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The Impact of the Weight of the Zinc Coatingon the Mechanical Properties of Hot Dip-Galvanized of Low Carbon Steels by usingthe Batch Hot-Dip Galvanizing Process.

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Abstract-*The application of the zinc coating in the batch galvanizing process involves immersion of the steel into a bath of molten zinc. However, in contrast with the continuous process, wherein the steel is immersed for a very brief time, the batch process requires that the part be immersed for much longer times to allow the part to reach the bath temperature, which is typically measured in minutes, not seconds. Nine samples were taken in the rolling direction and prepared from three galvanized samples immersed at different times in a zinc bath at 450 ^{o}C to conduct the Tensile test and Rockwell hardness test. The results show that zinc coating makes the yield strength, tensile strength, and hardness of the galvanized steel samples decrease, while the elongation and thickness anisotropy coefficients increase.*

Keywords*:Hot Dip- galvanizing Process; Zinc Coating ; Yield Stress; Tensile Strength;Elongation ;Hardness.*

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I. INTRODUCTION.

Hot-dip galvanizing is a metallurgical process where a coating is created on the surfaceofasteelsheetbymutualreactionofthebasematerialoftheproductandmoltenzincfroma bath[1]. The thickness, structure, and quality of the zinc coating are strongly impactedby the composition of the molten zinc and by the condition of the steel surface [2]. The diffusion zone is formed by layers of the intermetallic phases of the Fe-Zn system: Γ, δ_1, ζ. The phase characteristics of the Fe-Zn system are presented in Table-1[3]. The Γ phase layer is difficult to observe because it has a small thickness, usually not exceeding 1 µm [4]. The δ_1 phase layer is much thicker; its thickness is uniform, and its structure is relatively compact. The next ζ phase layer shows two distinct zones. The inner zone with a clearly compact morphology turns into a heterogeneous structure in the outer zone. Such a two-zone structure of ζ phase results from the mechanism of its formation. The compact zone is formed by reactive diffusion between Fe and Zn, which leads to the growth of the layer. However, this layer is in direct contact with the liquid zinc, which leads to its dissolution in liquid zinc. As a further consequence, in the zinc saturated with iron, the ζ phase is secondarily separated, creating a zone of loosely packed elongated crystals [5]. The diffusion layer of the coating formed in the zinc bath becomes covered when the product is taken out of the bath with the outer layer of the iron–zinc solution η. It is believed that the structure of coating shaped in this way is correct, making it possible to obtain the required and easily controlled thickness.[4&5]. The batch hot-dip galvanizing process, produces a zinc coating on iron and steel products by immersion of the material in a bath of liquid zinc at 450 ^{0}C Figure-1, before the coating is applied, the steel sheet is cleaned to remove all oils, greases, soils, mill scale, and rust[6].Surface preparation is a critical step in the application of any coating. In most instances where a coating fails before the end of its expected service life, it is because of incorrect or inadequate surface preparation. The galvanizing process has its own built-in means of quality control because zinc will not react with an unclean steel surface. Any failures or inadequacies in surface preparation will be immediately apparent when the steel is withdrawn from the zinc bath because the unclean areas will remain uncoated, and immediate corrective action can be taken[7].The cleaning cycle usually followed in the batch hot dip galvanizing dry process consists of degreased the steel sheet usually in an alkalisolution to remove oils,greases,andothercompounds,followedbyrinsinginwaterareperformed primarily to ensure that acid and iron contaminants carried from the pickling bath with the work are preventedfromadverselyimpactingthefluxingandgalvanizingoperations, picklingtoremoveadheringmillscale,rustandoxidefilmsonthesurfaceofthearticlebyimmersionineitherinhydrochloricorsulfuricacid,andrinsinginwater [8].The last step in the surface preparation is an immersion in flux solutions which consistsofzincchlorideandammoniumfluoride to dissolve any oxide filmsformed on the steel after

pickling, Figure-2 [9].Presenceofasufficientmetallic layercanbeusuallyverifiedusinga coatingthicknessmeasurementdevice,Figure-3. The mechanical properties of the steel deteriorated very significantly by the process of hot dip galvanizing the yield stress, tensile strength decreased and elongation only increased slightly [10].
The aim of this study is to investigate the effect of zinc coating weight on the mechanical properties of galvanized low carbon steel sheet by using dry batch hot dip galvanizing process.

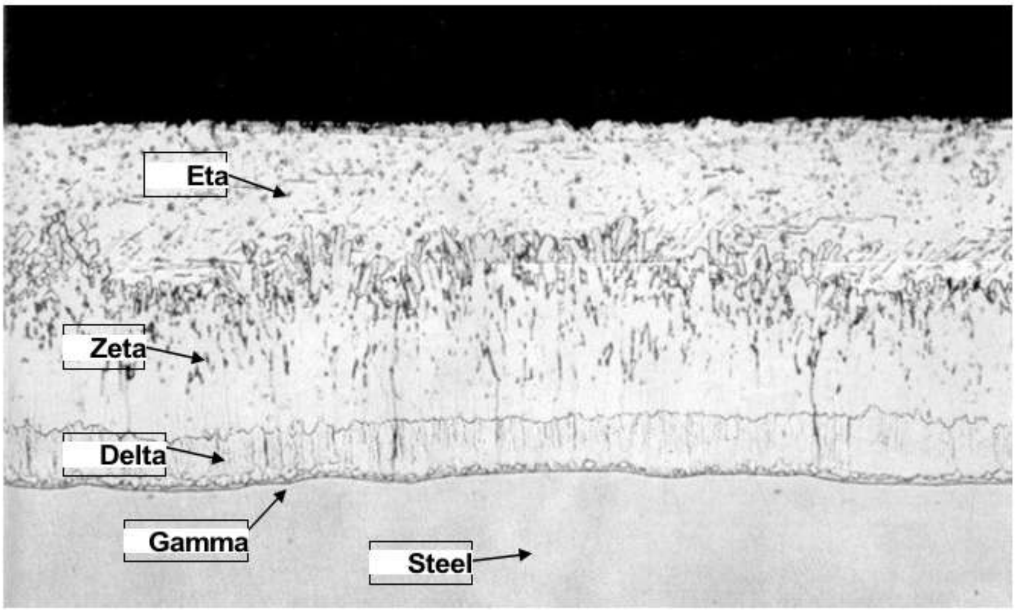


Figure 1:Cross-sectionofabatchhot-dipGalvanizedCoating [8].

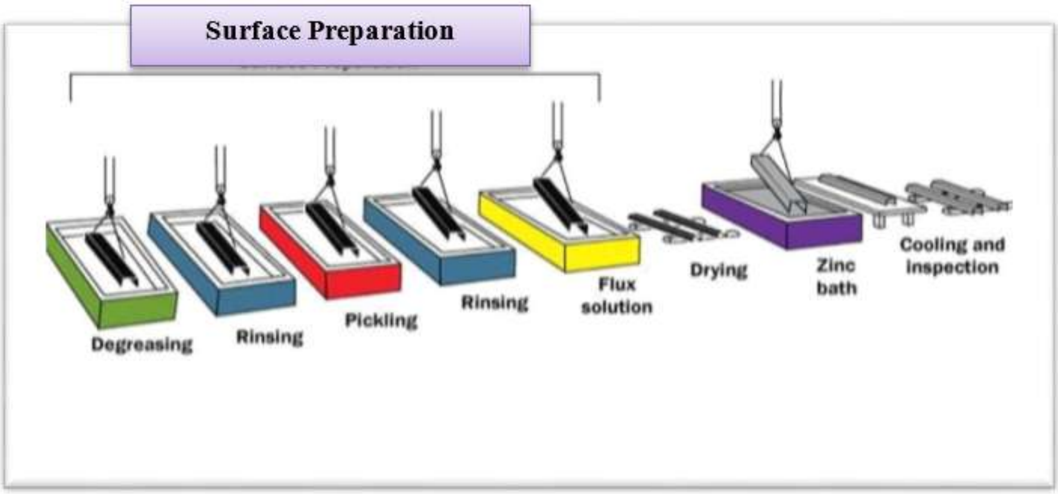


Figure 2: SchematicRepresentationoftheprocesssequenceofOperationsinadrygalvanizingprocessline [8].

Figure 3: Coating Thickness Measurement.

Table1:CompositionandPropertiesofAlloysLayersinBatchHot-DipGalvanize[3].

Phases	Content of Fe (wt.%) at 450 ^{0}C	Formula	Melting Point ^{0}C	(HV)
η	< 0.03	Zn	419	37
ξ	5 –6	$FeZn_{13}$	530	270
δ	7 –12	$FeZn_7$	530-670	470 – 450
Γ	23 – 28	$FeZn_{10}$	670-780	450
α	95	Fe	1510	150

II. METHDOLOGY.

A sample of cold-rolled low carbon steel sheet with dimensions of 1.8 x 1000 x 1000 mm in the rolling direction was taken and cut into three small samples, each with dimensions of 35 cm in width and one meter in length, and, by using the hot batch-dip galvanizing process, the samples were immersed in the zinc bathfor varying times, as follows: the first one for a minute, the second one for three minutes, and the last one for five minutes. Three samples were taken from each galvanizing sample to conduct the tensile test and hardness test on a tensile testing machine and a Rockwell hardness testing machine to determine their mechanical properties.

III. MATERIALS ANDMETHODS.

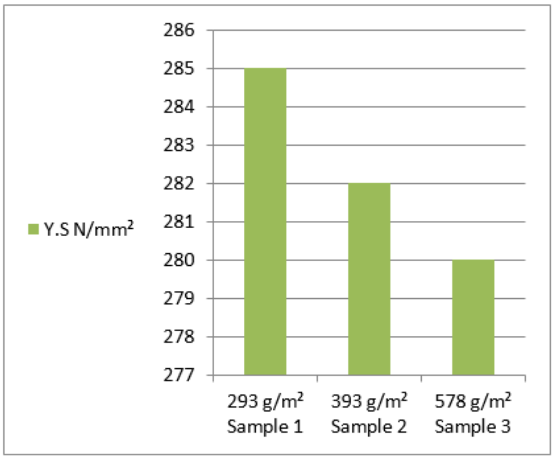
The material used in this study was a cold rolled low carbon steel sample. This sample was cut into three small samples with the dimensions mentioned in the methodology of this study, and they were immersed in a zinc bath using the hot dip batch galvanizing process. The tensile test and hardness test were done by tensile testing machines and a Rockwell hardness testing machine to determine their mechanical properties. The chemical composition of a cold-rolled steel sample is shown in Table-2 below.

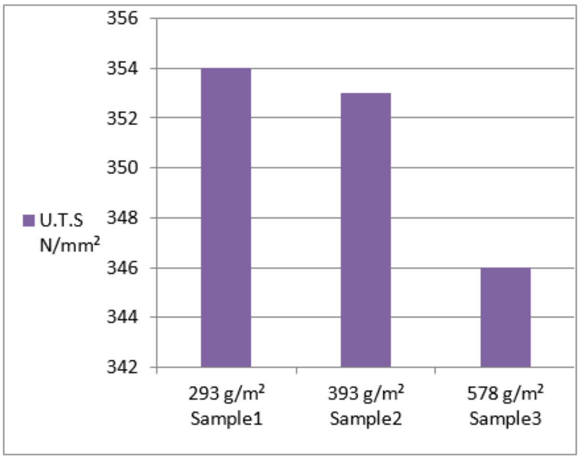
Table 2: Chemical Composition of cold rolled Low carbon steel Sample.

Element Name	Percentage %
C	**0.16**
Si	**0.02**
Mn	**0.35**
P	**0.017**
S	**0.019**

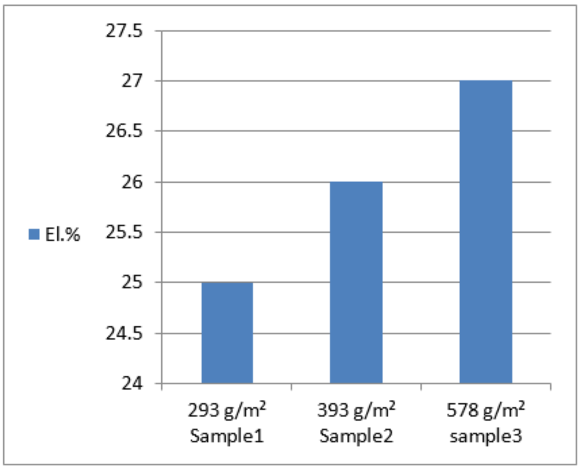
IV. RESULTS AND DISCUSSIONS.

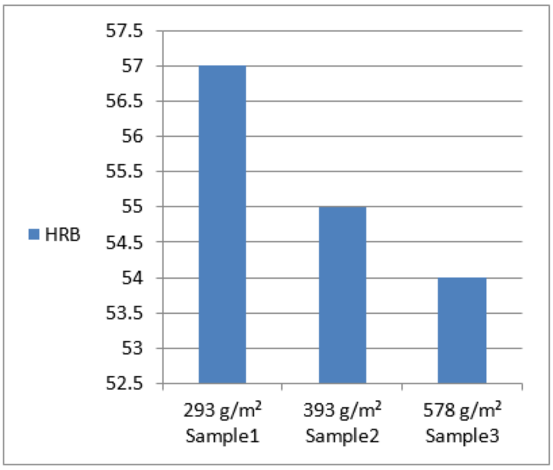
After conducting tensile and Rockwell hardness tests on nine samples rolled in the direction of rolling taken from three galvanized steel sheet samples and taking the average of each three samples, the results show that increasing the zinc coating reduces yield stress, ultimate tensile strength, and hardness while increasing elongation. This is due to the increase in immersion time, which makes the thickness of the galvanized layer increase and also is due to the influence of galvanizing temperature.Figure(3 a-d) represents the mechanical properties of tested samples.





(a) (b)





(c)(d)

Figure 3:The effect of Zinc coating weight on the Mechanical Properties of galvanized steel samples. (a) Yield stress, (b) Ultimate tensile strength, (c) Elongation, (d) Hardness.

V. CONCLUSIONS.

The following conclusions have beendrawnfrom thisstudy:

1. The longer the immersion time, the greater the weight of the zinc layer.
2. Increasing the zinc coating reduces yield stress, ultimate tensile strength, and hardness while increasing elongation.
3. Surface preparation is a critical step in the application of any coating because zinc will not react with an unclean steel surface.

REFERENCES.

[1]. Sepper,S.et.al.,(2011).“Methods for evaluating the appearance of hot dip galvanized coatings", Agronomy Research Bio system Engineering,Sp.Issue1,pp.229-236.

[2]. Amercian Galvanizers Association: Hot-dip Galvanized Steel, 6881.S holly Cir ,Centennial,Co 80112,United States.

[3]. P. Pokorny, J. Kolisko, L. Balik, P. Novak, (2015). "Description of Structure of Fe-Zn Intermetallic Compound present in Hot-Dip galvanizing Coatings on Steel".Metabk 54(4) 707-710.

[4]. Kania H., Liberski P. Kryteriadoboruskładuchemicznegokąpielicynkowej,(2011). Proceedings of the 18th Symposium PTC, PTC; Międzyzdroje, Poland. 29 May–1 June 2011; CD-ROM.

[5]. Liberski P., Tatarek A., Kania H., Podolski P. (2009). Coating growth on silicon-containing iron alloys in hot dip galvanizing process; Proceedings of the 22nd International Galvanizing Conference Intergalva, EGGA; Madrid, Spain. 8–12; pp. 181–187.

[6]. Dr. Tom Langill (2012). Batch Hot-Dip Galvanizing Production Process, American Galvanizer Association.

[7]. T.J.Langill. (2003}BatchProcessHotDip Galvanizing,Corrosion:Fundamentals,Testing,andProtection,Vol.13A,ASMHandbook,ASMInternational,pp794–802.

[8]. VlastimilKuklik& Jan Kudlacek (2016), Hot-Dip Galvanizing of Steel Structure Handbook, Elsevier.

[9]. Shibli,S.M.A.;Meena,B.N.;Remya,R (2015).Areview on recent approaches in the field of hot dip zinc galvanizing process.Surf.Coat.Technol,262,210–215.

[10]. Smak,M., Kubicek,J., Kala; J., Poldany,K., and Vanerek, J., (2021).The influence of hot-dip galvanizing on the mechanical properties of high- strength steels, Material 2021,14, 5219.