Composite coatings with electroplated Zn matrix

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Abstract

Composite coatings in galvanotechnics are surface treatments with functional qualities. Functional galvanic coatings are mostly exuded (besides alloyed coatings) on the principle of composite coatings too. The goal of these coatings is either the substitution of classical coatings and acquiring brand new qualities of surfaces compared to the original materials (lower friction and corrosion resistance) or acquiring suitable combinations of these qualities. Research on electrochemical composite coatings contributes to the possibility to create composite coatings with a matrix of wide ranges of metals or alloys with different particles. This paper is dealing with functional coatings with electroplated Zinc matrix and dispersed particles of PTFE. Our results indicate decrease of friction coefficient by using composite Zn-PTFE coatings. Practical purposes of improvement of these coatings are suitable for strength screwed joints.

Key words

Surface treatment, functional galvanic coatings, elctroplated composite coatings, friction coefficient, corrosion-protectection, Zn-PTFE coatings

1. Introduction

A very long, sound and economical operational frequency is demanded from the current technical equipment. All that leads not only to the development of new materials and ways of protecting surfaces of these materials, but also to the development of materials used for protection from the surrounding environment. Replacement of more expensive materials by cheaper ones, with the surface modified superior in quality, rose to the occasion in practical use.

The goal of the surface treatment branch is the obtainment of the required features and conditions of material surfaces that are needed for their optimal and long time functioning. All of that is most frequently brought into effect by creating coatings with required qualities on the material surfaces. This way, we can create inorganic coatings (so-called metallic and nonmetallic) and organic coatings (so-called coating composition and plastic coatings) as well. Metallic coatings are most often created by chemical and electrochemical plating methods, diffusion plating, vacuum plating, heat spraying, cladding and deposition.

Metallic surfaces can be created on the basis of bare metals, metal alloys and composites (so called materials composed of two or more different quality materials). Silicon and composite coatings are developed for most of the surface treatments recently, since the basic qualities of pure metals usually don‘t fulfill all of the challenging demands.

2. Composite coatings

The demands on qualities of a surface’s subjected parts are rising constantly. They have accelerated the development of combined coatings with composite coatings. Therefore they are combined mutually and thus widen the advantages and possibilities of the surface treatments.

Composites are combined heterogeneous materials created at least by two phases that are separated from each other by interface.
The phases usually are of different chemical composition and they differ by their physical and mechanic features. Composite materials consist of basic and disperse phases. The goal is to obtain a material with better physical and mechanic qualities than were the qualities of the previous materials.

2.1 Composite coatings in galvanotechnics

Functional coatings that are galvanic exuded come to the fore recently. These new functional galvanic coatings are mostly exuded on the principle of composite and alloyed coatings as well as their suitable combinations.´
The goal of these coatings is ether the substitution of classical coatings as for example hard chrome because of their noxious environment effects or acquiring brand new qualities of surfaces compared to the original materials (higher abrasion and corrosion resistance) or acquiring suitable combinations of these qualities.
These coating have a metallic matrix in which certain quantities of powdered particles are dispersed. By using the characteristics of alloyed and composite coatings by their suitable combinations, even by the possibility of their thermal processing, broad ranges of their uses are created. This way it is possible to exude hard coatings, abrasion resistant coatings, self-lubricating coatings, sliding coatings, anti-adhesive coatings, heat resistant coatings, and possible combinations of these and next features. Fast introduction and practical use of such coatings are conditioned by verification of their qualities and seeking suitable technologies, or more precisely electrolytes, to exude them effectively.

<u>The advantages and disadvantages:</u>

The advantages of electrochemical composite coatings:

- The possibility to create composite coatings with a matrix of wide ranges of metals or alloys with different particles.
- It is possible to regulate very precisely the thickness of the coatings and the component proportions.
- It is possible to process the product thermally and thus to improve its qualities.

The disadvantages of electrochemical composite coatings:

- Difficult exudation of coating on components of sophisticated shape
- Ecological demand.

2.2. Characteristics of selected composite coatings galvanic exuded

Composite coating Ni – Diamant, Ni – Knb and theirusage

In the text to follow both of these composite coatings will be described together since deposition of a coating with Diamond particles and KNB is very similar.
In this composite coating the matrix is of galvanic deposited Nickel. In the matrix there are diffused Diamond and KNB disperse particles (abradant). These coatings are used mostly as functional parts of fabricators. These are mostly various circular fabricators, cutting–off wheels, tubular brace and tackle, for example needle file. The tools are suitable where the machined materials are very hardly workable.

Composite coating Ni – P – PTFE

This is a composite coating whose matrix is a total of alloy Ni – P and disperse particles PTFE (Teflon). The particles PTFE (usually lower than 0,5 μm) are equally diffused in deposited coating. Coating is typical by its low friction factor caliber (lower than 0,2). It is caused by the linear structure of Teflon molecules which transfer to the counterpart during the attrition and thus create stiff dry lubricant film. The coating is characterized by its high attrition immunity, by good sliding characteristics, it is non-adhesive.

This coating is used for parts working in more demanding conditions (Higher temperature, insufficient lubrication, increased strain. The result is a calmer run, increased affectivity, safety, and service time of the components. Successfully it is applied to very effortful parts of injection forms, ejectors, sliding surfaces, leads, bearings and so on.

Composite coating Ni – Graphite

The technology of spreading the composite coating Ni – graphite consists in deposition from a special nickel pool in which graphite is contained. The pool is composited by nickel matrix with 3 to 3, 5 % weight of equally dispersed graphite suspensoid.

Aim of our study was to create composite coating with Zinc matrix and with dispersed particles with self lubricating function. PTFE was chozen for this experiment for lubricating function.

3. Material and methods

3.1 Electroplating

For coating we used by us proposed and realized electrolytic apparatus, which is used for galvanizing (fig. 1). Operational characteristics of galvanic bath are mentioned in table 1. It was used subacid zinc bath, fit for hangings and collective electroplated called Zylite HT supplied by Atotech. Galvanic bath was supplemented with PTFE dispersion. Technological process of galvanizing is shown in table 2. Origin material of samples using for coatings was steel 11 373.

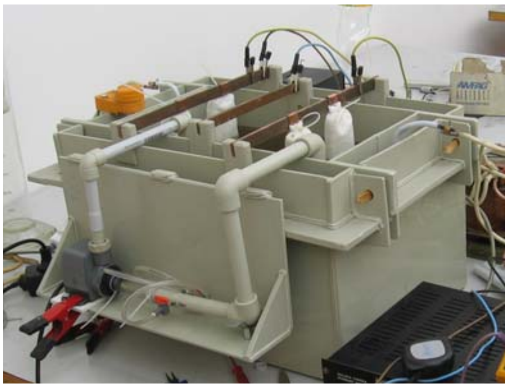

Fig. 1. *Experimental apparatus for galvanization.*

Table 1. *– Operational characteristics of galvanic bath Zylite HT*

Voltage	1,5 V
Current density	$2\ A \cdot dm^{-2}$
Temperature	20 °C
pH	4

Table 2. *– Technological process of galvanizing*

Op.Nr.	**Operation**	**Substance**	**Operating conditions**
01	Electrolytic grease removal		65 °C, 3-5 min
02	Two - step cold wash	Distilled water	20 °C, 30 s
03	Activation	10% solution HCL	20 °C, 60 s
04	Two - step cold wash	Distilled water	20 °C, 30 s
05	Galvanizing	Zylite HT + PTFE	20 °C, 20 min
06	Three - step cold wash	Distilled water	20 °C, 30 s
07	Drying	Air	60 °C

3.2 Quality definition

This experiment was performed to determine tribology characteristics of Zn-PTFE coatings. We focused on research problems of the adhesive friction, with the special attention on dry friction. The tribometer TOP3 (czech short cut for translation oscillatory motion), which was used for measuring, passed radical changes in the systems of the scanning of the measured frictional force. The test measurements to verify the usability of these changes and adjustments were designed. The kinematic pair „plate/plate" was selected for the measurements. The tribometer TOP3 simulates real mechanical stress in laboratory conditions. Scheme of this apparatus is on the figure 2.

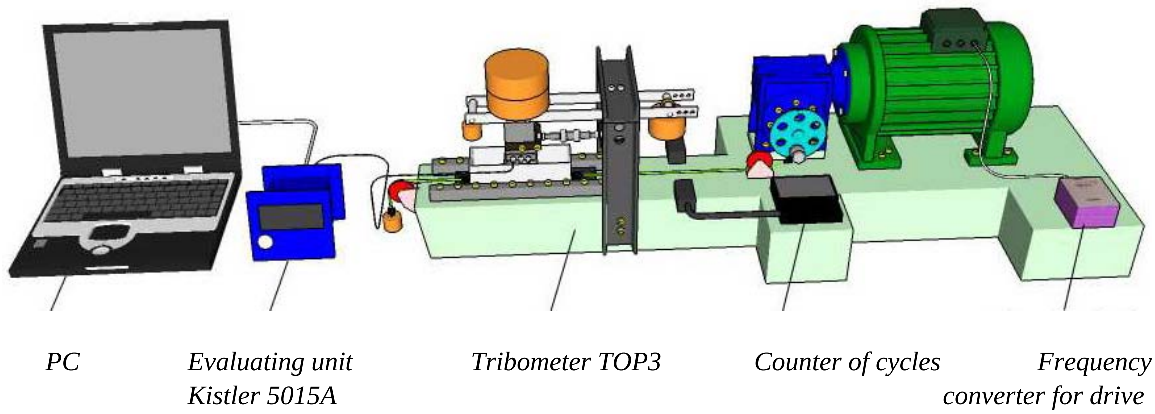

Fig. 2. *Scheme of measuring on tribometer TOP3.*

3.2.1. Experimental design

For this experiment we used 3groups of samples of different functional pairs:

1) experimental group – Fe/Zn-PTFE
2) control group 1 – Fe/Zn
3) control group 2 – Fe/Ni-PTFE

4. Results and discussion

We measured tribological qualities of different functiolnal pairs on tribometer TOP3. Functinal pairs were composed of steel 11 373 – „Fe", electroplated Zinc coating – „Zn", composite electroplated Zinc with PTFE –„ Zn-PTFE", electroplated Nickel with PTFE – „Ni-PTFE".

Figure 3 shows average levels of friction coefficient of different functional pairs in conditions with dry friction, with consistent direct load. It was found out lower friction coefficient in functional pair Fe/Zn – PTFE than Fe/Zn pair. The influence of presence of PTFE particles in coatings is indisputable, functional qualities are positively enhanced. Our measurement gives results, that functional pair Fe/Ni – PTFE has the lowest friction coefficient.

Presence of PTFE has an effect especially on duration of seizing of the functional pair. Seizing of the functional pair Fe/Zn comes in 640 sec., while by Fe/Zn – PTFE pair comes in 2280 sec. This fact might represent 3.5x longer lifetime up to seizing of the functional pair. Those measured tribological qualities shows positive influence of PTFE.

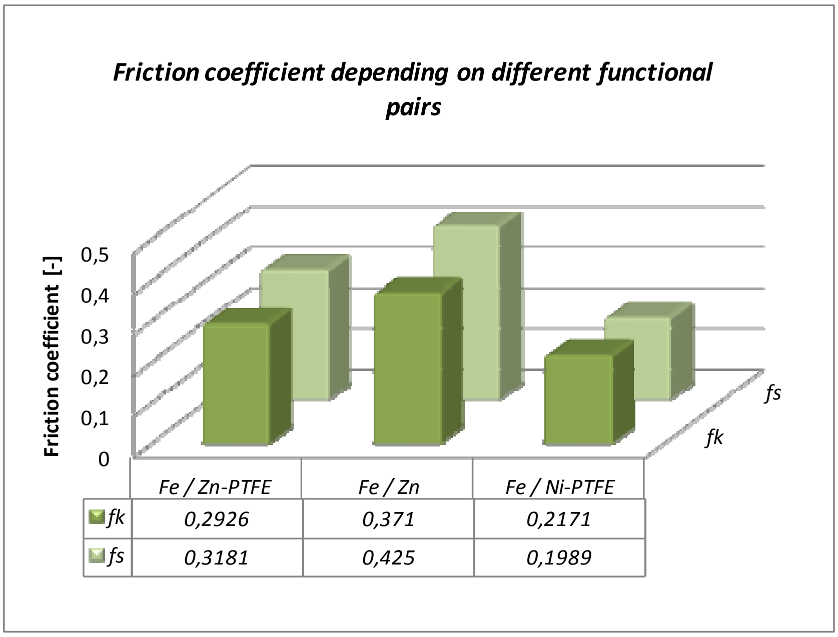

Fig. 3. *Comparison of different functional pairs on tribometer TOP3. Conditions - dry friction, Fn = 19,62 N. f_k is kinetic friction coefficient, f_s is static friction coefficient. Functinal pairs were composed of steel 11 373 – „Fe“, electroplated Zinc coating – „Zn”, composite electroplated Zinc with PTFE –„ Zn-PTFE“, electroplated Nickel with PTFE – „Ni-PTFE“.*

5. Conclusion

Based on our data we can conclude that our new composite coatings Zn-PTFE has lower friction coefficient. Further is known, that Zinc coatings provide proper cathode-protection of base material. For these reasons are these composite coatings very suitable surface treatment for strength screwed joints. A screw connection is a very important constituent in industries. For its optimization it belongs to decisive not only material, constructional, technological, but also to surface condition parameters.

But it is very important to perform subsequent experiments. For example to define volume of dispersed PTFE particles in the surface layer using electron microscopy method.

6. Acknowledgments

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