CORROSION CHARACTERISTICS OF ALUMINIUM (AL6063) IN CHLORIDE MEDIA

by

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Abstract

The corrosion behaviour of Aluminium (Al 6063) in chloride media in the presence of varying amounts of H^+ ions and Cl^- ions are studied in this research work. With the increase in the concentration of HCl, the pseudopassive section of the anodic polarization curves (see figure 3) are not present any more. The activation continued right from the start of polarization.

The amount of H^+ ions and Cl^- ions has some influence on the activation potential value and current density after the pseudopassivation. These ions had also some influence on the V_{SCE} potential value.

1.0 Introduction

As mentioned in the previous articles, Aluminium could be considered as a suitable material in corrosion studies, due to the formation of a thin oxide layer on its surface and also due to its negative potential of - 1.69 Volt (1,2,3,4,5,6,7,8). There is no uniform evidence about the reaction mechanism and the reaction velocity of this oxide layer in chloride media. According to M. Metzger and P. Aurora (9), the reaction between the oxide layer and the dissolution time of these layers depends on the concentration of the chloride media. As mentioned by some authors (1,7,11,12,13), the corrosion velocity depends on the amount of Cl- ions in the corrosive media. W. Schwartz (6) had studied the corrosion reaction of Aluminium in chloride media in the presence of H+ ions. According to Schwartz and some of the other authors (6,14,15,16,17) the concentration of H+ ions in chloride media influenced the corrosion reaction of Aluminium.

In this research work, the behaviour of Al 6063 in chloride media is to be studied in the presence of varying amounts of H+ ions and C- ions.

2.0 Experimental Procedure

5mm thick sheet Aluminium (Al 6063) with a chemical composition of 98 - 99% Al; 0.45 - 0.9% Mg; 1.2 - 0.6% Si; 0.25% Fe; 0.1% Mn; 0.01% Cu was used. The supplied material was 20% cold-worked. The degree of cold - work is measured by the percent of reduction of thickness of the material during cold rolling from the original state.

To conduct the experiments rectangular pieces were cut to the size of 30 mm x 20 mm (See figure 2). electrical contact was made via an Aluminium wire attached to the back face of the specimen (18). Except for the test surface, the rest was covered with an adherent epoxy called "picein" (18) to ensure that environmental and electrical isolation were maintained. All the specimens were then cleaned with acetone and alcohol to remove oil and dust on the surface of the material. They were then washed with distilled water, dried and kept in a desiccator.

Before the samples were placed in the corrosive media, they underwent a 4 minute polarization in 10% H_2SO_4 at 50°C by using a current density of 100 mA/cm^2. Polarization was done to remove the oxide layer. After the polarization the samples were washed with distilled water and placed in the respective electrolyte (See figure 2). Individual pieces were then coupled to a potentiostat using a conventional three-electrode technique as mentioned in (18) and (19) respectively (See figure 2). All reported potential values were referenced to a saturated calomel reference electrode.

The test solution was dearated with H_2 for about one hour before the sample immersion. Dearation with H_2 continued throughout the experiment. All testing were continued at laboratory temperature at 28°C. Prior to anodic polarization the material was kept for about 30 minutes in the respective electrolyte, to reach an average steady-state free corrosion potential V_{SCE}. At least two anodic polarization curves were generated for each condition. As they were similar, only one reading was taken for each condition to plot the graphs. The rate of polarization was 2 V/h for all the conducted experiments.

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3.0 Experimental Results and Discussion

The influence of Hydrochloric acid concentration on anodic polarization of 20% cold worked material was investigated and the results are shown in figure 3. The form and the characteristics of the anodic polarization curves in 5% HCl was discussed in the previous articles (3 and 4). The anodic polarization curves of Al 6063 in 5% HCl consisted of three distinct sections namely an active section, a pseudopassive section and an active section. But the anodic polarization curves in 12% and 20% HCl does not have the pseudopassive section. The activation of the surface of the material has taken place right from the start of the experiment and proceeded to the end of the experiment. Eventhough the current density was increased upwards to a final current density of about 80 mA/cm^2 and then reverted to the initial current density by reducing the potential gradually, there was no change in the form of the curves. The V_{SCE} potential value was - 1.020 Volt in 20% HCl and - 0.975 Volt in 12% HCl. With the increase in HCl concentration, the V_{SCE} potential value was shifted by about 45 mV in the negative direction. Due to the aggressiveness of 20% HCl, the oxide layer on the surface of the material could have been removed easily. Once the oxide layer is removed, the naked Aluminium surface is exposed to the corrosive media causing a more negative V_{SCE} potential value. In 12% HCl and 20% HCl, there are more H^+ ions and Cl^- ions in the electrolyte. As the amount of Cl^- ions were increased, the pitting corrosion could have started from the start of anodic polarization. Therefore, activation of the surface of the material could have taken place with the start of the experiment. As explained by Kaesche (20), the rate of pitting corrosion could have increased with the increase of Cl^- ions in the corrosive media.

Figure 4 shows the results of anodic polarization curves for Aluminium (Al 6063) in 1.4n H_2SO_4 with varying Cl^- ion concentrations. The form and the characteristics of the curves are very similar. There are three distinct sections in the curves and this phenomena was discussed in the previous articles (3 and 4). The V_{SCE} potential values vary between - 1.020 Volt and - 0.935 Volt. With the increase in Cl- ion concentration, the V_{SCE} potential value is shifted to a greater negative value. With the decrease in Cl^- ion concentration the length of the pseudopassive section of the curves increased. The activation potential value of the pseudopassive film varied between - 0.900 Volt and - 0.70-0 Volt. With the increase in Cl^- ion concentration, the activation potential value shifted by about 200 mV in the negative direction. The activation current density varied between 0.085 mA/cm^2 and 0.5 mA/cm^2. With the increase in Cl^- ion concentration, the activation current density decreased. When the Cl^-ion concentration is high enough, the activation begins at a lower current density. By further polarization the activation is continued due to pitting corrosion taking place on the surface of the material. When the Cl^-ion concentration is decreased , the activation of the pseudopassive film takes place at a higher current density. But, after a certain low Cl^-ion concentration, the activation of a pseudopassive film will not take place any more (see figure 4). The amount of Cl^-ions were not enough to activate the pseudopassive surface of the material.

In the next set of experiments the H^+ion concentration is varied by keeping the Cl^-ion concentration constant. The results of the anodic polarization curves in these electrolytes are given in the figure 5. All the curves exhibit similar characteristics.

The V_{SCE} potential value vary between - 1.170 Volt and - 0.975 Volt. With the increase in H^+ions in the corrosive media, the acidity of the media is also increased. Due to the increase in acidity of the electrolyte, the surface layer of the material would be removed easily causing the V_{SCE} potential value to shift to greater negative values.

The activation potential vary between - 0.850 Volt and - 0.750 Volt. The activation current density remained nearly the same and the value was about 0.1 mA/cm^2. This experiment shows that H^+ ion concentration had little influence on the activation corrosion current density. The activation corrosion current density was nearly the same for the same Cl^- ion concentration (See figure 4 and 5).

4.0 Conclusion

With the increase in the concentration of Hydrochloric acid, the form of the anodic polarization curves were changed. The pseudopassive section of the curve which was present in 5% HCl disappeared completely in 12% and 20% HCl. In 12% and 20% HCl the current density increased very rapidly for a small change in potential causing activation of the surface of the material from the start of the experiment.

The Cl^- ion concentration had some influence on the activation corrosion potential and activation current density after pseudopassivation of the surface of the material. With the decrease in Cl^- ion concentration, the activation potential value after pseudopassivation shifted to less negative potential values and the activation current density increased.

The H^+ion concentration had a greater influence on the V_{SCE} potential value. With the increase in H^+ion concentration, the V_{SCE} potential value shifted to greater negative values. With the decrease in H^+ion

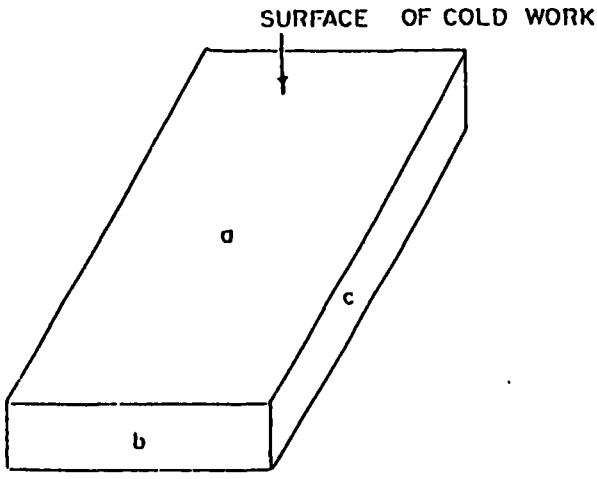

Figure 1 - Type of Surface

a - Longitudinal surfaces
b - Lateral surfaces
c - Altitudinal surfaces

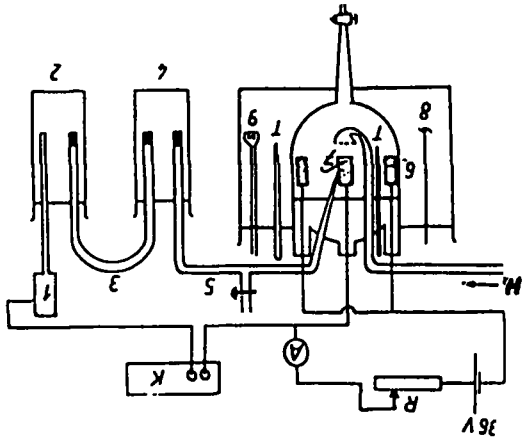

Figure 2

K - Potentiostat; 1 - Calomel electrode;
2 - Beaker with saturated KCl solution;
3 - Bridge with saturated KCl solution;
4 - Beaker with the electrolyte; 5 - Bridge with the electrolyte; 6 - Cathode (Pt);
7 - Anode (Al); 8 - Rotor; 9 - Heater;
T - Thermometer

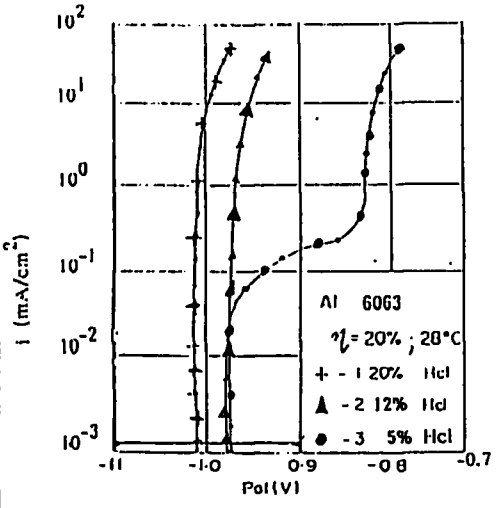

Figure 3 - Anodic polarization curves for the three conditions as mentioned in the figure.

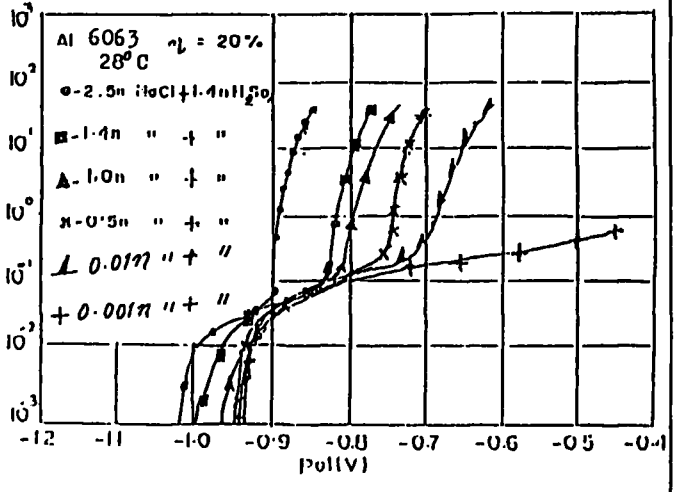

Figure 4 - Anodic polarization curves for the conditions as mentioned in the figure.

concentrations the activation corrosion potential after pseudopassivation shifted to less negative values. But, the activation corrosion current density after pseudopassivation remained nearly the same.

5.0 References

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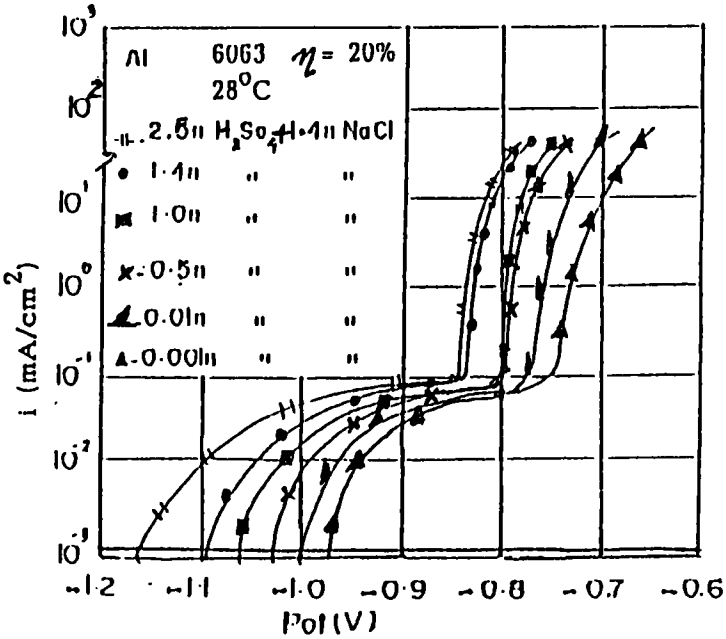

Figure 5 - Anodic polarization curves for the conditions as mentioned in the figure