THE EFFECT OF RE-ARTIFICIAL AGING TIME ON THE IMPACT TOUGHNESS OF AN ALUMINUM ALLOY FOR AUTOMOTIVE APPLICATIONS

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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 (Automotive)”

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"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"

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ABSTRACT

Over the course of the 20th century, the automobile rapidly developed from an expensive toy for the rich into the standard for passenger transport in most developed countries. In 2006, more than 69 million motor vehicles, including cars and commercial vehicles were produced worldwide. Because of the increasing numbers of vehicle in the road; road crashes, causing death, injury, and damage have always happened. Normally vehicles are used steel to the vehicle chassis and body. Nowadays many manufacture decided to replace steel to aluminum alloy. This report will explain about effect of re-artificial aging time on the impact toughness in automotive application. Apart from that, this report will touch about process of heat treatment and test that being used do study the effect of the process. At the end of the report, the discussion of the test result will be done to get the characteristic of the aluminum alloy.

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LIST OF SYMBOLS

h	=	initial elevation of the striker, m.
S	=	length of the pendulum distance to the center of strike, m.
β	=	angle of fall
α	=	angle of rise
h_1	=	height of rise, m.
v	=	velocity, m/s.
g	=	acceleration of gravity, 9.81 m/s^2
m	=	mass of pendulum striker, kg
Δh	=	h_1-h
D	=	diameter of the ball
d_b	=	diameter of the impression
P	=	load
d_v	=	arithmetic mean of the diagonals
F_0	=	preliminary minor load, N
F_1	=	additional major load, N
F	=	total load, N
e	=	permanent increase in depth of penetration due to major load
E	=	a constant depending on form of indenter
HR	=	Rockwell hardness number

CHAPTER 1

INTRODUCTION

1.1 Overview

An aluminum alloy is a premium casting which is knows for the properties of superior strength and corrosion resistance. Cast aluminum alloy are used extensively in a variety of structural, automotive, aerospace and engineering applications. The use of aluminum alloys in automotive industry has greatly increased in recent years. Using this aluminum alloy can reduce the weight of cars; it is because it has been attributed not only to the issues of fuel economy, but also to those of safety, resource conservation and environment friendliness.

In automotive, aluminum alloy especially T6-6061(Al–Mg–Si–Cu) type its use to made body components, brackets, suspension parts, driveshaft, driveshaft yokes, spare tire carrier parts, bumper reinforcements, mechanical fasteners, brake cylinders, wheels, fuel delivery systems and many more (www.autoaluminum.com). Although aluminum alloy provide good dent resistance and strength, failure of manufactured parts in testing is a frequently recurring problem. These failures are manifested in attaining tensile stresses and total percentage elongation (ductility) below minimum requirement.

In this project, the focus of material is only T6-6061 aluminum. The effect of resolution followed by re-artificial ageing heat treatment on the mechanical properties will be studied. The specimens will be tested by two type of test which is Brinell Hardness Test and Charpy Impact Test. Investigation of the microstructure characterization will be viewed by using Optical Microscope.

1.2 Problem Statement

Nowadays, many people are more interested in looking for a low fuel consumption and safer vehicle. It is because the incasing price of fuel in world market. This means that the manufacturer has to build lighter vehicle and the material that is used to build vehicles must have good strength to weight ratio to protect driver and passengers from any impact during accident. This is due to power pr weight ratio, lighter the vehicle, less power require moving it and less fuel were used.

Heat treatment is done to increase the strength of the material or in other way to improve the mechanical properties of T6-6061. By implementing heat treatment, the material does not have to be added by any other materials o improve its mechanical properties. In addition, it can reduce the fuel consumption of the vehicle.

It will need great amount of money to invent new materials that fulfill the need in automotive industries which is good strength and light. Heat treatment looks as better way to solve this problem. The cost needed to do the heat treatment is far to low comparing to invent the new material to replace aluminum alloy. Elsewhere, titanium has better mechanical properties than aluminum alloy but with higher cost needed. By using this aluminum alloy, manufacture not only can reduce the vehicle weight and increase the vehicle safety but also can reduce manufacturing cost, so the vehicle is cheaper. These shows why implementing heat treatment to aluminum alloy still the best options in automotive industries.

1.3 Objective

The objectives of this project are:

a) To study the effect of re-artificial aging time on the impact energy of an aluminum alloy.
b) To study the microstructures characterization of the re-solution heat treatment aluminum alloy followed by re-artificial aging.

1.4 Scope

The scopes of this project are:

a) To do literature study on heat treatment of an aluminum alloy and impact toughness.
b) To take look at the parts of automotive that used aluminum alloy.
c) To carry out impact and hardness test testing on aluminum alloy before and after re-solution heat treatment followed by re-artificial aging.
d) To study the microstructures characteristic of re-solution heat treated aluminum alloy followed by re-artificial ageing using Optical Microscope.

CHAPTER 2

LITERATURE REVIEW

2.1 Aluminum Alloy

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 (www.autoroadmap.com). 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.

2.1.1 Characteristics

At extremely high temperatures (200-250°C) aluminum alloys tend to lose some of their strength. However, at subzero temperatures, their strength increases while retaining their ductility, making aluminum an extremely useful low-temperature alloy.

Aluminum alloys have a strong resistance to corrosion which is a result of an oxide skin that forms as a result of reactions with the atmosphere. This corrosive skin protects aluminum from most chemicals, weathering conditions, and even many acids, however alkaline substances are known to penetrate the protective skin and corrode the metal.

Aluminum also has a rather high electrical conductivity, making it useful as a conductor. Copper is the more widely used conductor, having a conductivity of approximately 161% that of aluminum. Aluminum connectors have a tendency to become loosened after repeated usage leading to arcing and fire, which requires extra precaution and special design when using aluminum wiring in buildings (www.autoroadmap.com).

Aluminum is a very versatile metal and can be cast in any form known. It can be rolled, stamped, drawn, spun, roll-formed, hammered and forged. The metal can be extruded into a variety of shapes, and can be turned, milled, and bored in the machining process. Aluminum can riveted, welded, brazed, or resin bonded. For most applications, aluminum needs no protective coating as it can be finished to look good; however it is often anodized to improve color and strength.

2.2 Aluminum Alloy in Automotive Industry

Aluminum alloy represents an ideal solution for achieving future vehicles because it offers automakers the opportunity to design and manufacture safe, high-performance, energy-efficient, and environmentally friendly vehicles that are much lighter than current vehicles. In addition to taking advantage of the lighter mass of aluminum alloy compared to steel for the body of the vehicle, further weight reduction is possible through secondary weight savings in the engine, transmission, brakes, wheels, tires, fuel tank, and other systems (www.autoroadmap.com). Developmental work in aluminum alloy will contribute significantly to the long-term cost-effectiveness of using this material in automobiles.

2.2.1 Aluminum Alloy Benefits

There are significant benefits in using aluminum alloy to reduce vehicular weight, provide fuel savings, reduce exhaust emissions, and enhance the performance of future automobiles. The benefits of an aluminum alloy are:

a) Weight reduction.
b) Environment protection.
c) Vehicle advantage.
d) Aluminum in vehicle cost.

2.2.1.1 Weight Reduction

It is estimated that substituting aluminum for steel in an automotive body structure optimized for aluminum will directly reduce the automobile's body structure weight by 50 percent without compromising its performance, saving typically 300 pounds in a mid-sized sedan. As a general rule, a weight reduction of 10 percent can increase the vehicle's fuel economy by 6 to 8 percent. Thus, fuel savings of 0.9 to 1.4 gallons per 1,000 miles are achievable for each 100 pounds of weight reduction. The lifetime fuel savings of lighter-weight, aluminum-intensive vehicles compared to steel vehicles will continue to range from 500 to 700 gallons of gasoline (www.autoroadmap.com).

2.2.1.2 Environmental Protection

Aluminum is also environmentally friendly. Every ton of automotive aluminum that is used to replace twice this weight of iron or steel reduces greenhouse gas emissions (CO_2 equivalent) by as much as 20 tons over a vehicular life of 120,000 miles, compared to conventional vehicles. The recyclables of aluminum is another significant factor in analyzing the life-cycle of the metal to produce vehicles. Aluminum is completely recyclable, and virtually all post-manufacturing automotive aluminum scrap is recycled. In addition, about 85 to 90 percent of post-consumer automotive aluminum scrap (about 1 billion pounds per year) is recycled (www.autoroadmap.com). The technology for handling and recycling painted sheet and castings has been established for years, and aluminum can be recycled again and again, without a decline in material performance or quality or excessive buildup of impurities.

2.2.1.3 Vehicle Advantages

While the principal reason for using aluminum for automobile construction is to reduce weight, aluminum offers many other advantages, including improved performance without having to increase engine capacity; better acceleration and braking; and excellent road holding, handling, and noise, vibration, and harshness (NVH) characteristics. The latter are a result of stiff body structures that can be achieved with both space frame and weld-bonded stamped sheet construction. With proper design, choice of alloy, and appropriate processing, aluminum components also provide excellent energy absorption. The structural stiffness and crashworthiness of aluminum bodies are equal to or superior to steel. Further, with the excellent corrosion resistance of aluminum, the crashworthiness of aluminum structures will not deteriorate with time (www.autoroadmap.com).

2.2.1.4 Aluminum-in-Vehicle Cost

Cost particularly the cost of aluminum relative to the cost of steel is the main constraint on the further use of aluminum by the automotive industry. There is little chance that aluminum prices will approach steel prices on a per-ton basis. However, automotive components are considered on a functional basis, and aluminum has a density advantage over steel of 2.7 (www.autoroadmap.com). The critical issue is the cost-effectiveness and life-cycle performance of using aluminum as compared with steel. Initial material cost is not a complete indicator of the total cost of substituting aluminum for steel or other materials. Since the use of lightweight aluminum body structures also allows automakers to downsize other parts of the car (e.g., the chassis components can be lighter and the engine smaller), there are additional savings in the vehicle's weight and cost, and further reductions in exhaust emissions during its use. This is particularly important since it has been shown that greater than 85 percent of the life-cycle CO_2 emissions occur during the use phase of the vehicle. These secondary cost savings often can be substantial (www.autoroadma.com).

2.3 Type of Aluminum Alloy

There are two type of aluminum alloy that use in automotive industries, which is wrought alloy and cast alloy that use different identification systems.

2.3.1 Wrought Alloy

The first of four-digits used to identify a wrought aluminum alloy signifies the principal alloying element. The second digit refers to some particular modification of the original alloy composition.