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Study on Corrosion Behaviour of Dip Coating of Zinc on Mild Steel

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Abstract

Steel is the most widely used structural material in engineering applications. It has high strength and elasticity. But the major problem with steel is that it corrodes when comes in contact with the atmosphere. To avoid corrosion many techniques have been developed over the years. Coating the surface of steel with a non-corrosive element is the most common method. However, the currently used methods are expensive and need very controlled environmental conditions. In this paper, the dip coating method for coating zinc on mild steel is studied. The hardness of the surface after coating in measured and immersion tests was conducted. It was observed that the zinc coating done through the dip coating process could reduce the corrosion. This proves that the dip coating is an effective method to apply coating on mild steel. This method also has the advantage of lesser expenses.

Keywords: *Dip coating, Hardness, Immersion test, zinc, mild steel*

1.0 Introduction

Corrosion is a chemical reaction between a metals' chemical or electrochemical reactions with its environment. Alloy steel has been used extensively in marine applications because it offers superior mechanical properties and lower costs. Studying the corrosion phenomena of mild steels in sea water has become a great challenge for corrosion engineers or scientists. The inevitable breakdown of metals and alloys due to their interaction with the environment is called corrosion. Severe corrosion will be prevented by making the right alloy selection. But complete protection from corrosion is obtained when steel is completely separated from the environment. Zinc is the primary coating material used for steel and other materials because of its superior anticorrosion properties. Coatings that separate the metal substrate from its surroundings are an efficient approach to prevent steel from corroding since corrosion needs both the presence of water and oxygen. Coatings can be distinguished as soft coatings or hard coatings based on their support for hardness. Steels are far less likely to corrode when exposed to aqueous chloride solutions, when coated with zinc.

M.S. Noor Idoraa.et.al[1] used a weight loss methodology and polarisation approach with varying coating thicknesses

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to detect mild steel corrosion. They discovered that zinc offers mild steel good corrosion resistance for various coatings and environments. It is known that the rate of corrosion increased as coating thickness decreased. From this investigation, it can be inferred that the initial coat thickness had an impact on the long-term corrosion performance of mild steel coated with zinc. They studied two distinct maritime environments – salt spray and sea water immersion – and concluded that salt spray exhibits a greater rate of corrosion for mild steel that is zinc coated.

Fayomi and Popoola[2] explored mild steel deterioration symptoms linked to shifting circumstances, modifications in fluid composition, modifications in working pressures and temperatures, underlying or contact materials with work metals, and other ambient variables. The sensitivity of the chosen metal or alloy to the chosen medium or environment and the small fallout into that area will determine the degree of corrosion reactivity. In connection with the notion of matter, this research aimed to critically examine the steel issues in industrial processes.

According to Abioye O. P. et.al[3] it can be understood that materials degradation and component failure continue to be major challenges worldwide. Engineering materials that are expected to function in life threatening environments is one of the biggest challenges engineers face today. Experts in materials and corrosion are responsible for the conflicting choice of a suitable material for a specific application and its protection from environmental hazards. Therefore, the electrodeposited zinc coating technique has been employed to provide solutions to mild steel surface degradation in marine environments. A coat structure and the weight gain of the deposited particles determine how hard, corrosion-resistant, and wear-resistant mild steel is after electro-deposition. A variety of factors can influence the morphology of deposited Zn (uniformity, grain size, porosity, stresses built up on the coating). Enhancing corrosion properties and adhesion becomes possible with this approach.

Asmae El Fazazi et.al[4] conducted a study on zinc coating done by electro-deposition technique from free additives bath on mild steel the effect of current density on the deposition potential, thickness of deposited, deposition rate, and current efficiency was investigated and also composition and morphology of deposits.

Kanagalasara Vathsala et.al[5] to generate zinc-chitosan composite, sulphate bath electrode position was used. As part of the co-deposition process, precipitated chitosan was also coated with zinc. In addition to burden loss, polarization, impedance, and salt spray tests, composite coatings were evaluated for their performance. Overall, these studies show that Zn-chitosan composites exhibit better anti-corrosion properties. Based on the SEM images of the surface, chitosan is present in the coating and has a crystalline structure. As compared to zinc coatings, the composite corrosion rate was uniform and lower.

A. Amirudin, D. et.al[6] explored the corrosion resistance of automotive materials with zinc coatings and zinc alloy coatings has been studied. The substance was employed in the same setting, and the results were examined using the same methodology. This article's goal is to widen the range of observed results' differences through various mechanisms. The majority of the effort has been devoted to examining the effects of various alloy coatings in environments containing salt chloride. Studies on the role of nitrogen and sulphur gases in the corrosion of zinc alloy-coated metal have been conducted.

Naveen Manhar Chavan et.al[7] revealed in their study that, strong and thick cold sprayed zinc coatings offer mild cast steel substrates significant corrosion protection for at least 72 hours. The right use of subsequent treatment, which causes various advantageous modifications in its microstructure, considerably lengthens the durability of zinc coatings and their service life. Long-term natural exposure studies must be conducted in order to evaluate the long-term effectiveness of the coating's heat treatment. Based on AC impedance measurements, the intricate nature of the corrosion process happening in the cold spray Zn coating was understood. Cold spraying is a competitive approach that can increase the service life of zinc coatings based on the thickness that can be achieved and the appropriate post-heat treatment.

S.N. Ezekiel et.al[8] coated zinc on A36 mild steel by immersing in zinc phosphate bath enriched with calcium nanoparticles. To test the adhesion level of zinc on the mild steel, the coated mild steel was subjected to corrosion tests. Weight loss, corrosion rate and inhibition efficiency was measured to determine the effect of coating thickness to protect the mild steel.

Zhiwei et. al[9] compared the effect of pre-treatment on the corrosion behaviour of hot dipped galvanized coating. Their study inferred that ball milling is a superior pre-treatment process compared to that of the conventional pickling technique to improve corrosion resistance.

Grandhi et. al[10] investigated the effect of addition of Mn into molten zinc on steel. Their work showed significant reduction in corrosion under salty environment. However, intermetallic layers at the interface of coating steel were observed. These layers are brittle and require process optimization to ensure longevity under loading conditions.

Shibli et. al[10] explored the role of substrate chemistry on the performance of hot galvanic coating. They inferred that Ni diffusion form the substrate into the Zn coating creates a Ni-rich barrier which provided better galvanic performance compared to the steel that does not have Ni.

Hamid et. al[12] studied the characteristics of Zn coating on steel with and without barrier coatings. Their study showed that the steel specimens with Zn coating on bi-layered precoat consisting of ZnO and Ni-P had better hardness, enhanced corrosion resistance and improved adhesion.

2.0 Experimental Work

The mild steel samples are prepared with predetermined size and subjected to degreasing, pickling, and fluxing before coating zinc on mild steel. Later the samples are dipped in molten bath of zinc for around 20 seconds. The samples are subjected to immersion tests to explore the corrosion behaviour of coated samples. The immersion tests are conducted in three different mediums like tap water, salt solution and vinegar. The duration of the immersion test is one week. After a week the samples are tested for surface hardness using Vicker's micro hardness tester. Also, the weight of the samples before and after the tests are measured to check the deterioration of surface by corrosion.

3. Results and Discussions

3.1 Hardness Values of Zinc Coated Mild Steel

The figures below shows results of Micro Vickers's hardness test of zinc coated mild steel. The test is done for zinc coated mild steel which are in different conditions, the first sample which is tested is mild steel uncoated and the respective result for this sample is 197 HV under the load of 0.5 Kgf. The second sample which is tested is zinc coated mild steel following test result was 48.6 HV for the load of 0.5 Kgf. The third test sample was zinc coated mild steel which was immersed in tap water sample (pH-7.56) and the test result was 70.4 HV at the load of 0.5 Kgf. The fourth test sample was zinc coated mild steel which was immersed in salt solution sample (pH-6.38) and the test result was 58.5 HV at the load of 0.5 Kgf. The fifth test sample was zinc coated mild steel which was immersed in vinegar solution sample (pH-3.45) and the test result was 126 HV at the load of 0.5 Kgf. Table 1 illustrates the Vicker's hardness values of the mild steel with and without zinc coating and for the zinc coated samples after immersion tests in various medium. Fig.1 shows the variation of hardness values for various samples after immersion in various aqueous medium.

Table 1: Vicker's hardness values of various samples

Specimen	Load (kgf)	Hardness (HV)
Mild steel	0.5	197
Zinc coated mild steel	0.5	48.6
Zn coated MS (tap water)	0.5	70.4
Zn coated MS (salt solution)	0.5	58.5
Zn coated MS (vinegar)	0.5	126

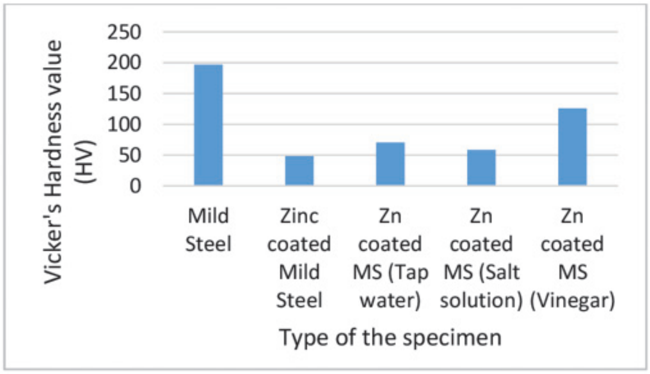

Figure 1: Vicker's hardness values for various samples after immersion in various aqueous medium

3.2 Immersion Testing

Immersion test was carried out on the mild steel after coating the zinc and before coating the zinc in various solution such as, tap water, salt solution, vinegar solution and we have noted down weight of the specimen before and after the test. The zinc coated mild steel was weighed and the weight was 61 grams. For the first test sample was zinc coated mild steel which was immersed in tap water sample (pH7.56) for a week and weighed which weighted 61.6 grams. Second test sample was zinc coated mild steel which was immersed in salt sample (pH-6.38) for a week and weighed which weighted grams 60.8.

Third test sample was zinc coated mild steel which was immersed in vinegar sample (pH3.45) for a week and weighed which weighted 59.2 grams. Table 2 illustrates the variation in weight of the samples before and after the immersion test in

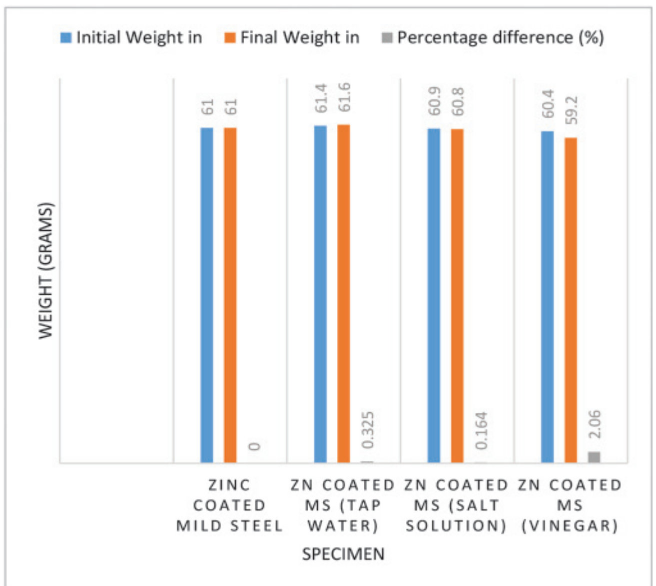

Fig. 2 Graphical representation of the change in weight under tap water, salt solution and vinegar solution immersion for a week

Table 2: Variation in weight of the samples before and after the immersion test in various aqueous medium

Specimen	Initial weight in (grams)	Final weight in (grams)	pH Value	Percentage difference (%)
Zinc coated Mild Steel	61	61	-	0
Zn coated MS (Tap water)	61.4	61.6	7.56	0.325
Zn coated MS (Salt solution)	60.9	60.8	6.38	0.164
Zn coated MS (Vinegar)	60.4	59.2	3.45	2.06

(a) Tap water immersed (b) Salt solution immersed (c) Vinegar immersed

Figure 3: Photographs of surface of the zinc coated samples after immersion

various aqueous medium. Fig.2 shows the graphical representation of the change in weight under tap water, salt solution and vinegar solution immersion for a week

4. Conclusion

The mild steel samples are zinc coated by dip coating route, and tested for corrosion resistance by immersion test method. Three types of aqueous medium are considered and the zinc coated samples were immersed over a period of one week. The weight of the samples were measured which indicated that, zinc coating is effective in reducing the corrosion. There is very small change in weight is observed after immersing the samples in three types of aqueous medium. The micro hardness values measured indicated that the hardness of zinc coated sample before immersion test is lower and after immersion it increases. This proves the formation of oxides due to corrosion and oxides are always harder in nature. However, the actual reason for the variation of surface hardness depends on the chemical compositions formed under various aqueous medium which needs further study. Hence this work proves that, the dip coating is an effective method to coat zinc on mild steel.

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