UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPLICATION OF TAGUCHI METHOD IN THE OPTIMIZATION OF CUTTING PARAMETER FOR SURFACE ROUGHNESS IN TURNING

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

by

NUR YASMIN BT ZULKIFLI
B050710001

FACULTY OF MANUFACTURING ENGINEERING
2011

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Application of Taguchi Method in the Optimization of Cutting Parameter for Surface Roughness in Turning**

SESI PENGAJIAN: 2010/11 Semester 2

Saya **NUR YASMIN BT ZULKIFLI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

____

Alamat Tetap:
A4-L3-01, PPR Paya Nahu II,
08000, Sungai Petani,
Kedah.

____

PENYELIA PSM

(Tandatangan dan Cop Rasmi)

Tarikh: ______________________

Tarikh: ______________________

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Application of Taguchi Method in The Optimization of Cutting Parameter for Surface Roughness in Turning" is the results of my own research except as cited in references.

Signature	:	………………………………….....
Author's Name	:	NUR YASMIN BINTI ZULKIFLI
Date	:	17 MAY 2011

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the Degree in Bachelor of Manufacturing Engineering (Manufacturing Process). The member of the supervisory committee is as follow:

……………………………………..

Supervisor

(Signature & Official Stamp of Supervisor)

ABSTRAK

Kekasaran permukaan merupakan satu peranan penting dalam pelbagai bidang dan ianya juga salah satu faktor yang amat penting dalam penilaian sesuatu ketepatan pemesinan. Ini adalah kerana kekasaran permukaan memberikan impak yang besar terhadap sifat-sifat mekanikal seperti sifat kelesuan, rintangan kakisan, rayapan dan lain-lain. Kertas kajian ini membincangkan tentang aplikasi kaedah taguchi dalam pengoptimuman faktor-faktor untuk menguji kekasaran permukaan dalam proses melarik keluli lembut. Ujian dijalankan menggunakan 'coated carbide'. Kelajuan pemotongan yang digunakan ialah 1500 dan 2000rpm dengan ukuran kedalaman pemotongan ialah 0.15 dan 0.17mm manakala kadar pemotongan ialah 0.020 dan 0.025mm/rev. Kajian ini menjurus kepada kesan kekasaran permukaan ketika pemesinan dengan menggunakan kadar pemotongan yang berbeza semasa proses melarik. Kaedah taguchi membantu untuk memilih atau menentukan syarat-syarat optimum pemotongan untuk menjalankan eksperimen. Oleh itu, kekasaran permukaan pada permukaan benda kerja akan diukur dengan menggunakan mesin penyukatan kekasaran mudah alih. Kekasaran permukaan setiap benda kerja, akan diukur untuk setiap pemotongan yang dijalankan. Hasil akan menunjukkan kesan daripada perubahan pemotongan kepada kekasaran permukaannya.

ABSTRACT

Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. This is because surface roughness has large impact on the mechanical properties like fatigue behaviour, corrosion resistance, creep life and etc. This study discusses the application of taguchi method in the optimization of cutting parameter for surface roughness in turning process of mild steel. The test carry out using coated carbide inserts. The cutting speed use is 1500 and 2000rpm with depth of cut is 0.15 and 0.17mm while feed rate is 0.020 and 0.025mm/rev. This study focuses on the effect of the surface roughness while machining under different cutting parameters of the turning process. The taguchi method helps to select or to determine the optimum cutting conditions for the experiments. Thus the surface roughness of the workpiece will measure using a portable roughness measuring machine. Surface roughness of every workpiece under various cutting parameter will be measure as an impact to surface quality. The result reveal of the effects of cutting parameters on responses like surface roughness.

ACKNOWLEDGEMENT

I would like to thank for those who have reviewed and/or made contribution to this project. I am especially Alhamdulillah to Allah s.w.t to give all the guidance and also Blessing me, to the following indebted individuals especially to my Supervisor En. Mohd Shukor Bin Salleh, for your kindness advises guidance in developing and producing this work, moral support, until my Final Year Project completed. I am also indebted to my parents for your kind always praying for my successful. I thank to our lecturer in FKP, too numerous to mention, have shared their input and contribution on how to make this project more effectives as a teaching and learning tool. To all those who have helped, I expressed my sincere “Thanks”!

Last, but certainly not be least, continual encouragement and support of my family and friends is deeply and sincerely appreciated.

DEDICATION

My Parents

Who has always been there for me and always prays for me,

My younger sister,

My friends

Who has support me,

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CNC	-	Computer Numerical Control
UTeM	-	Universiti Teknikal Malaysia Melaka
PSM	-	Projek Sarjana Muda
AISI	-	American Iron and Steel Institute
SAE	-	Society of Automotive engineers
TiC	-	Titanium carbide
TiCN	-	Titanium carbonitride
CVD	-	Chemical vapour deposition
PVD	-	Physical vapour deposition
R_a	-	Average surface roughness value
BUE	-	Built-up edge
PDE	-	Parameter Design Experiment
S/N	-	Signal-to-noise
MRR	-	Material Removal Rate
DOE	-	Design of experiment
FKP	-	Fakulti Kejuruteraan Pembuatan

CHAPTER 1

INTRODUCTION

1.1 Background

The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact (Hasan, 2007). Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy (Palanikumar, 2006). Surface roughness, an indicator of surface quality is one of the most specified customer requirements in a machining process. For efficient use of machine tools, optimum cutting parameters (cutting speed, feed rate and depth of cut) are required. So it is necessary to find a suitable optimization method which can find optimum values of cutting parameters for minimizing surface roughness.

In turning operation, it is an important task to select cutting parameters for achieving high cutting performance. Usually, the desired cutting parameters are determined based on experience or by use of hand book. But the ranges given these sources are actually starting values and not the optimal values. However, this does not ensure that the selected cutting parameters have optimal or near optimal cutting performance for a particular machine and environment (Srikanth, 2008). Since turning is the primary operation in most of the production processes in the industry, surface finish of turned components has greater influence on the quality of the product. Surface finish in turning has been found to be influenced in varying amounts by a number of factors such as feed rate, work material characteristics, work hardness, unstable built-up edge, cutting speed, depth of cut, cutting time, and tool nose radius.

The Taguchi method is statistical tool, adopted experimentally to investigate influence of surface roughness by cutting parameters such as cutting speed, feed rate and depth of cut. The Taguchi process helps to select or determine the optimum cutting conditions for turning process. Many researchers developed many mathematical models to optimize the cutting parameters to get lowest surface roughness by turning process. The variation in the material hardness, alloying elements present in the work piece material and other factors affecting surface finish and tool wear. The Taguchi design of experiments was used to optimize the cutting parameters and it is a powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize designs for performance, quality and cost. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. To determine the best design it requires the use of a strategically designed experiment. Taguchi approach to design of experiments in easy to adopt and apply for users with limited knowledge of statistic, hence gained wide popularity in the engineering and scientific community. The desired cutting parameters are determined based on experience or by hand book. Cutting parameters are reflected on surface roughness, surface texture and dimensional deviation turned product. In a manufacturing process it is very important to achieve a consistence tolerance and surface finish. Taguchi method is especially suitable for industrial use, but can also be used for scientific research (Hasan, 2007).

1.2 Problem statements

Cutting parameters and surface roughness of mild steel has to be studied in this project. In machining operation, the quality of surface finish is an important requirement for many turned workpieces. This project presents a study of application of Taguchi method in the optimization of cutting parameter for surface roughness in turning which allow it to be examined in more detail.

For this research study, it is targeted to find out the answer for the following questions:

1. What are the roles of optimized cutting parameters (cutting speed, feed rate and depth of cut) of the turning process for controlling the required surface roughness?
2. How Taguchi process helps to select or to determine the optimum cutting conditions for turning process?
3. How surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy?

1.3 Objectives

The objectives of this study are as follow:

1. To find the optimal cutting parameters for surface roughness in turning.
2. To define the number of levels for the process parameters and possible interaction between the process parameters.
3. To select the appropriate orthogonal array and assign of process parameters for the orthogonal array.

1.4 Scope

This project will involve machining by CNC turning in UTeM machine shop. Mild steel will be used as workpiece and coated carbide as a cutting tool in this project. This project will focused on cutting parameters and surface roughness in turning by Taguchi method.

1.5 Structure of the report

The summary of each chapter was described in the structure of report. The structure of the report includes Chapter 1 until Chapter 6 of the report.

1.5.1 Chapter 1: Introduction

This chapter includes the background of the project, problem statement, objectives, scope and project management of the whole project.

1.5.2 Chapter 2: Literature review

Literature review on cutting parameters, surface roughness, material used which is mild steel and inserts used (coated carbide).

1.5.3 Chapter 3: Methodology

This chapter describes the methodology of the project that contains a brief explanation about the work piece preparation (mild steel), preparation of the machine, the analysis of cutting parameter and surface roughness, discussion and conclusion.

1.5.4 Chapter 4: Result

1.5.5 Chapter 5: Discussion and Analysis

1.5.6 Chapter 6: Conclusion and Recommendations

Table 1.1: Gantt chart for PSM 1

No.	Task	Week																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Selection of PSM title																			
2	PSM title selected and filled the form																			
3	Research, study and understand the synopsys of title																			
4	Find all informations, journal and references book																			
5	Discuss the objectives and scopes with supervisor																			
6	Rework and make correction for objectives and scopes																			
7	Meet and discuss the progress of PSM with supervisor																			
8	Implement introduction and literature review																			
9	Review the introduction and literature review by supervisor																			
10	Make flow chart for preparing specimens, experiments																			
11	Implement methodology chapter																			
12	Review methodology by supervisor																			
13	Make a correction for methodology chapter																			
14	Complete the report and submit to supervisor																			
15	Preparation for oral presentation																			
16	Presentation PSM 1																			

Planning
Actual

Table 1.2: Gantt chart for PSM 2

No.	Task	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Improvement on PSM 1	■	■	■	■	■	■	■	■										
		■	■	■	■	■	■												
2	Additional literature review, books and journal	■	■	■	■	■	■	■	■	■	■	■	■						
		■	■	■	■	■	■	■	■	■	■	■							
3	Material and Tool Preparation	■	■	■	■														
		■	■	■	■														
4	Machine Preparation	■	■	■	■														
		■	■	■	■														
5	Discussion with supervisor	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
		■	■	■	■	■	■	■	■	■	■	■	■	■	■				
6	Start machining the project	■	■	■	■														
		■	■	■	■	■													
7	Collection data	■	■	■	■	■	■												
		■	■	■	■	■	■												
8	Chapter 4- correction after comment by supervisor								■	■	■	■	■	■	■				
									■	■	■	■	■	■					
9	Chapter 5 - correction after comment by supervisor								■	■	■	■	■	■	■				
									■	■	■	■	■	■	■				
10	Chapter 6 - correction after comment by supervisor								■	■	■	■	■	■	■				
									■	■	■	■	■	■	■				
11	Final correction on report writing														■	■			
															■	■			
12	Transferring paper work into journal															■	■		
																■	■		
13	Final editing														■	■			
															■	■			
14	Hard cover binding														■	■	■	■	■
															■	■	■		
15	Submission PSM report																■		
																	■		
16	Presentation and slide preparation																		■
																			■

Planning (black)
Actual (blue)

CHAPTER 2

LITERATURE REVIEW

2.1 Material selected

Carbon steel is sometimes referred to as 'mild steel' or 'plain carbon steel'. The American Iron and Steel Institute defines a carbon steel as having no more than 2 % carbon and no other appreciable alloying element. Carbon steel makes up the largest part of steel production and is used in a vast range of applications. Typically carbon steels are stiff and strong. Carbon also exhibit ferromagnetism, which means it is magnetic. This means it is extensively used in motors and electrical appliances. Welding carbon steels with carbon content greater than 0.3 % requires special precautions be taken. However, welding carbon steel presents far fewer problems than welding stainless steels. The corrosion resistance of carbon steels is poor which means it rust and so it should not be used in a corrosive environment unless some form of protective coating is used.

Mild steel is a carbon steel typically with a maximum of 0.25% Carbon and 0.4% - 0.7% manganese, 0.1%-0.5% Silicon and some traces of other elements such as phosphorous, it may also contain lead or sulphur is made of mild steel, even some of your pots and pans are. Mild steel is a general term for a range of low carbon (a maximum of about 0.3%) steels that have good strength and can be bent, worked or can be welded into an endless variety of shapes for uses from vehicles like cars and ships to building materials. (K.Muniswaran, 2007)

Advantages

- Cheap
- Wide variety available with different properties
- High stiffness
- Magnetic
- Most carbon steels are easy machine and weld
- It is often used when large amounts of steel are needed.

Disadvantages

- Poor corrosion resistance like rusts.

Table 2.1: Mechanical properties of mild steel (Geocities, 2010)

Mechanical properties				
Young's Modulus	200	-	215	GPa
Shear Modulus	79	-	84	GPa
Bulk modulus	158	-	175	GPa
Poisson's Ratio	0.285	-	0.295	
Hardness - Vickers	107.5	-	172.5	HV
Elastic Limit	250	-	395	MPa
Tensile Strength	345	-	580	MPa
Compressive Strength	250	-	395	MPa
Elongation	26	-	47	%
Endurance Limit	* 203	-	293	MPa
Fracture Toughness	* 41	-	82	MPa.m^1/2
Loss Coefficient	* 8.9e-4	-	1.42e-3	

Table 2.2: Thermal properties of mild steel (Geocities, 2010)

Thermal properties				
Thermal conductor or insulator?	Good conductor			
Thermal Conductivity	49	-	54	W/m.K
Thermal Expansion	11.5	-	13	µstrain/°C
Specific Heat	460	-	505	J/kg.K
Melting Point	1480	-	1526	°C
Maximum Service Temperature	* 200	-	350	°C
Minimum Service Temperature	* -68.15	-	-38.15	°C

Impact on the environment

The production energy of steel is comparatively low - per unit weight, about a half that of polymers; per unit volume, though, twice as much. Carbon steels are easy to recycle, and the energy to do so is small.

Table 2.3: Processability of mild steel (Geocities, 2010)

Processability (Scale 1 = impractical to 5 = excellent)			
Castability	3		
Formability	4	-	5
Machinability	3	-	4
Weldability	5		
Solder/Brazability	5		