THE MECHANISM OF TRIBOLOGICAL INTERACTION OF A FERROMAGNET IN A DIRECTED MAGNETIC FIELD

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1. INTRODUCTION

The researches, the article deals with, are consideres as a field of engineering. Development of engineering and the exploitation conditions are being improved constantly, that increases the specific loading on the details of friction pairs. A considerable part of themachine park uses such mechanisms, that pass efforts by means of hydraulic systems, the power units of which are hydraulic pumps, plunger ones as well as gear ones.

2. ANALYSIS OF LITERATURE AND THE PROBLEM SETTING

It is known that everything "alive" and "conditionally non-alive" are under the action of the magnetic field (MF). Materials that have an electronic structure and are expressed by the existence of a crystal cell, instantaneously react to the action of an external MF, as the electronic structural component has its own MF.

Electrolytes and their solutions are divided into positive and negative components, actively perceive the influence of external MF.

Non-electronic structures or "conventionally non-electronic" non-crystalline structures, are interesting because of the directional change in the state of the friction surface under the influence of MF.

Weak magnetic fields (0,0005 ... 0,01 T) effectively affect long-term structural rearrangements of a wide class of materials and systems, causing internal and external changes in the structure. The physical nature and mechanisms of the influence of such magnetic fields on nonmagnetic materials are still largely unclear. In this case materials with low permeability ($\mu \leq 1.5$) para-, dia-, and antiferromagnetic (which may include non-magnetic metals and alloys and some steels) are transferred in the MF in accordance with physical laws in relation to the direction of MF lines (for example, diamagnetic - copper) [1]

Non-metallic materials such as polymers, wood, etc., all react to the action of MF, especially if they are in an unstable state, under the influence of external deformation loads, during which the interatomic bonds deform and collapse (twisted trees in the forest in swamps).

The basis of the orientational movement relative to the Earth is the interaction of the moving surfaces, the bond between them is friction (the interaction of moving surfaces - bodies). However, the directed movement is not always directed according to natural parameters such as the Sun (sunflower, flowers to other plants), the direction of the magnetic component of the Earth (precipitation of water floods on the coast of the seas and oceans, the orientation of birds, bees), the mutual influence of large masses (sunny wind), and so on.

Consequently, the change in the energy state of the friction surfaces is impossible to imagine without affecting the MF, which reflects on the electronic structure of the surface layers of the material, and are in an unstable state. At moments of friction, between the surfaces undergoes a restructuring of the structural component due to the transfer of electrons and nuclei, creating new materials and their properties. The comprehensive influence of MF on the environment, and its local effect, on the internal restructuring of the structure during deformation and the instantaneous increase of temperatures in the local volume, and all these parameters in aggregate change the external parameters of the tribological structure of the surface. Unstable conditions that are formed due to the relative displacement of the surface layers undergo instantly changing structure in the process of friction, which provides accelerated conditions for studying the impact of MF on the change in state of the material which under stationary conditions will continue for years.

The unlimited number of mechanisms have in their structure details of a different class of materials for which, all the time, the MF of the Earth (0,0005T) acts. Taking into account that all materials and substances obey the action of the MF greater (ferromagnets) or less (paramagnetics), or counteract its direction (diamagnetics or antiferromagnets) in this broad class, the conditions that will affect the formation of the third body during the friction are created. Ideally, it is desirable to find a mechanism by which it is possible to transform conditions against wear, that is, to direct the effect of MF opposite to enhance the internal tribological parameters of the system.

It is hypothetically possible to imagine if the MF is directed towards the surface, which, when rubbing, wears out faster (by displacing a positive gradient), then the conditions for the outflow of wear products (ferromagnetic origin), will be directed to the MF for an energy-unstable friction plane which, due to its structural imbalance "settle" on the surface layers by forming the new structural components.

3. THE RESEARCH AIM AND TASKS

The purpose of this study is to determine the conditions under which the parameters of external friction will change from the action of the MF, and to confirm the mechanism of transformation by a metallographic analysis of the surface.

The task of this work is to determine the tribological parameters of materials ШХ-15 and glass taking into account the different orientation of MF in the oil.

4. METHODOLOGY OF THE RESEARCH CARRYING OUT

The methodology of the study is based on changing the state of the material under the influence of MF in the process of friction. The flow of magnetic lines perpendicularly crosses the actual contact area (ACA) and makes changes in the processes of structural transformation when deforming the surface. The material of ferromagnetic origin most actively reacts to the influence of MF.

The counter body (CB) was the glass, a chemically neutral material with diamagnetic properties with an ideal surface and high hardness. Given the presented friction pair, it is possible to predict that in this case the research is reduced only to the surface changes of the sample (ШХ-15). Support and explanation of any scientific hypothesis is an experiment, therefore, for the determination of the behavior of the friction mechanism, a study was carried out using a sample of steel ШХ-15 hardened to hardness HRC 60 (samples were made according to ГОСТ 25255–82), and the CB - glass as absolutely firm body with excellent roughness in the conditions of the reciprocating motion according to the friction pattern of the finger-plane.

Experiment terms:

-in space: the sample is placed on the top, the lines of the MF through it, possibly in both directions;

- CB from the bottom lies in the bath with М10Г2к oil and moves progressively in the reverse-reverse movement;

-MF along the magnet wire is fed through the sample and CB to the other half of the magnetic circuit.

Consequently, the flow of magnetic lines (ML) is concentrated in the contact zone of the sample on a glass with a magnetic induction of 0,3 T on a path of 60 km with a velocity of 0,2 m / s in the middle of a CB with the length of 40 mm with a normal load of 0,6 kg on a sphere with diameter 6.72 mm.

Such a power causes the conditions of regulation by moving the software in an environment of oil in the contact zone.

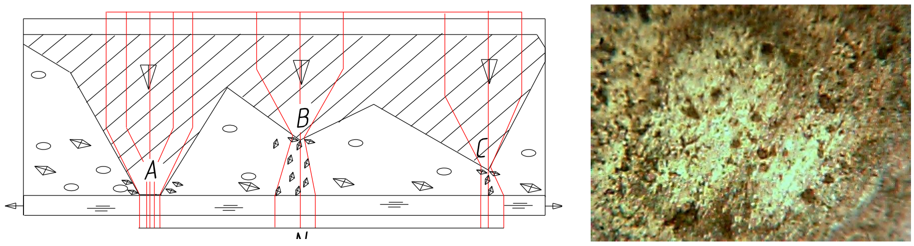
The object of scientific research will be the processes occurring in the surface layers of the sample with the formation of surface protective films (PF), changes in their parameters and properties.

The subject of scientific research is the discovering of regularities the processes occurring between physical objects (samples of friction surfaces and CB).

5. EXPERIMENTAL DATA AND THEIR PROCESSING

For carrying out of experimental researches was used the friction machine of reciprocating motion [2] under the scheme of the finger-plane.

Physical models. The justification of the physical model relies on the action of the directed MF to the products of wear (PW) relative to the ACA, and the zone adjacent to it. Taking into account that the flow of ML unevenly intersects the friction surface, depending on the roughness of the surface, the figure 1 shows the surface of the friction and the action of the MF in its direction from the sample and the conditions at which the software is assembled at the roughness points A, B, C. Each point will differently hold the PF on a tribocontact through which ML pass from the sample to the surface of the glass (diamagnetic). MFs are concentrated on the narrowing of the surface, collecting the ferromagnetic particles of wear at the sharp edges of the relief, holding them near the deformed surface where the accumulation of software around the contact zone is visible (fig.1b.). [3].



a b

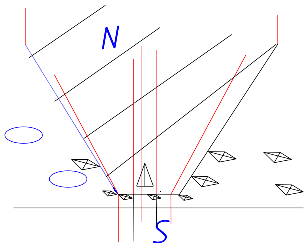
Fig. 1. (a) physical model, (b) contact area 300*

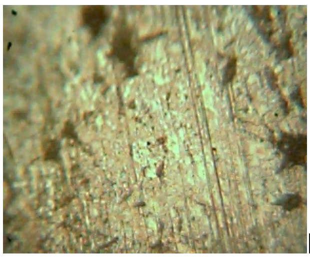
At the point A - at the end, will be kept and at the same time smearing the software on the surfaces of friction, their main mass will remain on the sample, which will have less hardness and easier to deform. It is proved, under static conditions, that the influence of MF facilitates deformation of the electronic structure in the volume of the material, which causes the magnetic-plastic effect (MPE), the material is easier to "float". [4]

Under the influence of MF, strength decreases, volume volatility of ferromagnetic material increases. Thus, the bulk of PF involuntarily "precipitates", that is, it is magnetized to the metal surface, while changing its internal energy. In the process of friction in the point A, when the contact is moved instantly, a temperature threshold that exceeds the Curie point is reached. In these conditions, the ferromagnetic material becomes a paramagnetic, which significantly reduces the influence of MF on the obtained period of time at this point.

But, in the points B and C, we will observe almost the same physics of the process, which consists in the collection of PF and when rubbed in the oil, larger particles will fall into the oil a little farther from the place of the ACA. That is, they will leave the area of operation of the MF. Small, on the contrary, will be kept around the acute zone until it is in contact with the CB (glass). Then the processes wich described in the point A will follow.

Figure 2 shows the surface of the friction conditions which pass with the direction of the MF in the direction of the sample. In this case, the SF will find a place on the path of the largest cluster of ML (Fig. 2) and will be pressed against the metal surface.





b *800

Fig. 2. Friction conditions in the direction of the magnetic field towards the sample (ferromagnet)

A significant accumulation of small SF will cause the effect of magnetic oils, in addition, the impact of MF softens the metal due to which it is well rolling on the surface and becomes brown in color (pictured) similar to protective films (PF). When the material is more fluid, the deformation processes are easier to pass in the surface layers of the material, therefore, the PF is smeared on the surface (Fig. 2b) on thin films up to (~ 0.5 ... 1 µm). The wear of steel ШХ-15 is almost 10 times less than without MF (fig.4, from 0,2 to 0,4 * 10-8 mm3 / km). On the surface of friction, first it is visually detected the directed formation of risks. in dark places on the picture 2 are assembled SF wich located in the depths in the form of dark conglomerates, but very few of them, the depths expanding appearing exfoliation. However, throughout the course of the work, lines are seen, in our opinion, these lines from the SF of a large fraction of the same material (ШХ-15).

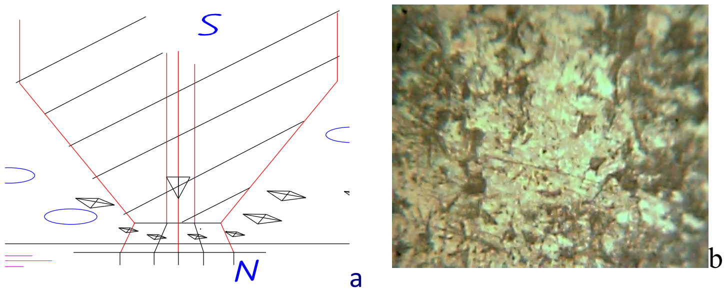


Fig. 3. Friction conditions in the direction of the magnetic field from the sample (ferromagnet)

Thus, in the direction of the MF, like all depreciation particles take part in the friction mechanism.

When directing the MF out from the sample (Fig. 3), the friction surface is characterized by less brown spots and larger areas of light. Black plaque in our opinion is a SF that remains magnetized to the sample. Indicators of wear also change in the direction of increase compared with the situation in Figure 2 almost 2 ... 2,5 times (Fig.4, from 0,7 to 0,9 mm^3 / km). The mechanism of work of the tribocouple is based on the direction of the energy flow of MF in the side of the counter body to the surface of the glass, from the ferromagnetic sample, although the SF will be guided by the sample. Traces of a larger fraction of SF were not found. Occasionally, significant conglomerates of SF up to 50 μm are observed. On the Figure 3 it is evident that conglomerates of wear products of a small fraction are collected around the contact area, from which thin films is formed.

Analysis of the topography of the friction surface the without the participation of the MF in the oil M10G2k after 500 hours of operation in the MF, reflects that films on the surface of the ШХ -15 steel are observed in thickness up to 5 ... 10μm, (Fig. 5) roughly smeared with sharp edges and cracks that break from the surface of friction and transferred to oil. Due to this, the sample has a significant wear (Figure 4, from 4 to 4 ... 6 * 10-8 mm^3 / km). The area of protective films on the surface of the friction reaches approximately 2500 ... 3000 $μm^2$.

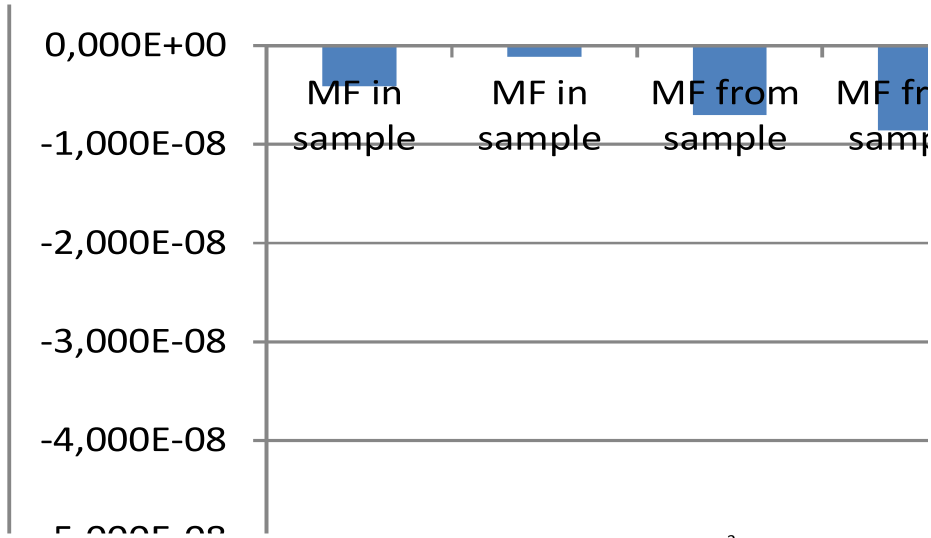
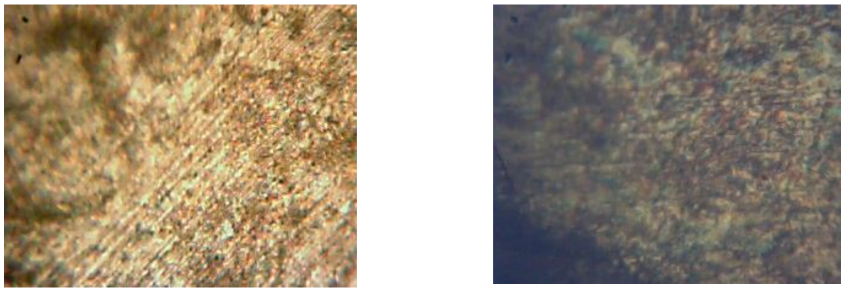


Fig. 4. Relative volumes of steel wear ШХ-15 в M10G2k, (mm^3/km), on a glass, 1,2-MF to the sample; 3,4-MF from the sample; 5,6- no MF



*300 *800

Fig. 5. Fractography of the friction surface of ШХ-15 on the glass in M10G2k (worked 500 h), (the oil is removed from the surface). For the experiment, oil was used after 500 hours in MF. On the surface small particles are distributed in the form of conglomerates

Thus, a significant difference in wear from the surface of a sample of steel ШХ-15 at tribological testing in three positions is justified by displacement of the energy flow of the MF in opposite directions.

6. DISCUSSION OF RESEARCH RESULTS

One of the most important parameters of wear is the reduction of the mass of material and the size of the friction zone, this value may be negligible in relation to the total mass and volume parameters of the detail. The difference between the surface of the friction and the area of the details can vary hundreds of times, so maintaining the working surface in working condition is an urgent problem to ensure the operational parameters of the entire mechanism. Even in the 50 years of the last century Selivanov O.I. [5] promoted the non-nominal parameters of friction units. At this stage of the development of mechanical engineering there were engines of millionaires, which usually took a step in scientific and technological progress, but the definition of the mechanism of restoration in the process of wearing did not find a broad definition and have not been thoroughly studied till this time.

During these times, numerous studies have been conducted with the use of alternative energy sources using the magnetic properties of materials, and collecting data on the impact of MF on materials and their properties.

In conditions of stretching of iron in MF there are no boundaries of domains in which dislocation is collected [6], processes of plastic deformation proceed at significantly lower efforts. Deformation of the material in the surface layers greatly facilitates the formation of wear-resistant films with a thin structure, similar to wear-free.

Ferromagnetic materials operate in MF to a temperature of 770 ° C, and then their magnetic properties are significantly reduced to the level of paramagnets. However, when the temperature drops, the magnetic steels return to the ferromagnetic state.

When changing its magnetic properties, the deformation parameters of the material change, which affects the positive gradient of mechanical properties, that is, it becomes a softer surface in the zone of point A (fig. 1). This is the zone that at the instant borrows all the loads and temperature increases of the curtain and decreases, by the time of its wear. At times, its area expands, decreases specific loads, which leads to a decrease in temperature and it again becomes ferromagnetic. The next line of point C and so on. Thus, the positive gradient of mechanical properties moves from point to point. According to the statements of Kragelsky B.I. to select a good friction pair, the minimum implementation of the second plane is necessary. In our model, this glass fulfills these requirements and has a smooth surface, which reduces the risk of abrasive wear.

It has been experimentally established that if the size of the abrasive particles contained in the oil or other fluid does not exceed 5 µm, they adsorb the oil oxidation products, which can reduce the intensity of wear of the details. Particles of larger sizes begin to cause damage. If there is less than 5 µm of particles in the lubricant, wear rate is 0.3 mg / h, and with particles of 10 µm - 0.92 mg / h. The firm "Vikers" (Great Britain) provides for the hydrosystems the following particle size distribution: 0 ... 5 µm -39%, 5 ... 10 µm - 18%, 10 ... 20 µm - 16%, 20 ... 40 µm - 18 %, 40 ... 80µm - 9%. [7]

The results of wear with a difference of almost 3 times, depending on the direction of the MF are based on increasing the deformation component, and, in our opinion, the separation of the products of wear due to the transfer of oil, which rinses larger particles of wear at a distance from the contact. In the case of directing the MF from the sample, the SF is shifted, which removes them from the magnet and reduces the strength of the hold in the friction zone. Thus, the direction of the MF from the sample repels particles of wear and they lose the ability to return to the friction zone. It is known that the force of the MF decreases in the cube to the distance of action.

The coefficient of friction is distributed with the increase from the conditions. In Figure 2 with ШХ -15 on the glass it is equal to 0,05..0,08, with the passage of MF from the sample slightly increases to 0,09 ... 0,1. The largest is within 0.1 with friction without MF.

The additional gradient of the friction pair between the ШХ-15 and the glass in the environment of the oil is created due to the presence of oil and an increase in the deformation component on the surface of the ШХ-15 from the impact of the MF and the direction of the ML that affect the displacement of the software from the surface of the friction. In addition, the appropriate pair is a glass with a characteristic of a rigid body and a stainless surface on roughness. Thus, the collection of factors provoked a reduction in wear and a justification of the structural components of the surface of the friction.

Scientific novelty is obtained due to the introduction of auxiliary energy friction technology in the direction of the MF, and taking into account the physical changes of the material from the action of the MF.

Practical significance. Ability to create friction conditions at which the build-up of the surface with wear material (matrix).

7. CONCLUSIONS

The basis of the mechanism of wear in the MF is saturation of the surface of the friction by ferromagnetic wear products that receives the lubricant from the operation of the mechanism.

With the direction of the MF to the surface of the sample, all the wear products involved both the scratchs and thin films.

If the direction is from the sample the scratchs is not observed but there is a fine-grained structure.

Friction surface without MF has a rough topography with the formation of SF with thickness up to 10 µm.

In the use of oil after the friction in the MF, it is not find thick SF on the friction surface of the sample, and instead of them there are thin SF spots, which suggests the use of fine fraction SF.

The proposed restoration technology in the process of operation is recommended for use in the nodes friction pairs.

REFERENCES:

[1] Vonsovsky S.V. Magnetism. Magnetic properties of di-, para, ferro-, antiferro-, and ferrimagnets. [Magnetizm. Magnitnyye svoystva dia-, para, ferro-, antiferro-, i ferrimagnetikov] M .: Nauka, Ch. Ed. fiz. -them. lit. 1981. - 1032 p.

[2] A device for studying materials for friction and wear in reciprocating motion [Prystriy dlya doslidzhennya materialiv na tertya ta znoshuvannya pry zvorotno-postupal'nomu rusi.]. Patent for utility model. No. 45574, G01N 3/56, Application u200908003, July 29, 2009. Pubwished Nov 10, 2009, Bul. No. 21. - 8 p. Svirid MM, Kudrin AP, Zadniprovskaya SM, Loveiko MG, Morozova IV.

[3] Dikov A.G., Zelinsky V.V., Borisova E.A. Influence of the magnetic field on the wear of rail steel [Vliyanie magnitnogo polya na iznos relsovoy stali] // Modern high technology. 2013. – № 8-1. – C. 98-99.

[4] M. A. Vasiliev. Features of plastic deformation of metals and alloys in a magnetic field [Osobennosti plasticheskoy deformatsii metallov i splavov v magnitnom pole]. M. A. Vasiliev, G. V. Kurdyumova of the National Academy of Sciences of Ukraine, Uspekhi fiz. meth. / Usp. Fiz. Met. 2007, v. 8, p. 65-105.

[5] Boyarskikh GA, Boyarskikh IG THEORY OF AGING MACHINES [TEORIYA STARENIYA MASHIN]Educational and methodological manual for practical exercises and independent work of students Technology of transport processes, 4th ed, Rev., and augmented. Ekaterinburg: Publishing house of the USMU, 2015. 47c.

[6] D. S. Kamenetskaya, I. B. Piletskaya, V. I. Shiryaev, FMM, 35, No. 2: 318 (1993)

[7] Zakalov, O.V. Basics of friction and wear in cars [snovy tertya i znoshuvannya v mashynakh]: Textbook / O.V. Zakalov, IO Zalac - Ternopil: Publishing House TNTU them. I.Polyuya, 2011. - 322 pp.

ABSTRACT

The mechanism of tribological model of ferromagnetic material ШХ-15 on a neutral countertile is substantiated, the effect of wear on the zone of actual contact under the influence of magnetic field (MF) in the М10Г2к oil is shown. With the direction of the MF to the surface of the sample, all the wear products involved both the scratchs and thin films. If the direction is from the sample the scratchs is not observed but there is a fine-grained structure. Friction surface without MF has a rough topography with the formation of SF with thickness up to 10 µm. In the use of oil after the friction in the MF, it is not find thick SF on the friction surface of the sample, and instead of them there are thin SF spots, which suggests the use of fine fraction SF.

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