STUDYING THE PROCESS OF ZINC WITH GALVANIZATION

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Abstract: This research paper is focused on process and quality verification of the zinc coating with galvanization. The purpose of this research is to describe the process and the circumstance that influence in quality as well adhesive resistence within the coating process. The investigated sample requiress knowledge of the technological processes for zinc coating, qualified sampiling, for verification of adhesion power, lacing power, both mechanical and physical, in the progress of the zinc coating on the surface of the material. At this occasion every attempt to determine the dimension of the surface layer should lead to the measurement of the hardness of this relation.
Hot-dip galvanizing process is one of the decent methods and the most frequent of applying zinc coating on steel surfaces. The research also included a review of methods for testing the thickness of the zinc coating. The purpose of this research paper is to test the zinc coating with magnetic gauge namely the QuaNix 7500, which monitors the quality of hot dip galvanizing.
The results of verifying this have been laid up to scientific analysis and the findings lead to the evaluation proposed by this technique and its application to technical practice.
Keywords: Hot-Dip Galvanizing - Hot-Dip Process, Steel construction, Zinc Alloy-Coated Steel Products - Zinc Coated - Zinc-Coated Steel Sheets - Zinc-Coated Conainers.

1. INTRODUCTION

The zinc galvanizing is the process of applying a zinc coating on the surface of steel or iron to prevent corrosion.Whereas zinc can be proceed by electrochemical processes (electrolysis), the most common current technique is hot-dipping zinc steel, in which the steel structures are immersed in a bath of molten zinc in temperature of 450 ° C. Electrolysis is commercially important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell. On the other hand, the effective protection against corrosion is of particular importance in saving energy as well as the necessity of facilities as well buildings. Nevertheless, every 90 seconds worldwide at least in quantity of 1 ton of steel is damaged by corrosion, while on the other hand in quantity of 2 tonnes produced steel at least 1 tonne out of this quantity will replace the damaged one. The use of hot-dip galvanizing steel to protect against corrosion means that at least each tonne of galvanized steel within this process we could save as much energy as would be sufficient for energy needs for a family for a several weeks. According to the American Galvanizers Association[1], the Hot-dip galvanizing is the process of immersing iron or steel in a bath of molten zinc to produce a corrosion resistant, multi-layered coating of zinc-iron alloy and zinc metal. While the steel is immersed in the zinc, a metallurgical reaction occurs between the iron in the steel and the molten zinc. This reaction is a diffusion process, so the coating forms perpendicular to all surfaces creating a uniform thickness throughout the part.

2. MATERIALS AND METHODS

The sample

While this is an important aspect of a that the sample consist of the steps of the preparation of steel surface on the process of galvanazing immersed on hot Dip Galvanizing conducted within the facilities of factory "Galvazink" Shpk – located in Prizren, Republic of Kosovo.
Initially, the steel structures are first conected or depend on the holders as in the following figure:

Fig1. Model of connection of steel structures to the holders

[1] https://galvanizeit.org/inspection-course/galvanizing-process

Preparation of the steel surface is the most important step for zinc coating because unproperr surface preparation can cause damage to the homogeneous coating of the zinc steel surface as well as the quality of the zinc-coated coating, just because zinc cannot respond metallurgical at the unclean steel surface.
The steel surface cleaning process includes technological operations such as folows:

- Diving in alkaline solvents (basic);
- Irrigation subsequently immersion;
- Cleanup with hydrochloric acid (corrosion removal);
- Irrigation subsequently cleaning with acid;
- Afflux and
- Dry out.

The technical steps of the process of production of the zinc coating
The process of galvazing
After drying the steel structures, they are immersed in a zinc bath at a temperature of (450 - 455) ^{0}C , whereby the coating is coated with a single layer of zinc.

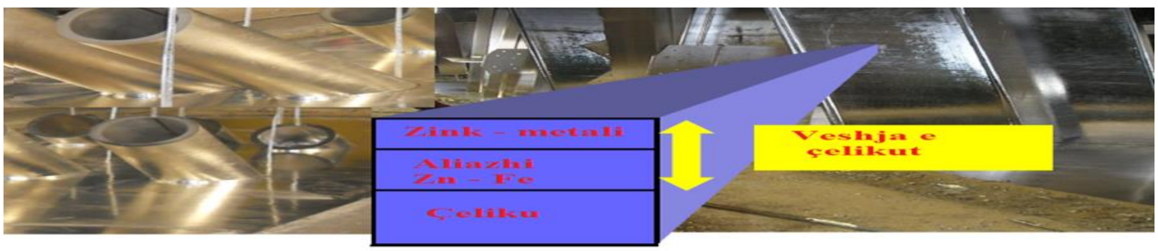


Fig 2. Emmersion of stee
1st structures from zinc tub and forming of zinc coating

Metallurgical bond of zinc with steel
It will be noted that the thickness of the coating after galvanizing is the total of the thicknesses of the inter-metallic layers (mainly depending on the composition of the steel as well the bathtub temperature from the time of immersion) and the thickness of the pure zinc layer (depending mainly on the zinc fluidity and the pulling speed). However, the constitution of alloy layer of the zinc-iron it is a process of difusion.
The pulling speed of the steel zinc bathtubs
In one hand, the ultimate immersion time, to the utmost is the amount of zinc deposit. Hereupon, the thickness of the zinc layer depends largely on the time the steel structure is pulled out of the zinc tub and the excess zinc slides. On the other hand, a quick pulling time rate causes the item to receive irregular amount of zinc.
Zinc temperature
The temperature of (445 - 455)^{0}C its pleasingly.However, (448 - 452)^{0}C is generally considered the best temperature.
Inspection of the zinc thickness
It follows from this that hot-dip galvanizing is one of the most widely used methods for protecting metal from corrosion. The final step in the zinc process is preambulation or inspection, in order to ensure quality in accordance with the EN ISO 1461 specifications or standards. The length of protection time is directly related to the protective thickness of the zinc coating. Thus, layer thickness is the single most important control inspection in order to determine the quality of a zinc coating and its durability.
Method for determination of weight (mass) of thickness of zinc coating
There are several methods to determine the weight or thickness of zinc coating in a zinc structure. The test methods selected will be dictated by the size, shape and number of parts being tested. Some test methods are non-destructive, where they are measured with magnetic devices.Other methods are destructive, as they require removal of the zinc coating or the coating material sector. Take a piece of rectangular steel of zinc (with thickness 3 mm), we weigh and record its length and width. Emasculate with propane, dry out, then weigh. Folowing this, put in hydrochloric acid (HCl) diluted in order to remove zinc. In this final stage, after the process is completed remove the piece of steel, clean it first with water afterwards with acetone.
Dry out and weigh.

Results:

(a) Length	=	30	mm	(b)	Initial gauge	=	28.26	g
x length	=	40	mm		Final gauge	=	29.21	g
ce	=	1200	mm^2		Gauge of the wet zinc larguar	=	0.95	g

Calculation:

Density of Zn its 7.14 g/cm^3 and use the result from (b), calculate the volume of zinc.

$$Volume\ of\ zinc\ (V) = \frac{mass\ of\ removed\ zinc\ (m)}{density\ of\ zinc\ (\rho)} = \frac{0.95\ g}{7.14\ {}^{g}/_{cm^3}} = 0.133\ cm^3$$

$$V = 0.127\ cm^3 = 0.133 \cdot 10^3 mm^3 = 133\ mm^3$$

$$Volume\ of\ zinc\ (V) = Sur\ (S) \cdot thickness\ of\ zinc\ (d) \Rightarrow d = \frac{V}{S}$$

$$d = \frac{V}{S} = \frac{133\ mm^3}{1200\ mm^2} = 0.110\ mm = 0.110\ \cdot 10^3 \mu m = 110\ \mu m$$

This is the total thickness of zinc, thus the thickness on each side is half this value:

$$\frac{d}{2} = \frac{110}{2} = 55\ \mu m$$

$$Zinc\ mass\ for\ sur.\left(\frac{g}{m^2}\right) = thickness\ of\ zinc(\mu m) \cdot 7.05 = 55 \cdot 7.05 = 387.75\ g/m^2$$

The table of the zinc thickness according to the standard EN ISO 1461, we say that for the steel thick by 3mm, the thickness of zinc coating is 55 µm or measures 387.75 g/cm^2.

Recording of the zinc measurment beforehand and after galvanizing process

A perspective (recording) attempts to explain how each stage is processed the average weight of zinc coating one may determined considering weighing the pre- and post-zinc structures, by deducting the first weight from the second one, and dividing the result by designated surfaces. E.g. first of all claculate the scow with steel construction and its weight is 36500 kg. After the construction is unloaded, deretermined again the empty scow and its mass is 14120 kg.

The difference among the mesaurmets: (36500 – 14120) kg = 22 380 kg of the steel constructions. After the construction is completed with zinc, the scow are loaded and weighed.

The measure of which is 37 770 kg.

The difference among measurments: (37280 – 14120) kg = 23 160 kg zinc steel constructions.The difference between the measures is (23 160 – 22 380) kg = 780 kg of pure zinc.

Calculation of percentage (780 kg pure zinc / 22 380 kg steel constructions) x 100 = 3.48 %

Thus the percentage of zinc in the plant of the factory "Galvazink" ranges from (2.5 – 5.5) %, depending on the factors mentioned above. This process can be analysed from different perspectives.

3. METHODS AND SAMPLE

It should, noted that the study for the material is represented by samples of steel structures of different shapes and thicknesses, and the method for determining the thickness of zinc coating is made with a magnetic meter QuaNix 7500.In the following we shall consider how the thickness of the coating determined by the QuaNix 7500 magnetic meter should take a minimum of five readings for each sample.

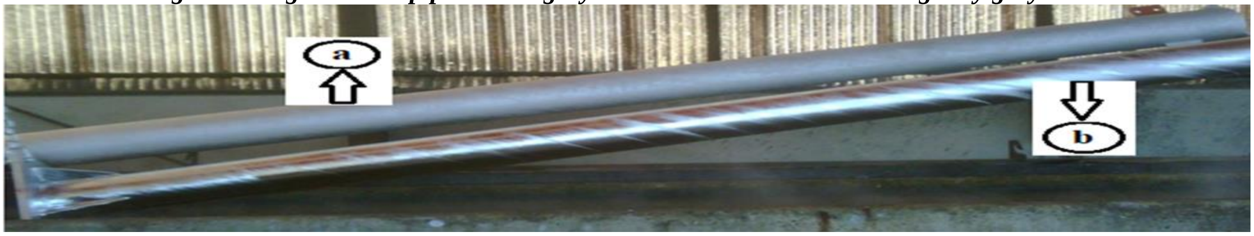
Chart 1. It represents the thickness of the zinc coating depending on the thickness of steel (1 g/m² coating measure = 0.14 µm coating thickness)

Steel thickness (mm)	The minimum thickness of zinc coating (µm)	The medium thickness of the zinc coating (µm)	Veshja mestare e zinkut në masë (g/m^2)
≤ 1.5	35	45	320
$> 1.5\ \leq 3$	45	55	390
$> 3\ \leq 6$	55	70	500
> 6	70	85	600

4. RESULTS

During the study of the fisrt expereminet we zinced the two electric pillars in the form of pipes and marked the top pipe with **a** and the bottom pipe with **b** as in the below figure:

Fig 3. a the galvanized pipe is dark gray in color and b the tube has a glossy gray color



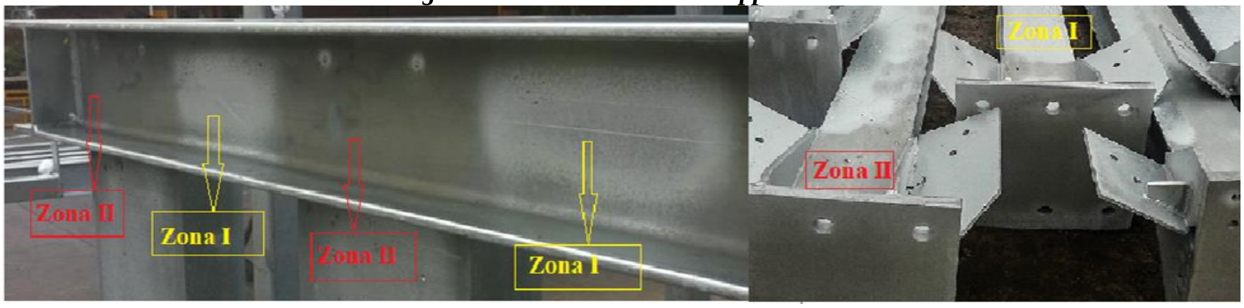
The results obtained from the zinc coating thickness measurement for both zinc pipes are presented in the following table.

Chart 2 Refering to the obtained thickness results of zinc coating

Tube of 3 mm	Mesaurement of I	Mesaurement of II	Mesaurement of III	Mesaurement of IV	Mesaurement of V	Average amount	Amount according EN ISO1461
A	56 µm	55 µm	56 µm	56 µm	56 µm	56 µm	55 µm
B	61 µm	63 µm	63 µm	62 µm	62 µm	62 µm	55 µm

Results of the second experiment: made galvanizing steel profile with the dimesion in 5 mm thickness. After galvanizing, we noted two zinc zones with different appearance, as in the following figure.

Fig 4. Zinc steel construction appearance



The zinc thickness measurement was done in two zones of this construction, where in each zone five parallel measurements were made, from which their average value was derived. The final results are presented in the below chart.

Chart 3. Obtained thickness results of zinc coating

Const. 4 mm	Measurement I	M II	M III	M IV	M V	Medium value	Value according EN ISO1461
Area I	69 µm	70 µm	70 µm	69 µm	70 µm	70 µm	70 µm
Area II	77 µm	78 µm	78 µm	77 µm	78 µm	78 µm	70 µm

Results of the third experiment: the third experiment it's referring to the zincing of waste containers with the dimension of 1.5 mm thickness. Considerable attention has been given to the method of processing, to three used containers that were taken and five measurements were conducted at the same time for each container, wherever their average value was extracted. The final results are presented in chart 4.

Chart 4. Reflecting the obtained results of thickness of zinc coating

Contanier 1.5 mm	Mesaurmen t I	M - II	M – III	M - IV	M -V	Average value	Value according to EN ISO1461
Contanier I	46 µm	45 µm	46 µm	46 µm	46 µm	46 µm	45 µm
Contanier II	47 µm	45 µm	47 µm	47 µm	47 µm	47 µm	45 µm
Contanier III	45 µm	46 µm	46 µm	46 µm	46 µm	46 µm	45 µm

5. DISCUSSIONS

Discussion on the results of first experiment

Referring to the data in the chart 1 the indicators as well in the chart 2 it is established: the thickness of zinc in tube a is 56 µm which is in accordance with standard. Whereas for tube b the value is 62 µm, which is a high value due to the steel composition. In particular, the impact of high silica content on steel is indicative of the increase in zinc layer and especially of Zn - Fe alloy. Taking this in consideration, its appearance is also distinguished from tube a, which is of dark grey colour as in Fig 2. Steels with chemicals content Si> 0.25% are known as highly reactive steel and these can cause the formation of highly coated galvanized coatings. These thick coatings are also known to be somewhat less resistant to treatment than standard coatings; however, they can also provide increased resistance to corrosion. Therefore, difference in brightness and colour of the zinc coating has no significant impact on corrosion resistance. The brightness or lack of brightness encountered in zinc products is a process of crystallization that depends on the chemical composition of the steel.

Discussion on the results of second experiment

The parti-coloured appearance (zones I and II, Figure 4.) of this galvanized coating is due to the silicon content and thickness of the steel. Glossy-looking areas are cooled faster and pure zinc is hardened on the surface, where the thickness of zinc is 70 µm. Other fields have cooled more slowly and the zinc reaction has continued until pure zinc is consumed and only the Fe - Zn intermetallic bonds i.e. the surfaces of the alloy are shown on the surface, so we have layer increasing its thickness to 78 µm. Over time, the surface will change to an even smoother final grey colour.

Discussion on the results of third experiment

Referring to data in chart 4 and indicators in chart 1 the following is confirmed: the zinc thickness for container I is 46 µm, for container II is 47 µm and for container III is 46 µm which is by standard. Nevertheless, from Fig 3. we noticed that we have a smooth and bright (glossy) zinc coating, which means (based on zinc thickness results) that we have a high quality of zinc.

6. CONCLUSIONS

Considering the impact of major infrastructure projects such as roads, airports, industrial facilities, corporate facilities etc. are designed to serve people for at least 25 - 30 years, but these projects incur high maintenance costs and sometimes need to recapitalize investments in less than 10 years due to corrosion of the metals used in their construction. Managers, builders, architects afraid of high cost investment were forced not to use steel with zinc content in such large projects. Using the hot zinc technique the cost is much cheaper than any other process such as protective coating, such as dyeing, powder coating, etc. The world annually loses 4% of its total steel output due to corrosion which is half of its annual growth in production. We as an informed buyer should always insist on zinc steel instead of any other kind, for reasons:

Durability (life-spam): zinc is a lightweight, clean surface widget that offers a maintenance-free life-spam of over 50 years. (It depends on the environment in which it is used). When maintenance eventually becomes necessary, it is straightforward: no complex preparatory treatments are needed.

Competitive cost: with many coatings applied, the cost of hot galvanized zinc is lower compared to other alternative applications. The reason is simple: other alternatives - especially colouring - require a lot of intensive work compared to zinc which is a highly mechanized and controlled technological process.

Lowest cost of durability: low initial cost and durability make zinc the most adaptable and economical way of protecting steel for long periods. There are benefits due to less maintenance or from extended maintenance intervals:

less access problems to remote areas, difficult terrain or when buildings are in close proximity to each other i.e. narrow space; even when there are security restrictions e.g. electricity poles.

Reliability: The process is relatively simple, straightforward and closely controlled. The thickness (weight) of the formed coating is regular, predictable and simply specified. Hot zinc is one of the few coatings that are fully defined by international standard, EN ISO 146 standard.

Time of application: A full protective cover can be applied within several hours; a complicated colour system can take up to a week.

Coating resistance: zinc is unique: the hot zinc process produces a coating that is metallurgically bonded to steel. No other coating process has this function and as a result zinc steel has the highest resistance to mechanical damage during handling, storage, transportation and construction - an important factor where steel works will be shipped worldwide.

Full Coverage: due to the dipping of steel structures into molten zinc, all parts of the steel surface are coated - inside, outside, inadequate angles, and possible narrow gaps;

Practicality of inspection: stainless steel simplifies inspection of protective coating. The nature of the process is such that if the coating appears continuous and undamaged, then the zinc thickness - specified simply through EN ISO 1461 - can be easily controlled by an electronic probe.

Faster construction: zinc steel is ready for use. Surface preparation, colouring, contact or inspection is not required. Once the steel structure is zinc-coated, it is ready for use, accelerating construction time.

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