DETERMINATION WITH A LASER MICROSCOPE OF THE THICKNESS OF THE PAINT AND ZINC LAYERS OF THE SEMI-MANUFACTURED PRODUCTS USED FOR METAL ROOF TILES

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Abstract: *Most residential buildings in Romania have metal tiles roofs usually made in our country by profiling semi-manufactured products imported from European Union countries (steel sheets with a thickness of 0.40 ÷ 0.50 mm, coated with zinc, primer, polyester-polyamide paint and epoxy-polyurethane paint layers). Inappropriate (smaller) thickness of the layers deposited on the steel sheet causes defects of the final product (roof tile); when receiving the semi-manufactured products from the external partners, the Romanian metal roof tile manufacturers are performing a series of quick tests, which do not always lead to the identification of regions with inadequate thicknesses of the layers covering the steel sheet. In this article are presented the results of the study conducted at the University "Stefan cel Mare" for the identification and measurement of the paint (polyester polyamide and epoxy polyurethane), primer and zinc layers of some semi-manufactured products used for making metal roof tiles, with a laser microscope (Olympus LEXT OLS4100); 23.81% of the measurements made on the polyester-polyamide paint layer and 31.58% of those made on the primer layer had values below the lower limit of the thicknesses prescribed for these layers..*

Keywords: *paint, primer and zinc layers, metal roof tile, laser microscope.*

1. INTRODUCTION

Today, most residential buildings in Romania adopts metal roofing tiles version; its advantages are that it has a low weight, long life, it is easy to install and thus the time of execution of a roof is short. In the last years, a large proportion of the metal roof tiles used by Romanian builders are produced in our country by profiling semi-manufactured products imported from European Union countries; they are in the form of steel sheets with a thickness of 0.40 ÷ 0.50 mm, coated with zinc, primer, polyester-polyamide paint and epoxy-polyurethane paint layers. Inapropriate thickness of these layers which does not comply with the technical specifications, leads to problems in the production of roof tiles, which ultimately generates defects. At the reception of the semi-manufactured products from the external partners, the Romanian metal roof tile producers make a series of quick tests on the quality of the raw material, but unfortunately the applied methods and the equipment used do not allow accurate identification and measurement of the layers deposited on the steel sheet, [1], [2], [3], [4].

This article presents the results of the study conducted at the University "Stefan cel Mare" of Suceava for the identification, measurement and characterization of the paint (polyester polyamide and epoxy polyurethane), primer and zinc layers of some semi-manufactured products for making metal roof tiles, with a laser microscope.

2. MATERIALS AND METHODS

Determination of the thickness of the layers covering the steel sheet used to make the metal roof tiles was done with an Olympus LEXT OLS4100 laser microscope (Olympus Corporation, Japan); it has a 405 nm laser illumination, a magnification range of 108x to 17280x, a measurement accuracy of 12 nm ± 2%, a display resolution of 1 nm and can perform ultra-accurate measurements in 2D and 3D, [5].

In the study, five samples (30 x 20 mm) were taken from different areas of some semi-manufactured products for metal roof tiles; the steel sheet was the grade DX51D + Z with a thickness of 0.45 - 0.50 mm, coated with zinc, primer, epoxy-polyurethane paint and polyester-polyamide paint layers (the epoxy-polyurethane paint was white-gray and the polyester-polyamide paint had four colors, black, gray, light brown, dark brown). The surfaces on which the determinations were made were processed with a Grinding/Polishing Machine SAPHIR 530 (ATM GmbH, Germany), first on a P1200 silicone carbite grinding foil (for 15 seconds) and then with a polishing cloth Zeta (for 15 seconds) soaked with diamond suspension mono cristalline (3 μm).

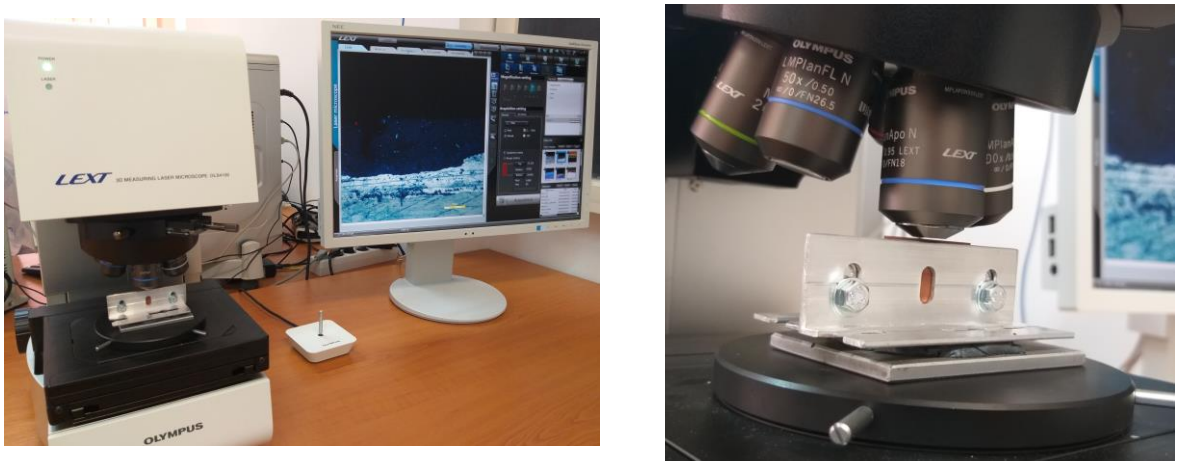

Figure 1 *Positioning the sample on the table of the Olympus LEXT OLS4100 laser microscope*

For a correct placement and positioning of the samples in front of to the microscope lens, they were fastened in a simple device consisting of two pieces of angle bar with egual sides (23.5 x 23.5 x 1.5 mm) of aluminum (Fig. 1). In some samples, in order to better highlight and measure the layers, a Differential Interference Contrast color observation (DIC color observation) was also performed.

3. RESULT AND DISCUSSIONS

According to the technical specifications of the manufacturers, most of the semi-manufactured products used for making metal roof tiles have two coats, "top coat" and "bottom coat" (Fig. 2); usually, the "top coat" consists of a "zinc layer" (with thickness between 9 and 20 μm), a "primer layer" (7 ÷ 15 μm) and a "polyester-polyamide paint layer" (10 ÷ 30 μm), and the "bottom coat" consists of a "zinc layer" (9 ÷ 20 μm) and a "epoxy-polyurethane paint layer" (with thickness of about 7 μm), [1], [2], [3], [4].

In the Romanian companies producing metal roof tiles, when receiving the semi-manufactured products from the external partners, a series of tests are carried out: for the film thickness (with ultrasound, SR EN 13523-1), of the hardness, with the pencil (SR EN 13523-4), of the adhesion after identation (SR EN 13523-6), the T-bend (SR EN 13523-

7), of the resistance to accelerate ageing by using of heat (SR EN 13523-13), of the colour differance (SR EN 13523-22). These tests can highlight some non-conformities of the semi-manufactured products, but do not allow neither a precise measurement of the zinc, primer and paint layers (polyester-polyamide and epoxy-polyurethane) covering the steel sheet nor the identification of all the regions where the thickness of these layers does not fall within the prescribed values (where it is smaller); in these regions, plastic cold deformation with high degrees of deformation results in cracks and exfoliations of the layers, the final product obtained (roof tile) being non-conforming, with defects (Fig. 3)

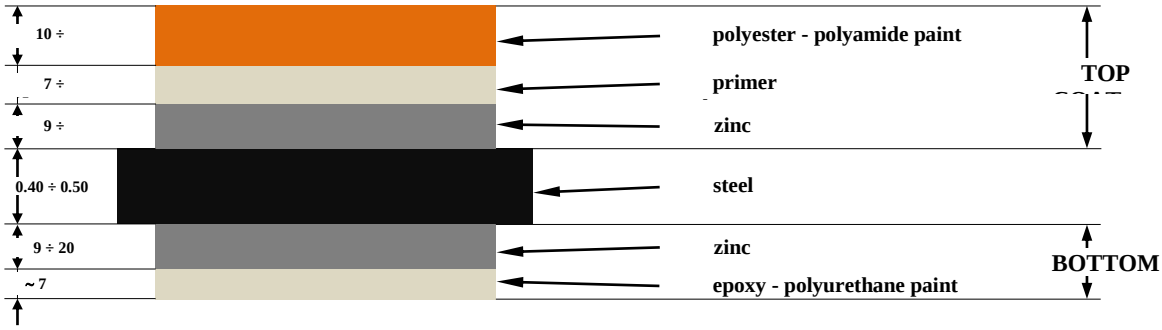

Figure 2 *Layers which cover the semi-manufactured products for metal roof tiles*

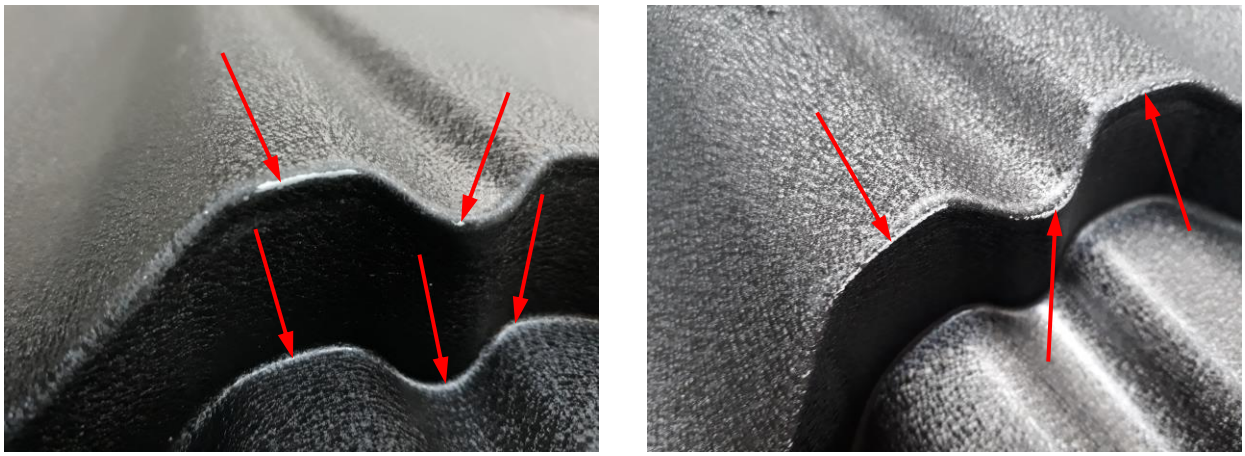

Figure 3 *Exfoliations of the polyester-polyamide paint layer*

In the studies conducted at University "Stefan cel Mare" of Suceava, five test fields were selected for each sample; they were established after a sample scan was performed (with a microscope magnification of approx. 500x) in order to identify regions with non-conforming thicknesses (Fig. 4). In each field of analysis, three measurements were made for each layer (zinc, primer, polyester-polyamide paint, epoxy-polyurethane paint), the microscope magnification for these measurements ranging from about 2900x to 4000x. From these determinations the following were found:

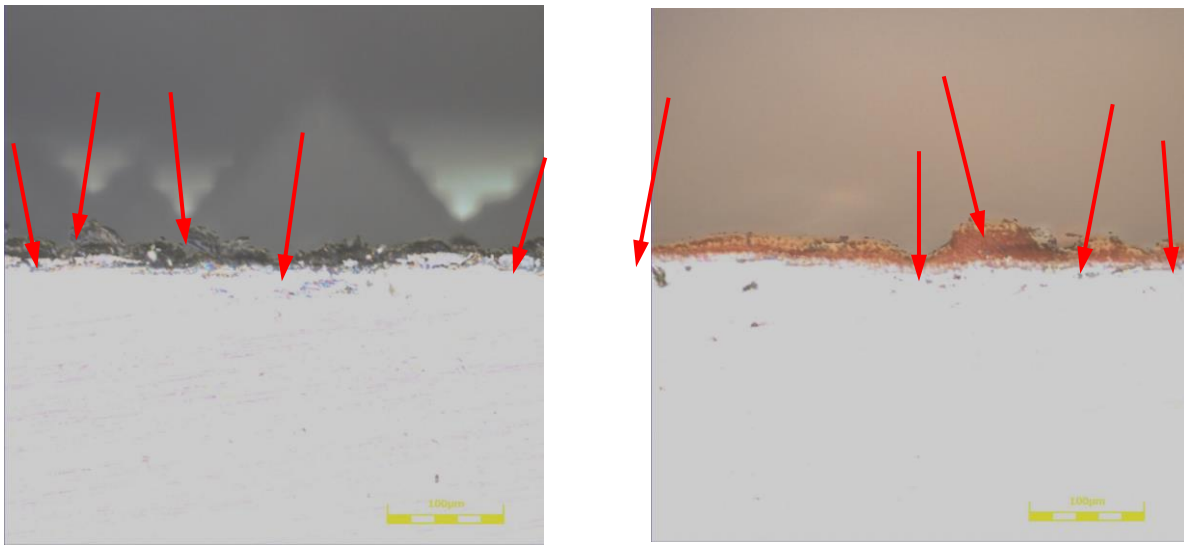

Figure 4 *Fields of analysis*

The two zinc layers of "top coat" and "bottom coat" did not have thicknesses below the lower limit prescribed by manufacturers (below 9 μm); the lowest thickness values were 10.68385 μm for the "top coat" layer (Fig. 5) and 13.32508 μm for the "bottom coat" (Fig. 6). Of the total measurements made on the zinc layers, 53.25% of the "top coat" and 15.16% of those determined in the "bottom coat" were above the upper limit prescribed by manufacturers (over 20 μm); the highest thicknesses were 40.36156 μm for "top coat" and 30.40439 μm for "bottom coat". They were not highlighted discontinuities of these layers.

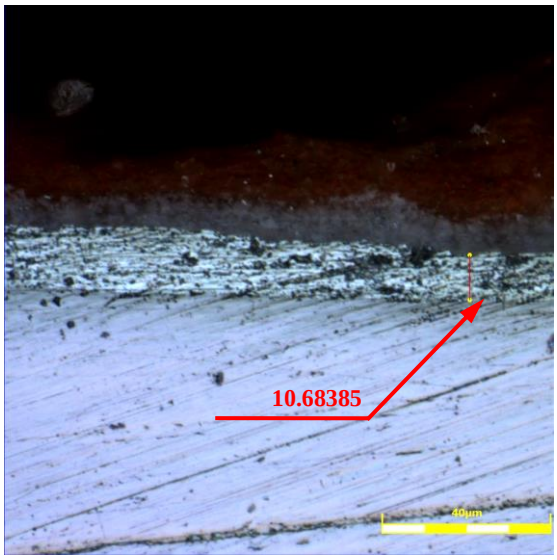

Figure 5 *The smallest thickness of the zinc layer in the "top coat"*

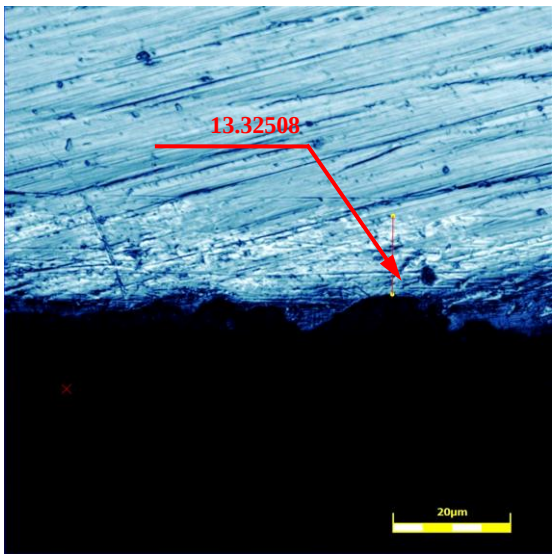

Figure 6 *The smallest thickness of the zinc layer in the "bottom coat"*

The primer layer in the "top coat", according to the technical specifications, must have a thickness between 7 and 15 μm. As a result of the measurements made it was found that 31.58% of the determined values were below the lower limit (below 7 μm) and 8.42% were above the upper limit (over 15 μm). The smallest thickness measured was 3.391698 μm

(Fig. 7), and the highest was 27.64442 μm (Fig. 8).

According to the technical specifications prescribed by manufacturers, the thickness of the polyester-polyamide paint layer should be between 10 and 30 μm. As a result of the measurements made, 23.81% of the values were below the lower limit (below 10 μm) and 13.10% were above the upper limit (over 30 μm). The smallest measured thickness was 3.876226 μm (Fig. 9), and the highest was 38.64417 μm (Fig. 10). In addition, some material discontinuities (polyester-polyamide paint) have been identified in some analysis fields (Fig. 10).

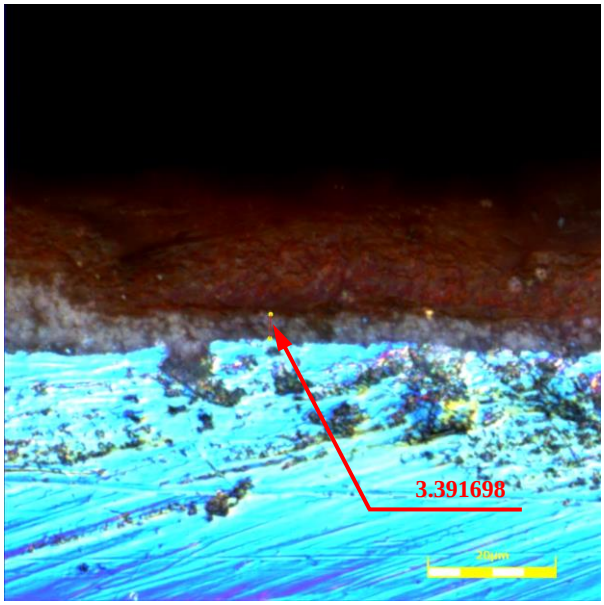

Figure 7 *The smallest thickness of the primer layer in the "top coat"*

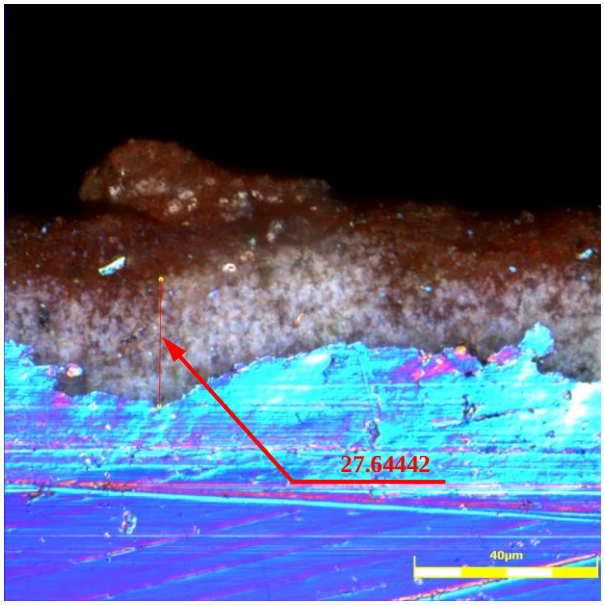

Figure 8 *The highest thickness of the primer layer in the "top coat"*

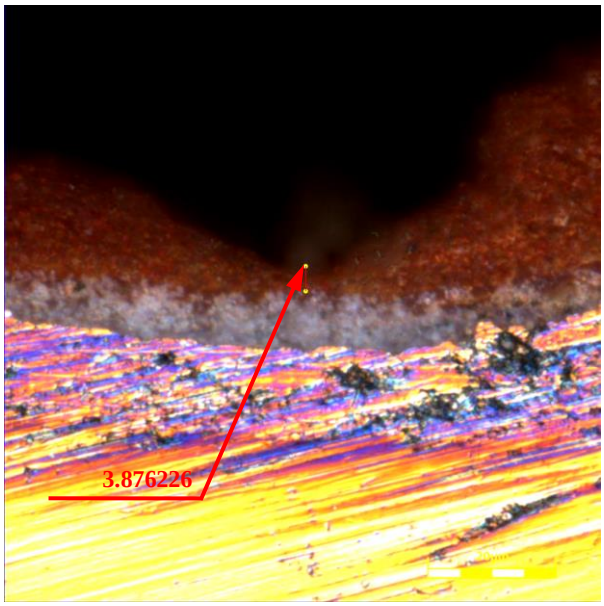

Figure 9 *The smallest thickness of the polyester-polyamide paint layer in the "top coat"*

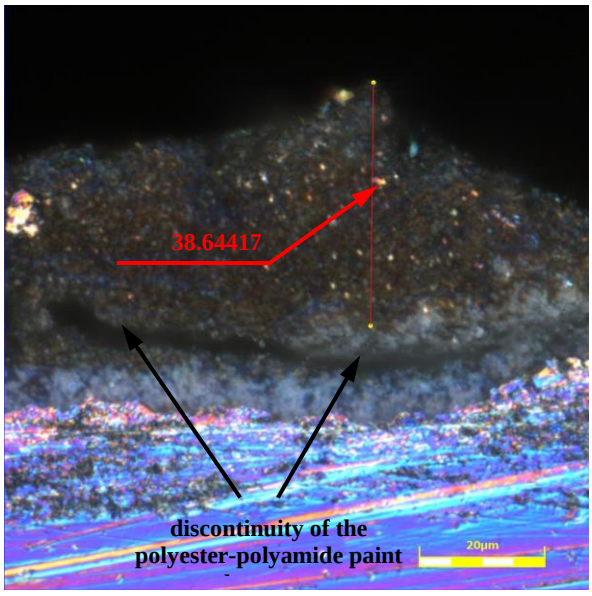

Figure 10 *The polyester-polyamide paint layer of "top coat"; the highest measured thickness and a material discontinuity*

Due to the color (white-gray) and the small thickness, the epoxy-polyurethane paint layer in the "bottom coat" was very difficult to highlight and measure (the layer could not be measured in all the fields selected for analysis); where this layer was measured, the thicknesses was greater than 7 μm (between 7.800906 and 15.94459 μm).

CONCLUSIONS

Metal roof tiles used in most residential buildings in Romania are produced in the our country by profiling steel sheets with thicknesses of 0.40 ÷ 0.50 mm, coated with a "top coat" (zinc, primer and polyester-polyamide paint layers) and a "bottom coat" (zinc and epoxy-polyurethane paint layers).

The romanian manufacturers are performing a series of tests on the semi-manufactured products used to make metal roof tiles, but they do not always highlight all the nonconformities; the tests do not allow a precise measurement of the layers covering the steel sheet. That is why at University "Stefan cel Mare" of Suceava we tried to measure these layers with a laser microscope.

In samples taken from semi-manufactured for metal roof tiles, the polyester-polyamide paint layer in the "top coat" had 23.81% of the thicknesses measured below 10 μm (below the lower limit prescribed by manufacturers) and 13.10% above 30 μm (above the upper limit prescribed by manufacturers). In some regions of the analysed samples were also identified discontinuities of the polyester-polyamide paint layer.

At the primer layer in the "top coat", 31.58% of the measured thicknesses showed values below 7 μm (below the prescribed lower limit) and 8.42% above 15 μm (above the prescribed upper limit).

The two zinc layers did not have thicknesses below 9 μm (below the prescribed lower limit); but, 53.25% of the values for layer in the "top coat" and 15.16% for the "bottom coat" were above 20 μm (above the prescribed upper limit).

In the regions where the measurement was made, the epoxy-polyurethane paint layer in the "bottom coat" had thicknesses between 7.80 and 15.94 μm (the prescribed thickness, about 7 μm).

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