Available online at www.sciencedirect.com

ScienceDirect

Surface & Coatings Technology 202 (2008) 2085 – 2092

SURFACE & COATINGS TECHNOLOGY

www.elsevier.com/locate/surfcoat

Effect of electroless-Ni-plating on corrosion fatigue behavior of magnesium alloy

S. Ishihara [a,*], H. Notoya [b], A. Okada [b], Z.Y. Nan [a], T. Goshima [a]

[a] *Department of Mechanical Engineering, University of Toyama, Toyama, 930-8555, Japan*
[b] *TAKAMATSU PLATING Co. Ltd. Yatsuo, Toyama, 939-2366, Japan*

Received 13 April 2007; accepted in revised form 27 August 2007
Available online 5 September 2007

Abstract

Fatigue tests were performed on electroless nickel-plated magnesium alloy specimens in laboratory air and 3% sodium chloride solution. In laboratory air, the effect of surface treatments (plating, blasting and polishing) on the fatigue lives of specimens was found to be minimal. However, in 3% sodium chloride solution, the electroless Ni-plated specimens were found to have shorter fatigue lives than those of the polished and blasted specimens. In order to study the fatigue mechanisms, successive observations of the specimen surfaces were conducted during the fatigue process in both laboratory air and sodium chloride solution. Observations of the fracture surfaces were also conducted to clarify the fatigue mechanism.

© 2007 Elsevier B.V. All rights reserved.

Keywords: Electroless deposition; Plating; Nickel; Polishing; Magnesium alloy; Corrosion fatigue

1. Introduction

Magnesium alloys are the lightest materials among the metals used for structural or mechanical applications. They also have excellent specific tensile strength, good stiffness, good cutting performance, and exhibit vibrational absorption [1]. Magnesium alloys are considered to be good candidates as materials in, for example, auto parts, portable personal computers and telephones, due to their energy and weight saving characteristics.

However, magnesium alloys have not been extensively used until recently, because of their vulnerability to corrosion. When considering the use of magnesium alloys as structural materials, a thorough understanding of the corrosion-fatigue characteristics is necessary to reflect the results in machine design.

The authors performed corrosion fatigue tests on AZ31B magnesium alloy [2], and clarified shorter fatigue lives than those in non-corrosive laboratory air, especially in the lower stress amplitude region. Electroless Ni plating is expected to be beneficial in improving the corrosion fatigue performance of magnesium alloys. However, studies on fatigue behavior of electroless Ni plated magnesium or other alloys have been limited. Punch-Cabrera et al. [3] studied the corrosion fatigue lives of electroless Ni deposited 7075-T6 aluminum alloy in 3% sodium chloride solution. They reported that the deposition increased the corrosion fatigue lives by 60–70% in the low cycle fatigue region of 10^4–10^5 cycles. Contreras et al. [4] reported a remarkable decrease in the fatigue lives of electroless Ni deposited AISI-1045 steel in laboratory air. Saeid et al. [5] investigated the fatigue behavior of electroless Ni deposited Ck45 steel in laboratory air. They also reported that the electroless Ni deposit decreased the fatigue life, because cracks were initiated early during the fatigue process at the interface between the deposit and substrate. Therefore, these results reported to date regarding the effectiveness of electroless Ni deposits on the fatigue lives of alloys are rather different.

In the present study, fatigue tests were conducted on electroless Ni plated AZ31 magnesium alloy specimens in laboratory air and 3% sodium chloride solution, in order to study the effect of electroless Ni plating on fatigue life. For comparison, specimens with different surface treatments, machine-polishing and glass bead-blasting, were also tested. The fatigue mechanisms of the electroless Ni-plated Mg alloy

---

* Corresponding author.
E-mail address: ishi@eng.u-toyama.ac.jp (S. Ishihara).

0257-8972/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.surfcoat.2007.08.061

Table 1
Chemical compositions of the material used

Wt.(%)								
Al	Zn	Mn	Fe	Ni	Si	Pb	Ca	Mg
2.98	0.97	0.004	0.007	0.005	0.02	0.01	0.04	Bal.

Table 2
Conditions used for electroless Ni-plating

Solution-pH	Plating time [min]	Plating temperature [K]	Plating bath	Plating thickness [μm]
6.0	60	344	Heat-resistant resin	24

specimens in both laboratory air and 3% sodium chloride solution were studied in detail.

2. Specimens and experimental methods

2.1. Specimens

The material used in the present study was an extruded AZ31 magnesium alloy. Its chemical composition is listed in Table 1. The main chemical compositions of the material are 3 wt.% aluminum and 1 wt.% zinc. The yield strength, tensile strength, elongation and Young's modulus of the material were found to be 200 MPa, 275 MPa, 11.0% and 45 GPa, respectively. Specimens were machined into a round bar shape with a minimum diameter of 5.6 mm, as shown in Fig. 1.

The as-machined specimens were blasted with glass beads, followed by electroless Ni plating prior to the fatigue tests. Tables 2 and 3 show the conditions for the electroless Ni plating and blasting treatments, respectively. Machine-polished specimens were also prepared by polishing the as-machined specimen with emery papers and diamond pastes. Fatigue tests of the glass bead-blasted and machine-polished specimens were conducted for comparison with the electroless Ni plated specimens.

2.2. Experimental methods

Fatigue tests were conducted using a cantilever type rotating bending fatigue machine. The tests were conducted at a frequency of 30 Hz, and at an R ratio of -1. 30 Hz was chosen as a typical frequency, since no significant effect of frequency was observed on the corrosion fatigue behavior within the range of 1–60 Hz. Fatigue tests in laboratory air were conducted at room temperature with humidity of 63–73%.

Corrosion fatigue tests were performed by dripping 3% sodium chloride solution in ion exchanged water onto the specimen surface at a constant rate using a metering pump. The corrosive solution was maintained at a temperature of 298 K. The replica method was used for the successive observations of the specimen surfaces during the fatigue process.

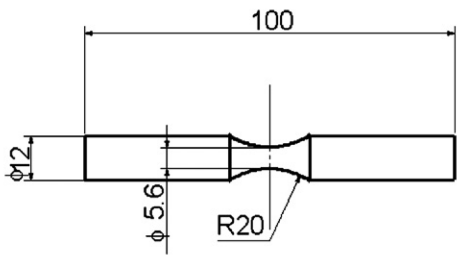

Fig. 1. Shape and dimensions of the specimen (units in mm).

Fatigue tests were interrupted at constant intervals for taking replicas. The collected replicas were examined using an optical microscope with a magnification of 400 times, in order to obtain information regarding crack size and shape during the fatigue process. A part of each specimen was observed directly with an optical microscope to study how cracks propagate and interact with the microstructure of the material. The specimen hardness was measured with a microhardness testing machine under experimental conditions of a 100 g load for 30 s of load time.

3. Experimental results

3.1. Characterization of the electroless Ni-plated film

Fig. 2(a) shows the cross section of an electroless Ni plated specimen. Good adhesion between the Ni plating film and the magnesium alloy (substrate) is observed, because no abruption was observed along the interface between the plating and substrate, both before and after the fatigue tests. However, sedulous investigation of the interface revealed that local defects are present in the plating film, as shown in Fig. 2(b). The defect density within the plating film was 0.2 per mm. The average thickness of the plated Ni film was 24 μm. The hardness of the plating film was $HV_{100}=487$, while that of the magnesium alloy (substrate) was $HV_{100}=57$. The latter possesses only 1/8 hardness of the former, indicating a large difference in hardness. Electron probe micro-analysis (EPMA) determined that the chemical composition of the plating film was 92 wt.% Ni and 8 wt.% P.

3.2. Effects of the surface treatments on the fatigue lives

Fig. 3 shows S–N data in laboratory air for the three types of surface treated specimens, polished, blasted, and electroless Ni plated specimens. The solid curve in the figure indicates the approximated S–N curve for the three types of specimens. The dashed line in the figure represents the S–N curve previously reported by the present authors [6] using similar AZ31 magnesium specimens with polished surfaces. The curve was added to make up for limited experimental data of the polished specimen. The dashed line agrees well with the present S–N

Table 3
Conditions employed for glass bead-blasting in the present study

Blasting pressure [MPa]	Blasting distance [m]	Blasting material
0.39	0.1	Glass beads, 150 μm in diameter

Download English Version:

https://daneshyari.com/en/article/1661759

Download Persian Version:

https://daneshyari.com/article/1661759

Daneshyari.com