UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE EFFECT OF DIFFERENT HEAT TREATMENT ON SURFACE RETROGRESSION ON ALUMINUM ALLOY 7075

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

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I hereby, declared this report entitled “THE EFFECT OF DIFFERENT HEAT TREATMENT ON SURFACE RETROGRESSION ON ALUMINUM ALLOY 7075” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) (Hons.). The member of the supervisory committee is as follow:

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(PM DR. MOHD WARIKH BIN ABD. RASHID)

ABSTRACT

Aluminum alloy 7075 have been widely used as structural materials in aeronautical industries due to comprehensive properties such as low density and high strength. However aluminum alloy 7075 are susceptible to local corrosion such as stress corrosion cracking. The corrosion resistance of aluminum alloy 7075 can be improved by developing new heat treatment process in order to obtain optimum mechanical properties and susceptibility to corrosion. In the sample preparation, aluminum alloy 7075 will go to solution heat treatment at 470 °C for one hour and followed by cold water quenching. The quenched samples have preheated for age hardening at 120 °C for 24 hours. Then, the surface retrogression and re-aging process has applied to the sample in the T6 condition to improve the resistance to stress corrosion cracking (SCC) and oil is use as medium for retrogression process. Temperature (170˚C, 190˚C and 210˚C) and time (10 minutes and 30 minutes) is the variable that use for the SRRA process. Samples that have done with surface retrogression method then have re-aging at 120 °C for 24 hours. Hardness value of SRRA is 88.5 HRB that reduced 1% compared to T6(89.4 HRB). Maximum stress of SRRA sample is 634.17 N/mm^2 that is sacrificed around 3% when compared to T6 (655.53 N/mm^2). Corrosion penetration rate when sample not subjected to force for SRRA sample was improved that is 0.003 mpy compare to T73 (0.011 mpy) and when sample is subjected to 55 kN force the corrosion penetration rate show the increased value which SRRA is 0.0020 mpy and T73 is 0.029 mpy. This properties is influence by precipitation of η-phase and η'-phase inside grain and also inside grain boundary.

ABSTRAK

.Aluminium aloi 7075 telah digunakan secara meluas sebagai bahan binaan untuk industri penerbangan kerana mempunyai sifat yang menarik seperti berkepadatan rendah dan juga berkekuatan tinggi. Namun begitu aluminium aloi 7075 senang terdedah kepada kakisan seperti kakisan tekanan retak. Rintangan terhadap kakisan aluminium aloi 7075 boleh diperbaiki dengan proses rawatan haba yang bertujuan untuk mendapatkan sifat mekanikal yang optimun dan kakisan yang rendah. Dalam penyediaan sampel, aluminium aloi 7075 akan dirawat dengan proses "solution heat treatment" pada suhu 470°C selama 1 jam dan diikuti dengan pelindap-kejutan mengunakan ais. Sampel yang telah terlindap-kejut akan dipanaskan kembali pada suhu 120 °C selama 24 jam. Kemudian, proses SRRA dilakukan pada sampel untuk meningkatkan keupayaan melawan kakisan tekanan retak dengan mengunakan minyak pelincir sebagai medium untuk proses "retrogression". Pembolehubah yang dikawal adalah suhu (170 °C, 190 °C dan 210 °C) dan masa (10 dan 30 minit). Sampel kemudian dipanaskan kembali utuk proses penuaan selama 24 jam pada suhu 120 °C. Nilai kekerasan SRRA adalah 88.5 HRB iatu pengurangan sebanyak 1% berbanding T6(89.4 HRB). Niali tegasan maksimun SRRA adalah 634.17 N/mm^2 iatu pengurangan sebanyak 3% berbanding T6(655.53 N/mm^2). Kadar penembusan kakisan apabila sampel SRRA tidak dikenakan daya semakin baik iatu 0.003 mpy bila dibandingkan dengan T73(0.011 mpy) dan apabila daya dikenakan sebanyak 55 kN pada sampel, ia menunjukkan kadar penembusan kakisan meningkat iatu untuk SRRA adalah 0.0020 mpy dan T73(0.029 mpy). Sifat-sifat ini adalah kesan pengaruh pemendakan fasa-η dan fasa-η' ke dalam bijiran dan juga sempadan bijiran.

DEDICATION

To my father; Zuhaimi Bin Zakaria, my mother; Norma Binti Ismail, my siblings and my friends. Your love is my driving force.

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To Alans Ng that mostly guide me in this project

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Thank you.

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LIST OF ABBREVIATIONS, SYMBOLS AND NONENCLATURES

AA	-	Aluminum Alloy
Al	-	Aluminum
ASTM	-	American Society for Testing and Material
Cr	-	Chromium
Cu	-	Copper
Fe	-	Ferum
GP	-	Guinier Presston
HNO_3	-	Nitric Acid
Mg	-	Magnesium
Mn	-	Manganese
MPa	-	Mega Pascal
OM	-	Optical Microscope
RRA	-	Retrogression and Re-Aging
Sc	-	Scandium
SCC	-	Stress Corrosion Cracking
SEM	-	Scanning Electron Microscope
SHT	-	Solution Heat Treatment
Si	-	Silicon

SRRA	-	Surface Retrogression and Re-Aging
TEM	-	Transmission Electron Microscope
Ti	-	Titanium
UTM	-	Universal Testing Machine
Zn	-	Zinc
Wt%	-	Weight percent

CHAPTER 1
INTRODUCTION

1.1 Background of This Project

Aluminum is one of most prevalent metallic elements in the solid portion of the earth's crust, comprising approximately 8%. It is always present in a combined form, usually a hydrated oxide, of which bauxite is the primarily ore (Schweitzer 2007). Aluminum also have many outstanding attributes that lead to a wide range applications including; good corrosion and oxidation resistance; high electrical and thermal conductivity; low density; high reflectivity; high ductility and reasonable high strength; and relatively low cost (Campbell 2008).

Aluminum alloy 7075, with nominal composition of 5.6% Zn, 2.5% Mg, 1.6% Cu, 0.3% Cr, has one of the highest attainable strengths of all aluminum alloys. Aluminum alloy 7075 have been widely used in as material in aeronautical, sports and transportation due to comprehensive properties such as low density, ductility, high strength, toughness and also their resistance to fatigue. However, Aluminum alloys 7075 have several failure such as sensitive to localized corrosion such as exfoliation corrosion, inter-granular cracking and also stress corrosion cracking (SCC) same as another 7xxx-series. (Li *et al*., 2008). Corrosion is a major concern involving the structural integrity of aircraft structure.

Heat treatment T6 treatment is the process to improved corrosion resistance of Aluminum Alloys 7075 that posses high strength but the ability to localized corrosion resistance is very weak. To overcame this problem, over-aging treatment is develop such as T73, T76 and T74. Aluminum alloys 7075 have new ability which

are high strength and also high stress corrosion resistance after do retrogression and re-aging. Usually heat treatment for Aluminum alloy 7075 is T6, T73 and RRA by using furnace. But sometimes oil is used as medium for treating AA 7075. Specimen is put in the oil and then heat the oil.

In order to improve the compromise between mechanical strength and corrosion resistance, it has been proposed to replace the traditional two-step heat treatment of these alloy by a three-step heat treatment called RRA which has been shown to offer a stress corrosion resistance as good as that T73 and offering a strength comparable of that T6 temper. (Marlaud *et al.,* 2010).

Several studies reported that the main microstructural changes during retrogression are partial dissolution of GP zones and fine η' $MgZn_2$ precipitated in the aluminum matrix grains that are re-precipitated during the re-aging process, while the η $MgZn_2$ precipitated in the grain boundaries is allowed to form and grow. The microstructure result from RRA is fine and homogenous distributed η' $MgZn_2$ precipitated in the aluminum matrix grains and η $MgZn_2$ precipitates in the grain boundaries. This combination results in good performance on both SCC and mechanical strength. (Yan *et al.*, 2011).

This project is to study about the effect of different heat treatment on surface retrogression on Aluminum alloy 7075. Three different type of heat treatment process, namely T6, T73 and Surface Retrogression are applied on aluminum alloy 7075. For observe microstructure after heat treatment process, Optical Microscope (OM) and Scanning Electron Microscope is done to Aluminum Alloy 7075. Tensile test by using hardness test (Rockwell) is applied to determine the mechanical properties of the specimen.

1.2 Problem Statement

The aluminum alloy 7075-T6 has been widely used for structural application in many aircraft design. The addition of Cu greatly improve the mechanical strength of this alloy by precipitation hardening. Meanwhile, 7075 alloys are susceptible to stress corrosion cracking (SCC) particularly when stress through thickness. SCC of 7075-T6 has frequently occur in service. To combat the SCC problem, a number of T7 temper have been develop for 7xxx alloys but in comparison to 7075-T6, there is strength reduce around 10-15%. An alternative is to perform the retrogression and re-aging (RRA) heat treatment on part purchased in T6 condition. Retrogression and re-aging (RRA) is heat treatment process performed on aluminum alloy 7075 in the T6 temper condition to improve its resistance to corrosion while at same time maintaining the high strength level required for aircraft structure application. There is small lost in strength, e.g. the RRA yield strength is typically 515 MPa compared to 530 MPa for same material in T6 condition. The corrosion resistance measured by stress corrosion cracking (SCC) are significantly better than T6 condition and approach that over-aging T73.

One of the problem with 7075 and similar alloys when they are heat treated to the peak-aged T6 temper has been stress corrosion cracking (SCC). Thick plate, forging and extrusions of these alloys are particularly vulnerable when stress in the through-the-thickness (short transverse) direction. In response to these in-service in failure, a number of over-aged T7 temper have been develop but there is some sacrifice in strength properties. Additional over-aged temper T77 have been develop that provide strength, SCC and exfoliation corrosion resistance. This tamper is a variation of a treatment called retrogression and re-aging. (Campbell, 2008).

According to Yan *et al*., (2011), adding Sc as alloying element can impart an attractive combination of strength, ductility and enhance crack growth resistance. These property improvement are attributed to Al_3Sc dislocation interactions. However, the poor corrosion resistance of aluminum alloy 7075 has not been fully overcome by adding Sc to aluminum alloy 7075. Some literatures reported that SCC resistance could improved by over-aging treatment but loss strength around 10-15 %.