# THE ANALYSIS OF QUALITATIVE PARAMETERS OF ANODISED COATING OF FINISHING STRIPS

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**Abstract**

The main purpose of the paper is the determination of basic causes of non-conformances of anodised coating on aluminium finishing strips. Results of the analysis allow to identify factors that should be paid special attention during the production process. In the first part of the paper the analysis of quantitative parameters of anodised coating of finishing strips was presented. 20 finishing strips made of aluminium, previously submitted to the anodising process in sulfuric acid were evaluated. In each test, the same elements were used, each one was assigned the same number for each analysis. The parameters of layer were measured at 5 specific points. Three basic parameters of coating were examined: thickness, grindability and microhardness. The elements of statistical analysis were used for analysis. In the second part of the paper the Ishikawa chart was used to determine the causes of defects in the coating.

**Keywords:** Quality, statistical analysis, finishing strips

## 1. INTRODUCTION

The application of quality management in companies is related to, among others, the use of control activities of production processes in order to locate and identify non-conformances occurring in products and the use of such activities that will help to eliminate both them and their causes [1,2]. In order to minimize the occurrence of non-conformances, appropriate quality management methods should be applied so that typical problems appearing in the production process can be solved. It is important, therefore, that the employees are aware and prepared to solve problems that may appear in the processes, especially to eliminate their causes. There is also a need to take preventive measures to avoid errors, resulting in higher costs and longer production cycles [3,4].

In many book publications and papers related to the subject of quality management, an approach that tools and techniques used in quality management are extremely important in supporting the development and improvement of the quality of final products that go to buyers, can be found [5].

The spectrum of methods and tools of quality assessment that are mentioned in the literature of the subject is very wide. A variety of quality management methods and tools can be used to monitor the entire production cycle from the design stage, through manufacturing to final product inspection. All of them are characterized by a planned, repetitive and scientifically based way of proceeding during their use [6].

The use of such tools can bring many tangible benefits, which should be mentioned: providing clear and objective information, supporting the improvement of processes and activities in organizations, improving the functioning of the organization in a systematic manner, enabling management of the organization based on real data (results of tests and analyses), employing employees in quality improvement processes, enabling observation, analysis and evaluation of cause and effect relationships in organizations, impact on reducing quality costs, which can contribute to the company's profits [7].

## 2. CHARACTERISTICS OF MATERIAL

The testing material taken to analysis are aluminium finishing strips with A02 profile. These are 120 cm long joining and finishing strips, coloured in silver. Finishing strips, having the category of coating thickness AA15 (15μm), are made of anodised aluminium. They are used for aesthetic, as well as functional merging of floors, so that they create a chic and uniform whole. In most cases, they combine wooden floors, floor panels, parquet floors, with carpets or ceramic tiles as well as decorative stone [8].

Dimensions of strips are: length - 120 cm, width - 30 mm and thickness - 2 mm. All finishing strips taken to the analysis come from a single source, from the same batch. Each of the samples is made from the same 6xxx alloy series - Al-Mg-Si alloy, which is characterized by medium strength, good plastic, good machinability, good corrosion resistance and heat treatability [8].

## 3. METODOLOGY OF THE ANALYSIS

The paper presents the analysis of three quality parameters of selected product: thickness of coating, its grindability and microhardness. 20 aluminium finishing strips that have undergone the anodising process in sulfuric acid were selected to the analysis. In each study (for each parameter), the same elements with the A02 profile were used, which was assigned the same number for each analysis. All samples were taken from one pendant, so they went through the same production process. The measurement of the parameters of the layer of analysed elements was carried out in 5 specific points, which are of significant importance for the recipient of products. The following element of the analysis were made:

- statistical evaluation of parameters of the product,
- analysis of variability of the average value of parameters in individual samples,
- analysis of causes of problems in anodising process (main causes of non-conformances).

## 4. ANALYSIS OF RESULTS

### 4.1. The analysis of coating thickness

The analysis of the results concerning the thickness of the anodised coating of the tested strips was performed. The basic descriptive statistics of the tested parameter were determined (**Table 1**) and the distribution of this parameter was presented graphically (**Figure 1**). Subsequently, the analysis of the variability of the average coating thickness in individual samples was made by comparing the results to the minimum of average thickness (15 μm) and to the minimum local thickness (12 μm for a single measurement). The results of the analysis are shown in **Figure 2**.

**Table 1** Descriptive statistics for coating thickness [Own study based on: 8, 9]

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| Average | 15.76 | Variability | 8.7% |
| Median | 16 | Asymmetry | -0.42 |
| Dominant | 15 | Minimum | 11 |
| Standard deviation | 1.37 | Maximum. | 18 |

Based on the results of presented analysis (**Table 1**, **Figure 1**, **Figure 2**), it can be concluded that:

- Average coating thickness is 15.76 μm with app. 9 % of variability. The distribution is clearly asymmetrical and indicates that most of the results exceeded the average minimum thickness. Only single results reached a value well below this number. The lowest result (11 μm) was recorded in only one measurement.

- The analysis of variation of average thickness in individual samples showed that in case of two samples the results were unsatisfactory. For sample No. 2 the average value of measurements was too low. In case of sample No. 11 the average value was satisfactory, however, for one of the measurements, too low thickness result (11 μm) was obtained, which exceeded the permissible value of the local thickness minimum. Both strips should be rejected. The average thickness for the rest of samples was much higher than minimum average thickness.

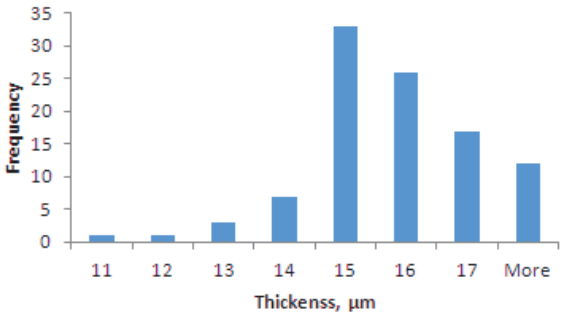


**Figure 1** The distribution of coating thickness [Own study based on: 8,9]

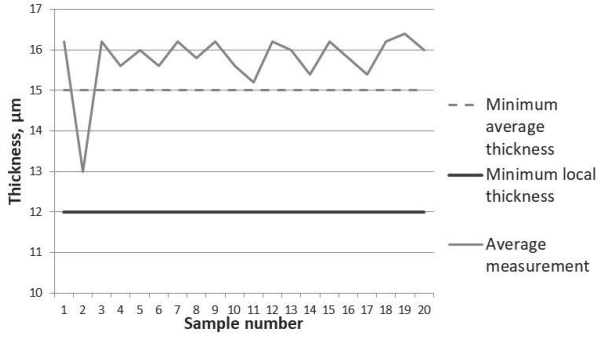


**Figure 2** Variability of the average coating thickness in individual samples [Own study based on: 8,9]

### 4.2. The analysis of coating grindability

The analysis of results concerning the grindability of anodised coating of aluminium finishing strips was made. The basic descriptive statistics for this parameter was evaluated (**Table 2**) and the distribution of this parameter was created on diagram (**Figure 3**). Then the analysis of variability of average of grindability in individual samples in comparison to the maximum loss (2 μm) was made. Results of this analysis is presented in **Figure 4**.

**Table 2** Descriptive statistics for coating grindability [Own study based on: 8,9]

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| Average | 1.32 | Variability | 40.11% |
| Median | 1 | Asymmetry | 1.39 |
| Dominant | 1 | Minimum | 1 |
| Standard deviation | 0.52 | Maximum. | 3 |

Based on the results presented in the paper (**Table 2**, **Figure 3**, **Figure 4**) it can be concluded that:

- Average grindability of coating for individual measurements was approx. 1.32 μm with 40 % variation. The distribution of the tested parameter is considerably asymmetrical. Most samples achieved a result of about 1μm. Only for three measurements a value of 3 μm was achieved.
- The analysis of variability of average grindability in individual samples showed that for one sample the results were not satisfactory. For 3 local measurements in sample No 2 the result of 3 μm was obtained, average value of this parameter for all 5 measurements was 2.6 μm. This result indicates that the strip No. 2 should be rejected. Average grindability for the rest of samples was much lower than maximum grindability.

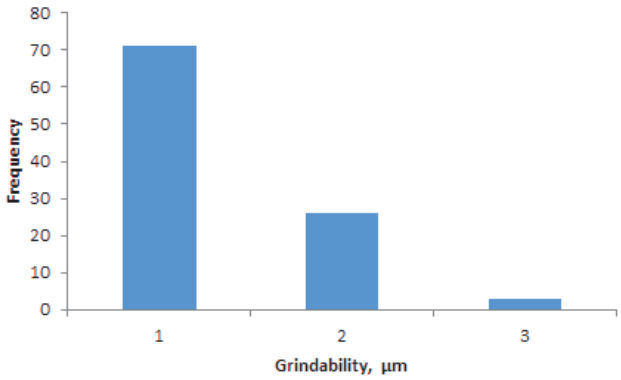


**Figure 3** The distribution of coating grindability [Own study based on: 8,9]

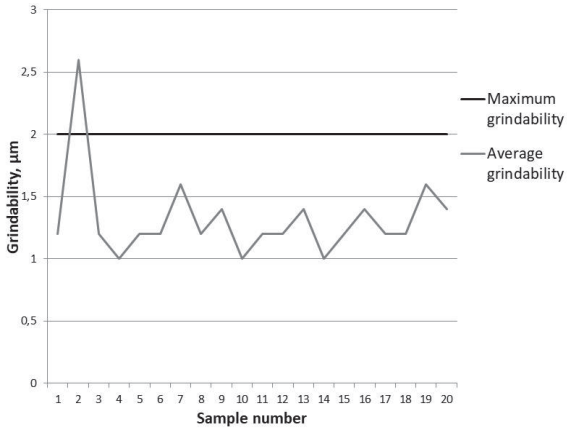


**Figure 4** Variability of the average coating grindability in individual samples [Own study based on: 8,9]

### 4.3. The analysis of coating microhardness

The analysis results of microhardness of anodising coating of aluminium finishing strips was performed. The basic descriptive statistics for the parameter were calculated (**Table 3**) and the distribution of this parameter was presented on the graph (**Figure 5**). Then the analysis of variability of the average microhardness of coating in individual samples was performed in comparison to normative value (135 HV). The result of the analysis are shown in **Figure 6**.

**Table 3** Descriptive statistics for coating microhardness [Own study based on: 8,9]

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| Average | 129.9 | Variability | 14.1% |
| Median | 130 | Asymmetry | -0.43 |
| Dominant | 109 | Minimum | 71 |
| Standard deviation | 18.32 | Maximum. | 169 |

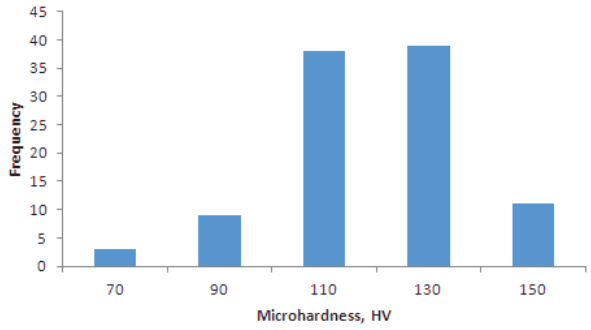


**Figure 5** The distribution of coating microhardness [Own study based on: 8, 9]

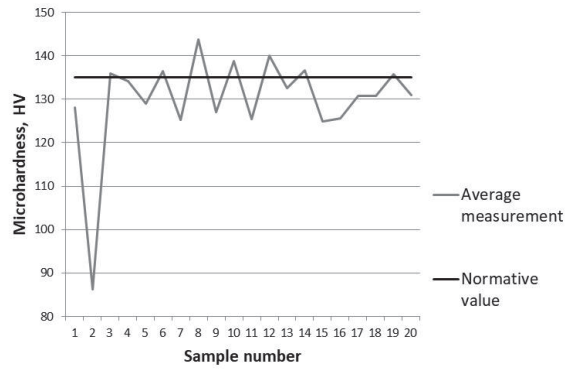


**Figure 6** Variability of the average coating microhardness in individual samples [Own study based on: 8, 9]

In assessing the results of the analysis (**Table 3, Figure 5, Figure 6**) it can be seen that:

- The average value of microhardness in the tested strips is app. 130 with 14.1% of variability. The distribution of the results is slightly asymmetrical, half of results exceeded vale of 130. Only for 3 individual measurements the results were significantly different and much lower than 100.
- The analysis of variability of average microhardness in individual samples showed that in most samples the results fluctuated in the normative value boundary. As in previous cases, results for sample No. 2 were significantly different from the norm. For one of the measurements, a result of 71 was obtained, the highest value of microhardness in this sample was 102. It confirms the earlier statement that strip number 2 should be rejected. It should be emphasized that between microhardness and the thickness of the coating there is a high dependence: the thinner the coating layer of strip, the worse the microhardness parameters.

### 4.4. The analysis of causes of non-conformances of anodised coating on aluminium finishing strips

The analysis of causes of non-conformances of anodised coating on aluminium finishing strips is presented in **Table 4**.

**Table 4** Ishikava analysis of causes of problems in anodising process [Own study based on: 8,9]

| Man | Material | Machine |
|---|---|---|
| ***Experience***<br>lack of experience results in improper performance of certain activities entrusted by the manager<br>***Seniority***<br>gaining knowledge and experience through many years of work teaches people to carry out tasks in proper way<br>***Qualifications***<br>lack of knowledge skills in handling equipment to perform tasks has great effect on the effects of work<br>***Job satisfactions***<br>satisfied employees show greater initiative, reliability and positive climate work, while lack of it may result in lowering organizational efficiency | ***Alloy class***<br>it is important that used material is in the appropriate class of alloys, does not have a large amount of admixtures, what can significantly affect the aesthetics of the profile or prevent the process from being carried out<br>***Structure of surface***<br>the profile cannot have various types of blemishes (scratches, dents), this will worsen the appearance and aesthetics of the strips<br>***Proper preparation***<br>processes such as sanding or brushing must be performed by experienced workers, because it affects the final effect and the quality of the strips | ***Technical conditions***<br>assessment of the technical condition and diagnostics of machinery and equipment on time may have a significant impact on the production volume<br>***Producer***<br>the manufacturer's goal should be to improve the quality and productivity of machines<br>***Construction-technology***<br>construction and at the same time the technology used by the device manufacturer is of particular importance to the level of products |
| **Method** | **Measurement** | **Money** |
| ***Anodising program***<br>the use of the appropriate anodising program is one of the basic factors determining the obtaining high quality of products<br>***The course of anodizing process***<br>performing the anodising process in accordance with the selected anodizing program<br>***Way of hanging profiles***<br>fasten the strips to the carriers in optimal way and using appropriate pendants, so that each element is coloured properly | ***Accuracy of the meter***<br>the meter should indicate value of 0.01μm to examine accurately the thickness of the profile<br>***Measurement method***<br>it is important that the strips from each tested series wad tested in five places at equal distance from each other<br>***Imprecision of the meter***<br>inaccurate readings may disturb the actual value of the measurement | ***Lack of training***<br>it is important to conduct periodic training to improve the employee's qualifications and professional skills<br>***Limitation of technical inspection***<br>a malfunctioning machine system can significantly reduce the production volume<br>***Cheaper consumables***<br>faster wear parts lead to frequent failures |

Non-conformances related to the parameters of coating of aluminium finishing strips are closely linked to the production process. Most of them are formed during the anodising process, where the coating is produced, the function of which is to increase the corrosion resistance and improve the decorative value. The analysis of causes of problems occurring during the anodising process of strips was made. The analysis was based on Ishikawa diagram principles. All reasons were divided into 6 main groups according to the principle of the diagram. For each group, the reasons were ordered from the most to the least important ones.

## 5. CONCLUSION

Nowadays, it is necessary to carry out the anodising process in the shortest possible time with achieving high level of quality of products. Unfortunately, the process is not always carried out correctly, what may result in inadequate parameters of products, including: thickness, grindability and microhadness. Therefore, it is necessary to constantly monitor the quality of finished products using a variety of methods and tools, including statistical methods.

Analysis of selected parameters of anodising coating of aluminium finishing strips showed that only two strips from entire sample turned out to be defective. It is a result that can be accepted. However, it should be emphasized that the philosophy of quality management requires striving for perfection and in the future removal all potential con-conformances.

In order to eliminate the causes of potential non-conformances, the analysis of production process was performed. Problems occurred during anodising process were identified. All problems identified in the analysis we divided into 6 main groups according to Iskikawa principles. The most important problems in anodising process can be the ones categorised into 2 groups: the method (it includes anodising program, the course of the process, way of hanging profiles) and man (experience, seniority, qualifications, job satisfaction).

With the purpose of constant quality assessment many different methods and tools can be used. They enable the analysis of results, identification of problems and their effective elimination. Thanks to this, companies can prevent the occurring of non-conformances of products in the future and increase customer satisfaction.

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