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

Mohd Yusri bin Mohd Rahim

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 (TiAIN) 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 entitled “STUDY OF OPTIMAL MACHINING PARAMETERS WHEN MACHINING AISI 304 STAINLESS STEEL WITH CARBIDE-PVD COATED (TiAIN) CUTTING TOOL” is the result of my own research 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

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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:

[Signature]

-------------------
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.
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 kesehatan 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 ke atas 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 penyejukan) 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 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.
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.
# LIST OF TABLES

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

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

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

2.30 Wrought products of Stainless Steel

3.1 Hitachi Seiki Hitec Turn 20SII 2 axis CNC Lathe

3.2 Pre machining works

3.3 Bar of Stainless Steel AISI 304.

3.4 Application map of Stainless Steel insert grade name

3.5 Carbide (TiAIN) cutting tool insert

3.6 Tool holder used

3.7 Workpiece mounted in the machine tool chuck at the 15mm stopper

3.8 Drawing for machining AISI 304

3.9 Wet machining flooded cooling

3.10 Machining with Air Pressure in difference view angle

(a) From top view (b) from below view

3.11 Air supply from main compressor through regulator

3.12 Tubing bringing low air pressure to be set-up at tool magazine
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 wear rate versus feed rate
at cutting speed 220 rev/min

4.12 Scatter chart for Flank ware rate versus feed rate

at cutting speed 280 rev/min

4.13 Scatter chart for Flank ware rate versus feed rate

at cutting speed 340 rev/min

4.14 Scatter chart for Flank ware rate versus cutting speed

at feed rate 0.1 (mm/rev)

4.15 Scatter chart for Flank ware rate versus cutting speed

at feed rate 0.3 (mm/rev)

4.16 Scatter chart for Flank ware rate versus cutting speed

at feed rate 0.5 (mm/rev)

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.

5.2 The effects of cutting speed on the coated cutting tool flank wear

5.3 The effect of cutting speed on the coated cutting flank wear at constant feed rate 0.1(rev/min)

5.4 The effect of cutting speed on the flank wear at constant feed rate 0.5(rev/min)

5.5 The effect of Coated insert on flank wear

5.6 The effect of feed rate on the flank wear at low cutting speed 220 (m/min)

5.7 The effect of feed rate on the flank wear at high cutting speed 280 (m/min)

5.8 Changes in the temperature increase in the cutting speed above 175m/min

5.9 Affect of Surface roughness at cutting speed 252 m/min
5.10 Affect of Surface roughness at cutting speed 252 m/m

5.11 the cold air pressure direction

5.12 Analysis of the tool wear microstructure

6.1 High-pressure coolant will direct coolant to the cutting zone

6.2 (a) Traditional Coolant (b) High Pressure Coolant.
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>Celcius</td>
</tr>
<tr>
<td>µm</td>
<td>micronmeter</td>
</tr>
<tr>
<td>AISI</td>
<td>American Iron and Steel Institute</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>Aluminium Oxide</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>BUE</td>
<td>Built-up Edge</td>
</tr>
<tr>
<td>C</td>
<td>Carbon</td>
</tr>
<tr>
<td>CBN</td>
<td>Cubic Boron Nitrat</td>
</tr>
<tr>
<td>CNC</td>
<td>Computer Numerical Control</td>
</tr>
<tr>
<td>Co</td>
<td>Copper</td>
</tr>
<tr>
<td>Cr</td>
<td>Chromium</td>
</tr>
<tr>
<td>DOE</td>
<td>Design of Experiment</td>
</tr>
<tr>
<td>FMS</td>
<td>Flexible manufacturing system</td>
</tr>
<tr>
<td>Gpa</td>
<td>Gigapascal</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>m/min</td>
<td>meter per minit</td>
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<tr>
<td>mm</td>
<td>milimeter</td>
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<tr>
<td>mm/rev</td>
<td>milimete per revolution</td>
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<tr>
<td>Mn</td>
<td>Manganese</td>
</tr>
<tr>
<td>Mo</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Symbol</td>
<td>Meaning</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Mpa</td>
<td>Megapascal</td>
</tr>
<tr>
<td>MQL</td>
<td>Minimum Quantity Lubricant</td>
</tr>
<tr>
<td>Ni</td>
<td>Nickel</td>
</tr>
<tr>
<td>Ø</td>
<td>Diameter</td>
</tr>
<tr>
<td>P</td>
<td>Probability</td>
</tr>
<tr>
<td>PVD</td>
<td>Physical vapor deposition</td>
</tr>
<tr>
<td>Ra</td>
<td>average roughness</td>
</tr>
<tr>
<td>Si</td>
<td>Silicon</td>
</tr>
<tr>
<td>Ti</td>
<td>Titanium</td>
</tr>
<tr>
<td>TiAlN</td>
<td>Titanium aluminum nitride</td>
</tr>
<tr>
<td>TiC</td>
<td>titanium carbide</td>
</tr>
<tr>
<td>TiCN</td>
<td>Titanium caronitride</td>
</tr>
<tr>
<td>TiN</td>
<td>Titanium Nitride</td>
</tr>
<tr>
<td>V</td>
<td>Vanadium</td>
</tr>
<tr>
<td>W</td>
<td>Tungsten</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENT

<table>
<thead>
<tr>
<th>ABSTRACT</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRAK</td>
<td>ii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLE</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xii</td>
</tr>
</tbody>
</table>

## CHAPTER

### 1. INTRODUCTION
- 1.1 Background
- 1.2 Problem Statement
- 1.3 Aims And Objectives Of The Research Work
- 1.4 Scope
- 1.5 Significant
- 1.6 Plan Of Study

### 2. LITERATURE REVIEW
- 2.1 Introduction
- 2.2 Machining
- 2.3 Lathe Machine
  - 2.3.1 Cnc Turning Machine
- 2.4 Mechanic Of Cutting
  - 2.4.1 Cutting Speed
  - 2.4.2 Depth Of Cut
  - 2.4.3 Feed Rate
  - 2.4.4 Cutting Fluids
    - 2.4.4.1 Purpose Of Cutting Fluids
    - 2.4.4.2 The Effect Of Coolant On Tool Performance
      - 2.4.4.2.1 Traditional Liquid Coolant
      - 2.4.4.2.2 Environmental Concerns Of Using Coolant
  - 2.5 Alternative Methods To Liquid Coolant
    - 2.5.1 Dry Machining
    - 2.5.2 Minimum Quantity Lubricant (MQL)
    - 2.5.3 Machining With High-Pressure Coolant
- 2.6 Cutting Tool
  - 2.6.1 Lathe Cutting Tool
  - 2.6.2 Lathe Tool Geometry
  - 2.6.3 Cutting Tool Material
  - 2.6.4 Common Coating Material Of Cutting Tool
    - 2.6.4.1 Titanium Nitrate (TIN)
    - 2.6.4.2 Titanium Carbide (TIC)
2.6.4.3 Titanium Carbonnitrat (TiCN) 30
2.6.4.4 Titanium Aluminum nitride (TiAIN) 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 46
  3.1 Introduction 47
  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 71
  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 Roughness 76
  4.5 Analysis On Graphical Chart For Surface Roughness 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
4.8 Main Effect Plots Analysis For Flank Wear
4.9 Residual Plots For Flank wear
4.10 Analysis On Graphical Chart For Flank Wear
  4.10.1 Scatter Chart For Flank Wear Rate Versus Feed Rate
  4.10.2 Scatter Chart For Flank Wear Rate Versus Cutting Speed
4.11 Validation Test

5. DISCUSSION
5.1 Introduction
  5.1.1 Influence Of Feed Rate
    5.1.1.1 Case Study I
  5.1.2 Influence Of Cutting Speed
    5.1.2.1 Case Study I
    5.1.2.2 Case Study II
  5.1.3 Influence Of Cooling Conditions
    5.1.3.1 Case Study I
5.2 Future Study
  5.2.1 Air Pressure Method
  5.2.2 Scanning Electron Microscope (SEM)

6. RECOMMENDATION AND CONCLUSION
6.1 Recommendation
  6.1.1 Eliminate Wet Machining Method
  6.1.2 Implementing Air Pressure Machining Method
  6.1.3 Implementing High Pressure Coolant Method
6.2 Conclusion

REFERENCE
APPENDICES
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 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 prolonged 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).