UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

**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**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**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.

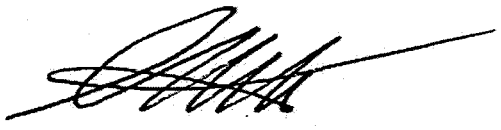
Signature : .....

Name : MOHD YUSRI BIN MOHD RAHIM

Date : 10 July 2013

# 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:



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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 (TiAIN) 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, menggurangkan 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 (TiAIN ) untuk menganalisa kesan kualiti kekasaran permukaan bendakerja dan kehausan alat pemotong masing-masing. Tiga parameter pemesinan (Kelajuan pemotongan, kadar suapan, dan keadaan penyejukkan) telah uji dan diubah pada tiga tahap yang berbeza. Di dalam merekabentuk pelan ujikaji, rekabentuk faktoran penuh (DOE) telah digunakan. Data daripada hasil kajian selepas beberapa siri eksperimen yang dijalankan akan di analisa mengunakan 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.*

# ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians and practitioners. They have contributed towards my understanding and knowledge. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Dr. Mohd. Hadzley bin Abu Bakar, for encouragement, guidance critics and friendship. I am also very thankful to my lecturers Dr. Nur Izan Syahriah Binti Hussein and Dr. Md. Nizam Bin Abd. Rahman for their guidance, advices and motivation during Research Methodology subject. Without their continued support and interest, this thesis would not have been same as presented here.

My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. Last but not least I am very grateful to all my family members for their support and understanding.

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| °C | - | Celcius |
| μm | - | micronmeter |
| AISI | - | American Iron and Steel Institute |
| $Al_2O_3$ | - | Aluminium Oxide |
| ANOVA | - | Analisys 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 |

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# 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 toolsand cutting fluid according to the type of machining activity carried out. Machining process is a complex activity in term of producing a good output, which is required a perfect mechanism and good control parameters. Machining activities has 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 academision and professional 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 increasing value of Cutting Tools life. However cutting tool selection must be suit with workpiece material and machining parameter that is use 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, pancrreas 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).