RETROGRESSION AND REAGING (RRA) HEAT TREATMENT PROCESS AND THE EFFECT ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ALUMINIUM ALLOY 7075

MOHD NAZIZI BIN SUNGIP

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Fakulti Kejuruteraan Mekanikal (FKM)
Universiti Teknikal Malaysia Melaka (UTeM)

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"I have read this literary work and that in my opinion it is fully adequate,
in scope and quality, as a masterpiece for the degree of
Bachelor of Mechanical Engineering (Structure & Material)"

Signature : _____

Supervisor Name : MRS SITI HAJAR BT SHEIKH MD FADZULLAH

Date : 06 APRIL 2009

"I hereby declare that all information in this document has been obtained and presented accordance with academic rules and ethical conduct. I have fully cited and referenced all materials and results that are not original to this work"

Signature : _____

Name : MOHD NAZIZI B SUNGIP

Date : 06 APRIL 2009

To my beloved family and friends

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ABSTRACT

A new pattern of heat treatment is produced known as retrogression and reaging (RRA) heat treatment to increase strength and hardness of aluminium alloy 7075 due to the need of high strength in application such as in aerospace industry. From the previous study, RRA heat treatment is done in two stages; retrogression process and reaging process. In this project, aluminium alloy 7075 is studied to determine its mechanical behaviour as an effect of RRA heat treatment. During retrogression process, materials are subjected at 200^{o}C for 5, 10, 20 and 40 minutes and followed by reaging process which is carried out at 120^{o}C for 24 hours. The material is tested for hardness and impact energy profile after RRA treatments. These profiles showed that the strength and toughness of material is exhibited slightly higher than original T6 temper. These increments are much related to the microstructural characteristic of the material. In the T6 temper, the structure primarily consists of a fine distribution of η' particles. The initial decrease in strength during the retrogression treatment is mainly due to the dissolution of small η' particles. During this condition, coarsening of grain boundary precipitates occurs resulting in an increase in the volume fraction of grain boundary precipitates as same with microstructure of T73. The function of the reaging is to promote re-precipitating of η'. The microstructure is similar with T6 but slightly denser and coarser and mores stable in nature. Thus, the used of RRA treatment is been a good way in enhancing the mechanical properties of aluminium alloy 7075.

ABSTRAK

Satu kaedah rawatan haba mundur telah dihasilkan dikenali sebagai proses kemerosotan dan penuaan semula rawatan haba mundur bagi meningkatkan kekuatan dan ketahanan aloi aluminium 7075 untuk keperluan aplikasi yang menggunakan kekuatan bahan seperti dalam industri aeroangkasa. Menurut kajian yang terdahulu, proses kemerosotan dan penuaan semula rawatan haba mundur ini telah dilakukan dalam dua peringkat; proses kemerosotan dan proses penuaan semula. Dalam projek ini, aloi aluminium 7075 telah dikaji bagi mengenalpasti sifat mekanikalnya kesan daripada tindakbalas proses kemerosotan dan penuaan semula rawatan haba mundur ini. Bagi proses kemerosotan, bahan dipanaskan pada suhu 200 ^{o}C selama 5, 10, 20 dan 40 minit diikuti proses penuaan semula, dipanaskan pada suhu 120 ^{o}C selama 24 jam. Spesimen kemudiannya diuji profil kekuatan dan ketahanan nya. Profil-profil ini menunjukkan, kekuatan dan ketahanan bahan meningkat sedikit berbanding pada keadaan T6. Peningkatan ini banyak bergantung kepada karakter mikrostrukturnya yang terhasil. Pada keadaan T6 ini, struktur pada mulanya terdiri daripada pembahagiaan butir η' yang baik. Penurunan awal kekuatan bahan ketika proses kemerosotan adalah disebabkan pembubaran butir kecil η'. Pada keadaan ini, mendakan butiran sempadan menjadi kasar menyebabkan pertambahan pecahan isipadu pada butiran sempadan, sama seperti yang berlaku pada keadaan T73. Fungsi penuaan semula adalah untuk mengembalikan mendakan η'. Mikrostruktur yang terhasil adalah sama seperti keadaan T6, tetapi lebih padat dan kasar dan lebih stabil pada keadaan semulajadi. Oleh yang demikian, rawatan kemerosotan dan penuaan semula ini adalah suatu langkah yang baik bagi meninggikan sifat mekanikal aloi aluminium 7075.

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LIST OF SYMBOL

Cu	=	Copper
Mn	=	Manganese
Mg	=	Mangnesium
Si	=	Silicon
Cr	=	Cromat
Zn	=	Zinc
F	=	Fahrenheit
^{o}C	=	Degree Celsius
$\bar{\ell}$	=	average length
ASTM	=	American Society Testing Material
Kg	=	kilogram
Mpa	=	mega Pascal
kPa	=	kilopascal
wt	=	weight
h	=	hour
mm	=	millimetre
η'	=	nucleation site
η	=	equilibrium precipitate
GP	=	Guiner Preston
HRB	=	Hardness Rockwell (Scale B)
kJ	=	kilo Joule
BCC	=	body-centred cubic
FCC	=	face-centred cubic

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CHAPTER 1

INTRODUCTION

1.1 Overview

Aluminum is a silverish white metal that has a strong resistance to corrosion and like gold, is rather malleable. It is a relatively light metal compared to metals such as steel, nickel, brass, and copper with a specific gravity of 2.7. Aluminum is easily machinable and can have a wide variety of surface finishes. It also has good electrical and thermal conductivities and is highly reflective to heat and light. Aluminum alloys are lightweight and strong, but do not possess the corrosion resistance of pure aluminum. Pure aluminum is too soft for most structural applications and therefore is usually alloyed with several elements to improve its corrosion resistance and of course to increase the strength.

Aluminum 7075 is one of the highest strength aluminum alloys available. Its strength to weight ratio is excellent and it is ideally used for highly stressed part. It may be formed in annealed conditions and subsequently heat treated. It is available in the clad form to improve the corrosion resistance with the over-all high strength being only moderately affected. This aluminum 7075 is widely used where highest strength is needed such as in aerospace industry; construction of aircraft structure like wings and fuselages, rock climbing equipment and also in producing bicycles components.

1.2 Problem Statement

Retrogression and reaging heat treatment (RRA) is a treatment process of changing the mechanical properties, the metallurgical structure of a metal product. In aluminum alloy, it is frequently used to increase strength and hardness of the precipitation hardenable alloys.

In the previous studies of RRA shows that RRA are capable of producing a material with mechanical and stress corrosion strengths at higher temperature. This study is carried out to study whether RRA at lower temperature ranges produces the same positive effect on the mechanical properties of aluminum alloy.

1.3 Objective

The objectives of this project are:

(a) To study the retrogression and heat treatment process at lower temperature range.

(b) To study the effect on microstructure and mechanical properties of aluminum alloy 7075.

1.4 Scope

The scopes of this project are:

(a) To carry out RRA heat treatment process for aluminum alloy 7075.

(b) To carry out mechanical testing after heat treatment process.

(c) To study the microstructures characterization of the RRA heat treatment aluminum alloy 7075 followed by mechanical testing.

1.5 Planning and Execution

The overview of research activities involved is tabulated in Table 1.1 and Table 1.2 respectively.

Table 1.1: Planning and Execution for PSM I

RESEARCH ACTIVITY	JULY				AUGUST				SEPTEMBER				OCTOBER	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1. Literature Review														
2. Research Methodology														
a) Research Overview														
b) Design of Experiment														
i. RRA Heat Treatment														
ii. Mechanical Testing														
c) Analysis of Result														
3. Report Writing for PSM I														
4. Preparation for PSM Seminar I														
5. Submission of PSM Report and Log Book														

Table 1.2: Planning and Execution for PSM II

RESEARCH ACTIVITY	DECEMBER		JANUARY				FEBRUARY				MARCH				APRIL	
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16
1. Literature Review																
2. Experimental Activities																
a) Specimen Preparation																
b) RRA Heat Treatment																
i. Aging Process																
ii. Retrogression Process																
iii. Reaging Process																
c) Surface Analysis																

d) Mechanical Testing																
i. Hardness Test																
ii. Impact Test																
3. Result Analysis																
4. Report Writing for PSM II																
5. Submission of PSM Report & Log Book																
6. Preparation for PSM Seminar II																

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss more detail about all key components related to this topic such as aluminum alloy, aluminum 7075, retrogression and reaging (RRA) heat treatment, hardness test, impact test and microstructure characterization.

2.1 Aluminum Alloys

Aluminum alloys are mixtures of aluminum with other metals, often with copper, zinc, manganese, silicon, or magnesium. They are much lighter and more corrosion resistant than plain carbon steel, but not as corrosion resistant as pure aluminum. Bare aluminum alloy surfaces will keep their apparent shine in a dry environment due to the formation of a clear, protective oxide layer. Galvanic corrosion can be rapid when aluminum alloy is placed in electrical contact with stainless steel, or other metals with a more negative corrosion potential than the aluminum alloy, in a wet environment. Aluminum alloy and stainless steel parts should only be used together in water-containing systems or outdoor installations if provision is made for either electrical or electrolytic isolation between the two metals.