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EFFECT OF RE-SOLUTION HEAT TREATMENT TEMPERATURE ON THE IMPACT TOUGHNESS OF AN ALUMINUM ALLOY FOR AUTOMOTIVE APPLICATION

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I hereby declare that this project report is written by me and is my own effort and there is no part has been plagiarized without citations.

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ABSTRACT

The effects of resolution heat treatment temperature on the impact toughness of an aluminum alloy for aluminum alloy were study. 6061-T6 aluminum alloy were heat treated for four different re-solution treatment temperatures at 2 hour (520˚C, 540˚C, 560˚C and 580˚C). Brinell Hardness Test and Charpy Impact Test were conduct after all the heat treatment had been done. From hardness test show that highest hardness was achieved at the highest temperature for heat treated aluminum alloy but the hardness value of non heat treated sample is obviously increased. From impact toughness, the result show that heat treated sample is proportional to the increasing of heat treatment temperature. Microstructure characterizations that were carried out by optical microscope using image analyzer showed that as the solution treatment temperature increased the precipitates and the grains coarsened.

ABSTRAK

Objektif utama kajian ini ialah mengkaji kesan rawatan haba semula 6061-T6 aluminum aloi. Rawatan haba semula ke atas 6061-T6 aluminum aloi dilakukan dalam keempat keadaan selama dua jam pada suhu yang berlainan iaitu 520˚C, 540˚C, 560˚C dan 580˚C. Ujian kekerasan Brinell dan ujian hentaman Charpy dijalankan setelah kesemua rawatan haba telah dilakukan. Daripada ujian kekerasan menunjukkan bahawa nilai tertinggi kekerasan dicapai pada suhu tertinggi rawatan haba ke atas aluminum aloi berbanding nilai kekerasan ke atas aluminum aloi tanpa rawatan haba jelas sekali tinggi. Hasil daripada ujian hentaman menunjukkan bahawa haba dirawat sampel ialah berkadar untuk terus ke atas penambahan suhu rawatan haba. Gambaran mikrostruktur yang telah dijalankan mengunakan mikroskop optik imej penganalisis menunjukkan bahawa zarah-zarah specimen disebarkan dan bertambah.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Heat treatable aluminum alloys gain strength from subjecting the material to a sequence of processing steps called heat treatment, quenching and aging. Developing solution heat treatment times and temperature has typically involved extensive trial for the impact testing and various experiment, sequentially to get the best results.

After heat treatment process, impact test will be proceeding to investigate the toughness of 6061-T6 aluminum alloy. Hardness test will be also conducted to examine the effect of various in precipitation of heat treatment. Microstructures will be observed at after heat treatment process a different temperature.

This study the effect of re-solution heat treatment temperature on the impact toughness of an aluminum alloy in automotive application. As we know, most part in the automotive use aluminum alloy as the main body because it is light and applicable. 6061 aluminum alloys is the major usage in automotive industry, such as body components, suspension parts, driveshafts, wheels, and also the fuel delivery systems.

1.2 Problem statement

Aluminum intensive automotives include with its aluminum body, aluminum front and rear axle, and numerous other aluminum components. Lighter vehicle tend to consume less fuel. Aluminum alloys is used for the purpose of making them lighter, glossy, and corrosion-resistant. Thus, re-solution heat treatment is done to increase the strength of an aluminum alloy. Characterization studies were carried out by optical microstructure, impact toughness test and hardness test.

Heat treatment of aluminum alloys is done for the purpose of making them more like pure aluminum, which is light, glossy, and corrosion-resistant. The heat treatment of aluminum alloys strengthens their hardness and electrical conductivity, thus making them even more suitable for the manufacture of automotive components.

Solution heat treatment is heat treatment of aluminum method is usually done to increase the strength of an alloy. It involves heating an alloy at a high temperature for a specific period of time, and then rapidly cooling or quenching the material by immersing it in water.

1.3 Objectives

The objectives of this dissertation are to;

(a) Study the effect of re-solution heat treatment temperature on the impact energy of an aluminum alloy.

(b) Study the microstructures characterization of re-solution heat treated aluminum alloy.

1.4 Scopes

The scopes of this dissertation are to:

(a) Study the parts of automotive that used aluminum alloy.
(b) Carry out impact and hardness testing on aluminum alloy before and after re-solution heat treatment.
(c) Study the microstructure characterization of re-solution heat treated aluminum alloy using optical microscopic with image analyzer.

CHAPTER 2

LITERATURE REVIEW

2.1 Aluminum alloy

Aluminum is a silvery and ductile member of the poor metal group of chemical elements. It has symbol Al and atomic number 13. Aluminum alloys used in many industries to manufacture a large variety of products and is very important to the world economy, such as modern aircraft, other area transportation and building due to its high strength to weight ratio. The strength and durability of aluminum varies widely, plus a learning-curve in employing it, has from time to time gained aluminum a bad reputation. This has happened in both bicycle and automotive applications, but in both cases has proven to be correctable with proper engineering considerations.

Adding alloying elements to enhance the physical properties of aluminum for specific purposes creates these alloys. Wrought aluminum alloys are designated using a four-digit system, with the first digit specifying the alloying element. In the Table 2.1 is the list of major series including alloying element and general uses for each series. (www.matsci.ucdavis.edu/MatSiLT/HT_aluminum)

Table 2.1: Aluminum Alloy Series and Description

(Source:www.matsci.ucdavis.edu/matsilt/HT_aluminum)

Alloys Series	**Major alloying element**	**General properties**	**General Uses**
1xxx	none	Excellent corrosion resistance, high thermal and electrical conductivities, low mechanical properties, excellent workability	Chemical Equipment, reflectors, heat exchangers, electrical conductors
2xxx	Copper	Heat treatable, high strength to weight ratio, limited corrosion resistance, limited weldabilty	Truck wheels, truck suspension components, aircraft fuselage
3xxx	Manganese	Moderate strength without heat treating	Beverage cans, cooking utensils, heat exchangers, storage tanks
4xxx	Silicon	Low thermal expansion, high wear resistance	Forged engine pistons, welding rod, brazing alloys, architectural products,
5xxx	Magnesium	Good weldability, good corrosion resistance,	Ornamental trim, cans, household appliances, boats and ships
6xxx	Magnesium and Silicon	Heat treatable, good formability, moderate-strength, good weldability, good machinability, good corrosion resistance,	Architectural applications, bridge railings, welded structures, racecar components
7xxx	Zinc	Heat treatable, moderate to very high strength	Airframe structures, high-strength forgings,

Aluminum alloy produced in wrought form such as sheet, plate, extrusions, rod and wire are classified according to the major alloying elements they contain. A four-digit numerical designation is used to identify aluminum wrought allots. The first digit indicates the alloy group that contains specific alloying elements. The last two digits identify the aluminum alloy or indicate the aluminum purity. The second digit indicates modification of the original alloy or impurity limits. (Smith W. F., 2004). The general properties of aluminum alloy show in Table 2.2.

Table 2.2: Properties of Aluminum alloy (Source:www.matweb.com/specificmaterial)

Physical Properties	**Metric**
Density	2600-2800 kg/m^3
Mechanical Properties	
Modulus of Elasticity	70 GPa
Poisson's Ratio	0.33
Shear Modulus	26 GPa
Thermal Properties	
Heat of Fusion	390 J/g
Specific Heat Capacity	0.88 J/g-°C
Thermal Conductivity	190 W/m-K
Melting Point	620 - 650 °C
Solidus	620 °C
Liquidus	650 °C

2.1.1 Temper Designations of Aluminum Alloy

Temper designations for wrought aluminum alloys follow the alloy designation and are separated by a hyphen. Subdivisions of a basic temper are indicated by one or more digits and follow the letter of the basic designations, for example, 1100-H14. The temper designation system is used to specify the condition, or temper, of a heat treatable alloy. The most common designations include O (sometimes erroneously referred to as TO), F, T4 and T6. T4 designates that the alloy was solution heat treated and naturally aged. T6 is sometimes referred to as fully heat treated and is the result of solution heat treating and artificial aging. (www.matsci.ucdavis.edu /HT_aluminum)

Table 2.3: Basic Temper Designations (Source: Smith W. F., 2004)

Designations	Description
F	As fabricated. No control over the amount of strain hardening, no mechanical property limits
O	Annealed and recrystallized. Temper with the lowest strength and highest ductility
H	Strain-hardened
T	Heat-treated to produces stable tempers other than F or O

2.1.2 6061-T6 Aluminum Alloy

6061-T6 is an aluminum alloy with magnesium and silicon as the alloying element. The first digit of the aluminum alloy designation, “6”, means that the Al alloy contains magnesium and silicon. The relative weight percentages (wt.%) are given by the third and the fourth digits, where “6” means that there is 0.6 wt.% Si and “1” means that there is 1.0 wt.% Mg, respectively. The second digit “0” means that no other alloying elements were used. It has generally good mechanical properties and is heat treatable, weldable and corrosion resistance. It can be fabricated by most of the commonly used techniques. 6061 has a density of 2.70 g/cm³ (0.098lb/in³). In the annealed condition it has good workability. The full T6 properties can be obtained by artificial aging.

2.1.3 Aluminum Alloys in Automotive Application

The aluminum industry distinguishes one alloy from another through a standardized numbering system are used. Wrought alloys and cast alloys are commonly used in automotive. Cost, both material and manufacturing, is the largest barrier to the use of aluminum in automotive applications. The lead time, risk and investment are higher for aluminum. The infrastructure to support wide application of aluminum bodies needs to be developed. The need to improve fuel economy and reduce emissions is an opportunity to expand the automotive applications of aluminum, particularly in body structures. Research is making significant contributions to improving the technologies for aluminum vehicles. (www.cs.virginia.edu/icaa7/trends)

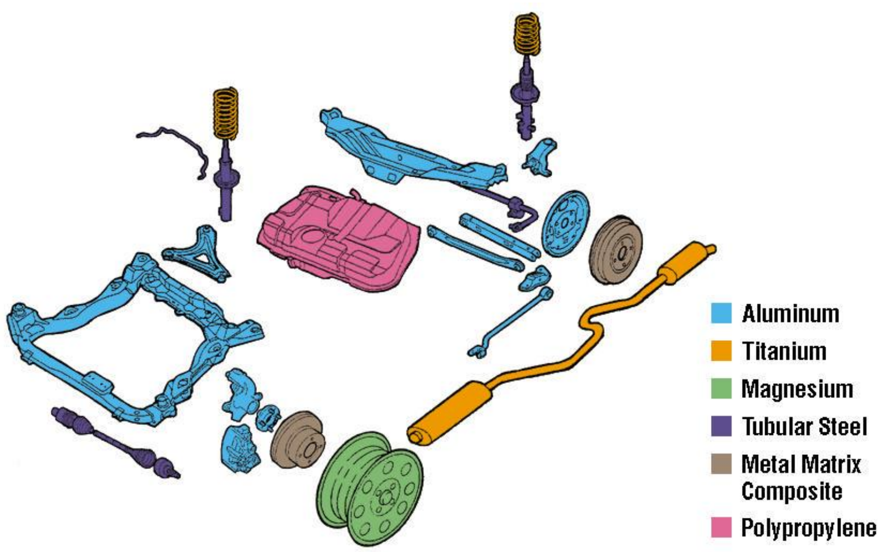

Figure 2.1: Chassis material usage (www.cs.virginia.edu/icaa7/trends)

Magnesium is one of the most effective and widely used alloying elements for aluminum, and is the principal element in the 5000 series alloys. When it is used as the major alloying element or combined with manganese, the result is a moderate- to high-strength, non-heat-treatable alloy. Alloys in this series are readily weldable and have excellent resistance to corrosion, even in marine applications.

Alloys in 6000 series aluminum alloys utilize magnesium and silicon in various proportions to form magnesium silicon, making them heat treatable. A major alloy in this series is 6061, one of the most versatile of the heat-treatable alloys. The magnesium-silicon alloys possess good formability and corrosion resistance with high strength.

Table 2.4: 5000, 6000 and 7000 series aluminum alloy in automotive application.
(Source: www.autoaluminum.org/main/index)

Series	Applications
5052	Interior panels and components, truck bumpers and body panels
5182	Inner body panels, splash guards, heat shields, air cleaner trays and covers, structural and weldable parts, load floors (sheet)
5454	Various components, wheels, engine accessory brackets and mounts, welded structures (i.e. dump bodies, tank trucks, trailer tanks)
5754	Inner body panels, splash guards, heat shields, air cleaner trays and covers, structural and weldable parts, load floors (sheet)
6009	Outer and inner body panels, load floors, bumper face bars, bumpers reinforcements, structural and weldable parts, seat shells
6010	Outer and inner body panels, seat shells and tracks

6061	Body components (extruded), brackets (extruded and sheet), suspension parts (forgings), driveshafts (tubes), driveshaft yokes (impacts and forgings), spare tire carrier parts (extruded), bumper reinforcements, mechanical fasteners, brake cylinders (extruded), wheels (sheet), fuel delivery systems
6063	Body components (extruded)
6082	General structural, brake housings
6111	Body panels
6262	Brake housings, brake pistons, general screw machine parts (anodized)
6463	Luggage racks, air deflectors
7003	Seat tracks, bumper reinforcements
7004	Seat tracks, bumper reinforcements
7021	Bumper face bars, brackets (sheet), bumper face bars (bright), bumper face bars (bright anodized), bumper reinforcements
7072	Condenser and radiator fins
7129	Bumper face bars, bumper reinforcements, headrest bars (extruded), seat track

Aluminum alloys product forms include:

(i) Rolled Products - Aluminum sheet applications include heat exchangers, heat shields, bumper stock as well as closure sheet and structural sheet for complete body assemblies.

(ii) Extruded products - Applications include: space frames, suspension, seat frames and rails, sun roofs, window and door frames, and aluminum/aluminum metal matrix composite drive shafts.

(iii) Cast products - Die castings are used for pistons, transmission housings, and suspension components and aluminum metal matrix brake drums and rotors. Structural permanent mold castings are used for body structures and sub frames, and permanent mold castings for wheels used on 45% of new passenger vehicles today.