



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**INVESTIGATION ON THE EFFECTS OF RAKE ANGLE
VARIATIONS ON THE END MILL WEAR, CUTTING FORCES
AND SURFACE FINISH**

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

by

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FACULTY OF MANUFACTURING ENGINEERING

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ABSTRACT

This project represents the investigation of the effect of rake angle variation on the endmill wear, cutting force and surface finish. Conventional milling machine is being used in this analysis. The main purpose of this project is to study the effect of end mill rake angle variation to rate of wear of end mill and surface finish of the machined workpiece and also to understand the impact of endmill rake angle variation to the cutting force during milling process. The workpiece use in this experiment is limit on mild steel only. The workpieces is machined first before machining with dynamometer that clamps with workpiece to get cutting forces data. This experiment was using 3 different rake angles of endmill cutting tool that machined using CNC Tool Grinding. Surface roughness and tool wear also the finding for this experiment. The parameter will be in fixed setting such as depth of cut, spindle speed and feed rate. Then the data will be analysis using Microsoft Office Excel to find which cutting tool is suitable with the industry usage. Finally, rake angle with 10° is the best endmill cutting tool in conventional milling machine through the experiment.

ABSTRAK

Projek ini menerangkan suatu kajian mengenai kesan sudut pencakar mata alat mesin pengisar pada haus, daya pemotongan dan juga pada permukaan projek. Mesin pengisar konvensional digunakan untuk menyelesaikan analisis ini. Tujuan utama projek ini adalah untuk mengkaji kesan kepelbagaian sudut pencakar mata alat pengisar terhadap kadar haus dan juga pada hasil akhir pemesinan dan untuk memahami impak kepelbagaian sudut pencakar ini pada daya pemotongan. Benda kerja yang digunakan di dalam analisis terhadap kepada besi lembut sahaja. Benda kerja akan dimesin terlebih dahulu sebelum dimesin bersama Dynamometer yang diletakkan di bawah benda kerja tersebut untuk mendapatkan daya pemotongan. Eksperimen ini menggunakan 3 jenis mata alat yang berlainan yang akan menggunakan mesin “CNC Tool Ginding”. Kelicinan permukaan dan kadar kehausan juga akan dinilai bagi eksperimen ini. Parameter yang digunakan adalah tetap seperti kadar kedalaman pemotongan, kelajuan gelendong and kadar suapan. Kemudian, segala data akan dianalisis menggunakan Microsoft Office Excel untuk mencari mata alat yang sesuai untuk dijadikan bagi tujuan kegunaan industri. Akhirnya, sudut pencakar yang mempunyai sudut 10° merupakan mata alat yang paling sesuai untuk digunakan di dalam mesin pengisar konvensional.

DEDICATION

I would like to dedicate these special thanks towards my beloved parents and siblings for their endless encouragement, who inspired me throughout my journey of education. I would also like to thank all my lecturers and colleagues.

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TABLE OF CONTENT

Abstract	i
Table of Content	ii
Dedication	iii
Acknowledgement	iv
List of Figures	v
List of table	vi
1. INTRODUCTION	1
1.1 Background	1
1.2 Objectives of the study	2
1.3 Scope of study	2
1.4 Problem statement	3
2. LITERATURE REVIEW	4
2.1 Milling	4
2.1.1 Machining center	5
2.1.2 Milling machining operation	7
2.1.2.1 Peripheral milling	7
2.1.2.2 Face milling	8
2.1.2.3 End mill	9
2.2 Type of end mills	10
2.2.1 Two-flute end mills	10
2.2.2 Three-flute end mills	10
2.2.3 Multiple-flute end mills	11
2.2.4 Roughing end mills	11
2.3 End mill features	12
2.3.1 Outside diameter	12
2.3.2 Root Diameter	12

2.3.3	Tooth	12
2.3.4	Tooth face	13
2.3.5	Land	13
2.3.6	Flute	13
2.3.7	Gash angle	13
2.3.8	Fillet	13
2.3.9	Peripheral cutting edge	14
2.3.10	Face cutting edge	14
2.3.11	Relief angle	14
2.3.12	Clearance angle	14
2.3.13	Radial rake angle	14
2.3.14	Axial rake angle	15
2.3.15	Blade setting angle	15
2.4	Rake angle	16
2.5	Tool life: Wear	18
2.5.1	Types of wear	18
2.5.1.1	Flank wear	18
2.5.1.2	Crater wear	19
2.5.1.3	Chipping	19
2.6	Cutting forces	20
2.7	Surface finish	22
2.7.1	Description of surface roughness	23
2.8	Cutting tool material	24
2.8.1	Carbide	25
2.8.1.1	Tungsten carbide (WC)	25
2.8.1.2	Titanium carbide (TiC)	26
2.9	Work piece material – mild steel	27
3.	METHODOLOGY	29
3.1	Introduction	29
3.2	Flow chart	30

3.3	Summary of project implementation	32
3.3.1	Project mission	33
3.3.2	Literature review	33
3.3.2.1	Journal and articles	33
3.3.2.2	Books	34
3.3.2.3	Internet and web pages	34
3.4	Methodology approaches	35
3.4.1	Selection of work piece material ang cutting tool material	35
3.4.2	Machining parameters	36
3.4.3	Machining	37
3.4.4	Cutting tool selection	38
3.5	Data collection	39
3.5.1	Cutting forces	39
3.5.2	Surface finish	42
3.5.3	Tool wear	45
3.6	Method analysis	46
3.7	Gantt chart for PSM 1	47
3.8	Gantt chart for PSM 2	48

4 RESULTS AND ANALYSIS

4.1	Introduction	49
4.2	Quantitative analysis	49
4.2.1	Quantitative analysis on Surface Roughness (Ra)	52
4.2.2	Quantitative Analysis on Tool Wear	55
4.2.3	Quantitative Analysis on Cutting Forces	58

5 DISCUSSIONS

5.1	Introduction	61
5.2	Surface quality	61
5.3	Tool wear	62
5.4	Cutting forces	64

6 CONCLUSION AND RECOMMENDATIONS	66
6.1 Conclusion	66
6.2 Recommendations For Further Study	67
REFERENCES	68
APPENDICES	

LIST OF FIGURES

2.1	VCM with parts name	6
2.2	Movement of the VCM machine	6
2.3	Conventional milling	7
2.4	Climb milling	8
2.5	Face mill with indexable inserts	8
2.6	End Milling	9
2.7	Two flute end mills	10
2.8	Three flute end mills	10
2.9	Multiple flute end mills	11
2.10	End mill feature	12
2.11	Angle in End mill	13
2.12	Rake angle view	16
2.13	Effect of rake angle on machined workpiece surface	17
2.14	Tool wear phenomena	18
2.15	Flank wear	19
2.16	Crater wear	19
2.17	End mill operations	20
2.18	Force acting in the cutting zone during two dimensional cutting	21
2.19	Profile in surface appeared on the workpiece	23
2.20	Microstructure of carbon steel	28
3.1	Process flow chart of the project	30-31
3.2	Mild steel plate	35
3.3	Conventional milling machine	38
3.4	Carbide end mills tool	39
3.5	Dynamometer setup for milling process	40
3.6	Dynamometer experimental set-up for turning	40
3.7	Profilometer Mitutoyo Surftest SJ-301	42
3.8	Wear measurement	47

3.9	Experiment analysis method	46
4.1	Graph plot between Distance (mm) and Surface Roughness (Ra) - 0°	52
4.2	Graph plot between Distance (mm) and Surface Roughness (Ra) - 5°	53
4.3	Graph plot between Distance (mm) and Surface Roughness (Ra) - 10°	54
4.4	Graph plot between Distance (mm) and Tool Wear (mm) - 0°	55
4.5	Graph plot between Distance (mm) and Tool Wear (mm) - 5°	56
4.6	Graph plot between Distance (mm) and Tool Wear (mm) - 10°	57
4.7	Data cutting forces for rake angle- 0° (N)	58
4.8	Data cutting forces for rake angle- 5° (N)	59
4.9	Data cutting forces for rake angle- 10° (N)	60
5.1	The finishing workpiece after machining	62
5.2	Endmill cutting tool after machining (0° rake angle)	62
5.3	Endmill cutting tool after machining (5° rake angle)	63
5.4	Endmill cutting tool after machining (10° rake angle)	63
5.5	Endmill cutting tool after machining	64
5.6	Graph plot cutting forces between 3 rake angle	65

LIST OF TABLE

2.1	Material properties Tungsten Carbide (WC)	26
2.2	Tensile test data for alloy	28
3.1	Recommended milling parameters	36
3.2	Conventional milling machine	37
3.3	Basic Specifications MITUTOYO Surftest SJ-301 Portable Surface Roughness Tester	43
3.4	Gantt chart PSM 1	47
3.5	Gantt chart PSM 2	48
4.1	Result data for Surface Roughness (Ra)	50
4.2	Data result for Tool Wear	50
4.3	Data for cutting forces	51
4.4	Resultant forces	51

CHAPTER 1

INTRODUCTION

1.1 Background

In metal cutting, a cutting tool is used to remove excess material from a workpiece in order to convert the remaining material into shaped that required to produce. To produce high quality products at low cost, proper selection of tool materials, cutting parameters, tool geometry, and machine tools is essential. A considerable amount of these investigations has been directed towards the measurement and prediction of the cutting forces during machining. Knowledge of cutting forces is important because it can effect to the work piece material during machining. (M. Gunay et al., 2006)

Milling cutters are cutting tools used in milling machines or machining centers. This process removes material by their movement within the machine or directly from the cutters shape. Nowadays, milling cutters come in several shapes and many sizes. There is also a choice of coatings, as well as rake angle and number of cutting surfaces. Several types of milling cutters are end mill, slot drill, roughing end mill, ball nose cutter, slab mill, hobbing cutter, face mill and so on that can use in milling cutters. When using milling cutters, we cannot avoid taking consideration on its surface cutting speed, spindle speed, diameter of the tool, feed per tooth, feed rate and also depth of cut. (Kalpakjian and Schmid, 2006)

In this study, the effect of rake angle variation on end mill with respect to end mill wear, cutting force and also surface finish will be studied. Finding from this experiment might be applicable in industrial application in maximizing life and performance to the end mill.

1.2 Objective of the study

The outcomes of the study will be:

1. To study the effect of end mill rake angle variation to rate of wear of end mill and surface finish of the machined work piece.
2. To understand the impact of end mill rake angle variation to the cutting force during milling process.

1.3 Scope of study

This experiment will be done using manual operation. The study will focus on rake angle variation of end mill effect on end mill, cutting forces and surface finish. This experiment will be conducted using end milling tungsten carbide as the cutting tool and mild steel as the material. Four flute end mill shape will be using in this experiment. All data and result will be taken from dynamometer setting in measuring the cutting forces base on vibration during the cutting operation within the time domain and frequency domain.

1.4 PROBLEM STATEMENT

Nowadays there are several types of milling cutters such as end mill, face mill, slab mill and so on. In this project will be focus only on end mill milling cutters. On end mill cutter, there are many problems occur such as breakage, wear, rough surface finish, short tool life and so on. This problem affects finishing of machined product, life of cutting tool and reduces productivity of milling. Through this study, it will determine three effects such as cutting forces, tool wear and also surface finish on workpieces based on three different rake angles.

CHAPTER 2

LITERATURE REVIEW

2.1 Milling

The milling is the most using in cutting process in modern production. The primary objective of the modeling of the cutting forces in milling is to facilitate effective planning of the machining operations to achieve optimum productivity, quality, and cost. The developed analytical methods for cutting force prediction are frequently limited with spectrum of material and machining parameters. The great majority of researches in the area of cutting force use conventional deterministic prediction techniques. Since modern production is influenced by wide range of parameters, it is possible in most cases to obtain by conventional methods only sub-optimal solutions of problems. (M. Kovacic et al. (2004).

Milling machine is capable of performing a variety of cutting operations and is among the most versatile and useful machine tools. The first milling machine was built in 1820 by Eli Whitney (1765-1825). Its basic form is that of a rotating cutter which rotates about the spindle axis (similar to a drill), and a table to which the workpiece is affixed. The workpiece is held securely on the work table of the machine or in a holding device clamped to the table. It is then brought into contact with a revolving cutter. (Stephenson and Agapiou)

Used for general purpose milling operation, column and knee type machines are the most common milling machines. It can be used in one, two, three planes (X, Y, Z axes). The spindle on which the milling cutter is mounted may be horizontal for peripheral milling or vertical for face and end milling, boring, and drilling operations. A wide selection of typical standard milling machine with numerous features is now available. However, these milling machine and operations are now

being replaced with computer controls and machining centers. It can be highly automated in order to increase the productivity, and it is indeed the principle behind transfer lines. (Stephenson and Agapiou)

2.1.1 Machining Center

A machining center is an advanced, computer controlled machine tool that is capable of performing a variety of machining operations on different surfaces and different orientations of a workpiece without having to remove it from its workholding device or fixture. The workpiece is generally stationary, and the cutting tools rotate as they do in milling, drilling, honing, tapping, and similar operations. Whereas in transfer lines or in typical shops and factories the workpiece is brought to the machine, note that in machining centers, it is the machining operation that is brought to the workpiece. CNC machines allow more operations to be done on a part in one setup instead of moving from machine to machine for various operations. These machines greatly increase productivity because the time formerly used to move a part from machine to machine is eliminated. (Stephenson and Agapiou)

There are three main types of machining centers which are horizontal, the vertical spindle and universal machines. They are available in many types and sizes which may be determined by the following factors:

- The size and weight of the largest piece that can be machined.
- The maximum travel of the three primary axes (X, Y, Z).
- The maximum speed and feeds available.
- The horsepower of the spindle.
- The number of tools that the automatic tool changer (ATC) can hold.

Vertical machining centers (VCM) are capable of performing various machining operations on parts with deep cavities, such as in mold and die making. A vertical-spindle machining center is a saddle-type construction with sliding bedways that use a sliding vertical head instead of a quill movement and it is shown in figure 2.1. The

tool magazine is on the left of the figure and all operation and movements are directed and modified through the computer control panel. Because the thrust forces in the vertical machining are directed downward, such machines have high stiffness and produces parts with good dimensional accuracy. (Steve and Arthur, 2006)

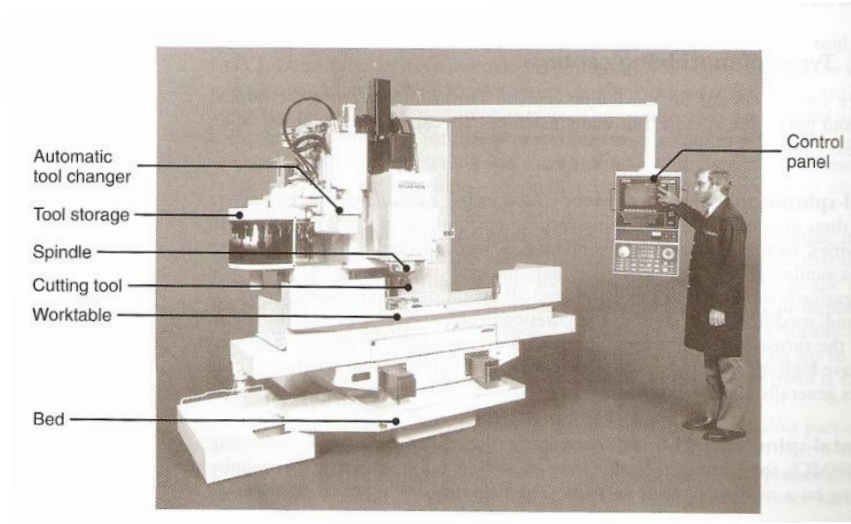


Figure 2.1: VCM with parts name

The vertical machining center operates on three axes which show in figure2.2:

- The X axis controls the table movement left or right.
- The Y axis controls the table movement toward or away from the column.
- The Z axis controls the vertical movement (up or down) of the spindle or knee.

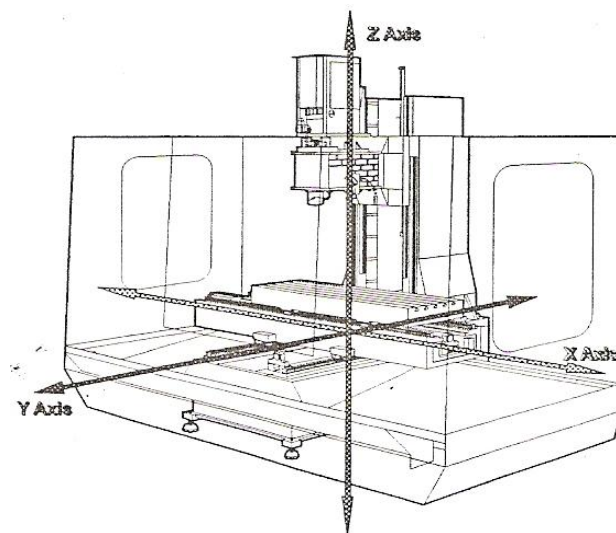


Figure 2.2: Movement of the VCM machine

2.1.2 Milling machining operation

There are three basic types of milling operations, which is

- a) Peripheral milling
- b) Face milling
- c) End milling

2.1.2.1 Peripheral milling

Peripheral milling also called plain milling which the axis of cutter rotation is parallel to the workpiece surface as show in figure. The cutter body which generally is made of high speed steel has a number of teeth along its circumference; each tooth acts like a single-point cutting tool. Cutter of peripheral milling may have straight or helical teeth, resulting in orthogonal or oblique cutting action.

There are two type of peripheral milling:

- Conventional milling
- Climb Milling

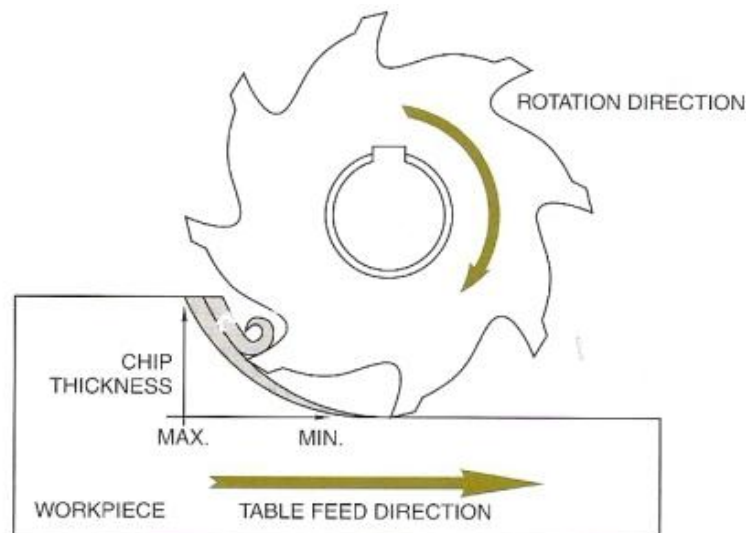


Figure 2.3: Conventional milling