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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I hereby declared this report entitled **"Investigation On The Effects Of Rake Angle Variations On The Endmill Wear, Cutting Forces And Surface Finish"** is the result of my own research except as cited in the references.

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(Signature of Supervisor)

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(Official Stamp of Supervisor)

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(Signature of Principle Supervisor)

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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^{o} 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 hausan,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 hausan dan juga pada hasil akhir pemesinan dan untuk memahami impak kepelbagaian sudut pencakar ini pada daya pemotongan. Benda kerja yang digunakan di dalam analysis terhad 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^{o} 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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In the name of Allah,The Most Gracious, Most Graceful.

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A Special thanks to my supervisor, Prof Dr Mohd Razali b. Muhamad and En Md Nizam b. Abd Rahman for their very valuable editorial advices, comments, guidance and support.

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THANK YOU

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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 centers is an advanced, computer controlled machine tools 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 machine allow more operation 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 is horizontal, the vertical spindle and universal machines. They are available in many types and sizes which may determine by 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 to 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 figure2.1**.** 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)

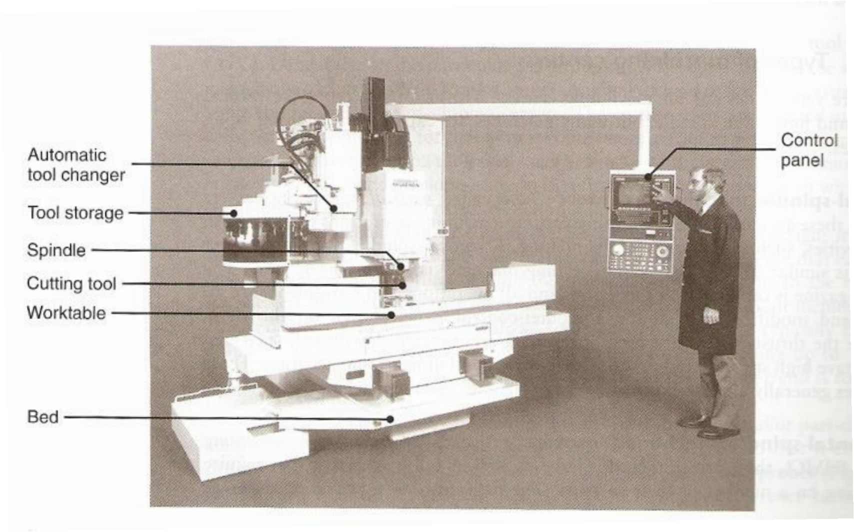

Figure 2.1: VCM with parts name

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.

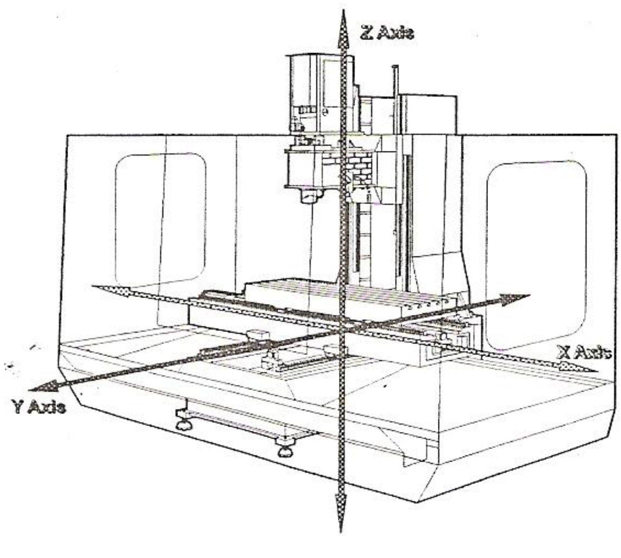

Figure 2.2: Movement of the VCM machine

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

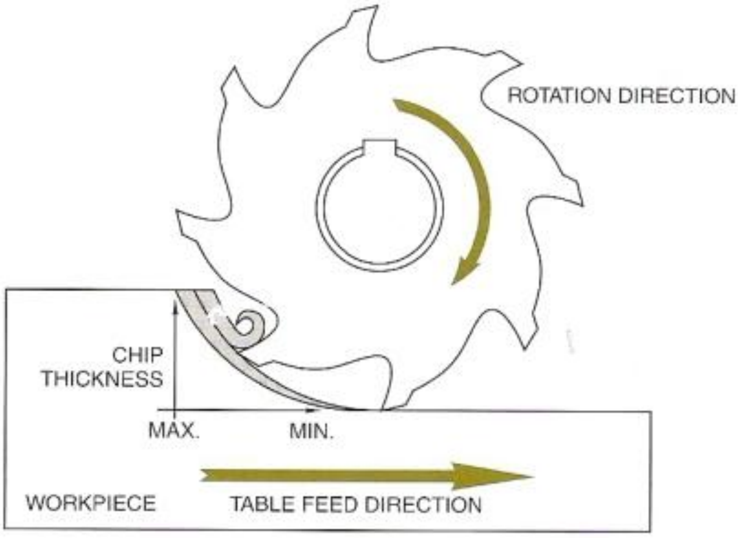

Figure 2.3: Conventional milling