



Faculty of Manufacturing Engineering

**STUDY OF OPTIMAL MACHINING PARAMETERS WHEN
MACHINING AISI 304 STAINLESS STEEL WITH CARBIDE -
PVD COATED (TiAlN) CUTTING TOOL**

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**Master of Manufacturing Engineering
(Manufacturing System Engineering)**

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MOHD YUSRI BIN MOHD RAHIM

**A thesis submitted
in fulfillment of the requirements for the degree of Master of Manufacturing
Engineering (Manufacturing System Engineering)**

Faculty of Manufacturing Engineering

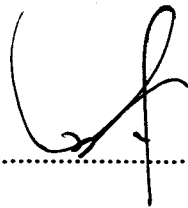
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2013

DECLARATION

I declare that this thesis entitle “**STUDY OF OPTIMAL MACHINING PARAMETERS WHEN MACHINING AISI 304 STAINLESS STEEL WITH CARBIDE-PVD COATED (TiAlN) CUTTING TOOL**” is the result of my own reaesrch except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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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 Master of Manufacturing (Manufacturing System Engineering). The member of supervisory committee is as follow:



Dr. MOHD. HADZLEY BIN ABU BAKAR

DEDICATION

To my beloved mother (Mariam bt. Ishak), father (Mohd Rahim bin Ahmad), wife (Murni bt. Mat Yusof), sons (Muhammad Qusyairi & Muhammad Adi Muqry) and daughter (Nur Farah Nisya). Thanks for all your prayers, outstanding support, patience and deep understanding.

ABSTRACT

This study is based on the actual manufacturing situation in Alpha Precision industry. The industry currently in effort to improve machining efficiency, reduce the cost of manufacturing, preserving the environment through control of liquid waste disposal and improve the safety and health of workers. The objective of this study is to determine the optimal machining parameters affecting the machining response and the interaction between them after a series of experiments. This study was also to compare the type of cooling conditions (wet, water pressure and dry) used through a series of experiments. Experiments are carried out using Hitachi Seiki CNC Lathe Machine, to machined on material AISI 304 stainless steel and carbide cutting tools carbide coated aluminum titanium nitride PVD (TiAlN) to analyze the impact of the quality of workpiece surface roughness and flank wear of the cutting tool, respectively. Three machining parameters (cutting speed, feed rate, and cooling conditions) have been tested and varied at three different levels. In the design of the experimental plan, a full factorial design (DOE) has been used. Data from the study after a series of experiments carried out will be analyzed using the software package MINITAB 16, through analysis of variance (ANOVA) and graphical charts. Results of the study found that wet machining does not influence the quality of the workpiece surface roughness and cutting tool flank wear compared to dry machining and air pressure, especially at high cutting speeds.

ABSTRAK

Kajian ini dijalankan adalah berdasarkan situasi sebenar pengeluaran di Alpha Precision industri. Pihak industri kini dalam usaha untuk meningkatkan kecekapan pemesinan, mengurangkan kos pembuatan, memelihara alam sekitar melalui kawalan pelupusan sisa cecair dan meningkatkan mutu keselamatan dan kesihatan pekerja. Objektif kajian ini adalah untuk menentukan parameter pemesinan optimum yang mempengaruhi parameter pemesinan dan interaksi di antaranya selepas beberapa siri eksperimen. Kajian ini juga untuk membandingkan jenis keadaan penyejukan (basah, semburan angin dan kering) yang digunakan menerusi beberapa siri ujikaji yang disahkan. Ujikaji yang dijalankan adalah dengan menggunakan mesin larik CNC Hitachi Seiki keatas bahan keluli tahan karat AISI 304 dan alat pemotong karbida bersalut karbida nitrida titanium aluminium PVD (TiAlN) untuk menganalisa kesan kualiti kekasaran permukaan bendakerja dan kehausan alat pemotong masing-masing. Tiga parameter pemesinan (Kelajuan pemotongan, kadar suapan, dan keadaan penyejukan) telah uji dan diubah pada tiga tahap yang berbeza. Di dalam merekabentuk pelan ujikaji, rekabentuk faktor penuh (DOE) telah digunakan. Data daripada hasil kajian selepas beberapa siri eksperimen yang dijalankan akan di analisa menggunakan perisian MINITAB 16 oleh analisa Varian (ANOVA) dan juga carta grafik. Hasil daripada kajian dijalankan di dapati bahawa pemesinan basah tidak mempengaruhi kualiti kekasaran permukaan bendakerja dan kehausan alat pemotong berbanding dengan pemesinan kering dan semburan angin.

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LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Factors Influencing Machining Operations	12
2.2	Insert basic shape designation, no. of edges and nose angel	27
2.3	Mechanical Properties in Typical Room Temperature	43
2.4	AISI 304 Chemical composition	44
3.1	Chemical composition of AISI 304	49
3.2	Physical properties of Stainless Steel AISI 304	49
3.3	Chemical and mechanical properties PVD Carbide coated (TiAlN) insert	51
3.4	Specification of tool holder	51
3.5	Factor and Levels	52
3.6	Full Factorial design of experiment plan	53
3.7	Data collection	57
3.8	Wet Machining Methods	58
3.9	Synkool® SS Typical Properties	58
3.10	Air Machining Method	60
3.11	Dry Machining Method	63
4.1	Minitab data analysis	73
4.2	Analysis of Variance for Surface Roughness using Adjusted SS for Tests	75
4.3	Result of the Analysis of Variance for	

	Flank wear using Adjusted SS for Tests	82
5.1	Result of the Analysis of Variance for surface roughness	92
5.2	ANOVA for surface roughness	94

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Deformation of material in machining	8
2.2	(a) Orthogonal cutting (b) Oblique cutting	9
2.3	Deformation zones during machining	9
2.4	CNC Lathe Machine	11
2.5	Basic machining operation and important parameters	13
2.6	Coolant application in turning process	15
2.7	Tool tip cooled by traditional cutting fluid.	17
2.8	(a) Flooded cooling applied on the rotating workpiece (b) wet machining generate mist.	18
2.9	Dry Machining	19
2.10	Schematic view of MQL unit.	20
2.11	Affect of flank ware rate under machining condition MQL, dry and wet at 334/min cutting velocity.	20
2.12	Flank wear rate, with machining time under dry, wet and MQL conditions	21

2.13	(a) Basic components of the high pressure coolant supply unit	
	(b) The tool holder delivers the coolant jet from the specially	
	designed nozzle to the tool-chip interface (c) Special designed nozzle	22
2.14	(a) Machining with high pressure coolant (b) Powerful jet of cutting fluid	23
2.15	Schematic illustration of typical single-point cutting tool	
	For turning application	24
2.16	Workpiece-tool-machine system for turning operation	25
2.17	Cutting Tool's angles	25
2.18	Terminology used to define the radius and surfaces angles,	
	for single point Tool.	26
2.19	Discontinuous chips	32
2.20	Continuous Chips.	32
2.21	Built-up Edge (BUE)	33
2.22	Tool Life criterion according to the ISO Standard 3685-(1993)	34
2.23	Wear patterns (a) flank wear (b) crater wear	36
2.24	Notch Wear	36
2.25	Tool breakage	37
2.26	Roughness and waviness profiles	39
2.27	Schematic illustration to determine arithmetic	
	average surface roughness, R_a of surface texture	39

2.28	Surface Roughness by turning process	39
2.29	Typical applications of Stainless Steel process (Everfit Technology CO,2012); (a) High-frequency induction hardening machine for hot forging (b) Stainless steel cut to piece before next process (c) stainless steel valves, pipes and fitting	42
2.30	Wrought products of Stainless Steel	42
3.1	Hitachi Seiki Hitec Turn 20SII 2 axis CNC Lathe	47
3.2	Pre machining works	48
3.3	Bar of Stainless Steel AISI 304.	49
3.4	Application map of Stainless Steel insert grade name	50
3.5	Carbide (TiAlN) cutting tool insert	50
3.6	Tool holder used	51
3.7	Workpiece mounted in the machine tool chuck at the 15mm stopper	54
3.8	Drawing for machining AISI 304	57
3.9	Wet machining flooded cooling	59
3.10	Machining with Air Pressure in difference view angle (a) From top view (b) from below view	61
3.11	Air supply from main compressor through regulator	61
3.12	Tubing bringing low air pressure to be set-up at tool magazine	62

3.13	Machining with Air Pressure	63
3.14	Mitutoyo measurement microscope	64
3.15	small (Jig) hand vice	64
3.16	Flank wear measurement	65
3.17	Surface Roughness Tester	66
3.18	The stylus of the tester	66
4.1	Main Effect Plot for Surface Roughness	76
4.2	Probability Plot for Surface Roughness	77
4.3	Scatter chart for surface roughness versus feed rate at cutting speed 220(m/min)	78
4.4	Scatter chart for surface roughness versus feed rate at cutting speed 280 (m/min)	78
4.5	Scatter chart for surface roughness versus feed rate at cutting speed 340 (m/min)	79
4.6	Scatter chart for surface roughness versus cutting speed at feed rate 0.1(mm/rev)	80
4.7	Scatter chart for surface roughness versus cutting speed at feed rate 0.3(mm/rev)	80
4.8	Scatter chart for surface roughness versus cutting speed at feed rate 0.5(mm/rev)	81
4.9	Main Effect Plot for Flank wear	84
4.10	Probability Plot for flank wear	85
4.11	Scatter chart for Flank ware rate versus feed rate	

	at cutting speed 220 rev/min	86
4.12	Scatter chart for Flank ware rate versus feed rate at cutting speed 280 rev/min	86
4.13	Scatter chart for Flank ware rate versus feed rate at cutting speed 340 rev/min	87
4.14	Scatter chart for Flank ware rate versus cutting speed at feed rate 0.1 (mm/rev)	88
4.15	Scatter chart for Flank ware rate versus cutting speed at feed rate 0.3 (mm/rev)	88
4.16	Scatter chart for Flank ware rate versus cutting speed at feed rate 0.5 (mm/rev)	89
5.1	The effect of feed rate on the surface roughness at 220 m/min cutting speed. Feed rate of 0.1 rev / min produces a better surface roughness compared to the feed rate of 0.5 rev / min at the same cutting speed of 220m/min.	93
5.2	The effects of cutting speed on the coated cutting tool flank wear	95
5.3	The effect of cutting speed on the coated cutting flank wear at constant feed rate 0.1(rev/min)	96
5.4	The effect of cutting speed on the flank wear at constant feed rate 0.5(rev/min)	97
5.5	The effect of Coated insert on flank wear	98
5.6	The effect of feed rate on the flank wear at low cutting speed 220 (m/min)	99
5.7	The effect of feed rate on the flank wear at high cutting speed 280 (m/min)	100
5.8	Changes in the temperature increase in the cutting speed above 175m/min	101
5.9	Affect of Surface roughness at cutting speed 252 m/min	102

5.10	Affect of Surface roughness at cutting speed 252 m/m	102
5.11	the cold air pressure direction	104
5.12	Analysis of the tool wear microstructure	105
6.1	High-pressure coolant will direct coolant to the cutting zone	108
6.2	(a) Traditional Coolant (b) High Pressure Coolant.	109

LIST OF ABBREVIATIONS

°C	-	Celcius
µm	-	micronmeter
AISI	-	American Iron and Steel Institute
Al ₂ O ₃	-	Aluminium Oxide
ANOVA	-	Analisis of Variance
BUE	-	Built-up Edge
C	-	Carbon
CBN	-	Cubic Boron Nitrat
CNC	-	Computer Numerical Control
Co	-	Copper
Cr	-	Chromium
DOE	-	Design of Experiment
FMS	-	Flexible manufacturing system
Gpa	-	Gigapascal
ISO	-	International Organization for Standardization
m/min	-	meter per minit
mm	-	milimeter
mm/rev	-	milimete per revolution
Mn	-	Manganese
Mo	-	Molybdenum

Mpa	-	Megapascal
MQL	-	Minimum Quantity Lubricant
Ni	-	Nickel
Ø	-	Diameter
P	-	Probability
PVD	-	Physical vapor deposition
Ra	-	average roughness
Si	-	Silicon
Ti	-	Titanium
TiAlN	-	Titanium aluminum nitride
TiC	-	titanium carbide
TiCN	-	Titanium carbonitride
TiN	-	Titanium Nitride
V	-	Vanadium
W	-	Tungsten

TABLE OF CONTENT

	PAGE
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENT	iii
LIST OF TABLE	iv
LIST OF FIGURES	vi
LIST OF ABBREVIATIONS	xii
CHAPTER	
1. INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	3
1.3 Aims And Objectives Of The Research Work	4
1.4 Scope	4
1.5 Significant	5
1.6 Plan Of Study	6
2. LITERATURE REVIEW	
2.1 Introduction	7
2.2 Machining	7
2.3 Lathe Machine	10
2.3.1 Cnc Turning Machine	10
2.4 Mechanic Of Cutting	11
2.4.1 Cutting Speed	13
2.4.2 Depth Of Cut	14
2.4.3 Feed Rate	14
2.4.4 Cutting Fluids	15
2.4.4.1 Purpose Of Cutting Fluids	15
2.4.4.2 The Effect Of Coolant On Tool Performance	16
2.4.4.2.1 Traditional Liquid Coolant	16
2.4.4.2.2 Environmental Concerns Of Using Coolant	17
2.5 Alternative Methods To Liquid Coolant	18
2.5.1 Dry Machining	18
2.5.2 Minimum Quantity Lubricant (MQL)	19
2.5.3 Machining With High-Pressure Coolant	21
2.6 Cutting Tool	23
2.6.1 Lathe Cutting Tool	24
2.6.2 Lathe Tool Geometry	25
2.6.3 Cutting Tool Material	28
2.6.4 Common Coating Material Of Cutting Tool	29
2.6.4.1 Titanium Nitrate (TiN)	29
2.6.4.2 Titanium Carbide (TiC)	29

2.6.4.3	Titanium Carbonnitrat (TiCN)	30
2.6.4.4	Titanium Aluminum nitride (TiAlN)	30
2.7	Chip Formation Process	31
2.7.1	Types of chips	31
2.7.1.1	Discontinuous chips	31
2.7.1.2	Continuous Chips	32
2.7.1.3	Continuous Chips With Built-up Edge (BUE)	33
2.8	Tool Life	33
2.8.1	Tool Wear	34
2.8.2	Flank wear	35
2.8.3	Crater wear	35
2.8.4	Notch wear	36
2.8.5	Tool breakage	37
2.9	Surface Integrity	37
2.9.1	Surface topography/surface roughness	38
2.9.2	Effect Of Machining Parameter On Surface Finish	40
2.10	Stainless Steel	40
2.10.1	Austenitic Stainless Steel (typically an AISI-304)	41
2.10.2	Stainless Steel AISI-304 properties	43
2.10.3	Challenge in machining Stainless steel	44
2.10.4	Machinability study of stainless steel	45
3.	METHODOLOGY	
3.1	Introduction	46
3.2	Experimental Components	47
3.2.1	CNC Turning Lathe	47
3.2.2	Work Material	48
3.2.3	Cutting Tool Insert	49
3.3	Design Of Experiment (DOE)	51
3.4	Machining Setup	54
3.4.1	Wet Machining Method	58
3.4.2	Air Machining Method	59
3.4.3	Dry Machining Method	62
3.5	Measurement Tool	63
3.5.1	Tool Wear Measurement	63
3.5.2	Surface Roughness Measurement	65
3.6	Flow Of Experimental Procedures	67
3.6.1	Methodology Flow Process	69
3.6.1	Flow Chart Of Machining Experimental Procedures	70
4.	RESULT AND ANALYSIS	
4.1	Introduction	71
4.2	Analysis Of Variance (ANOVA) For Surface Roughness	74
4.3	Main Effect Plots Analysis For Surface Roughness	75
4.4	Residual Plots For Surface Rouhness	76
4.5	Analysis On Graphical Chart For Surface Rouhness	77
4.5.1	Scatter Chart For Surface Roughness Versus Feed Rate	77
4.5.3	Scatter Chart For Surface Roughness Versus Cutting Speed	79
4.6	Validation Test	82

4.7	Analysis Of Variance (ANOVA) For Flank Wear	82
4.8	Main Effect Plots Analysis For Flank Wear	83
4.9	Residual Plots for Flank wear	84
4.10	Analysis On Graphical Chart For Flank Wear	85
4.10.1	Scatter Chart For Flank Wear Rate Versus Feed Rate	85
4.10.2	Scatter Chart For Flank Wear Rate Versus Cutting Speed	87
4.11	Validation Test	90
5.	DISCUSSION	
5.1	Introduction	91
5.1.1	Influence Of Feed Rate	91
5.1.1.1	Case Study 1	91
5.1.2	Influence Of Cutting Speed	94
5.1.2.1	Case Study 1	94
5.1.2.2	Case Study II	96
5.1.3	Influence Of Cooling Conditions	98
5.1.3.1	Case Study I	98
5.2	Future Study	103
5.2.1	Air Pressure Method	103
5.2.2	Scanning Electron Microscope (SEM)	104
6.	RECOMMENDATION AND CONCLUSION	
6.1	Recommendation	106
6.1.1	Eliminate Wet Machining Method	106
6.1.2	Implementing Air Pressure Machining Method	107
6.1.3	Implementing High Pressure Coolant Method	107
6.2	Conclusion	109
	REFERENCE	111
	APPENDICES	116

CHAPTER 1

INTRODUCTION

1.1 Background

Machining is a process in which it is intended to remove the outer surface of the workpiece, using various types of cutting tools and cutting fluid according to the type of machining activity carried out. Machining process is a complex activity in terms of producing a good output, which is required a perfect mechanism and good control parameters. Machining activities have failed when it can't produce good output accordance to the specifications and quality requirement. Machining activities also failed when the output gave a negative impact to the consumers' health and the environment today and in near future.

To make a successful activity in the machining process, there are many researchers have been working to make improvements in the machining process. A lot of studies that have been conducted are composed of the individual or group of academicians and professionals that aims to improve the quality of a system under certain conditions. In the context of research activities associated with the machining process, many studies have been carried out related to optimize Cutting Tools, minimizing Cutting Fluid consumption, increase the surface finish of the product, process life cycle, reducing cutting energy, environmental impact and the others.

The improvement in Optimizing of Cutting Tools also associated with increasing of the Cutting Tools life directly, which is the higher quality of Cutting Tools will increase the value of Cutting Tools life. However cutting tool selection must be suitable with workpiece material and machining parameter that is used in machining process. The correct cutting

parameter selection in machining process is to ensure product meets surface finish quality, can reduce tool wear hence to increase tool life when machining difficult workpiece to machined such as Austenitic stainless steels AISI 304. C. Özek, (2006) states, tool flank wear will decreased when we increase the cutting speed parameter, Besides, due to the austenitic stainless steel AISI 304 has a low thermal conductivity; This material may not release heat quickly, So very poor performance of the workpiece will be seen at lower cutting speeds.

In metal cutting processes, the use of cutting fluids is also the most common strategy to improve the tool life, the product surface finish and the size accuracy. Cutting fluids make chip-breaking and chip-transport easier. However, the introduction of cutting fluids often produces airborne mist, smoke and other particulates in the shop floor air quality. These products bring the environmental, health and safety concerns. In addition, the cost of using cutting fluids is several times higher than tool costs.

According to Hands, et.al (1996) claim, long term effect due prologed exposure to the cutting fluid mist in machining process will increases caused in cancer of the stomach, colon, rectum, pancreas and prostate. (King et. al. 2001), stated that the high cost will be used in the machining process when using the wet machine (cutting fluid), the estimated cost is between 7-16% of the total cost of production as compare to 4% for tooling cost. During the machining process running, air pollution will occur mainly due to waste cutting fluid. While the cost of disposal of waste cutting fluid will contribute 16-20% of the cost of machining. (Sreejith, 2000).

1.2 Problem Statement

ALPHA- precision turning & engineering, is a manufacturing company located at Kulim Kedah. ALPHA-precision combining the latest innovative technology with a highly skilled workforce, Alpha-precision try to be world-class quality products with highly investment on machine equipment like CNC that was known as one of the most important innovations in the manufacturing industry to produced mass production now days. ALPHA-precision has become a leading force in the manufacturing of metal turning precision components by consistently providing competitive prompt delivery and excellent service to customers. Their products involves 'Turning Precision Metal Component' in the production of high-tech equipment components related to the level of precision machining such as parts for component oil & gas, automotive, medical equipment, hard disc drive, watch industries etc.

According to Lean Manufacturing, green manufacturing and growing of environmental awareness today has made the company works hard to make it something real and will give a very good impact on the safety and health of workers, the company achievement and the environmental affect totality. The company has formed a working team for the purpose of improving the quality of work that consists of 5 members of the group in it, led by a senior engineer.

Prior to survey made together with early discussion with their operation engineer on the problems at Alpha Precision industry, the data shows the main problem related the manufacturing efficiency which is to minimizing the use of Cutting Fluids normally to reduce total cost of company production, to increase cutting tool life and improve quality of surface finish product (surface roughness).