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Impact of Sensitization on the Weight Loss of Austenitic Stainless Steel (Type 304) in Fresh Water

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Abstract

The rate of weight loss of austenitic stainless immersed in fresh water after sensitization is the target focus of research scholars. This trend of study is subjected to a determination of the weight loss of austenitic stainless steel (type 304), immersed in fresh water. Thus, the presentation of this paper is one of such using SPSS for the data analysis. Analysis from the result attest strong relationship between weight loss of austenitic stainless steel (type 304) in fresh water after sensitization period of about 96.6% ≃ 97%. The result further attest that the nature of correlation is positive which implies that weight loss of austenitic steel (type 304) in fresh water increases progressively with sensitization period. The results attest that the study is significant with a P – Value of 0.00 which is lee than 0.05 (5%) significant level.

1. Introduction

Iron and the most common iron alloy, steel, are from a corrosion viewpoint relatively poor materials since they rust in air, corrode in acids and scale in high temperature furnace atmospheres. Inspite of this there is a group of iron-base alloys, the iron-chromium (Fe- Cr) alloys, often with nickel (Ni) additions, known as stainless steels, which “do not rust in sea water,” “are resistant to concentrated acids” and which “do not scale at temperatures up to1100^0C.” It is this largely unique universal usefulness, in combination with good mechanical properties and manufacturing characteristics, which makes the stainless steels indispensable for the designer. The use of stainless steel is small compare with that of carbon steels but exhibits a steady growth [1].

Austenitic stainless steel is a good corrosion resistance material when properly heat treated and used in a low temperature environment. In a way, they are susceptible to corrosion when exposed to temperatures between 550°C – 750°C [2-5]. This is due to the formation of Cr-rich Carbides at the grain boundaries and neighboring matrix, leaving a Cr-depleted zone extending to both side of the grain boundaries. However, it is susceptible to pitting and crevice corrosion in presence of chloride ions, which results in the initiations of pits.

The use of austenitic stainless steel (ASS) in the petroleum and gas industries cannot be over emphasized. Its exquisite properties which range from high tensile strength, good impact, wear and corrosion resistances have found many applications in the petroleum and gas industries. This material is use in almost all environments that need an optimization of these properties, some of which are, Fossil-fired power plant, flue gas desulphurization equipment [6-8]. ASS is known for its corrosion resistance principally due to the presence of chromium which is soluble in the austenitic matrix. Chromium adds to the overall corrosion resistance through a passivation process by forming a complex spinel-type [(Fe, Ni) 0 (Fe, Cr)203] passive film [9-11]. These austenitic stainless steels when exposed to temperature in the range of 538°C to 850°C undergoes precipitation of chromium carbides at the grain boundaries. This precipitation of chromium carbides at the grain boundaries is termed as sensitization. This sensitized steel suffers from intergranular corrosion. The presence of nitrogen is thought to improve resistance to intergranular attack due to retardation of carbide precipitation. Sensitization is a prime hassle in stainless steels that affects the alloy's durability. Chromium additions in steel is the primary contributor to sensitization.

Sensitization is described when a carbide precipitation prompted by the heat treatment which cause chromium-depletion near the grain boundaries. Chromium is immensely reactive with oxygen and will form a very thin chromium oxide layer on the surface of stainless steel. Sensitization treatment which expressively modifies the stress corrosion cracking geste and the cause of this is the intergranular precipitation and the grain boundary chromium depletion [12].

2. Materials and Method

This work adopted the method used by [13] to determine the impact of sensitization and weight loss of the test steel in received and sensitized condition.

Austenitic stainless steel 304 grade was used. Investigation on weight loss and sensitization were conducted. This special grade of steel was obtained from NNPC Warri in the form of a sheet. The chemical composition is shown in Table 1.

Table 1. Chemical Composition of Austenitic Stainless Steel Type 304

Type	Fe(%)	Mn(%)	Cu(%)	V(%)	Co(%)	Cr(%)	Ni(%)	Mo(%)	Ti(%)
304	69.40	1.25	0.22	0.07	−	18.82	9.99	0.26	−

Five sets of the coupon were given sensitization treatment under different soaking time of (30mm, 1 hour, 3 hours, 5 hours and 10 hours), in the temperature range of 550°C-750°C, using a digital heat treatment furnace, and cooled in air (normalized). Five coupons of the material were fully immersed in five beakers containing fresh water, labeled. The coupons were cleaned with soft brush and air dried in every two days intervals for weight loss reading for the total exposure time of 42days, a digitals balance is used for the reading. Another five coupons of the material in the treated condition was cut, to serve as a control specimen for metallographic studies. The coupons were mounted and ground progressively on emery grit papers (220-1000 grits) with water as the coolant. The ground coupons were then polished with diamond polishing paste, and etched with freshly prepared oxalic acid (HCL) and distilled water in the ratio 30:70. The micrograph of each etched coupon were viewed under a metallurgical microscope using a magnification of X 100 and the data analysis was done using SPSS.

3.0. Result and Discussion

Table 2 depicts results from the data analysis of the impact of sensitization on the weight loss of austenitic stainless steel type 304 in fresh water. It shows that there is a strong relationship between the sensitization period and weight loss. A strong relation of about 96.6% ≃ 97% exist between them.

The data analysis further shows positive between them which implies that as the sensitization period increases the rate of weight loss of austenitic stainless steel (type 304) immersed in fresh water also increases progressively. This result is true because it is observed that the weight loss in ASS 304 increases progressively, which is attributed to increase in the time of exposure for the sensitization of ASS 304 [13]. A P-value of 0.00 is obtained from the analysis shown in Table 3. This implies that the study is significant, hence the null (H_O) hypothesis is rejected.

Table 2. Soaking Time for Type 304

Soaking Time	48	96	144	192	240	288	336	384	432	480	528	576	624	672	720	768	816	864	912	960
Type 304	o	0	0	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.02	.02	.03	.03	.03	.04	.04

Table 3. Correlations

		Soaking Time	Austenitic Stainless Steel Type 304
Soaking Time	Pearson Correlation	1	.966**
	Sig. (2-tailed)		.000
	N	20	20
Austenitic Stainless Steel Type 304	Pearson Correlation	.966**	1
	Sig. (2-tailed)	.000	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

4.0. Conclusion

The study shows that weight loss of austenitic stainless steel (type 304) increases progressively with an increase in sensitization period.

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