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Characteristics of galvanized, graphene oxide and aluminum waste powder for coating on medium carbon steel

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Abstract. Medium carbon steel is one of the components vulnerable to corrosion although it has been coated. The purpose of this study is to measure the rate of corrosion penetration on low carbon steel coated galvanized penetration, graphene oxide, and aluminum waste powder. The process used is the use of hot dip galvanizing, where steel samples with temperature variations are immersed in hot liquid aluminum waste powder. Corrosion Penetration Rates (CPR) using dipped weight loss method in NaCl solution, the results obtained do not exceed the usual corrosion rate (0.5 mm / year) needed.

1. Introduction

To date, the coating given to corrosion-resistant medium carbon steel (steel containing 0.25 0.6 per cent carbon) is a form of ERGENE 809 Zinc Rich Cold Galvanize Coating galvanized with a layer of Zinc Oxide (ZnO) and Galvanize Galvanized Compound form, galvanized with aluminum, zinc and special resin composition. However, the issue that arises is the coating, which means that the widely used coating usually breaks down and peels off when the steel is lifted [1]. Study has been carried out on steel layers by creating alternative layers of graphene material. Since Geimdan Novoselov discovered it, graphene has drawn much attention from researchers to improve its application in the engineering world. Graphene has good conductivity of electrons, a high thermal conductivity and is 207 times stronger than steel [2]. Furthermore, graphene can form a gas and salt barrier, since it has a smaller lattice geometric hole than the smallest atom [3]. And for materials that appear to be reactive, graphene has the ability to be used as a corrosion protector. Study of coating steel ASTM A36 with graphene oxide + waterborne paint. Corrosion testing by immersing ASTM A36 steel samples in seawater (NaCl), and corrosion test for room temperature and 500^0C. Final results showed that CPR values for ASTM A36 steel samples with graphene oxide + waterborne paint coating obtained CPR value that did not exceeded the allowable standard rate (0.5 mm/yr) [4]. Another research, to utilize graphite rods from used batteries as the source material of graphene oxide. The as prepared material used for the corrosion coating on steel. Liquid exfoliation is the method that used for synthesizing graphene, assisted by a surfactant solution. The weight loss method for calculating the corrosion rate which is conducted by immersing low carbon steel samples in 0.1M NaCl solution for 2,4,6 hours. The final results showed that Corrosion Penetration Rate (CPR) values for low carbon steel samples was obtained when the coating system was added with 0.5-gram graphite bars on using batteries + 25ml distilled water+ 25ml H_2SO_4. The value of did not exceeded the allowable standard rate (0.5 mm/yr). Applications for this research showed that CPR of low carbon

steel that coated using graphene oxide from graphite bars of used batteries lower than CPR of steel with a coating in general (galvanize) [5].

The aim of this study is to attempt to combine a widely used galvanized solution for coating steel with graphene oxide and waste aluminum powder. For the acid mine drainage process, aluminum waste (from used cans) is used as the raw material for coagulant. The findings showed that the optimum dose of 1.5 grams of coagulant (KAl (SO$_4$) 2.12H2O) from the used cans will minimize TSS = 237.2 mg / l (62.47 percent), Metal Fe = 19.15 mg / l (13.13%) and Mn = 12.32 mg / l (35.49%) and pH moves to 2.62 (3.06%) [6]. In the construction sector, concrete mixtures with a partial material of aluminum flakes range from 0 percent, 5 percent, 7.5 percent and 10 percent, the test results indicate that the that percentage of aluminum flakes decreases the specific gravity of the test object but does not include lightweight concrete categories. Although it also reduces its effect on the compressive strength and tensile strength of concrete slabs [7]. Aluminum waste may also be used to manufacture exothermic jacket, a sand molding enhancer device for casting steel products that is commonly used to resolve metal shrinkage in order to achieve a higher casting yield than a sand riser enhancer device. Results showed that the use of exothermic sleeve from aluminum alloy 30 per cent dross and aluminum powder 20 per cent was able to withstand the solidification rate for 650 seconds at 1350-1450°C. The exothermic sleeve from the principal aluminum dross material has a greater temperature keeping effect compared to the sand riser and is almost equal to the manufactured exothermic sleeve. For the sand riser the modulus extension factor sleeve is 1.42 [8]. Aluminum waste used in this analysis is aluminum waste from the turning of aluminum metals (Figure 1a).

2. Methods

The steps in the research methodology carried out are: (1) preparing a sample of A53 steel pipe, with a diameter of 41 mm, thickness of 1.5 mm and height of 40 mm. (2) Coating the sample in two ways, (a) for Cold Galvanize Compound galvanized mixture Graphene, and (b) coatings using the Hot Dip Galvanizing (HDG) method. HDG coating is widely used because it is relatively easier to control the quality of the coating, is durable and resistant to impact [9]. HDG coating is a coating process that is done by dipping the base metal into a liquid solution. The coating process uses molten aluminum waste (in a furnace) with a temperature variation of 600^{0}C and 700^{0}C. (Figure 1b), with the same immersion time of 1 minute. and cooled quickly by dipping it in water. Both ways after going through the coating process are also weighed to find out how thick the coating is. Furthermore, all samples were tested for corrosion by immersing them in a salt solution (NaCl) for 24 hours. Finally, weighing the final weight of the sample after the corrosion test. Clearly shown in flow chart Figure 2.
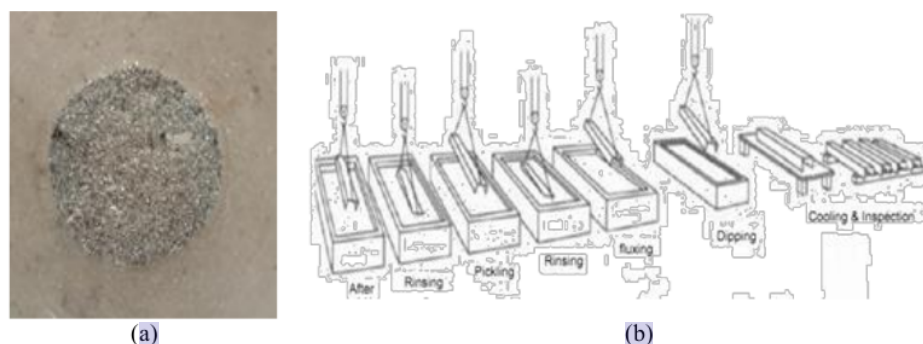

| (a) | (b) |

Figure 1. (a) Aluminum waste powder, (b) Step of Hot Dip Galvanizing for aluminum waste.

Calculation of corrosion rate (CPR) is the speed of propagation or the speed of deterioration of material quality over time. In calculating the corrosion rate, the unit commonly used is mm/yr (international standard) or mill / year (mpy, British standard). The level of resistance of a material to corrosion

generally has a corrosion rate between 1 - 200 mpy. Table 1 below is a classification of the level of material resistance based on the corrosion rate [10].

The method used for measuring the corrosion rate was Weight Loss Method [10]. This method was used as a measurement of the Corrosion Penetration Rate (CPR) which is expressed in mile per year (mpy) or millimeter per year (mm/yr). When the material density (ρ), testing time (t) and weight were known to have lost during the testing process, the CPR can be calculated by the equation:

$$CPR = \frac{KW}{ADT} \tag{1}$$

Description:
CPR= Corrosion Penetration Rate (mpy) or reduction in the thickness of the material per time unit. Unit: mile per year (mpy) or millimeter per year (mm /yr) (1 mil = 10-3 inches). W = weight loss during testing (mg) = mo – m, m = weight after corroded mo = weight before corroded. K= constant depends on unit used. when K = 534 the mpy will be used. When K = 87.6, mm/yr will be used. ρ = density (gr/cm3) t = time (hours) A = surface area (inchi2) A = cm2 (same units other such as CPR wear mpy) When the value of CPR was less than 20 mpy (0.5 mm / yr), the value/coefficient was still acceptable.

Table 1. Classification of the level of material resistance based on the corrosion rate.

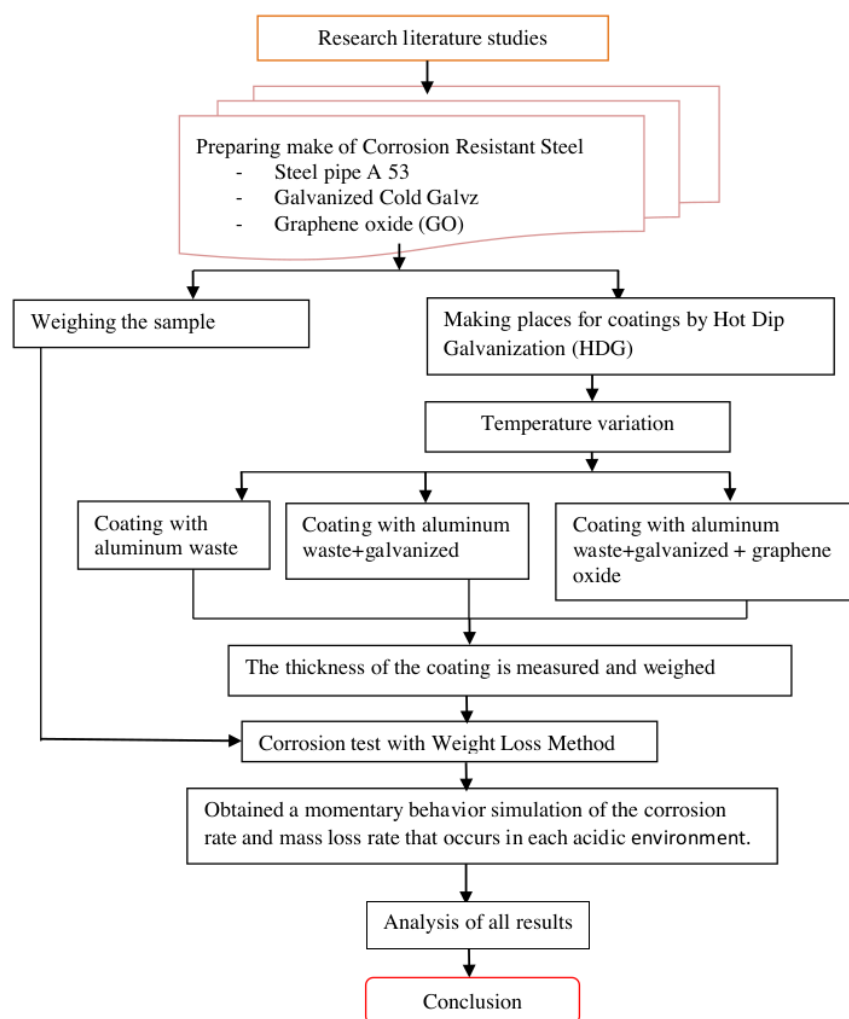| Relative Corrosion Resistance	Approximate Metric Equivalent				
	mpy	mm/year	μm/yr	nm/yr	pm/sec
Outstanding	7 1	<0.02	<25	<2	<1
Excellent	1 - 5	0.02 – 0.1	25 - 100	2 - 10	1 - 5
Good	5 - 20	0.1 – 0.5	100 – 500	10 – 50	5 - 20
Fair	20 - 50	0.5 - 1	500 - 1000	50 - 100	20 - 50
Poor	50 - 200	42125	1000 - 5000	150 - 500	50 - 200
Unacceptable	200 +	5+	5000 +	500 +	200 +

Figure 2. Flow chart of research.

3. Results and discussion

3.1. Results of CPR (dipped in 0,1 M NaCl)

The result for CPR data obtained from effect of time in wet corrosion test when dipped in solution of 0.1M NaCl, shown in Table 2 respectively. The graphene oxide coated steel has lowest value of corrosion rate when dipped in solution of 0.1 M NaCl for six hours. Showed that corrosion attack is slow, when compared to the galvanized coated sample.

Table 2. CPR obtained by wet corrosion test (0.1 M NaCl).

Sample	Time (hours)	Average CPR (mm/yr) x 10^{-4}
GO A	2	81.7
	4	55.9
	6	41.2
GO B	2	5.2
	4	4.5
	6	3.9
GO C	2	9.4
	4	11.5
	6	9.7
Galvanis	2	2.8
	4	6.3
	6	9.9

3.2. Wet corrosion test (Dipped in 0.1 M NaCl solutions)

The result for CPR data obtained from effect of time in wet corrosion test when dipped in solution of, 0.1 M NaCl, shown in Table 3 respectively. The fastest of corrosion rate for six hours was occurred in solution of NaCl for samples ASTM A36 steel were not coated. Samples ASTM A36 steel were coated with graphene and waterborne paint coating were seen that the corrosion attack is slow, meaning that the CPR of them is low when compared to the galvanized coated sample (Figure 3a, 3b, 3c).

When the sample is dipped in the solution of NaCl which contains of ions Na^+ and Cl^-, Cl^- ions tend to react with the oxygen bonding of aluminum, so the process of corrosion takes place more rapidly than in the alkaline environment. The corrosion rate values for the four samples when dipped in a solution of NaCl reach up to 0.034 mm/yr, with one-week period of 6 hours.

Table 3. CPR obtained by wet corrosion test (0.1 M NaCl).

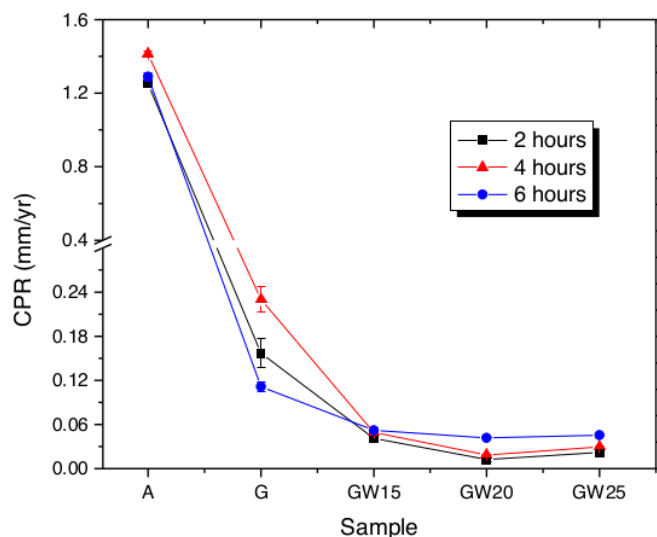| Sample	Time (hours)	Average CPR (mm/yr)
A	2	1.24
	4	1.38
	6	1.41
G	2	0.16
	4	0.21
	6	0.23
GW15	2	0.04
	4	0.04
	6	0.05
GW20	2	0.01
	4	0.02
	6	0.02
GW25	2	0.02
	4	0.03
	6	0.03

Figure 3. Corrosion penetration rate in NaCl 0.1 M.

4. Conclusion

Koma material for imported products are still superiors to the value of hardness and has an elemental composition that is in accordance with the standards of white cast iron. The micro structure formed shows the austenite phase with hard and tough pearlite granules.

Acknowledgement

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