THE CORROSION RESISTIVITY MONITORING OF MAGNESIUM ALLOY BY THE ACOUSTIC EMISSION

SUSTR MICHAL, ZACAL JAROSLAV, DOSTAL PETR, SRIWONGRAS PIYAPONG
Department of Technology and Automobile Transport Faculty of Agronomy
Mendel University in Brno
Zemedelska 1, 613 00 Brno
CZECH REPUBLIC

michal.sustr@mendelu.cz

Abstract: The article deals with the corrosion resistivity monitoring of magnesium alloy AZ31B-H24 by the acoustic emission method. The subject of this article is the corrosion resistivity of the magnesium alloy exposed to corrosion environment NaCl. Magnesium alloys are very useful in automotive and other sectors including agriculture. For finding a new possibilities for using this material in different applications is necessary to measure the mechanical and corrosion properties of the material. The aim of this work is to find the solution of effective measurement of corrosion degradation of magnesium alloy. For this approach is used the acoustic emission testing method. By means of this technology there is found the system of analyzing the corrosion progress. The article describes the methodology of installation including protection of sensor, assessment of results from specialized software and corrosion effects on measured material.

Key Words: corrosion, acoustic emission, magnesium, protection, sensors

INTRODUCTION

The magnesium usage and its alloys affect the automobile, aircraft and consumer industry in this time. They substitute the heavy materials as steel, iron, copper alloy and even the aluminium alloys. The magnesium and his alloys dramatically decline operating costs. It is possible thanks to low total weight of machines (in the automobile industry we can talk about lower production of CO_2).

There are some limiting factors of magnesium alloys, e.g. lower resistibility of creep, lower value of pulling elasticity module and high chemical reactivity that means sizeable corrosion disposition. Very important is also to know that except static characters there is also specific demeanour during the measuring by time variable powers (Ptacek et al. 2002).

That is the point in keeping researches to obtain new information about fatigue demeanour including initiation and cracks dissemination. There are many situations of the magnesium alloy usage, due to its low weigh, when we cannot miss out to assure their acceptable resistance to atmospheric corrosion in connection with the cyclic tension (Drapala et al. 2004).

The main reason is the pitting corrosion which is typical for magnesium alloys attacking. This process dramatically speeds up the cracks dissemination initiation. The corrosion fatigue methodology of cladding metals is much more complicated and there is no complement described. So many scientific papers deal with this phenomena effort to extend information about magnesium alloys and their usage (Avedesian, Baker 1999).

For exact description of corrosion degradation and recognizing the speed and intensity of this process are suitable the methods of non-destructive testing. By means of these methods is possible to describe the processes in real time.

Non-destructive testing (NDT) is defined as the technical method to examine materials or components in ways that do not impair future usefulness and serviceability. NDT can be used to detect, locate, measure, and evaluate flaws; to assess integrity, properties, and composition; and to measure geo-metric characteristics. Various NDT technologies, such as ultrasonic-based methods, radiographic methods, dynamic methods, acoustic emission (AE) techniques, and acoustoultrasonic

(AU) techniques have been studied. Each NDT technique has both advantages and dis-advantages with regard to cost, speed, accuracy, and safety (Dostal et al. 2014).

Acoustic emission is a phenomenon frequently encountered in everyday life. An example of acoustic emission is the sound of a pencil being broken or wood being split. Technically, acoustic emission (AE) is defined as the class of phenomena in which transient elastic waves are generated by the rapid release of energy from a localized source or sources within a material. The term also applies to the transient elastic waves so generated (Kawamoto, Williams 2002).

In this paper, the acoustic emission method will be used for measurement the corrosion resistivity of magnesium alloy.

MATERIAL AND METHODS

Magnesium alloy

In this research the magnesium alloy was chosen as an experimental material.

The following table provides the chemical composition of magnesium AZ31B-H24 alloy.

Table 1 Chemical composition of magnesium AZ31B-H24

Element	Content (%)
Magnesium, Mg	97
Aluminum, Al	2.5-3.5
Zinc, Zn	0.60-1.4
Manganese, Mn	≥0.20
Silicon, Si	≤0.10
Copper, Cu	≤0.050
Calcium, Ca	≤0.040
Iron, Fe	≤0.0050
Nickel, Ni	≤0.0050

Acoustic Emission System

For this experiment, the acoustic emission system was used. It contains the analysator, preamplifier, sensor and computer with specialized software Daemon.

It was necessary to protect the sensor against corrosion because of measurement directly in the corrosion environment – salt chamber for corrosion acceleration. Special liquid Bitumen for protection of sensor was used. The application of this liquid was made in laboratory conditions. The thickness of the protection layer is 3 mm.

Corrosion chamber NaCl

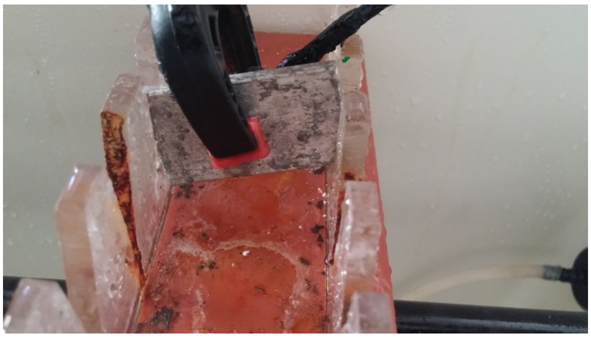
The accelerated corrosion tests were performed at the Department of Technology and Automobile Transport MENDELU agreeable with ČSN ISO 9227. We used the corrosion environment – the salt fog (atmosphere of chloride NaCl) in concentration 50±5 $g \cdot l^{-1}$ of distilled water. The density of solution with the defined concentration and the 25°C temperature is 1.0225–1.0400 $g \cdot cm^{-3}$. This test used to be used for metals and their alloys, metal plating or organic plating on metal bases and the usual temperature is 35°C.

The test process

The acoustic emission sensor was fixed on tested sample (the parameters are 3x6 cm) by the clamp (see Figure 1). The corundum part of the sensor has been covered by binding gel for signal transformation. The sensor was covered also by corrosion protection layer from the outside site. The tested sample and the sensor were submitted in the accelerated conditions of corrosion environment NaCl for 144 hours. The corrosion chamber was in continuous operation. Consequently the sample together with the sensor were pulled out of the corrosion chamber after the test end and were documented. After removing was the sample cleaned (see Figure 5).

Figure 1 The insertion of the sample to corrosion chamber

Figure 2 The passivating layer

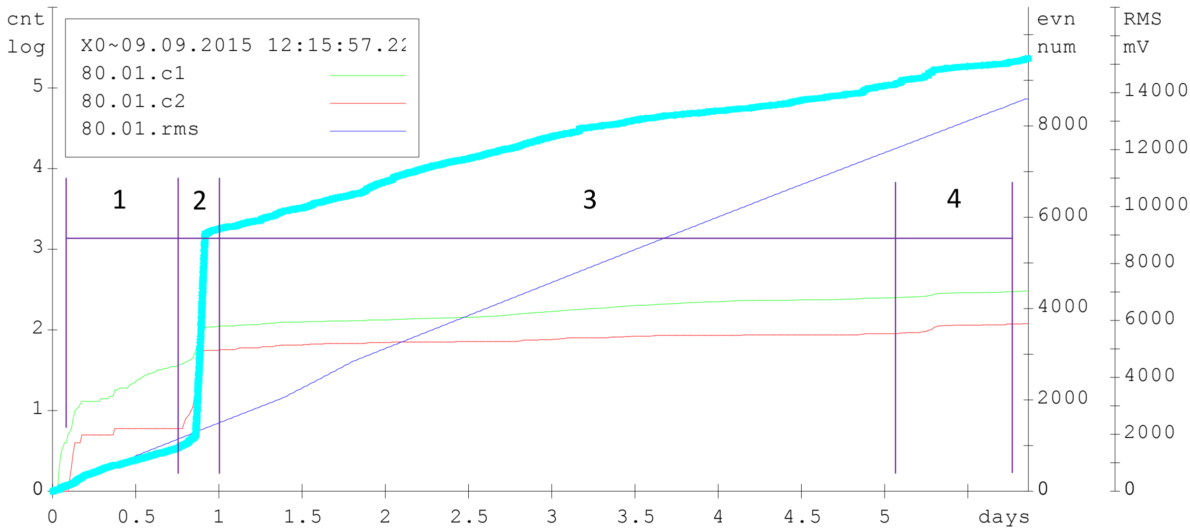


RESULTS AND DISCUSSION

Corrosion in salt solution

The solution of the neutral reaction is connected with the magnesium resistibility. The resistibility depends on the type of attendant cations and anions. The cations of heavy metals increase corrosion assault. It means that cations are outed on the surface of magnesium and micro piles rises up. Anions are applied accordingly if they are form soluble or insoluble (fluorides, phosphates, chromans and nitrates) substances. These substances decline the corrosion rate by creating protective layers on the magnesium alloy surfaces only on condition that there is no pH decline. On the other hand in soluble solutions of chlorides, bromides and sulphates (they do not protector layer on the surface) the corrosion runs usually by technically unacceptable rate (Boyer, Gall 1997).

Figure 3 Record of AE



In the Figure 4 we can see graphically demonstrated process of acoustic emission and divided into four parts. The first part shows insidious process of acoustic emission signals. The chemical processes starts to affect the magnesium alloy surface. The second part demonstrates the high manifestation of acoustic emission. There is transition of oxide layer on the magnesium alloy surface to the hydroxide profile and furthermore to the carbonate character that rises the protector layer effect (see Figure 2). The third part is typical for corrosion passivating layer and starts the pitting corrosion degradation of material. The last part the acoustic emission manifests the increased intensity in comparison with the part tree. It is caused by assault of magnesium alloy hexagonal gratin.

Figure 4 The sample after 144 hours of accelerated corrosion degradation (sordid)

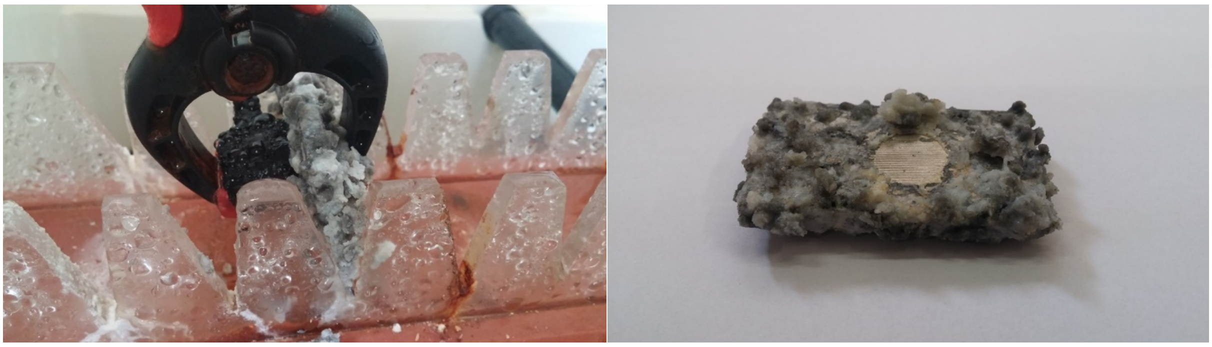


Figure 5 The sample after 144 hours of accelerated corrosion degradation (refined)

It is obvious that the corrosion degradation process in corrosion chamber NaCl for 144 hours is very aggressive. The pitting corrosion leaked in the material up to the depth 2mm (see Figure 5). There are visible the typical locations of pitting corrosion and point corrosion.

CONCLUSION

The acoustic emission method makes possible to follow up the development of corrosion processes. The research is focused on explanation how quick and aggressive is the corrosion in salt environment and on reactions of magnesium alloy on it. Very important part of the research is the use of acoustic emission system for continuous monitoring of the reactions of tested specimen. The work proves that the acoustic emission is the useful method for monitoring of corrosion on magnesium alloy. By means of this method is possible to monitor the corrosion in real time.

The damage by corrosion process is still common reason for fatal failures of mechanical stressed constructions. Nevertheless, there are also possibilities of detection and visualization of the damage by the acoustic emission method that is why the coming construction damage is possible to predict. Thank to this visualization of acoustic emission is enabled to observe active defects mainly those especially dangerous.

This research gave the principles for further research of magnesium alloys. It will be necessary to focused on corrosion protection layers of magnesium alloys. Because of very good mechanical properties of this material there is a big potential for use in a lot of engineering applications. With suitable corrosion protection is possible to use the material also in corrosion conditions which affords to use it also in corrosion environment. For research in this field and finding the suitable corrosion protection layer offer this research the methodology for continuous monitoring of degradation by means of acoustic emission system.

The experiment also brings information applicable by constructing the new sensor type that is withstanding to corrosion degradation processes. The information are applicable in many other sciences because the knowledge about the corrosion process can prevent many relevant accidents.

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