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Corrosion inhibitor behavior in typical car radiators

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Abstract. A minor breakdown of the cooling system will cause engine overheating. One of the factors causing the engine overheating is the crust on radiator of cooling system. Based on the problem, therefore, corrosion on the cooling system, especially radiator, should be controlled. There are some methods in controlling the corrosion; one of them is the inhibitor treatment. The research aims to know the corrosion mechanism, the corrosion type, and the kind of inhibitor that produces the lowest corrosion rate. The tool used to measure the chemical composition of the radiator is spectrometer, while microscope optic is used to know the radiator corrosion type. The corrosion rate testing is used three electrode cells according to tafel extrapolation method. The results of the test of the nitric acid inhibitor treatment with the addition of various methods showed that the most optimal result is on the addition of nitric acid inhibitor by 5%. It is proven by the decrease of corrosion rate from 0.002207 mmpy to 0.0171 mmpy.

1. Introduction

Indonesia is a tropical country in which it has high air temperature, crowded traffic, and lack of reforestation. It causes high environmental temperature. The high environmental temperature affects the engine performance of cooling system in which it makes the cooling system work harder. A minor breakdown of the cooling system will cause engine overheating. One of the factors causing the engine overheating is the crust on radiator of cooling system that makes the cooling water circulation is obstructed. It will be worse when there is corrosion on the cooling system.

Radiator of vehicles is susceptible to corrosion since it is made of metal. The cooling system engines of the vehicles that often have a high risk of corrosion are *House Hose* and *Upper Glower Tank Radiator*, as seen in the Figure 1 and Figure 2.



Figure 1. Water hose



Figure 2. Upper glower tank radiator



Corrosion on radiator occurs because the used radiator coolant contains high chloride ion. The high rain intensity in Indonesia's ecosystem contains high calcium, that makes the corrosion is formed easily [1]. Radiator coolant is water has been added by chemical component named glycol that has higher boiling point than water to make it becomes water resistant, is not easily frozen, is not easily evaporate, and is not easily gravitate [2], [3]. The problem should be noticed is that the pigment used in radiator coolant can cause corrosion. The radiator only can cool down the engine, but cannot prevent the corrosion. Corrosion cannot be eliminated, but it can be controlled [4]. There are three ways to control the corrosion; that are surface coating, cathode protection, and inhibitor treatment [5]. This research aims to know the corrosion characteristic and mechanism on the radiator with the variable of inhibitor kind and chooses the inhibitor type that can give the lowest corrosion rate of radiator.

2. Method

2.1 Research Procedure

The research is conducted by applying water coolant + 0% of nitric acid, water coolant + 5% of nitric acid, and water coolant + 10% of nitric acid. Then, it is compared with water coolant + 0% of hexamethylenetetramine, water coolant + 5% of hexamethylenetetramine, and water coolant + 10% of hexamethylenetetramine. The steps of the research are shown in the Figure 3.

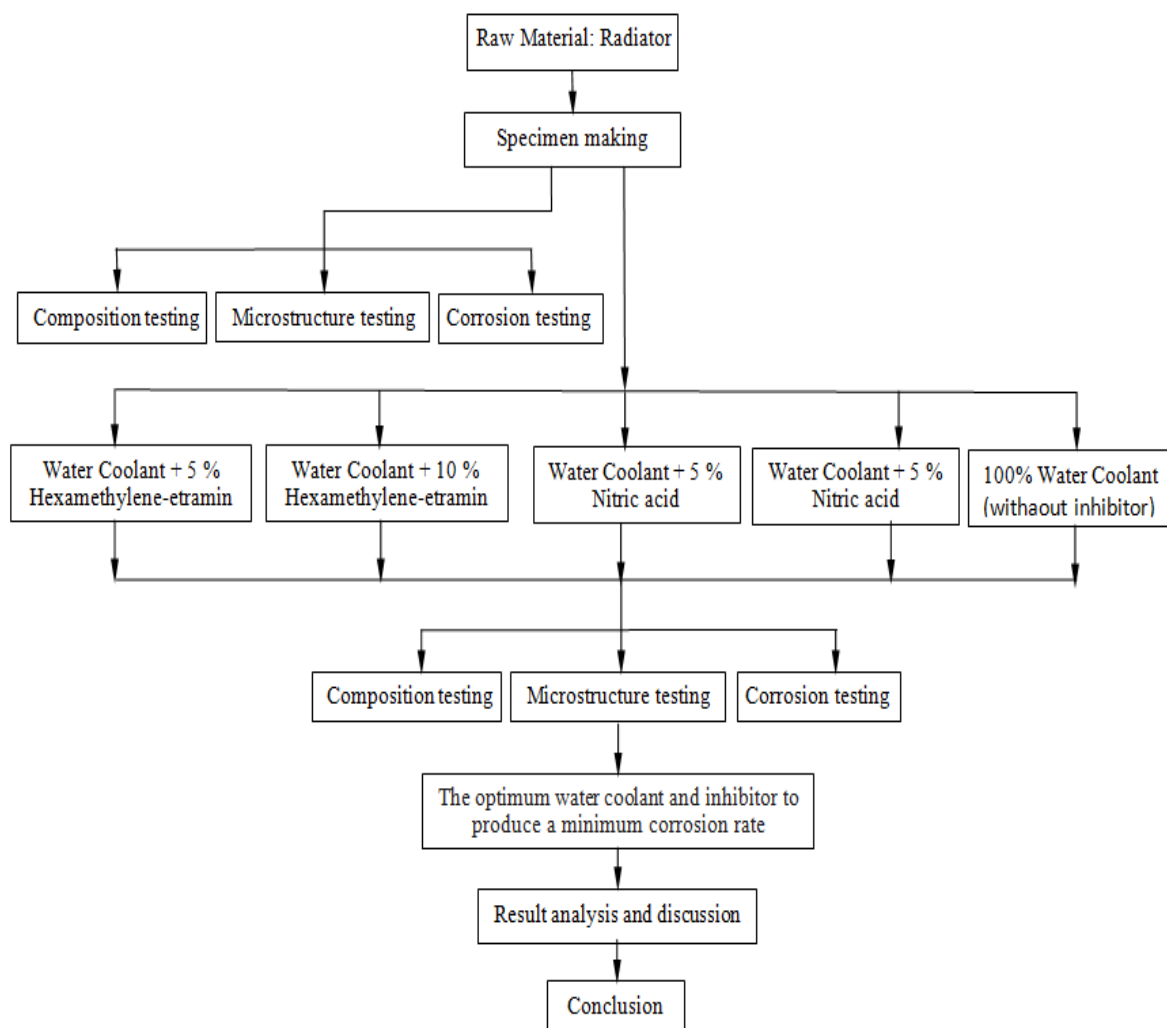


Figure 3. Diagram of research steps

2.2 Testing Method

2.2.1 Specimen Preparation

Cut the part of radiator tube become a button with 14 mm diameter as the Figure 4 below. Sanding the part that will be test until the surface has the same flattening [6], [5].

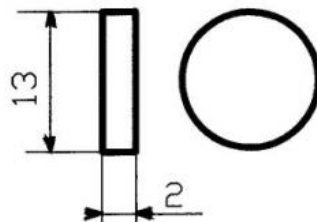


Figure 4. Media test (mm)

2.2.2 Corrosion Test

Corrosion rate testing using three electrode cells based on tafel extrapolation method. The three electrode cells is a standard laboratory apparatus for quantitative research to the corrosion material properties. On Figure 5 below, shows the corrosion rate test equipment type electrode three cells with Potentiostat PGA-201 T type. Corrosion rate calculate using Equation (1) and Equation (2) [5]

$$r = 0,129 \frac{a \cdot I_{kor}}{n \cdot D} \text{ (mpy)} \dots\dots\dots(1)$$

$$r = 0,129 \frac{I_{kor} \cdot (EW)}{D} \text{ (mpy)} \dots\dots\dots(2)$$

Note :

- R = corrosion rate (mpy)
- I_{kor} = flow of corrosion
- EW = weight of equivalen
- D = specific sample weight (gr/cm)
- a = atomic weight
- n = atomic valensi



Figure 5. Potenziostat PGS 201 T

3. Result and Discussion

3.1. Composition Test

The result of radiator tube with chemical composition test:

Table 1. Chemical composition test

The test kinds	: Chemical composition
Method	: IK 5.4-1-1
Grade	: Cu_000

The result shows that the main radiator tube compiler is copper or (Cu) with 67% and the second composition in radiator tube is zinc with 32% [7].

3.2. Corrosion Test Graphic

From Figure 6 the result corrosion test used the mixing of watercoolant and Nitrat Acid inhibitor showed that the decrease in corrosion rate happened in the mixing of water coolant and 5% Nitrat Acid inhibitor. On that test corrosion rate treatment decrease from 0.002207 mmpy become 0.00171 mmpy.

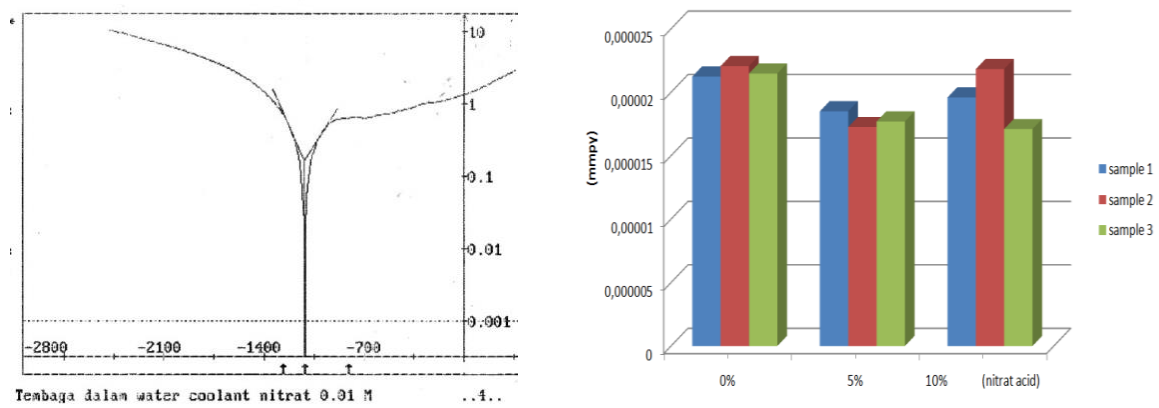


Figure 6. The test result used Nitrat Acid inhibitor

According Figure 7 the result of corrosion test used water coolant and Hexamethylene-extramin inhibitor mixing showed that the decrease in corrosion rate happened on water coolant and 10% Hexamethylene-etramin inhibitor mixture. On that test the corrosion rate decrease from 0.002207 mmpy become 0.001411 mmpy.

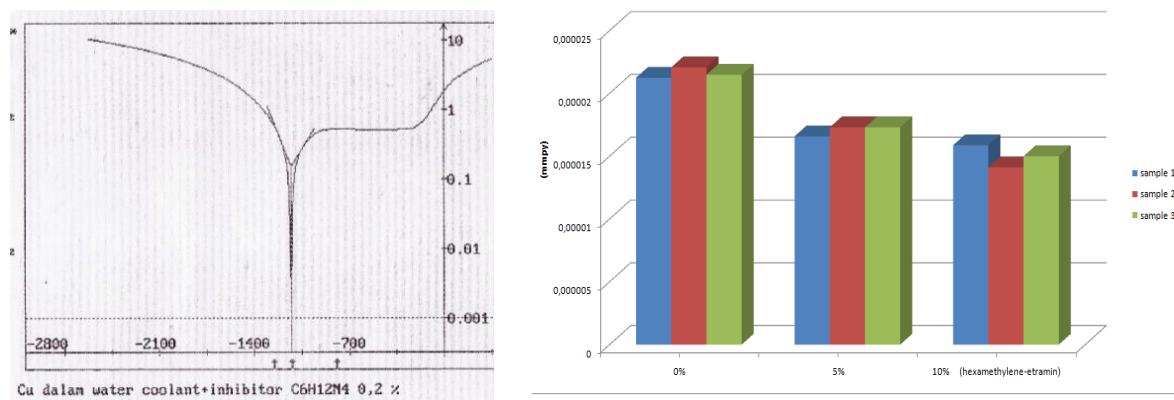


Figure 7. Result corrosion test used hexamethylene-etramin inhibitor

3.3. Test Result of Micro Photo

According to Figure 8 the result of micro photo test could be explained that corrosion test used 5% Nitrat Acid inhibitor, corrosion happened in part of media surface test. This is suitable with graphic 1. of corrosion test result used 5% Nitrat Acid inhibitor that produce decrease in corrosion rate from 0,002207 mmpy to 0,00171 mmpy, this means has corrosion resistance in the excellent category [8], [9]. From micro photo test result, can be know that the kinds of corrosion happened in radiator is the kinds *pitting corrosion* [5], [10]. This research is suitable with the research before that stated corrosion inhibitor can produce the decrease in corrosion rate to 86% [3].

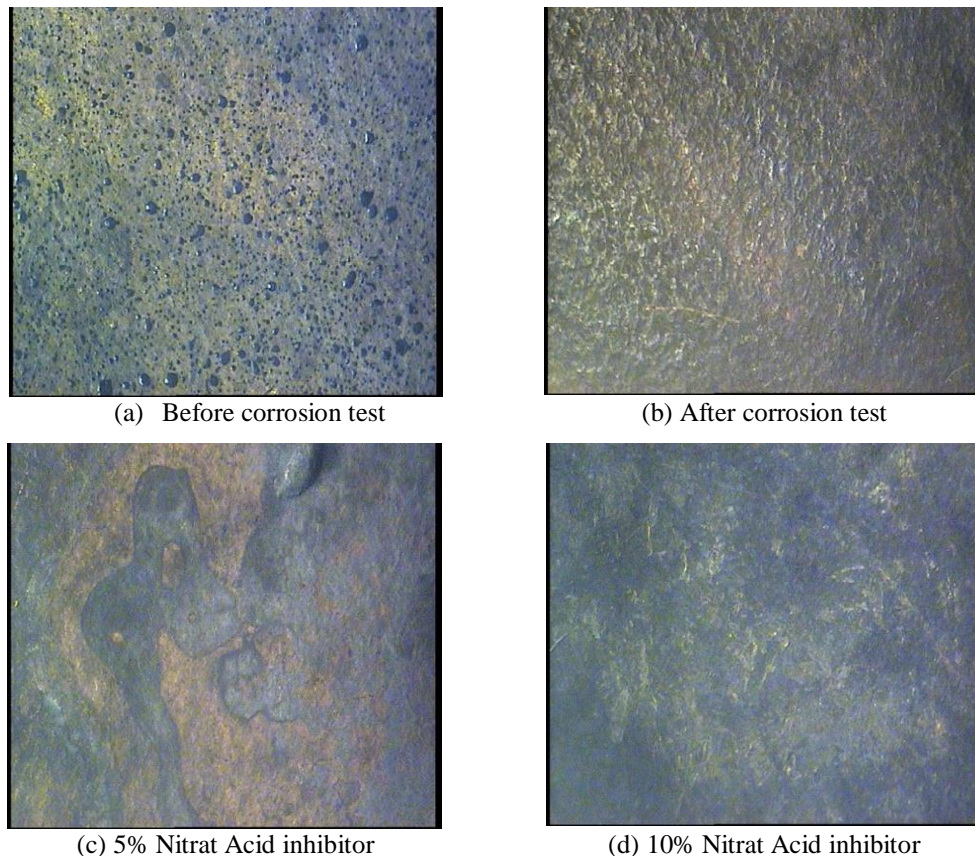


Figure 8. The result picture of micro photo test

4. Conclusion

The test used Nitrat Acid inhibitor (NH_4NO_3) with 2%-7% concentrate can be produce lowest corrosion rate with 0.002207 mmpy to 0.00171 mmpy. The test used Hexamethylene-atramin inhibitor ($\text{C}_6\text{H}_{12}\text{N}_4$), the concentrate mixing between 2%-7% produce lowest corrosion rate with 0.002207 mmpy to 0.001411 mmpy. The kinds of corrosion that happened in vehicle radiator is a pitting corrosion. From the research, to get the maximum value of the thing, the thing that will be test should be flatten on the surface by polishing or sanding and choose the kind of inhibitor that able to stabilize the acidity of water coolant liquid.

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