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Corrosion Behaviour of Ductile Iron in Different Environment

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ABSTRACT

Ductile Iron has been a great material in water carrying pipes, heavy duties parts of farm equipment and other great applications. This work looked into the corrosion rate of ductile iron in different corresponding to areas of usage and storage for a period of six (6) months. The environments are outside, air conditioned, brackish (salty) and alkaline. As the period increases the corrosion rate decreases. There was a sharp corrosion rate at the first few months for the entire environment but as the month increases the corrosion slows down. Brackish (NaCl) environment had the highest weight loss with a difference (last month – initial month) of 1.1456g followed by outside with a difference of 1.0284g while A/C had the lowest with zero. The results obtained will help the engineers, scientists, materials sellers and users, policy makers especially in the area this product finds usage and storage.

Keywords: *Ductile Iron, Environment, Reaction, Corrosion.*

1. INTRODUCTION

Over forty years ago, the birth of a new engineering material ductile iron was announced at the 1984 American Foundry men's society annual conference [3]. Ductile iron is not a single material, but a family of versatile cast irons exhibiting a wide range of properties which are obtained through microstructural control. The most important and distinguishing microstructural feature of all ductile irons is the presence of graphite nodules which act as " crack – arresters" and give ductile iron ductility and toughness superior to all other cast irons, and equal to many cast and forged steels [2].

Much of the annual production of ductile iron is in the form of ductile iron pipe, used for water and sewer lines. Since its introduction into the marketplace in 1955, Ductile Iron pipe has been recognized as the industry standard for modern water and wastewater systems [2]. More than four decades of field experience have proven its strength, durability, and reliability for transporting raw and potable water, sewage, slurries, and process chemicals. Ductile iron pipe is stronger and easier to tap, requires less support and provides greater flow area compared with pipe made from other materials. In difficult terrain it can be a better choice than PVC, concrete, polyethylene, or steel pipe [2]. Ductile iron is specifically useful in many automotive components, where strength needs surpass that of aluminium but do not necessarily require steel. Ductile Iron finds application in the oil and gas industry especially oil well pumps [7]. Ductile Iron can be used in heavy duty farm machineries like class 8 trucks, agricultural tractors. Other major industrial applications include off-highway diesel trucks.

Corrosion is one of the most destructive agents and probably the greatest consumer of metal known to man. Corrosion is an electrochemical process involving the oxidation of a metal (the anodic reactions) and the corresponding reduction of another material (the cathodic reactions) [6]. Corrosion may be defined as "the undesirable reaction of a metal or alloy with its environment" and it follows that the control of the process may be affected by modifying either of the reactants (the metal or the environment). Corrosion is the gradual degradation of a material. Corrosion in the modern society is one of the outstanding challenging problems in the industry. Most industrial design can never be made without taking into consideration the effect of corrosion on the life span of the equipment. Recent industrial catastrophes have it that many industries have lost several billion of dollars as a result of corrosion. Reports around the world have confirmed that some oil companies had their pipeline ruptured due to corrosion, oil spillages are experienced which no doubt created environmental pollution, in addition, resources are lost in cleaning up this environmental mess and finally large scale ecological damage resulted from corrosion effects [4]. Corrosion in fresh or salt water is always the result of an electrochemical reaction [5].

This work is borne out of the need to ascertain the corrosion rate of ductile iron in environments like open air, brackish (salty), Alkaline and Air conditioned environments. These environments coincide with the environment where the material finds usage and storage after casting. This will help the engineers, scientists, materials sellers and users, policy makers especially in areas of usage and storage.

2. METHODOLOGY

The cut pieces of Ductile Iron were machined into ASTM standard [1] as shown in the diagram below (Fig 2.6). Three samples per environment were taking per month for six months and weigh to determine their weight loss. And the result was inputted in the equation(1) to compute the rate of Corrosion (mg/mm^2/yr):

$$corrosion\ rate = \frac{W}{TSA \times \frac{T}{365}} \quad (1)$$

Where:

W = weight loss (milligram)

TSA = total surface area (mm^2)
T = time of exposure (days)

The table below shows the data for the weight loss used for determining the rate of corrosion.

Table 2.1: Weight of Ductile Iron in Different Environment

EXPOSURE TIME (DAYS)	WEIGHT OUTSIDE (g)	WEIGHT LOSS (OUTSIDE)	WEIGHT (NaOH) (g)	WEIGHT LOSS (NaOH)	WEIGHT A/C (g)	WEIGHT LOSS A/C (g)	WEIGHT BRACKISH (NaCl) (g)	WEIGHT LOSS (NaCl) (g)
1	21.451	-	21.451	-	21.451	-	21.451	-
30	20.6521	0.7989	20.59	0.861	21.451	0	20.6309	0.8201
60	20.6062	0.0459	20.584	0.006	21.451	0	20.5658	0.0651
90	20.5603	0.0459	20.59	-0.006	21.451	0	20.5007	0.0651
120	20.5144	0.0459	20.584	0.006	21.451	0	20.4356	0.0651
150	20.4685	0.0459	20.59	-0.006	21.451	0	20.3705	0.0651
180	20.4226	0.0459	20.584	0.006	21.451	0	20.3054	0.0651

Table 2.2: Corrosion Rate of Ductile Iron in Different Environments

Exposure time(days)	Outside($mg/mm^2/yr$)	NaOH($mg/mm^2/yr$)	A/C ($mg/mm^2/yr$)	NaCl ($mg/mm^2/yr$)
30	0.024297	0.026186	0	0.024942
60	0.000698	9.12409E-05	0	0.000989964
90	0.000465	-6.08273E-05	0	0.000659976
120	0.000349	4.56204E-05	0	0.000494982
150	0.000279	-3.64999E-05	0	0.000396024
180	0.000232687	3.04167E-05	0	0.000330021

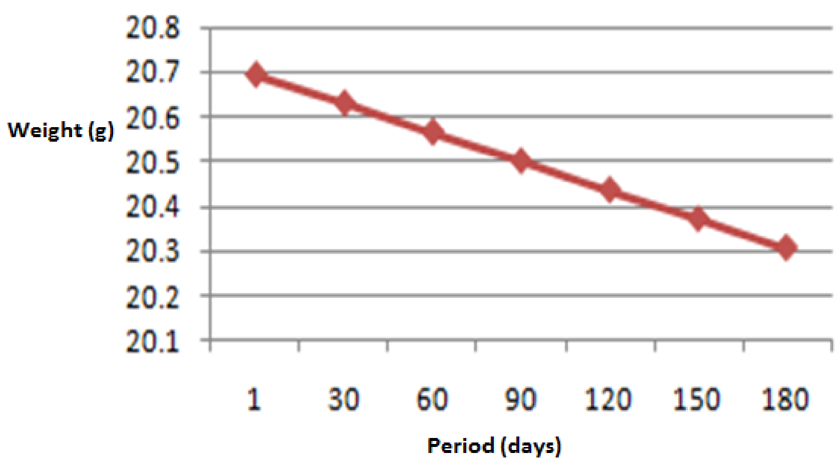

Fig 2.1: Graph of Weight of Ductile Iron in Sea Water (Brackish) Environment

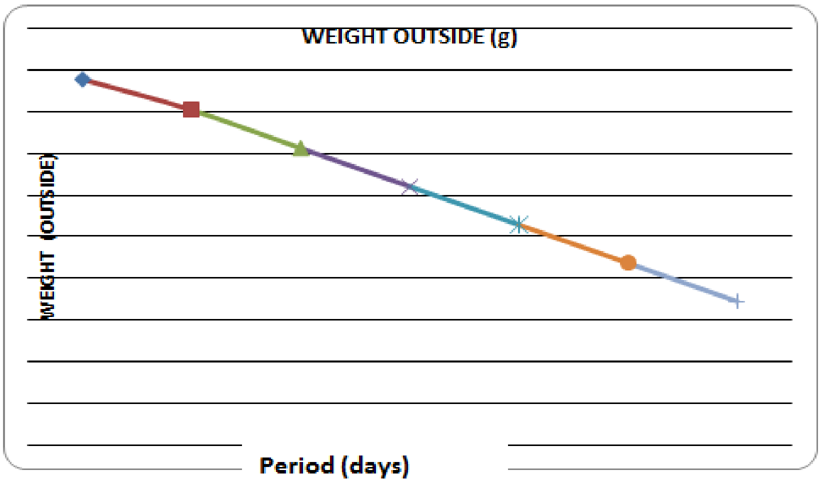

Fig 2.2: Graph of Weight of Ductile Iron in Outside Environment

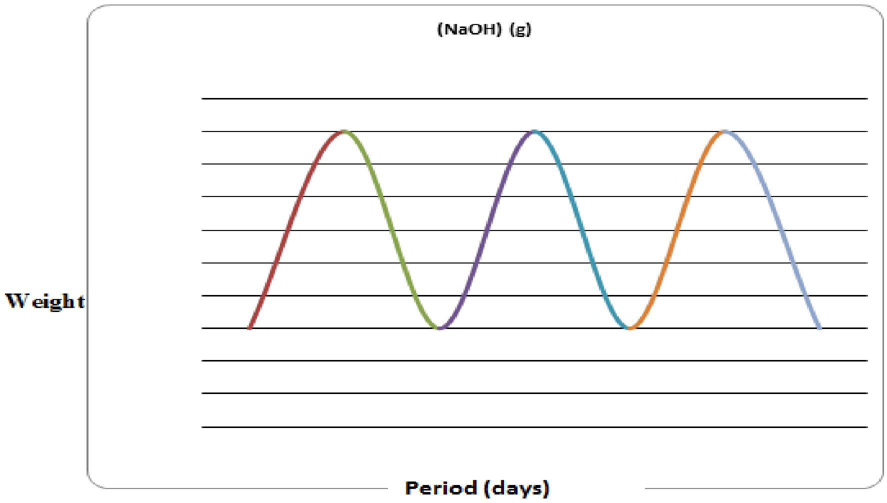

Fig 2.3: Graph of Weight of Ductile Iron in Basic Environment

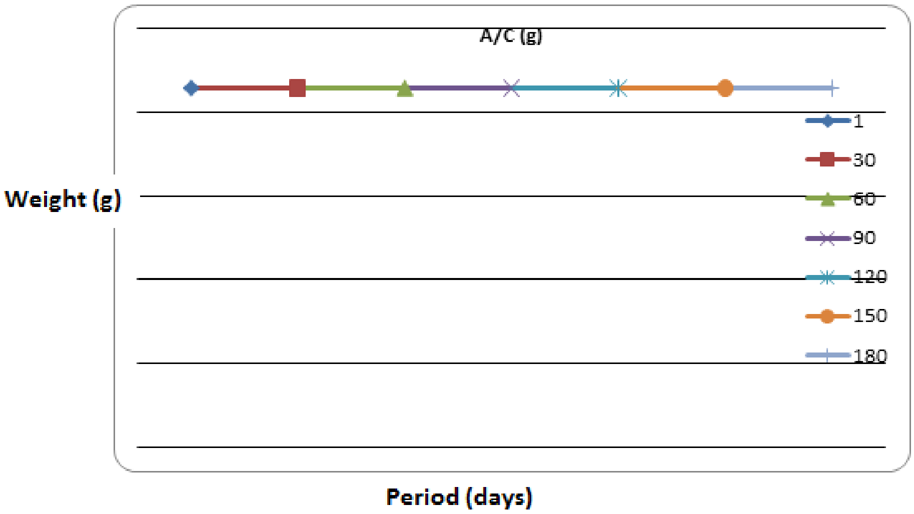

Fig 2.4: Graph of Weight of Ductile Iron in A/C Environment

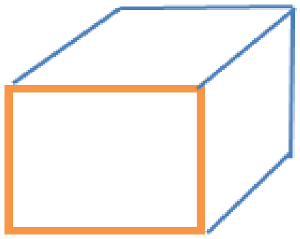

Fig 2.6: Weight Loss Specimen

Fig 2.7: Electronic Weight Balance used for Measuring Weight of the Sample

3. RESULT AND DISCUSSION

It was observed that the ductile iron placed in the outside was found to have a steady decrease in weight throughout the months but the rate at which the weight decreases in the first month (0.7989) is higher than the other months (0.0459) as indicated in Table 2.1. This is due to change in outside environment humidity and temperature owing to seasonal change that arose between the first month and the remaining months of the experiment. Alkaline being a basic solution dissolved in water, in this case Sodium Hydroxide. There was an increase in weight of 0.006g between the first and second month which was due to the absence of Iron III Oxide (Fe_2O_3 - rust) while for between the third and fourth month there was a weight decrease of 0.006g. This fluctuation pattern was repeated for the other months. The ductile iron placed in the air conditioned environment did not experience any weight change. This might be due to the fact that the samples were kept away from the vent of the Air Condition in the room because moisture is needed for there to be corrosion. Aluminium always form a passive layer of gamma Alumina ($\gamma - Al_2O_3$) on its surface during corrosion (Gurappa and Reboul, 1984) for the first few period of exposure causing it to gain weight, after a while this passive layer give way to the attack and thereby make the Aluminium to loss weight however in this case, the ductile iron placed in the salty environment (NaCl) experienced a weight loss of 0.0641 between the first and second month and maintained a steady decrease of 0.0651. For the first and second month there was no presence of rust but as the month progresses.

4. CONCLUSION

As the period increases the corrosion rate decreases. There was a sharp corrosion rate at the first few months for the entire environment but as the month increases the corrosion slows down with Brackish (NaCl) having the highest rate followed by outside environment and A/C had the lowest value as shown in Table 2.2.

5. RECOMMENDATION

It is important at this point to recommend to the seller of DI that it is advisable that the product be store in a conditioned environment in order to maintain both the physical property of the product. Moreover, since the product react less with most of the environment as indicated in the experiment, the product can therefore recommended for usage in most of these environments.

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