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Development of Battery Materials to Function as Corrosion Protection on Car Body Plates

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Abstract. Most car bodies made for mass production are made from steel or aluminum. Both are strong metals, but steel is cheaper than aluminum and is more commonly used in lower-end cars for a broader consumer range. The weakness of steel compared to aluminum is that it is susceptible to corrosion under certain conditions, and thus it may deteriorate over time without proper care. To prevent corrosion, modern cars are coated with paint to prevent direct contact with the environment. As a second line of protection, a car battery can be connected to the body to create an impressed current cathodic protection circuit. In this study, a steel sample from the car body is connected to an ICCP or impressed current cathodic protection circuit with a small 12v battery and a graphite anode. The specimen's paint layers are removed through grinding and tested in water, wet soil, and open air. The specimens in water and wet soil experienced minimum corrosion during the testing period, while the ones in open air experienced significant corrosion products on the surface. Overall, due to the small specimen size compared to battery output, all specimens experience a case of overprotection of up to -5516 mv in wet soil and -2666 mv in water. Due to limitations, we are unable to do proper measurements in the open-air environment.

Keywords: Corrosion, Cathodic Protection, ICCP, Steel, Battery,

INTRODUCTION

Cars have become a common means owned by the public in this era. In 2018 [1], The number of passenger cars in Indonesia alone was 16,400,987. The most frequently used material as the car body is steel. Steel was chosen because of its low price, strength, and ease formed [2]. In its application, the car body will experience corrosion caused by a harsh environment such as driving on roads containing much salt, acid deposition from acid rain, for example, acid mist, coastal environment atmosphere, and many more [3]. In the United States [4], corrosion on the highest car is caused by the content of salt and gas emissions (such as SiO_2 and NiOx). Therefore, Corrosion control on car plates is essential [5]. One method of corrosion control is Catholic Protection.

Corrosion control in cars generally only uses coatings [6]. A coating has value permeability, namely the ability to absorb water. When it rains, it does not rule out the possibility of water flowing able to penetrate the coating [3]. By using the ICCP system or impressed current cathodic protection, rainwater will be used as an electrolyte to drain the protection current from the current source (Accumulator or ACCU) to the car plate. So, adding the ICCP system will increase the life of the car plate. However, this ICCP system only works when there is water on the car plate. The ICCP system will not work on car plates without water.

In this study, the ICCP system will use a dry battery as a source current to protect the car body plate so it can function well in the rainy season or drought. The dry battery used is a 12v dry battery.

MATERIAL AND METHODS

Materials

The material used in this study was a steel plate measuring 10cm x 10cm, which was taken from pieces of car door plates that had been cleaned from the paint coating layer. In addition, the anode is also used inert graphite and also the GS ASTRA MF GTZ-5S battery.

Methods

After the steel plate specimens were cut and stripped of the paint coating, each specimen was weighed with an accuracy of 0.1 mg and measured the graphite anode's total surface area and surface area. Steel plates are assembled in the system ICCP by connecting to the negative pole of the battery and graphite to the positive pole. Each steel plate is tested in different media: water, wet soil, and free air. To calculate the need for protection current on the ICCP system and graphite current output used equations 1 and 2. Figure 1 shows the circuit ICCP system trials.

$$Ip = Ap. Cd \quad (1)$$
$$IE = Aa.Cda \quad (2)$$

Where:
Ip = Requirement of protection current
Ap = Surface area to be protected (m^2)
Cd = Pipe current density without coating (A/m^2)
I = Tolerance 20% (1,2)
IE = Anode current output (A)
Aa = Anode surface area (m^2)
Cda = Anode current density (A/m^2)

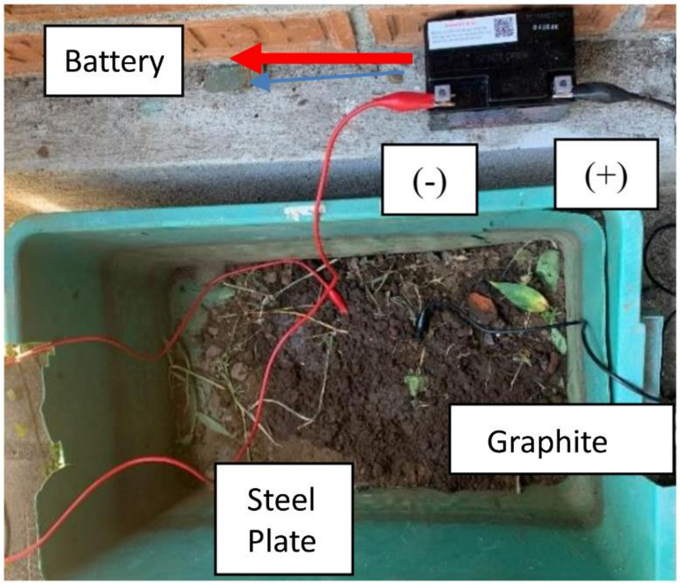

FIGURE 1. ICCP Circuit on Soil Medium

After connecting to the battery, the current flowing in the circuit and the potential difference in steel were measured using the saturated calomel electrode (SCE). To protect the steel, the current record at the measurement time must exceed the theoretical current requirement in equation 1. Steel must have a potential difference range of -800mV to -1050 mV vs. Ag/AgCl for a protected water environment [7]. Meanwhile, NACE SP0169[8] stipulates that the cathodic protection criteria for steel and cast iron are between -850 mV to -1000 mV vs. Cu/CuSO4. The series was left for 48 hours before being removed. Its mass was measured again to determine the mass changes that occurred.

RESULT AND DISCUSSION

After 48 hours of testing, the three specimens experienced an increase in mass and corrosion on their surface. Of the three specimens, the most significant mass change occurred in free air media; this is due to no conducting medium/electrolyte that can conduct current in the circuit, so the metal does not protect. The mass changes of the three specimens are shown in table 1.

TABLE 1. Change of Specimen Mass during Experiment

Specimen No.	Materials	Medium	Initial Mass (gram)	Final Mass (gram)	Mass Change (gram)
1		Air	73.5978	75.6845	2.0867
2	Steel Plate	Wet Soil	68.9451	69.1737	0.2286
3		Water	73.4695	73.582	0.1125

Based on calculations using equation 1, the protection current requirement of the steel plate is shown in table 2. Compared with the current measured in the circuit, it can be concluded that the current is sufficient for the cathodic protection of steel plates.

TABLE 2. Protection Current during Experiment

Specimen No.	Materials	Medium	Protection Current Requirement (mA)	Graphite Current Output (mA)	Protection Current in Circuit (mA)
1		Air	13.671		-
2	Steel Plate	Wet Soil	13.041	72.346	60.34
3		Water	13.734		66.56

Figure 2 shows the potential difference vs. SCE recorded on this test. Steel plate in wet soil media has the most negative potential difference value, followed by steel plates in water media. In contrast, the steel plates in free air, the potential difference cannot be measured without any conducting medium/electrolyte. In water and wet soil, metals suffer overprotection due to too negative potentials. Overprotection can also cause this peeling/bubbling of the coating layer and an increased risk of hydrogen embrittlement [9]. The more negative the potential difference on the steel, the wider the coating layer's peeling area on the surface [10]. However, if the ICCP system is turned off, the specimen will experience quite massive corrosion after five days [11] which can be seen in the current condition of the steel plate in Figure 3.

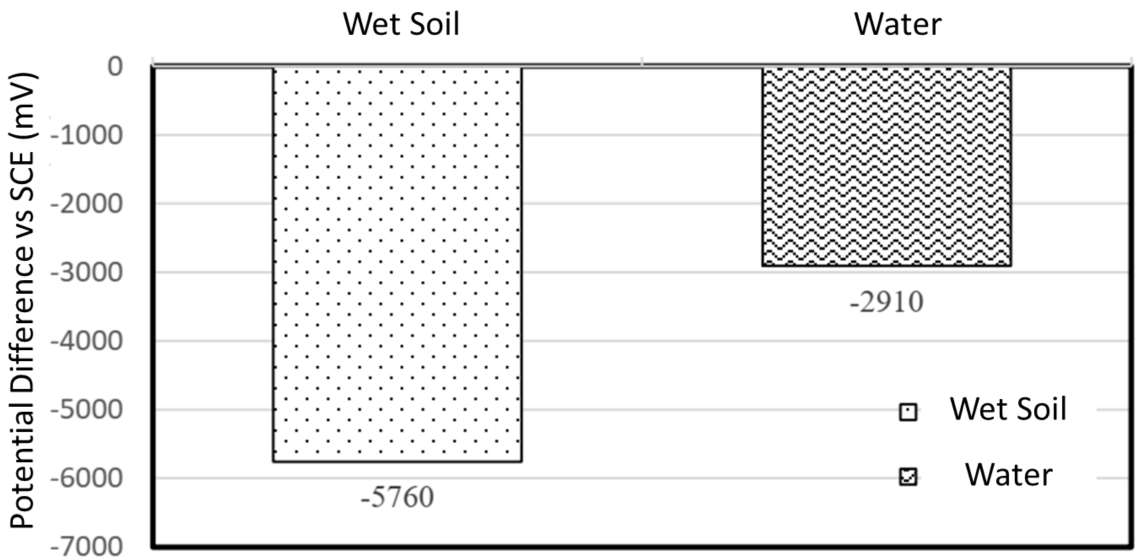

FIGURE 2. The potential difference between the steel plate to the Saturated Calomel Electrode

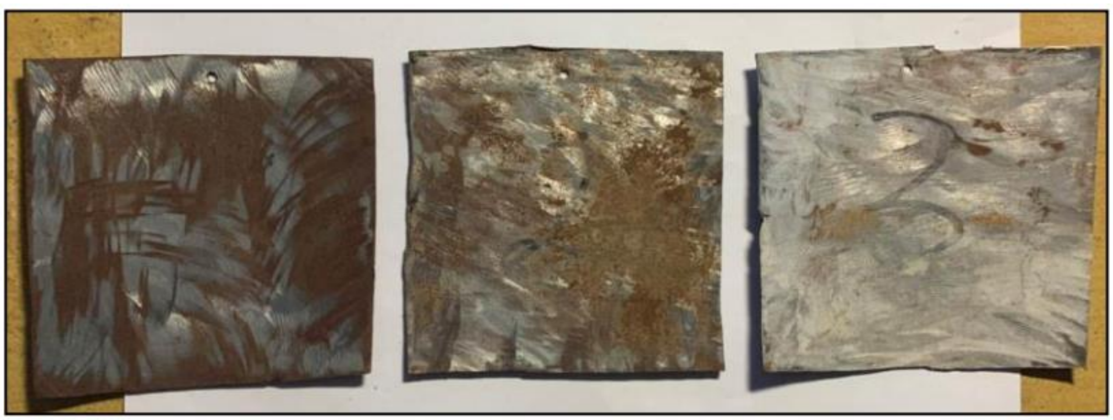

FIGURE 3. The surface of the steel plate after testing

CONCLUSIONS

Through the process of developing the function of the battery material as corrosion protection on the car body plate, conclusions could be drawn as follows:

1. Battery material as corrosion protection on the car body plate can only work well when in a medium or environment that can conduct electric current
2. The good battery material, as corrosion protection on the car body plate, is only used as additional protection with a layer of paint/coating on the car body.
3. Using a battery with a current and voltage unsuitable for the surface being protected will cause overprotection, which is harmful to the metal coating layer and the mechanical properties of the metal.

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