

Galvanic Corrosion Prediction Technology for Aluminum Parts of Chassis

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ABSTRACT

The time for evaluations can be reduced because it is now possible to predict corrosion by simulation of the depth of galvanic corrosion in aluminum chassis parts. Based on input of polarization curves conforming to the specific corrosion environment, this simulation technology is able to calculate the reduction in aluminum volume due to galvanic corrosion from the corrosion current, and to output the depth of corrosion. It can replace corrosion tests previously requiring 5000 hours with a simulation of approximately 20 minutes, making it possible to predict the depth of galvanic corrosion occurring in the market in a short period.

1. Introduction

The use of aluminum rather than steel materials is one method of achieving weight savings in automotive chassis, but because galvanic corrosion (corrosion occurring due to the difference in electrolytic potential between different materials) can be expected in areas such as the suspension parts that are used in corrosion-promoting environments, methods of evaluation of corrosion resistance are becoming an issue. During the development of suspension parts, corrosion resistance is evaluated by studies using accelerated corrosion testers employing corrosion conditions corresponding to those found in the market, and of the status of corrosion during driving on test courses. However, these tests require a period of several months, necessitating their replacement by a method enabling an equivalent evaluation in a shorter period. For this purpose, the project discussed here selected the existing galvanic corrosion simulation software (3D-Cafe⁽¹⁾, manufactured by Mizuho Information and Research Institute, Inc.) from among methods using computer-aided engineering (CAE), but because this software simulated immersive environments such as seawater, it was unable to reproduce the galvanic corrosion occurring in the different environments to which automobiles are exposed.

A peripheral program using 3D-Cafe was therefore developed in order to reproduce automotive environments. This program added a new function to the commercially

available simulation software, making it possible to respond to changing corrosion environments such as automotive environments. In addition, the project focused on the fact that the automotive corrosion environment involved a state of coverage with thin water films rather than being an immersive environment, and measured the parameters to be input into the simulation under conditions approximating those of a water film environment. This made it possible to reproduce the depth and the profile of corrosion in actual test specimens in simulations. The program discussed in this paper is a simulation technology that can be used in place of accelerated corrosion tests, and its ability to reproduce the results of these tests has been verified.

2. Mechanism of Galvanic Corrosion

Galvanic corrosion is a phenomenon in which the metal with the lower electric potential is preferentially corroded when metals of differing electric potential are in contact in a corrosion environment. It is also called bimetallic corrosion. Figure 1 shows the galvanic series for various metals in seawater⁽²⁾.

As Fig. 1 shows, the electric potential of aluminum is lower than that of steel. In this case, the aluminum is termed base, and the steel is termed noble. When aluminum and steel are in contact in a corrosion environment such as a saltwater solution, electrons are transferred from the aluminum to the steel in the reactions represented by Eqs.

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(1) and (2), and galvanic corrosion occurs, in which the aluminum is preferentially corroded.



Equation (1) shows the reaction occurring on the surface of the steel, termed the cathode reaction, and Eq. (2) shows the reaction occurring on the surface of the aluminum, termed the anode reaction. The current occurring due to electron transfer is called the corrosion current. The corrosion current flows through a circuit formed from the steel, aluminum, saltwater solution, and steel, in that order. The corrosion current divided by the area of the cathode is termed the cathode current density, and the corrosion current divided by the area of the anode is termed the anode current density.

Because galvanic corrosion between steel and aluminum is cathode-dominant, the reaction shown in Eq. (1) governs the corrosion reaction. The current density at this time can be read from the polarization curves of the steel and aluminum.

Figure 2 shows the polarization characteristics of steel and aluminum. The polarization curves are divided into

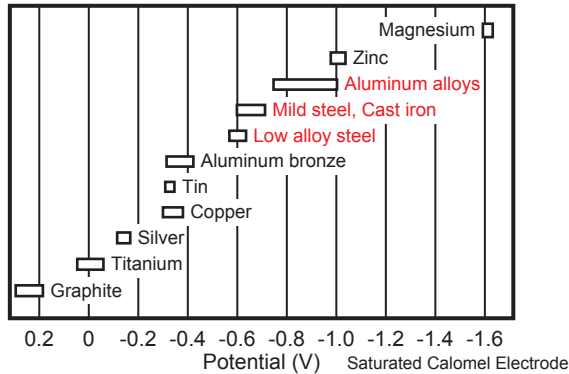


Fig. 1 Corrosion potential in sea water

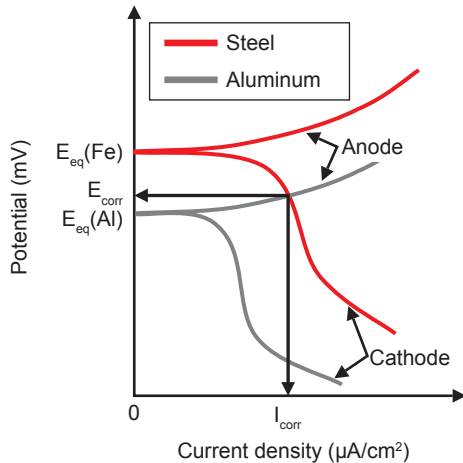


Fig. 2 Polarization curve

anode polarization curves and cathode polarization curves. The signs of the two types of curve are opposite, and to aid visualization they are generally expressed as absolute values. At the point at which the corrosion current is 0, the steel and aluminum are at their equilibrium potentials, $E_{eq}(\text{Fe})$ and $E_{eq}(\text{Al})$, respectively. The potential at which the cathode curve of the steel and the anode curve of the aluminum intersect is the potential at which galvanic corrosion occurs, E_{corr} , and the current density at this time is I_{corr} , the current density at which galvanic corrosion occurs.

3. Theory of Simulation of Galvanic Corrosion

Galvanic corrosion occurs due to the corrosion current generated when different metals are in contact. It is therefore necessary to calculate the corrosion current in order to simulate galvanic corrosion. The commercial software employed in the research discussed here (3D-Cafe) calculates corrosion current for each mesh using a boundary element method (BEM). This section will discuss the basic theory of this simulation software⁽³⁾.

First, a system consisting of a steel bolt and an aluminum material covered by a solution (saltwater) will be considered. Figure 3 shows a diagram of this system.

The area bounded by the solution in the diagram will be termed Area Ω . The current density, i , the electrical conductivity of the solution, κ , and the internal electric potential, ϕ , satisfy the following relationships:

$$\text{div} i = 0 \quad (3)$$

$$i = -\kappa \text{grad} \phi \quad (4)$$

$$\nabla^2 \phi = 0 \quad (5)$$

The relationship between the internal electric potential, ϕ , and the external electric potential when polarization measurements were taken, E , is shown by Eq. (6).

$$\phi = -E \quad (6)$$

Next, the boundary conditions of Area Ω will be considered. As Fig. 3 shows, the boundary between the solution and air is termed Γ_n , the boundary between the

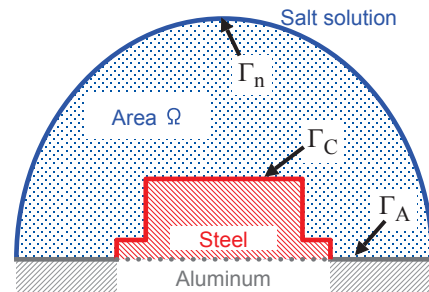


Fig. 3 Model of galvanic corrosion

Table 1 CCT conditions

Order	State	Salt concentration	Temperature	Humidity	Duration time
1	Salt spray	5 wt%	35 °C	98%	1 hr
2	Drying		50 °C	30%	2 hr
3	Wetting		35 °C	95%	3 hr

Table 2 Measurement conditions

Order	State	Salt concentration	Temperature
1	Salt spray	5 wt%	35 °C
2	Drying	26 wt%	50 °C
3	Wetting	26 wt%	35 °C

solution and the steel bolt is termed Γ_C , and the boundary between the solution and the aluminum is termed Γ_A .

Because there is no exchange of current across the boundary between the solution and the air, Γ_n , the current density here is 0. At Γ_C and Γ_A , current densities are generated in response to specific electric potentials, ϕ . Based on the preceding discussion, the following boundary conditions can be assumed:

$$\text{At } \Gamma_n, i=0 \quad (7)$$

$$\text{At } \Gamma_A, \phi=f_A(i) \quad (8)$$

$$\text{At } \Gamma_C, \phi=f_C(i) \quad (9)$$

$f_A(i)$ and $f_C(i)$ are nonlinear functions measured by means of polarization measurements.

Governing equation (5) will be solved on the basis of these boundary conditions. Terming the $N \times N$ matrices $[H]$ and $[G]$, the following boundary integral equation can be obtained.

$$\kappa[H]\{\phi\}-[G]\{i\}=\{0\} \quad (10)$$

If calculations are conducted using a corrected Newton-Raphson method until the solutions to Eq. (10) converge, because the electric potential, ϕ , and the current density, i , of each element are known, the level of corrosion for each element can be obtained from Faraday's Law.

The commercial simulation software employed is based on the theory outlined above, but because it is configured to output a single solution for a single corrosion-promoting environment, when it is applied to changing corrosion environments like those faced by automobiles, a new function must be added.

In addition, because the software simulates the depth of corrosion from the corrosion current, it is unable to simulate corrosion weight loss that is unrelated to the corrosion current, for example corrosion weight loss due to the phenomenon of crystal grain dropouts due to grain boundary corrosion. In these cases, it is necessary to

conduct the calculations while applying a correction factor to the obtained figures for corrosion weight loss. In order to simulate changing corrosion environments, the research discussed in this paper formulated a routine program that integrates individual results and outputs the ultimate depth of corrosion.

4. Input Model and Parameter Setting

4.1. Corrosion Environments for Simulation

It was essential to set the input models and parameters in accordance with the corrosion environments that would be simulated. This paper presents a case examination of a method of setting models and parameters for input based on cyclic corrosion tester (CCT) data obtained under conditions close to those of a rust environment in an actual vehicle.

Table 1 shows the CCT test conditions used when comparing models and parameters.

The saltwater was supplied in a spraying process, and adhered to the test piece whether in dry or wet states. It can be assumed that in the drying process, the evaporation of the water increased the concentration of the salt, resulting in saturation, and that in the wetting process, the deliquescence of the salt resulted in absorption of moisture, producing a saturated salt concentration.

The salt concentration at saturation was therefore set at 26 wt%. Table 2 shows the environment in which the input parameters were measured.

The data output by the simulation are corrosion current density (mA/cm^2), electric potential (mV), and speed of corrosion (mm/year). The depth and the profile of the corrosion can be obtained from the product of the speed of corrosion and the period of the CCT tests. The models and parameters for input were therefore verified by comparison with the actually measured corrosion current density and depth and profile of corrosion.

4.2. Setting Model for Input

In order to conduct a simulation, it is first necessary to set a model. Because galvanic corrosion between steel and aluminum was to be simulated, Γ_n was the surface of the

saltwater solution, Γ_C was the surface of the steel, and Γ_A was the surface of the aluminum. The analysis described below was conducted assuming an M10 bolt fastened in an aluminum sheet. Figure 4 shows the analytic model. The model is a one-dimensional simulation model in which the centerline of the bolt in the test piece is regarded as the axisymmetric axis of symmetry, and the distance in the radial direction is a variable. The saltwater solution covers the steel bolt and the aluminum sheet, and the point of contact between the steel boundary line and the aluminum boundary line is the area of contact of the steel bolt. The thickness of the saltwater solution, d (termed “water film thickness” below), was set through comparison with the results of profile measurements taken following CCT tests.

4.3. Setting Input Parameters

4.3.1. Polarization characteristics

Polarization measurement tests were conducted in order to obtain the polarization characteristics of steel and aluminum. 50 x 15 x 2 mm test pieces were obtained from corrosion test materials. The test pieces were abraded with #600 emery paper, leaving a 1 cm² test surface, and were coated with silicon gum. Ag/AgCl was used for the reference electrode. Polarization was measured in sweeps at a voltage of 0.02 V/min. Measurements were conducted in a solution under the conditions shown in Table 2. The simulation results obtained using the measured polarization curve were verified through comparison with the corrosion current densities measured in CCT tests.

4.3.2. Electrical conductivity of solutions

Table 3 shows the results of electrical conductivity measurements for each of the corrosion environment solutions shown in Table 2.

4.3.3. Physical values of materials

Table 4 shows the ionic valence, specific gravity, and mass per 1 mol of the materials.

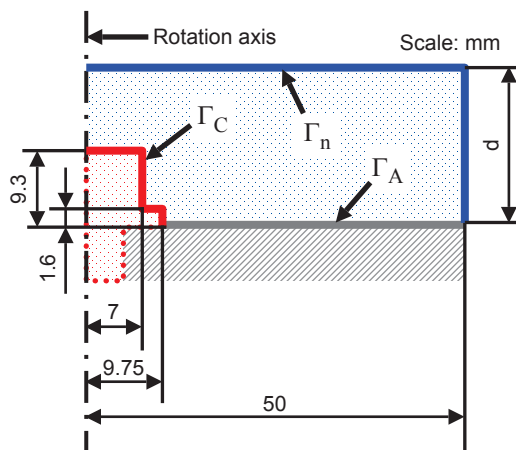


Fig. 4 Simulation model

Table 3 Electrical conductivity

Salt concentration	Temperature	Electrical conductivity
5 wt%	35 °C	9.56 S/m
26 wt%	50 °C	49.47 S/m
26 wt%	35 °C	40.03 S/m

Table 4 Physical values for materials

Material	Ionic valence	Specific gravity (g/m ³)	Mass (g/1 mol)
Aluminum	3	2.69×10^{-3}	26.982
Steel	2	7.86×10^{-3}	55.845

5. Accelerated Corrosion Tests

5.1. Test Materials

A356⁽⁴⁾ was used as the aluminum material, and SCM435⁽⁵⁾ was used for the steel bolts.

5.2. Accelerated Corrosion Test Method

A CCT manufactured by Suga Test Instruments Co., Ltd. was used in the accelerated corrosion tests. The tests used conditions 1 to 3 as shown in Table 1, repeated in that order. The test pieces were fitted in the tester at a 75° incline.

5.3. Corrosion Current Measurements during CCT Tests

Figure 5 shows a cross-section of a test piece used for measurements of corrosion current. To create the test piece, a steel bolt and an aluminum sheet with an electric wire attached were coupled, with a Teflon sheet insulating the

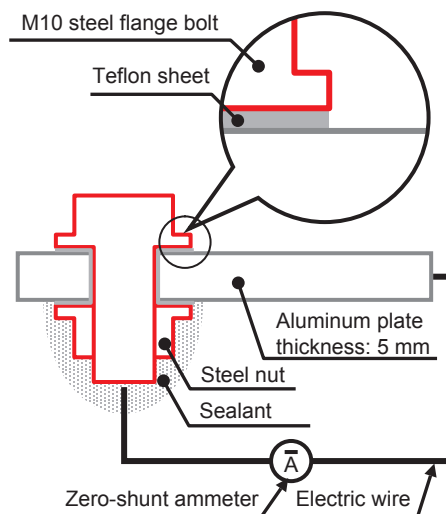


Fig. 5 Cross-section of test piece for corrosion current measurement

contacting surfaces. Using this test piece, corrosion currents were measured during the CCT tests using a zero-shunt ammeter.

5.4. Measurement of Oxygen Concentration in Corroded Area during CCT Tests

In order to obtain the electric potential of the aluminum during CCT tests, oxygen concentration was measured in the area undergoing galvanic corrosion and the general area (i.e., not undergoing galvanic corrosion). The measurements were conducted using a test piece that had undergone 1728 hours of CCT testing (Fig. 6). The measurement device was a Microx TX3 oxygen meter fitted with a needle, manufactured by PreSens Precision Sensing GmbH. $\phi 0.5$ mm holes were drilled 1.5 mm and 5 mm from the area of contact with the steel bolt, and the needle of the oxygen meter was inserted from the underside. Using this setup, the oxygen concentration was then measured after the state of corrosion had been stabilized in one day of CCT tests.

5.5. Measurement of Corrosion Profile following CCT Tests

Following the corrosion tests, the steel bolts were taken out and the corrosion product ($\text{Al}(\text{OH})_3$) was removed from the surfaces of the aluminum sheets. The solution used to remove the corrosion product was formulated by adding 1 L 85 wt% H_3PO_4 and 340 g CrO_3 to 10 L distilled water. The aluminum sheets were immersed in the solution, heated to 60°C and ultrasonically cleaned. The status of removal of the corrosion product was checked every hour, and when completely removed the aluminum sheet was washed in tap water. After the aluminum test piece was dried following washing, the corrosion profile on the sheet was measured using a Conoscan 3000 non-contact, three-

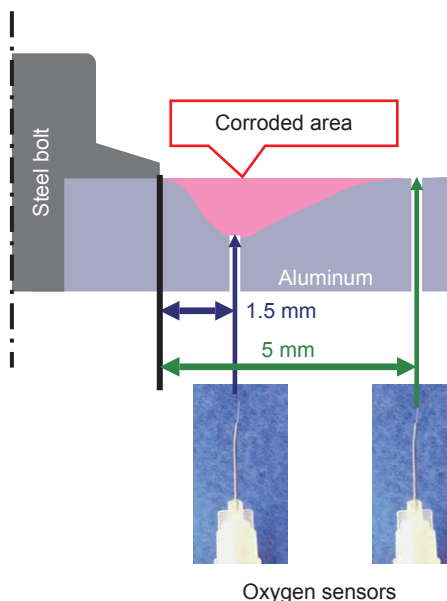


Fig. 6 Measurement of oxygen concentration

dimensional measurement system manufactured by Optical Metrology Ltd. The relationship between the average depth of corrosion in concentric circles with the same radii and the distance of each circle from the bolt contact area was compared with simulation results.

6. Setting Models and Parameters through Comparison with Actual Measurements

6.1. Setting Water Film Thickness Model

Figure 7 shows the effect on the simulation when the water film thickness was varied, using the analytic model shown in Fig. 4. The vertical axis shows the ratio of the depth of corrosion to the maximum depth of corrosion considered as 1, and the horizontal axis shows the distance from the area of contact with the steel bolt. When the water film is thin, galvanic corrosion tends to be concentrated in the area of contact with the steel bolt. Just as electrical resistance increases as an electrical wire becomes finer, electrical resistance increases when the water film becomes thinner, and it is considered that this results in the flow of the corrosion current being concentrated close to the area of contact with the steel bolt. Because of this, the area of corrosion becomes narrower as the water film decreases in thickness. Here, the corroded area is defined as the area extending from the area of contact with the steel bolt in which the depth of corrosion is at least 5% of the maximum depth of corrosion, as shown in Fig. 8. Figure 9 shows the results of profile measurements of the corroded area on a

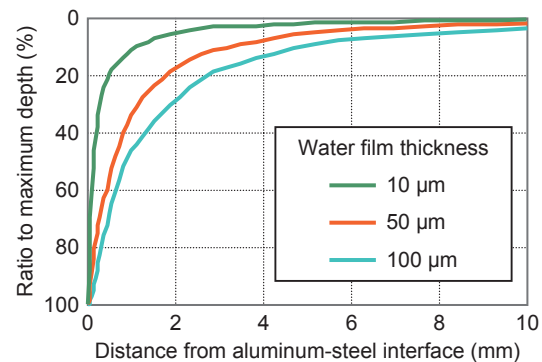


Fig. 7 Influence of water film thickness on simulation

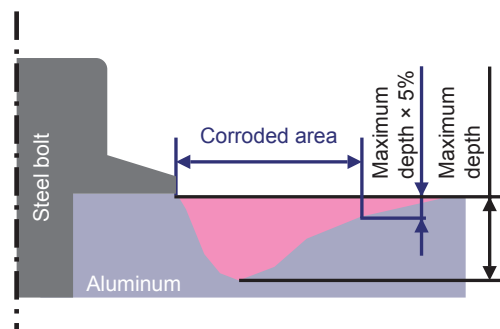


Fig. 8 Definition of corroded area

test piece following 816 hours of CCT testing. The area of corrosion on this test piece was 3.1 mm. Figure 10 shows the results in Fig. 7 organized for water film thickness and area of corrosion. For a 3.1 mm area of corrosion, Fig. 10 shows a corresponding water film thickness of 30 μm . The thickness of the water film in the simulation model was therefore set at 30 μm .

6.2. Parameter Setting

6.2.1. Polarization curve of steel

Table 5 shows a comparison of values for corrosion current density obtained from the simulation using the polarization curves measured under the conditions shown in Table 2, and measurements of corrosion current density taken during CCT tests.

The figures for corrosion current density obtained from the simulation are clearly low. Figure 11 shows the polarization curve during the saltwater spray, as used in the simulation. The figure shows that the corrosion current was 20 $\mu\text{A}/\text{cm}^2$ when the corrosion electric potential during the saltwater spray was -670 mV. For the steel polarization curve, there is almost no change in current density in response to changes in electric potential in the area close to the point of intersection of the steel cathode

Table 5 Comparison of corrosion current density

Condition	Simulation	Measured value
Salt spray	20 $\mu\text{A}/\text{cm}^2$	120 $\mu\text{A}/\text{cm}^2$
Drying	10 $\mu\text{A}/\text{cm}^2$	100 $\mu\text{A}/\text{cm}^2$
Wetting	10 $\mu\text{A}/\text{cm}^2$	100 $\mu\text{A}/\text{cm}^2$

curve and the aluminum anode curve. The current in this area is called an oxygen diffusion current, and the amount of oxygen consumed by reduction on the surface of the steel is in equilibrium with the amount of supplied oxygen that diffuses through the solution. A higher supply of oxygen would therefore activate the cathode reaction, while a lower supply would inhibit it.

Because test materials must be immersed in saltwater for measurement of polarization curves, as shown in Fig. 12, measurements were conducted using a bulk solution. A bulk solution is a solution that fills the test vessel.

By contrast, the saltwater adhering to the test materials

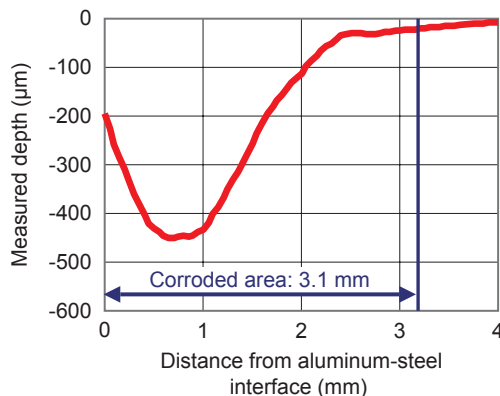


Fig. 9 Corrosion profile after 816-hour CCT test

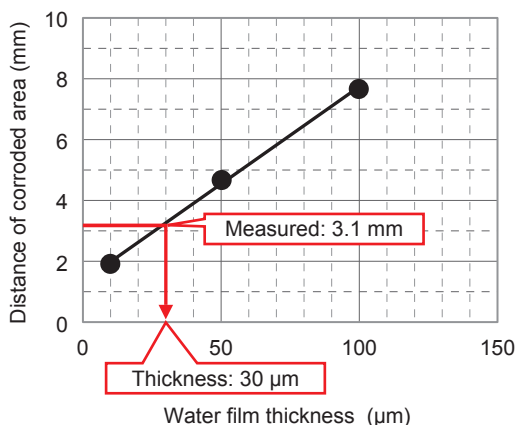


Fig. 10 Water film thickness versus distance of corroded area

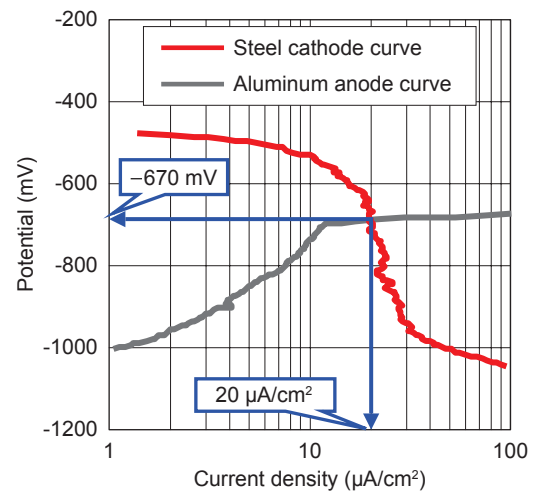


Fig. 11 Potential versus current density in galvanic corrosion

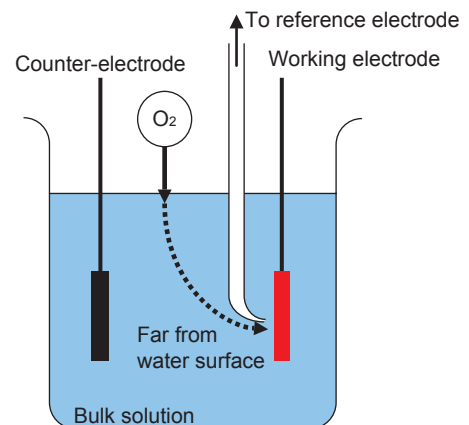


Fig. 12 State of salt solution for polarization measurement

in the CCT tests forms a thin water film on the surface of the test materials, as shown in Fig. 13. This state is called a water film environment.

Because the necessary distance for oxygen diffusion from the boundary between the water and air to the cathode reaction boundary is shorter in a water film environment than a bulk solution environment, the amount of oxygen diffusion supplementing the oxygen consumed by the cathode reaction is greater⁽⁶⁾. It can therefore be considered that the cathode reaction is active, and the oxygen diffusion current becomes higher.

Because the cathode reaction is taking place on the surface of the steel when galvanic corrosion occurs, it is the polarization curve of the steel that is affected by this phenomenon. By contrast, because the dissolution reaction of aluminum during galvanic corrosion is an anode reaction, it is almost entirely unaffected.

It is necessary to input the polarization curve in a water film environment in order to simulate such an environment, but because there is no method of directly measuring the polarization characteristic in this type of environment, hydrogen peroxide was added to the bulk solution. By this means, an artificial water film environment with an equivalent amount of oxygen supply was created, and measurement of the polarization curve in this environment made it possible to estimate the polarization curve in an actual water film environment.

Hydrogen peroxide breaks down as shown in Eq. (11), and promotes the cathode reaction by supplementing the oxygen consumed on the surface of the steel or being directly reduced on the surface of the steel as shown in Eq. (12).

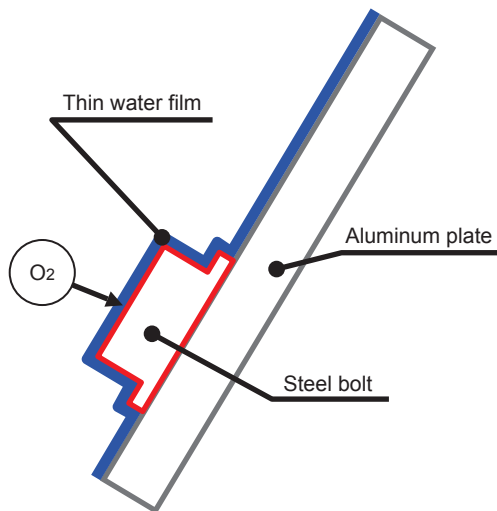


Fig. 13 State of salt solution for CCT

Hydrogen peroxide was added to the solution under the conditions shown in Table 2, and the polarization characteristic of the steel was measured. As Fig. 14 shows, the oxygen diffusion current density increased as the amount of hydrogen peroxide added was increased.

Figure 15 shows the dependence of the corrosion current density on the concentration of hydrogen peroxide when the corrosion electric potential is -670 mV for the polarization curves obtained when the hydrogen peroxide concentration was varied. The relationship between the concentration of hydrogen peroxide and current density is described by a linear expression. Figure 15 shows that the current densities of 120 $\mu\text{A}/\text{cm}^2$ and 100 $\mu\text{A}/\text{cm}^2$ measured under the conditions in Table 5 correspond to concentrations of hydrogen peroxide of 0.0075% and 0.015%, respectively.

Table 6 shows the simulation results for corrosion current density when the polarization curves measured at these concentrations of hydrogen peroxide were input. It was possible to bring simulation values for corrosion current

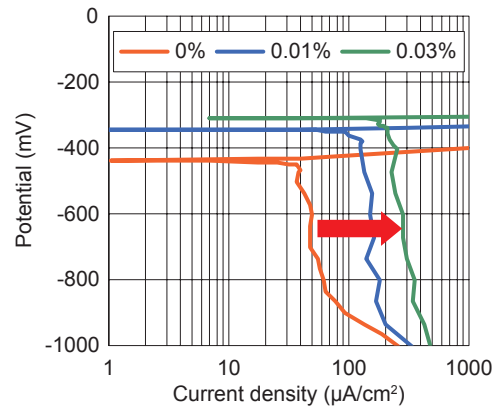


Fig. 14 Polarization characteristic when hydrogen peroxide is added

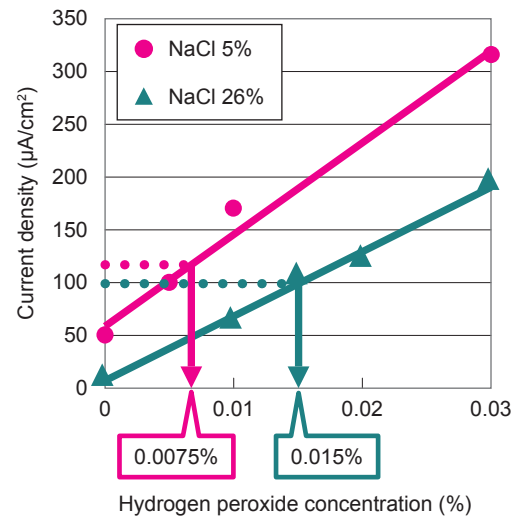


Fig. 15 Hydrogen peroxide concentration versus current density

Table 6 Simulation results for current density using polarization curves measured at different hydrogen peroxide concentrations

Condition	Salt concentration	Measured value	Hydrogen peroxide concentration	Simulated value
Salt spray	5 wt%	120 $\mu\text{A}/\text{cm}^2$	0.0075%	123 $\mu\text{A}/\text{cm}^2$
Drying	26 wt%	100 $\mu\text{A}/\text{cm}^2$	0.015%	96 $\mu\text{A}/\text{cm}^2$
Wetting	26 wt%	100 $\mu\text{A}/\text{cm}^2$	0.015%	103 $\mu\text{A}/\text{cm}^2$

density closer to measured values by using polarization curves measured in solutions to which an appropriate amount of hydrogen peroxide had been added.

6.2.2. Polarization curve of aluminum

Figure 16 shows results for measurements of the corrosion profile from the simulation and CCT tests for test pieces after 816 and 1728 hours of CCT testing. The horizontal axis shows the distance from the area of contact with the steel bolt, and the vertical axis shows the depth of galvanic corrosion. The area of maximum corrosion in the simulation was the area of contact with the steel bolt, while the area of maximum corrosion was distant from this in the actual measurements.

Figure 17 shows the relationship between the distance from the aluminum-steel interface to the maximum depth of corrosion and the depth of corrosion at that time for aluminum materials used in actual tests. The relationship between the maximum depth of corrosion, x (mm), and the distance from the aluminum-steel interface, y (mm), is given by Eq. (13). The area of maximum galvanic corrosion moves further from the aluminum-steel interface with the increase in the depth of corrosion. This shows that points more distant from the aluminum-steel interface are more prone to corrosion than the aluminum-steel interface itself.

$$y = 0.77x + 0.06 \quad (13)$$

Here, if it is hypothesized that the state of the areas of deep galvanic corrosion on the aluminum is similar to those

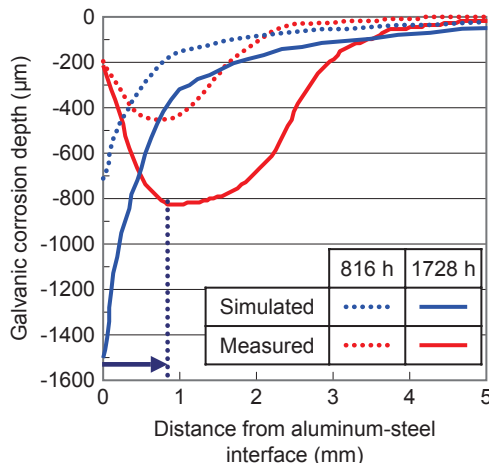


Fig. 16 Comparison of corrosion profiles

of differential aeration corrosion and pitting corrosion, it can be conjectured that oxygen is consumed in the cathode reactions occurring on the surface of the steel and in the areas of shallow galvanic corrosion on the aluminum, and that the oxygen concentration and the electric potential are low in the areas of deep galvanic corrosion on the aluminum. Figure 18 shows the results of measurements of the oxygen concentration in actual areas of galvanic corrosion using the method described in Section 5.4. Oxygen concentration was as low as 0% in the area of

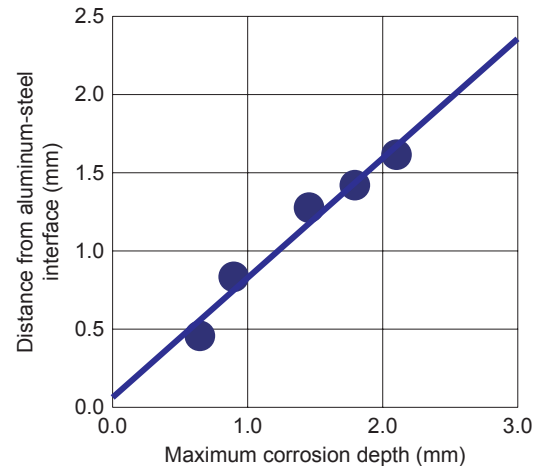


Fig. 17 Maximum corrosion depth versus distance from aluminum-steel interface

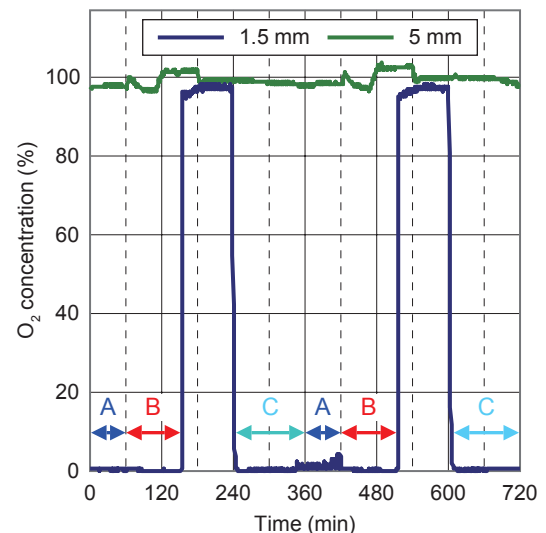


Fig. 18 O₂ concentration

deep galvanic corrosion (1.5 mm from the aluminum-steel interface) when galvanic corrosion was occurring (during saltwater spray: A; until saltwater dries: B; when test piece was wet and salt had deliquesced: C). The polarization characteristic when the oxygen concentration was 0% was obtained by conducting measurements after sufficient substitution of N_2 gas (deaeration) had occurred in the solution used in the measurements.

A program that uses empirical Eq. (13), derived from the relationship shown in Fig. 17, and with the polarization curve when the oxygen concentration is 0% in the areas of deep galvanic corrosion in the aluminum newly set, was therefore added to the previously formulated routine program. However, because the relationship shown in Fig. 17 is described by an empirical formula, it will be necessary to conduct actual measurements for each material.

6.2.3. Setting correction factor

Figure 19 shows the microstructure of an area with galvanic corrosion. Because galvanic corrosion tends to proceed following the grain boundary, and some crystals detach from the parent phase, the detached crystals are removed together with the corrosion product. As discussed above, the simulation software was unable to simulate corrosion weight loss that did not depend on corrosion current, and because of this it was necessary to set a correction factor. Figure 20 shows the weight loss calculated from theoretical galvanic corrosion and weight

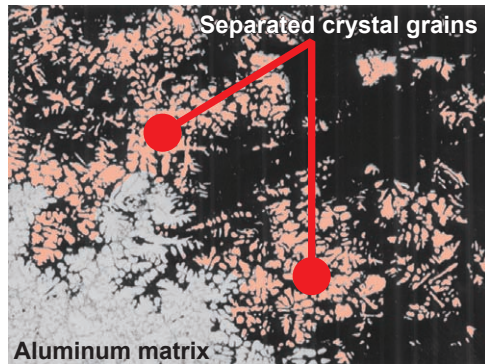


Fig. 19 Microstructure of area with galvanic corrosion

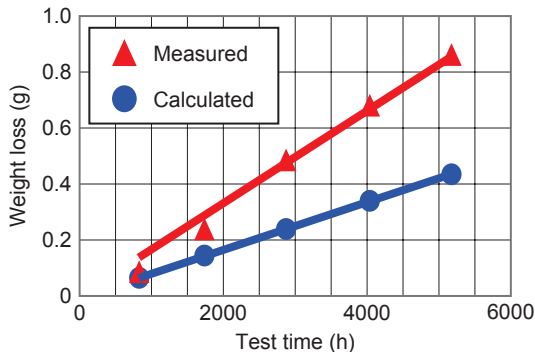


Fig. 20 Measured and calculated weight loss versus CCT testing time

loss measured after removal of the corrosion product. The theoretical galvanic corrosion weight loss was calculated using Faraday's Law, with 0.25 mA as the average corrosion current for the various conditions used in CCT tests. The weight loss following removal of the corrosion product was calculated from the volume of corrosion of the areas in which corrosion profiles were measured. Figure 20 shows that the measured weight loss in the test pieces following CCT tests is 2.0 X the theoretical value converted from the corrosion current. The correction factor for the corrosion weight loss in simulation results was therefore set at 2.0.

6.2.4. Simulation results

A simulation program was created based on the results obtained up to this point. Figure 21 compares corrosion profiles for test pieces following 2880 and 5084 hours of CCT testing and for the simulation.

The profiles obtained from the simulation correspond well with the actually measured profiles. The developed routine program could calculate results for 5084 hours of CCT testing in approximately 20 minutes, and was able to reproduce the profile and depth of galvanic corrosion.

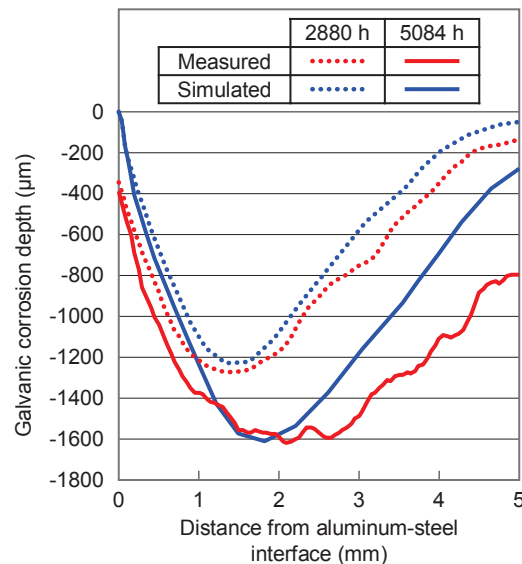


Fig. 21 Simulated and measured profiles

7. Conclusions

A technology for the simulation of CCT tests was developed in order to predict the galvanic corrosion of aluminum parts in the market. The following results were obtained:

(1) Modeling of water film environment

Because the area of corrosion was typically wide in the simulation model if the water film was thick, the water film thickness was set at 30 μm. Consequently, the model corresponded with the actual area of corrosion.

(2) Polarization curve of steel

In order to activate the cathode reaction, hydrogen peroxide was added to the bulk solution when polarization was measured. Consequently, the model corresponded with the corrosion current density in a water film environment.

(3) Polarization curve of aluminum

A corrosion-promoting environment was reproduced by setting the polarization curve for an oxygen concentration of 0% (N_2 deaeration) in the areas of deep galvanic corrosion. Consequently, the model corresponded with the actually measured profile of galvanic corrosion.

(4) Effect of grain boundary corrosion

A correction factor was set by comparing the amount of galvanic corrosion calculated from the corrosion profiles of test pieces following galvanic corrosion and the amount of corrosion converted from actually measured corrosion current. Consequently, the model corresponded with the actually measured depth of galvanic corrosion.

The developed routine program can calculate results for 5084 hours of CCT testing in approximately 20 minutes, and is able to reproduce the profile and depth of galvanic corrosion.

The developed simulation software can be made to respond to a variety of environments by conforming the input polarization characteristics and electrical conductivity to the corrosion environment. This method is not limited to 3D-Cafe, but can be applied to all solvers that use polarization curves to simulate corrosion current.

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