UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION OF SURFACE ROUGHNESS BETWEEN THE CONVENTIONAL AND CLIMB MILLING FOR ALUMINUM PRODUCT

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

By

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I hereby declare that this report entitled "Investigation of surface roughness between conventional and climb milling for aluminum product" is the result of my own research except as cited in the references.

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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 Process) with honours. The members of the supervisory committee are as follow:

Signature	:	....
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ABSTRACT

This study has to be done in order to fulfill the requirement to complete the course in Degree in Manufacturing Engineering (Manufacturing Process). The main purpose of having this project is to investigate the difference of the surface roughness obtains between using conventional milling and climb milling. This is because there are surveys that show a slightly different surface finish between conventional and climb milling. It is very important to use an appropriate method of milling to get a better surface finish. Besides, the project also will determine the best machining process characteristic that can obtain the best quality surface finish between the conventional and climb milling. The experiments are carried out by using a CNC milling machine. The workpiece used is aluminum 6061. According to the acceptable ranges of cutting depth, cutting speed, and feed per tooth, the block was then milling by using the face milling cutter. The stylus surface profiler was used to measure the surface roughness. A number of 27 experiments are carried out by conventional milling method. The experiments are carried out with combination of different parameter of cutting speed, feed rate, and depth of cut. The maximum value of the surface roughness obtain is 0.352*um* occurs at experiment no 3. The minimum value of the surface roughness obtain is 0.138*um* occurs at experiment no 16. There are another 27 experiments are carried out by climb milling method. The maximum value of the surface roughness obtain is 0.350*um* occurs at experiment no 12. The minimum value of the surface roughness obtain is 0.110*um* occurs at experiment no 25. The surface roughness obtain are better with climb milling than the conventional milling. The experiments show that the higher the cutting speed and the lower the FPT, the surface roughness obtained will be better.

Key word: Conventional milling, Climb milling, Aluminum.

ABSTRAK

Kajian ini perlu dilakukan untuk memenuhi keperluan bagi melengkapkan kursus Ijazah Sarjana Muda Kejuruteraan Pembuatan (Proses Pembuatan). Tujuan utama dalam menjalankan kajian ini adalah untuk menkaji pembezaan kahalusan permukaan antara *conventional milling* dan *climb milling*. Ini adalah kerana kajian telah menunjukkan terdapat perbezaan dalam kehalusan permukaan antara *conventional milling* dan *climb milling*. Ini adalah sangat penting untuk mengunakan teknik yang betul untuk mendapatkan permukaan yang bagus. Selain daripada itu, kajian ini juga akan mencarikan parameter yang betul untuk mendapatkan qualiti permukaan yang bagus antara *conventional milling* dan *climb milling*. Kajian ini dilakukan dengan mengunakan CNC milling mesin. Bahan yang digunakan dalam kajian ini adalah aluminum 6061. Blok aluminum dimesin dengan mengunakan parameter yang ditetapkan. Stylus surface profiler digunakan untuk mengkaji kehalusan permukaan yang dimein. Tedapat 27 ujian telah dijalankan dengan kaedah *conventional milling*. Nilai maksimum yang terdapat dengan mengunakan kaedah ini ialah 0.352*u*m pada ujian ke 3. Nilai minimum yang terdapat dengan mengunakan kaaedah ini ialah ujian ke 16. Selain itu, 27 ujian yang lain telah dijalankan dengan mengunakan kaedah *climb milling*. Nilai maksimum yang terdapat dengan mengunakan kaedah ini ialah 0.350*u*m pada ujian ke 12. Nilai minimum yang terdapat dengan mengunakan kaedah ini ialah 0.110 *u*m pada ujian ke 25. Kehalusan permukaan yang terdapat dengan kaedah *climb milling* adalah lebih baik daripada *conventional milling*. Ujain also menunjukkan cutting speed yang tertingi, dengan FPT yang rendah, kehalusan permukaan akan meningkat.

Key word: Conventional milling, Climb milling, Aluminum.

DEDICATION

To my beloved parent, Mr. Yee and Mrs. Yee, and family.

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First and foremost, I would like to convey my most heartfelt gratitude to Mr. Johny Purnomo as my final year project supervisor who has graciously offered his time, attention, experience and guidance throughout the completion of the investigation thus far. Besides that, I would also like to extend my thanks to all the FKP technician who had teach me and helped me in obtain the machining process to get the result and also use the surface roughness tester to investigate the surface finish of the product. Moreover, I would like to deliver my special thanks to my lovely family. Without my family support, I could not complete the project on time. Next, I would like to thank each and every individual who have either directly or indirectly helped me throughout the efforts of this report be it in the form of encouragement, advice or kind reminders. Last but not least, I want to thank to all my sincere friends for sharing their ideas and supports in helping me to complete my tasks. Their comments have given me many ideas to construct the project.

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NOMENCLATURE

AA	–	Arithmetic Average
AFM	–	Atomic Force Microscope
ATC	–	Automatic Tool Changer
CLA	–	Centre Line Average
CNC	–	Computer Numerical Control
CPT	–	Chips Per Tooth
D	–	Diameter of the Cutter (mm)
DIN	–	Deutsche Institut für Normung (German Standards Institute),
FPT	–	Feed Per Tooth
ISO	–	International Organization for Standardization
LCD	–	Liquid Crystal Display
N	–	Rotational Speed of the Milling Cutter (rpm)
Ra	–	Arithmetic Average Height
Rpm	–	Revolution Per Minute
Rq	–	Root Mean Square Roughness
Ry	–	Maximum Roughness Height
Rz	–	Ten-point Height
UK	–	United Kingdom
USA	–	United States
V	–	Cutting Speed (m/min)
VMC	–	Vertical Machining Centers
v	–	Feed Rate (mm/min)
d	–	Depth of Cut (mm)
n	–	No. of Teeth in the Cutter

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Among several CNC industrial machining processes, CNC milling is a fundamental machining process. Milling includes a number of highly versatile machining operations, taking place in a variety of configurations with the use of a milling cutter-a multi-tooth tool that produces a number of chips in one revolution. Besides that, computer-controlled machining centers, CNC milling have the required flexibility and the versatility that other individual machine tools do not have.

In a milling process, material is removed from the workpiece by a rotating cutter. Surface can be generated by two methods; conventional milling and climb milling. In conventional milling, the cutter and the table feed are going in opposite direction. Whereas in climb milling, the cutter rotates in the same direction as the table feed.

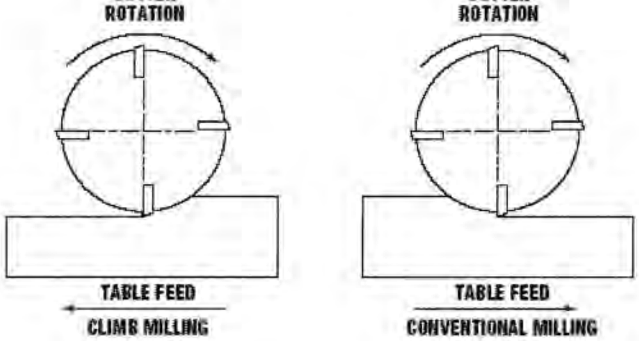

Figure 1.1: Conventional and climb milling

In conventional milling, also called up milling, the cutter rotates against the direction of feed of the workpiece. The depth of the cut starts at zero thickness, and increases up to the maximum. The cut is so light at the beginning that the tool does not cut, but slides across the surface of the material, until sufficient pressure is built up and the tooth suddenly bites and begins to cut. The sliding and biting behaviour leaves a poor finish on the material.

Meanwhile, in climb milling, also called down milling, the rotation is in the same direction of the feed of the workpiece. Each tooth engages the material at a definite point, and the width of the cut starts at the maximum and decreases to zero. The chips are disposed behind the cutter, leading to easier swarf removal. The tooth does not rub on the material, and so tool life may be longer. However, climb milling can apply larger loads to the machine, and so is not recommended for older milling machines, or machines which are not in good condition. This type of milling is used predominantly on mills with a backlash eliminator.

The quality of the surface plays a very important role in the performance of milling as a good quality-milled surface significantly improves fatique strength, corrosion resistance, or creep life. Surface roughness is one of the most common performance measures in machining and an effective parameter in representing the quality of machined surface. Surface roughness is influenced by controlled machining parameters such as feed rate, cutting speed, and depth of cuts. Therefore, the desired finish surface is usually specified and the appropriate processed are selected to reach the required quality.

In fact, once the machine and the cutting tools have been selected and the coolants is specified for the part under consideration, there are only three other parameters remaining that can influence the success of the machining. These are cutting speed, feed rate and depth of cut to be used for each operation.

1.2 PROBLEM STATEMENT

With CNC milling machine, the part program automatically moves the slides to produces a part, instead of conventional milling that the operator manually moves the machine slides to produce a part. There are numerous advantage states by using the CNC milling machine instead of conventional milling machine. But, even the CNC milling is used in machining process, there is still a significant different of the surface finish between the conventional milling (up milling) and climb milling (down milling). Beside that, the parameters used also influence the success of the machining. So, what is the most suitable parameter to be use to reach a good surface finish of both conventional milling and climb milling?

1.3 OBJECTIVES

The main purposes of having this project are:

a) To investigate the difference of the surface roughness obtains between using conventional milling and the climb milling.

b) To determine the best machining process characteristic that can obtain the best quality surface finish between conventional and climb milling.

1.4 SCOPE OF STUDY

The scope of this research is on the comparison analysis of surface roughness for Aluminum product only (not compare with other materials). The study is also focus on the CNC milling machine between conventional and climb milling technique. Beside that, the research is focus on certain machining process characteristic such as feed rate (v), cutting speed (V), and depth of cut (d) only.

CHAPTER 2

LITERATURE REVIEW

2.1 Surface Technology

2.1.1 Basic Principle of Surface Technology

Surface technology is the activity that describes, details, and evaluates both the surface and subsurface layers of manufactured components. Traditionally, surface texture is defined as the exterior effect; it has been accepted as the criterion that controls the quality of a surface. Direct relationships are widely assumed to exits between surface texture and surfaces roughness

However, tests have indicated that surface texture is only part of the consideration. Metallurgical and other alterations below the surface, referred to as surface integrity, also have a major influence on material performance. The performance of a material becomes particularly important when high stresses or severe environments are encountered by the workpiece (Wick, 1987).

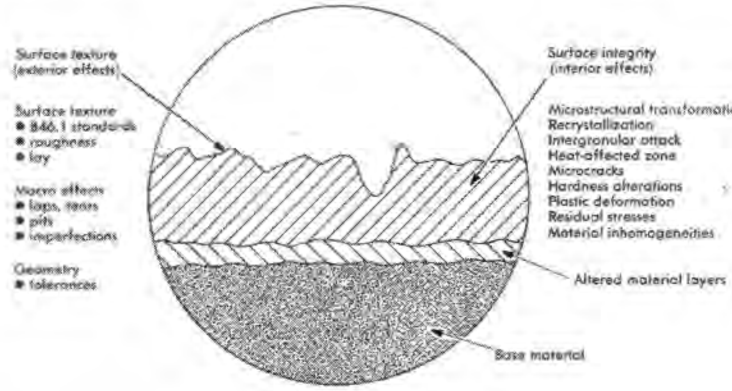

Figure 2.1: Simulated section of the surface texture and surface layers of a manufactured workpiece. (Wick, 1987)

Surface texture is an phrase used to describe the quality of a workpiece surface. The term *surface finish* is used widely to indicate the general quality of a surface. It is not specifically tied to the texture or characteristic pattern of the surface but it is tied to the specific roughness values. However, a good "finish" implies low roughness values and vise versa (Wick, 1987).

Surface texture depends on:

a) Production process
b) Composition of material
c) Tool wear / machine defects
d) Machining condition
e) Strains in materials
f) Operating procedure

2.1.2 Usefulness of Surfaces Texture

The important of surface texture is often neglected. It has to be deal with not too much trouble. 'Make the finish as fine as possible – it is bound to be better.' This statement has been made often because of ignorance: not intentionally but used nevertheless (David, 2002).

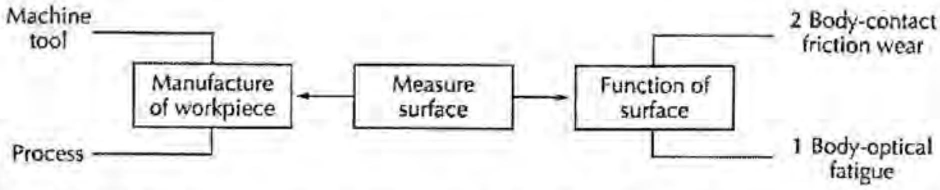

Figure 2.2: Surface measurements in manufacture and performance sequence. (David, 2002)

Figure 2.2 shows that the relationships of the surface measurement in between the manufacture of the workpiece and its function. It is now reasonably established that the surface metrology has two roles; one to help control the manufacture, including the process and the machine tool, and the other to help optimize the function. These two roles can have a profound impact on the quality (David, 2002).

2.1.3 Surface Finish or Surface Texture

Surface finish is concerned with only the geometric irregularities of surfaces of solid materials and the characteristics of instruments for measuring roughness. Surface finish is defined in term of roughness, waviness, lay and flaws (Davis *et al.*, 1985).

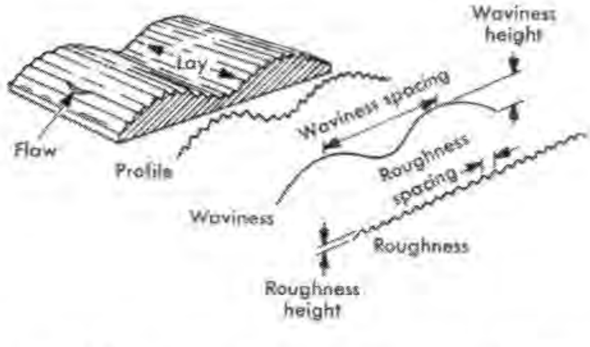

Figure 2.3: Components of surface texture (Wick, 1987).

a) Surface roughness – consists of fine irregularities in the surface texture, usually including those resulting from the inherent action of the production process, such as feed marks produced during machining.

b) Waviness – is a more widely spaced component of surface texture and may result from such factors as machine or work deflections, vibration, or chatter.

c) Lay – is the direction of the predominant surface pattern, ordinarily determined by the production method used.

d) Flaws are unintentional, unexpected, and unwanted interruptions in the surface, for example, cracks, nicks, scratches, and ridges (Davis *et al.*, 1989).

Both surface roughness and waviness can be measured by a variety of instruments, including both surface contact and non-contact types (Davis *et al.*, 1989). The most universal technique uses to measure the surfaces roughness is stylus contact type instrument that provides a numerical value for surface roughness.

2.1.4 Surface Roughness

To describe the surface roughness, it is measured by using the surface roughness tester. The height and width of the irregularities is measured and rated in microns and mm respectively. There are many factors that affect surface roughness, which include:

a) Type of coolants used
b) Cutting parameter such as feed rate, cutting speed, and depth of cut.
c) Type of machining
d) Rigidity of system consisting of machine tool, fixture, cutting tools and work.
e) Vibrations
f) Material of tool and workpiece.

Since the type of machining will be the same, that is CNC milling machine, so the type of coolants and other characteristic of machine used will be the same. The material of tools and workpiece used will be constant also, so the only variable need to be considered is only the cutting parameters.