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STUDY THE EFFECT OF SOLUTION TREATMENT ON MECHANICAL PROPERTIES OF AL-7%SI-0.3%MG ALLOY

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ABSTRACT

This research includes study the effect of solution treatment (T6) on wear behavior of Al-Si-Mg alloy. The tested samples were solution treatment at (150,170,200 ^{o}C) for range of aging time (60, 90, 120 min.) with sliding speed 0f (0.94 m/s) during test time of (5, 10, 15, 20 min.). The results show that as aging time was increased ,the wear rate was decreased ,also we observed that as wear test time was increased, the wear rate was increased also, for aging temperature we found the were rate was decreased with the increasing of aging temperature. The vickers hardness number Hv was increased with increasing of aging time and aging temperature. The optimum hardness value was found at aging temperature of (200 ^{o}C) and minimum wear rate at aging temperature (120 ^{o}C), and we found at that solution treatment improved the were rate by 5% and 55% for hardness number at aging temperature 200 ^{o}C as compared with cast alloy.

Keywords: Solution treatment, wear rate, hardness

INTRODUCTION

Aluminum Association AA A356.0 composition castings are found as aircraft parts, fittings, structures, and control components. In the field of automotive castings, these castings are used as differential carriers and water-cooled cylinder blocks and heads. A356-T6 is the common alloy and temper for light alloy automotive wheels and is finding increased usage as lightweight, high integrity automotive suspension parts. A356.0-T6 has, probably, the most extensive list of recorded mechanical properties of any aluminum foundry alloy. Further, there is exibility in the alloy system as aging times during heat treatment can be varied in order to attain different tradeoffs between strength and ductility. Aluminum and aluminum alloy are gaining huge industrial significance because of their outstanding combination of mechanical, physical and tribological properties over the base alloys. These properties include high specific strength, high wear and seizure resistance, high stiffness, better high temperature strength, controlled thermal expansion coefficient and improved damping capacity [1]. These properties obtained through addition of alloy elements, cold working and heat treatment. Alloying elements are selected based on their effects and suitability. The alloying elements may be classified as major and minor elements, microstructure modifiers or impurities; however the impurity elements in some alloys could be major elements in others [2].

Kozyrev and Sedakova, 2008 [3] perform a theoretical and experimental analysis within a non-equilibrium thermodynamic framework to derive a dependence of wear rate on the load in stationary state. They demonstrate that the linear increase in wear rate with an increased load may be interrupted as a result of reduction in wear rate. They observe a nonlinear behavior of wear W as a function of pressure p. That is, in a particular range of load, wear can decrease by increasing the pressure. This phenomenon is explained by tribological reactions that results in formation of wear resistant oxide layers. Kozyrev and Sedakova take into account the effect of another independent process which is the diffusion of material into tribo-film, beside the friction process. The diffusion process can be considered as an external element that lead to self-organization and wear reduction.

(Y.C.cheng & etals, 2010) [4] were studied the casting structure of Al-7Si-0.3Mg (A356) alloys by spinning deformation processing which was analyzed by OM and SEM, correlated with the wear and corrosion durability. The spinning deformation processing elongated typical casting structure of A356 alloys, broke and distributed the eutectic silicon phase over the Al-matrix, eliminated the casting defect. The contribution of spinning deformation processing to microstructure diminished the crack nucleation at sliding wear environment. The improved wear rate of A356 alloys related to refinement of eutectic silicon phase and elimination of casting defect. The resistance to corrosion was increased by elimination of casting defect.

Surface Treatment of Aluminum Alloys had studied by (Majid H. & Mohamed A.,2011)[5], a pulsed Nd:YAG laser with wavelength (1064nm) and (532 nm) and pulse duration (100 ns) for different energies [250 mJ,500 mJ,750 mJ,1000 mJ] and spot size (1.5mm) was used. Laser surface treatment is the most important way in industrial application because of its ability to improve the surface properties of metal and alloys. The alloys used were [Al-Cu-Si], [Al-Si-Mg] and [AL-Zn-Mg].The essential aim for this work includes study the effect of laser parameters on aluminum alloys. In laser surface engineering the micro hardness and wear tests will be studied after laser treatment.

Studies have been made on the mechanical properties upon thermal ageing of a sand cast antimony-modified A356-type Al-Si-Mg alloy by (M. Abdulwahab & et als, 2013) [6]. The produced alloy was solution heat treated at 540oC/1 h then subjected to thermal ageing treatment at 180oC for 1-5 h. There mechanical properties; Tensile properties, Hardness and Impact strength were used as criterion. From the results, the tensile properties and hardness increased with thermal ageing treatment. While the impact energy and elongation decreased upon ageing. The tensile properties of antimony-modified Al-Si-Mg alloy improved with ageing time and that the microstructures indicate spherodization of the silicon flakes to fine structures, which account for the improved properties.

EXPERIMENTAL WORK

Introduction

Alloy A356 is currently the workhorse of aluminum structural castings, and the most popular alloy used in squeeze casting and semi solid metal processing. The 356/A356 family of alloys is used for a variety of commercial castings too; electrical hardware, marine hardware, pumps bodies and many other components. A356 has long been the material of choice for cast aluminum automobile wheels in North America and has become the standard for most automotive chassis and suspension castings as well. Alloy 357 is similar to A356 but has higher strength. It, too, is used to make “premium quality” castings. Alloys 360 and A360 are in the same family as A356, but were designed specifically for die casting and, as such, contain more silicon and higher iron and allow more impurities than A356. **A356** aluminium alloys are characterized by very good mechanical properties and low porosity with a globular microstructure which is fine and uniform. The mechanical properties can be further improved through heat treatments such as T5 and T6. These alloys are used for casting general-purpose die castings. The common alloys used are 356-T6 for cast wheels. A356 has largely been replaced by 295 used in permanent mold castings for machine tool parts, aircraft wheels pump parts, tank car fittings, marine hardware, valve bodies, and bridge railing parts [7, 8].

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Samples Preparation

Samples were prepared as follows: -

1- Alloy rods diameter (30 mm) and length (250 mm) was obtaining, and machining these bars on a turning machine with presence of coolant and cut them into several samples with diameter (10 mm) and length (20 mm) .
2- Samples were heating in an electric furnace to the temperature (300 ^{o}C) and cooled in the furnace to remove the resulting stresses from the casting and machining process.

SOLUTION TREATMENT (T6) METHOD

The samples were treated at 540c for three hours and then water quenched .After that the samples were reheated to temperature of (175,200,225 ^{o}C) for aging time of(60,90,120) minutes, The solution treatment was done by using a resistance electrical furnace.

Wear test

Wear measuring device

In this research was the study of the impact speed slid and pregnancy vertical and time slipping on the properties and behavior of wear and tear sliding dry samples of aluminum-356 alloy using a measuring wear and tear sliding Dry (Pin-on-disc) for the purpose of obtaining the status of contact between sample and turntable made of steel (45HRC). The device consists of an electric motor with a speed of rotation of the electric power (1.5) hp and arm with a rectangular section showing the sample by holder with a diameter 10mm, has been proven on the scale arm emotion Strain gauge to measure the force of friction. I have been using five load (10) N under the influence of linear sliding speed (0.94) m / s where time of aperture range of (5, 10, 15, 20 min.). The speed was controlled by transmission belts of the electric motor as shown in Figure (1). All tests were testing samples in normal atmospheric air and at room temperature.

Figure 1. Wear Apparatus

Wear calculation

Prepared samples of dimension (ϕ 10*20 long) mm were tested and the wear rate was calculated following the gravimetric method, which includes an account of the weight loss of a sample as sample weight was calculated before and after the test by an electric balance delicate precision (± 0.0001 gm) was calculating the rate of wear and tear and in accordance with the following equation:

The wear rate was calculated by using the following equation:

$$W_R = \frac{\Delta m}{2\pi rnt} = \frac{m_1 - m_2}{2\pi rnt} \qquad \text{..................(1)}$$

Where:-

W_R :- wear rate (g/cm)

Δm :- Weight lost (gm) which is the difference in mass of the samples before and after the test that the mass loss.

m_1 :- Mass of the sample before the examination (gm)

m_2 :- Mass of the sample after examination (gm)

t :- Sliding time (examination) minutes

r:- The radius of the sample to the center of the disc

n:- Disk rotational speed (r / min)(540 RPM).

RESULTS AND DISCUSSION

Wear behaviour

From Figures (2-4) the wear rate was decreased with increasing of aging temperature and aging time due to increased of hardness of samples with increasing of aging temperature (150,170,200 ^{o}C). also the wear rate was increased with wear time and this result was natural. The wear rate of (Al-Si-Mg) alloy as cast was higher than the wear rate of treated samples and this behaviors shows the effect of solution treatment on improving the were rate resistance of (Al-Si-Mg) alloy

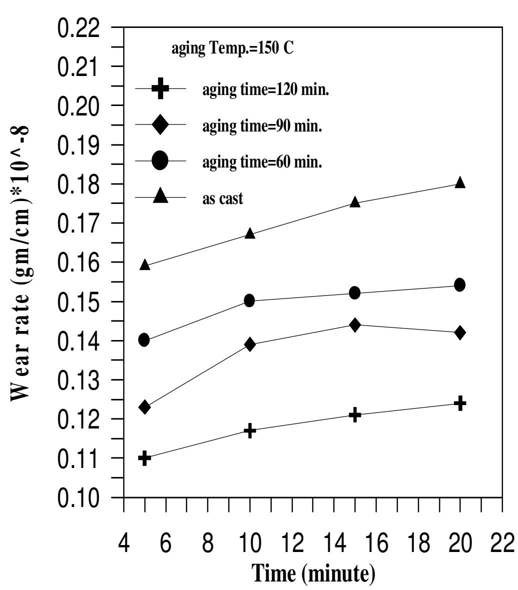

Figure 2. The relationship between wear rate and aging time of aging temp.=150 ^{o}C

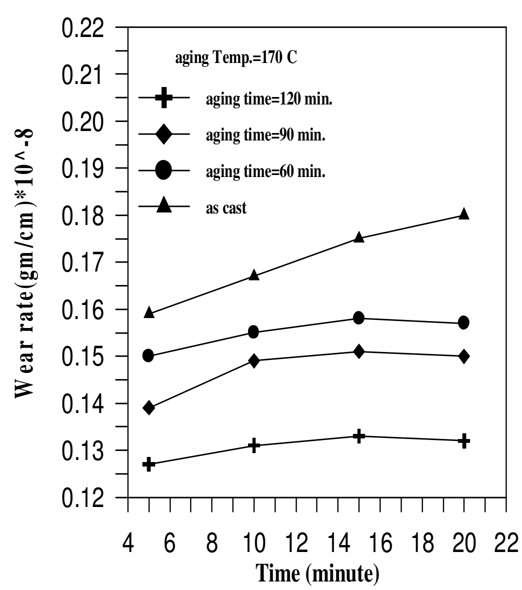

Figure 3. The relationship between wear rate and aging time of aging temp.=170 ^{o}C

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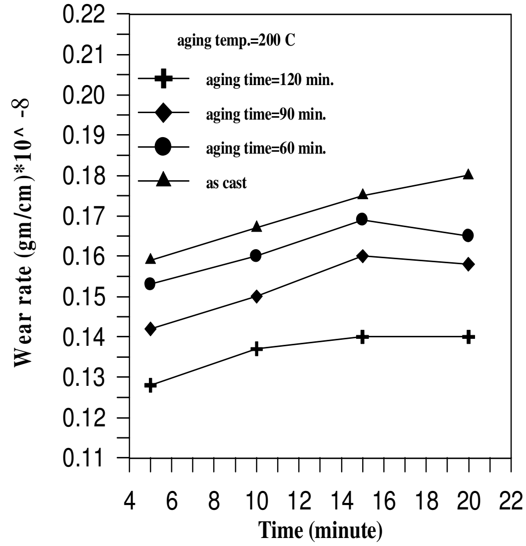

Figure 4. The relation ship between wear rate and aging time of aging temp.=200 °C

Hardness Behavior

Figure 5 indicates the relation between hardness value and aging time at different aging temperature that shows the increasing of hardness value with the increasing of both parameters of aging temperature.

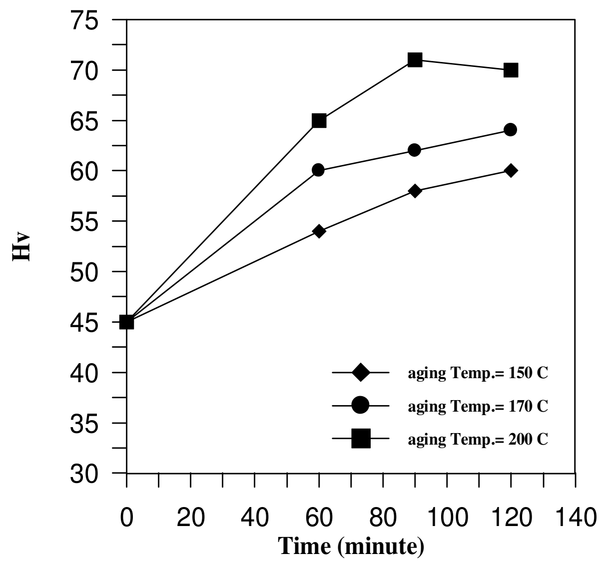

Figure 5. The relationship between Vickers Hardness value and aging time

CONCLUSIONS

1- The wear rate was decreased with increasing of aging time because the increasing of aging time leads to increased of hardness value.

2- The effect of aging temperature on wear rate was as aging temperature was increased the wear rate was also decreased.

3- Hardness values were increased with increasing of aging time.

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