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The Effect of Using Variations of Radiator Coolant on the Effectiveness of Engine Cooling and the Rate of Corrosion of Radiator Materials in 1300 cc Cars †

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Abstract: Engine coolant plays an important role in maintaining optimal engine performance, where it has good effectiveness and can prevent corrosion in the engine cooling system (radiator). This study aims to determine the effect of the use of coolant variations (engine coolant) on the effectiveness of engine cooling (radiator) and to determine the effects of the coolants on the corrosion rate. To achieve this, coolant variations were used in the forms of mineral water, radiator coolant (prestone), and power coolant (TOP 1), which were applied at engine speeds of 1000, 1500, and 2000 rpm. Temperature data collection at the coolant inlet and outlet was carried out every 10 min at different rpm. The corrosion rate test used the AA 3102 series aluminum radiator material, which was tested using the potentiodynamic polarization method. The results showed that the best coolant effectiveness value was found for the power coolant (TOP1). This is influenced by the ethylene glycol contained within it, which helps to accelerate the decrease in temperature in the engine. The lowest corrosion rate was found for the power coolant (TOP1), with a corrosion rate value of 0.0074480 mm/year. This is because the power coolant (TOP1) contains organic carboxylate rust inhibitors, which can inhibit corrosion.

Keywords: radiator; coolant; engine cooling system; corrosion rate

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1. Introduction

The engine cooling system (radiator) is one of the most important components in a vehicle. The role of the engine cooling system is to lower the temperature of the engine and to maintain the engine heat at its ideal working temperature [1,2]. As we know, an engine will carry out a combustion process to produce energy so that the car can run. However, when the car engine is working, the engine will heat up, which can cause the engine to die because the car temperature is too hot. Therefore, a cooling system is needed. The radiator cooling system basically functions to prevent the engine from overheating so that the engine can continue to work at its best performance [3–5].

In general, there are several types of coolants used, including mineral water, coolant mixed with mineral water, and coolant with ethylene glycol content, which basically have

the same function, namely as a heat release medium for the radiator [6,7]. According to its specifications, coolant has a higher boiling point, so it is better at absorbing heat from the engine. In addition, coolant has components that are not easily evaporated and contains chemicals that can inhibit corrosion in the engine cooling system [8,9]. This means that coolant can be used in the long term compared to mineral water. Often, vehicle users use mineral water as a substitute for coolant because mineral water is considered more practical and easy and cheap to use [10]. However, the use of mineral water as a coolant will affect the effectiveness of the radiator and can cause corrosion in the radiator [11].

Previous research on the use of variations of radiator coolant on the effectiveness of engine cooling and the rate of corrosion in radiator materials is limited. Therefore, this study was conducted to determine the effects of the use of coolant variations on the effectiveness of engine cooling at engine speeds of 1000, 1500, and 2000 rpm, to determine the effects of the coolants on the corrosion rate of the radiator material with potentiodynamic polarization testing, and to determine the macrostructure of the radiator material. These findings are expected to be used in selecting a good coolant for the long-term use of engine radiators.

2. Research Method

This study used a cooling system in the form of a radiator as the main tool, as shown in Figure 1. To determine the effectiveness of the engine cooling system, coolants were used in the forms of mineral water, radiator coolant (prestone), and power coolant (TOP1). The engine speed was set to 1000 rpm, 1500 rpm, and 2000 rpm. The following were the steps taken by the researcher: (1) The engine speed was measured using a tachometer measuring instrument so that it was exactly at 1000 rpm, 1500 rpm, and 2000 rpm. (2) The engine speed drove the radiator fan, which functioned to circulate air to the radiator grille. The higher the engine speed, the faster the pump and radiator fan rotated. (3) The temperature of the water entering and leaving the radiator was measured using a thermometer every 10 min at each specified rpm. (4) Then, the data obtained were entered into a data table to facilitate data analysis. (5) The engine speed was reduced, and then the engine was turned off. These steps were carried out for each data collection on each type of coolant.



Figure 1. Radiator cooling system.

In this study, the method used to determine the effects of the use of variations of coolant on the corrosion rate of radiator materials was potentiodynamic polarization testing using a Cortest Model CS 150 potentiostat/galvanostat (Wuhan China) and a set of computers as data processors. The test object was the AA 3102 aluminum alloy material, which is a basic radiator material, with dimensions of 80 mm × 20 mm × 0.5 mm, and 3 pieces were used, which can be seen in Figure 2. The chemical composition of the AA 3102 aluminum alloy material can be seen in Table 1.

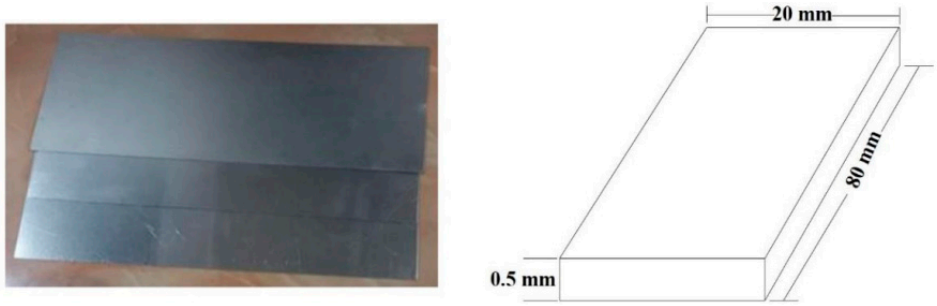


Figure 2. Dimensions of radiator material specimens.

Table 1. Chemical composition of AA 3102 (wt%).

Material	Si	Fe	Cu	Mn	Mg	Ti	Cr	Ni	Pb	Al
AA 3102	0.13	0.42	0.21	1.00	1.12	0.013	0.031	0.016	0.002	balance

The material was tested with mineral water coolant, radiator coolant (prestone), and power coolant (TOP1). To obtain the corrosion data, potentiodynamic polarization was required, consisting of the corrosion potential (ECorr), corrosion current density (ICorr), and corrosion rate (ICorr). The polarization method used was in the panel potential range of −200 mv to 200 mv OCP (open circuit potential) with a standard scan speed of 1.5 mv. This test used three types of electrodes, namely reference electrodes, working electrodes, and auxiliary electrodes, which can be seen in Figure 3. The test was carried out on each specimen at a temperature of 30 °C with a test time of 1 h. The software automatically read and displayed the current potential, current density values, graphic diagrams, and corrosion rates of each specimen with different coolants. Then, a curve was obtained, which was used as a standard reference for ASTM G-5 (standard method for measuring potentiostatic and potentiodynamic anode polarization).

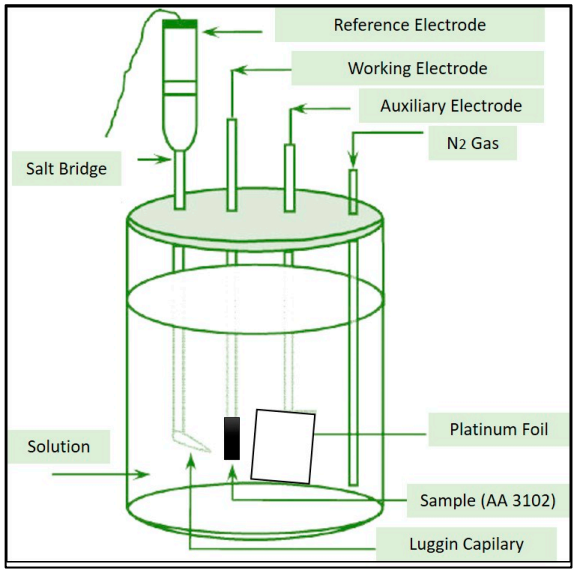


Figure 3. Test instrument for three-electrode potential cell polarization.

Visual observation was performed after the specimens were tested with potentiodynamic polarization. The tool used was a redmi note 11 pro (Xiaomi. Inc. Changping, Beijing, China) cellphone camera with a magnification of 1.5× to identify corrosion in the specimens.

3. Results and Discussion

3.1. Effectiveness of Engine Cooling System

The results of the engine cooling system effectiveness test at a 1000 rpm engine speed produced a value of 16% for the mineral water, 20.10% for the radiator coolant (prestone), and 20.30% for the power coolant (TOP 1), while at 1500 rpm, they produced a value of 16.60% for the water, 20.30% for the radiator coolant (prestone), and 20.50% for the power coolant (TOP 1), and at 2000 rpm, they produced a value of 17% for the water, 20.60% for the radiator coolant (prestone), and 20.90% for the power coolant (TOP 1). The engine cooling effectiveness value was obtained using Equation (1). The results of the engine cooling system effectiveness test are shown in Figure 4.

$$\varepsilon = \frac{Th.in - Th.out}{Th.in - Tc.in} \quad (1)$$

where (ε) is the radiator effectiveness, (Th.in) is the hot water temperature entering the radiator, (Th.out) is the hot water temperature leaving the radiator, and (Tc.in) is the incoming air temperature in front of the radiator.

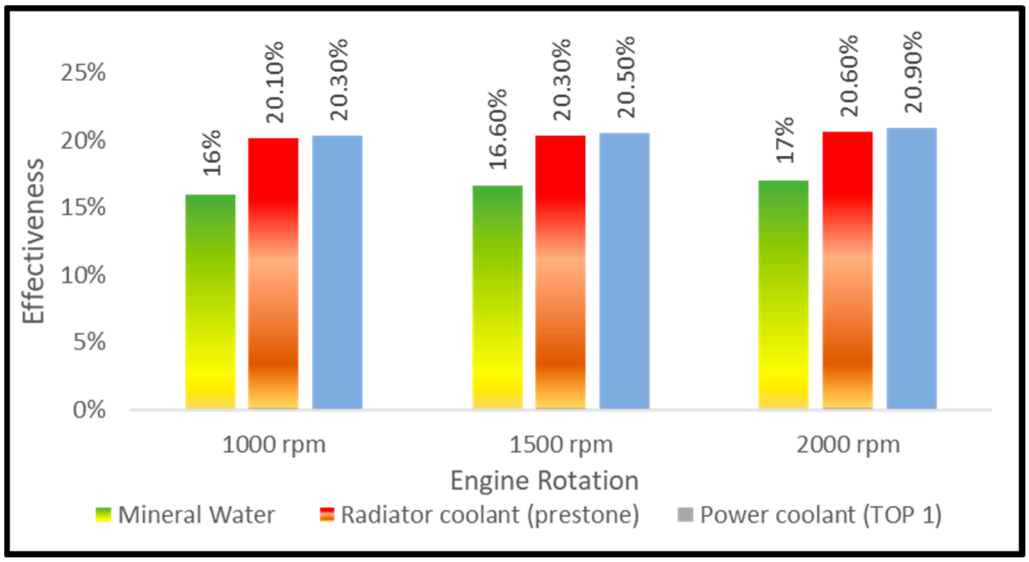


Figure 4. Results of testing the effectiveness of the engine cooling system (radiator).

The test results of the engine cooling system (radiator) using mineral water as a coolant showed the lowest effectiveness value. This value was the lowest value when compared to the other types of coolants. So, it can be concluded that mineral water is not recommended for use as a coolant in the long term because its reaction heats up quickly, causing damage if used continuously. The test results for the use of the radiator coolant (prestone) showed quite good effectiveness because it contains 25% ethylene glycol. However, the highest effectiveness value was found for the power coolant (TOP1). This is influenced by its ethylene glycol content of 33%. The higher the ethylene glycol content contained in the coolant, the faster the temperature in the engine will be reduced [12,13]. In addition, the power coolant (TOP1) can reduce engine heat when driving, lower the freezing point of the radiator, and prevent rust on the radiator [14,15].

3.2. Corrosion Rate Testing

Tests conducted on each specimen showed that the coolant with mineral water had the highest corrosion rate effect of 0.0083695 mm/year. Meanwhile, the lowest corrosion rate value was found with the use of the power coolant (TOP 1), which was

0.0074480 mm/year, and the use of the radiator coolant (prestone) produced a corrosion rate value of 0.0075662 mm/year. The results of the corrosion testing using potentiodynamic polarization can be seen in Figure 5.

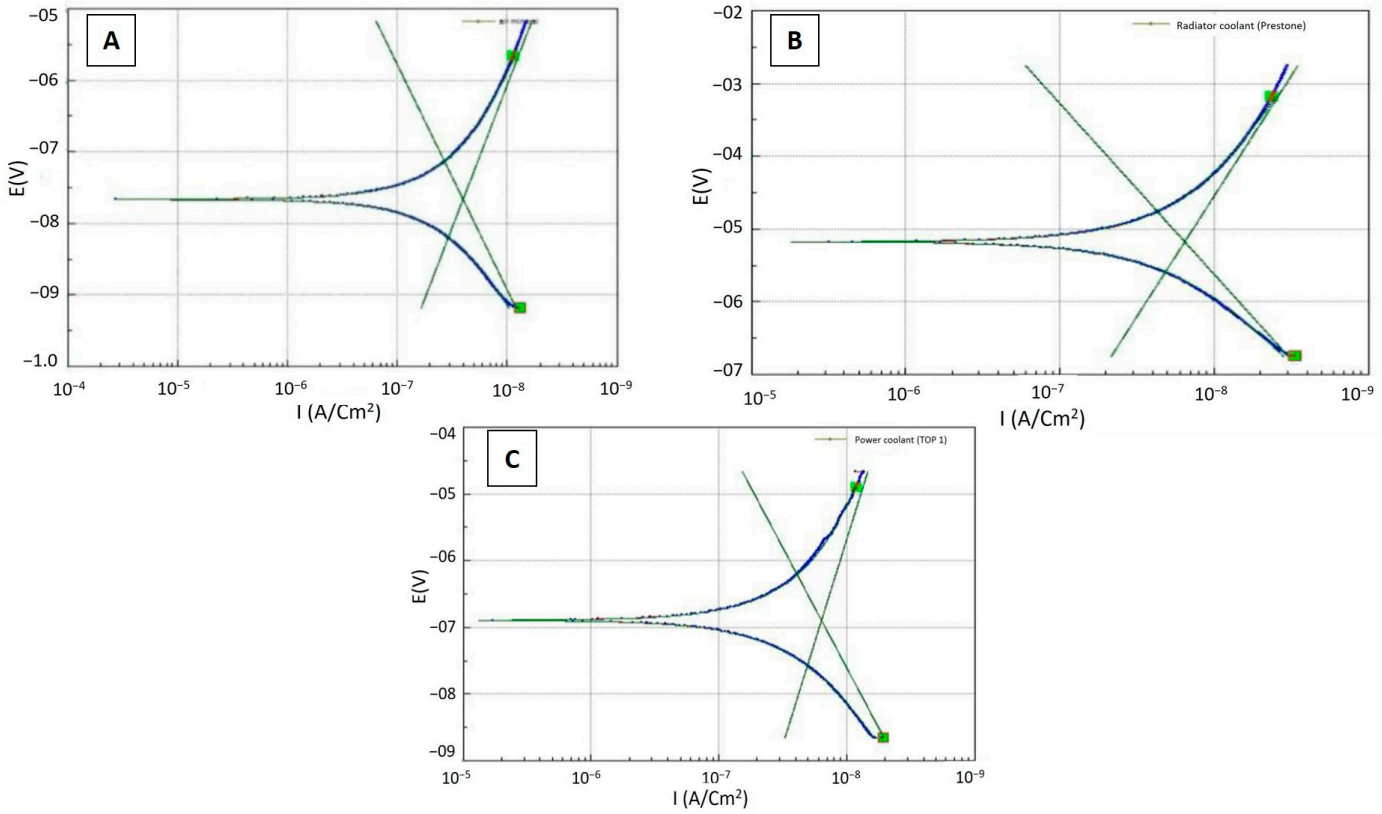


Figure 5. Results of potentiodynamic corrosion rate polarization with coolant variations: (**A**) mineral water, (**B**) radiator coolant (prestone), and (**C**) power coolant (TOP 1).

The results of the corrosion rate test showed that the use of mineral water as a coolant was inappropriate; this was because the mineral water content did not have good anti-corrosion substances compared to the radiator coolant (prestone) and power coolant (TOP 1). The absence of anti-corrosion substances caused a very fast corrosion rate on the metal and had a bad impact on the material. Meanwhile, the use of the power coolant (TOP 1) slowed down the corrosion rate. This is because the power coolant (TOP 1) contains anti-corrosion substances in the form of organic carboxylate rust inhibitors. These substances can prevent or reduce corrosion on metal surfaces in corrosive environments [16,17].

3.3. Physical Characteristics

Visual observation was carried out after the specimens were tested with potentiodynamic polarization. The results of the observations showed that the specimens did not change at all visually, as shown in Figure 6. Aluminum is a material that has good corrosion resistance and heat resistance. Therefore, aluminum is chosen as the basic material for making radiators. Radiators can be used for years provided that periodic maintenance is carried out, including replacing the coolant and not using water as a substitute for coolant [18].

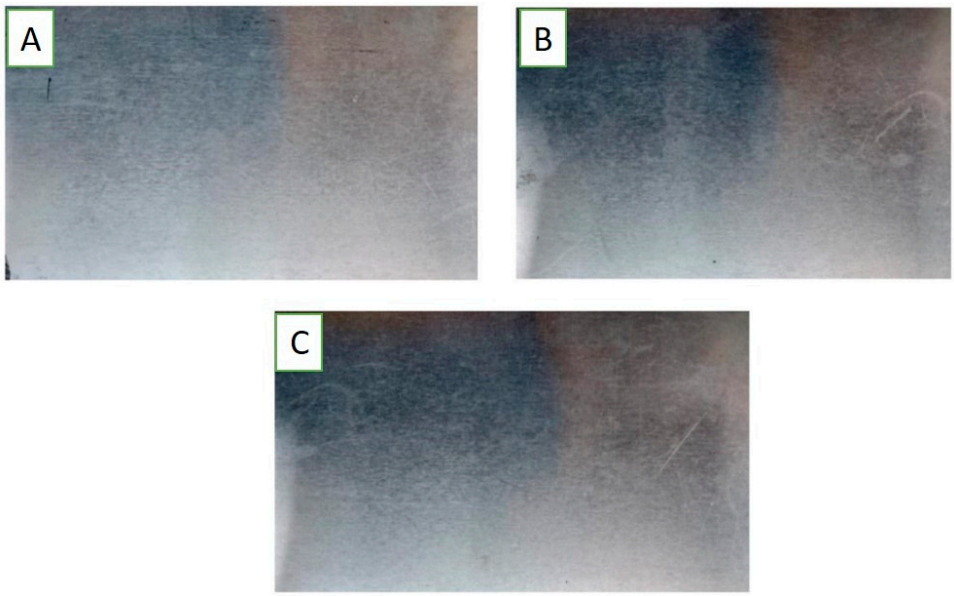


Figure 6. Visual observation results of specimens using different coolants: (**A**) mineral water, (**B**) radiator coolant (prestone), and (**C**) power coolant (TOP 1).

4. Conclusions

From the results of the tests that have been carried out, it can be concluded that the highest effectiveness value for the 1300 cc car cooling system with engine speeds of 1000 rpm, 1500 rpm, and 2000 rpm was obtained with the power coolant (TOP1), with a value of 20.90%, while the lowest value was found during testing with the coolant using mineral water, which was 16%. In the corrosion rate test, the highest value was found with the use of mineral water, with a value of 0.0083695 mm/year, while the lowest value was found for the power coolant (TOP1), with a value of 0.0074480 mm/year, and with the use of the radiator coolant (prestone), the value obtained was 0.0075662 mm/year. Therefore, mineral water is not recommended for use in the cooling system (radiator) because it has a very low level of effectiveness. In addition, mineral water is very slow in reducing heat and, if used in the long term, can damage the cooling system (radiator) and cause corrosion effects. Corrosion is at risk of becoming dirt that will clog the flow of the engine cooling system. The use of the power coolant (TOP 1) as an engine coolant is highly recommended because it can increase the service life of the engine cooling system (radiator).

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