METHOD OF COMPREHENSIVE SURFACE HARDENING OF STEEL PRODUCTS

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Introduction

One of the most important tasks of modern material science applied to technology issues is the need to ensure the surface properties of reinforcing products for over the tough conditions of their work. To solve this problem, it is now widely used methods for the application of protective coatings in the vacuum by physical vapor deposition on a protected surface to form compounds that are resistant to the destructive mechanical effects [1]. Obtained in this method coating provides high wear resistance, micro and nanohardness, but have a narrow area of practical application, because their operational properties are limited on load and efforts that can withstand the coating without punching. One of the promising ways to expand opportunities for the coatings is the use of complex methods of surface hardening involving preliminary hardening treatment of the substrate material and subsequent deposition of high hard coating [2].

The proposed method in this work relates to the field of functional coatings resistant to abrasion and fracture under load during operation and to methods of their preparation on the surface of steel products. This method can be used for hardening of precision machine parts and mechanisms, cutting tools, die tooling parts, bearings parts, parts of fuel equipment, also prospects in the fields of medicine and space applications where required high static load of surface in combination with a low friction coefficient and high corrosion resistance.

Materials and methods

The developed method is based on a combination of two complementary hardening effects: Thermochemical treatment of the surface with followed application of nanostructured TiN coating by reactive magnetron sputtering.

As the pretreatment used a low temperature carburization in powder mixtures, which enhances the fatigue strength about 50-80%, a rapid increase of wear resistance as compared with the carburizing and nitriding. Obtained nitride and carbide phases on the surface, don`t show tendency to gripe and subsequent catastrophic wear even without lubricant.

As coating used titanium nitride coating, which is widespread, cheap and has a high level of tribological characteristics. The coating may be alloyed by aluminum.

The microhardness values of the samples obtained in the measurement of hardness indentation recovery method with a load on the indenter 0,09-0,98 N. Nanohardness values obtained in the processing of the loading and unloading curves obtained on the machine Nanoindenter G200 (MES Systems, USA) according to the method of Oliver-Pharr [3] using a triangular Berkovich`s diamond indenter with a radius of curvature at the vertex 20 nm, indentation of nanoindentor to a depth of 200-300 nm. Tribological tests were carried out according to the scheme of dry sliding friction "shaft - block", wear was determined by the amount of wear for 1 h at normal load of 0.1 N.

Results and discussion

The microhardness of the surface of the composite - 9-10 GPa. Nanohardness is 28-30 GPa. Modulus of elasticity - 750-770 GPa. Stiffness - 2.3-2.5 N / m. The strength of adhesion between coating and substrate samples provides full coverage of coating on trials at attention by Erichsen`s spherica hole. The coefficient of friction is 0.35.

These results are explained by the appearance in the samples reinforce, by the proposed method, the extended transition layer with gradually increasing hardness between the base material and coating, damping gradient their rigidity and prevents punching coating. Abd forming a transitional diffusion layer between the substrate and the coating, as consequently, the diffusion engagement of the coating on a metal substrate.

The set values of wear resistance (Table 1) suggest that the known disadvantages of PVD / CVD coating and the existing technologies to produce laminates composite from steel and nanostructured titanium nitride can be substantially eliminated by pretreating of substrate. The values of the tribological characteristics of such a laminates system are higher than compared to composites having as a base alloying structural steel or Nitralloy.

Table 1 – Results of wear resistance

Index of wear-resistance	Surface condition			
	Untreated	After thermochemical treatment	Coated TiN	After complex processing
Linear wear, um	1073,3	1010,7	698,2	520,5
Volumetric wear ($\times 10^3$), um^3	1718,0	1435,0	474,2	194,9

A significant advantage of the proposed combined treatment is the ability to get away from the standard volume hardening treatment and finishing operation. The effective fields of use are: toolmaking, stamping production and technology of plastics, bearing manufacturing, machining and precision mechanics, weaving and textiles, general machinery parts.

Conclusions

Together with the collective of the Research Institute of Applied Physical Problems A.N. Sevchenko Belarusian State University led by F.F. Komarov developed a complex method of surface hardening of steel products using thermochemical treatment and vacuum ion-plasma technologies (applying high hard coating). The method allows to increase the microhardness up to 4,5–5,1 times, up to 4,1–7,0 times wear resistance and more than 2,5 times the corrosion resistance products of structural steels by forming on the surface the new composite material.

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