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WEAR RESISTANCE OF MATERIALS UNDER REVERSAL AND ONE-DIRECTED FRICTION SLIDING

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Wear resistance comparative testing of materials in conditions of one-directed and reversal friction sliding were made. Wear resistance of coverings, which were made from plasma and titanium alloy BT-22, under low speed friction sliding were determined. It was defined that wear under low speed in condition of one-directed friction sliding is much more greater, than in reversal.

Розглянуто результати порівняних випробувань зносостійкості матеріалів в умовах однонаправленого та реверсивного тертя ковзання. Визначено зносостійкість плазмових покриттів та титанового сплаву ВТ-22 при терті ковзання з низькою швидкістю ковзання, сумірною з фретинг-корозією. Встановлено, що знос матеріалів при низькій швидкості в умовах однонаправленого тертя ковзання значно вище, ніж знос у результаті реверсивного за однакових умов навантаження.

Рассмотрены результаты сравнительных испытаний износостойкости материалов в условиях однонаправленного и реверсивного трения скольжения. Определена износостойкость плазменных покрытий и титанового сплава ВТ-22 при трении скольжения с низкой скоростью скольжения, соизмеримой с фреттинг-коррозией. Установлено, что износ материалов при низкой скорости скольжения в условиях однонаправленного трения скольжения значительно выше, чем износ в результате реверсивного трения скольжения при одинаковых условиях нагружения.

Introduction

In any sphere where machines, mechanisms and different devices are used, the tasks of increasing their efficiency and duralibility are initial. Reliability and duration of that type of units where interaction between their parts is structurally embedded are caused by such phenomenon as friction and wear.

Wear leads to interruption of mechanism units tightness, accuracy of details’ arrangement and also to their mutual displacements. As the result, wedging, impacts, vibration are appeared. Eventually, they lead to failures of mechanisms. Friction, in its turn, causes the loses of energy, reheating of the mechanism units and as the result - the reducing of their effective work.

Phenomenon of friction and wear are interconnected: friction leads to wear, and wear of the detail surfaces causes the changes of friction.

Work resource of mechanism units usually is limited by the premature wear or destruction of the contacting parts.

These appear as the result of development of damages which are caused by such processes as one-directed and reversal friction.

The mentioned above processes are subspecies of such a phenomenon as friction sliding. It’s necessary to mark the special type of corrosion-mechanical wear under the alternating friction.

This name is fretting-corrosion. This process usually is observed in the immovable connections which exposed the vibration.

Under the fretting-corrosion the cyclical micro displacements in contacts of the details lead to deformations, intensive accumulation of structural defects, appearance of micro- and macro-cracks [1].

At the identical conditions of alternating and one-directed friction sliding the properties of the working surfaces differ. As the result, alternation of friction affects on the wear resistance of the machine details.

Analyses of researches publications

In techniques, low speeds under friction sliding very often are met. For example, in hinges of units, machine pillars, places where the vibration takes place and others. As the result of vibration under the action of fretting-corrosion the wear process appears. That’s why, it will be interesting to compare the material damages in case of alternating and one-directed friction sliding. These types of friction siding are parts of one process, but at the same time have their own peculiarities. It’s important to mark, that wear at fretting-corrosion and friction sliding – are the different types of surfaces wear. So, the comparative analyses should be made by certain criterions.

There exists some information about similar researches [2-4], but they don’t show the full picture of wear resistance at one-directed friction sliding and alternating friction.

In the work [2] author conducts the researches under different loading conditions at friction sliding in fretting-corrosion. But the comparative analyses of characteristics of one-directed and alternating friction sliding were not provided.

Authors [3; 4] made the similar comparison of processes of one-directed and alternating friction for construction models of friction processes. But really the comparative tests on the coverings and construction materials were not provided.

That’s why, it was decided to make the comparative analyses of materials wear resistance under reversal and one-sided friction sliding at low speed displacements of materials.

The aim of the work is comparison of the tribe-technical characteristics of plasma coverings at fretting-corrosion and one-sided friction sliding under identical loading conditions.

Researching methodic

That’s why, on the base of installation, named МФК-1, for tests on fretting-corrosion, the new installation was created. It allows to provide the investigations under low speed sliding in different environment and at the different temperatures [5].

The main features of this installation is replacement of recurrent-forward motion on the direct rotation with the given speed. It’s necessary to mark that there is the complete accordance of specimens for testing on friction sliding and fretting-corrosion.

This fact has the economical effect and expedience of comparative results under both types of wear. The another peculiarity of this installation is possibility to make the comparative testing of different steels, alloys and covering in the liquid and gases environment with the help of special chambers.

Installation gives possibility to conduct the comparative researches of steels, alloys, coverings and composite materials at small speeds of sliding in different liquid and gases environments under different temperatures.

The specimens are the cylindrical rollers with the diameter of 20 mm on which by means of plasma method the coverings ВКНА, Mo, ПС and ПГ were applied. The thickness of coverings equaled to 400 mcm. Except of this, comparisons were made on the titanium alloy ВТ-22, which was thermo-treated by the adopted in aviation regime of three-stages processing. This processing is stabilizing dropped and soft hardening on the air with the following aging. The specimens were made from the alloy 95Х18Ш.

The specimens with the plasma coverings and titanium alloys were used during the tests. The choice of materials is explained by the following: these materials are widely used in the aviation techniques.

As the comparative criterions during the experiment were taken into account the following:

– way of friction;

– sliding speed.

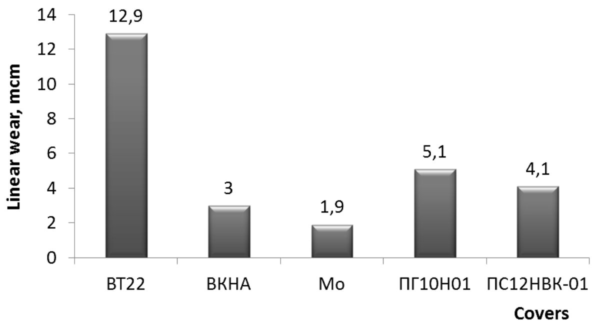
Investigations at the cyclical friction sliding were made under the loading of 20 MPa and amplitude of 50 mcm. Oscillation frequency remained constant and was 30 Hz. Tests bases was $5\cdot10^5$ cycles.

Under one-directed friction sliding as the confirmative criterions between researches at the cyclical and one-sided friction sliding were taken average speed of sliding, which was 3 mm/s, and way of friction 50 m. The tests were made in such a way, that work during l experiments was constant. Investigations of the change of linearity and intensity of wear of colored alloys were conducted on the air during the friction and without oil material.

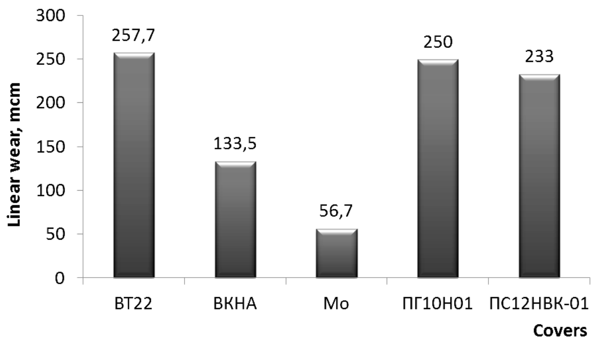
The linear wear of the immovable specimen was determined with the help of the vertical type optimeter ИКВ by the given number of cycles, the values of which determine the wear resistance of investigation material. The amount of experiments were three per each point.

The results of the researches

The results of the researches are shown on the fig. 1 [6].



a



b

Fig. 1. Histograms of the changes of linear wear of plasma coverings and titanium alloy BT-22:
a – reversal friction (fretting-corrosion);
b – one-directed friction.

Making the analyses of histograms of wear resistance of materials, we can talk about that fact that wear of materials at the one-sided friction is in ten times greater than at the reversal friction. That's why, it's very interesting fact that at the one-sided friction sliding wear resistance of titanium alloy BT-22 can be compared with the wear resistance of plasma covering ПГ10Н01 and ПС12НВК-01. At the realization of the similar condition of work in techniques, the titanium alloy does not require any coverings at all. Wear of titanium alloy and coverings ПГ10Н01, ПС12НВК-01 is practically the same.

The high wear of coverings ПГ10Н01 and ПС12НВК-01 is explained by their chemical composition and structure. Covering of the self-fluxing powder ПГ10Н01 is the alloy from parts of chromium, silicon and iron in the nickel matrix. Covering ПС12НВК-01 consists of three main phases, the main elements which determine the distribution of this phase are nickel 76% and chromium 18%, the rest is tungsten. At the one-sided friction sliding the solid parts of chromium and tungsten, which are inside the covering, crimp and intensively destroy the surface, like the abrasive material. Micro hardness of chromium parts and tungsten in the coverings is H_{m50} = 13,7 GPa [1].

This is confirmed by the topographies of coverings' surfaces of friction which are illustrated on the fig. 2.

Wear résistance of the titanium alloy BT-22 at the one-sided friction is approximately in 20 times less, than at the reversal friction sliding. During one-sided friction the gradual smearing of the titanium alloy on the material of contra-specimen 95X18 is appeared. Subsequently, the transferred titanium on the contra-specimen becomes harder and its micro hardness becomes higher in comparison with initial material. At one-sided friction appears the constant transfer of the titanium alloy BT-22 on the contra-specimen 95X18, it's explained by the high ability of the titanium alloy to anointing.

On the fig. 2, *k* is shown the surface of the contra-specimen with the anointing hardened titanium alloy BT-22.

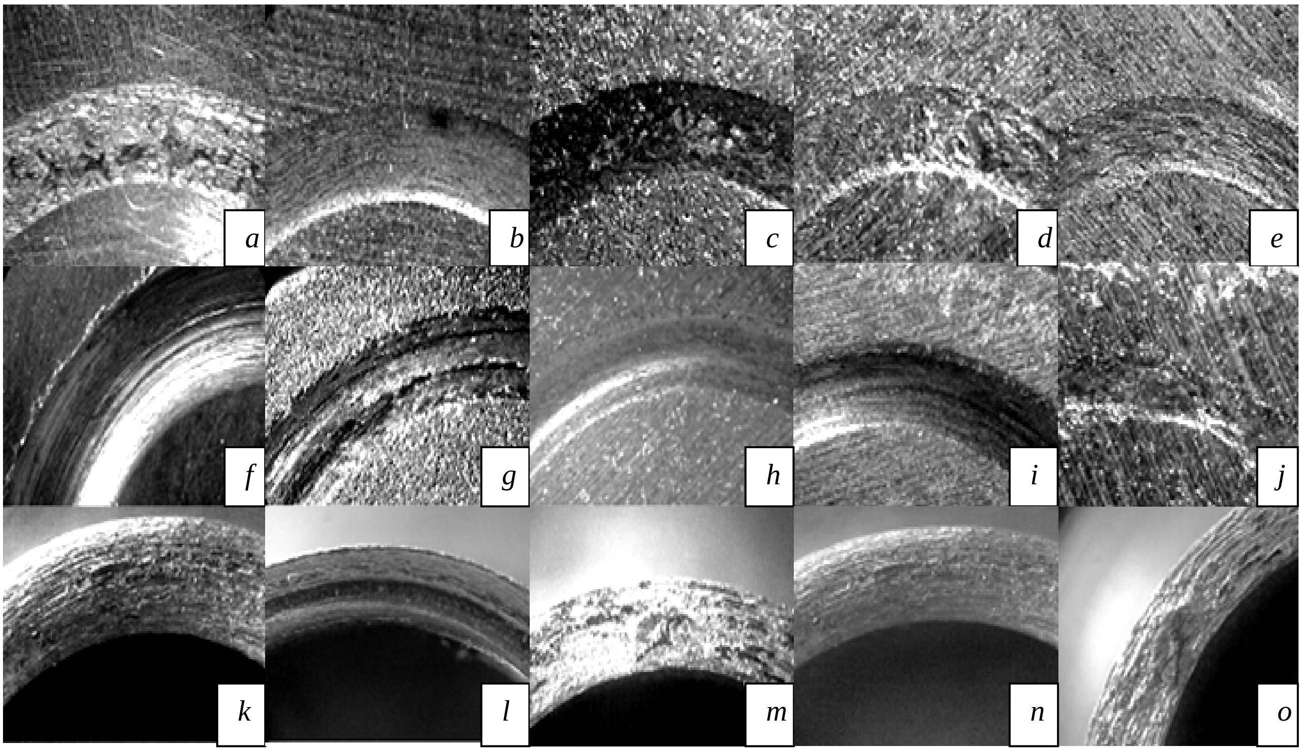


Fig. 2. Friction topography of specimens at fretting (*a,b,c,d,e*), friction sliding (*f,g,h,i,j*) and friction sliding contra-specimens (*k,l,m n,o*):
a, f – ВТ-22; *b*,
g – ВКНА;
c, h – Mo;
d, i – ПГ10Н01,
e, j – ПС12НВК01;
k – 95Х18 with ВТ-22,
l –95Х18 with ВКНА;
m – 95Х18 with Mo;
n – 95Х18 with ПГ10НВК01;
o – 95Х18 with ПС12НВК01

At the reversal friction of the titanium alloy ВТ-22 with the 95Х18 appears the intensive oxidation of the surface of both materials and formation of corrosion products. In this case wear intensity of the titanium alloy is usually proportional to the pressure, the friction coefficient obtains the values, which are closer to its values in case of friction titanium on titanium. The friction has the character of gripping. Rupture, of the improved by deformation and gassy bridges of welding, appears in the depth of surface of titanium specimens. As the result the surface of the steel contra-specimen becomes covered with the parts of adhering titanium alloy and the oxidation with the formation of TiO_2 takes place.

These oxides at the reversal friction sliding work as the hard oil material, which create the space between two surfaces of friction. At the one-sided friction sliding the oxides which appeared during the experiment pour from the friction zone, and it leads to creation of the new sites of settings.

The least wear between tested coverings at one-sided and reversal friction sliding has the molybdenum covering (fig. 1).

The high wear resistance of plasma molybdenum covering is explained by the specific of this covering. During the spraying inside the covering the hard small parts of nitro-oxides of molybdenum are appeared, their micro hardness is 13 GPa.

In the covering the “Sharpie’s rule” is realized. There exist the soft matrix for damping impacts during friction and the hard blotches for high wear resistance.

The covering ВКНА takes the mid position by the wear resistance between molybdenum coverings and ПГ10Н01.

It’s interesting to mark, that during the comparison of wear resistance histograms of tested materials we see the full compliance between them.

The wear resistance histograms of materials save their consequence as at the cyclical friction and one-sided. It may indicate the high probability of the results of experiment, and the designed installation can be used for determination the most wear resistance materials among the existing.

The high wear at the one-sided friction sliding can be explained by the fact that at the cyclical friction sliding appears the intensive oxidation of the surface and the created oxides work like a hard lubricant between two surfaces. At one-directed friction sliding oxides, which appeared as the result off friction, precipitate and the new surfaces of friction make contact.

During making the analyses of examples of the friction surface topography (fig. 2, *f*, *g*, *h*, *i*) we can say that all friction ways are smooth, without plucks and visible uncles, which appear as the result of testing on fritting-corrosion.

The friction ways of all tested materials have the cup form as the result of crumbling of the surfaces. More hard parts of the surfaces at the one-sided friction sliding, which are between friction surfaces, perform the function of abrasive parts, that is one of the reason of so high wear of materials at one-sided friction sliding.

Conclusion

So, on the base of the provided investigations the following conclusions can be made:

1. The comparative investigations of the materials at one-sided and cyclical friction sliding were made.
2. It was determined that wear resistance at one-directed friction sliding is in ten times greater than at the cyclical friction sliding in the conditions of fretting-corrosion. It’s explained by the formation of the oxides which work like a hard lubricant.
3. It’s determined that the consequence of the wear resistance of histograms at the one-sided and cyclical friction sliding (in condition of fretting-corrosion) is similar.

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