TESTING THE CORROSION RESISTANCE OF THE SURFACES FORMED BY SPRAYING THE JET OF PLASMA

Galuşca E., Dîntu S., Țărnă R., Majeru V.

Technical University of Moldova, Chisinau, Republic of Moldova

Galuşca Eduard: egalusca@mail.ru

Abstract: Food quality largely depends on the processing equipment. Therefore, major requirements are imposed for resistance to wear and corrosion of the installations for the food industry, because they work in rather difficult conditions: high speeds, aggressive environments, high temperatures.

Currently there is an increased necessity for reducing and control the wear and corrosion.

Some of them are: prolonging the lifetime of equipment and bio-systems, the streamlining of engines and devices, the creation of new and advanced products, conservation of scarce resources, saving the energy and increasing the safety.

Keywords: corrosion resistance, spraying the jet of plasma, tribotechnic couplers

Introduction

Recently there was a new approach to control friction and wear, namely the application of surface treatment and deposition of coating layers. This approach led to the development of a new discipline: engineering areas. This development was based on two main factors. The first factor was the creation of new methods of treatment and coating surfaces, which provides surface characteristics and tribochemical properties that previously were not possible.

The second factor that led to the development of this area was the conclusion of production engineers and scientists, namely that the surface is the most important part in the majority of engineering components. Most problems occur on the surface, caused by wear, or corrosion.

The surface has a dominant influence on the lifetime, the cost and performance including the maintenance of equipment.

Corrosion- specific processes (chemical corrosion – electrochemical, biochemical corrosion – pressure corrosion and fretting corrosion - impact of corrosion)

Nature predominant processes (chemical, electrochemical, mechanical, thermal processes.)

The thermal plasma spraying process is based on the formation of the plasma jet in which the powder is introduced. The materials are melted, mixed and projected onto the base material, thus achieving microlayers coating - composite type. The principle consists in passing a powder material through the jet of plasma which is generated by an electric arc of plasma generator.

Due to the high temperature powder melts and is transported by the jet of gas to the base material. The particles reaching the surface of the base material in plastic state, adheres to it, being based on specific mechanisms.

The impact of molten particles with the substrate leads to solidification, forming thereby the depositation.

Methods of forming and testing the layers to corrosion

The selection of coating regime and coating formation with necessary properties took place at **УПУ-3Д** installations (produced in series) and at **OB-1955** for plasma formation (product name - ИЭС Патон).

The УПУ-3Д installation was completed by the device ПВК-50 of plasma formation. 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 installation OB-1955, and as a forming plasma was used argon (Ar) and as a gas transportation - nitrogen (N).

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

The experimental study for choosing the optimum coating regime for various pulverous materials and different base materials, the distance influence for coating formation, and other factors were carried out at the УПУ-3Д installation. Some technological regimes occurred simultaneously at both installations.

The layer adhesion to the base material depends on mechanical linkages of the particles and the physicochemical interaction between the layer and the base. The increasing force of adhesion is obtained through preventive processing of the base surface. The maximum adhesion occures if particles of the base surface after processing and the particles of the pulverulent material are approximately equal. This requirement is achieved if the surfaces are processed with air jet and abrasive, forming a proper roughness. All test pieces examined at the adhesion and corrosion resistance, and pump assemblies were processed with air jet and abrasive. The processing carried out with boron carbide powder, the fractional component constituting 800 – 1200 μm or electrocorundum powder - 300 – 900 μm. Compressed air pressure for processing is 0.4 – 0.6 MPa. The distance from the device head of the processing installation with air jet and abrasive to the surface constitutes 100-150 mm.

Roughness after processing must be 1,25 μm.

The influence of preventive processing with air jet and abrasive, at an increased adherence force of the layer to the base material, occured with test pieces of 3M titanium alloy, steel carbon3, steel 12X18H10T. Some of the test pieces were processed until the surfaces achieved the roughness of 1.25 μm. Before coating the test pieces were defatted, another part of them were processed with quartz sand. The distance for formation of the layers is 120-200 mm.

High corrosion resistance of friction couplings is a basic condition, ensuring the reliability of sliding bearings in their operation in harsh environments.

Corrosion of materials in drinking water (sa lasam drinking sau doar water) and seawater was established depending on:

1. outside state of test pieces;
2. the loss or weight increase of test pieces
3. changing the physico-mechanical properties of the material under the influence of corrosion.

The test pieces were sprayed with the material whose wear resistance was studied; they were degreased, dried and weighed on scales of ВЛА-200 Г-М type, with accuracy of ± 0.0002 g.

The researches were spent at a room temperature for 500 hours. For some layers which require a high precision of the corrosion rate, the test period was extended up to 1000 or even 1500 hours.

Evaluation of corrosion resistance of the material of test pieces was carried out in dependence on the mass loss during the research - the rate of corrosion.

$$K = \frac{\Delta m}{s\tau} = \frac{m_0 - m_1}{s\tau} \tag{1}$$

where $\mathbf{m_0}$ – weight of the test pieces untill the experiments, g;
$\mathbf{m_1}$ – weight of the test pieces after a certain time τ after experiments g.

Permeation rate of corrosion is determined in accordance with ГОСТ 9908-85.

The results of testing the corrosion resistance of the layers formed in the plasma jet.

The corrosion resistance testing of selected layers was carried out in accordance with the methodology (point 2), in seawater and drinking water.

The testing was performed with special test and natural pieces.

Only covered surfaces of test pieces had a contact with the abrasive medium, uncoated surfaces being protected with a film of paraffin. The test pieces were tested in non-flowable water at room temperature. The layers were deposited on steel carbon 3, 12X18H10T steel and 3M titanium alloy. When spraying ceramics and titanium carbide- ПС-12НВК-01 powders on the base material, an intermediate layer ПТ-НА-01was applied.

The results of testing the corrosion resistance in drinking water showed that ПС-12НВК-01 layer on steel 3 with intermediate layer ПТ-НА-01 has a corrosion rate of 1.5 – 2 times lower than the layer СНГН-55.

For ПС-12НВК-01 powders, the corrosion rate after 2 test results is 0.011 – 0.026 g/m^{2}h, for СНГН-55 k = 0.01 – 0.043 g/m^{2}h.

For powder, after two tests, the corrosion velocity is: forСНГН-55 k = 0.01 – 0.043 g/m^{2}h.

k- weight indicator of corrosion

The 12НВК-01 coverage surface for a thousand hours of testing was in good condition.

On the surface roof СНГН-55 were observed more dark points. Basically the same corrosion rate was obtained at testing the ПС-12НВК-01 and ПГ-АН9 layers, formed on steel 3 without intermediate layer. For a thousand hours of testing in drinking water-2874-73 ГОСТ, the corrosion rate of ПС-12НВК-01 layer was 0.012 – 0.029g/m^{2}h and for ПГ-АН9 (ТУ-ИСО371-83) layer constituted 0.0101 – 0.0169 g/m^{2}h.

The indicator of penetrating layers is about 0.0099 – 0.028 mm/year, thus characterizing the coatings as corrosion resistant.

A high corrosion resistance was demonstrated by 70%Al_2O_3 + 30%Al layer, formed on the base material steel 3 and 12X18H10T steel, with ПТ-НА-01intermediate layer.

The weight indicator of corrosion of the layer containing 30% and 10% Al is basically the same and constitutes 0.001-0.006 g/m^2h for base material from steel stainless steel and 0.001-0.008 g/m^2h for base material steel 3.

Small deviations of the weight indicator depending on the basis material is explained by the fact that uncoated surfaces were insufficiently insulated with paraffin film for the 3steel material.

It was mentioned earlier that the layer consisting of pure aluminum oxide with ПТ-НА-01 intermediate layer, because of high porosity of the layer, corrodes at a water temperature of 343-353 ° K. The corrosion products of the ПТ-НА-01 intermediate layer form elevations, bulges at the top of surfaces .

The wear resistance testing of the roof formed in the jet of plasma from СГ-Т (П) powders on the base material titanium alloy 3M, for 2000 hours in seawater and drinking water showed that practically is not subject to corrosion. The surface covered with СГ-Т (П) on base material - alloy 3M, had a good condition without corrosion. The weight indicator of corrosion is k=0.012g/m^2h for 3M base material and for steel carbon 3 base material.

The СГ-Т(П) material is one of the materials with the prospect of working in conditions of lubrication with seawater.

A high corrosion resistance of the layer, formed in the jet of plasma from ПН55Т45 powders, in acids and bases environments was demonstrated in the works (point 4).

The corrosion rate of the ПН55Т45 layer is 0.09 mm / year in 30% HNO3; 1.47 mm / year in 10% H2SO4; and 0.045 mm / year in 30% KOH.

The ПН55Т45 layer testing in seawater for a thousand hours, have demonstrated a high wear resistance.

The weight indicator of corrosion is 0.0006-0.0014 g/m^2h.

Conclusions

Testing the wear resistance of the layers formed in the jet of plasma from different pulverous materials, with or without intermediate layer on the base material from metal alloy titanium 3M, stainless steel and steel carbon 3, showed a high wear resistance in seawater and drinking water.

The weight indicator of corrosion of the layers formed on the base material from stainless steel and titanium alloy 3M, is lower than in case of layers formed on the base material from steel carbon 3. This shows that the layers does not provide a high protection of the base material from steel carbon 3, because of porosity.

This is especially characteristic for layers with a thickness smaller than 0.2-0.3 mm and the ceramic layers.

A lower porosity of the layer and a higher protection of a base material is formed by spraying a material containing nickel and aluminum.

An increased corrosion resistance of the layers can be achieved spraying and then a further remelting of the sprayed layer.

Bibliography

1. Метода коррозионных испытаний. ОКЕ.199.379. СКТБН, Кишинев, 1985
2. **Кудинов В.В.**, **Иванов В.М.** «Нанесение плазмой тугоплавких покрытий». «Машиностроение», 1981, стр.192.
3. Отчет «Исследование и разработка износостойких антифрикционных покрытий на основе материалов титан-никель для деталей черного оборудования и большегрузных автомашин». УДК.621.793.7. Тула, 1982.