

DETERMINATION OF CORROSION RATE OF MILD STEEL IN DIFFERENT MEDIUM MEASURING CURRENT DENSITY.

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Abstract- This Paper focuses on the study of the Corrosion of mild steel in different medium namely Sulfuric acid, Nitric Acid, NaCl solution. 3 sample of mild steel whose area 34.6 cm² are taken for observing the corrosion for 3 weeks in these mediums. Linear Polarization Method has been used to measure corrosion current density to predict the corrosion rate. Data has been tabulated & shown graphically for analysis. The experimental result shows that the corrosiveness of mild steel is most in nitric acid then in sulfuric acid then NaCl. The corrosiveness in nitric is high because of its high oxidizing nature and then it follows to the sulfuric acid then NaCl.

Keywords: Current Density, Corrosion rate, Linear Polarization method

1. INTRODUCTION

By natural process, all materials tend towards achieving a state of equilibrium, which is going back to its origin. Steel being an alloy and a material obeys this call of nature and as such must go back to its equilibrium and stable form. Hence all metals and materials must corrode. The word corrosion was derived from the Latin *corrosus* which means eaten away or consumed by degrees; an unpleasant word for an unpleasant process^[1]. Mild steel and high carbon steels are classified as ferrous metals (they contain a large percentage of iron). Carbon steels are essentially iron-carbon alloys. They are sometimes subdivided by the broad range of carbon content, which include: (a) mild or low carbon steel (0.08 – 0.30% carbon) (b) medium carbon steel (0.3 – 0.5% carbon) and (c) high carbon steel (0.55 – 1.40 carbon)^[2]. In the world today, mild steel is used in different Engineering applications for the production of some automobile components, structural shapes (I beam and angle iron) and sheets that are used in pipelines, buildings, plants, bridges and tin cans^[3]. Corrosion is a natural phenomenon, which is inevitable; instead it can be controlled to an appreciable extent. For this control to be implemented, certain tests are carried out by placing the metal in the environment to which it's utility is needed and a careful study of the metal is undergone for a specified time, based on the observation and inference drawn, the corrosion rate can be assessed and a proper measure can be made to control the rate of corrosion^[4]. This work is also done to know the corrosion behavior by linear polarization method when exposed to various medium like sulfuric acid nitric acid NaCl solution and tap water.

2. METHODOLOGY

In this chapter the corrosion measurement procedure along with sample preparation will be discussed. This includes experimental setup to data taking.

2.1 Linear Polarization Technique

In this experiment the linear polarization method has been used. Electrical conductivity (the reciprocal of resistance) of a fluid can be related to its corrosiveness. A two or three electrode probe is inserted into the process system, with the electrodes being electrically isolated from each other and the process line. A small potential in the range of 20mV (which does not affect the natural corrosion process) is applied between the elements and the resulting current is measured. The polarization resistance is the ratio of the applied potential and the resulting current level. The measured resistance is inversely related to the corrosion rate.

The electrical resistance is given by

$$R=V/I$$

Where R=Effective instantaneous resistance

V = Applied voltage

I = Instantaneous current between electrodes, If the electrodes are corroding at a high rate with the metal ions passing easily into solution, a small potential applied between the electrodes will produce a high current and therefore a low polarization resistance. This corresponds to a high corrosion rate^[5].

2.2 Measuring Corrosion Rate

Corrosion current values may be obtained from galvanic cells and polarization measurements, including polarization resistance measurements. The first step is to convert the measured or estimated current value to current density. This is accomplished by dividing the total current by the geometric area of the electrode exposed to the solution. It is assumed that the current distributes uniformly across the area used in this calculation. In the case of galvanic couples, the exposed area of the anodic specimen should be used. This calculation may be expressed as follows:

$$i_{corr} = \frac{I_{corr}}{A}$$

Where,

i_{corr} = Corrosion current density, $\mu\text{A}/\text{cm}^2$

I_{corr} = Total anodic current, μA and

A = exposed specimen area, cm^2 .

Other units may be used in this calculation. In some computerized polarization equipment, this calculation is made automatically after the specimen area is programmed into the computer.

Equivalent weight (EW) may be thought of as the mass of metal in grams that will be oxidized by the passage of one Faraday (96489 C (amp-sec)) of electric charge. The value of EW is not dependent on the unit system chosen and so may be considered dimensionless. For pure elements, the equivalent weight is given by:

$$EW = \frac{W}{n}$$

Where,

W = the atomic weight of the element, and

n = the number of electrons required to oxidize an atom of the element in the corrosion process, that is the valence of the element

Faraday's Law can be used to calculate the corrosion rate in terms of penetration rate (CR)

$$CR = K_1 \frac{i_{corr}}{\rho} EW \dots\dots\dots (1)$$

Where,

CR is given in mm/yr,

i_{corr} in $\mu\text{A}/\text{cm}^2$,

$K_1 = 3.27 \times 10^{-3}$, mm g/ $\mu\text{A cm yr}$

ρ = density in g/cm^3 [5]



Fig.1: Samples taken for observation

3. EXPERIMENTAL RESULT & DATA ANALYSIS

Welded the mild steel and reference electrode with the wire reference and submerged in the electrolyte solution. Then measure the potential between the two electrodes in a definite period. After sometime Ammeter reading is also recorded carefully, the current is so low. Then total value has put in the above formula and finds the corrosion rate.

Area of corroding metal (A)	3 samples of area 34.6 cm^2
Density of the coupon (ρ)	7.85 g/cm^3
Number of electron produced or consumed	2
EW	18.89
Charge of electron	$1.6 \times 10^{-19} \text{C}$

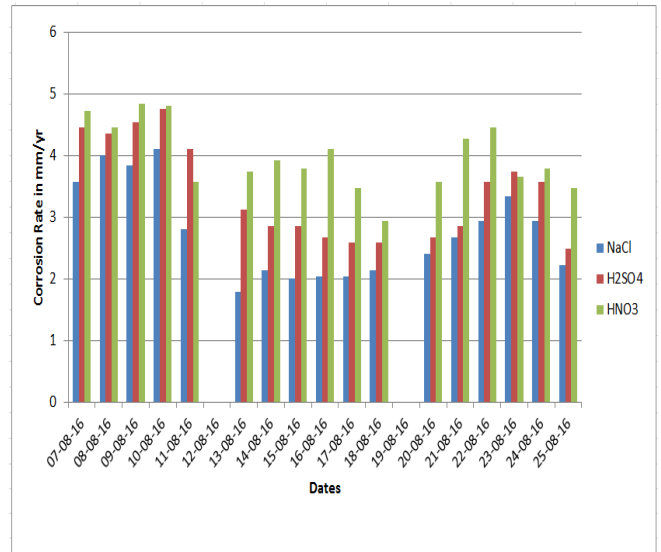
3.1. Experimental Data

Table 1: Data of specimen 1 (NaCl Solution)

Date	Current (I_{corr}) mA	Voltage (V) V	Corrosion current ($i_{corr} = \frac{I_{corr}}{A}$) $\mu\text{A}/\text{cm}^2$	Corrosion rate ($CR = K_1 \frac{i_{corr}}{\rho} EW$) mm/yr
7-8-16	4	1.7	115.6	3.57
8-8-16	4.5	2.2	130.1	4.02
9-8-16	4.3	1.98	124.3	3.84
10-8-16	4.6	1.8	133	4.11
11-8-16	3.15	1.85	91.04	2.81
13-8-16	2	1.603	57.8	1.79
14-8-16	2.4	1.7	69.4	2.14
15-8-16	2.25	1.9	65	2.01
16-8-16	2.3	1.85	66.5	2.05
17-8-16	2.3	1.873	66.5	2.05
18-8-16	2.4	1.763	69.4	2.14
20-8-16	2.7	1.91	78	2.41
21-8-16	3	2.1	86.71	2.68
22-8-16	3.3	2.3	95.4	2.95
23-8-16	3.75	2.4	108.4	3.35
24-8-16	3.3	2.8	95.4	2.95
25-8-16	2.5	2.36	72.3	2.23

Table 2: Data of specimen 2 (H₂SO₄ solution)

Date	Current (I _{corr}) mA	Voltage (V) V	Corrosion current ($i_{corr} = \frac{I_{corr}}{A}$) $\mu\text{A}/\text{cm}^2$	Corrosion rate ($CR = K_1 \frac{i_{corr}}{\rho} EW$) mm/yr
7-8-16	5	.66	144.5	4.46
8-8-16	4.9	.86	141.6	4.37
9-8-16	5.1	.943	147.4	4.55
10-8-16	5.33	1.7	154	4.76
11-8-16	4.6	1.85	133	4.11
13-8-16	3.5	1.9	101.2	3.13
14-8-16	3.2	1.92	92.5	2.86
15-8-16	3.2	1.950	92.5	2.86
16-8-16	3	2.060	86.71	2.68
17-8-16	2.9	2.010	83.82	2.59
18-8-16	2.9	2.010	83.82	2.59
20-8-16	3	2.019	86.71	2.68
21-8-16	3.2	2.023	92.5	2.86
22-8-16	4	2.033	115.6	3.57
23-8-16	4.2	2.054	121.4	3.75
24-8-16	4	2.1	115.6	3.57
25-8-16	2.8	2.143	80.92	2.5



Graph 1: Corrosion penetration rate for 3 samples in various dates

Table 3: Data of specimen 3 (HNO₃ solution)

Date	Current (I _{corr}) mA	Voltage (V) V	Corrosion current ($i_{corr} = \frac{I_{corr}}{A}$) $\mu\text{A}/\text{cm}^2$	Corrosion rate ($CR = K_1 \frac{i_{corr}}{\rho} EW$) mm/yr
7-8-16	5.3	1.65	153.2	4.73
8-8-16	5	1.75	144.5	4.46
9-8-16	5.43	1.93	157	4.85
10-8-16	5.4	2.02	156	4.82
11-8-16	4	1.803	115.6	3.57
13-8-16	4.2	1.9	121.4	3.75
14-8-16	4.4	1.65	127.2	3.93
15-8-16	4.25	1.62	122.8	3.8
16-8-16	4.6	1.73	133	4.11
17-8-16	3.9	1.65	112.7	3.48
18-8-16	3.3	1.72	95.4	2.95
20-8-16	4	1.8	115.6	3.57
21-8-16	4.8	1.71	138.73	4.28
22-8-16	5	1.75	144.5	4.46
23-8-16	4.1	1.73	118.5	3.66
24-8-16	4.25	1.75	122.8	3.8
25-8-16	3.9	1.83	112.7	3.48

3.2. Result Analysis

From this experiment it can be said that corrosion has occurred as we have seen various current densities along with the rust formation on the samples after being corroded. It has been seen that the rate of corrosion is more severe in HNO₃, followed by H₂SO₄ and lastly NaCl. The findings are shown in the data table. The corrosion of mild steels in HNO₃, H₂SO₄, NaCl solutions are attributed to the presence of water, air and H⁺ which accelerated the corrosion process. The graph also shows the comparison in corrosion occurring in different specimen. The data has been taken for 3 weeks and the corrosion rate was going normally increasing for some days and later than it suddenly drops down abruptly because of the corroding surface doesn't allow the full touch of the solutions. Lastly it showed again in the previous form.

4. CONCLUSION

The corrosion rate determination is a most prior as mild steel as well as other metals are used in various applications. So that's why the corrosion rate should be determined by a proper way where corrosion is closely observed. As in our day to day life we cannot hope anything else of good communication with easy life so science is making it easy by making structures which made by mild steel. So we have to think about how to make this corrosion less or prevent from corroding by any means.

5. REFERENCES

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8. NOMENCLATURE

Symbol	Meaning	S. I. Unit
ρ	Density	Kg/m ³
I	Current	A