UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECTS OF END MILL HELIX ANGLE ON ACCURACY OF THIN-WALLED ALUMINUM RIBS

This report is submitted in the accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

by

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SESI PENGAJIAN: **2015/16 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment 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:

……………………………….

(Mr. Salleh Bin Aboo Hassan)

ABSTRACT

Aerospace industry contains high usage of thin-walled aluminium ribs. The machining of aerospace structural components is a critical process due to high flexibility and it involves several thin-walled ribs section. The components that contain thin-walled ribs section must be considered with the design consideration to meet required strength and weight limitation. Generally, these structural components undergo casting process to cast out the approximate final shape and the end milling process steps into secondary process whereby involves finishing cuts. Dimensional accuracy or deformation results in the low precision of dimensions are more likely to occur in the machining of thin-walled components. The available study develops adequate end milling cutting force model to analyse the surface dimensional accuracy of thin-walled workpiece. The cutting forces that produced during machining is one the factor causes the deflection of the thin-walled section, and consequently lead to dimensional accuracy that cause the finished part to be failed from the specification or failure. The end mill with different helix angles are modelled that can be more accurately stimulate the specific geometry and structural behaviour of the cutter. In this study, a new methodology is investigated and presented to become a solution for the prediction of wall deflection on thin-walled section during milling process. Referring to the existing research for machining thin-walled components, the study is related only to the focus of the process planning and the effects of cutter geometric feature is often out of the range of studies. In technically, tool geometric feature is a major factor that can influence on the cutting performance during milling process. The experiment testing is carried out by using aluminium alloys parts that reduce the wall deflection and thus improving the component accuracy.

ABSTRAK

Industri aeroangkasa mengandungi penggunaan aluminium nipis berdinding yang tinggi. Pemesinan komponen struktur aeroangkasa adalah satu proses yang kritikal kerana fleksibiliti yang tinggi dan melibatkan beberapa bahagian berdinding nipis. Komponen yang mengandungi bahagian berdinding nipis perlu dipertimbangkan dengan mengambil kira rekabentuk untuk memenuhi kekuatan yang diperlukan dan had berat badan. Secara umumnya, komponen struktur menjalani proses pemutus untuk mengusir bentuk akhir anggaran dan langkah-langkah proses pengilangan akhir ke dalam proses menengah di mana melibatkan pemotongan penamat. Ralat dimensi atau keputusan ubah bentuk dalam ketepatan yang rendah dimensi adalah lebih kerap berlaku dalam pemesinan komponen nipis berdinding. Kajian didapati kekerasan untuk menganalisis permukaan kesilapan dimensi bahan kerja nipis berdinding. Kuasa-kuasa memotong yang dihasilkan semasa pemesinan adalah salah satu faktor yang menyebabkan pesongan bahagian berdinding nipis, dan seterusnya menyebabkan kesilapan dimensi yang menyebabkan bahagian siap untuk gagal dari penentuan atau kegagalan. Pengisar hujung dengan sudut heliks yang berbeza model yang boleh menjadi lebih tepat merangsang geometri tertentu dan tingkah laku struktur pemotong. Dalam kajian ini, kaedah baru disiasat dan disampaikan untuk menjadi satu penyelesaian untuk ramalan dinding pesongan pada bahagian berdinding nipis semasa proses berkerumun. Merujuk kepada kajian yang sedia ada, kajian itu hanya berkaitan dengan fokus perancangan proses dan kesan pemotongan sering diabaikan. Alat pemesinan merupakan faktor utama yang boleh mempengaruhi prestasi pemotongan semasa proses berkerumun. Ujian eksperimen dijalankan dengan menggunakan aloi aluminium bahagian yang mengurangkan pesongan dinding dan meningkatkan ketepatan komponen.

DEDICATIONS

This dedication is dedicated to my beloved parents, who are always mentally support me and always pray for my success. Their prayer is the keys of my success.

I also would like to take this opportunity to thank to my supervisor, Mr. Salleh Bin Aboo Hassan for his support and care.

Also, I am dedicating this thesis to certain of people or groups who have inspired me while doing this thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

Al	=	Aluminium
WC-Co	=	Tungsten Carbide
CMM	=	Coordinate Measuring Machine
D	=	Diameter of End Mill
D_w	=	Inscribed Circle Diameter of End Mill
N	=	Number of Flute of End Mill
γ	=	Rake Angle of End Mill
η	=	Clearance Angle of End Mill
β	=	Helix Angle of End Mill

CHAPTER 1

INTRODUCTION

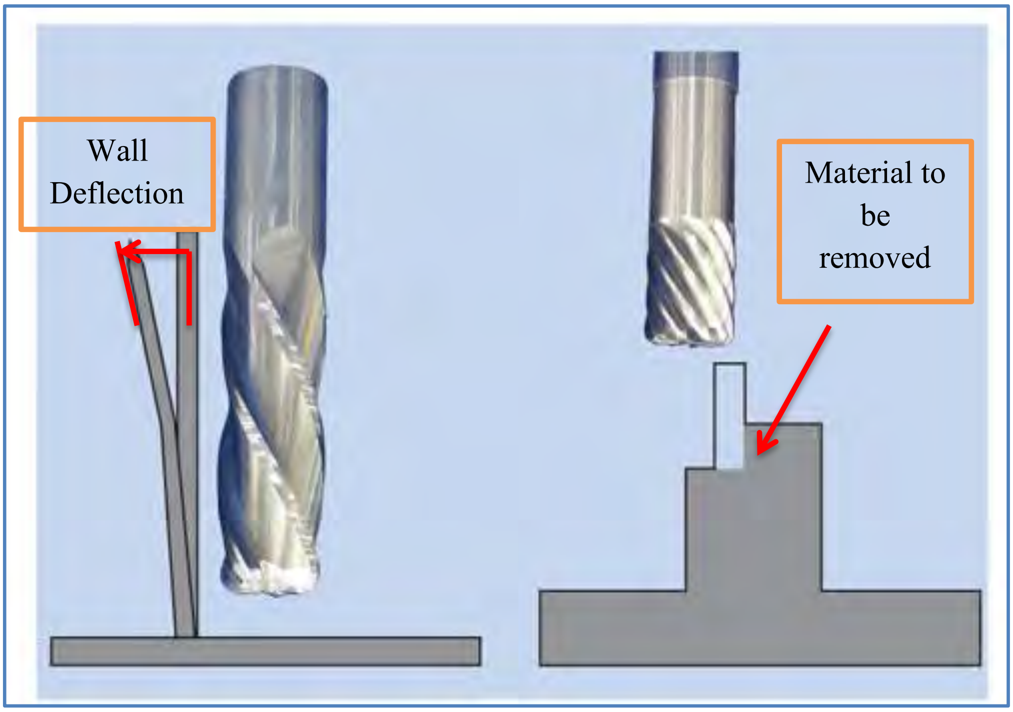
1.0 Introduction

In this fast pace moving demand generation, aerospace industry has motivated to improvements in terms of cost effectiveness, structural design with the use of high technology materials and high performance wise aircrafts (J & M, 2009). Due to the demand in the global market, most of the aerospace industries are preferred to use up to 95% of aluminium blocks for aircrafts components (P, 1998).

1.1 Background of Research

There are many components used in the aerospace industry are usually thin-walled structures. The thin-walled structures have poor stiffness which is easy to deform under the acting of cutting force during the process of milling (J-S & C-L, 1999). The most common method used in manufacturing is to cut the wall several times without feed in depth after the finishing cutting. However, this will increase working time and surface roughness thus lead to surface accuracy or dimensional failure (H, et al., 2003). It was suggested by (H, et al., 2003) that using high speed milling machine is a better approach to avoid the wall deflection occurrence in thin-walled aluminium ribs.

Aluminium alloys provides good machinability for machining process. In the aerospace industry, machining process is well established and it is widely used for fabrication of thin-walled ribs components. Thin-walled ribs component normally is made up of aluminium material and it is usually used in the fabrication of the important parts of aerospace industry. However, to ensure maximum accuracy of machined component and reduce surface roughness of the machined component are the biggest challenges for the manufacturer, especially during milling process. In order to overcome the challenges in machining thin-walled aluminium alloys. The manufacturers have to keep up the demand to improve their product quality by studying the tolerances of thin-walled aluminium alloys during machining process. One of the most significant dimensional accuracy that will occur on thin-walled aluminium alloys is the deflection of the thin-walled aluminium ribs. The occurrence of deflection accuracy is due to poor stiffness characteristic which ending a dimensional surface errors (W, et al., 2010).



a) Deflection of wall. b) Machining of thin-walled component.

Figure 1.1: Dimensional surface accuracy produce during machining thin-walled aluminum ribs. (Anon., 2009)

On the other hand, the cutting force during milling process could also contribute to the surface dimensional accuracy. Milling cutting tool has multiple teeth that allow close contact between each tooth and the workpiece for a fraction of the total time. Since there is a relative contact between the workpiece and the cutting tool, there will be inconstant thickness of chip produced. The surface dimensional accuracy of workpiece produced by the process is highly dependent on the cutting force induced (Kline, et al., 1982). Cutting forces has become one of the factor causes the deflection on the thin-walled aluminium ribs due to the close contact between the cutting tool and the workpiece. Thus, cutting forces that applied during the milling process must be suitable because it may cause deflection to the thin-walled section. In addition, these circumstances will increase the surface roughness thus lead to dimensional accuracy that caused the finished part of workpiece to be out of the specification or failed. The thickness of these aluminium ribs may vary from 100 to 0.1mm. Later, the effects of cutting force and surface roughness in milling process has conducted by (Turgut, et al., 2011). His studies include the effect of cutting speeds, feed rates and depth of cut on cutting forces. His conclusion stated on the cutting force increased with increasing feed rate and depth of cut whereas cutting force decreased with higher cutting speed.

According to a study conducted by (Kline, et al., 1982) , they examined the milling process applied on hard workpiece. In their study, a thin-walled rectangular plate element was clamped on three edges during milling process that showed different effects of end mill's flexibility. However, the study did not focus on the milling forces formed and the structural deformation (Kline, et al., 1982). Kline's model later is then improved by considering the dynamic milling forces and the regeneration mechanism into a reflection (Sagherian & Elbestawi, 1990). Nevertheless their study did not focus on the cutting geometry which may affect the workpiece deflection (Sagherian & Elbestawi, 1990). The study is improved again to consider the milling plate structure whereby the structural properties on the material removal rate were previously neglected (Altintas, et al., 1992). The study was then further developed to include consideration of the cutting force distribution which helps to reduce the wall deflection (J-S & C-L, 1999).

Budak and Altintas preferred the helical end mill for peripheral milling of which the slender helical end mill includes the consideration of the cutting forces involved (Budak & Altintas, 1994). They suggested a cutting strategy to reduce surface roughness thus lead to dimensional surface accuracy produced during the milling process but the productivity decreases due to reducing the feed rate and thus machining time takes longer time (Budak & Altintas, 1995). According to the study by (Alauddin, et al., 1996), the suggestion stated the possibility in selecting a combination of cutting speed and feed rate that can reduces the machining times without increasing the surface roughness. Later, the study is further conducted by (Mansour & Abdalla, 2002), the suggestion shown that an increase in either the feed or the axial depth of cut increase the surface roughness whereas an increase in the cutting speed decreases the surface roughness.

Apart from that, the effect of tool geometric feature is one of the contributions to the accuracy of thin-walled ribs (Raja, et al., 2013). This is because the design and the shape of the tool geometric are directly influencing the cutting performance and so leads to the errors in dimensions and accuracy. The cutter geometrical feature which is the helix angle definitely is an important role to be studied. The deflection of the thin-walled structural workpiece happens during milling process due to low stiffness thus leads to dimensional accuracy (H, et al., 2003). Remarkably, at the end of the research is to study the effects of end mill helix angle on accuracy of thin-walled aluminium ribs.

1.2 Problem Statement

The research is to study the effects of end mill helix angle specifically on thickness accuracy and the surface roughness of thin-walled aluminium ribs. The end mill helix angle exerts several possible effects thickness accuracy and surface roughness on the aluminium ribs. Phenomenal lead to driven by the necessity to continuous enhance the machining efficiency and part precision from perspective of cutting tool geometry, research study on the effect of helix angle factor should be analysed.

1.3 Research Objective

The main objectives of the project are:

a) To investigate the effect of end mill helix angle on thickness accuracy of thin-walled aluminium ribs.

b) To investigate the surface roughness (arithmetic mean value, Ra) of thin-walled aluminium ribs after machining.

1.4 Scope of Work

This research is conducted within these following conditions:

a) Commercially available 10mm diameter tungsten carbide end mill with cutting length of 25mm, shank length of 10mm and tool length of 75mm.

b) The material of the workpiece was Aluminium alloy 7075-T6.

c) T-shaped thin-walled component of 100mm in length and 50mm in width with the cutting depth is 3mm in thickness on thin-walled aluminium ribs.

d) Helix angles of 30°, 40° and 45° end mill with 2 flute number.

e) Conventional milling machine with the cutting speed of 2400rpm, feed rate of 0.1mm/tooth and the spindle speed of 1040rpm.

f) Limited to thin-walled with less than 3mm thickness of workpiece.

g) Rake angle of end mill was 10°.

h) Clearance angle of end mill was 2°.

i) The checking method used to check thickness accuracy was Carl Zeiss Contura G2 RDS Coordinate Measuring Machine (CMM).

j) The checking method used to check surface roughness was Mitutoyo Portable Surface Roughness Tester SJ-401.

k) Collection of data and analysed by using Minitab software.