



CORROSION BEHAVIOR OF TWO ALUMINUM BASED MATERIALS IN CHLORIDE MEDIA

Florina CONSTANTIN^{1,2}, Marioara ABRUDEANU¹, Jean-Pierre MILLET²

¹) University of Pitești, Materials Science and Engineering Laboratory, 1 Târgul din Vale, Pitești, 110040, Romania

²) INSA-Lyon, MATEIS, CNRS UMR5510, F-69621 Villeurbanne, France;

Abstract. *Influence of the chloride amount on the corrosion resistance of two aluminium based materials (AlMn and AlSi/AlMn/AlSi) was determined using electrochemical methods (free corrosion potential versus time, potentiodynamic curves and polarization resistance evolution versus time) at the room temperature. It was found that corrosion resistance of these materials decrease with the increasing amount of chloride and that AlSi/AlMn/AlSi presents a better behaviour in these media.*

Keywords: aluminium, chloride, corrosion, electrochemical characterization

Introduction

Aluminium alloys are well known to show a good enough corrosion resistance in various media, for instance atmospheric, aqueous and saline ones [1]. In the present work, the studied materials are: an AlMn alloy and a sandwich material AlSi/AlMn/AlSi. The aim is to determine the influence of the chloride amount on their corrosion resistance.

These materials are employed in the automotive cooling systems [2], more especially for the radiators, and the used liquids contain often a mixture of several salts, as ammonium or potassium chloride.

The chloride anion is often responsible of the break of the passive layer spontaneously formed on the Al surface [3]; this passive layer protects efficiently the material.

Three chloride concentrations have been chosen: 100, 300 and 500 ppm. The study was carried on at room temperature with several electrochemical techniques.

Experimental details

The used experimental techniques and procedures are classical. The samples are prepared from the rough materials elaborated by Vitmetco Arlo, Romania¹ (table 1 presents their chemical composition). After cutting in small pieces (about 1.2 *1.2 cm²), an electrical connection is assured by a welding cooper wire, then there are etched in NaOH (40 g/L) for 5 min to destroy the natural oxide layer. Finally they are degreased in alcohol ultrasonic bath for 2 min and dried with hot air.

The so prepared samples constitute the working electrode of the experimental device. This later is composed too of a reference electrode (SCE, saturated calomel electrode) and of a carbon counter electrode. The electrolytic solutions are commercial cooling liquids, Glaceol RX D (available on the Romanian market) with a 70 vol.% dilution with deionised water and different additions of NaCl amounts (100, 300 and 500 ppm). In common use, this cooling liquid must be diluted and often the dilution water is

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not exempt of salt. Moreover, the salt additions increase the medium conductivity. The solution volume is of 140 cm³ and the tests are carried on at room temperature.

Table 1. Nominal chemical composition (wt.%) of investigated materials

		Si	Fe	Cu	Mn	Mg	Other	Al
AlMn		0.2	0.4	0.15	1.05	0.003	0.4	Remaining
Sandwich material	AlMn	0.24	0.55	0.066	1.15	0.03	0.4	Remaining
	AlSi	9.25	0.37	0.002	0.003	0.001	0.4	Remaining

An EGG PAR potentiostat (model 263) allows performing the experiments. It is connected to a computer device (software M352) in order to pilot the tests and record the results. Figure 1 presents the schema of electrochemical cell. Three types of measures are performed: free corrosion potential versus time, potentiodynamic curves and polarization resistance evolution versus time.

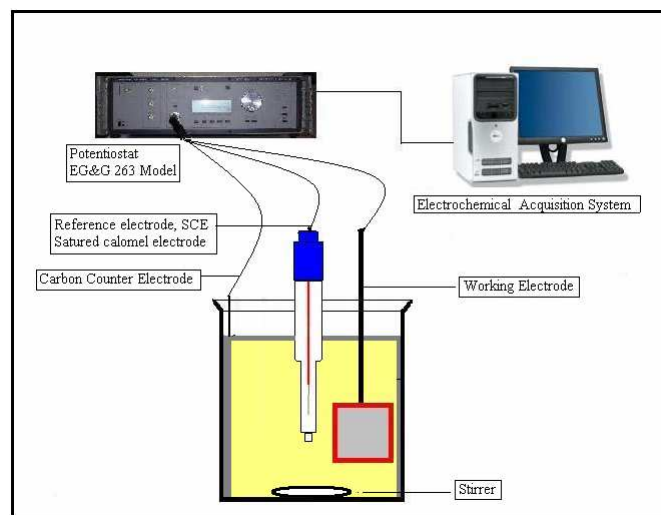


Figure 1. Schema of electrochemical cell

Results and discussions

Figure 2 shows: (a) the evolution of open circuit potential versus time and (b) the potentiodynamic polarization curves at the room temperature for the two alloys. The electrolytic solution contains Glaceol RX D (30%) and 100ppm NaCl. For both materials it can be observed a decreasing of the natural potential vs. time. For AlMn, this decline is relative constant over time in comparison with the sandwich aluminium material where the potential decreased relatively quickly (~300mV in the first 30 minutes). This means that the material becomes less and less noble in a short time. But its natural potential stabilizes and even increases in the late testing time. This may be due to an ennoblement of the surface by a growth of a protective layer. The electrochemical determinations, obtained from these recordings, are presented in table 2.

Table 2. Electrochemical determinations for aluminium alloys in Glaceol RX D 30 % and 100ppm NaCl

Aluminium alloys	E_{corr} (mV/SCE)	i_{corr} ($\mu\text{A}/\text{cm}^2$)
AlMn	-830	30
AlSi/AlMn/AlSi	-620	10

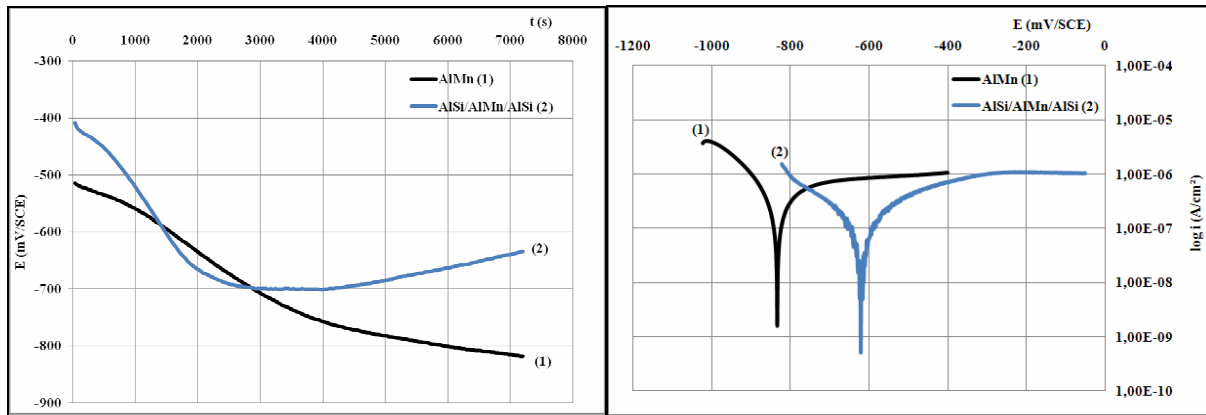


Figure 2. Evolution of open circuit potential versus time (a) and potentiodynamic polarization curves (b) for the two materials in Glaceol RX D 30% +100ppm NaCl at room temperature

Figure 3a represents the evolution of polarization resistance versus time for AlMn alloy, in Glaceol RX D with different additions of Cl^- ions (100, 300 and 500 ppm NaCl). The corrosion experiments were conducted after stabilization of the free corrosion potential. The resistance polarization plots were obtained after immersion in the electrolyte solution (1h, 3h, 9h and 19h), and then the resistance values were calculated by QuickCalc software M352, considering only the linear zone of the curve. It may be noted that in the case using 100 or 300 ppm NaCl, the polarization resistance increases rapidly in the first half period of the immersion up to 130-165 $\text{k}\Omega\cdot\text{cm}^2$ and after this point (after 9 hours of immersion), it can be observed a fall of approximately four decades: this means that in this period the corrosion rate increases. In 500ppm NaCl medium, it was found that the polarization resistance remains constant throughout the experiment. Their values are a little smaller compared with the values measured for 300ppm NaCl, at the end of the test (19h).

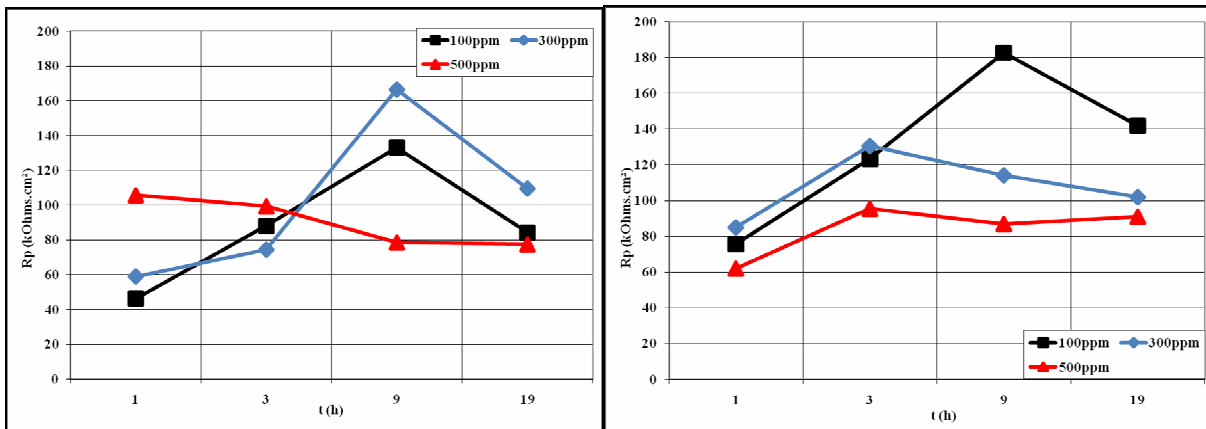


Figure 3. Evolution of polarization resistance versus time in Glaceol RX D with different additions of Cl^- ions: a. AlMn and b. AISi/AlMn/AISI.

Figure 3b shows the evolution of polarization resistance versus time for AISi/AlMn/AISI alloy, in Glaceol RX D with the same concentrations of Cl^- ions. It can be observed that the curve drawn for the media containing 100 ppm has the same appearance with those recorded for AlMn in Glaceol RX D with 100 ppm NaCl. As for the other two additions of NaCl (300 and 500ppm) it can be noticed the same shape of the curve, that remains almost constant in time. The values of the polarization resistance are approximately $100\text{k}\Omega\cdot\text{cm}^2$ after the test period.

Figure 4 shows the evolution of the resistance polarization versus immersion time for the two materials in Glaceol RX D (with 100 and 500ppm NaCl). The effect of AlSi can be observed in comparison with AlMn uncovered. In the both solutions the corrosion rate is littler in the case of the aluminium sandwich material; the value of the resistance polarization is almost 200kOhms.cm², for the solution containing 100ppm NaCl, respectively 140kOhms.cm² for that containing 500ppm NaCl.

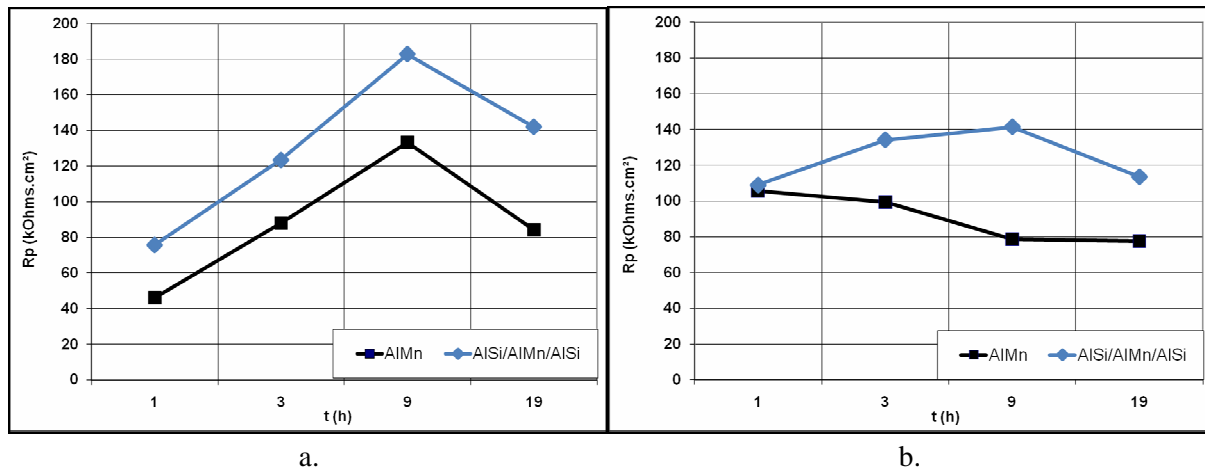


Figure 4. Evolution of polarization resistance versus time in Glaceol RX D - comparison of the two aluminium alloys: a. with 100ppm NaCl and b. with 500ppm NaCl.

Conclusions

The two investigated materials, AlMn and AlSi/AlMn/AlSi alloys, have shown a good enough corrosion behaviour in the cooling liquid, Glaceol RX D (30vol.%) recommended by Dacia constructor, even with addition of Cl⁻ ions (100 to 500ppm NaCl). These additions represent the eventuality of Glaceol D dilution in natural distributive water and lead to more corrosive media. It has been shown, in this work, the importance of the Cl⁻ amount, so the importance of using a no mineralized water to dilute the antifreeze liquid. It was also observed a better behavior of the AlSi/AlMn/AlSi then AlMn in all these media.

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