Faculty of Mechanical and Manufacturing Engineering Technology

STUDY OF MECHANICAL PROPERTIES OF HEAT TREATED ALUMINIUM ALLOY

Wan Mohd Amierul Bin Wan Ruzzeli

Bachelor of Manufacturing Engineering Technology

(Process and Technology) with Honours

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WAN MOHD AMIERUL BIN WAN RUZZELI

A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) With Honours

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This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

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DEDICATION

The sake of Allah, the Creator.

To Al-Quran, the greatest source of knowledge.

To my beloved parents who never stop giving support and a great source of inspiration.

To my supervisor, the one who has been a constant source of knowledge

To all my friends who encourage and give their support

ABSTRACT

Heat treatment is one of the important controlling factors used to enhance the mechanical properties of an alloy. This research about the mechanical properties of heat-treated aluminium alloy by implementing two testing which is hardness testing and tensile testing. Main problem statement of this research is to see how aluminium can be increased its hardness and strength. The main objective of this research is to determine the mechanical behaviour of heat treated aluminium alloy 6061. Another objective is to conduct the hardness and tensile testing in order to analyse the properties of the heat treated aluminium alloy. The material that is used is aluminium alloy 6061 series and had been undergone lasercut process to the dogbone shape. There are 4 specimen of dogbone shape which is will divided to two section. The first section is non heat treated while another section is heat treated. The heat treated will undergone heat treatment process which is solution heat treatment. All specimen the will go through first testing which is hardness testing by using Rockwell hardness Machine. In this testing, the specimen will be tested to get the value of the hardness of each specimen. The second process is tensile test. In tensile testing, result of max load, Ultimate tensile Strength and Young's Modulus are been investigated. In tensile testing, the result show the change in mechanical properties of the heat treated. From the hardness result also, we can see the difference of method use in testing the hardness value. In conclusion, the aluminium alloy become more ductile compare to the normal after analysing the graph.

ABSTRAK

Rawatan haba adalah salah satu faktor pengawalan penting yang digunakan untuk meningkatkan sifat mekanik aloi. Kajian ini mengenai sifat-sifat mekanik aloi aluminium yang dirawat haba dengan melaksanakan dua ujian iaitu pengujian kekerasan dan pengujian tegangan. Pernyataan masalah utama penyelidikan ini adalah untuk melihat bagaimana aluminium dapat meningkatkan kekerasan dan kekuatannya. Objektif utama penyelidikan ini adalah untuk menentukan tingkah laku mekanikal aloi aluminium yang dirawat haba. Objektif lain adalah untuk menjalankan kekerasan dan ujian tegangan untuk menganalisis sifat aloi aluminium yang dirawat haba. Bahan yang digunakan adalah aloi aluminium 6061 dan telah menjalani proses *lasercut* dengan bentuk *dogbone*. Terdapat 4 spesimen bentuk *dogbone* yang akan dibahagikan kepada dua kategori. Kategori pertama adalah yang dikenakan rawatan haba manakala kategori yang kedua adalah yang dikenakan rawatan haba. Semua spesimen akan melalui ujian pertama iaitu ujian kekerasan dengan menggunakan Mesin Kekerasan Rockwell. Dalam ujian ini, spesimen akan diuji untuk mendapatkan nilai kekerasan setiap spesimen. Ujian kedua adalah ujian tegangan. Dalam ujian tegangan, hasil beban maksimum, *Ultimate Tensile Strength* dan *Young's Modulus* telah disiasat. Dalam ujian tegangan, hasilnya menunjukkan perubahan di dalam sifat mekanikal spesimen yang dikenakan rawatan haba. Dari hasil kekerasan juga, kita dapat melihat perbezaan penggunaan kaedah dalam menguji nilai kekerasan. Sebagai kesimpulan, aloi aluminium menjadi lebih mulus berbanding dengan normal selepas graf dianalisa.

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LIST OF ABBREVIATIONS

UTeM	-	Universiti Teknikal Malaysia Melaka
ASTM	-	American Society for Testing and Materials
MPa	-	Megapascal
N	-	Newton
HV	-	Vickers Pyramid Number (unit of hardness)
HRB	-	Type of scales in Rockwell Hardness
UTS	-	Ultimate Tensile Strength

CHAPTER 1

INTRODUCTION

The first section of this report explains the background of this research, problem statement, objectives, scope and general methodology further as the expected result from this research. This report is to show the reader a lot closer in the study of mechanical properties of aluminium alloys.

1.1 Background

Aluminium is nice and light, but as an easily crushable soft drink can shows, that come at the cost of strength. It is also one of the most common metal present in our lives. It is because it's highly sought after in many industrial application in which the metal possess sensible characteristics. Thus, making it a viable choice over other metals. The properties mentioned including highly strength in compression, shear, toughness and tension. Furthermore, it also provide a significant strength to ratio for density, a high resistance in corrosion, and the material is rather affordable, easy to acquire and rather unchallenging to use. No matter how good some metals are, it is still susceptible to a failure, and aluminium is one of them.

From back then until now, continuous researches have been done so that the properties of the aluminium material can be improve by increasing their strength and others.

It is important to know the reliability of the material by conducting study of the mechanical properties of the material.

1.2 Problem Statement

Aluminium alloys have two types which is non-heat treated and heat treated. Heat treatment is only appropriate to the alloys that are heat treatable. Then, by a process called rapid quenching the alloys are retained. Aluminium are weak material without combining with other material and can melt if exposed to some heat. Therefore this research will see how aluminium can be increased its hardness and strength. So we are conducting an experiment which will examine its material properties before and after heat treatment process.

To get a better result, the alloys that will be into solution must have sufficient time. It also need a good time at temperature but depending on the alloy type and the loads of furnace. In the early phase of the overheating, are not obvious but will result a change in mechanical properties. So, overheating must be avoided to eliminate some failures.

1.3 Objective

The objective of this project is as below:

1. To study the difference of mechanical properties of aluminium alloys before and after heat treatment process.
2. To conduct and analyse hardness and tensile test of the aluminium alloys in order to study the mechanical properties of the material.

1.4 Scope

This research is to examine the mechanical properties of aluminium alloys. These aluminium alloys have many categories which are non-heat treatable and heat treatable. Non heat treatable alloys cannot undertake heat treatment process, so the experiment will only applied to the heat treatable aluminium alloys only. The only test that will applied to the specimen is hardness and tensile testing.

1.5 General Methodology

The writing of the report is based on the primary source which is from journal, article and as well as trusted source in internet. The secondary source is from book that are borrowed from UTeM's library.

1.6 Thesis Outline

Chapter 1 is an overview of the research project includes material use, techniques or approach use in determining the material properties. In this chapter also, the problem statement, objectives, scope, and general methodology are stated.

Chapter 2 is about the research about the mechanical properties, aluminium alloys and heat treatment process. The result of the research has given the general idea and information to conduct the experiment and show the best method to use in the project.

Chapter 3 discuss the flow of the project. It also explained the procedures that are used in order to complete the project.

Chapter 4 is the result achieve from the testing which is hardness and tensile. In this chapter also, the error in achieving the result also been stated.

Chapter 5 is the conclusion of the overall project report and contain some future work and recommendation.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Heat treatment is one of the important controlling factors used to elevate the mechanical properties of an alloy (Taherishargh 2014).

Mechanical properties are the physical properties of a material when it is deformed by elastic or inelastic behaviour when mechanical forces are used. A mechanical properties of a material is always changing and never constant. From the mechanical properties we can identify and knowing the characteristic of material. In designing structure comprises Young's Modulus of Elasticity, yield strength and tensile strength, some measured properties must be considered. As stated by Alexandar Borydyuk (2013), materials scientist studies by testing materials about mechanical properties. The test's outcome depends on the way of performing test, the shape and size of material specimen, and how it is held. Thus, common procedures were used including ASTM's published standards.

2.1 Mechanical Properties

There are many types of mechanical properties but most commonly considered are:

i. Tensile Strength
ii. Compressive Strength
iii. Hardness
iv. Toughness
v. Elasticity
vi. Ductility
vii. Plasticity

These material properties of the most material are different with orientation. To predict the attributes of a system, some of materials properties are being used. For instance, if a material of a known specific heat gains or loses a known amount of heat, we can determined the temperature change of that material. Materials properties are most reliably measured by standardized test methods. In the journal written by Ramnath et al., (2014) there are 4 testing method that had been used by the author which is tensile test, flexural test, impact test and hardness test which is Brinell hardness test.

2.1.1 Tensile Strength

Ultimate Tensile Strength (UTS) often shortened to Tensile Strength (TS). It is the ability of a material to hold loads tending to elongate or in other words, tensile strength resist from being pulled apart. Tensile strengths are important in brittle members but rarely used in the design of ductile members. They are tabulated for common materials such as composite materials and alloys. Alexandar Borydyuk (2013) had mentioned that if the stress are too large, the strain deviated from being proportional to the stress.

Yield strength refers to level of maximum stress that can be produced in a material without causing plastic deformation. Thus, in engineering structural design, yield strength is very important. The yield strength also commonly used as upper limit for allowable stress that can be applied in design applications. In the presence of high stresses and loads, it is important in material applications that require precise dimensional tolerances to be maintained.

According to Ramnath et al., (2014) stated that at certain temperature that is increased, the tensile properties of aluminium alloy (LM 25) are affected by the condition of the castings.

In general, the yield strength increases with strain rate and decreases with temperature. Based on journal written by Prashanth et al., (2014) had stated that room temperature tensile test reveal a remarkable mechanical behaviour which is the sample show yield and strength.

2.1.2 Compressive Strength

Compressive strength is the capability of material to withstand loads tending to reduce size. In other words, it resist compression which mean being squeeze together. Compressive strength is measured on universal testing machine. Concrete and ceramics particularly have higher compressive strengths than tensile strengths. Composite materials, such as glass fiber epoxy matrix composite, tend to have higher tensile strengths than compressive strengths. Metals tend to have tensile and compressive strengths that are very similar. On compression, the specimen will be shorten. Thus, the material will tend to increase in cross sectional area and spread in the lateral direction.

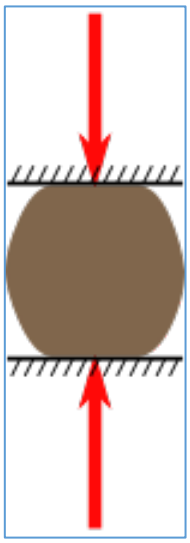

Figure 2.1: Material is being pushed together.

(https://en.wikipedia.org/wiki/File:Barelling.svg)