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CORROSION BEHAVIOUR OF DIFFERENT PERCENTAGE OF COBALT ALLOYING ELEMENT ON DUCTILE IRON UNDER 3.5% NaCl

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ABSTRACT

The purpose of this research is to investigate the corrosion behavior of ductile iron (DI) and ductile iron added with different percentage of cobalt alloying element. All the samples were produced by casting technique which is ductile iron (DI), 0.5%Co–DI, 1%Co–DI, 2% Co–DI. All the composition of these samples was determine by using spectrometer machine. For corrosion behavior, two different testing techniques were used which is polarization test and weight loss measurement. Testing was done under 3.5% NaCl in room temperature. All specimens with alloyed addition on DI give a better result in corrosion rate. This research will give better understanding and exposure about the corrosive behavior of DI, thus, improvement can be made for prevention of corrosion.

Keywords: corrosion, alloyed ductile iron, NaCl, polarization, and weight loss measurement.

INTRODUCTION

Ductile iron or ductile cast iron is a cast iron with spheroidal graphite. Other terms for ductile iron are nodular, spherulitic, and spheroidal cast iron [1]. Ductile iron is much more flexible and elastic, due to its nodular graphite inclusions. Ductile cast iron, which has excellent mechanical properties, has been widely used as an underground pipeline, gas pipelines, a structural material in the machine, the automobile industry, the mining industry, and so on [2]. It is produced by treating low-sulfur molten iron of proper chemical composition with magnesium. The reaction with magnesium allows the excess carbon (graphite) present in the iron to form as round nodules or spheres. The nodular graphite, along with the proper heat treatment, allows ductile iron to have strength characteristics similar to mild steel including excellent tensile strength, impact resistance, and beam strength. For ductile iron that has been added with the alloying element, its properties will be changed. Cobalt alloyed ductile iron has an increasing trend in both the nodule count and the ferrite content in the microstructure. This clearly implies that the cobalt element plays an important role in stabilizing the ferrite phase in ductile iron [3].

Corrosion can be defined as a chemical or electrochemical reaction between a material, usually a metal, and its environment that produces a deterioration of the material and its properties [4]. Most metals do not exist as a solid metal piece of material. In their natural state, they exist in the form of oxides. These metal oxides (or other metal compounds) must be refined to create the pure metals or alloys which become useful structural materials that can be used to build things [5]. Pure metals and alloys have a much higher energy state and there is a natural tendency to return to their lower energy state. Corrosion is natural process. Just like water flows to the lowest level, all natural processes tend toward the lowest possible energy states. Thus, for example, iron and steel have a natural tendency to combine with other chemical element to return to their lowest energy state. In order to return to lower energy states, iron and steel frequently combine with oxygen and water, both of which are present in most natural environments, to form hydrated iron oxides (rust), similar in chemical composition to the original iron.

The problem of corrosion arises in various environments ranging from urban and marine atmospheres to industrial chemical plant installations. It is a major factor governing the design and operation of plant and equipment as it reduces their useful life and can often result in unscheduled shutdowns or catastrophic failure. Therefore this research is done to study the effect of addition the different percentage of cobalt alloying element in ductile iron to analyze its corrosion behavior. It will give better comparison results in term of corrosion behavior between the different percentages of alloy element added to ductile iron.

EXPERIMENTAL SET UP

EXPERIMENTAL PROCEDURE

Two testing techniques were used which is polarization test and weight loss measurement. Testing were done on ductile iron (DI) and ductile iron added with different percentage of Cobalt alloying element which is 0.5%Co-DI, 1%Co-DI and 2%Co-DI.

POLARIZATION TEST

In polarization test, the specimens must be grinded with a series of wet sanding paper of different grit size (120, 180, 320, 400, 600 and 1200). Then the specimen was cleaned with distilled water and dried at room temperature. This experiment carried out in room temperature for one specimen in each composition. Electrochemical measurements were performed in a single compartment three electrode cell with specimen (surface area = 100mm^2) as working electrode, graphite rod as counter electrode and silver/silver chloride (Ag/AgCl) as reference electrode.

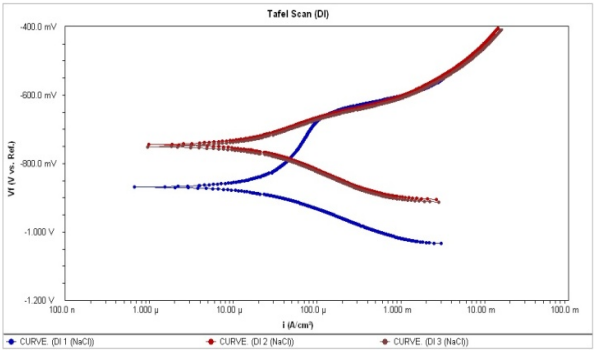
WEIGHT LOSS MEASUREMENT

Weight loss measurement also known as immersion test is conducted by immersing the specimen into a corrosion medium. An analytical balance is required for both before and after weight measurement. This testing is done in room temperature on cylindrical specimen with diameter of 20 mm and 40 mm height. This specimen was immersed into 3.5% NaCl in an open-beaker for 672 hours.

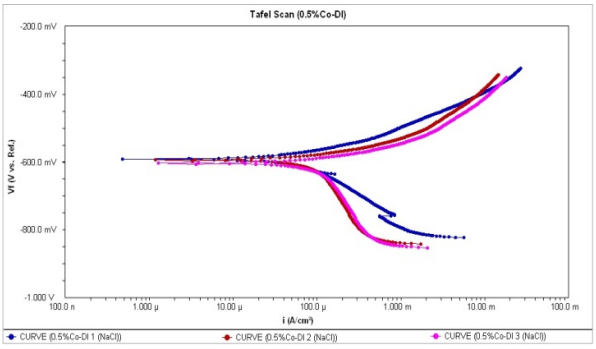
RESULT AND DISCUSSION

POLARIZATION TEST

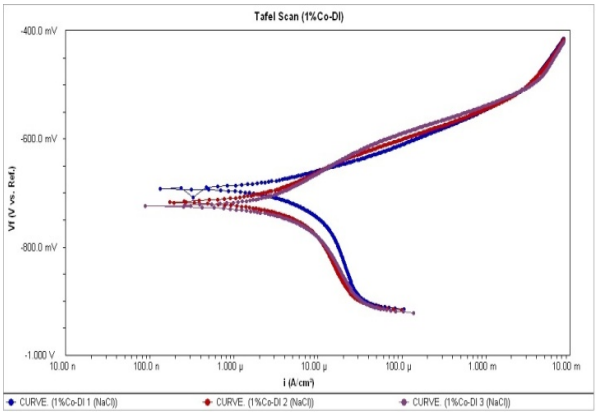
After polarization tests in 3.5 wt.% NaCl solution at room temperature, the polarization curves of specimens (0.5%Co-DI, 1%Co-DI and 2%Co-DI) were obtained from the relationship between corrosion potential (Ecorr) and current (Icorr) (see Figure-1). All the corrosion rate data obtained from the experiments were summarized graphically in Figure-2, and from that, it can be seen that by adding cobalt alloying element, the corrosion rate became much better than DI. Moreover, the corrosion rate also decreased with addition of alloying element. From the graph, it can be concluded that corrosion rate decrease with the increasing percentage of cobalt added to DI. However, the 0.5%Co-DI's corrosion rate is higher than other alloying element due to the higher value of carbon equivalent weight (CE). High carbon content resulting to higher corrosion rate.



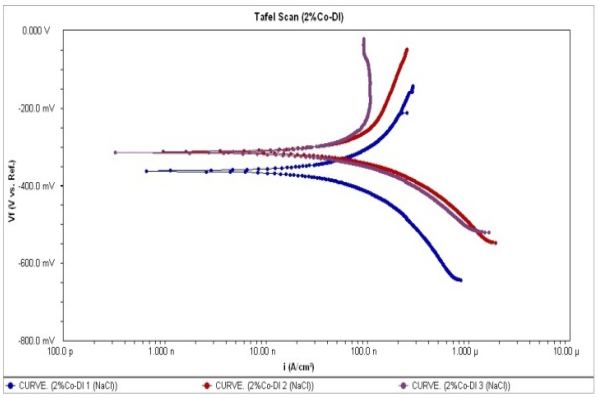
(a)



(b)



(c)



(d)

Figure-1. Polarization curves of (a) Ductile iron; (b) 0.5%Co-DI; (c) 1%Co-DI; (d) 2%Co-DI.

WEIGHT LOSS MEASUREMENT

In previous research [6]–[11], most of them doing the weight loss test other than polarization test in determining the corrosion behavior of specimens. In this research, total immersion method were used for weight loss measurement. The corrosion solution used is 3.5% NaCl. Noted that the NaCl used for the overall experiment follow the JIS K 8150 standard. The specimens were immersed for 672 hours at room temperature. From the data obtained, all the specimens recorded the loss in weight. From this weight loss, the corrosion rate being calculated. By referring to the graph in Figure-2, it can be seen that all the specimens have better corrosion rate compared to ductile iron. Similar to polarization result, the corrosion rate decreased marginally with the increasing percentage of cobalt.

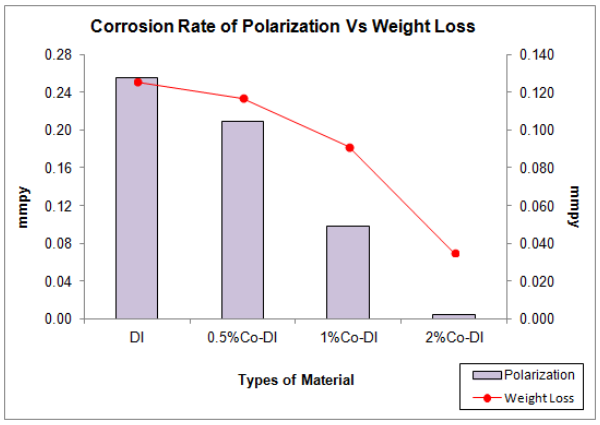


Figure-2. Corrosion rate of polarization vs weight loss measurement.

CONCLUSIONS

Results obtained from the experimental works had successfully met the objective of this research. The conclusions can be deduced from this research is, the similar corrosion rate trend were obtained between the polarization test and weight loss test. For both test, the ductile iron recorded the fastest corrosion rate and all the alloyed ductile iron have better corrosion resistance compared to ductile iron.

ACKNOWLEDGEMENTS

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