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EXPLORATION OF PASSIVE HARDNESS OF HARDENED SIMPLE STEEL IN CONDITIONS OF ABRASIVE CHAFING

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Results of explorations of a surface hardening and abrasive hardness effect on abrasive passive hardness of simple steel are presented.

General setting of the problem and its connection with scientific-practical problems

Abrasive chafing results in shattering machine components and losses of their serviceability.

For some machine components intensity of abrasive chafing during their maintenance attains 1 mm / h [1].

This aspect of chafing influences on details of agricultural, road - structural, mountain, transport machines and transporting devices, clusters of metallurgical inventory, cutting machines, landing gears of airplanes, vane wheel rotors and guiding apparatuses of hydraulic turbines, pipes of economizers, pipes of steam boilers, blades of flue-gas pumps, pipes and pumps of suction-tube dredgers, boring inventory for oil and gas industry, bearings of shafts of paddle wheels, bearings of propeller shafts of the vessels floating a shoal water, etc. [1; 2].

Tools of shredders of a percussion are exposed to especially intensive chafing [3]: working elements of pencil shredders with one or two twirled disks, deflecting pays of rotor and centrifugal - shock shredders and structural crumbs, forks of hammer shredders and blades of centrifugal shredders, etc. For the maintenance of termed assemblies, in particular at powdering of very much grinding materials, the resource of quickworn details is measured by days and even hours.

Soil, ground, ore, coal and muck, ashes, the dust which has hit on a friction surface, the metal chip, sulls, fixed on a friction surface or blasted, a carbon and yields of the wear, in particular the crumbled corpuscles solid structural components produce abrasive chafing.

Hardness of grit, their shapes and geometrical sizes, a loading, a travelling speed, physical-mechanical properties of an outworn surface, its structural condition and many other factors have a profound effect on the intensity of an abrasive chafing. A variety of these factors, and also their diverse influence on the processes of abrasive chafing impede the development of generalpurpose methods of protection against wear.

Related works and the analysis of unsolved problems

Many explorations [1–5] are devoted to the problems of abrasive chafing of metals, alloys and nonmetallic materials. There is a row of works [6; 7] in which different wear indexes are offered concerning abrasive and shock - abrasive chafing. The process of abrasive chafing and its aspects represent assemblage of mechanical, physical and physico-chemical appearances. At the same time the surface layers causing the mechanism of shattering during the abrasive chafing are formed. The analysis of the mechanism of the chafing testifies, that the onevalued answer concerning roles of external and structure factors does not exist.

As it is noted in work [4], not all structural changes are reflected in abrasive passive hardness of metal. So, for example, the superficially - plastic straining accompanying with structural change, does not influence resistance to chafing of steel and color alloys.

It is typical that for one metals the abrasive passive hardness varies after a flowage, and for others - does not vary, that testifies to dual influence of straining processes on character and kinetics of abrasive chafing about what it is emphasized in work [5].

To raise the passive hardness of the details working with abrasive chafing, technological and operational methods are applied. Among technological methods the special attention is given for raise of hardness of effective surfaces, however, the onevalued answer to this problem does not exist.

The purpose of exploration

The present work is devoted to exploration of influence of a method of a face hardening of steel 45 on passive hardness in conditions of abrasive chafing.

A procedure of exploration

Experiments have been lead with machine of a friction (fig. 1) which is used for a comparative sizing up of passive hardness of materials and plating at a friction at the presence of a loose abradant.

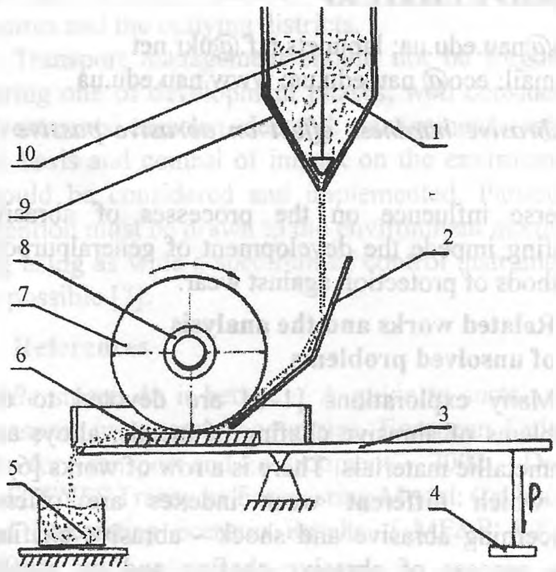


Fig. 1. Circuit design of the test facility:
1 – loose abradant; *2* – a chute for supply of abradant; *3* – the lever for adjustment of force of pressing; *4* – load; *5* – bunker for collecting waste abradant; *6* – a specimen; *7* – rubber roller; *8* – the cartrige for roller; *9* – bunker for loose abradant; *10* – the lever for a speed adjustment of supply of abradant

The method of definition of passive hardness taken over in explorations coincides with the polish standard [8] and is close to the American method under standard АСТМС 6585.

The substance of this method consists in the following. The specimen *6*, which sizes make 30 × 30 mm and thickness of 4 mm with the marked covering, was pressed with rubber roll *7* diameter 50 mm with which twirl the loose abradant *1* of the loading pocket *9* was moved in a contact zone. The force of a press was controlled with the help of the lever *3* and loads *4*. The feed rate of grit was controlled by the batcher of corpuscles *10*.

Explorations conducted at sliding speed of 0,158 m/s and a loading 44,1 H.

Testing for abrasive passive hardness was conducted in medium of arenaceous quartz (SiO_2) and silicon carbide (SiC) graininess with 120–160 μm. Before drawing of covering samples ground up to the roughness corresponding $Rz = 0{,}63 \pm 0{,}32$ μm. Roughness of surfaces was determined on the surface waviness recorder – roughness indicator of a sample piece 201. Wear was measured with a weight method on analytical balance АДВ-200 to within 0,0001. Before testing samples have been washed out in an acetone, baked and weighed.

In the capacity of a strengthening agent applied diffusive borating and a detonation spraying of oxidic covering, as perspective methods of inoculation of surface layer of machine components [9; 10].

Borating of steel was realized in powder blends at temperature 950°C during 3 h in welded containers of sheet heat-resistant steel thickness of 3 mm. In the capacity of saturating medium powders of technical carbide of boron (B_4C) were used, as activator aluminium fluoride(AlF_3) served.

Pressure seal of the container realized by induction of the meltable gate as which material the neutral water glass served. For displacement of air from an empty filling at a heating of the container a chip of petroleum paraffin was it utilised. A heating of the packaged container was realized in the electric furnace such as Г-30 with automatic control of temperature. After the termination of process of borating a hardening it is model by their refrigeration in running water was realized. After a hardening borated samples were exposed temper at temperature 350°C.

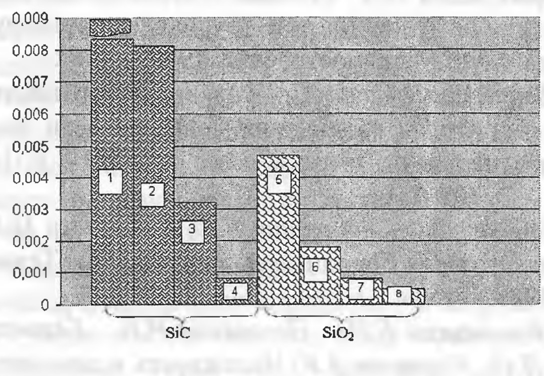
Structure of diffusive borated courses determined by pickling glazed hardened steel it is model 3 %-s' solute of hydrogen nitrate in ethanol. And piths measured microhardness of borated courses on microhardness gauge ПМТ-3. Phase composition of a diffusive borated matting determined a method of a X-ray phase analysis, using diffractometer ДРОН-2 with application of cobaltic Kα-radiation.

The diffusion layer on steel 30 comprised of two phases: highly borated phase FeB and low borated phase Fe_2B with microhardness 17–18 and 15–16 GPa, accordingly. Thickness of a diffusive boron course made 135 μm.

A detonation spraying of covering on a base of adamant was realized with machine constructed in National Aviation University. In the capacity of working gas used an acetylene-oxygen mix of composition $S_2N_2 \div O_2 = 1:1{,}2$. A spraying conducted at firing rate of 60 cycles/min. Thickness of detonation coverings made 150 μm. For evaluation test of spraid coverings determined the following parameters: cohesive resistance, porosity and microhardness. Cohesive resistance of coverings determined a pin a method. For explored materials at optimum behaviours of a spraying cohesive resistance of covering with a base made 30–40 MPa. Porosity determined at magnification in 100 times a comparison method with photomicrography of a scale of porosity. At optimum behaviours of a spraying porosity of covering did not exceed 1,5 %. Microhardness of the detonation matting consisting from γ-Al_2O_3 and α-Al_2O_3 made 11,5–12 GPa, and a covering containing except for γ-Al_2O_3 and α-Al_2O_3 oxide of titanium – 13–14 GPa.

Choosing of detonation oxidic coverings is stipulated by a unique combination of their properties, namely: hardness, reagent resistance, strength, refractoriness, good wettability of metal surfaces, practically the unbounded liquid solubility, resistance to chafing [11].

The received coverings tested for abrasive passive hardness in conditions of nonrigidly fixed abradant on the mentioned above procedure. Some effects of these explorations are instanced in fig. 2.



№	Covering	Wearing, g
1	St.30	0,0446
2	Al_2O_3	0,0081
3	Al_2O_3+TiO_2	0,0032
4	Br	0,0009
5	St.30	0,0047
6	Al_2O_3	0,0018
7	Al_2O_3+TiO_2	0,0008
8	Br	0,0003

Fig. 2. The diagram of weight wear covering on the Steel 30

Effects of explorations

According to fig. 2, maximal passive hardness has two-phase boron covering both in medium SiO_2, and in SiC, and minimum – detonation covering, consisting of adamants.

The diffusion layer on steel 30 comprised of two phases: highly boron phase FeB and low boron phase Fe_2B with microhardness 17–18 and 15–16 GPa, accordingly. Thickness of a diffusive boride course made 135 μm. Detonation covering, consisting of adamants and titanium takes an in-between position. Analysing the received data it is possible to conclude, that for data of test specifications estimating a value has microhardness explored covering. So, microhardness of high layer diffusive boron covering in 1,5 times is higher coated of adamants.

It is necessary to mark, that in medium of arenaceous quartz passive hardness of all explored covering is much higher as contrasted to their passive hardness in conditions of silicon carbide that speaks the greater microhardness of grit of silicon carbide in comparison with corpuscles of arenaceous quartz.

The additive in composition detonation covering on a base of Al_2O_3 a powder of oxide of titanium it is favourable influences on its passive hardness in these test specifications. Effects of these explorations coincide with the data received by us earlier [11] at testing detonation covering, drawn on medium-carbon steel the Steel 45.

The analysis of the received data testifies, that with increase of hardness of coverings their passive hardness increases, while for the steels tested in conditions of abrasive chafing, this regularity is not observed. Explorations [12] have shown, that different steels of equal hardness at testing for abrasive chafing have different passive hardness. It is typical, that steels of equal hardness and major plasticity have the greater level of passive hardness, i.e. to higher value of passive hardness of steel always will match maximal value of a contraction ratio in explored group of steels. Apparently reason of differences of passive hardness of steels of equal hardness can be explained by the composite character of an intense - strained state of metal on contact to an abradant at chafing when the taken root abrasive corpuscle moves on an outworn surface.

It is necessary to mark, that in conditions of abrasive chafing increase of hardness as explorations [13; 14] have shown, has the boundary lines. So, for test specifications [13] it is recommended to hold on to conditions:

$$H_m = 1{,}3H_a,$$

where H_m – hardness of a test material; H_a – hardness of an abradant.

The further raise of hardness of an explored material does not result in raise of its passive hardness.

Authors [14] consider, that raise of hardness of an abradant also has the boundary lines. This boundary line after which the further raise of hardness of an abradant does not result in change of ability for chafing, is determined by an interval relationship of hardnesses:

$$1{,}8 \le \frac{H_m}{H_a} \le 2{,}2 .$$

Boundary line of influence of hardness increase at passive hardness of explored coverings is not established.

For explored coverings, having tall microhardness, processes of a flowage are difficult, that reduces extent of a reinforcement during a straining of the microcollars proceeding at the first stage of chafing. Electron-microscopic studies have shown, that the shelling-out of solids of covering happens in places of concentrators of tension which pores are, scores, microcracks, phase boundaries, etc.

The further exploration should be directed on determination of the mechanism of chafing of coverings in conditions of an abradant, an interval relationship of hardnesses, kinetics of evolution of microcracks, determination of ways of decrease of microfriability of the coverings, possessing by tall microhardness, raises of their damping current capacity with the purpose of dispersing energy of a damping and decrease of the critical stresses promoting evolution of microcracks.

Conclusions

The lead explorations have shown expediency of application diffusive boron covering for a reinforcement of the details working under conditions of abrasive chafing. Among detonation covering on a base of adamants advantage have covering in which oxide of titanium composition enters.

Prospects of the further explorations

The received data about passive hardness coverings under conditions of abrasive chafing testify to perspectivity of application covering for a face hardening of machine components and the mechanisms operated in medium of an abradant. The further explorations should be directed on optimization of definition of tribotechnical characteristics of the covering, received by high performance methods and, in particular, high-tension alloying, laser machining, etc. in the abrasive medium exceeding hardness of silicon carbide.

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А.П. Кудрін, В.Ф. Лабунець, О.А. Вишневський

Дослідження зносостійкості зміцненої вуглецевої сталі в умовах абразивного зношування

Розглянуто результати досліджень впливу поверхневого зміцнення і твердості абразиву на абразивну зносостійкість вуглецевої сталі.

А.П. Кудрин, В.Ф. Лабунец, О.А. Вишневский

Исследование износостойкости упрочненной углеродистой стали в условиях абразивного изнашивания

Представлены результаты исследований влияния поверхностного упрочнения и твердости абразива на абразивную износостойкость углеродистой стали.