ANALYSIS OF THE OCCURRENCE OF DEFECTS IN BULK OR PENDANT ELECTROPLATING TECHNOLOGY

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Abstract

Material coating is a technology that is used in a variety of materials, and thanks to this adjustment, we improve the surface properties. It increases corrosion resistance, wears resistance, improves a functional quality and changes or improves aesthetic design. Increased demands are placed not only on productivity but also on the quality of finished products. The paper deals with galvanic plating. The work experimentally evaluates the occurrence of defects when is comparing the technology of mass and suspension plating. The research focused on the progress and evaluation of the results obtained in the experiment. There were performed the control measurements of coating thicknesses, was controlled the correct ratio of elements of the alloy used for electroplating and visual inspection of defects in products.

The results of the work should contribute to the comparison of the technology of drum and hinge method of galvanic coating with ZnNi alloy. The aim of the thesis is to compare possible defects and propose measures for their removal. The correct coating thickness does not only increase the life of the product, but also has a significant impact on the quality of the final parts.

Keywords: Electroplating technology, defects, bulk technology, pendant technology

1. INTRODUCTION

Metals together with semi-metals and nonmetals form three major groups of chemical elements in the periodic table. Metals are widely used industrially due to their physical properties, easy workability and availability. The spectrum of their applicability is unlimited today and is encountered across all industries, either mechanical, electrical, aerospace, automotive or even construction industry. The production of metals entails high energy and material demands, which has an impact on the environment, and the deteriorating air quality is a fundamental environmental problem in the Czech Republic. To increase the durability and endurance of metals and their products, it is necessary to cover these metals and products with a suitable coating. This technological treatment protects metals from the surrounding environment. Most metals are exposed to the action of oxygen, aggressive gases in the air, water, and other aggressive substances. These effects have impact mainly on the metal surface. The result is not only a change in appearance, but also a change in mechanical properties, making the product unsatisfactory or dangerous. Therefore, it is important to protect the surface of metals and, thanks to this protection, metals become more resistant and appealing to the eye.

The case study was conducted at Massag a.s., the company located in Moravia.This company has been dealing with the surface treatment of materials for many years. In addition to material surface treatment, it is engaged in the production and renovation of logistics equipment and the production of small metal goods.

2. LITERATURE REVIEW

Material surface treatment is a technological process by which the properties of a given material surface are improved. Material surface treatment increases corrosion resistance, wear resistance, we improve performance, change or improve aesthetic appearance of the material. Thus, surface treatment is actually an adjustment of the material surface and surface microgeometry, which means that artificial surface layers of the treated material have different chemical composition and physical properties than the original material. [1,2,3]

Chemical treatment of metals results in the formation of coatings that originate from the chemical reaction between the basic material and the chemical solution. These layers then protect the material from external influences and improve its appearance. Major surface treatments include degreasing, dipping, phosphating. These treatments mostly serve as surface preparation for coatings. [1,2,3] Achieving a clean surface before subsequent processing is very important. Incorrect and insufficient surface preparation can cause premature failure of metal finishes. [4,5]

Electroplating is one of the most widely used metal plating methods. Galvanic coatings have universal applications, such as surface corrosion protection, or they improve the physical properties of the surface or create a decorative surface appearance. [6] The protective value of electroplating is based on the ability of this coating to protect the basic metal from corrosion. Factors affecting the quality of protection include the thickness and integrity of the coating, the corrosion properties of the coating and the basic metal, the electrochemical properties between the metal, the coating, and the environment. [6,7,8,9]

Electroplating is a process based on the electrolysis principle where metal ions in solution move in an electric field so that they can form a coating on the electrode. Electroplating takes place in the presence of direct current. The supplied electrical current and voltage are the main electrolysis factors. The coating layer can consist of only one metal or multiple layers of different metals. The layer thickness is about 10 - 35 µm. [5,8] Faraday's Electrolysis Laws are important for electroplating. [3]

The main types of galvanic plating processes include galvanic copper, brass, zinc plating, nickel plating, tin plating, gold plating and silver plating. The technological procedure of the galvanization process varies according to the type of plating, the type of products and the possibility of galvanizing. In general, the process can be divided into the following phases: degreasing, water rinsing, dipping, water rinsing, electroplating, water rinsing, possibility of passivation according to a customer and the possibility of a line, or drying. Depending on the type of galvanization, specific defects may occur. [1,3,6]

3. CASE STUDY

The experiment was running all the time with the specified plating process parameters **Table 1**.

Table 1 Balance parameters for electroplating technology

	Bulk Technology	Pendant Technology
Temperature (°C)	30 ± 1	30 ± 1
Current (A)	380	480
Time (minutes)	46	90
Concentration ZnNi in the bath (g/l)	6 - 7 Zn 1 - 1.5 Ni	5.6 Zn 1.5 - 2 Ni

The experiment was performed on two types of products. One product was chosen for hinge technology, the other for drum technology (**Figure 1**). Both products were measured in a period corresponding to ten contracts. For each order, 10 pcs were measured for both products, which is prescribed by internal regulations. The measured quantity was the thickness of the ZnNi coating and the percentage of nickel in the alloy. The measurement was performed on an X-ray meter. The measurement process is shown in **Figure 1**.

The measurement results are shown in **Figures 2, 3**. The coating thickness measurement results (**Figure 2**) show that the minimum and maximum coating thicknesses required by the customer were not exceeded during the experiment period, so no defects were recorded. The graphs show that the drum coating technology has a more stable coating thickness than the hinge technology; the main reason is the technological process itself, where the components are constantly moving in the drum and have direct contact with each other, resulting in a more even distribution of the coating. In contrast, hinge technology is static and has a specific product layout, and there may be shielding of products on the hinges. Furthermore, the graph shows that the thickness of the coating lies at the lower limit set by the customer.

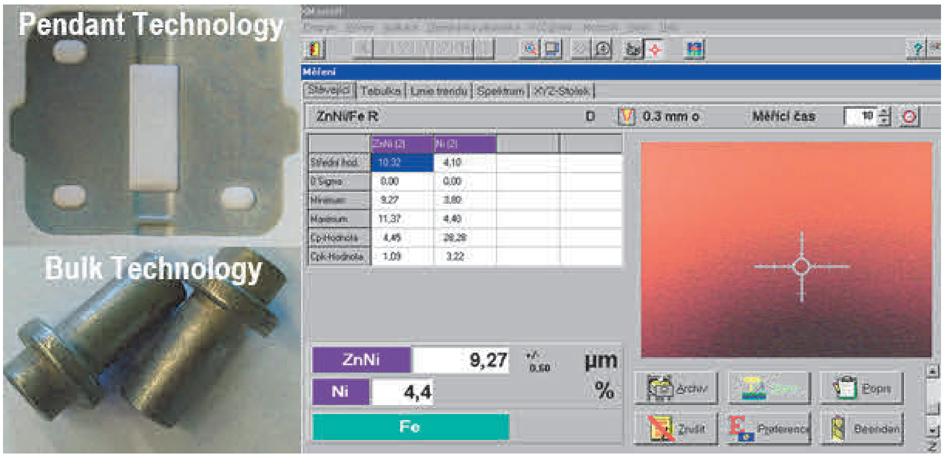

Figure 1 Measurement recording and test parts

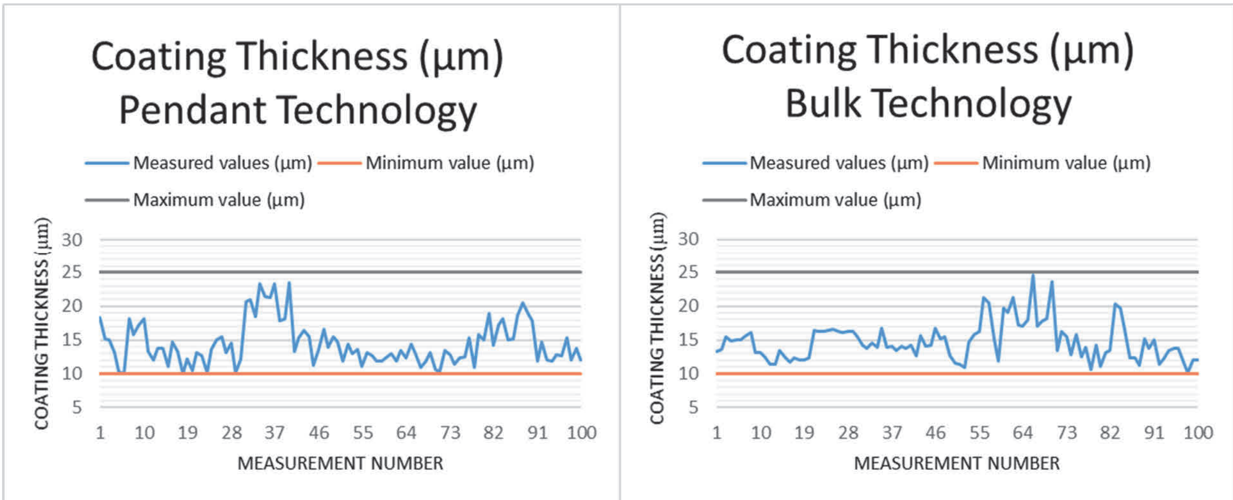

Figure 2 Coating Thickness (µm) Pendant Technology, CoatingThickness (µm) Bulk Technology

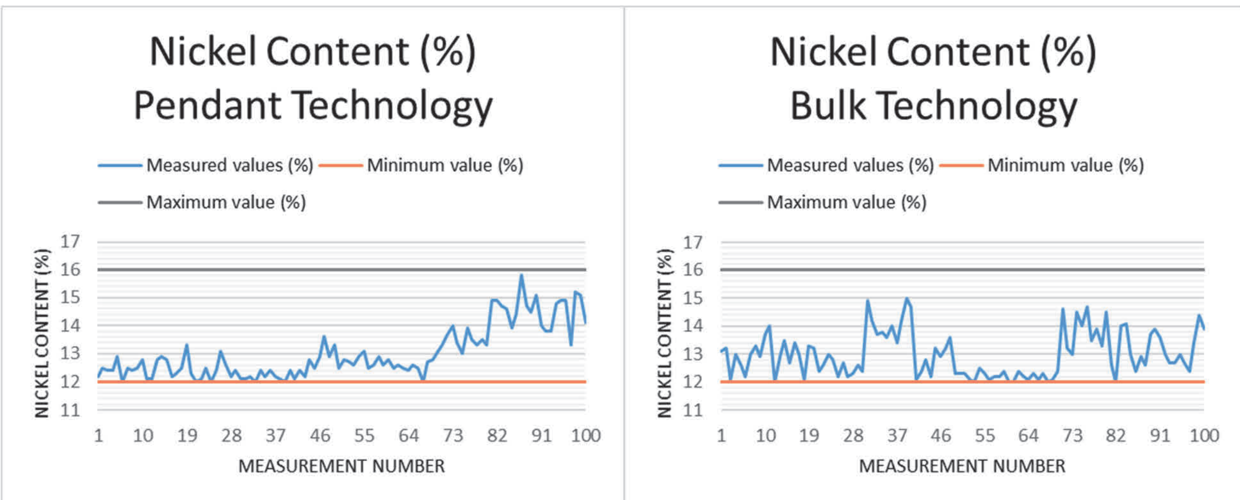

Figure 3 Nickel content (%) Pendant Technology, Nickel Content (%) Bulk Technology

The measurement results of nickel content in ZnNi alloy (**Figure 3**) show that during the experiment time the minimum and maximum Ni content of the alloy determined by the customer was not exceeded. Therefore, no defects were recorded. We can also see from the course of the graph that the hinge technology was better. For both technologies, the main parameter is the correct ratio of components in the galvanic bath. Furthermore, it can be seen from the graph that the thickness of the coating lies at the lower limit set by the customer.

For both technologies, the occurrence of defects was compared (**Figure 4**), these defects are recorded and sorted according to the defect catalogue (**Figure 5**). For hinge technology, each product is visually inspected, and for drum technology, the inspection is random.

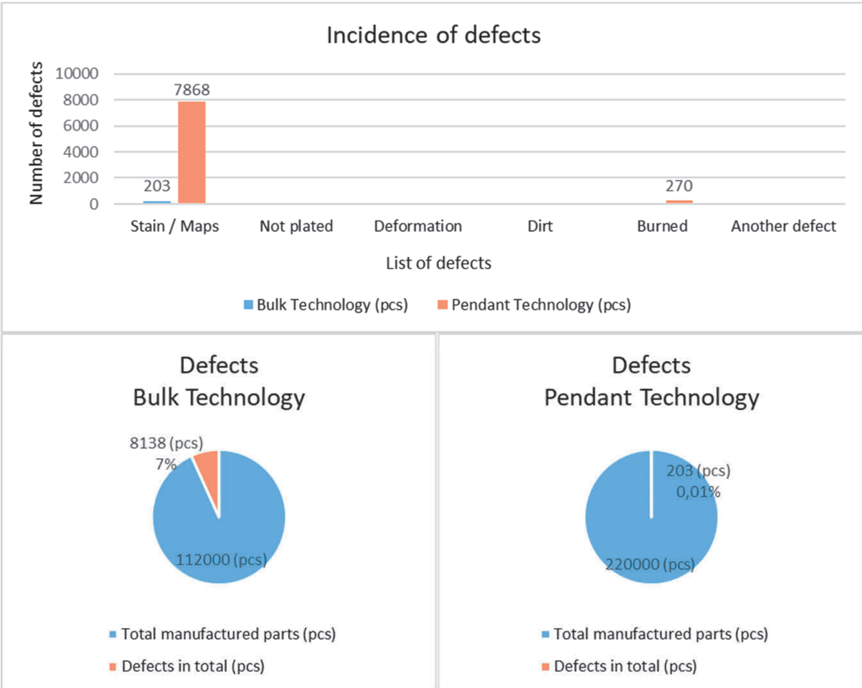

Figure 4 Defect analysis

The results of the defect measurement (**Figure 4**) show that 7 % of defective products were found in hinge technology for the specified period, mainly Stain / Maps defects. These defects are due to a number of reasons, including excessive grease of parts before the galvanization process begins, poor rinsing, poor bath ratio, or poor suspension of products on the hinges. There are almost no defects in drum technology.

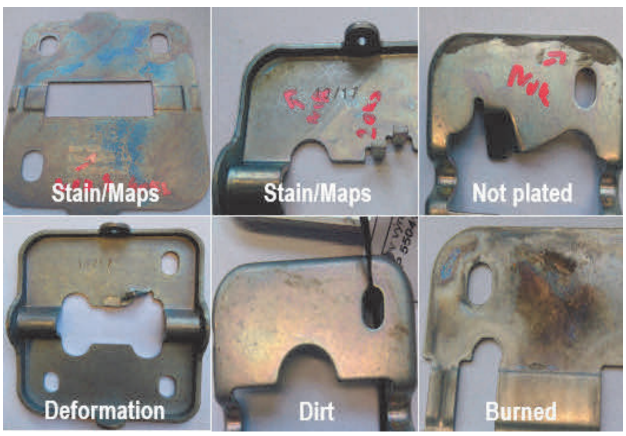

Figure 5 Catalogue of defects

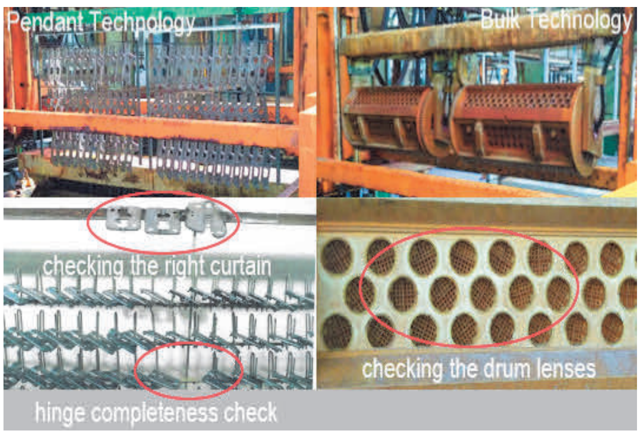

Figure 6 Pendant Technology, Bulk Technology

The next part of the study was focused on drum plating technology. During common operation, different surface quality was found at the beginning and the end of the shift, it means the resulting surface quality varied over time. The temperature of the galvanic bath was repeatedly measured in dependence on time with the specified parameters (**Table 1**). Measured temperatures over time and changes in surface quality are shown in **Figure7**.

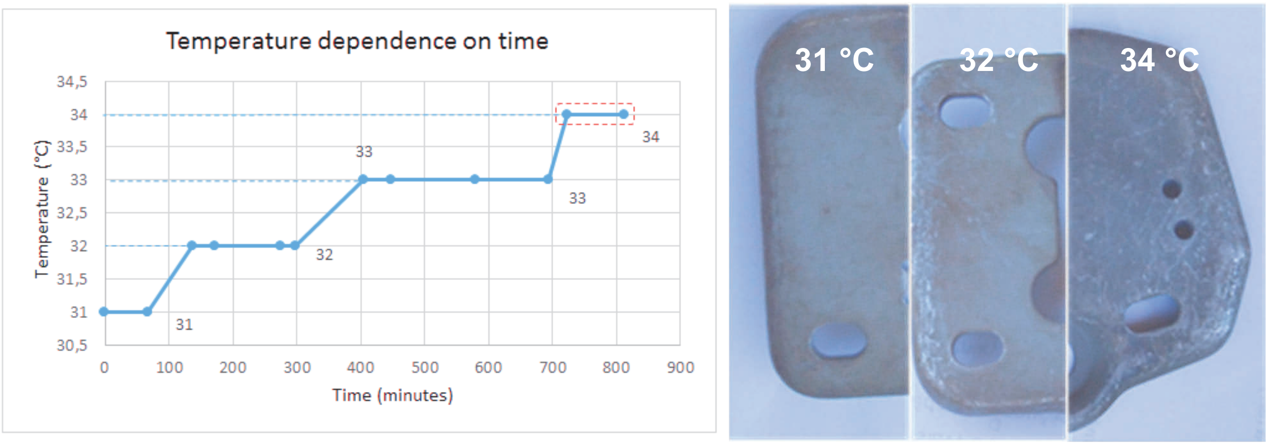

Figure 7 Temperature dependence on time and changing surface quality with increasing temperature

From the graph it is noticeable that at time 0 (the beginning of a shift), after the first passing by of the drum, the measured temperature is at the desired value of 31 °C, during the shift and after next getting through of drums through the bath, the temperature increased by 3 °C and at the end of the shift, after undergoing of the all 12 drums, the temperature had reached 34 °C.

In the physical process of electrolysis, heat is generated, which results in heating of the bath. The higher bath temperature requires an ever higher current and thus the galvanic bath itself degrades and this consequence is the decomposition of the organics in the bath, which causes increased consumption of Ni and Zn in the bath itself, thereby reducing the free Ni and Zn to the metal plating itself. As a result of these changes, the color of the product is unsuitable, as **Figure 7** (fail to meet the customer´s requirements) because the required amount of ZnNi cannot applied. In order to prevent the increasing of temperature of the bath, a measure has been proposed in the form of a cooling system which has been added directly to the galvanic bath. This measure is in the testing phase, but the first results hold the temperature at the specified level.

4. CONCLUSION

The experiment shows that the hinge technology is worse in the occurrence of defects at the specified plating process parameters when I myself compared the hinge and drum technologies. For other product types, this can be the other way around, and it depends on the technicians' experience with technology process. However, this technology cannot be omitted because it is used for large-scale products, as opposed to drum technology, which is intended for small materials. For both technologies, it is important to have properly set parameters of the plating processes and plating baths, to perform a thorough degreasing in the degreasing baths to prevent defects. The preparation before the actual plating process is very important, as it is necessary to check the completeness of the hinges for proper spreading of the coating and also to check that the lenses are not missing in the drum (**Figure 6**).

An increasing bath temperature was found in the normal operation of the drum technology, and it as negative affects of the the plating quality. Therefore, has been proposed a step in the from of cooling to avoid heating and the galvanic process takes place at a constant temperature.

The results of the experiment can contribute to the correct selection of the electroplating technology. Properly selected technology can not only save money but also bring savings during the application of a sufficient coating layer.

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