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Characterize of Corrosion Rate and Mechanical Properties of Low Carbon Steel in Potassium Chromate Solution

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Abstract. *Corrosion is one of the degradation materials in Industrial problem. One of the processing to choose material is to determine how to have resistance to all the environment. This research is carried out to determine characterize the effect of various temperatures (150, 200, 250 ºC) and time (4,6 and 8 hours) of exposure of Low Carbon Steel in corrosion rate and mechanical properties by using Mass Balance method and Potassium Chromate vapor as medium corrosion. The results have been shown that the increasing temperature ids increasing corrosion rate which is the maximum value is 5,1215 x 10^{-4} miles/years. The difference in corrosion rate increasing by 6,3 % based on increasing temperature. The microstructure has shown is intergranular corrosion mode.*

Keywords: Low Carbon Steel, Potassium Chromate, Corrosion rate.

1. Introduction

In everyday life, we easily encounter corrosion and occur in various types of metal. Electronic equipment and building material are metal components such as copper, zinc, steel and others that can be attacked by corrosion. In addition to large metals, corrosion can also attack metals on electronic equipment components, ranging from computer components, watches and equipment used in the lives of humanity, both in domestic life and in industrial activities. Corrosion is very common in iron. Iron is a metal that is susceptible to corrosion if a protective coating is not provided. Rust in iron is a substance that is produced in the event of corrosion that is, in the form of a reddish brown solid which is fragile and porous.

Corrosion process occurs in almost all metal materials that occur slowly, corrosion results in a material having a limited life, where the material is expected to be used for a long time turns out to make a shorter life span than the average usage life.

Corrosion prevention can be done in various ways, one example is cathodic protection, by providing a coating on a metal surface, and adding a corrosion inhibitor. The addition of corrosion inhibitors is one of the most effective ways to prevent corrosion because it requires a relatively low cost and simple process.

Corrosion events are very detrimental to industry and society. One example of the phenomenon of the effects of corrosion is a broken bridge due to the metal parts affected by corrosion. The metal parts of the bridge which is affected by corrosion will reduce the strength of the bridge construction.

2. Method and Materials

Carbon steel is an alloy between iron (Fe) with carbon content between [illegible]. Based on the amount of carbon content, carbon steel can be clarified into [illegible] types. The material caused carbon steel [illegible].

2.1. Strain Gauge

A strain gauge is a metal or semiconductor element whose resistance changes when under pressure [illegible]. Strain gauge consists of three core parts, namely wire, base, and adhesive. Because all materials are resistant to deformation, several forces must be applied to cause a deformation. Then, resistance can be related to the force applied.

The number of strain gauges applied at high temperatures using platinum metal group has been developed. Platinum, a metallic metal used in strain gauge has a composition in percent of weight platinum [illegible] tungsten [illegible], platinum-nickel-tungsten [illegible], platinum-nickel-chromium [illegible], and palladium-chrome [illegible]. Strain gauges containing non-precious metals are copper-nickel [illegible], nickel-chrome [illegible], and iron-chrome-aluminum (Fe-Cr-Al) [illegible].

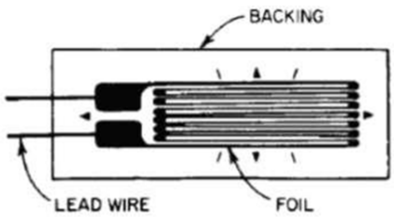

Figure [illegible] Strain Gauge

Corrosion is metal degradation or damage caused by a redox reaction between a metal and various substances in the surrounding environment that produce unnecessary compounds. In everyday language, corrosion is called rusting. The most common example of corrosion is iron rusting [illegible]. In the event of corrosion, the metal undergoes oxidation, while oxygen (air) has a reduction. Metal rust is generally in the form of oxide or carbonate. The chemical formula for iron rust is $Fe_2O_3 \cdot nH_2O$, a red-brown solid. The average static corrosion rate at high temperature is indicated by the change in mass per unit area expressed in Equation [illegible].

$$\Delta m = (W_F - W_0)/A \quad [illegible]$$

With
- Δm = changing of mass divided by exposed area (g/m²)
- W_F = oxide mass (g)
- W_0 = before oxide mass (g)
- A = exposed cross-section area (m²)

When the relationship curve is made between changes in the mass of the broad units with the oxidation time, for materials that have corrosion resistance at high temperatures, because the surface has a strong and stable protective layer, usually the curve is parabolic, the standard parabolic equation can be stated in Equation [illegible].

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3. Results and Discussions

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The following table is the calculation results overall for [illegible] Steels in Figure [illegible] and Table [illegible].

Table [illegible] Mass Calculation Results in [illegible] Steel with Temperature [illegible]^0 C, [illegible]^0 C, [illegible]^0 C with [illegible] Different Time

No.	Test (Hour)	Temperature					
		150°C		200°C		250°C	
		m (gram)	Δm (gram)	M (gram)	Δm (gram)	M (gram)	Δm (gram)
1	0	0.009560348	0	0.009615656	0	0.009631576	0
2	1	0.009536839	0.000023509	0.009711973	0.000096317	0.009687713	0.000056137
3	2	0.009583973	0.000047314	0.009752677	0.000040704	0.009736354	0.000048641
4	3	0.009615656	0.000031683	0.009785486	0.000032809	0.009785486	0.000049132
5	4	0.009720086	0.000104430	0.009818518	0.000033032	0.009835117	0.000049631
6	5	0.009760859	0.000040773	0.009860122	0.000041604	0.009885254	0.000050137
7	6	0.009793723	0.000032864	0.009902079	0.000041957	0.009952903	0.000067649
8	7	0.009826811	0.000033088	0.009952903	0.000050824	0.010004251	0.000051348
9	8	0.009876862	0.000050051	0.010012860	0.000059957	0.010047447	0.000043196

Table [illegible] Results of Calculation of Average Corrosion Rate per Year against Temperature on Testing For [illegible]

No.	Temperature (^{0} C)	m (gram)	Δm (gram)	Corr.Rate (mm/hour)	Corr.Rate (*mils/year*)
1	[illegible]	[illegible]	0	0	0
2	[illegible]	[illegible]	0.000041387	0.0008427446	4.5872 x 10^{-6}
3	[illegible]	[illegible]	0.000040572	0.0008261573	4.4969 x 10^{-6}
4	[illegible]	[illegible]	0.000040708	0.0008289225	4.5119 x 10^{-6}

Table [illegible] Results of Calculation of Average Corrosion Rate per Year against Temperature on Testing For [illegible]

No.	Temperature (^{0} C)	m (gram)	Δm (gram)	Corr.Rate (mm/hour)	Corr.Rate (*mils/year*)
1	[illegible]	[illegible]	0	0	0
2	[illegible]	[illegible]	0.000040082	0.0008161674	4.4425 x 10^{-6}
3	[illegible]	[illegible]	0.000040917	0.0008331742	4.5351 x 10^{-6}
4	[illegible]	[illegible]	0.000045903	0.0009347019	5.0877 x 10^{-6}

Table [illegible] Result [illegible] Calculation [illegible] Average Corrosion Rate Per Year Against Temperature On Testing For [illegible]

No.	Temperature (^{0} C)	m (gram)	Δm (gram)	Corr.Rate (mm/hour)	Corr.Rate (mils/year)
1	[illegible]	[illegible]	0	0	0
2	[illegible]	[illegible]	0.000040412	0.0008228911	4.4791×10^{-6}
3	[illegible]	[illegible]	0.000044134	0.0008986804	4.8917×10^{-6}
4	[illegible]	[illegible]	0.000046208	0.0009409124	5.1215×10^{-6}

Results [illegible] Discussion and Analysis [illegible] Observation [illegible] Macro Structure and Micro From the observation [illegible] micro and macro structure corrosion testing with a temperature [illegible], [illegible], [illegible] for [illegible] hours, [illegible] hours, [illegible] hours, seen in the macro structure there are green spots caused by the evaporation of potassium chromate solution on the microstructure testing it is clear that the structure that looks ferrite and pearlite. The test using [illegible] nital etching [illegible] times magnification each it be seen in the example [illegible] Figure [illegible]

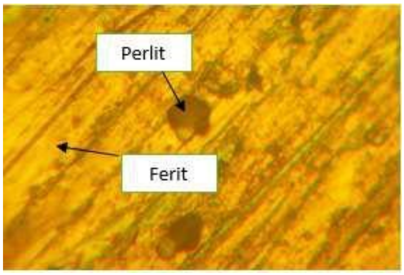

Figure [illegible] The sample it had been in [illegible] magnification

Vickers hardness test results on [illegible] steel obtained using the Micro Hardness Test [illegible]EE. On this hardness test, the hardness value of specimen [illegible] to specimen [illegible] is obtained, the value of hardness does not increase constantly because homogenization has not been done before.

No. Specimen	D1 (µm)	D2 (µm)	HV
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

4. Conclusion

1. The highest corrosion rate is found in the specimen tested at temperature [illegible]°C, because the higher the test temperature, the greater the mass change that occurs.
2. Potassium chromate solution is alkaline which means it is also corrosive.
3. The results of the calculation of the corrosion rate on the [illegible] steel for [illegible] hours with the temperature [illegible]°C is [illegible] mils/year, at a temperature [illegible]°C with a corrosion rate [illegible] mils/year, and at a temperature [illegible]°C with a corrosion rate [illegible] mils/year.
4. The results of the calculation of the corrosion rate on the [illegible] steel for [illegible] hours with the temperature [illegible]°C is [illegible] mils/year, at a temperature [illegible]°C with a corrosion rate [illegible] mils/year, and at a temperature [illegible]°C with a corrosion rate [illegible] mils/year.
5. The results of the calculation of the corrosion rate on the [illegible] steel for [illegible] hours with at temperature [illegible]°C is [illegible] mils/year, at a temperature [illegible]°C had a corrosion rate [illegible] mils/year, and at a temperature [illegible]°C with a corrosion rate [illegible] mils/year.
6. Percentage change in corrosion rate in [illegible] steel [illegible] using a solution of potassium chromate [illegible].

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References

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