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# STRENGTHENING OF WORKING SURFACES SHVYDKOZNOSHUVALNYH AGRICULTURAL MACHINES tungsten carbide

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*The article regularities obtaining wear-resistant materials such as powder karbidostaley based systems "chrome steel, chromium carbide" and development on the basis of working parts of agricultural machines.*
***Working bodies, abrasive wear, chromium steel, composite materials, durability, chromium carbide.***

**Problem.** The majority of modern machines and mechanisms is movable combination that provides the ability to perform their job functions, so the creation and development of new effective materials industry that can operate reliably in different conditions, represent an important problem in engineering and transport. From materials require low values of energy loss due to friction, high wear resistance, and in some cases, high corrosion resistance for use in harsh environments. These materials include powder materials with nerivnovazhenoyu structure without tungsten hard alloys and karbidostali. Carbide powders are heterogeneous composite materials, which consist of solid refractory compounds distributed in the plastic matrix of iron triad metals.

Bezvolframovi hard alloy is an alloy based on titanium carbide and karbonitridu cemented nickel-molybdenum-binding. They are characterized by a lower modulus of elasticity and a higher coefficient of thermal expansion that is sensitive to shock and thermal loads than tungsten-cobalt alloys, hard, and in some cases contain expensive and scarce nickel and molybdenum.



A distinctive feature of powder structural materials is their porosity, which may be adjustable within a wide range of physical and mechanical properties of manufactured parts. There are several methods for structural parts of high density. This is repeated pressing and sintering, hydrostatic, and hot isostatic pressing, rolling metal powder compaction beveled punch and metal shells, hot stamping porous workpieces, explosive pressing, extrusion, impregnation liquid metal sintering to form a liquid phase. Karbidostali in their properties are intermediate between hard alloys and tool steels. High hardness, wear resistance and the ability to maintain these properties at high temperatures determine the possibility of their widespread use.

**Analysis of recent research.** There currently are mostly rare karbidostali phase sintering. Their basis is often alloyed steels, including stainless steel, as well as solid component they use carbide or titanium carbonitride. The disadvantages of the known karbidostaley belongs carbide grains and increase susceptibility to oxidation during sintering, insufficient corrosion resistance. In the application of a number of methods required very high pressures, and this is a big operation mold. Therefore, the most successful are methods of forming metal-bearing parts that make it possible to obtain details of complex geometry at low pressure or without the use of special molds. Manufacturing technology gives a load-bearing parts of products or workpieces with sufficient strength, ductility, hardness, low residual porosity and other specific properties.

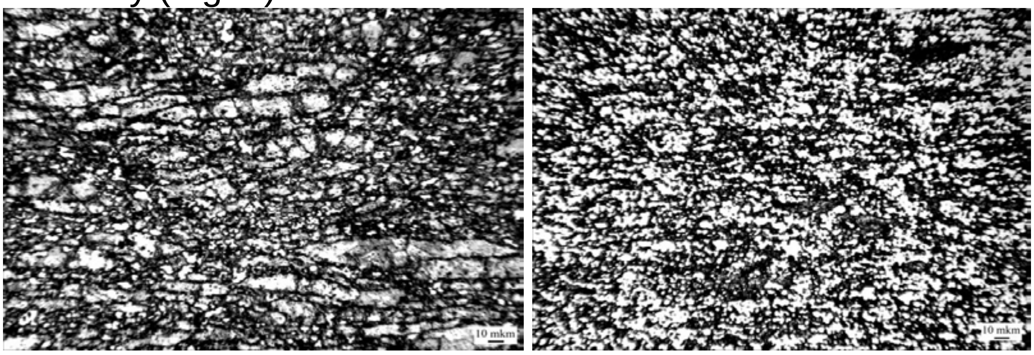
There have work to create karbidostaley on the basis of iron-chromium carbide. The downside is the lack of resistance to corrosion. Developed earlier Composites "stainless steel austenitic chromium carbide-class-molybdenum dysylitsyd" in Class triathl technical materials and have a coarse structure (with an average size of 50-100 microns), which affects the physical and mechanical characteristics. Strength properties of metal structural materials increased by doping iron base alloy. One of the most common dopants are chrome.

Alloys based on nickel chromium carbide (KHN) and phosphoric nickel (KHNF) bonds different set of important properties, which makes it possible to effectively use them for the manufacture of working in conditions of friction, abrasive wear, aggressive chemical environments and high temperatures. The first attempts to create a solid carbide alloys with chromium iron carbon bonds was done in [1]. Alloys held 20% bonds, which was the bleached iron with 3,8% C, were of high hardness (88 HRA), but had low strength characteristics ($\sigma_{bend}$=190 МПа). The interaction of titanium carbide chromium during sintering studied in [2,3], which the authors found that the sintered material has a new phase-TiC. Dissolution of chromium carbide takes place in the temperature range from 950 to 1250 ° C. Since TiC has a different type and lattice parameters than chromium carbide, we should expect that its formation is accompanied by a change in the size of the sample. When used in a mixture of titanium carbide particles of chromium, having a small carbon potential (particles less than 20 microns). In this temperature range dissociation of chromium carbide and titanium carbide formation in places of concentration of carbon. Details of chromium carbide alloys obtained from a mixture of powdered chromium carbide Cr3C2 and nickel pressing and sintering in protective environment at temperatures above 1200 ° C. Nickel may be 5-40%.

**The purpose of research** is to establish patterns of wear-resistant and corrosion-receiving powder materials such karbidostaley based systems "chromium steel, chromium carbide" methods rarely phase sintering, hot pressing and hot pressing impulse and development on the basis of working parts of agricultural machines.

**Results.** A large number of experiments devoted to the investigation of the effects of production on the phase composition of powder materials such znosokoroziynostiykyh karbidostaley obtained by sintering, hot pressing pulse (IGP) and hot stamping (GSH). Established that, regardless of the method of obtaining karbidostaley, chromium carbide is actively engaged with steel base, which is the diffusion of carbon and chromium carbide in a matrix, and iron - with a carbide matrix and accompanied by the formation of complex heterophase structures and increase the total number of carbide phase in material. The increase in the solid phase in the material leads to increased hardness and wear resistance.

An analysis of the impact of content on the structure of sintered components karbidostali, the effect of grinding microstructure with increasing amounts of chromium carbides from 7.5 to 30% vol., Allowing you to control structure formation to achieve the required properties karbidostaley (Fig. 1).




*a) b)*

Fig. 1. Microstructure haryacheshtampovanyh at 1200 ° C karbidostaley H17N2-7,5% vol. Cr3C2 (*and*), 30% vol. Cr3C2 (*to*), Annealed at 1150 ° C.

Established that haryacheshtampovana karbidostal has anisotropy base metal grains in the direction perpendicular effort stamping. The feature structure haryacheshtampovanoyi karbidostali is no transition zone in contact with the metal carbide grain base. It sometimes helps to increase strength karbidostali that provides general increase mechanical properties of the material.

The regularity and structure formation processes fazo- by local microprobe X-ray microanalysis on MS-46 Sames company, in the amount of consolidated samples znosokoroziynostiykyh karbidostaley - "chrome steel - chromium carbide" while grinding their pre-mixing. The analysis and the average composition of phases in karbidostali shown in Fig.

Selective microanalysis karbidostaley H13M2- (15, 30)% vol. Cr3C2 showed that karbidostalyah based H13M2 mechanism of interaction is like karbidostalyam based steel H17N2. To some feature of the microstructure karbidostali H13M2-15% vol. Cr3C2 carbide formation is Me3S after melting the sample at 1300 ° C. Karbidostal H13M2-30% vol. Cr3C2 after sintering at 1300 ° C is different preservation carbide Me23S6 along with newly carbide Me3S. What can explain the presence of molybdenum carbide which is an active element.

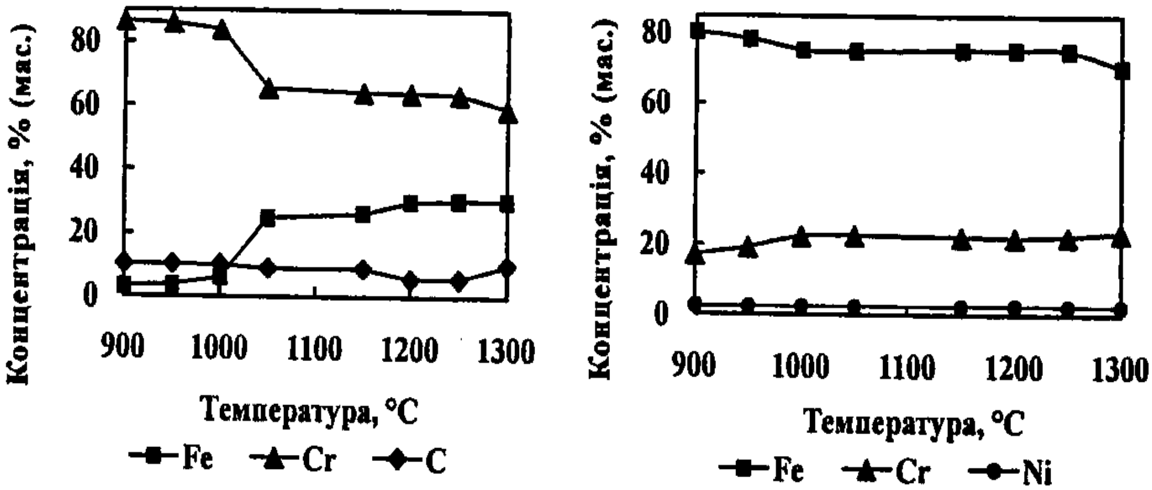



Fig. 2. Average composition of carbides (*and*) And grains of the matrix (*to*) In sintered sample at different temperatures karbidostali H17N2-15% vol. Sr3S2.

These X-ray diffraction studies on "drone-3" in Co-kα-radiation showed that the initial powder mixtures H17N2, H13M2 15% vol. Cr3C2 with lattice defects, which further influences on structure and mechanical properties karbidostaley. The study allowed us to establish the method of X-ray analysis phase composition karbidostaley, sintered at temperatures of 1150, 1200, 1250, 1300 ° C.

At a temperature of 1150 ° C sintering samples are composed of carbides Cr7C3 and Me7C3 with increasing sintering temperature to 1200 ° C and 1250 ° C (Fig. 3) - the structure remains available Me7C3 and appears complex carbide Me23C6. At a temperature of 1300 ° C sintering phase formed in Me2C karbidostali H17N2-Cr3C2, but karbidostali H13M2-Cr3C2 phase crystallized Me3C also observed traces Me23C6. The results coincide with the results of microanalysis and demonstrate active cooperation with steel chromium carbide matrix.

X-ray diffraction studies of the samples H17N2 Sr2S3 obtained by pulsed hot pressing indicate inherited grinding effect on the formation of the fine structure in these samples. The accumulation of strain in the samples increases the intensity of the flow diffusion processes during formation karbidostaley, this effect causes the accumulation of microdefects in the samples, resulting in an increased level of hardness (81-82 NRA).

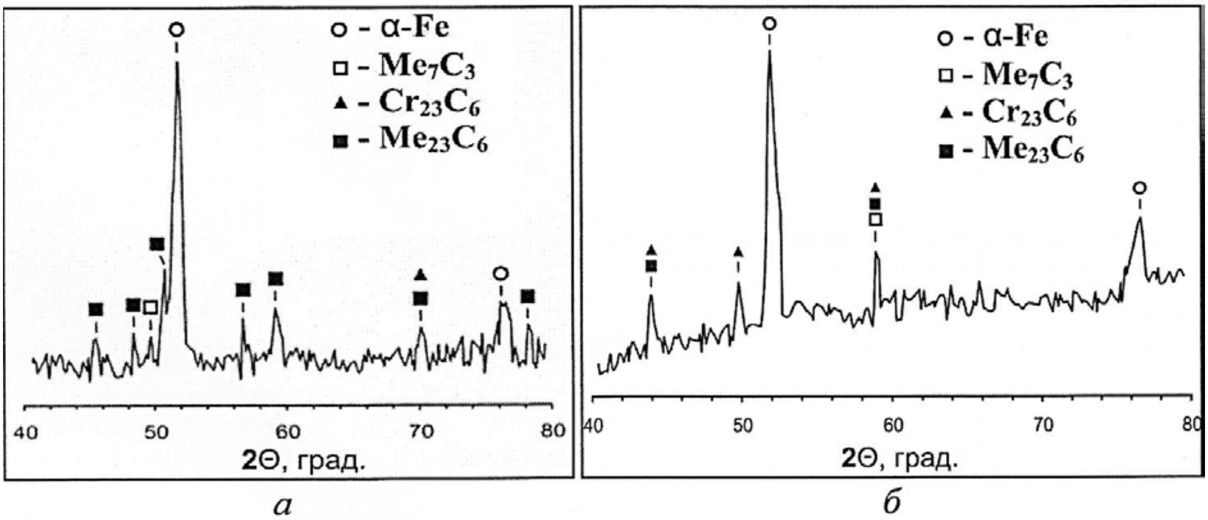
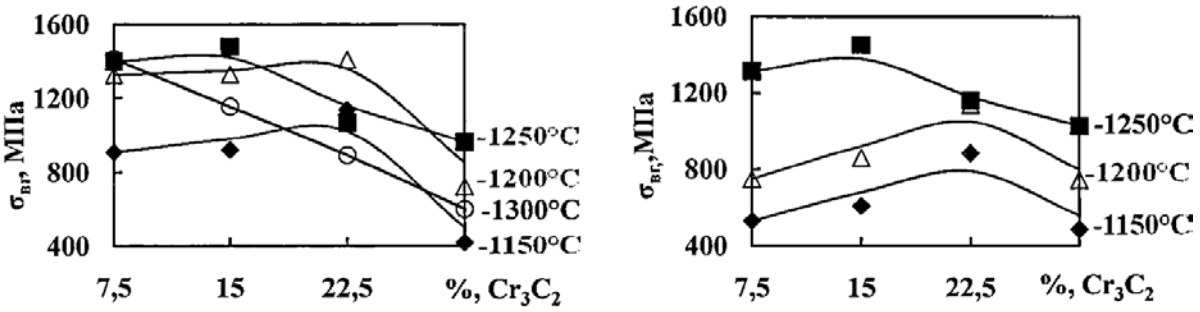



Fig. 3. The diffraction pattern karbidostaley H17N2 about. - 15% Cr3C3, (*and*) And H13M2-15% vol. Cr3C2 (*to*) Sintered at 1250 ° C.

The authors conducted a study of mechanical properties and corrosion resistance znoso- karbidostaley "chrome steel Sr3S2." Investigation of bending strength of sintered karbidostaley content Sr3S2 showed that with the introduction of its strength increases as compared with the original steel (H17N2, H13M2) throughout the sintering temperature range, reaching its maximum values of 1450-1470 MPa at sintering temperature 1200 and 1250 ° C (Fig. 4). Hardness karbidostali based H17N2 with increasing content Sh3S2 and sintering temperature increases and reaches a maximum (74 NRA) after sintering at 1300 ° C (Fig. 5). Karbidostali based H13M2 30% vol. Sr3S2 have the highest hardness (80 NRA) after sintering at 1250 ° C, which is due to close part of a martensitic region characterizing structural diagram Sheflera [6].

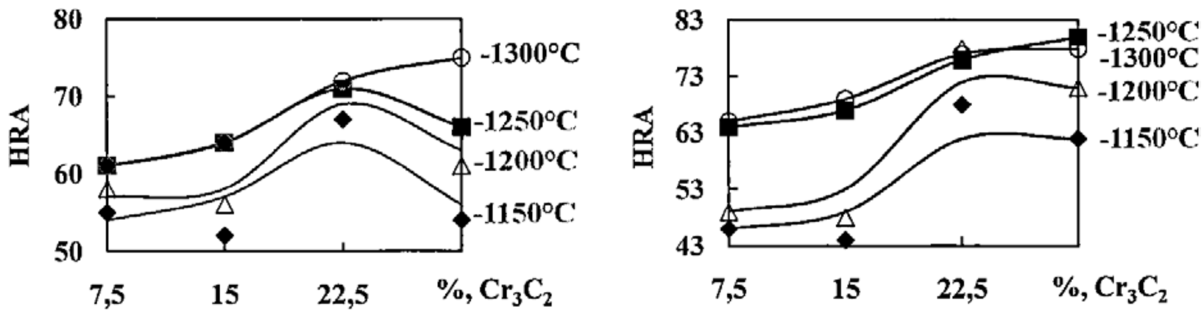
Some mechanical properties karbidostaley drop of 15% vol. chromium carbide in the temperature range 1150-1200 ° C to obtain can be explained by the fact that so many of the solid phase at these temperatures znemitsnyuye steel frame. When the number karbidostali

Sh3S2 22.5% vol. its composition is close to eutectic and who, at these temperatures, the significant amount of liquid phase mass transfer processes intensified, leading to an increase in mechanical properties. At 30% vol. Sr3S2, due to the increasing number of carbide phase there is increasing rigidity while reducing bending strength.




*a* *б*

Fig. 4. The dependence of the bending strength karbidostali the content of chromium carbide sintering at different temperatures: *and*) H17N2 steel; *to*) H13 steel M2.




*a* *б*

Fig. 5. Dependence of hardness karbidostali the content of chromium carbide sintering at different temperatures: *and*) H17N2 steel; *to*) Steel H13M2.

Karbidostal H17N2-44% vol. Sr3S2 obtained IGP has a hardness of 80-82 NRA but characterized by low flexural strength (400 MPa). This is due to high content Sh3S2 large and fragile material. Reducing the amount of chromium carbide in karbidostalyah obtained IGP increases the flexural strength up to 1350 MPa while maintaining hardness at 79-80 NRA. It is also possible due to the use of sprayed and not received calcium hydride-restoration H17N2 steel powder. The greatest influence on the strength and hardness karbidostaley based steel H17N2 received GSH causes the following annealing at 1150 ° C (Fig. 6). This can be explained by increased adhesion between particles and metal carbide phases and relieve tension and diffuse interaction between matrix and carbides.

Comparison of the results of the study of mechanical properties karbidostaley obtained by different methods suggests that the use of GSH leads to increased hardness karbidostaley 1.2 times compared with baked karbidostalyamy based H17N2, due to intense thermomechanical action GSH leads to fade effect thermomechanical processing. Flexural strength karbidostaley obtained IGP is on the lower level and is 400 MPa. In karbidostaley obtained by sintering and hot stamping one level of strength (1410-1470 MPa), while GSH karbidostali obtained at lower temperatures preheat than baked.

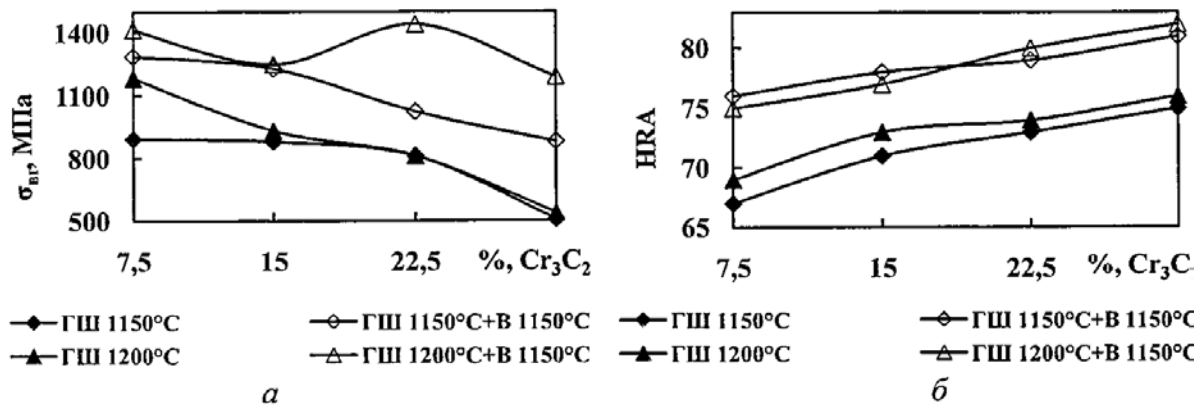



Fig. 6. The dependence of the bending strength (*and*) And hardness (*to*) Karbidostali the content of chromium carbide obtained by hot stamping (GSH) and GSH followed by annealing (B).

Investigation of crack karbidostaley obtained optimal modes of chromium carbide content showed that, as expected, increasing the number of solid component, along with increasing hardness, fracture toughness leads to a reduction karbidostaley (Fig. 7).

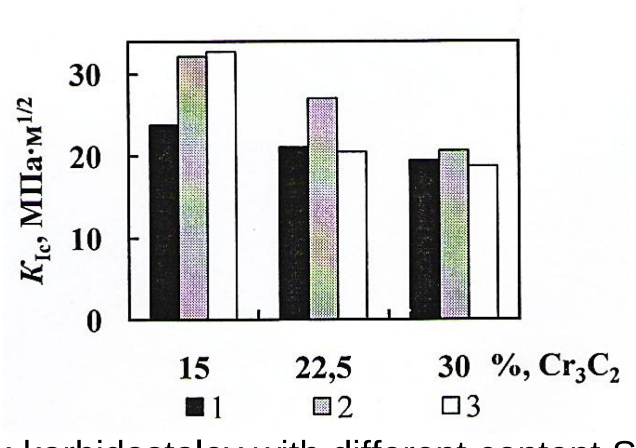



Fig. 7. crack karbidostaley with different content Sh3S2 at optimum temperatures get: *1* - H17N2-Sr3S2 (GSH obtained at 1200 ° C); *2* - H17N2-Sr3S2 (obtained by sintering at 1250 ° C); *3* - H13M2-Sh3S2 (obtained by sintering at 1250 ° C).

Fracture toughness of sintered karbidostaley different basis is approximately the same level as some of the fall in karbidostali H13M2-22,5% vol. Sh3S2 can be explained by the increase of microhardness base to ~ 4.5 GPa, and generally makrotverdosti karbidostali to 78 HRA. This is due to the formation of a liquid phase by close to eutectic composition, which intensifies the diffusion of carbon and chromium in the base, and iron carbides.

Karbidostali received hot stamping, with slightly lower fracture toughness than sintered karbidostali similar composition. This pattern is observed chromium carbide content of 22.5% vol. inclusive, then they crack and aligned within 19-21 MPa · m1 / 2.

Somewhat lower fracture toughness haryacheshtampovanyh karbidostaley can be explained nahartovanistyu structure. In this way we increase the value of hardness 79-82 NRA, leading to a drop in value of fracture toughness. In summary, we note that the investigated crack karbidostaley is high enough, such as fracture toughness of hard alloy VK21 - 11-13 MPa · m1 / 2, steel R18 - 21 MPa · m1 / 2.

The stability karbidostaley against abrasive wear on fixed particles paired with a diamond wheel. Tests showed that the wear resistance of sintered samples of powdered steel H17N2 and H13M2 low and increasing pressure more than 0.6 MPa leads to catastrophic wear [7].

Introduction Sh3S2 increases resistance to wear of sintered materials ~ 20 times compared with the original steel. Coefficient of friction karbidostaley based H17N2- (7,5-30% vol.) Sr3S2 decreases with increasing load (Fig. 8 a). Least endurance is karbidostal of 7.5% vol. Sr3S2, and the most resistant to wear - high in karbidostali carbide (Fig. 8 b).

Karbidostali based H13M2 durability are 1.5-3 times higher compared to karbidostallyu H17N2-Sr3S2. This can be explained by the presence of 2% molybdenum, which increases the diffusion mobility of chromium and lead to an increase in its concentration in the surface layers and which is known to increase wear resistance (Fig. 9, *and,* b).

Research results abrasive wear resistance of steel H17N2 samples (obtained IGP) have shown that they have been catastrophic deterioration during loading of 0.6 MPa. Introduction to charge carbide impurities significantly changes the nature of durability, increasing it to about 50 times. Comparison of durability karbidostaley shows that the intensity of wear karbidostali Sr3S2 13.5 times less than karbidostali of TIS. This may be due to the higher concentration of Cr in the metal component of karbidostali Sr3S2 also possible due to low intensity Tees interaction with a steel base and a weak adhesive bond between the particles of titanium carbide and matrix.

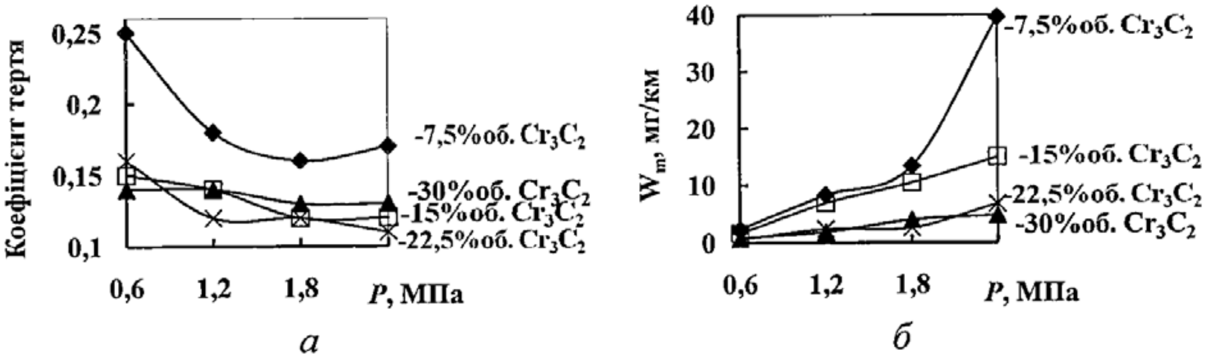



Fig. 8. Dependence of friction (a) mass and deterioration (b) the load karbidostaley samples from H17N2 with different content Sr3S2 obtained by sintering (1sp = 1250 ° C).

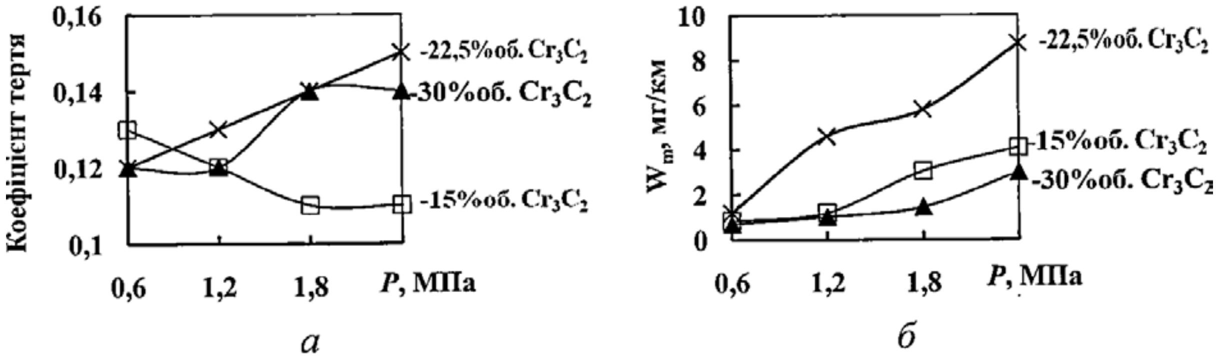



Fig. 9. Dependence of friction (a) mass and deterioration (b) the load karbidostaley samples from H13M2 with different content Sr3S2 obtained by sintering (1sp = 1250 ° C).

The study received GS durability samples showed that administration of chromium carbide increases durability by 10 times compared with the original steel. With increasing content Sh3S2 karbidostali resistance against abrasive wear increases (Fig. 10 b). The coefficient of friction for steel H17N2 and karbidostaley of 7.5 and 15% vol. Sr3S2 slightly increases with the load, and for karbidostaley high in Sr3S2 it decreases (Fig. 10 a).

Comparison of values of mass wear steel H17N2, and H13M2 karbidostaley on the basis showed that endurance karbidostaley obtained by sintering, IGP and GSH in ten times the wear resistance of steel output and increases with the number of carbide component. Coefficient of friction karbidostaley, unlike steel, decreases with increasing load abrasive wear.

Wear on fixed abrasive particles is a very hard process, in which is the direct destruction of the surface layer in this case, wear resistance and friction coefficient is determined by the mechanical properties of the material and its resistance to direct destruction.

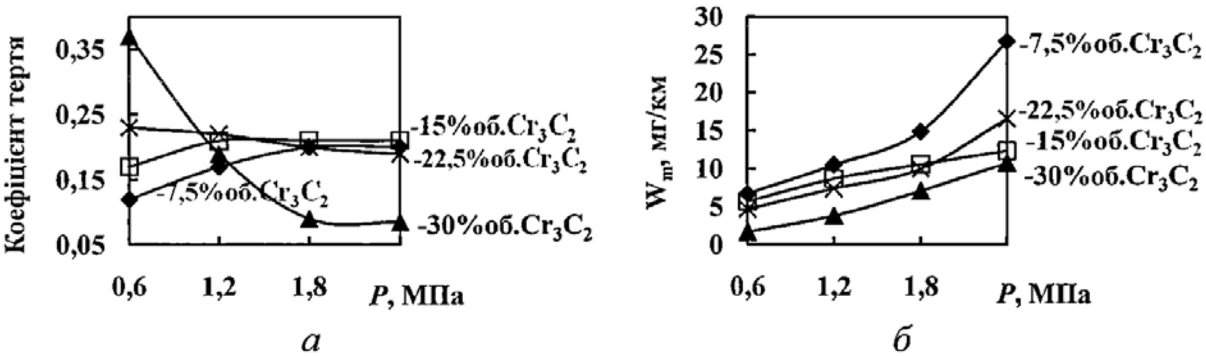



Fig. 10. Dependence of friction (a) mass and deterioration (b) the load karbidostaley samples from H17N2 with different content Sr3S2 received GS 1200 ° C + 1150 ° C in.

Karbidostali of 7.5% vol. Sr3S2 have low wear resistance compared to karbidostalyamy (15-30% vol. Sr3S2), regardless of the method of obtaining. It's probably just due to feature microstructure where there are significant size metal phase (average size of 35 microns) and the presence of porosity of 12%.

Increase carbide content leads to increased wear resistance, which caused increasing of the solid component by heterophase interaction with the base size and milling metal phase, abrasion wear on fixed particles leads to increased durability.

We investigated the corrosion resistance of materials in 3% solution of NaCl, 30% solution of NaOH and 20% solution of HNO3 at room temperature. Corrosion protection chosen based on literature data on corrosion resistance of steel output and anticipated applications.

Studies have shown that the corrosion resistance of sintered samples karbidostaley H17N2 and H13M2 15% vol. Sr3S2 30% solution reaches 10 NaON ball (completely resistant). Perhaps carbide additives during sintering actively interact with a steel base, in some cases increase the corrosion resistance of materials. With increasing content Sr3S2 30% vol. it decreases to 3-4 score (downgraded resistant). The 3% solution of NaCl only karbidostali of 22.5% vol. Sr3S2 with 10 scores with other formulations 2-3 score (slabostiykyy) (Table. 1).

***1. Corrosion resistance of sintered karbidostaley***

| Number of sample | Composition,% | | Relative density p% | Corrosive properties | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 30% solution of NaOH | | 3% NaSI | | 20% solution of HNO3 | |
| | steel | Sr3S2 | | P, mm / year | Score * | P, mm / year | Point | P, mm / year | Point |
| 1 | H17N2 | 7.5 | 0.95 | 0.06 | 4 | 0.48 | 3 | 0.54 | 2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | H17N2 | 15 | 0.96 | 0.00 | 10 | 0.26 | 3 | 0.09 | 4 |
| 3 | H17N2 | 22.5 | 0.95 | 0.28 | 3 | 0.00 | 10 | 0.03 | 4 |
| 4 | H17N2 | 30 | 0.93 | 0.49 | 3 | 0.36 | 3 | 2.53 | 1 |
| 5 | H13M2 | 15 | 0.93 | 0.00 | 10 | 0.33 | 3 | 0.11 | 4 |
| 6 | H13M2 | 22.5 | 0.95 | 0.41 | 3 | 0.00 | 10 | 0.06 | 4 |
| 7 | H13M2 | 30 | 0.97 | 0.03 | 4 | 0.59 | 2 | 0.31 | 2 |

* - A ten-point scale.

For corrosion resistance in 20% solution of HNO3 karbidostali based H17N2 and H13M2 belong to the class slightly lowered and stable, this indicates that the introduction of carbides reduces the corrosion resistance of the material in this corrosive environment. Karbidostal 30% vol. Sr3S2 is unstable in this solution and has 1 point corrosion resistance, this can be explained, on the one hand, relatively high porosity (up 7%) and intensive interaction with the solid component basis, leading to the diffusion of carbon in steel structures and formation martensytopodibnyh (microhardness base is 2,1-4,1 GPa), which reduces the corrosion resistance of the material as a whole [8, 9].

Corrosion resistance karbidostaley H17N2-44% vol. Sr3S2 obtained IGP vacuum is on the 3rd ball (slabostiykyy) in the studied solutions. This is significant nahartuvannyam structure.

Corrosion resistance karbidostaley obtained GS, 30% solution NaON score is 10 (completely resistant) to chromium carbide content of about 15%. including, but further increase in content Sr3S2 corrosion resistance drops to 4th ball (downgraded resistant). The 3% NaCl solution the opposite situation, relatively low corrosion resistance at the 3rd ball (weakly stable) has karbidostal of 7.5% vol. Sr3S2 (tab. 2), with karbidostali (15-30% vol.) Sr3S2 with 10-point resistance against corrosion. In 20% solution of HNO3 steel H12N2 has 1 point (unstable) and karbidostal H12N2-15% vol. Sr3S2 - 2 score (slabostiykyy), other stocks have karbidostaley 3 (slabostiykyy) point corrosion resistance.

***2. Corrosion resistance karbidostaley obtained by hot stamping.***

| Number of sample | Composition,% | | Relative density p% | Corrosive properties | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 30% solution of NaOH | | 3% NaSI | | 20% solution of HNO3 | |
| | steel | Sr3S2 | | P, mm / year | Score * | P, mm / year | Point | P, mm / year | Point |
| 1 | H17N2 | 7.5 | 0.99 | 0.00 | 10 | 0.14 | 3 | 0.81 | 2 |
| 2 | H17N2 | 15 | 0.99 | 0.00 | 10 | 0.00 | 10 | 0.25 | 3 |
| 3 | H17N2 | 22.5 | 0.99 | 0.09 | 4 | 0.00 | 10 | 0.16 | 3 |
| 4 | H17N2 | 30 | 0.98 | 0.09 | 4 | 0.00 | 10 | 0.16 | 3 |

* - A ten-point scale.

Thus, corrosion resistance karbidostaley largely determined by the ability of selective external action to the components of the material. At a time when the stability of carbide phase resistance than steel ties to the action of reagents, the total resistance of carbide - steel is increased with a decrease in the content of steel. Otherwise, there will be a reverse pattern.

We brought aspects of the practical use of research results. Fig. 11 presents the proposed technological scheme of production znosokoroziynyh inserts for hammers kormodrobarok.

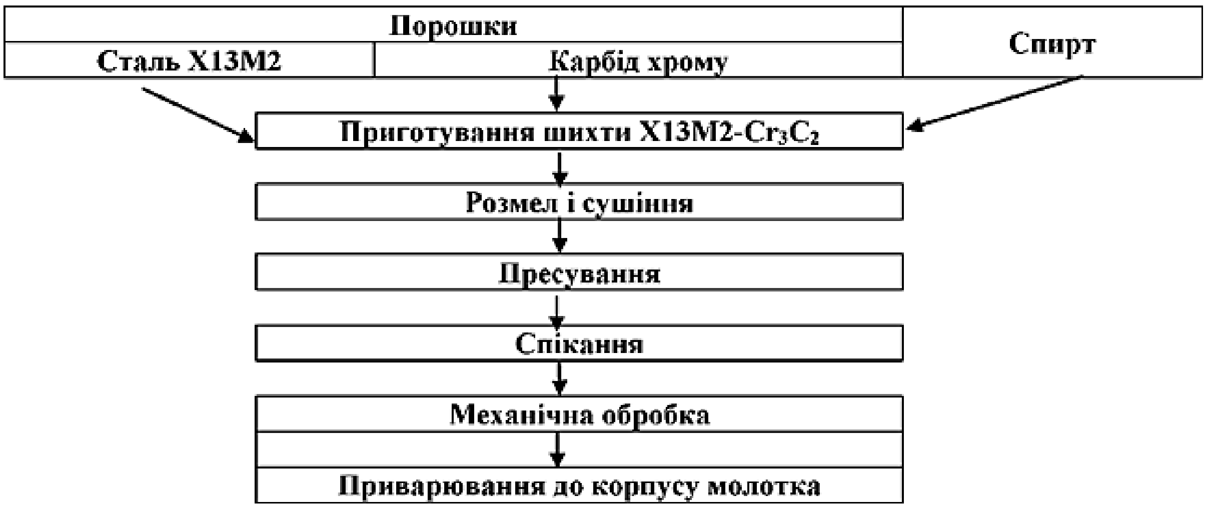



Fig. 11. flowsheet to produce a "modular inserts" to kormodrobarok hammers.

Performance testing was performed on hammers kormodrobartsi BMK-1 with grinding coarse grains. Along with hammers, reinforcing inserts with H13M2-30% vol. Sr3S2 (Fig. 12), proved hammers of base material with heat treated steel 65G. Durability hammers determined by changes in their weight. Production tests have shown increasing longevity experimental hammers, reinforced with inserts karbidostali H13M2-30% vol. Sr3S2, 2-2.5 times and improved technological operation grinding feed compared with serial hammers, steel 65G [10].

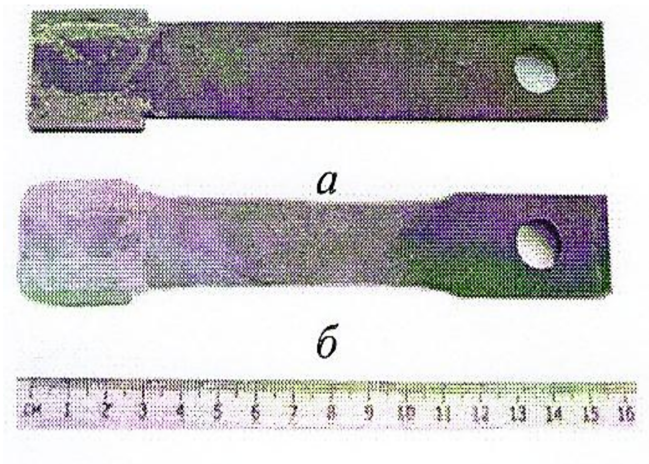



Fig. 12. Hammer Crusher BMK-1 with inserts of karbidostali H13M2-30% vol. Sr3C2 connected Electric (*and*- For testing; *to*- After production testing).

According to the results of tests that were performed in teaching and research farm at the National University of Life and Environmental Sciences of Ukraine, hammers, reinforced with alloy inserts H13M2-30% vol. Sh3S2 recommended for use in feed mills BMK-1.

## Conclusions

1. On the basis of "chromium steel X17H2, X13M2-Cr3C2, and data diagrams Cr-Fe-C, the results of microstructure, microanalysis and phase analyzes and studies the physical and mechanical properties, wear resistance and corrosion characteristics developed znosokoroziynostiyki powder materials: X13M2- (15-30% vol.) Cr3C2 and X17H2- (7,5-30% about.) Cr3C2 constructional purposes.
2. A production test hammers kormopodribnyuvachiv reinforced with inserts designed karbidostaley X13M2-30% vol. Cr3C2 in NUBiP of Ukraine "agronomic research station." Tests have shown increasing longevity experimental hammers 2-2.5 times and improved technological operation grinding feed compared with serial 65G steel hammers.

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*In this article set zakonomernosty obtain yznosostoykyh poroshkovыh materials based on the type of karbidostalej "hromystaya karbyd chromium steel" and development workers details organs agricultural machines.*

***Rabochie orhanы, abrazyvnoe yznashyvanye, hromystaya steel kompozytsyonnыe materials, Durability, karbyd chromium.***

*In paper conformities to law of receipt of wearproof powder-like materials are set to type of karbidostaley on basis of systems «chromic steel-carbide of chrome» and development of details of workings organs of agricultural machines.*

***Workings organs, abrasive wear, chromic steel, composition materials, longevity, carbide of chrome.***

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