Effect of Some Plating Variables on Zinc Coated Low Carbon Steel Substrates

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ABSTRACT

This work examined the effect of plating variables on zinc coated low carbon steel substrates. The electrodeposition of steel substrates was carried out in zinc electrolyte bath. Time, voltage, distance from the anode to the cathode and the immersion depth served as plating variables. The results showed that weight gained increases as the plating time increases for the constant depth of immersion while the weight gained per unit time by varying immersion depth is irregular. Also, the study demonstrated that sample plated for 20 minutes; 20cm from the anode, 45cm depth of immersion at 0.8V exhibited the best plating properties with homogeneity of diffuse plating efficiency.

Keywords: *Variables, Zinc-coated low carbon steel substrates, Depth of immersion, Electrodeposition*

1. INTRODUCTION

The use of materials has encountered increase number of stresses brought about by recent technology. Both the use and the stresses have probably grown at a greater rate than the number of materials that can be used to meet them. This is particularly true for structural materials which are almost entirely metallic[1]. Combination of stresses such as wear (caused by friction), corrosion (due to chemical) and high temperature have imposed restriction on the use of metallic materials.

However, in view of these negative effects, many new alloys have been produced with improved properties to subdue the negative effects posed by different environment[2]. But little is the protection that can be afforded by this means alone. Chemical attack occurs mostly in marine environment such as when ambient oxygen, droplets of sea salt and impurities in the fuel combine to form molten sodium which attack the metallic turbine blades, ship bodies and submarines[3]. Thus, there is increasing fear that someday coating of metals will be subdued by these interacting stresses if nothing is done to forestall such occurrences. Therefore, the present

work has examined the effect of plating variables on zinc-coating low carbon steels, in particular, to understudy more effective conditions for electrodeposition.

2 MATERIALS AND METHODS

2.1 Materials

The low carbon steel rod substrate used for this research was obtained from Osogbo Steel Rolling in Osun State, Nigeria. The chemical composition of the steel was analysed with mass spectrometer and analysis is shown in Table 1. The steel was later cut into cylindrical pieces with dimension of 20mm diameter by 40mm length.

Table 1. Chemical Composition of Low Carbon Steel

Elements	C	S	Si	P	Mn	Ni	Cu	Mo	V	Ti	Al	Mg	Sn	Fe
wt%	0.18	0.08	0.10	0.62	0.75	0.010	0.23	0.082	0.005	0.002	0.006	0.004	0.008	97.60

2.2 Samples Pre-Treatment before Electroplating Operations

The samples were removed from the desiccators in turn and pickled in 0.5M H_2SO_4 for 2 minutes, then rinsed in distilled water before degreasing in an 100 litre electrolytic degreasing tank containing alkaline solution and rinsed in distilled water for 2 minutes. The samples were weighed using a digital weighing balance model Mettler Toledo Pb153 of accuracy $\pm$ 0.001g and the weight was recorded as the initial weight.

2.3 Electroplating Operation

The samples were electroplated at 0.8 volt for different plating times ranging from 10mins - 30mins, and the distance from anode to cathode varied from 10cm-30cm at varying immersion depth from 35cm-55cm. The surfaces of the samples were activated with acid solution. The samples were then dipped into the zinc plating bath and the electroplating rectifier switched on. The electroplated samples were removed, passivated, dried and the weights recorded.

3. RESULTS

Table 2: Weight Deposited (g) of Zinc on low carbon steel at varying depth of immersion and at 10cm distance from anode

Weight Gained(g)	Weight deposited per unit area (mg/mm^2)	Thickness (µm)	Time (Mins)	Immersion Depth(cm)
0.02	1.82	0.052	10	35
0.10	9.12	0.260	15	40
0.04	3.65	0.104	20	45
0.08	7.29	0.208	25	50
0.06	5.47	0.156	30	55

Voltage = 0.8V

Table 3: Weight Deposited (g) of Zinc on low carbon steel at
constant depth of immersion and at 10cm distance from anode

Weight Gained (g)	Weight deposited per unit area (mg/mm ^{2})	Thickness (µm)	Time (Mins)	Immersion Depth (cm)
0.06	5.47	0.156	10	35
0.09	8.20	0.234	15	35
0.14	12.76	0.364	20	35
0.18	16.41	0.468	25	35
0.20	18.23	0.520	30	35

Voltage = 0.8V

Table 4: Weight Deposited (g) of Zinc on low carbon steel
at varying depth of immersion and at 20cm distance from anode

Weight Gained (g)	Weight deposited per unit area (mg/mm ^{2})	Thickness (µm)	Time (Mins)	Immersion Depth (cm)
0.06	5.47	0.156	10	35
0.08	7.29	0.208	15	40
0.12	10.94	0.312	20	45
0.21	19.14	0.534	25	50
0.12	10.94	0.312	30	55

Voltage = 0.8V

Table 5: Weight Deposited (g) of Zinc on low carbon steel at constant
depth of immersion and at 20cm   distance from anode

Weight Gained (g)	Weight deposited per unit area (mg/mm ^{2})	Thickness (µm)	Time (Mins)	Immersion Depth (cm)
0.04	3.65	0.10	10	45
0.07	6.38	0.18	15	45
0.12	10.94	0.31	20	45
0.15	13.67	0.39	25	45
0.18	16.41	0.47	30	45

Voltage = 0.8V

Table 6: Weight Deposited (g) of Zinc on low carbon steel at varying depth of immersion and at 30cm   distance from anode

Weight Gained (g)	Weight deposited per unit area (mg/mm ^{2})	Thickness (μm)	Time (Mins)	Immersion Depth (cm)
0.18	16.41	0.47	10	35
0.04	3.65	0.10	15	40
0.08	7.29	0.208	20	45
0.10	9.12	0.260	25	50
0.18	14.59	0.416	30	55

Voltage = 0.8V

Table 7: Weight Deposited (g) of Zinc on low carbon steel at constant depth of immersion and at 30cm distance from anode

Weight Gained (g)	Weight deposited per unit area (mg/mm ^{2})	Thickness (μm)	Time (Mins)	Immersion Depth (cm)
0.02	1.82	0.052	10	55
0.05	4.56	0.130	15	55
0.08	7.29	0.208	20	55
0.10	9.12	0.260	25	55
0.18	14.59	0.416	30	55

Voltage = 0.8V
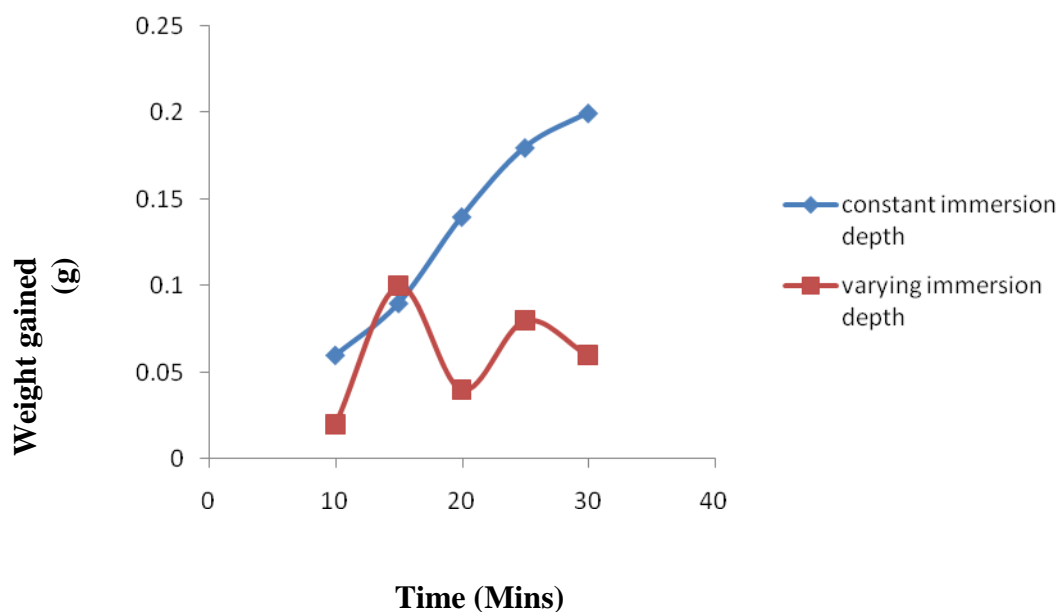
Time (Mins)
Fig. 1 Plot of Weight gained (g) against Time (Mins) of zinc plated on low carbon steel at 10cm from the anode and at varying and constant immersion depth
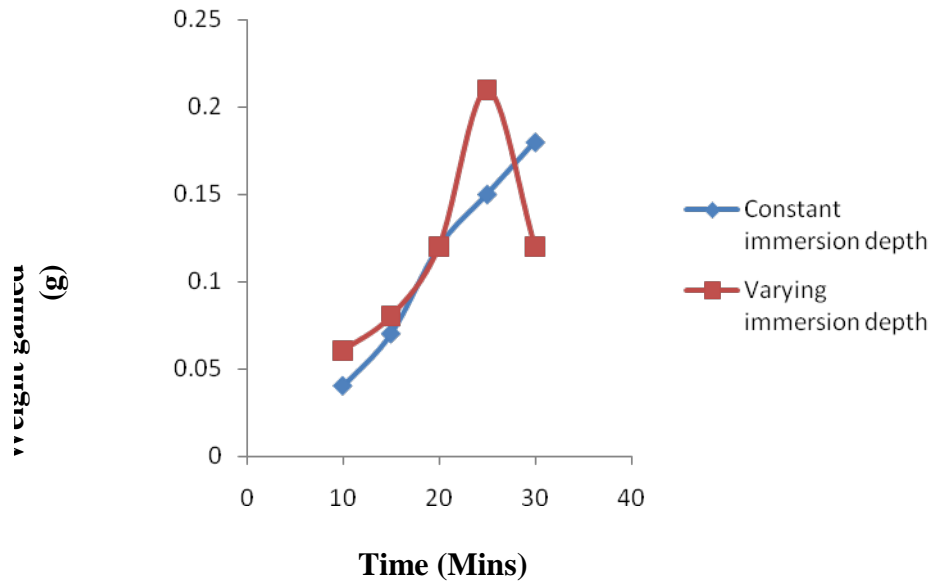
Fig. 2 Plot of Weight gained (g) against Time (Mins) of zinc plated on low carbon steel at 20cm from the anode and at varying and constant immersion depth
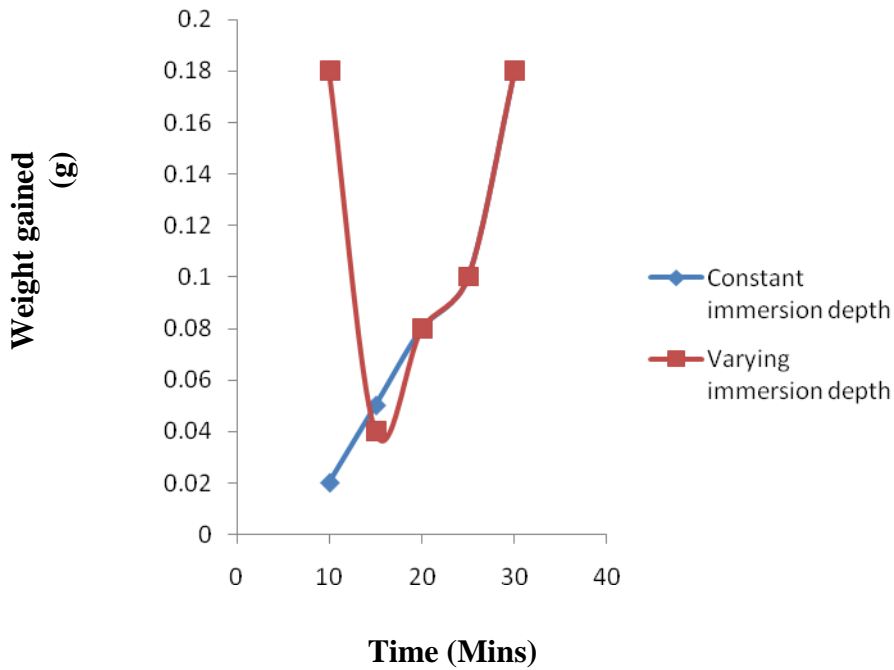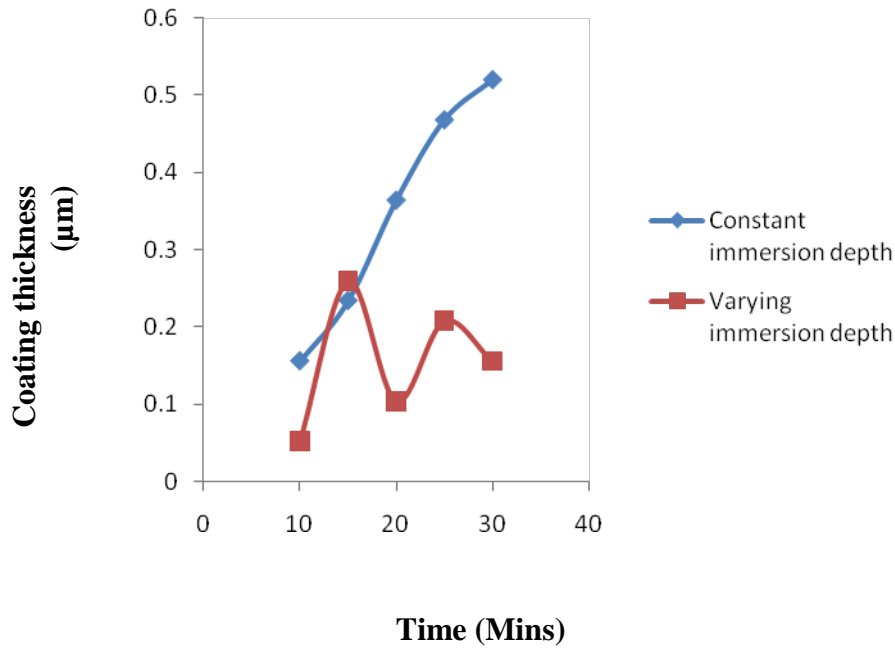

Fig. 3 Plot of Weight gained (g) against Time (Mins) of zinc plated on low carbon steel at 30cm from the anode and at varying and constant immersion depth

Fig. 4 Plot of Thickness (µm) against Time (Mins) of zinc plated on low carbon steel at 10cm from the anode and at varying and constant immersion depth
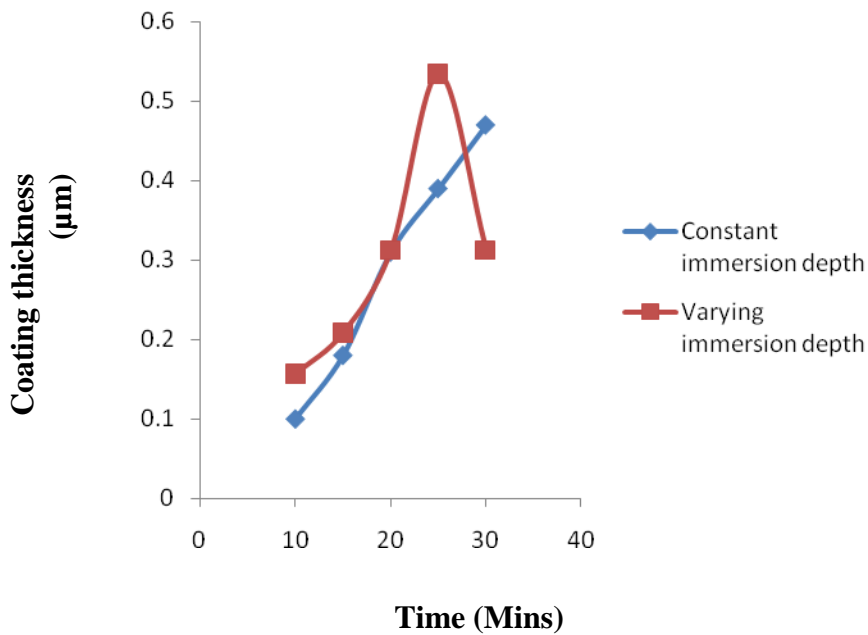

Fig. 5 Plot of Thickness (µm) against Time (Mins) of zinc plated on low carbon steel at 20cm from the anode and at varying and constant immersion depth
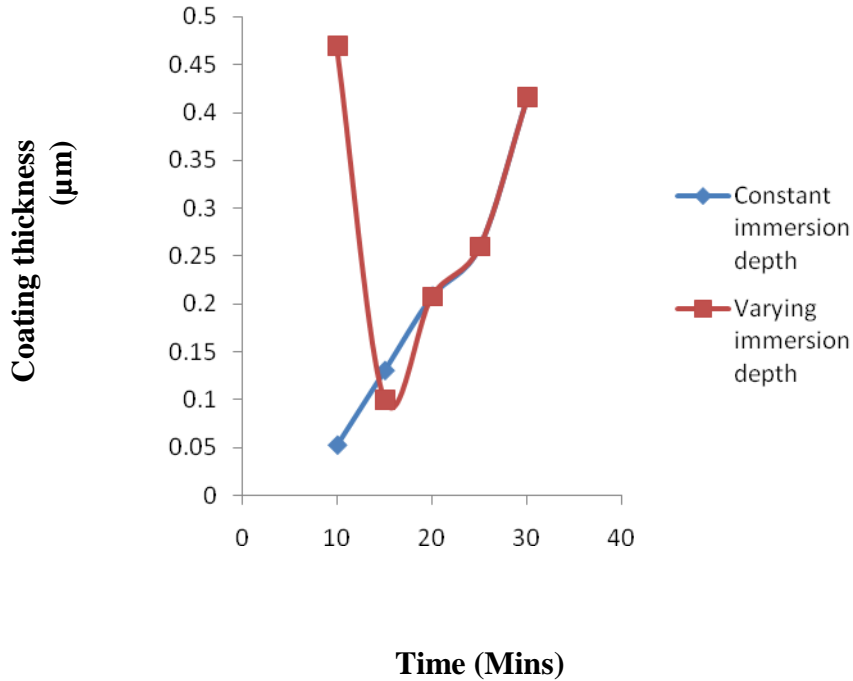
Time (Mins)

Fig. 6 Plot of Thickness (µm) against Time (Mins) of zinc plated on low carbon steel at 30cm from the anode and at varying and constant immersion depth
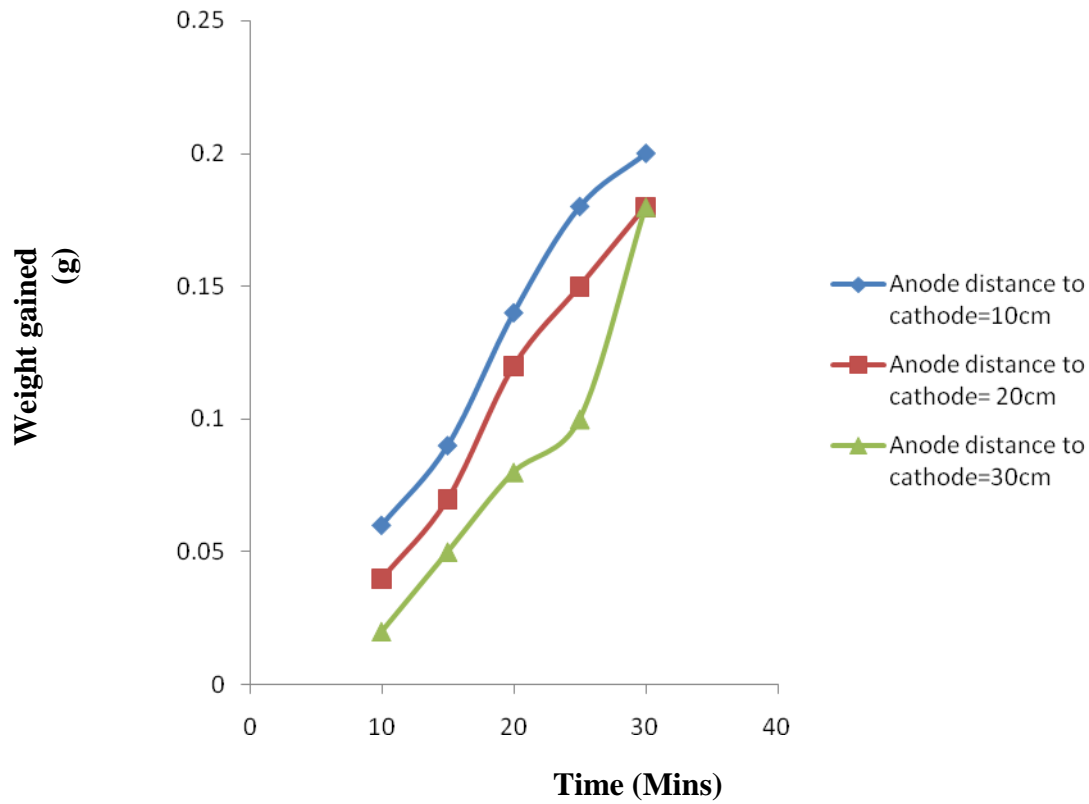

Time (Mins)

Fig 7 Plot of Weight gained (g) against Time (Mins) of zinc plated on low carbon steel at various constant distances 10cm, 20cm and 30cm from the anode

4. DISCUSSION

4.1 Effect of Immersion Depth on Weight Gained and Coating Thickness

Figures 1, 2 and 3 show that at given distances of 10cm, 20cm and 30cm from anode weight gained increases as the plating time increases for the constant depth of immersion . However the weight gained per unit time by varying immersion depth is irregular. There is no linear relationship between electrodeposition and varying immersion depth. The same phenomenon is reflected for the thickness of coat film as revealed in Figures 4-6. So, the immersion depth must be controlled to avoid operating at point zero pumping action[4].

However, Figure 5 projects a coincidence at 20mins plating time when the immersion depth was kept constant at 45cm and when it was varied between 35cm and 55cm. This phenomenon could probably explain the good electroplating effects experienced by the coated steel under the stated conditions.

4.2 Effect of Distance from the Anode on Weight Gained

Figure 7 relates the weight deposited against time at different distances from the anode. This indicates that as the distance from the anode increases the weight gained decreases.

5. CONCLUSION

This present study has demonstrated that electrodeposition increases at constant immersion depth at a given particular distance from anode while there is no linear relationship between electrodeposition and varying immersion depth.

However, this study showed that sample plated for 20 minutes; 20cm from the anode, 45cm depth of immersion at 0.8V exhibited the best plating properties with homogeneity of diffuse plating efficiency.

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