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icse@bwu.edu.ly

Anodizing of Aluminum-Silicon Alloy

Zayad M. Sheggaf[a], Omar A. Addbeeb[b] Ahmed A. Assed[b] Abdualkareem M. A[b]
Arwa S. M[b] , and Haya A. A[b]
[a]Libyan Center for Engineering Research and Information Technology, Bani Walid, Libya
[b]Department of mechanical engineering /Bani Walid University, Bani Walid, Libya
*Crosspnding author: zayad1976@gmail.com

Abstract: The anodizing process is one of the coating methods used to protect metals and their alloys from corrosion. It is also used to increase hardness and fatigue resistance. This technique can be applied to the Al-Si alloy. Furthermore, to control the thickness of the thickness of the oxide film formed by the anodizing process, the parameters of the procedure should be specified. In this investigation, the effect of oxide film thickness on anodizing time has been studied for an aluminum-silicon alloy, and an optical microscope was used to examine the formed morphology surface and measure the oxide layer thickness. The results showed that the treated alloy acquired a gray-dark color on its surface. In addition, the oxide film has a direct relationship with the process time.

Keywords: aluminum ally, anodizing process, oxide film

Introduction

Aluminum alloys are the preferred material to produce gasoline and diesel engines parts such as pistons and cylinders block, due to their unique properties, like low density, high thermal conductivity, simple net-shape fabrication techniques (casting and forging), ease of machinability, high reliability. In addition, Al-Si alloys have an excellent recycling characteristic [1]. Al alloys are susceptible to corrosion in the environment, which could deteriorate the surfaces and possibly lead to stress corrosion cracking, which would lead to the failure of the aluminum alloys. In order to prevent corrosion on aluminum and improve paint and adhesive adhesion, anodic coatings have been created. [2]. Anodizing is an electrochemical process that is used to form the oxide films on the surface of metals, which creates a hard, corrosion- and abrasion-resistant oxide coating on metal alloys. Aluminum alloys are frequently coated with anodized coatings to provide surfaces that are resistant to wear and corrosion. It is noted that anodized coatings have been demonstrated to negatively impact the fatigue performance of the underlying aluminum alloys, notwithstanding their advantages [3, 4]. Therefore, anodizing is the amplification of naturally occurring phenomena through highly controlled oxidation. When aluminum is anodized conventionally, direct electrical current, (DC) is passed through a bath of sulphuric acid -the electrolyte -while the aluminum being treated serves as the anode. This produces a clear film of aluminum oxide on the aluminum's surface [5]. DEBIH Ali, study the effect of anodizing time in a sulfuric medium on the thickness of the oxide layer and the mechanical properties of an 1100 aluminum alloy (commercially pure" wrought), he found that the anodizing coating process improve both mechanical properties, tensile and hardness [6]. Other investigation showed that current density and electrolyte temperature of anodizing process reflect on oxide film thickness for AA 2024-T3 alloy, and

the surface of the alloy became hard. Also, The voltage determines the linear porosity, which undergoes a morphological change between 25 and 30 V. High current density and/or low electrolyte temperature can also accelerate cell growth. [7]. However, anodizing parameters is very important on oxide film thickness. The aim of the present study is to investigate the effect of anodized parameters on oxide film thickness for Al-Si alloy.

Experimental procedure

A consumed car engine cylinder block used in the present study. The chemical composition of the alloy was determined using FOUNDARY-MASTER Pro emission spark spectrometer. Table 1 shows the chemical composition of cylinder block alloy.

Table 1: The chemical composition of cylinder block alloy

Element	Cr	Zn	Mg	Mn	Cu	Fe	Si	Al
Wt.%	0.026	0.714	0.257	0.151	2.59	0.762	11.5	Bal.

Nine specimens are taken from cylinder block, three for each anodizing parameter, which are cut into plates 35 mm×35 mm and 5 mm thick, then grounded and polished. Finally, the samples were cleaned (degreasing) removing any residuals from the surface that are caused by touching and machining the material such as oil and dirt. Anodizing process carried out according to ASTM B580-79, where, the aluminum alloy sample connected to the positive electrode, acting as an anode, and a lead piece was connected to the negative electrode, which acting as a cathode. Both pieces immersed in a solution of sulfuric acid (as electrolyte), used plastic container, and then connect the system to power supply. Current and voltage values were constant, which were 0.24 A and 18 V respectively. Anodizing process conducted with three different time, 20, 40 and 70 min. Three specimens for each coating time were used. Optical microscope used to exam surface texture and measure oxide thickness. Figure 1 showed the alloy specimen and setup preparation of anodizing coating cell.

Fig. 1: The alloy specimen and setup preparation of anodizing cell

Results and discussion

The photograph in Figure 2 showed surface morphologies of the anodized specimens, it be seen that the surface covered with a dark gray coating film, which indicated that anodizing process occurred successfully, and the Al oxide precipitated along the specimen surface.

Fig. 2: The alloy specimen after anodizing process

It has been reported that the 4XXX series which alloyed with silicon results in a dark gray color after the anodizing process that may not be visually appealing for your application, otherwise the other Al series showed a pale gray color or clear oxide layer [5, 8]. Optical

microscope image showed oxide film resulted from anodizing process, presented as dark color, as shown in Figure 3. The process of anodizing aluminum and its alloy-based products results in protective and aesthetically pleasing coatings. The article is made the anode of an electrolytic cell with aqueous sulfuric acid as electrolyte where the following overall oxidation reaction occurs, according to the following chemical equation [9]:

$$2Al + 3H_2O \rightarrow Al_2O_3 + 6H+ 6e- \ldots (1)$$

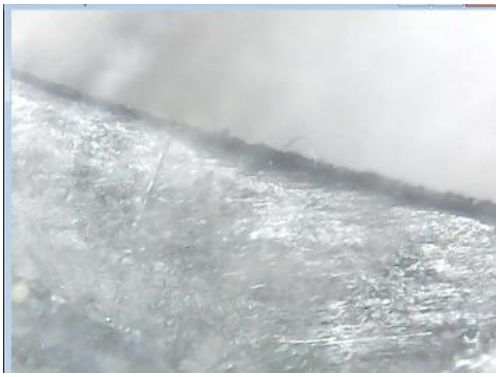

Fig. 3: optical microscope image showed oxide film (x50)

As the current is flowing in the cell, sulphuric acid begins to decompose, the hydrogen ions moving to the cathode where they are reduced to hydrogen gas, illustrated in the equation:

$$2H+ + 2e- \rightarrow H_2 (g) \ldots (2)$$

Negatively charged anions, such as hydroxide, sulphate, and maybe oxide ions, migrate to the anode simultaneously. Positively charged aluminum ions (Al_3+) are produced in the anode by the circuit's electrical charge, and they subsequently migrate in the direction of the cathode. [10]. Figure 4 illustrate relationship between anodizing time and oxide film thickness. The evaluation of the thickness of the oxide layer was carried out in the transverse section of the anodized profile. It was found that the thickness increases as the anodizing time increases. The average of maximum thickness occurred at 70 min anodizing time was 0.0548 mm, while the average value was 0.0269 mm for anodizing at 40 min time, and 0.01355 mm for 20 min anodizing time. This is due to more chemical deposition of the anodized layer with time, resulting in a higher anodic film thickness [6].

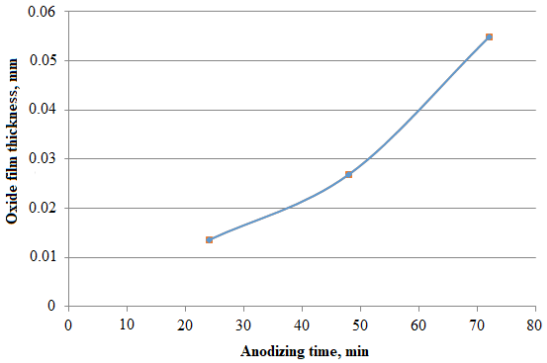

Fig. 4: Effect of anodizing time on oxide film thicknesses

Conclusion

The effect of anodizing process time on oxide film thickness for Al-Si alloy was investigated. From the analysis, the following can be summarized:

1. The anodizing treatment was well preserved, as the sample's morphological color transitioned to a gray-dark.
2. The oxide layer thickness increases with an increase in the anodizing time.
3. The highest value of the thickness of the oxide layer was achieved at the highest time, which is 0.0548 mm at 70 min.
4. The aluminum-silicon alloy produces a dark gray, sooty appearance when anodized. The coating provides protection, but the surface color is unappealing.

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