969	224.885	309.863	276.983	300.785
CLASS 15	3	2.095	2.596	2.885	3.196	3.387	3.597
CLASS 15	5	1.806	2.029	2.065	2.179	2.194	2.396
CLASS 15	10	1.966	2.299	2.483	2.801	2.966	2.900

When the thickness of the composite coating is 10 mm, a diffusive layer with a homogeneous structure consisting of mealed powder particles form on its 2.0–2.5 mm thick surface area. In the depth of the composite coating materials, the two phase structure consists of a lighteburide colony covered with a alloyed thin layer of nickel and chrome which connected with cast iron and unmolten powder particles.

According to chemical composition intergranular, the "submerged layeburid ledeburit composition" is close to the acid resistant iron carbon alloys (steel and cast iron). In the composition cover, the amount of nickel and chromium is 22–28% and 3.5–4.2% in the diffused layer between the powder particles and the ledeburit colony of the cast iron. Corrosion resistance of 5 mm thick powder coated surface alloyed composite coated cast iron casting is higher than that of nirezist cast iron in sulphate and chloride acid mixture, but when the thickness of the coating layer is 10 mm, corrosion resistance is relatively low.

It has been established that when the coat layer thickness is 5, 10 mm, and the pouring temperature of cast iron is 1380–1420 °C, the composition cover has a high tolerance in 1–20% sulphate and chloride acid and is not left behind from the nirezist type austenite cast for acid resistance.

Comparison of the test results shows that corrosion velocity in the transition zone in all investigated composite coatings is relatively higher than that of the middle and surrounding zones.

During test of 5, 10 and 15 mm thick composite coated samples at 70 °C for 75 hours, they do not destruct and the corrosion rate is relatively high at 20 °C.

Thus, effective technological parameters have been proposed for obtaining high durability and corrosion-resistant surface alloyed composite coated casting. Technological processes have been developed for the preparation christmas tree, casing heads, valve parts, valve body, bolt, shaft and so on.

## Results

In the bimetal covering process, the creating mechanism of the surface alloyed layer is determined by used powder material, the method of pulling their on the surface of the mold and properties of the alloyed materials. Moreover, depending on the properties of these materials, the main role of processes can be done by melting, dissolving, filtering, diffusion, overheating. It has been found that in order to increase the depth of the absorption and to obtain a more similar structure of the composition coating according to thickness of the coating, it is necessary to reduce the thickness of the powder coating to 3–5 mm and raise the pouring temperature of the alloy to 80–100 °C from the melting temperature of the powder particle metal. The formation of the high quality surface alloyed composite coated casting occurs when thickness of powder layer is decreased to 3 mm and liquid cast iron is pouring at 1420–1440 °C and dispersion of the powder particles equals to 50–160 μm.

The result of tests of the composite coated material of the casting shows that the mechanical properties of the coating material ( $\sigma_B$  and HB) are 1.90–1.96 and 1.25–1.28 times higher than that of the uncoated cast iron casting.

It has been established that when the thickness of the powder layer equals to 5.10 mm and the pouring temperature of the cast iron is 1380–1420 °C, the formed composite coating has a high tolerance of 1–20% sulphate and chloride acid, and does not stay behind nirezist type austenite cast irons for acid resistance, tolerance is 42 times higher in 10% sulfuric acid.

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