UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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THE EFFECT OF CUTTING PARAMETER ON SURFACE ROUGHNESSDURING END MILLING OF AISI D2 TOOL STEEL

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

by

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DECLARATION

I hereby, declared this report entitled "The Effect of Cutting Parameters on Surface Roughness during End Milling of AISI D2 Tool Steel" is the results of my own research except as cited in 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 Management) (Hons.). The member of the supervisory is as follow:

…………………………………

(DR MOHD SHAHIR BIN KASIM)

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TAJUK: THE EFFECT OF CUTTING PARAMETERS ON SURFACE ROUGHNESS DURING END MILLING OF AISI D2 TOOL STEEL

SESI PENGAJIAN: 2013/14 Semester 2

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ABSTRAK

Alat keluli AISI D2 adalah bahan yang mengandungi karbon yang tinggi dan juga keluli kromium aloy merujuk kepada bahan yang sukar untuk dimesin. Pengajian ini dijalankan untuk mengenalpasti kesan pemotongan laju terhadap bahan keluli AISI D2 mengunakan jenis mata alat masukkan. Ujikaji ini dibuat menggunakan kaedah Metodologi Permukaan Sambutan (RSM) oleh pendekatan Box Behken. Kesan pembolehubah pemotongan adalah kelajuan pemotongan (Vc), kadar suapan (fz), dan lebar pemotongan (ae) yang masing-masing berada dalam julat 100-150 m/min, 0.1-0.2 mm/gigi, dan 2.0-8.0 mm. pengajian ini membuktikan bahawa pemboleh ubah yang memberikan kesan yang paling ketara terhadap kekasaran permukaan dalam turutan kebawah bermula dengan kelajuan pemotongan, kadar suapan, dan lebar pemotongan. Kesan faktor masukan terhadap tindak balas dikenalpasti dengan menggunakan analisis variant iaitu (ANOVA). Tindak balas terhadap kekasaran permukaan dioptimumkan secara serentak. Pembolehubah optimum yang menghasilkan kekasaran permukaan yang terbaik adalah dengan kelajuan pemotongan sebanyak 150 m/min, kadar suapan sebanyak 0.1 mm/gigi dan lebar pemotongan sebanyak 8mm iaitu dengan menghasilkan kekasaran permukaan sebanyak 0.189 µm.

ABSTRACT

The material of AISI D2 tool steel contains high carbon and chromium alloyed is referred as difficult material to be machining. This research was performed to identify the implications of machining variables in High Speed Machining of milling using material of AISI D2 tool steel with inserted end mill tool. The experiment work was carried out using Box-Behken techniques, a part of response surface methodology (RSM) approach by generating from the Design Expert Software. The effect of milling parameters that are cutting speed, feed rate, and width of cut were studied to evaluate their effects on surface roughness. In this study, the cutting speed, feed rate, and width of cut were in the range of 100-200 m/min, 0.1-0.3 mm/tooth, 0.2mm and 2.0-8.0 mm respectively. This study prove that the parameters that give the most significant to the surface roughness in descending order starting from cutting speed, feed rate and width of cut. The effects of input factors on the response were identified by using analysis of variance ANOVA. The responds of surface roughness then simultaneously optimized. The optimum parameters that yield the best surface roughness are cutting speed of 150 m/min, feed rate of 0.1 mm/min and the width of cut of 8mm that produce the surface roughness of 0.186 µm.

DEDICATION

I would like to thank my supervisors Dr Mohd Shahir Bin Kasim, lecturers, friends, families and to those that helps me to finishing this report and research.

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HSM	High Speed Machining
CNC	Computer Numerical Method
RSM	Response Surface Methodology
DOE	Design of Experiment
ANOVA	Analysis Of Variance
PVD	Physical Vapor Deposition
CVD	Chemical Vapor Deposition
MQL	Minimum Quantity Lubricants

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Milling is the process of highly versatile machining operations that can be performed in various ways on flat, curved or can be vertical or irregular surface with a variety of configurations by using a tool which is called milling cutter. This experiment performed because nowadays, the machining condition has become increasingly important in satisfying manufacturing requirements in term of product quality, time consuming, customer specifications and productivity. The product quality included the surface roughness that which has a small tolerance, and lowest surface roughness, Ra. According to Yih-Fong and Ming-Der (2005), Due to increase the productivity and throughput, High-Speed Machining of CNC milling technology has been increasingly used in the producing a mould and die. By Benardos and Vosniakos (2002), the automated of flexible manufacturing systems integrate employed for that purpose along using CNC machines that will be simultaneously increase high accuracy machining and with low the processing time.

AISI D2 tool steel, are contain the high element of chromium, carbon, tool and die steel. The material is very strong with the hardness of 54-62 HRc, exhibits remarkable characteristics as the result, this material have high temperature operations, high strength, very high resistance to cracking and high resistance to softening and wear. Basically D2 tool steel is commonly used in making of mould and die, cutting tool, aerospace, and power generation industries. However, AISI D2 tool steel was generally known as the most difficult material to be machined because of its high abrasion resistance, and high strength properties (Koshy et al., 2002).

To investigate the best surface roughness, each cutting parameter of milling operation needs to be studied in detail. Any changes on the parameter greatly affect the surface roughness. Based on previous research, (Buj-Corral et al., 2012), with reducing width of cut parameter, the roughness is decreasingly regardless of feed employed during machining operation. Surface roughness basically known to be highly affected by machining parameters consists of feed rate, cutting speed and depth of cut (Davim, 2010). The shape of cutting tool also is other factor considered in influencing the surface roughness, (Yasir et al., 2009). Other researcher Iqbal et al. (2008), is found that, the material inclination angle, radial depth of cut, this parameters that significantly affects surface finish after machining.

The experiment is performed on investigate the surface roughness when finish milling at several of milling parameter under flooded coolant systems. The low of Surface roughness commonly used to determine the best cutting parameters under various cutting parameters. This study aims to find the machining that will result in the lowest value of surface roughness. The response surface methodology (RSM) method is used for carrying out the design of experiment, analysis of variance (ANOVA), mathematical modelling, validation and optimization process. The experimental design has three parameters, consequently carrying out a total number of 17 experiments. According by Öktem et al. (2005), the use of Response Surface Methodology (RSM) could develop an effective methodology in determine the optimum cutting conditions which can producing a minimum surface roughness in milling operation.

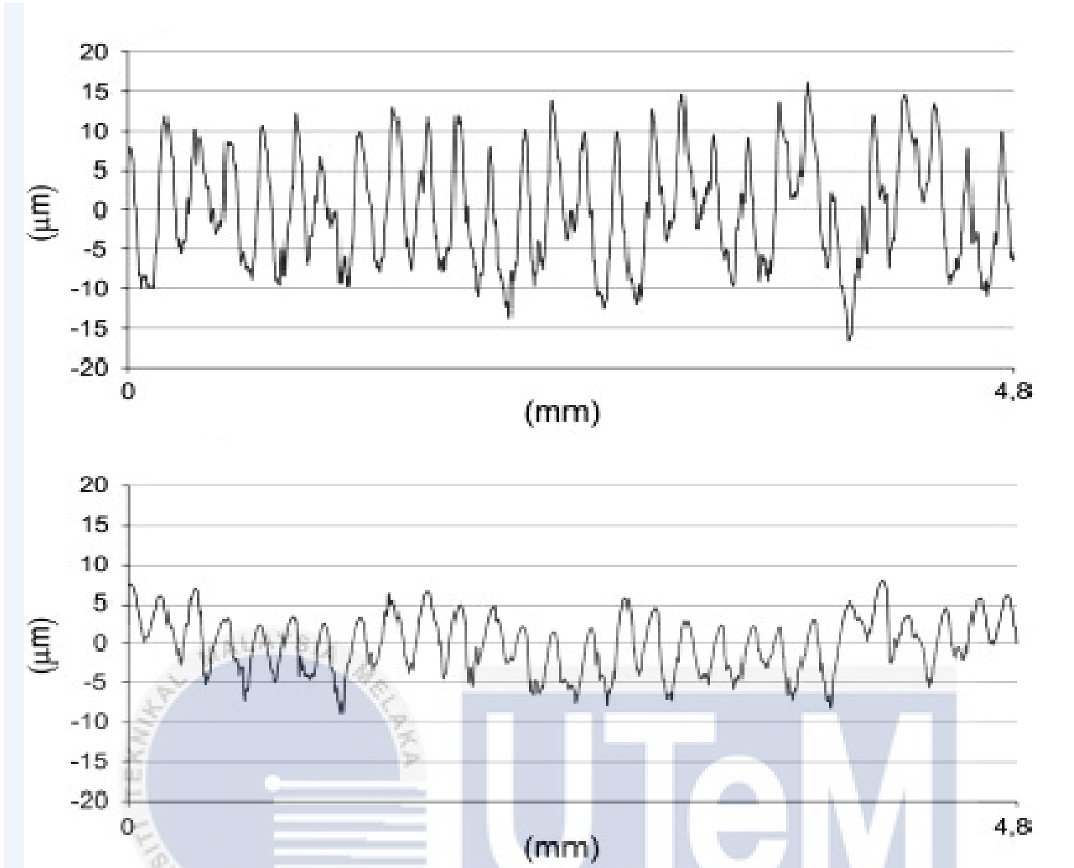

Figure 1.1: Surface roughness profiles

Figure 1.1 exemplifies how the surface roughness for A and B have a lot of variation in terms of amplitude and valley but A is much rougher compared to B. It can be seen from figure 1.1 (A) that the highest amplitude is 16 µm and the lowest valley is -16 µm. For figure 1.1 (B), the highest amplitude is 8 µm and the lowest valley is -8 µm. It can be concluded that elimination of variation and lower amplitude can produce a better surface roughness.

The surface roughness is important in die making industries, when a die is made with lower value of surface roughness. The product made from the die will have a good dimensional tolerance and good surface finish. In automotive industries, the surface roughness is crucial in making an engine block. The surface roughnesses of piston and block have significant effect on the efficiency of the engine. In combustion of engine block, the energy generated in between the piston and block will be dissipated through irregular surface between block wall and piston. Moreover, the surface roughness is used in brake pad application especially vehicle. The brake pad requires high surface roughness to ensure the gripping force is sufficient to slow down the vehicle. Furthermore, the ball bearing is made with high precision to assure the movement of ball bearing is smoothing thus reduced the friction between ball and its housing. When the friction is reduced, it will improve the rotational speed of a particulate application. Based on the example above, it shows that the important of surface roughness in an application. Kalpakjian (2001), mentioned that surface roughness design in particular application differs. Some examples are as follows:

- Bearings balls 0.025μm
- Crankshafts bearings 0.32μm
- Brake drums 1.6μm
- Clutch-disk faces 3.2μm

$$R_q = \sqrt{\frac{1}{L}\int_0^L Z^2\ (x)dx}$$ Equation 1.1

L= length

Z= Height

X= distance of measurement

Refer to Equation 1.1, as illustrated a theoretical measurement length of L is characterize as the length of profile used for the analysis of surface roughness parameters. Generally containing a few inspect length, the five successively samplings length are taken as standard. Rq is the rms parameter corresponding to Ra. Surface roughness texture can be separated into two types consists of:

a) Amplitude parameter – a measures of the vertical characteristics of the surface deviations

b) Spacing parameters – a measures of the horizontal characteristics of the surface deviations

1.2 PROBLEM STATEMENT

In identifying surface roughness quality, research on factors which control machining performance of milling machine parameter has been performed to analyze the effect of cutting parameters on surface roughness. To obtain good surface roughness during machining process, the most important thing is to make sure the parameter that will be used is suitable with the type of work piece material, otherwise probably the surface machining will be exposed to various types of defects. The improvement of quality of cutting process for high-speed machining on industries will result in increased customer demand for better quality products in the process of cutting metals. In machining process, a more precise tolerance can produce a product with better quality surface roughness. Among the metal cutting metal materials, end mill is one of the tools which are involved in the process. Surface roughness in mould and die is most important factor to represent the functionality of the products produced. Determining the accuracy of the cutting of parameters is very important before machining process is performed as to determine the level of quality of the surface. There are three parameters that are chosen in this research, cutting speed, feed rate, and depth of cut. These three parameters that had been selected are to determine the effect cutting parameters on surface roughness and the best cutting variable that can be produced the minimum value of surface roughness.

1.3 OBJECTIVE

The purposes of this study are:

I. To investigate the effect of cutting parameter namely cutting speed, feed rate and width of cut on surface roughness at the end of milling process on D2 tool steels material

II. To develop mathematical model using Response Surface Methodology (RSM) method by generating from the Design expert software

III. To identify the optimized cutting parameter under flooded coolant system.

1.4 SCOPE

The scope of the study is mainly to determine the best cutting parameter during machining operation. The selected cutting parameters consists of cutting speed, feed rate, and width of cut as variable input in order to obtain a minimum quality of surface roughness in the end mill process. The materials being used in this experiment is AISI D2 tool steel with hardness of 62HRc. The machining process is conducted by using 3-axis CNC milling machine. Strategy machining that is climb milling is used for a cutting operation which starts at the surface of the work piece where the chip is thickest. The machining process is carried out under flooded machining condition with using fresh tool for every run of experiment. The linear cutting motion is used on the machining method perform on the work piece during the machining operation. Surface roughness obtained from the machining process will be measured by using a portable Mitutoyo SJ-301. After that, the data gained will be interpreted and analyzed with using Response Surface Methodology (RSM) to obtain the best cutting condition in producing the lowest surface roughness.

1.5 ORGANIZATION OF REPORT

The report of *Projek Sarjana Muda (PSM)* will cover the whole project that need to be done by fourth year student. The report cover sixth chapters consist of chapter 1 introduction, chapter 2 literature reviews, chapter 3 methodologies, chapter 4 results and discussion, chapter 5 conclusions and chapter 6 is reference. The summary of the organization of this report is represented in table 1.1:

Table 1.1: Organizational report

CHAPTER	DESCRIPTION
1	• Overview of the study • Introduction • Problem statement • Objective • Scope • Organization of report
2	• Literature review containing the theory involves that taken from journal and books.
3	• The method that have been used to achieve the objective of this research • Process flow chart
4	• Result • Analysis • Discussion • Findings
5	• Conclusion • Suggestion and recommendation
6	• references

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND

Milling contains a variety of machining operations that includes variety of configurations which use milling cutter that is made up from multi tooth tool which produce lot of chip in one revolution (Kalpakjian and Schmid, 2013). Types of milling include peripheral milling, face milling, and end milling. Other operations of peripheral milling are straddle milling, form milling, slotting and slitting. In peripheral milling the axis of cutter rotation is parallel to the work piece surface (Kalpakjian and Schmid, 2013). Meanwhile for face milling operations the axis of the cutter is perpendicular to the work pieces surface (Kalpakjian and Schmid, 2013). Face milling process basically it is used to remove the upper surface of work pieces and commonly used for roughing process. In end milling process it is the same as with face milling but, it is capable to produces various profile and curves surfaces.

2.2 END MILLING

End milling is basic machining operation and commonly used in industry because of its versatility and capability to made variety shapes and curves profiles of the product. The milling cutter namely end mill has either a straight shank or a tempered shank and is mounted into holder at spindle of the milling machine. According to Kasim and Sulaiman (2013), end milling can be part of the final machining process. Basically end mill cuter is made from high speed steels or with carbides inserts, similar with face milling. The milling cutter basically rotates on an axis perpendicular to the work pieces surface during machining, and it's also can be tilted to conform machine tapered or curves surfaces. Based on previous researches Saedon et al. (2012). Saedon et al. (2012), Material deposited onto the cutting edges and on the end face of the tool will have a direct influence on cutting forces and work piece surface roughness.

2.3 END MILL CUTTER