International Journal of Mechanical Engineering and Technology (IJMET)
Volume 9, Issue 5, May 2018, pp. 1003–1010, Article ID: IJMET_09_05_111
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=5
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

EVALUATION OF CARBON STEEL ROD CORROSION IN A DIFFERENT MEDIAS

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ABSTRACT

Experimental investigation is performed to simulate the steel rod corrosion into the machinery parts after used and exposure to different corrosive medias. Five samples of carbon steel used in this study and it is submerged into three types of water medias (pure water, drainage water , and sulfuric spring water) with periods (3, 6, 12, and 24 Weeks).

It was concluded that the values of the corrosion rate at low exposure time (t=3 Weeks) are greater than that for long exposure with the fact that the weight loss of carbon steel increased with time. In addition to, it was found that corrosion rates of these products vary in the different corroding media the steel rods into pure water media has a higher corrosion resistivity than that it submerged into a drainage water media and a sulfuric spring water media , and that the samples into a drainage water media has a higher corrosion resistivity than that into the sulfuric spring water media.

Also the rod samples with high percent carbon essentially corroded more than that it has low percent of carbon samples at the same environments.

Keywords: Steel Carbon, Corrosion, Drainage Water , Sulfuric Spring Water, and Exposure Time

Cite this Article: Suadad Noori Ghani and Thaier J. Ntayeesh, Evaluation of Carbon Steel Rod Corrosion in a Different Medias, International Journal of Mechanical Engineering and Technology, 9(5), 2018, pp. 1003–1010.
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=5

1. INTRODUCTION

The corrosion is a major problem that may be occur in metal of the factories. The causes of corrosions in metal are corrosion due to environment, electrochemical, and differential potential. The corrosion of metal lead to loss in economical due to damage in the metal machines, therefore the corrosion problem must be treatment by using a modern methods (periodic maintenance). **[ASM Handbook, 2003]**

The used method of the corrosion in this study is a wet corrosion method which the media transferred electric through it , and the interaction is called electrochemical, such as corrosion

of steel carbon submerged into water media. Steel carbon are used in many structures and machines such as, pipes of water and oil, machines of water heating, water tanks, factories, bridges, ships, planes, …..etc. The corrosion of the steel carbon rod into water media is similar to the steel bar corrosion of the steel carbon in natural exposure environmental.

The steel rods corrosion depends upon period length that the exposure surface of steel rod is wet, in additional to that there are many factors may be effected on the corrosion such as metal composition, type and amount of water media, temperature values, relative humidity, , exposure environmental , atmospheric pollution, properties of the formed oxide, etc. **[Morcillo et al. (2015)]**

2 REVIEW OF LITERATURE

Many methods have been developed by several investigators for estimation of the effects of the corrosion of carbon steel rods.

The corrosion of the plain carbon steel and copper samples due to the rain regime was studied by Corvo et al. (2005). It was concluded that the acceleration rate of the corrosion was increased with increasing the rain regime caused by chloride ions in atmospheric conditions. Garcia et.al (2008) concluded the increase in chloride ions leaded to increase in loss weight of the carbon steel. In additional to increase the corrosion rate with increasing NaCl.

Basheer and Al-Sraij (2012) studied the effect of heat on the carbon steel corrosion submerged into sulfuric water media. The results show that the highest resistance of corrosion can be noted of the annealed steel, but it's becomes lowest for hardened steel case. The influence of the presence of salt with water on the corrosion rate is studied by Sharaf (2012). It was concluded that the corrosion of the steel placed into media contents salt is higher than that for without salt. Uzorh (2013) investigated the effects of the corrosion on plain carbon steels. It was founded that the corrosion rates increases with increasing degree of cold work. Also, the corrosion rates depending upon corroding media with moist soil.

Cesen et al. (2014) studied the different forms of the carbon steel corrosion properties of such as (sheets 240 μm, rods with a diameter of 5.0 mm, and wires with a diameter of 0.8 mm). It was found that the steel in the form of a wire having the highest corrosive ability, followed by the steel rod and then steel in the form of a sheet. The corrosion of carbon steels due to marine atmospheric is studied by Morcillo et. al.(2015). From the result study, can be included that the concentration of the chloride at the exposure site (atmospheric salinity) plays a decisive influence on the carbon steel corrosion.

In recently, Yan (2017) studied the influence of the temperature on the mechanical properties of corroded steel bars. The combined influence of temperature and corrosion can be observed on the results of nominal yield and ultimate strength.

3. EXPERIMENTAL WORK

3.1. Tools Used

A three class box is used with dimensions of its width, length and height are **250mm**, **1000 mm**, and **1000mm** respectively. Steel carbon bars are solid and designed with diameter **16 mm** and length **=200 mm**). Carbon steels rods have a small holes at the top of the rod to allow hanging by using high tensile weirs. These class box are filled with pure water, drainage water, and sulfuric spring water. For each class box, five steel carbon rods models at a various carbon percent's are submerged into water medias as shown in Figure(1).

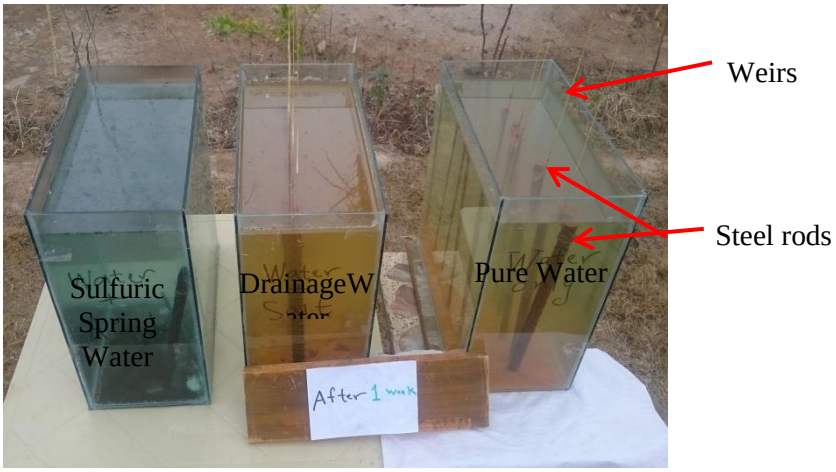


Figure 1 Experimental model

3.2. Water Used

Three types of corrosion cell were used with an approximate volume of water 0.25 m^3. The specimens were exposure to three types of pure water, drainage water, sulfuric spring water. The chemical properties of the three types of water used are listed in Table(1).

The three water medias used were stimulated to the natural water, drainage water from plant, sulfuric spring water respectively as shown in Figure (2).

Table 1 Chemical and physical properties of water media used

Properties	Values		
	Pure Water	**Drainage Water**	**Sulfuric Spring Water**
Mineral content , mg/l	231	1980	9200
Calcium Hardness, mg/l	119	223	3420
CL^-, mg/l	34	2115	133
Mg^{+2}, mg/l	27.3	298	1302
Electrical Potential, Volt	-67.7	-26	-22
Electrical Conductivity, E_c	477	1990	2230
PH	8.42	7.88	7.79
Ca^{+2} (mg/l)	51.2	210	1423
So_4^{-2} (mg/l)	21	260	1567

Figure 2 Drainage Water

3.3. Steel Rods Samples

Carbon steels used are divided into five categories as a [1.Very low 2.Low 3.Medium 4.High 5.Very high carbon steels] . Table (2) shows chemical composition of carbon steel bars. Table (2) shows the percent's of carbon into steel rods. The chemical composition of carbon steel bars can be shown in Table(3). Figure (3) shows the micro-images of steel rods with different values of carbon percent's.

Table 2 Carbon percent's into steel rod

Sample No.	Carbon Percent	Description of sample
.1	0.121	[Very low]
2.	0.234	[Low]
3.	0.322	[Medium]
4.	0.563	[High]
5.	0.71	[Very high]

Table 3 Chemical composition of steel rod

Samples No.	Chemical Compositions (%)								
	[S_i]	[M_n]	[P]	[S]	[C_r]	[N_i]	[C_u]	[Al]	[Mo]
1	0.22	0.498	0.0101	0.021	0.124	0.0502	0.02	0.004	0.014
2	1.72	1.01	0.026	0.008	0.0172	0.009	0.032	0.027	0.006
3	1.68	0.71	0.0164	0.006	0.067	0.0272	0.025	0.014	0.009
4	0.268	1.31	0.0071	0.039	0.456	0.088	0.035	0.01	0.032
5	0.223	0.97	0.0049	0.037	0.0901	0.078	0.045	0.053	0.054

(a). C=0.121%

(b). C=0.234%

(c). C=0.322%

(d). C=0.563%

(e). C=0.71%

Figure 3 Micro-images of steel rods with different percent's of carbon

4. DISCUSSION RESULTS

In order to explain the effect of the different medias of water and carbon percent of steel rods on the corrosion, the results are presented as a Corrosion Rate (CR) with time at a constant temperature 30 C^o. The rate of corrosion can be calculated depending upon weight loss method as in equation (1) **[Winston (2000) & Fontana and Green (1986)]**

$$CR = \frac{(534*W)}{(D*A*T)} \quad \text{.....} \quad (1)$$

[CR]: Corrosion rate in (mpy).

[**W]:** Weight loss (mg)

[**D]:** Steel bar density (g/cm^3)

[A]: Surface area of steel bar (in^2)

[T]: Exposure time of corrosion (hour)

After a period of exposure of steel rods (T= 3, 6, 12, and 24 Weeks) of water media, the steel rods were extracted from water media and cleaned carefully to remove only the corrosion products by using soft brush and water. Then the samples submerged into chlorine diluted acid (HCl) and washing with water and alcohol, finally it dried. The new weights of the steel rods can be recorded by using electronic weighing balance with accuracy (0.1 mg) as shown in Figure (4). The processes of cleaning , washing, drying, and weighing were repeated for the samples at a different exposure times.

For a short time period (24 hours) from the starting of the samples exposure to water media, no corrosion of sample can be occurred, it was noticed after a period (48 hours).

Figure 4 The processes of cleaning and weighing of steel bar

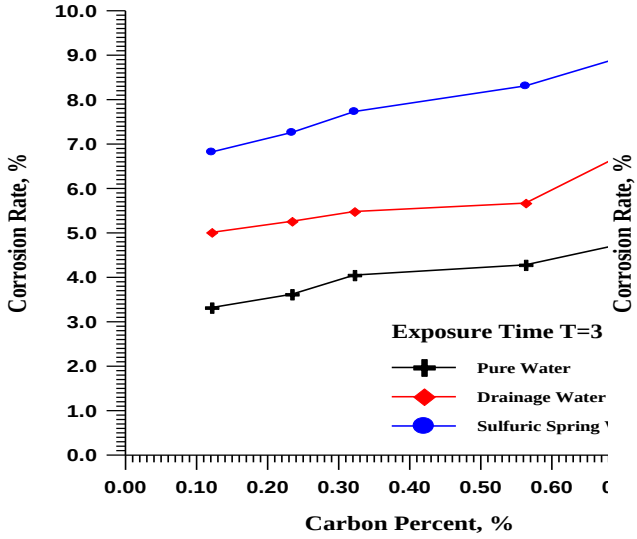
Figures from (5a) to (5d) show the variations of corrosion rate (CR) with the carbon percent of steel rod for three cases of the water medias (Pure water, drainage water, and sulfuric spring water) when the samples submerged at a different periods (T= 3, 6, 12, and 24 weeks). It is seen from the figure that when the steel rod samples were submerged into sulfuric spring water, the values of the corrosion rate (CR) are greater than that for other water medias. The main reason for this is that the concentration of So_4^{-2}, Mg^{+2} , and Ca^{+2} (mg/l) is high and it leaded to a rapid corrosion of the steel rods.

The effects of the drainage water in increasing the corrosion rate are higher than that of pure water, this is probably due to the fact that the presence of high percent of negative chlorides which it is leaded to accelerate the steel rods corrosion. For all figures from (5a to

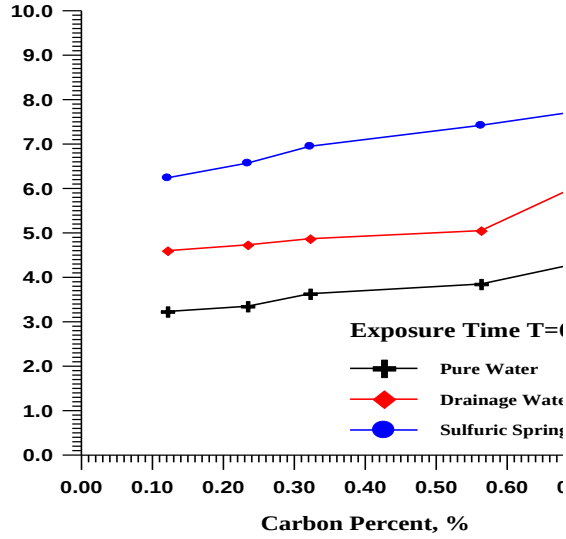
5d), The two curves for the pure and drainage water medias conditions have an approximately low slope (flat curves). The vertical distance among a three curves for each water medias are approximately equally.

Generally, for all water medias, the magnitudes of the corrosion rate increases with increasing the carbon percent's into steel rods as an approximately linear, but this behavior does not apply to high carbon percent (0.71%).

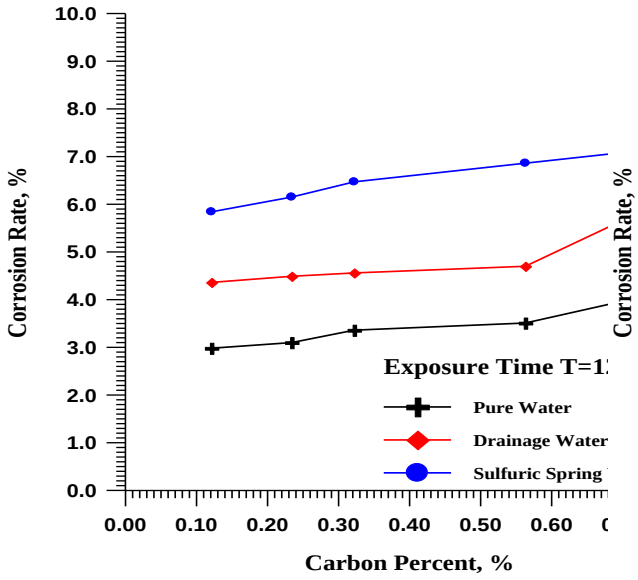
Relationships among corrosion rates and carbon percent's at a different exposure time are shown in Figures (6a), (6b), and (6c) for the cases of water medias (pure water, drainage water, and sulfuric spring water) respectively. It is obvious from this figure that the values of the corrosion rates of the carbon steel rod at a low time length are greater than that the cases of other samples at a different time length with a constant fact that the weight loss of carbon steel rod increased with time. The curves characteristic for all exposure time are similarity, the difference between them is in values.



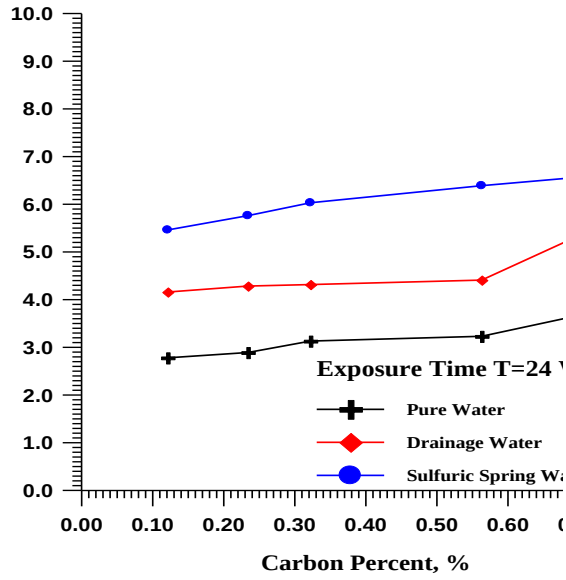
(a). Exposure Time, T=3 Weeks



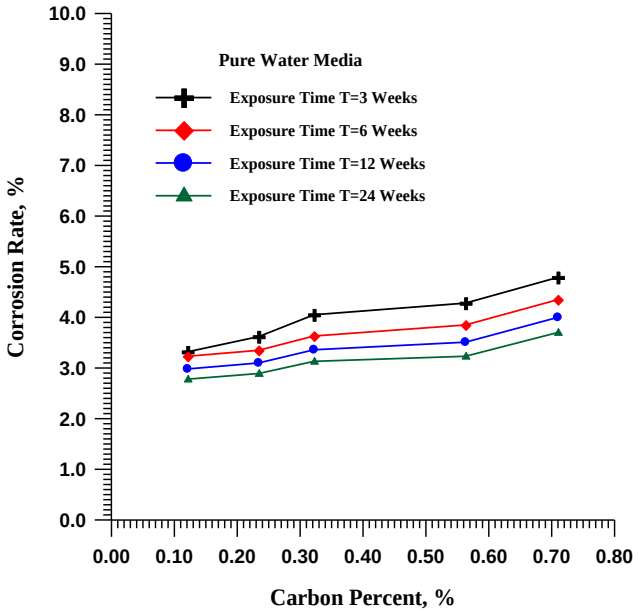
(b). Exposure Time, T=6 Weeks



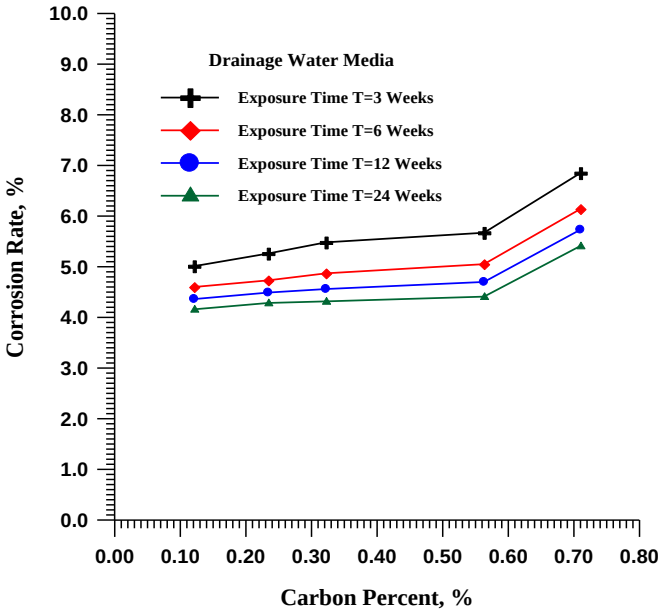
(c). Exposure Time, T=12 Weeks



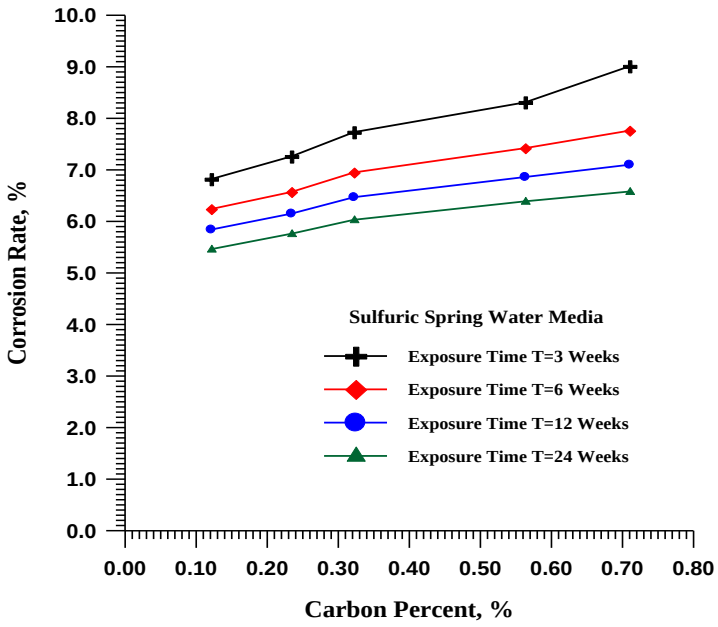
(d). Exposure Time, T=24 Weeks



(a) Pure Water Media



(b) Salt Water Media



(c) Sulfuric Water Media

Figure 6 Relationship between the corrosion rate and carbon percent at different periods

5. CONCLUSIONS

- The corrosion rate values at a low time length of exposure of water medias time (t=3 Weeks) are greater than that for a large time length.
- The weight loss of carbon steel increased with time.
- The peak values of the corrosion rate of steel rod are marked when it submerged into sulfuric spring water followed by drainage water and then pure water.
- At the same environments, the rod samples with high percent carbon essentially corroded more than that it has low percent of carbon.

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