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APPLICATION METHODS AND SELECTED PROPERTIES OF ZINC FLAKE COATINGS

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This article presents examples of properties of nickel and silver coatings applied by galvanic method. For quality tests, profilometric and thermal expansion methods were used.

Keywords: galvanic method, coating, silver, nickel, properties

INTRODUCTION

It divide galvanic coatings into several categories due to the functions they perform, e.g. protective, decorative or technical. Proper protection depends not only on the selection of the best coating, but also on the layer application process itself. One of the most popular protective and decorative coatings are silver and nickel coatings [1].

Silver coatings are widely used for protective-decorative and protective-technical purposes. They are used in the electrical and electronics industry for the production of electrical contacts and high-frequency power cables. In the chemical industry, they have also found application in the construction of chemical apparatus, enabling corrosion protection of reactors for the production of chemicals. In the automotive industry, silver coatings are used to cover headlights, mirrors, engine components, e.g. spark plugs [2, 3].

Meanwhile, nickel coatings are used for technical and protective purposes as well as for protective and decorative purposes. Nickel protective and decorative coatings are used to cover elements of bathroom fittings, household items and tools. Decorative accessories used in interiors or jewellery made of base metals gain a beautiful mirror shine thanks to this type of nickel coating [4, 5].

MATERIALS APPARATUS AND TEST PARAMETERS

Brass sheets (Figure 1a) were used to test the galvanisation process of silver coatings, while steel sheets for nickel coatings (Figure 1b). Both the steel and brass sheets served simultaneously as cathodes in the process. The brass and steel sheets were 100 mm x 30 mm. The steel sheets were made of S235JR steel, and the brass sheets had the following chemical composition: lead 0,94 %, zinc 38,96 %, copper 58,45 % and iron 0,24 %.

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Table 1 **Parameters of the electroplating process of nickel coatings**

Sample No	Time / s	Current / A
1	300	0,9
2	600	0,9
3	900	0,9
4	300	1,5
5	600	1,5
6	900	1,5
7	300	2,1
8	600	2,1
9	900	2,1

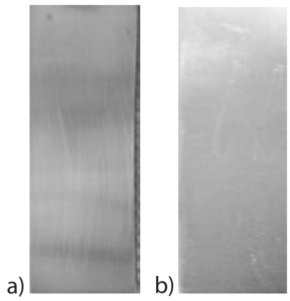

Figure 1 Sheets used for coating by electroplating: a) brass, b)steel

The galvanic bath used for the silver plating tests consisted of silver cyanide AgCN, potassium cyanide KCN and antimony fluoride SbF5. On the other hand, the bath of the nickel electroplating process consisted of nickel sulphate, nickel chloride, boric acid, sodium-sulphate salts and ethoxy alcohols.

Steel and brass sheets were ground and polished prior to the galvanisation process in order to obtain a uniform surface and get rid of impurities. Immediately before applying the coatings, they had been etched in concentrated sulphuric acid (VI) in order to remove oxides from their surfaces. A graphite anode was used to test the galvanisation process.

Table 2 **Parameters of the galvanisation of silver coatings**

Sample No	Time / s	Current / A
2	30	1,2
3	60	1,2
4	90	1,2
5	120	1,2
6	120	1,5
7	90	1,5
8	60	1,5
9	30	1,5
10	120	2
11	90	2
12	60	2
13	30	2
15	120	0,6
16	90	0,6
17	60	0,6
18	30	0,6

The stand used to test the electroplating process consisted of a Quasar 500 power supply and a galvanic bath, while the surface topography of the obtained silver and nickel coatings was determined using the FRT MicroProf non-contact optical profilograph, the characteristics of which are presented in. In turn, the FCF 22HP chamber furnace by Czylok was used to test the adhesion of brass sheets after silvering and steel sheets after nickel-plating, the parameters of which are presented in the authors' study [6].

The previously etched samples were subjected to the galvanisation process, selecting the increasing parameters of the current intensity and duration of the process. After coating, the samples were rinsed with water and then dried. The samples prepared in this way were weighed. The parameters of the galvanisation process of nickel and silver coatings are presented in Tables 1 and 2.

FINDINGS

The nickel and silver coatings obtained as a result of the galvanisation process were tested with the use of an optical profilograph, and the structure of these coatings was analysed, giving a two- and three-dimensional image and a profile outline. Exemplary results of these tests are presented in Figures 2 - 5, while the values of selected roughness parameters are presented in Tables 3 and 4.

The obtained results of the surface roughness and topography tests of nickel coatings are characterised by a continuous structure, lack of chipping and pitting, and even arrangement. Comparing the results with the control sample shows a significant improvement in the roughness parameters. This indicates the correctness of the selected parameters in the entire range of current intensity and galvanisation time. The results for individual samples differ from each other, indicating the influence of the process parameters on the course of the electrodeposition process. Sample 3 shows the best roughness parameters.

Table 3 **Sample results of surface topography tests of samples with nickel coating**

Sample No	R_a / µm	R_z / µm	R_v / µm	R_c / µm	R_t / µm	R_{ku} -
1	0,201	0,804	0,360	0,701	1,530	2,330
2	0,198	0,757	0,365	0,670	1,140	2,380
3	0,111	0,420	0,209	0,351	0,667	2,190
4	0,150	0,637	0,326	0,506	1,180	2,390
5	0,192	0,758	0,338	0,611	1,310	2,400
6	0,236	0,968	0,487	0,785	1,450	2,330
7	0,203	0,844	0,446	0,679	1,520	2,230
8	0,224	0,869	0,424	0,659	1,550	2,190
9	0,227	0,887	0,460	0,772	1,510	2,310

Table 4 **Sample test results for the surface roughness parameters of brass sheets.**

Sample No	*Ra* / µm	*Rz* / µm	*Rv* / µm	*Rc* / µm]	*Rt* / µm	*Rku* -
2	0,392	3,2	1,49	1,2	4,57	4,53
7	0,403	2,93	1,34	1,19	4,27	3,58
9	0,615	4,57	1,85	1,83	6,32	4,43
11	0,145	0,98	0,504	0,408	1,24	3,23
13	0,23	1,7	0,793	0,702	2,19	3,76
16	0,309	2,31	1,24	0,951	2,99	3,78
18	0,397	2,87	1,35	1,18	3,84	3,61

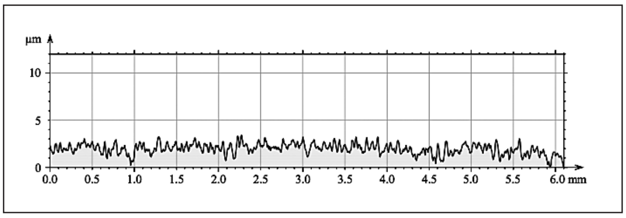

Figure 2 Digital recording of the surface of the nickel plated sample 2 - surface profilei

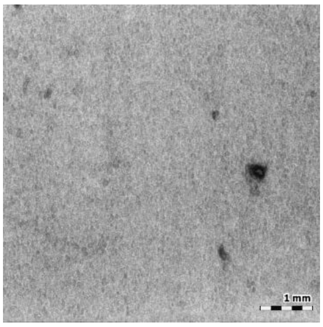

Figure 3 Digital recording of the surface of a nickel plated sample 2 - numerical photograph of the surface

Based on the obtained results of the surface topography analysis of samples with a silver coating and comparing them to a sample that was not covered with the coating, it was found that the process parameters had a great influence on the shape of the surface. In case of samples 11 and 13, the deposition process of which took place at the intensity of 2 *A*, much lower values of the roughness parameters (*Rz*, *Rc*, *Ra*) were observed compared to the rest of the samples. The increase in the deposition time (90 *s*) of the silver coating on the sample 11 resulted in obtaining the lowest values of surface

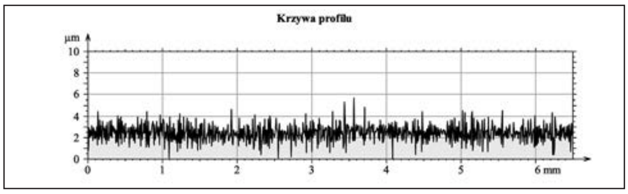

Figure 4 Digital recording of the surface of the silver coating (sample 2) - surface profile

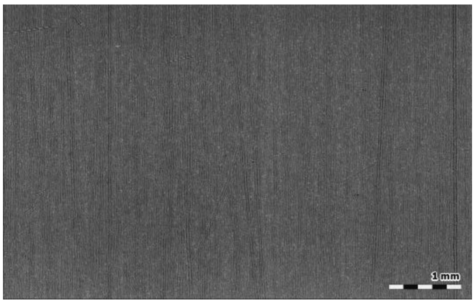

Figure 5 Digital recording of the silver coating surface (sample 2) - numerical photograph of the surface

parameters. On the other hand, sample 9, for which the deposition process was carried out at the intensity of 1,5 *A* for 30 *s*, had the highest roughness parameters (*Rz*, *Rc*, *Ra*) compared to the rest of the tests.

The quality of silver and nickel coatings was tested by the thermal expansion method. The test of the adhesion of electroplating coatings on brass and steel elements showed in all analysed cases that the tested samples showed good temperature resistance up to 573 *K*. After removal from the furnace, the samples had a dense coating with no visible damage.

SUMMARY

Based on the research, the following conclusions were drawn:

Nickel and silver coatings obtained in the galvanisation process had an even and dense coating. All samples were characterised by a continuous macrostructure, without visible pits and chips, and the applied nickel and silver coatings were uniform along the entire length.

The best decorative qualities (silver colour, gloss) were obtained when using a current of 0,6 *A* in the galvanisation process for silver coatings, and for nickel coatings for a current of 1,5 *A*.

In the case of using the current of 2 *A* for silver coatings and 2,1 for nickel coatings, white matte coatings were obtained.

The lowest Ra roughness values for silver coatings (0,145 µm) were obtained for the highest current intensity of 2 *A* and a process time of 90 seconds, while for nickel coatings (0.111 µm) for the lowest current of 0,9 *A* and a process time of 900 seconds.

Tests of silver and nickel electroplating coatings carried out by the thermal expansion method showed their good adhesion up to the temperature of 573 *K*.

Acknowledgments

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Note: Gondek A. is responsible for English language, Katowice, Poland