UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYZE THE EFFECT OF DEPTH OF CUT TOWARDS SURFACE ROUGHNESS IN MILLING

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

By

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APPROVAL

This report 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 member of the supervisory committee is as follow:

……………………………………………….

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ABSTRACT

This paper presented an Analyze Depth of Cut towards Surface Roughness in Milling. Milling is the most common process when the workpiece demands good surface, dimensional and geometrical quality. In this experiment, a design of experiment (DOE) approach was used in finding the actual effect of depth of cut on surface roughness in milling process. The material used was mild steel 1030 and aluminium 6061.Surface roughness parameters *R*a was developed with the cutting conditions such as feed rate, cutting speed and depth of cut as the affecting process parameters. The surface roughness of work piece had been analyzed by using a Portable Roughness Measurement Machine. The data was compared and analyzed using MINITAB 14 software. The result showed the optimum depth of cut and interaction between the factors.

ABSTRAK

Kajian ini membentangkan tentang kedalaman pemotongan dan kesannya terhadap ke arah kekasaran permukaan dalam proses mesin kisar. Di sektor perkilangan, proses kisar adalah proses biasa dan kerana kualiti permukaan benda kerja, dimensi dan kualitinya. Dalam eksperimen ini, satu rekabentuk ujikaji Design of Experiment(DOE) digunakan bagi mendapatkan kesan sebenarnya kedalaman pemotongansesuatu bahan itu bagi menghasilkan kekasaran permukaan dalam proses pengilangan. Bahan digunakan adalah keluli sederhana 1030 dan aluminium 6061. Bagi parameter kekasaran permukaan ialah Ra dihasilkan atau diperoleh dengan menjalani makmal dengan syarat-syarat memotong ibarat kadar suapan, kelajuan dan ukur dalam proses kisar. Kekasaran permukaan kerja telah diuji dengan menggunakan satu Portable Roughness Measurement Machine. Data akan dibanding dan dianalisis menggunakan perisian MINITAB 14. Keputusan kajian ini akan menunjukkan kedalaman pemotongan paling optimum dan kesan yang terlibat.

DEDICATION

Dedicated to my father, Husman Bin Hj. Abd. Karim and my mother, Rahmah Tan Bte Abdullah.

To my supervisor, lecturers and friends for all of their help and friendship.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

PSI	-	Per square inch
ft^2	-	feet square
in^2	-	square inches
RPM	-	revolution per minute
HSS	-	high speed steel
CBN	-	cubic boron nitride
ANSI	-	American National Standard Institute

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CHAPTER 1

INTRODUCTION

1.1 Background Analysis

Milling is the indicated process when needed to make all the other parts that cannot be made on the lathe. The demand of low tolerances and better quality products have forced manufacturing industry to continuously progress in quality control and machining technologies. Wang and Chang (2004) classified one of the fundamental metal cutting processes is end milling which is very often utilized for pocket milling in die and mould making.

Yang and Chen (2001) specified surface roughness is used as the critical quality indicator for the machined surfaces and has influence on several properties such as wear resistance, fatigue strength, coefficient of friction, lubrication, and wear rate and corrosion resistance of the machined parts. For this purpose, a number of experiments with four flute high-speed steel end mills were carried out on an aluminium material. Based on the data obtained a model was trained and tested, the system was proved capable of predicting the surface roughness with accuracy.

In today's manufacturing industry, special attention is given to dimensional accuracy and surface finish. Thus, measuring and characterizing the surface finish can be considered as the predictor of the machining performance noted by Reddy and Roa (2005). A lot of research have been conducted for determining optimal cutting parameters in machining processes.

However, surface roughness is also affected by the cutter path strategies. For minimizing the surface roughness, the proper selection of cutter path strategies is very important. Different cutter paths in pocket milling operations can be used with end mills. Therefore, it is essential to investigate the effects of cutter path strategies in pocket milling. The aim of this study is, first, to investigate optimum cutting characteristics of DIN 1.2738 mould steel, which is one of the most commonly used plastic mould steel that noted by Thomas et al. (2000).

Hence the proper estimation of surface roughness has been the focus of study for several years. The surface roughness describes the geometry of the surface to be machined and combined with surface texture. The formation of surface roughness told by Benardos and Vosniakos (2003) that mechanism is very complicated and mainly depends on machining process.

Existing high-speed machining technology for rough milling is found on an unnecessary compromise. In order to increase two of the primary machining parameters spindle speed and federate two other primary parameters depth-of-cut and step over are reduced. While the machine certainly moves faster, material removal rates fall far short of what they could be. This is entirely due to the fact that all tool path algorithms since the inception of numerical control is fundamentally flawed, and the specialized high-speed milling algorithms that have emerged over the past decade contain the exact same flaws by Bernados and Vosniakos (2003).

The fatigue life of a machined part depends strongly on its surface condition. It has long been recognized that fatigue cracks generally initiate from free surfaces. This is due to the fact that surface layers experience the highest load and are exposed to environmental effects. Stress concentration, oxidation, and burning out of alloy elements (at high operational temperatures) are the factors acting upon the surface layers that contribute to crack initiation. Crack initiation and propagation, in most cases, can be attributed to surface integrity produced by machining noted by Zahavi and Torbilo (1996). A large number of theoretical and experimental studies on surface profile and roughness of machined products have been reported. These studies show that cutting conditions, the material properties of tool and work piece, as well as cutting process parameters (including cutting speed, depth of cut, feed rate, and tool geometry) significantly influence the surface finish of machined parts.

The obvious difference between turning and milling processes is that, in turning the main power is used to rotate an essentially cylindrical work piece with feed motions applied to the tool. But, in milling the main power rotates a cutting tool with the prismatic work piece undergoing feed motions. Milling cutting tools have many cutting edges and are more complicated than turning tools and each edge cuts only intermittently. The cost of the tools makes it prudent to remove metal more slowly and vibrations set up by the intermittent tool contacts reinforce this. The longer cutting times make, the non-productive time less significant noted by Thomas et al. (2000).

1.2 Problem Statement

Currently in milling operation there are a few condition of part after machining. The conditions of the part are recognized by referring the accuracy of the dimension and surface roughness. The good surface roughness is caused by many variables. It might be cutting speed, feed rate or depth of cut. For this analysis the main effect to analyze is depth of cut while machining process towards surface roughness. After machining process, the surface roughness shall give results depending on several of depth of cut used. Type of material used was mild steel and aluminium. In order to study the problem, an analysis has been carried out with help of the previous study on the literature review on investigations into the effect of cutting conditions on surface roughness in milling, design of experiments (DOE) and other references for this analysis and research method.

1.3 Objectives

The objectives of this analysis are:

- To analyze the effect of depth of cut on mild steel and aluminium
- To identify the suitable depth of cut to get fine surface roughness.
- To study the effect of machining parameters on feed rate, depth of cut and cutting speed

1.4 Scope of Project

The scope of this study was limited to only 2 types of material. Those were mild steel 1030 and aluminium 6061. Design of experiments (DOE) methodologies used where full fractional designs will be used based on the 3 main factors. Normal probability, Pareto chart, cube plot, interaction plot, main effect plot and other tools will be constructed by using MiniTab software which will be applied for this study. The machining process was done using conventional milling machine and to get the result of surface roughness precisely where it used the apparatus in metrology lab. The method used for milling was climb milling where face mill cutting tool with 6 insert used. Face mill was preferred because that type of cutting was easy to find at the lab. There were two value of depth of cut used for each material in gaining the good result.

1.5 Report Outline

Chapter 1 gives an introduction to the analysis which includes the objectives, scope and background. In this chapter, it describes the background of milling process.

Chapter 2 presents the literature review on surface roughness in milling with DOE concepts and what is the correlation about surface roughness and depth of cut in milling process.

Chapter 3 describes the DOE concepts and description of the methodology used in this analysis.

Chapter 4 will display the result and data collection from machining process and the experiment done. In this chapter, all collected data will be analyzed stage by stage.

Chapter 5 presents the conclusion of the whole project and suggestions for future work.

1.6 Gantt Chart

Table 1.1: Gantt chart for PSM1

No	Task Item	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16
1	Selection of PSM title																
2	Identify PSM title														proper actual		
3	Develop detail plan																
4	Interpret Project Requirement																
5	Journal, books references																
6	Review Experiment Method																
7	Discussion Project Implementation																
8	Background of research																
9	Problem Statement																
10	Objective of the research																
11	Journal Research																
12	Books and machine manual																
13	Machining method and procedure																
14	Evaluation method and procedure																
15	Presentation PSM 1																

Table 1.2: Gantt chart for PSM2

NO	Task Item	W1	W2	W3	W4	W5	W6	W7	W8	W9	W 10	W 11	W 12	W 13	W 14	W 15	W 16	W 17	W 18	W 19
1	Improvement on PSM 1																			
2	Books, journals, etc																			
3	Discussion with supervisor																			
4	Machine and material preparation																			
5	Machining process																			
6	Surface roughness measurement																			
7	Analysis using MINITAB 14																			
8	Subsurface analysis																			
10	Correction on chapter 4																			
13	Submit draft to supervisor																			
15	submission report to supervisor and judger																			
16	Presentation slide																			
17	PSM presentation																			
18	Final editing / hard cover																			
19	Submission PSM report																			

CHAPTER 2

LITERATURE REVIEW

2.1 Milling Features

Milling is a machining process for generating machined surfaces by removing a predetermined amount of material progressively from the work piece. The milling process employs relative motion between the work piece and the rotating cutting tool to generate the required surfaces. In some applications, the work piece is stationary, and the cutting tool moves, whereas in others, the cutting tool and the work piece are moved in relation to each other and to the machine. A characteristic feature of the milling process is that each tooth of the cutting tool takes a portion of the stock in the form of small, individual chips.

The feeds and speeds with which materials may be milled using the carbide, cermet, ceramic, and advanced cutting tool materials such as cubic boron nitride (CBN) that are used widely in industry today (Ronald A Walsh, 2001). Cutting tool technology has advanced rapidly, and new tools and materials are being made available at a rapid pace.

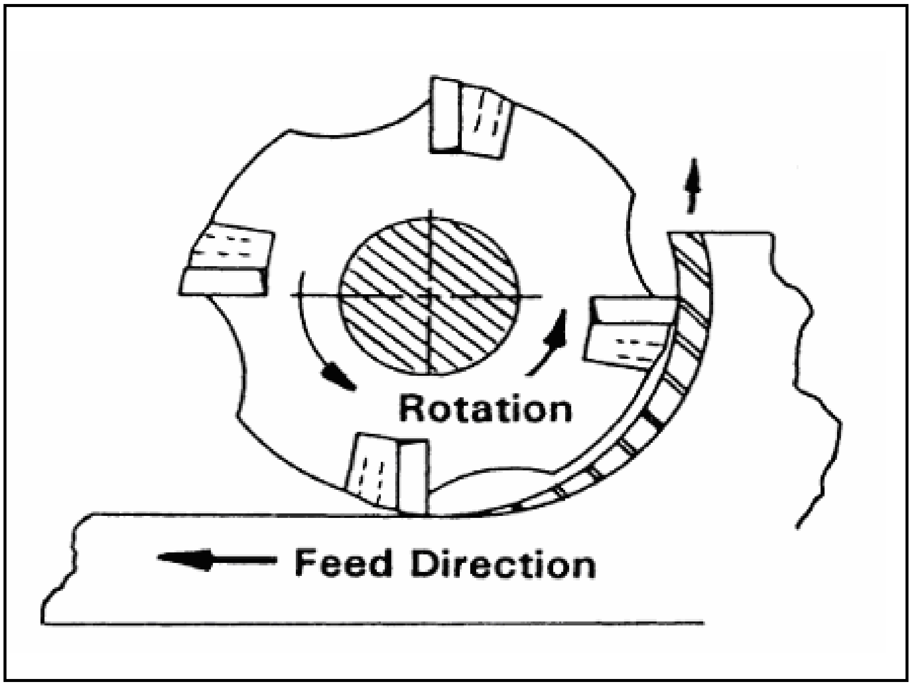

Figure 2.1: Up milling (Ronald and Denis, 2006).

It is a common practice for many years in the industry to mill against the direction of feed. This was due to the type of tool materials then available (HSS) and the absence of antibacklash devices on the machines. These methods are known as conventional or up milling as in Figure 2.1. Up milling is also considered to as conventional milling. The direction of the cutter rotation opposes the feed motion. For example, if the cutter rotates clockwise, the work piece is fed to the right in up milling. The chip formation in up milling is opposite to the chip formation in down milling. Nevertheless, for up milling the chips usually come to the user if they could not stand at the right side because the cutting tool starts to mill the small chip thickness. Then, the chip thickness gradually increased. This type of milling method is not preferred because it may injure the user while machined the sample because the rotation of cutting tool makes the chips come to the user rapidly.

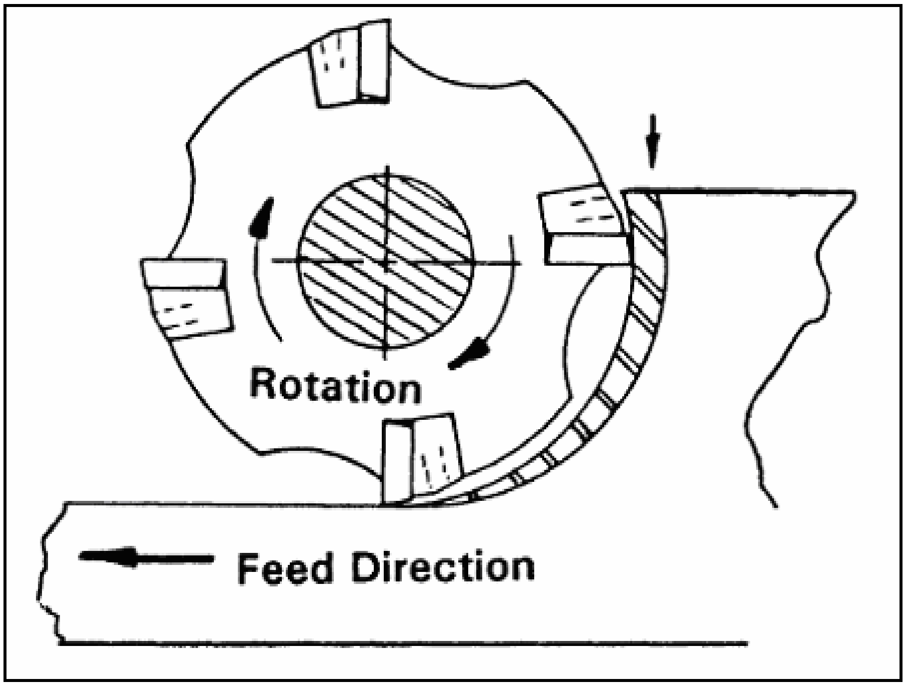

Figure 2.2: Down milling (Ronald and Denis, 2006).

Ronald and Denis (2006) noted that climb milling or down milling is now the preferred method of milling with advanced cutting tool materials such as carbides, cermets and CBN as in Figure 2.2. The insert enters the cut with some chip load and proceeds to produce a chip that thins as it progresses toward the end of the cut. This allows the heat generated in the cutting process to dissipate into the chip. The cutting tool will rotate anticlockwise and the work piece will come from right side. The cutting tool will climb the work piece along the machining process. The user will be able to avoid the chips by standing in front of the machine and at the right side.

Climb milling is preferred when milling heat treated alloys, stainless steel to reduces work hardening. Climb-milling forces noted by Ronald and Denis push the work piece toward the clamping fixture, in the direction of the feed. Conventional-milling (up-milling) forces are against the direction of feed and produce a lifting force on the work piece and clamping fixture.