STRENGTHENING OF ALUMINIUM ALLOY 6061 BY USING PRECIPITATION HARDENING HEAT TREATMENT

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(Structure and Material)

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This report submitted in partial fulfillment of the requirement for the award of degree mechanical engineering (structure and material)

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Declaration

"I hereby declare that work in this report is my own except for summaries and quotations which have been duly acknowledged"

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ABSTRACT

Strengthening of aluminium alloy using precipitation hardening heat treatment involves several processes in order to achieve the objectives. The material selected is Aluminium alloy 6061 with ASTM standard. During heat treatment process, the process include such as solution treatment, precipitation hardening and over aging. In this studies, one of the specimen Aluminium alloy which is fulfill the criteria from the standard requirement will only undergo tensile test and the others will perform heat treatment process and after that will also undergo tensile test. Firstly, result will get from as delivered condition and shows that tensile stress at maximum yield load is 188.28 MPa and for solution treatment the value show is 135.96 MPa and elongation is increase to 37.2% compare to as delivered result for elongation which is 25.4%. After that, in precipitation hardening process, the result shows tensile stress at maximum load is 159.18 with elongation is 22% occur at 4 hours in precipitation hardening process. With increasing in time, over aging will occur and in this studies, after 6 hours overaging occur with result in tensile stress at maximum load is 155.32 and èlongation is 11.33%. Finally after experiments is done, the result between non heat treated and heat treated will be compared. During heat treatment process, temperature will be holding constant at 530°C in solution treatment and precipitation hardening is 200°C with variable time in order to enhance strength and ductility.

ABSTRAK

Untuk menguatkan aluminium aloi menggunakan pemendapan pengerasan melibatkan beberapa proses untuk mencapai objektif. Bahan yang dipilih adalah Aluminium aloi dan mengikut ASTM standard. Ketika proses rawatan haba, proses yang terlibat adalah kaedah penyelesaian pemanasan, pemendapan pengerasan dan proses penuaan. Dalam kajian ini, satu daripada spesimen aluminium aloi yang telah mengikut spesifikasi yang ditetapkan akan hanya melalui ujian tegangan dan selebihnya akan melalui proses rawatan haba dan selepas itu proses ujian tegangan. Pertama, keputusan eksperimen akan diperolehi pada keadaan bahan aluminium yang biasa iaitu pada beben tegasan maksimum adalah menunjukkan 188.28MPa dan kaedah penyelesaian haba pula adalah 135.96Mpa dan pemanjangan meningkat kepada 37.2% berbanding keadaan bahan keadaan biasa iaitu 25.4%. Selepas itu, paa proses pemendapan pengerasan, keputusan pada beban tegasan maksium adalah 159.18 dengan pemanjangan 22% terjadi pada 4 jam selepasa proses pemendapan pengerasan berlaku. Dengan peningkatan masa, penuaan bahan akan berlaku dan keputusan padan beban tegasan maksimum adalah 155.32 dan diikuti pemanjangannya adalah 11.33%. Akhir sekali, keputusan kajian diantara specimen yang tidak melalui proses rawatan haba dan melalui rawatan haba akan dibandingkan. Dalam proses ini, suhu akan ditetapkan pada 530°C dan 200°C dan mengikut pelbagai waktu ketika proses rawatan haba untuk meningkatkan kekuatan dan kemuluran.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering and quenching. It is noteworthy that while the term heat treatment applies only to processes where the heating and cooling are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

Each one of the material has advantage and disadvantage in industry and other application that use in structure, material composite and any others. Most of the materials give the problem with their strength, heat resistance in order to apply in industry environment. Heat treatment is one of the solutions to increase strength and hardness of the precipitation hardenable wrought and cast alloys.

In this studies about Aluminium, it is the third most plentiful element, only oxygen and silicon exist in greater quantities. The element Aluminium, chemical symbol Al, has the atomic number 13.The studies are included about strengthening of aluminium alloy 6061 by using precipitation hardening heat treatment. This series is from categories heat-treatable because the studies will apply heat treatment to achieve the objective.

This group of heat-treatable alloys uses a combination of magnesium and silicon (magnesium Silicide) to render it heat-treatable. Typical alloys in this group include 6063 and 6082.

Since the aluminium alloy have many benefit involves it's strength, hardening and others, for many years it's was apply to industrial such as in aircraft. Aluminium alloys are used extensively in aircraft due to their high strength-to-weight ratio. Besides that, aluminium alloy also have apply in automotive industry. It's used for external automotive body panels, with 5083 and 5754 series for aluminium used for inner body panels. Example for hood for a car, the hoods have been manufactured from 2036,6016, and 6111 series of aluminium alloys. Truck and trailer body panels have used 5456 series of aluminum.

1.1 PROBLEM STATEMENT

Aluminium alloy 6061 is one of most used Aluminium alloy which have moderate strength on as delivered condition. However, the mechanical properties of Aluminium alloy 6061 can be enhanced through heat treatment, i.e. precipitation hardening, to increase their strength and hardness [1]. Precipitation hardening must be carried out with optimum temperature and holding time in order to avoid over aging. If over aging occurs, the mechanical properties will decrease it's precipitate.

1.2 OBJECTIVE

- To study the mechanical properties of Aluminium alloy 6061
- To optimize holding time in order to enhance strength and ductility.
- To understand the influence of precipitate particles to the mechanical properties of Aluminium alloy 6061.

1.3 SCOPE

- In this research, the material used is limited to aluminum alloy 6061 series.
- The mechanical properties will be determined by using universal tensile test and the microstructure will be then examined.
- The strengthening mechanism will be performed by heat treatment process with holding time variable. The heat treatment process will be done in two steps namely solution treatment and precipitation hardening.
- Temperature will be holding constant 530°C and 200°C at variable time.

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

This literature review shows the investigation for the background of this experiment process and the studies for mechanical properties, heat treatment and process included in this studies. This literature review will help and give some information for experiment or process included in these studies.

2.1 Aluminimum Alloys

2.1.1 Properties of Aluminium

Aluminium and its alloys process many attractive characteristics including light weight, high thermal and electrical conductivities, a nonmagnetic nature, high reflectivity, nontarnishing nature, high resistance to corrosion, reasonably high strength with good ductility, work hardenable or heat treatable and easy fabrication. Nevertheless probably the most important characteristics of Aluminium its low density, which is about one-third that of steels and copper alloys [11]. Because of this certain Aluminium alloys have a better strength-to-weight ratio than high-strength steels.

Besides that, among the many alloying elements added to Aluminium, the most widely used are copper, silicon, magnesium, zinc and manganese shown in figure 2.1.1(a), these are used in various combinations, and in many cases they are used together with other additions to produce classes of age hardening, casting and work hardening alloys [11].

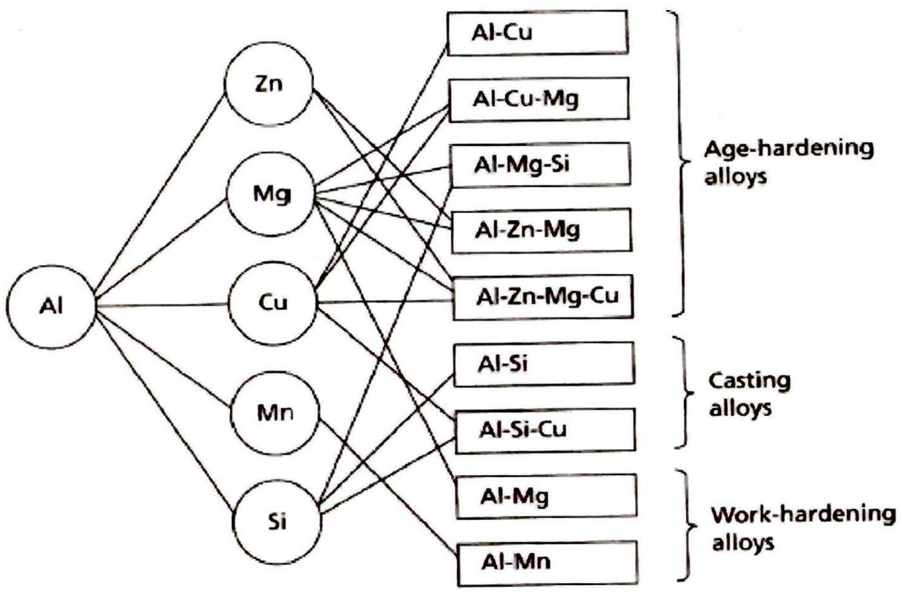

Figure 2.1.1 (a) Major Aluminium alloy system [12].

For tensile strength, aluminium alloy shows a behavior under tension is generally considered the first yardstick of an engineering material, and figure 2.1.1(b) shows typical tensile stress-strain curves for four different aluminium alloys and compares them with a range of engineering metals. The alloys are 99.5% pure aluminium (1050A) in the fully annealed state, a 4.5% magnesium-aluminium alloy (5083) after strain-hardening, by rolling, to the "half-hard" temper, used in marine a magnesium-manganese-silicon alloy 6082 after solution treatment and ageing to the fully heat treated "T6" condition, used in commercial structures and a zinc-magnesium-copper-aluminium alloy 7075 in the fully heat treated condition used in aircraft construction.

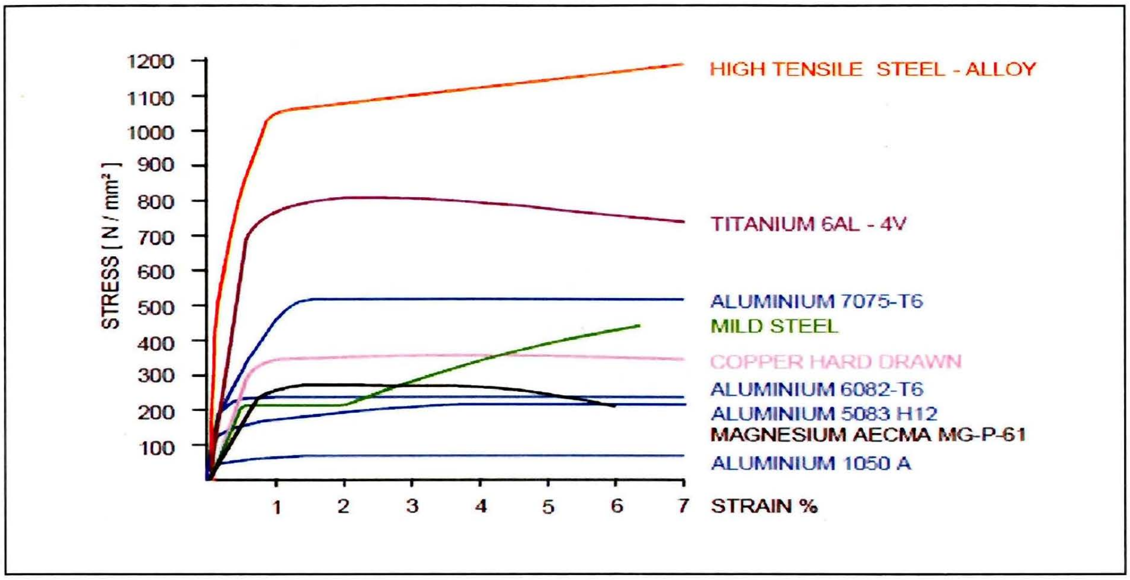

Figure 2.1.1 (b) Stress-strain curve in Aluminium in comparison with various metal and alloy [15].

2.1.2 Microstructure of Aluminium

2.1.2.1 Phase diagram

In automotive applications, aluminium alloys containing Mg and Si as major additions, were chosen for an interesting combination of properties. The hardening phase in these alloys has recently been identified to be the coherent metastable β″ phase . An understanding of the kinetics of the precipitation of this phase is valuable since it would allow an optimization of the paint–bake process that the alloys would undergoes part of manufacturing of car bodies [4].

The LIU Hong et.al in journal effect of different tempers state that the effects of different processing parameters, such as holding temperature and holding time, on the semisolid microstructures during partial remelting have been investigated. It was found that the optimal partial remelting parameters should be 630°C and 10–15 min for 6061 alloy cold rolled with 60% reduction in height of pre-deformation. Figures 2.1.2 (a) and (b) show the microstructures of 6061 alloy isothermally treated at different temperatures for 15 min. It have be seen that the liquid phase increases with the increase of temperature [5].

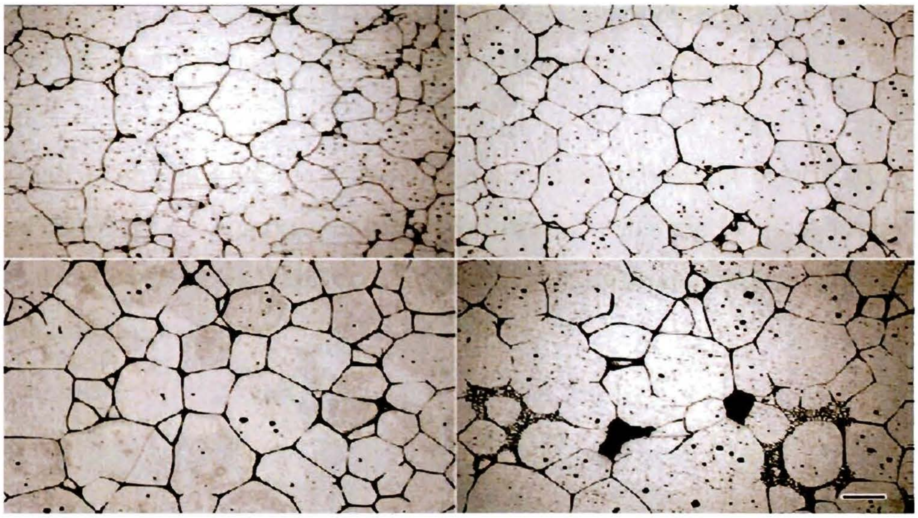

Figure 2.1.2.1 (a).Microstructures of the remelted 6061 alloys at different temperatures (as cast) with holding time of 15 min with temperature 610°C 620°C, 630°C, and 640°C [5].

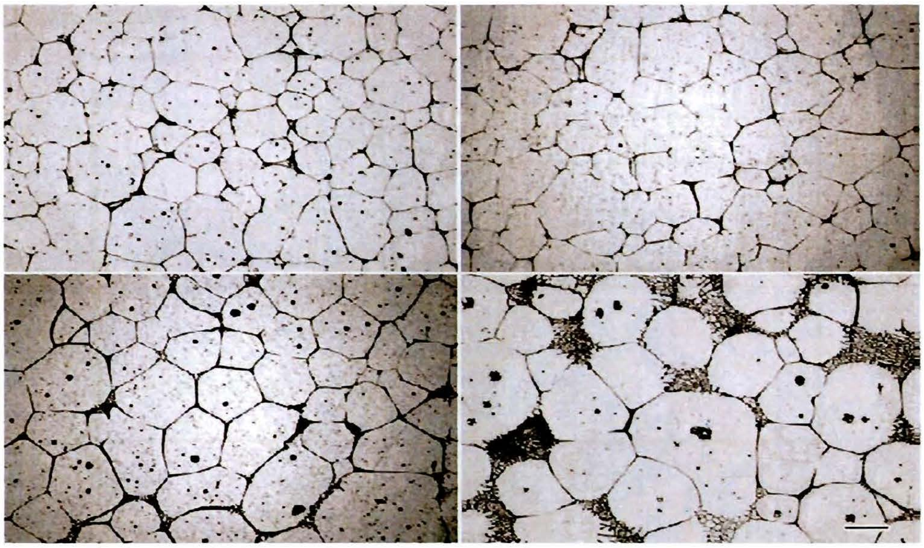

Figure 2.1.2.1 (b).Microstructures of the remelted 6061 alloys at different temperatures (pre-deformed) with holding time of 15 min with temperature 610°C, 620°C,630°C, and 640°C [5].

For Aluminium alloy 6061, it's contain Mg and Si as the major solutes, are strengthened by precipitation of the metastable precursors of the equilibrium β (Mg2Si) phase. The precipitation of these metastable precursors occurs in one or more sequences, which are quite complex and is not fully understood. This is largely due to confusions regarding the number of precipitation sequences occurring during ageing, and also in the number, structure and composition of the metastable precursors that are involved in a given precipitation sequence [7].

Finally, the phase of a liquid solution depends on both the temperature, as the concentration. A phase diagram can then be drawn, showing at what temperatures and at what concentrations what phase is present. An example is a phase diagram of copper and aluminum shown in figure 2.1.2.1 (c).

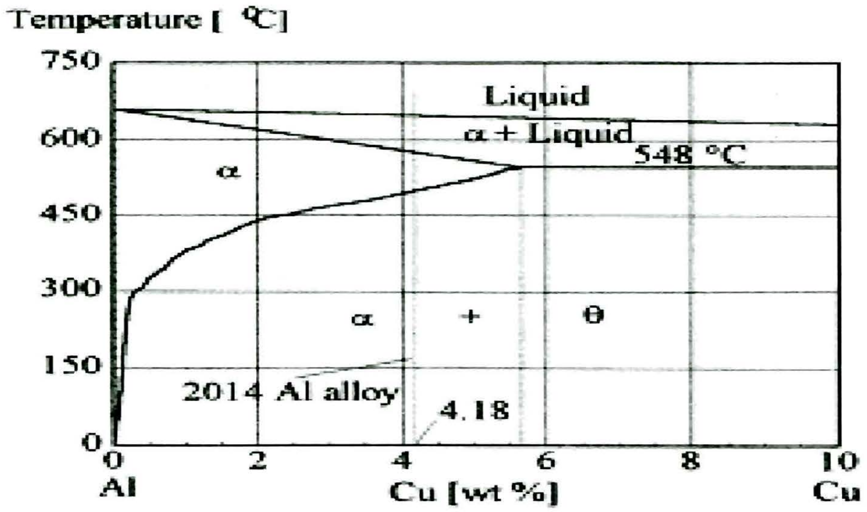

Figure 2.1.2.1 (c) Aluminium-Cu phase diagram [15].

2.1.2.2 Intermetallics

Intermetallics are formed by a process called dissolution or migration. Tin migration occurs when the solder alloy begins to liquefy or melt, and this tin migration will continue rapidly as long as the temperature is above the melting point of the solder alloy, and would continue until all tin has been depleted. However we want to control the time and temperature to cause the wetting of the tin to the conductor, this is when the intermetallic is formed [1].

Besides that, according to the D. Maisonnettea et.al [2] in journal effect of heat treat to microstructure, it's state that large intermetallics are visible in the micrographs at low magnification. However, it is important to note that the intermetallics do contain silicon, so that the corresponding quantity will not be available for hardening precipitation.