DESIGN AND ANALYSIS OF THIN WALLED ALUMINIUM 7075 AIRCRAFT PARTS

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The members of the supervisory committee are as follow:

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DEDICATION

Specially dedicated to my family,
Academic Supervisor,
All my friends as well who have
Encouraged, guided, and inspired me throughout my journey of education.

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In the name of Allah, the Most Gracious and the Most Merciful

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Thank You.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Design) with Honours.

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ABSTRACT

7000 series aluminum alloys are widely used because of its advantages of high strength but low density. It is widely used in the aircraft manufacturing industry which is becoming particularly important basic component of aluminum alloy 7075 (Al 7075) series. Al 7075 has been used at the aircraft rib for Boeing 737. The objective of this project is to investigate and identify the minimum thickness that the material can be machined. This project was carried out by analysis using SolidWork and by experiment using CNC machine. To ensure data is more reliable, this project was conducted together with another two materials, general purpose aluminium (GPAl) and mild steel (AISI 1018). All of them were tested under the same procedure but different in parameter of machining and force applied during analysis. This is due to the different properties of the material. From the experiment it is identified that the minimum thickness that Al 7075 can be machined by experiment is 1 mm while in analysis using SolidWork software is 0.80 mm thick. A different between two results is 2%. For GPAl and AISI 1018 material it found that the minimum thickness can be machined in theoretically is 5 mm and 2 mm respective, but for experimental result is 5 and 3 mm.

ABSTRAK

Siri 7000 aloi aluminium digunakan secara meluas kerana kelebihannya yang mempunyai kekuatan tinggi tetapi berkepadatan rendah. Ia digunakan secara meluas dalam industri pembuatan pesawat yang menjadi komponen asas penting untuk siri aloi aluminium 7075 (Al 7075). Al 7075 telah digunakan di rusuk pesawat untuk pesawat Boeing 737. Objektif projek ini adalah untuk menyiasat dan mengenal pasti ketebalan minimum bahan ini yang boleh dimesin. Projek ini telah dijalankan melalui analisis menggunakan SolidWork dan eksperimen menggunakan mesin CNC. Untuk memastikan data yang boleh dipercayai, projek ini telah dijalankan gabungan bahan lain dua, aluminium kegunaan umum(GPAl) dan aloi keluli(AISI 1018) . Kesemuanya telah diuji dengan prosedur yang sama tetapi berbeza dari segi parameter pemesinan dan daya yang dikenakan semasa analisis. Ini adalah kerana sifat-sifat yang berbeza bahan tersebut. Daripada ujikaji tersebut ia dikenal pasti bahawa ketebalan minimum yang Al 7075 boleh dimesin dalam keputusan eksperimen adalah 1 mm manakala di analisis menggunakan perisian SolidWork adalah 0.80 mm tebal. Perbezaan antara dua keputusan ialah 2%. Untuk bahan GPAl dan AISI 1018 didapati bahawa ketebalan minimum boleh dimesin secara analisis ialah 5 mm dan 2 mm masing-masing, tetapi untuk keputusan eksperimen adalah 4 dan 3 mm.

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AA	-	Aluminium Association
AC	-	Alternative Current
AMC	-	Aluminium Matrix Composite
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CATIA	-	Computer Aided Three-dimensional Interactive Application
CAM	-	Computer Aided Manufacturing
DC	-	Direct Current
EST	-	Elfini Structural Analysis 2 (CATIA software)
F	-	Fahrenheit
FEA	-	Finite Element Analysis
FMS	-	FEM Surface 2 (CATIA software)
FSW	-	Friction-Stir Welding
GAS	-	Generative Assembly Structural Analysis 2
GMAW	-	Gas Metal Arc Welding
GP1	-	Generative Part Structural Analysis 1 (CATIA software)
GPS	-	Generative Part Structural Analysis 2 (CATIA software)
MMC	-	Material Matrix Composite
MIG	-	Metal Inert Gas
RAP	-	Partial Melting Route
SSP	-	Semi-Solid Forming
SSM	-	Semi-Solid Metal
TAA	-	Tolerance Analysis of Deformable Assembly 3 (CATIA Software)
VS	-	Versus

CHAPTER 1

INTRODUCTION

1.1 Background of Project

For 70 years, aluminium alloys have been the materials of choice for both military and commercial aircraft structures. Aluminum alloys are divided into two general categories, namely heat-treatable and non-heat treatable (Jasim M. Salman, 2013). The 7xxx series is one of the heat treatable by solution and aging, considered as the high strength aircraft alloy family. Due to their attractive, comprehensive properties, such as low density, high strength, ductility, toughness and resistance to fatigue it have been widely used as structural material (Brian Smith, 2003). The 7075 aluminium (Al 7075) alloy also knows as aerospace aluminium is one of the important engineering alloys and has been utilized extensively in aircraft structures because of its high strength-to-density ratio.

The 7075 wrought aluminum alloy is an Al-Zn-Mg-Cu alloy, has one of the highest attainable strengths of all aluminum alloys. There are many applications using this material especial in the aircraft manufacturing industry since it was introduced in 1944. On commercial airplane part, aluminium typically uses at the frames, stringers, floor beams and wing ribs (Staley, 1993). In Boeing 737, the application of aluminium 7075 is used as a material for wing ribs (Chris Brady, 2013). Aircraft wing is a crucial and most critical component of an aircraft not only from an aerodynamics point of view but also from a structural point of view.

To make a wing rib structure, that material must undergo a series of machining process. In this project, the investigation to find the minimum thickness of that material can machined, is done by analysis and experimentation. Analysis is performed using SolidWork 2010 software while for experiment it is done with a CNC milling machine. To get accurate and reliable data, other materials are used in this research namely the general purpose aluminum (GPAl) and ANSI 1018 mild steel for comparison between them. Results of both will be analyzed to make the final conclusion if there have any improvement in terms of the thickness of the selected material.

1.2 Problem Statement

Market pressure for a reducing airplane transportation cost continues to increase year by year. Increasingly, not only commercial airplane manufacturers needing to account for high technological barriers, but growing financial, economic, environmental, and government concerns as well (Ashford, 1985; Esposito, 2004; Gillett and Stekler, 1995). The overall weight effect the fuel consumption of the aircraft and it will make the transportation cost using aircraft is high. Metallic material used, especially aluminium is one of the factors that contribute to the weight. For example, 70 percent of aircraft model Boeing 777 is made from aluminium including the wing box and fuselage (Advance Material and Process, 2003). Due to that problem, many parts originally made from aluminium are replaced by composite material. Growth, congestion, economic and environmental factors are driving the need to develop new solutions. Another possible solution is by reducing the minimum thickness of thin walled without reducing their performance and have same desired properties for the particular part. Due to the manufacturing process for wing rib which require the machining process, the need to know the minimum thickness for the purpose of machining process is highly important for material Al 7075.

1.3 Objective

The objective of this project is:

I. To investigate the use of Al 7075 in aircraft part.
II. To identify the properties of Al 7075.
III. Identify the minimum thickness of Al 7075 grades for aircraft wing rib structure can be machined.
IV. To make comparisons between different materials (GPAl and AISI 1018 mild steel) with Al 7075 in terms of ability of machining.

1.4 Scope of Work

The studies of this paper cover the analysis and experiment of different thickness of Al 7075, GPAl and AISI 1018 mild steel material. The research will focus on the wing ribs structure in commercial aircraft part. The research is done using SolidWork 2010 simulation express to analyze the given thickness and specific forces apply at that specific location. Force apply is calculated using cutting force formula where every material have different cutting force. For experimental, it's done by using CNC machining center, where these machines can produce high precision cutting. A dial gauge is used to analyze the machined surface behavior after workpiece have been machine. The size of workpiece is 150 mm x 130 mm and analysis surface is 100 mm x 100 mm for both analysis and experiment.

1.5 Important of Study

This project is an idea to analyze and identify the minimum thickness of the thin walled used in aircraft parts. The investigation will focus on the metal material Al 7075 used in the commercial wing ribs aircraft and other two materials (GPAl and AISI 1018 mild steel). The analysis is conducted using SolidWork CAD software on the important aspect that influences the thickness of wing ribs had been studied in detail. For the experiment, it conducted using a CNC milling machine by analysis the surface finish after it is machine by 1 mm each layer. By undertaking this project, the minimum thickness of material can be identified and from the resulting data it helps a designer to reduce the thickness of existing wing rib design.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the literature review on application and properties of aluminum 7 series using in wing ribs aircraft part. Is basically an assessment of to find the minimum thickness of thin walled Al 7075 can be machined, that be used in producing wing ribs part for airplane Boeing 737. The GPAl and mild steel properties also included.

2.2 Aircraft

The aircraft is a transportation device that typically uses to transport people, animal or cargo from one location to another by air. The idea that human can fly is coming when they saw a bird fly. The first attempt was an effort to fly like a bird by attaching feathers to their arms and flapping. This attempt was unsuccessful. Since then, many inventors have thought, a way to fly by designing a device or thing that looks like a bird and fly. On December 17 1903, after facing many failures the Wright Brothers finally become the first people to successfully fly and descended without damage with a person in it. They named a powered airplane as “flyer”. The plane that had a 12 horse powered engine and build by themselves (Rick Young, 2001).

Now, the aircraft come in with a variety of sizes, shapes and wings depending on the application and mission. There are many applications of airplane and commonly use as