UNIVERSITI TEKNOLOGI MARA

THE STRENGTHENING OF ALUMINIUM 2024 SHEET BY ACCELERATED AGING

SYAFRUDDIN NOER

Thesis submitted in fulfillment of the requirements for the degree of Master of Science

Faculty of Mechanical Engineering

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of University Technology MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non academic institution for any other degree or qualification.

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Name of Candidate	Syafruddin Noer
Candidate's ID No.	2002103739
Programme	EM780
Faculty	Mechanical Engineering
Thesis Title	The Strengthening of Aluminium 2024 Sheet by Accelerated Aging
Signature of Candidate	
Date	27 April 2007

ABSTRACT

This study is based on daily experience in the Aerospace Industries. Aircraft structures are mostly made from Aluminium Alloys, especially the 2024 alloy. Strengthening of this material to achieve the T42 condition is by heat treating and quenching (solution treatment) after which it is left at room temperature (natural aging) for 96 hours approximately. This is time consuming and will adversely affect productivity.

Precipitation hardening of aluminium and aluminium alloys occurs either at room temperature (natural aging) or at elevated temperature (artificial aging or precipitation treatment).

An attempt was made to accelerate this aging process and examine the properties of the material when introduced at above room temperature (40°C, 50°C, 60°C, 70°C, 80°C and 90°C) but below the normal precipitation treatment temperature (120 °C) after being solution heat treated.

The material selected for this study was aluminium 2024 sheet with 1.6 mm thickness, manufactured by ALCOA.

Microstructures of aged materials were difficult to differentiate between natural and artificial aged, the grains were almost equiaxed which consist of rounded Al_2CuMg as an undissolved excess phase, irregularly shaped particles of unreacted $(Mn,Fe)_3SiAl_{12}$ and reaction product Al_7Cu_2Fe, along with fine dispersoid of $Cu_2Mn_3Al_{20}$.

Aging at elevated temperatures (artificial aging), the ultimate strength tended to decrease by increasing the aging temperature. Although the strength was low at temperature 40°C but the minimum acceptance criteria for T42 condition has been achieved within 24 hours of aging time. The highest ultimate strength was achieved by aging at temperature 50°C and the lowest strength was by aging at temperature 90°C. One of the factor caused this phenomenon was by exposure to temperature whereby a number of microstructural changes were introduced including coarsening of the matrix precipitates and grain boundary precipitation or development of a precipitate free –zone.

Conditioning this material above room temperature showed that strengthening process is successfully done and aging time to achieve T42 condition was decreased by increasing the ambient temperature and the optimum ranges of accelerating aging temperatures are 40,50 and 60°C. The ability to accelerate this aging process will be of great benefit to processors (manufactures) particularly where time is concerned.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Background

The selection of materials during aircraft design depends on the applications. Factors to be considered include yield and ultimate strength, stiffness, density, fracture toughness, fatigue crack resistance, creep, corrosion resistance, temperature limits, produceability, maintainability, cost and availability [1].

Aluminium is the most widely used material on aircraft due to its excellent on strength-to-weight ratio, good formability, moderate cost and resistant to chemical corrosion. The most common aluminium alloy is 2024, which consists of 3.8-4.9% copper, 0.30-0.9% manganese, 1.2-1.8% magnesium and the rest is aluminium [16]. Aluminium 2024 is a heat treatable Aluminium Copper Alloys which is available in a wide variety of products, forms and tempers.

Wrought Aluminium alloys are divided into heat treatable and non heat treatable alloys. Non heat treatable alloys are strengthened by cold work, whereas heat treatable alloys are heat treated by solution treatment followed by quenching and then aging (natural or artificial aging/precipitation treatment).

In some heat treatable alloys (particularly, the 2000 series), sufficient natural aging or precipitation hardening occurs in a few days at room temperature to yield stable products with properties (T3 or T4 temper conditions) that are adequate for many applications.

As a general reference for acceptance criteria of aluminium 2024 T42 condition (sheet 1.6 mm thick) as follows: Minimum ultimate strength (UTS) is 415 MPa, minimum proof stress is 250 MPa, minimum elongation is 15%, minimum Hardness is 125 HV and Conductivity 29.2 to 33.8 % IACS. [19]