THE EVALUATION OF WEAR RESISTANCE OF THE TRIBOLOGICAL COUPLES WITH SPRAYED LAYERS IN THE PLASMA JET, DURING THE STARTING AND STOPPING PROCESSES

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INTRODUCTION

The formation of the sprayed layers in the plasma jet.

The thermal spray process consists of a group of processes for achieving thin layers, in which the fine metal or non-metal powders are deposited in the molten or semi-molten state, to form a coating with properties required by the field of application.

The thermal spray process with plasma is based on the formation of the plasma jet in which the powders are introduced. The materials are melted, mixed and projected on the base material, thus achieving covering layers -composite type.

The principle consists in passing a powder material by plasma jet - generated by an electric arc of plasma generator. Due to high temperature the powders melt and are entrained by the gas to the base material. The particles in plastic state adhere to the surface of the base material due to specific mechanisms. The impact between molten particles and the substrate leads to their solidification on the substrate forming thereby the deposition [1, 2, 5].

The thickness of the deposited layer affects the adhesion, by its more frangible character. The spray distance is an essential key factor for determination of a certain value of adhesion.

The defects that may appear at the layers deposited in the plasma jet [1, 5].

- The layers deposited by the thermal spray process in the plasma jet may contain defects such as pores due to the choice of inappropriate spray distance, or if the powder is not calcined (presents clusters).

- Exfoliation type imperfections that may result from the deposition of materials with different thermal expansion coefficient to that of the substrate.

- The inappropriate interface between the adhesion layer and substrate, the presence of microcracks, defects of continuity related to distribution and variety of micro-porosity.

- Segregation of the density of the unmelted powders of the compounds dispersed in the basic matrix.

- Increased remanent internal tensions which leads to the layer destruction.

MATERIALS AND METHODS

The resistance to wear of the sliding bearings with resistant layers formed in the plasma jet with ПС-12НВК-01, ПР-Н17Д7СХ, СГ-Т (П), СГ-Т (П) + 20% TiC, 50% ПТ55Т45 + 50 % TiC powders, was investigated in couple with АМС-3 material, КВ graffitoflourplast.

The behaviour of layers and their resistance to wear under extreme conditions of lubrication for the couple of friction has studied in the process of research. These regimens are specific when the couples of friction are starting and stopping. It has also been determined the dependence of the size of wear on the specific pressure and frequency of bearing rotation.

RESULTS AND DISCUSSION

The tests have shown when the couples of friction functions with softer material during the starting and stopping processes the surface wears out more intensively several times.

The wear of the layer from the material ПС-12НВК-01 practically is not observed at 10000 on-off cycles. The maximum wear of the АМС-3 material is 0.034 mm (figure 1). A more intense wear occurs early during the 2000-4000 operation cycles, corresponding to the processing period, breaking-in. It is obvious that the wear is different from one another and constitutes about 0.22 mm (figure 1 the left side of the curve). Further the wear rate stabilizes and the dependence on number of cycles is almost linear at constant specific tasks.

The same dependence is observed at the wear of materials coated with ПР-Н17Д7СХ in couple with graffitoflourplast (figure 2).

For the given couple of friction the processing period corresponds to 3000 cycles. The same dependence is observed at the wear of materials coated with ПР-Н17Д7СХ in couple with graffitoflourplast (figure 2).

For the given couple of friction the processing period corresponds to 3000 cycles. The wear of material occurs during the subsequent period as during initial period. The wear value of the ПР-Н17Д7СХ material is about 5μm during 10000 cycles (figure 2, curve 1); and of КВ material is about 10 μm (figure 2, curve 2). 50% of the total amount of wear are assigned to the processing cycles, breaking-in.

The wear value of the ПР-Н17Д7СХ material is about 5μm during 10000 cycles (figure 2 curve 1); and of КВ material is about 10 μm (figure 2, curve 2). 50% of the total amounts of wear are assigned to the processing cycles, breaking-in.

It should be mentioned that the size of wear during the starting and stopping processes depends not only on the number of cycles and specific tasks at boot time, but also on the time between adjacent cycles.

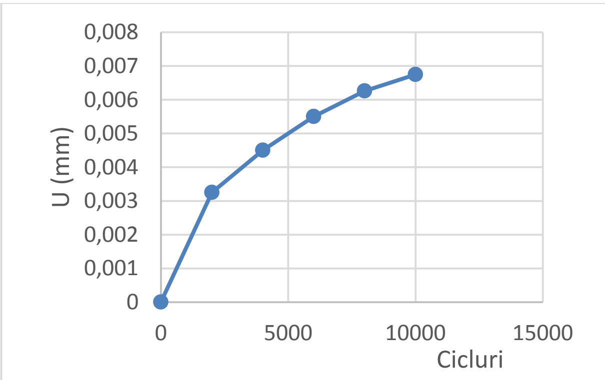

Figure 1. The wear of AMC-3 material in couple with the layer from ПС-12НВК-01 powders.

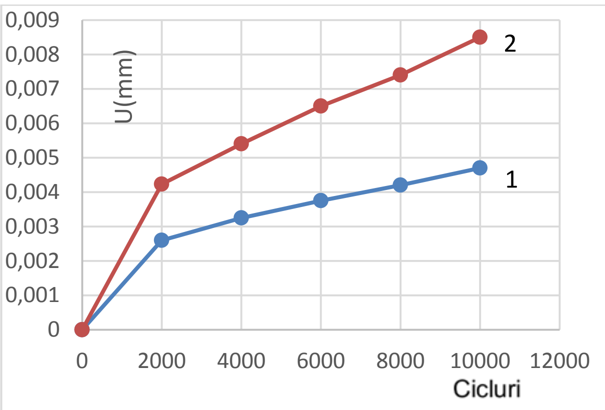

Figure 2. The wear dependence of the couple of friction with ПР-Н17Д7СХ layer and КВ graffitoflourplast during the starting and stopping processes. *1 – ПР-Н17Д7СХ; 2 – КВ.*

According to this, the wear value during the starting and stopping processes corresponds to the working regime, determined of the pumps and can be used for the comparative assessment of the materials in couple of friction.

The surfaces formed from compositional a material which contains elements with high hardness at the functioning in couple with the same material or close by elements with a high hardness, both surfaces are subject to wear.

The wear of surfaces at 10000 cycles is 0.008 mm for the 50% ПН55Т45+50%TiC layer in couple with СГ-Т (microhardness 2200 kgf/mm^2) (figure 3, curve 2); and counterbody - 0.007 mm (figure 3, curve 1).

The wear processing for the given couple of friction is practically absent. The dependence of the size of wear on the number of cycles is approximately a linear dependence. This gives the possibility to assume that a wear with a similar character to exploitation occurs.

The couple of friction with СГ-Т(П) and СГ-Т coating is at the same level of wear resistance. The wear layer constitutes 0.01 mm at 10000 cycles (figure 4, curve 2); СГ-Т – 0.006 mm (figure 4, curve 1). The difference between the speed wear of the couples can be explained by a small amount of silicon carbide in the layers.

The layers formed in the plasma jet on both parts of the couples of friction, with the СГ-Т(П) and СГ-Т (П) + 20% TiC layers, of the immobile ring 50% ПТ55Т45 + 50% TiC, have a high wear resistance during the starting and stopping processes.

For this couple, the maximum wear rate is observed at the first 2000 cycles, period of processing (figure 5). The summary wear during this period is 0.005 mm and constitutes 0.007 mm for the further period. Fissures and strappings are missing. On the surfaces of couples of friction, that functions at starting with a 0.9 MPa load, is observed the processing with the surface smoothing up to the roughnesses R_a=0.32-0.16.

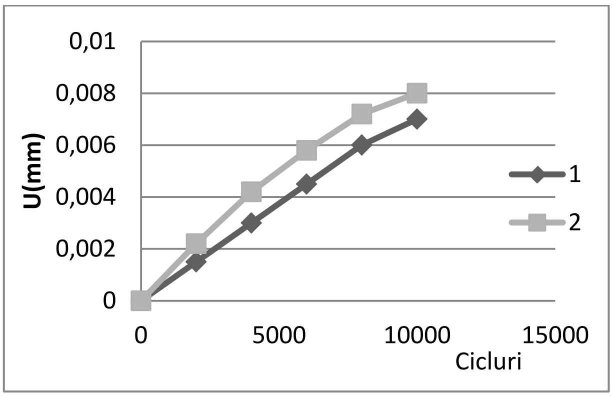

Figure 3. The wear of couple of friction during the starting and stopping processes. *1 – 50% ПН55Т45+ 50% TiC layer; 2 – СГ-Т layer.*

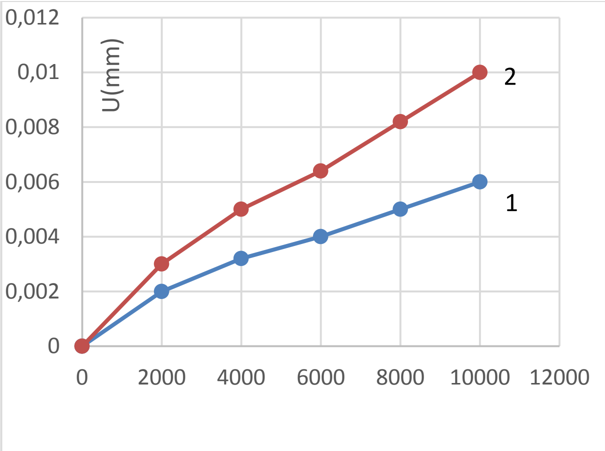

Figure 4. The materials wear of the couple of friction. *1 – СГ-Т(П) layer; 2 – СГ-Т layer.*

The wear of couples of friction are described by the following scheme:

1. The surfaces become smooth when the couples operate
2. The working surfaces become smoother and cleaner, they are approaching and as a result the liquid lubricant is eliminated
3. At some points of contact the soldering occurs, further being destroyed; their destruction leads to the increasing of the surface roughness
4. Further the carbide granules are chipping and contact surfaces become cleaner. The surfaces approaches and the process repeats.

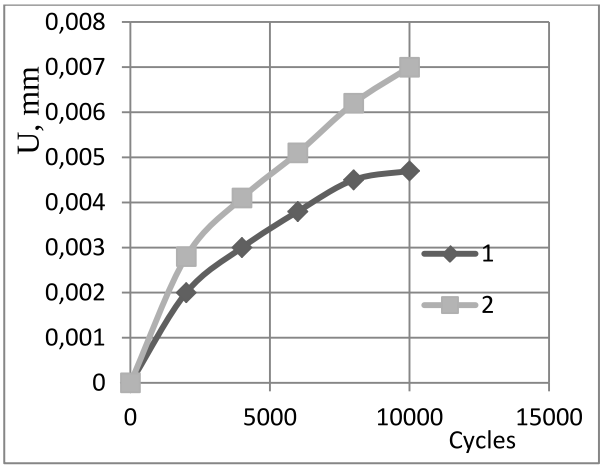

Figure 5. The wear of the surfaces of coupes of friction deposited by spraying in the plasma jet during the starting and stopping processes. *1 – the ring 50% ПН55Т45+ 50% TiC; 2 – СГ-Т(П) + 20% TiC.*

The couples of friction with layers containing tungsten carbides, chromium carbides and other materials have an identical behavior.

CONCLUSIONS

The tribological layers deposited by spraying in the plasma jet, provides the ability of functioning of the technical equipment. The compliance of deposition regimes gives the possibility to obtain coatings with the required properties by the field of application of couples of friction.

The following powders: ПС-12НВК-01, ПР-Н17Д7СХ, СГ-Т(П), СГ-Т(П) + 20% TiC, 50% ПТ55Т45+50%TiC with particle sizes of 40-90 μm were dried in the cupboard at 393-403 K° for 2-3 hours. The deposition took place at УПУ-3Д and OB-1955 installation. The УПУ-3Д installation has been completed with plasma forming ПВК-50.

As a forming plasma, the mixture CO_2 + C_3H_8 + C_4H_{10} (carbon dioxide and natural gas propane-butane) was used. The OT – 1000 device was used for the OB-1955 installation, and argon (Ar) was used as a plasma forming, and – nitrogen (N) as a gas transportation.

Both installations are supplied by ИПП 160/600 power supply, that allows to provide a wide volt-ampere characteristic and a current not less than 400 A. Using CO_2 + C_3H_8 + C_4H_{10} gas as a plasma forming, allowed the power to lower to 200-250 A, at a tension of 125 V.

The current constitutes 420-470 A and tension U = 38-40V for the OB-1955 installation that functions with argon.

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