



Faculty of Manufacturing Engineering

**THE PERFORMANCE OF TOOL HOLDER CLAMPING
TECHNIQUE IN CONVENTIONAL LATHE WITH PASSIVE
DAMPING SYSTEM**

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Master of Manufacturing Engineering

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**THE PERFORMANCE OF TOOL HOLDER CLAMPING
TECHNIQUE IN CONVENTIONAL LATHE WITH PASSIVE
DAMPING SYSTEM**

GWEE CHIOU CHIN

A thesis submitted

**In fulfillment of the requirement for the degree of Master of Manufacturing
Engineering (Manufacturing System Engineering) in Manufacturing Engineering**


Faculty of Manufacturing Engineering

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2013

DECLARATION

I declare that this thesis entitle “**The Performance Of Tool Holder Clamping Technique In Conventional Lathe With Passive Damping System**” 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 : **GWEE CHIOU CHIN**

Date :

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the degree of Master of Manufacturing (Manufacturing System Engineering). The member of supervisory committee is as follow:

Dr. Ahmad Kamely bin Mohamad

DEDICATION

To my beloved parents, Gwee Tee San and Yew Be Bee, all my friends. Thank you for the continuous support and encouragement.

ABSTRAK

Terdapat pelbagai teknik yang dicadangkan oleh beberapa penyelidik untuk meramal dan mengesan getaran di mana tujuannya adalah untuk mengelakkan berlakunya getaran dalam proses memotong untuk mendapatkan permukaan produk selesai yang lebih baik, produktiviti yang lebih tinggi dan jangka hayat mata alat. Kajian-kajian ini kebanyakannya mengenai sistem redaman aktif dengan kawalan parameter proses pemesinan. Teknik redaman aktif tidak bersesuaian bawah semua keadaan kerana, sebagai contoh, keperluan kuasa, kos, alam sekitar, dan lain-lain. Dalam situasi sebegini, teknik-teknik redaman pasif adalah alternatif yang sesuai. Rekaan mana-mana struktur redaman pasif biasanya dibuat berdasarkan salah satu daripada empat mekanisme redaman: bahan viscoelastic, cecair likat, magnet atau piezoelektrik pasif. Penyelidikan ke atas redaman viscoelastic dan bahan redaman lain dalam mesin larik hampir tidak dijumpai. Oleh itu, pengaruh relatif redaman viscoelastic dan redaman kayu lembut pada mesin larik konvensional terhadap kehausan alat, getaran alat, dan kemas permukaan yang disiasat. Objektif keseluruhan kajian ini adalah untuk menilai prestasi alat pemegang teknik baru pengapitan dengan menambah viscoelastic dan kayu lembut sistem pasif redaman bagi permohonan mesin pelarik konvensional. Objektif khusus kajian ini ialah untuk menilai keberkesanan viscoelastic dan sistem redaman kayu lembut dalam mengurangkan kehausan mata alat dalam kerja memesis keluli AISI D2 45 HRC, mengkaji pengaruh teknik pengapitan pada getaran alat, dan untuk mengkaji kesan redaman viscoelastic dan sistem redaman kayu lembut pada kekasaran permukaan. Sembilan set eksperimen telah dijalankan, tiga bagi setiap keadaan redaman: tiada redaman, redaman neoprena, dan redaman kayu pain. Data diperolehi daripada eksperimen telah analisis dengan menggunakan perisian ezANOVA. Sebagai ringkasan penemuan eksperimen, redaman neoprena menunjukkan kesan positif yang sangat besar ke atas prestasi pemesinan mesin pelarik konvensional dalam mengurangkan kehausan mata alat dan getaran mata alat. Percubaan menggunakan kayu pain sebagai bahan redaman mempunyai keputusan yang sangat ketara terhadap getaran mata alat yang lebih rendah juga. Walau bagaimanapun, kayu redaman tidak memberi kesan yang ketara kepada kehausan alat dan kemas permukaan.

ABSTRACT

There are various techniques proposed by some researchers to predict and detect the chatter where the objective is to prevent the occurrence of chatter in the cutting process to get a better surface finish product, higher productivity and tool life. These studies are mostly about active damping system by control the machining process parameters. Active damping techniques are not applicable under all circumstances because, for example, power requirements, cost, environment, etc. In those situations, the passive damping techniques are viable alternatives. Designed in passive damping for any structure is usually based on one of four damping mechanisms: viscoelastic materials, viscous fluids, magnetics or passive piezoelectric. Research on viscoelastic damping and other damping material in a lathe machine is hardly found. Thus, the relative influence of viscoelastic damping and softwood damping on conventional turning tool wear, tool vibration, and surface finish is investigated. The overall objective of this research is to evaluate the performance of new tool holder clamping technique by adding viscoelastic and softwood passive damping system for the application of conventional lathe machine. The specific objectives of the research are To evaluate the effectiveness of viscoelastic and softwood damping system in reducing tool wear during machining cold work tool steel AISI D2 of 45 HRC, To study the influence of clamping technique on tool vibration, and to study the effect of viscoelastic and softwood damping system on the surface finish. Nine set of experiments had been carried out during the experiment, three for each damping conditions: no damping, neoprene damping, and pine wood damping. Data obtained from experiment has been analysis by using ezANOVA software. As the summary of the experiment findings, neoprene damping shows extremely significant positive effect on the performance of machining of conventional lathe machines in tool wear and tool vibration. The attempt of using pine wood as damping material has result extremely significant lower tool vibration too. However, wood damping does not give significant effect on the tool wear and surface roughness.

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TABLE OF CONTENT

	PAGE
APPROVAL	
DECLARATION	
DEDICATION	
ABSTRAK	i
ABSTRACT	ii
ACKNOWLEDGEMENT	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF ABBREVIATIONS	viii
CHAPTER	
1 STUDY BACKGROUND	
1.1 Introduction	1
1.2 Problem Statement	2
1.3 Objectives of the Study	2
1.4 Scope of the Study	3
2 LITERATURE REVIEW	
2.1 Machining	4
2.2 Turning	5
2.2.1 Parameters and Related Quantities	5
2.2.1.1 Cutting Speed	5
2.2.1.2 Uncut Chip Thickness	6
2.2.1.3 Depth of Cut	7
2.2.2 Dependent Variable	7
2.2.2.1 Tool Wear	8
2.2.2.2 Tool Vibration	8
2.2.2.3 Surface Finish	9
2.2.3 Lathe Tools	10
2.2.3.1 Mixed (Al ₂ O ₃ + TiCN) Ceramic Coated With TiN Cutting Tools	10
2.3 Tool Wear and Tool Life	11
2.3.1 Tool Failure Criteria	12
2.4 Neoprene	13
2.5 Pine Wood	14
2.6 Analysis of Variance (ANOVA)	15
3 METHODOLOGY	
3.1 Project Design	18
3.2 Project Methodology	19
3.2.1 Data Measurement	23
3.2.1.1 Mixed Ceramic (Al ₂ O ₃ + TiCN) Coated With TiN Inset Tool Wear	23
3.2.1.2 Tool Vibration	23
3.2.1.3 Cold Work Tool Steel AISI D2 of 45 HRC Surface Roughness	23

4	RESULTS AND DISCUSSION	
4.1	Mixed Ceramic (Al ₂ O ₃ + TiCN) Coated With TiN Insert Tool Wear	27
4.2	Tool Vibration	31
4.3	Cold Work Tool Steel AISI D2 of 45 HRC Surface Roughness	34
4.4	Summary	38
5	CONCLUSIONS AND RECOMMENDATIONS	
5.1	Conclusions	39
5.2	Recommendations	40
	REFERENCE	41
	APPENDICES	44

LIST OF TABLES

TABLE	TITTLE	PAGE
2.1	AISI D2 Turning Guiding Parameter.	6
2.2	Typical ways to obtain surface roughness.	10
3.1	Specifications of cutting tools, cutting conditions and tool holder.	19
4.1	Tool wear measurement of mixed ceramic ($Al_2O_3 + TiCN$) coated with TiN insert.	31
4.2	Tool Wear pairwise comparison summary	31
4.3	Cutting tool vibration measurement	32
4.4	Tool vibration pairwise comparison summary.	33
4.5	Surface roughness of cold work tool steel AISI D2 of 45 HRC after machining.	35
4.6	Surface roughness pairwise comparison summary.	35
4.7	Experiment result significances compare to no damping.	38
5.1	Dynamic flexural behaviour of material at 0.2 Hz.	40

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	Geometry of Cut in Turning.	7
2.2	A Typical Wear Curve for a Cutting Tool	12
3.1	Tool holder without damping material.	20
3.2	Tool holder with neoprene damping.	20
3.3	Tool holder with pine wood damping.	21
3.4	Momac SM200X1500 conventional lathe machine.	21
3.5	Example of surface roughness tester setting.	22
3.6	Digital microscope with V.i.S version 2.90 Professional Edition.	24
3.7	VI-400Pro hand-held real time vibration analyzer.	24
3.8	Vibration measurement of cutting tool.	25
3.9	Cold Work Tool Steel AISI D2 of 45 HRC after machining.	25
3.10	Project Flow	26
3.11	Experiment Flow	26
4.1	Tool wears analysis with ezANOVA.	28
4.2	Tool wears analysis result.	29
4.3	Tool Wear dependent variable no errors bar.	29
4.4	GraphPad Software.	30
4.5	Tool wears mean value comparison.	30
4.6	Tool vibration Analysis with ezANOVA.	32
4.7	Tool vibration analysis result.	33
4.8	Tool vibration dependent variable no errors bar.	34
4.9	Tool vibration mean value comparison.	34
4.10	Surface roughness analysis with ezANOVA.	36
4.11	Surface roughness analysis result.	36
4.12	Surface roughness dependent variable no errors bar.	37
4.13	Surface roughness mean value comparison.	37

LIST ABBREVIATIONS

AISI	American Iron and Steel Institute
Al ₂ O ₃	Sapphire Crystal
ANOVA	Analysis of Variance
AVG	Automatic Guided Vehicle
C	Carbon
CBN	Cubic Boron Nitride
CNC	Computer Numerical Control
Cr	Chromium
HRC	Rockwell C Hardness
HSS	High Speed Steel
NC	Numerical Control
Mn	Manganese
Mo	Molybdenum
Ra	mean roughness
Si	Silicon
TiCN	Titanium Carbo Nitride
TiN	Titanium Nitride

CHAPTER 1

STUDY BACKGROUND

This chapter includes the introduction about chatter that occurs during machining process, problem statement of the study, objectives of the study, and scopes of the study.

1.1 Introduction

Monitoring of manufacturing processes and equipment conditions is an important part of critical strategies that drive manufacturing industry towards becoming more lean and competitive (Al-Habaibeh and Gindy, 2000; Frankowiak et al., 2005). Machining performance is usually defined by accuracy, repeatability, and resolution.

Chatter occurs in machining environment due to dynamic motion between the cutting tool and the work piece. The presence of chatter during the machining resulting in poor surface finish, high pitch noise and accelerated wear which in turn reduces the life of the machine tool, reliability and safety of the machining operation. It also influences the dimensional accuracy of the machined components. Today, the standard procedures adopted to avoid chatter during machining are by careful planning cutting parameters and damping of cutting tools.

Damping is the capacity of a mechanical system to reduce the intensity of a vibratory process. Damping effect on the performance of mechanical systems due to the reduction of intensity of unwanted resonances; acceleration decay (settling) of transient vibration excited by abrupt changes in motion parameters of mechanical components; prevention or eradication of self-excited vibrations; prevention of impact between vibrating

parts when their amplitude is reduced by damping; potential to reduce heat generation, and consequently to an increase in efficiency due to reduced peak velocity of the vibrating components with frictional or micro impacting interactions; reduction of noise and vibration generating hazardous effect to human operators and more. Active and passive damping techniques are common methods reduce the resonant vibrations excited in the structure.

1.2 Problem Statement

There are various techniques that are proposed by previous researchers to predict and detect the chatter where the objective is to prevent the occurrence of chatter in the cutting process to get a better surface finish product, higher productivity and longer tool life. These studies are mostly about active damping system by control the machining process parameters. Active damping techniques are not applicable under all circumstances because, for example, power requirements, cost, environment, etc. In those situations, the passive damping techniques are viable alternatives.

Designed in passive damping for any structure is usually based on one of four damping mechanisms: viscoelastic materials, viscous fluids, magnetics or passive piezoelectric (Johnson, 1995). Research on viscoelastic damping and other damping material in a lathe machine is hardly found.

Thus, the relative influence of viscoelastic damping and softwood damping on conventional turning tool wear, tool vibration, and surface finish is investigated.

1.3 Objective of the Study

The overall objective of this research is to evaluate the performance of new tool holder clamping technique by adding viscoelastic and softwood passive damping system

for the application of conventional lathe machine. The specific objectives of the research are as follows:

- a) To evaluate the effectiveness of viscoelastic and softwood damping system in reducing tool wear during machining cold work tool steel AISI D2 of 45 HRC.
- b) To study the influence of clamping technique on tool vibration.
- c) To study the effect of viscoelastic and softwood damping system on the surface finish.

1.4 Scope of the Study

The research will be conducted within the following limits:

- a) Use commercially available mixed ceramic ($Al_2O_3 + TiCN$) coated with TiN cutting tools.
- b) Use commercially available tool holder MCLNL 1616H 12
- c) Work material use is AISI D2 cold work tool steel (45 HRC). The work material will be through hardened prior to machining by steel supplier ASSAB.
- d) Use neoprene as a Viscoelastic material.
- e) Use pine wood as softwood material.
- f) The machining operations will be out on a Momac SM200X1500 conventional lathe machine under dry cutting
- g) The performance of the clamping technique will be compared in terms of tool wear, tool vibration, and surface finish.

CHAPTER 2

LITERATURE REVIEW

This chapter literature review topics related to the study such as machining in the manufacturing process. Cutting tool, work piece material, and damping material used in the experiments are reviewed.

2.1 Machining

Machining has become indispensable to modern industry. It is used directly or indirectly in the manufacture of almost all goods and services created around the world. It is the basis of everything that is manufactured like a sewing machine, paper, drugs, clothing, computers, cars, and spacecraft. Wherever metal is used in any man-made object, one can be sure it must have reached the final stage through processing with machine tools. Even the parts that are made of plastic require metal dies made by machining process.

The fastest growth of machine tool industry and technology has occurred in the 20th century. Significant achievements of the last century are new tool materials such as carbides and oxides, special purpose machine for flow line production, machining head, transfer machines, numerically controlled machine tools, the development of robots, automated guided vehicles (AVGs) and flexible manufacturing systems (Juneja and Seth, 2003).

2.2 Turning

Turning is a machining operation to generate the outer surface of the revolution; while in boring; internal surfaces of revolution are machined. In both operations, the work piece or tool is rotated about its axis and the cutting tool or work piece is also given a feed motion in a direction normal to the cutting speed.

The machine tools used to operate the turning operation is called lathe. There are many types of lathes. General purpose lathes are of two types: horizontal centre lathe and vertical centre lathe. The latest developments in lathes are the NC and CNC lathes (Juneja and Seth, 2003).

2.2.1 Parameters and Related Quantities

2.2.1.1 Cutting Speed

Cutting speed (V) is the relative velocity between the work piece and tool cutting edge that is responsible for the cutting action. In turning it is given by the following relations.

$$V = \frac{\pi DN}{1000} \text{ m/min} \quad (1)$$

Where D is the diameter of the work piece in mm at point of tool engagement with the work piece and N is the work piece rotational speed in rpm . The work piece used is 38 mm in diameter. The turning guiding parameter from the supplier (Table 2.1) is valid for AISI A2 in soft annealed condition, are to be considered as guiding values which must be adapted to existing local conditions for 62 HRC AISI A2. Considering the lower hardness of work piece and the capability of the lathe machine, the rotational speed, N is set to 425 rpm , as the result cutting speed of 50.74 m/min is obtained.

2.2.1.2 Uncut Chip Thickness

Uncut chip thickness is the thickness of the layer of material removed by the cutting tool in the direction of the feed motion. The feed, in case of turning, is usually expressed in *mm* per revolution. Let '*f*' be the feed/rev and let γ_s (Figure 2.1) be the side cutting edge angle of the turning tool,

$$\text{UncutChipThickness} = t = f \cos(\gamma_s) \quad (2)$$

Based on Table 2.1, the feed of 0.4 *mm/rev* is selected, the side cutting edge angle of the turning tool is set to -5° (Kamely et al., 2008). The uncut chip thickness will be about 0.4 *mm*.

Table 2.1: AISI D2 Turning Guiding Parameter. (Bohler-Uddeholm Corporation, 1999)

Cutting Data	Turning with carbide		Turning with high speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (Vc) f.p.m. m/min	230-360 70-110	360-500 110-150	50 15
Feed (f) i.p.r. mm/r	0.012-0.023 0.3-0.6	-0.012 -0.3	-0.012 -0.3
Depth of cut (ap) Inch mm	0.08-0.20 2-6	-0.08 -2	-0.08 -2
Carbide designation US ISO	C2 K15*	C2 K15*	- -

*Use a wear resistant Al_2O_3 coated carbide grade, for example Sandvik Coromant GC 4015 or Seco TP100.

2.2.1.3 Depth of Cut

Depth of cut is the normal distance between the machined surface and un-machined measured along the normal to the machined surface. In the case of turning it is the radial distance between the machined and un-machined surfaces. As shown in Figure 2.1, the cutting edge engagement is b while the depth of cut is ' d ' which in term of b is given by

$$D = b \cos(\gamma_s). \quad (3)$$

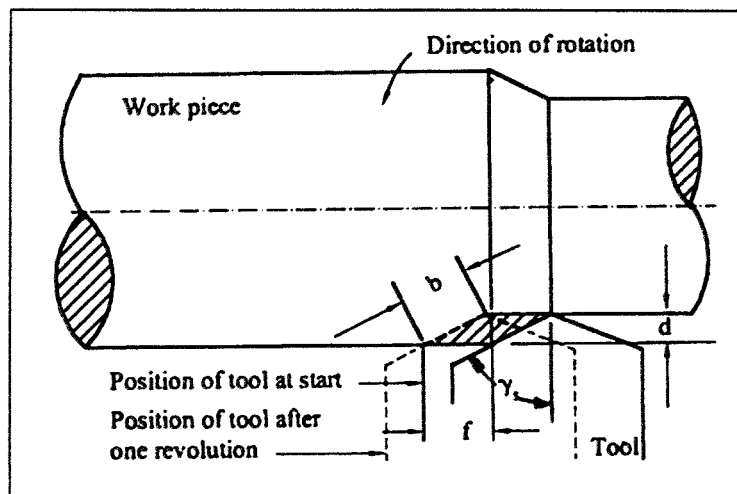


Figure 2.1: Geometry of Cut in Turning (Juneja and Seth, 2003).

0.4 mm depth of cut will be use; this will lead to the cutting edge engagement of about 0.4 mm also.

2.2.2 Dependent Variable

The dependent variable is the variables tested in scientific experiments. The dependent variable is 'dependent' on the independent variables. As the experiments changed the independent variable, the changes in the dependent variable is observed and recorded. Dependent variable for this study is tool wear, tool vibration and surface finish.

2.2.2.1 Tool Wear

Tool wear is the gradual failure of cutting tools due to regular operation. It is a term often associated when mention tool, tool bits, or drill bits that are used with machine tools. There are two type of wear: flank wear and crater wear.

Flank wear occur when the portion of the tool in contact with the work piece erodes. Flank wear can be described by using the Tool Life Expectancy equation. Crater wear occurs when contact with chips erodes the rake face. This normally occurs for tool wear, and does not seriously affect the use of a tool until serious enough to cause a cutting edge failure. This study is focus on the flank wear of the tool.

2.2.2.2 Tool Vibration

Vibrations in metal cutting are common to every machine tool user. There are several reasons why this problem occurs in operations such as internal turning, threading, grooving, milling, boring and drilling. The machine tool itself, the clamping of the tool, the length and diameter of the tool holder and the cutting data to be used could be the reasons of vibration occur.

Reducing the process parameters is one such consideration to solve this problem. However, this could have a negative effect on productivity (AB Sandvik Coromant, 2006).

In the world of mechanical maintenance, vibration remains one of the earliest indicators of a machine's health. Many companies don't have the resources to fully understand and be competent in understanding machinery health with traditional vibration analysers which require them to make significant investments for initial setup and training, change their maintenance culture from Preventive Maintenance to Predictive, allocate full time resources to learn and perform vibration analysis, and allow at least a year for maintenance teams to be trained and get proficient in understanding vibration signatures.

Vibration used to be something that was overlooked by employers and employees alike. However, with the effects of vibration being revealed, it was necessary for manufacturers and employers to take a serious stance to protect the workforce. The vibration magnitude is the frequency weighted acceleration value measured in m/s^2 . If steps are not taken to limit the amount of vibration a machine produces and the level of exposure an individual receives, then injuries such as Vibration White Finger (VWF) will occur through Hand-Arm Vibration (HAV).

Bonifacio and Diniz (1994) had shown that the vibration of the tool can be a good way to monitor on-line the growth of surface roughness in finish turning and, therefore, it can be useful for establishing the end of tool life in these operations.

2.2.2.3 Surface Finish

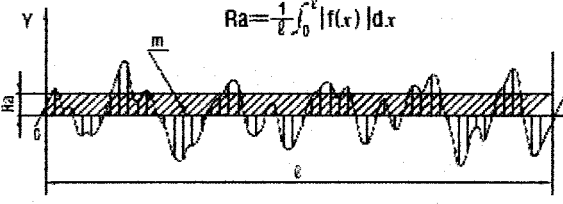
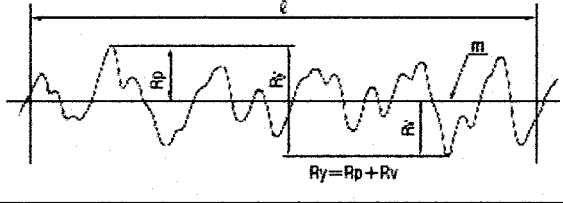
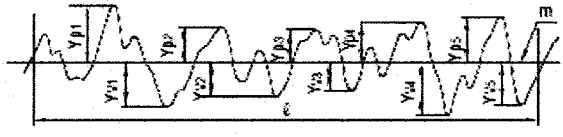
Surface finish or surface texture is the characteristics of a surface. It included three components: lay, surface roughness, and waviness. Lay is the direction of the predominant surface pattern ordinarily determined by the production method used. Surface roughness is a measure of the finely spaced surface irregularities. Waviness is the measure of surface irregularities with spacing greater than that of surface roughness. Waviness usually occurs due to warping, vibrations, or deflection during machining.

In this study surface roughness of the work piece is measured. Arithmetical mean roughness (R_a) is measured. Table 2.2 shows typical ways to obtain surface roughness.

2.2.2 Lathe Tools

The main types of turning tools are the straight-shank turning tools, bent-shank turning tool, small nose radius turning tool or broad-nose finishing tools, facing tools, cut-off or parting tools, thread cutting tools and boring tools. Nowadays the throw away tool bits are quite popular.

Table 2.2: Typical ways to obtain surface roughness. (Misumi, 1994)

Typical ways for obtaining surface roughness	
<p>Arithmetical mean roughness (Ra)</p> <p>A section of standard length is sampled from the mean line on the roughness chart. The mean line is laid on a Cartesian coordinate system wherein the mean line runs in the direction of the x-axis and magnification is the y-axis. The value obtained with the formula on the right is expressed in micrometer (μm) when $y=f(x)$.</p>	 $Ra = \frac{1}{l} \int_0^l f(x) dx$
<p>Maximum peak (Ry)</p> <p>A section of standard length is sampled from the mean line on the roughness chart. The distance between the peaks and valleys of the sampled line is measured in the y direction. The value is expressed in micrometer (μm).</p> <p>Note : To obtain Ry, sample only the standard length. The part, where peaks and valleys are wide enough to be interpreted as scratches, should be avoided.</p>	 $Ry = Rp + Rv$
<p>Ten-point mean roughness (Rz)</p> <p>A section of standard length is sampled from the mean line on the roughness chart. The distance between the peaks and valleys of the sampled line is measured in the y direction. Then, the average peak is obtained among 5 tallest peaks (Yp), as is the average valley between 5 lowest valleys (Yv). The sum of these two values is expressed in micrometer (μm).</p>	 $Rz = \frac{ Yp_1 + Yp_2 + Yp_3 + Yp_4 + Yp_5 + Yv_1 + Yv_2 + Yv_3 + Yv_4 + Yv_5 }{5}$ <p>$Yp_1, Yp_2, Yp_3, Yp_4, Yp_5$: Tallest 5 peaks within sample</p> <p>$Yv_1, Yv_2, Yv_3, Yv_4, Yv_5$: Lowest 5 peaks within sample</p>

2.2.2.1 Mixed ($\text{Al}_2\text{O}_3 + \text{TiCN}$) Ceramic Coated With TiN Cutting Tools

Hard turning is great interest topic in today's industrial production and scientific research. The hard turning technology has the potential to increase productivity by replacing grinding in the manufacturing process. There are only two types of super-hard materials in the past, which are diamond and cubic boron nitride (CBN). Today, manufacturers are constantly developing new combinations of tools coating and substrate

to accurately match different work piece materials and operations. Uses of coated cutting tools to machine a variety of materials now represent the state-of-the-art technology (Kamely et al., 2008)

Kamely, et al. (2008) has evaluate the performance of coated mixed ceramic as a low cost alternative cutting tools when machining hardened AISI D2 cold work tool steel (60HRC) in their research. In their tool life tests, it showed that mixed ($\text{Al}_2\text{O}_3 + \text{TiCN}$) ceramics coated TiN has better performance than CBN cutting tools. As a class of materials, ceramics have high melting point, excellent hardness and good wear resistance. It shows that mixed ceramic cutting tools coated with TiN has significantly better tool-life for all cutting speeds, enabling the hard turning for components at low cost.

2.3 Tool Wear and Tool Life

A new or newly ground tool has sharp cutting edges and smooth flanks. When put into operation, it gets subjected to cutting forces that are concentrated over a relatively small contact area on the rake face and the flank. Also the chip slides across the rake face and machined surfaces rub over the flank surface of the cutting tool (Juneja and Seth, 2003). The temperature over the contact surface is pretty high. Each times the tool in or out from the cut, it is subject to mechanical and thermal shock. Under such bad conditions, hard tool materials such as HSS and carbide gradually wear out and even broken requires a tools change. Machine has to stop while the tool is being retracted, changed and returned to the cutting position. Valuable machining time is lost in the process. Tool wear and time between tool changes (tool life) therefore subject great importance in the theory and practice of metal cutting.

2.3.1 Tool Failure Criteria

The time for which a cutting edge or a cutting tool can be usefully employed without regrinding (HSS tools) or replacement (throwaway carbide and oxide inserts) is called as the tool life.

It is not economical to continue using the tool beyond its useful time. This is due to increased bluntness of the cutting edge causes an increase in cutting forces, and, as a result also increases the temperature of tool. As the result the dimensional accuracy and surface finish of machined piece suffers, eventually leading to the production of rejects. Also, after flank wear has continued up to a certain point, further wear occurs at a rapid rate increases.

The progress of crater wear is also of similar nature. Continued used of the worn tool would ultimately cause catastrophic failure or total loss of the tool and even damage to the component and the machine. If tool change sometime before catastrophic failure, the amount of material to be ground off the tool (regrinding cost) will not be excessive. Therefore, some tools failure criteria have been devised to specify the maximum tool wear acceptable before regrinding or change it.

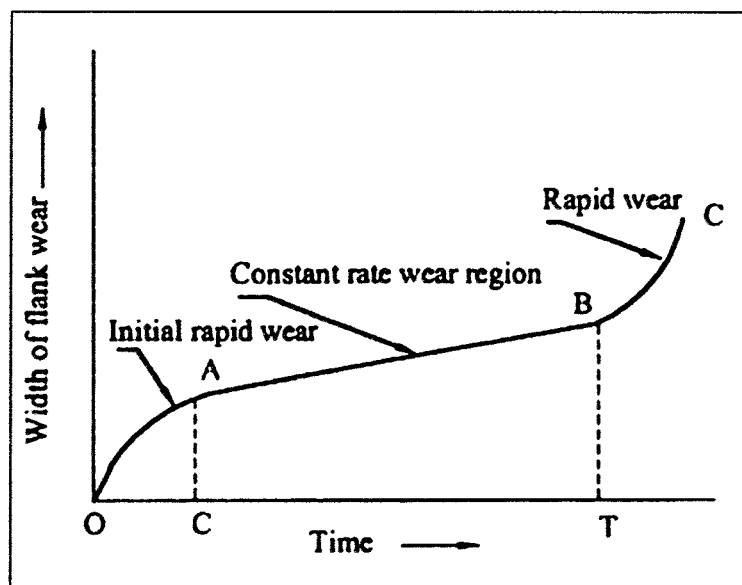


Figure 2.2: A Typical Wear Curve for a Cutting Tool (Juneja and Seth, 2003).

Tools failure criteria (tool life criteria) can be classified as direct and indirect.

Direct Criteria depend on direct measurement or direct visual, such as:

- a) Limiting Value of Width of Wear Land at the Flank,
- b) Limiting value of Maximum Depth of Crater, and
- c) Limiting Extent of Chipping and Crack Formation.

Indirect criteria depending on the measurement of the effects produced by wear and chips, such as:

- a) Limiting Value of Surface Roughness,
- b) Limiting Value of Change in Machined Dimension,
- c) Limiting Value of Increase in Cutting Forces,
- d) Limiting Volume of Metal Removed,
- e) Preliminary Failure, and
- f) Complete Failure.

2.4 Neoprene

Neoprene (polychloroprene) is a synthetic Latex-free polymer. Neoprene was first used to make wetsuits for its flexibility and insulation properties (Stern, et al., 1998). Neoprene exhibits good chemical stability, and maintains flexibility in a wide temperature range. It is used in various applications, such as laptop sleeves, orthopaedic braces, electrical insulation, liquid and sheet applied elastomeric membranes or flashings, and automotive fan belts (DuPont, 2010). Neoprene was invented by DuPont scientists on April 17, 1930 (Smith, 1985)

Neoprene resists degradation more than natural or synthetic rubber. This relative inertness makes it ideal for demanding applications such as gaskets, hoses, and corrosion-resistant coating (Obrech et al., 2012). It can be used as a base for adhesives, noise isolation in power transformer installations, and as padding in external metal cases to protect the contents while allowing a comfortable fit. It resists burning better than exclusively hydrocarbon rubber, causing its appearance in weather stripping for fire doors and in combat-related clothing such as gloves and face masks. Because tolerance to extreme conditions, neoprene is used to line landfills. Neoprene burning point is approximately 260 ° C (500°F) (DuPont, 2008).

2.5 Pine Wood

Pines are trees in the genus *Pinus*, in the family Pinaceae. They are the only genus in the subfamily Pinoideae. Pines are among the most commercially tree species, valued for their timber and wood pulp throughout the world. They are fast-growing softwoods that will grow in relatively dense stands in temperate and tropical regions, their acidic decaying needles inhibiting the sprouting of competing hardwoods.

Commercial pines are grown in plantations for timber that is denser, more resinous, and therefore more durable than spruce (*Picea*). Pine wood is widely used in high-value carpentry items such as furniture, window frames, panelling, floors and roofing, and the resin of some species is an important source of turpentine. Because pines have no insect or decay resistant qualities after logging, they are generally recommended for construction purposes as indoor use only.

There are three main subgenera of *Pinus*, the subgenus *Strobus* (white pines or soft pines), the subgenus *Ducampopinus* (Pinyon, Bristlecone and Lacebark pines), and the subgenus *Pinus* (typical pines, or yellow or hard pines). This classification into the three

subgenera is based on cone, seed and leaf characters:

- a) Subgenus Pinus - Scale with a sealing band. Umbo dorsal. Seed wings articulate. Two fibro vascular bundles per leaf.
- b) Subgenus Strobilus - Scale without a sealing band. Umbo terminal. Seed wings andante. One fibro vascular bundle per leaf.
- c) Subgenus Ducampopinus - Scale without a sealing band. Umbo dorsal. Seed wings articulate. One fibro vascular bundle per leaf.

2.6 Analysis of Variance (ANOVA)

Analysis of variance (ANOVA) is a collection of statistical models used to analyse the differences between group means and their associated procedures. In ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes t-test to more than two groups. Doing multiple two-sample t-tests would result in an increased chance of committing a type I error. For this reason, ANOVAs are useful in comparing three or more means for statistical significance.

ANOVA is a particular form of statistical hypothesis testing heavily used in the analysis of experimental data. A statistical hypothesis test is a method of making decisions using data. A test result (calculated from the null hypothesis and the sample) is called statistically significant if it is deemed unlikely to have occurred by chance, assuming the truth of the null hypothesis. A statistically significant result (when a probability (p-value) is less than a threshold (significance level)) justifies the rejection of the null hypothesis.

In the typical application of ANOVA, the null hypothesis is that all groups are

simply random samples of the same population. This implies that all treatments have the same effect (perhaps none). Rejecting the null hypothesis implies that different treatments result in altered effects.

By construction, hypothesis testing limits the rate of Type I errors (false positives leading to false scientific claims) to a significance level. Experimenters also wish to limit Type II errors (false negatives resulting in missed scientific discoveries). The Type II error rate is a function of several things including sample size (positively correlated with experiment cost), significance level (when the standard of proof is high, the chances of overlooking a discovery are also high) and effect size (when the effect is obvious to the casual observer, Type II error rates are low).

The terminology of ANOVA is largely from the statistical design of experiments. The experimenter adjusts factors and measures responses in an attempt to determine an effect. Factors are assigned to experimental units by a combination of randomization and blocking to ensure the validity of the results. Blinding keeps the weighing impartial. Responses show a variability that is partially the result of the effect and is partially random error.

ANOVA is the synthesis of several ideas and it is used for multiple purposes. As a consequence, it is difficult to define concisely or precisely.

ANOVA is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest. The statistical significance of the experiment is determined by a ratio of two variances. This ratio is independent of several possible alterations to the experimental observations: Adding a constant to all observations does not alter significance. Multiplying all observations by a constant does not alter significance. So ANOVA statistical significance results are independent of constant bias and scaling errors

as well as the units used in expressing observations. In the era of mechanical calculation it was common to subtract a constant from all observations to simplify data entry.

CHAPTER 3

METHODOLOGY

The focus of this project is to evaluate the performance of new tool holder clamping technique by adding viscoelastic and softwood materials passive damping system for the application of conventional lathe machine. This chapter describe the technique that has been used during the period of undergoing the project. The method and skill that is carried out in understanding the project is included. Project Design, Project Methodology, and Project Tools will be discussed.

3.1 Project Design

This study is started with conducting three sets of turning experiment for each damping condition to collecting data. All experiments are conducted with the same constant parameter as shown at Table 3.1. The first set of experiment is conducted without the damping at the tool holder (Figure 3.1), the second set of experiment is conducted using the tool holder with the viscoelastic damping (Figure 3.2), and the third set of experiment is conducted using the tool holder with the softwood damping (Figure 3.3).

The 38 *mm* diameter AISI D2 solid round bar with 110 *mm* length and 45 HRC hardness is used as work pieces. The composition of this special alloy steel is: 1.55 %C, 0.4 % Mn, 11.6 % Cr, 0.8 % Mo, 0.9 % V and 0.3% Si (Kamely et al., 2008). The machining operations are carried out on a Momac SM200X1500 conventional lathe machine (Figure 3.4) under dry cutting conditions at UTeM laboratory. Before conducting machining tests, a thin layer of 0.5 *mm* is machined with new cutting edge to remove

uneven surface from previous operations and to ensure consistency. The tool materials used in this study is mixed ceramic ($Al_2O_3 + TiCN$) coated with TiN. Vibration of the tool holder is recorded by using vibration analyser during machining.

Table 3.1: Specifications of cutting tools, cutting conditions and tool holder

Tool Holder	MCLNL 1616H 12
Insert	CNMG 12408P KC5010
Cutting edge angle	750
Work piece rotation speed	425 rpm
Depth of Cut	0.4 mm
Feed	0.15 mm/rev
Coolant	None (dry)

These tool wear tests are conducted with the usual measure of progressive tool-wear. Flank wear land width is measured from the original major cutting edge position (Kamely et al., 2008). Tool wear is measured at the flank face and the rake face of the inserts without dismounting it from the tool holder by placing the tool holder underneath a digital microscope with magnification of 7x. Surface roughness of work piece is measured by using surface roughness tester with the setting at Figure 3.5 at the end of experiments. Figure 3.6 shows the project flow of this study. Experiment flow is show in Figure 3.7.

3.2 Project Methodology

Main purpose of project methodology is to get as much information to understand the project title and concept. The technique and method that will be used to gather data and information for the study that will be carried out is discuss.

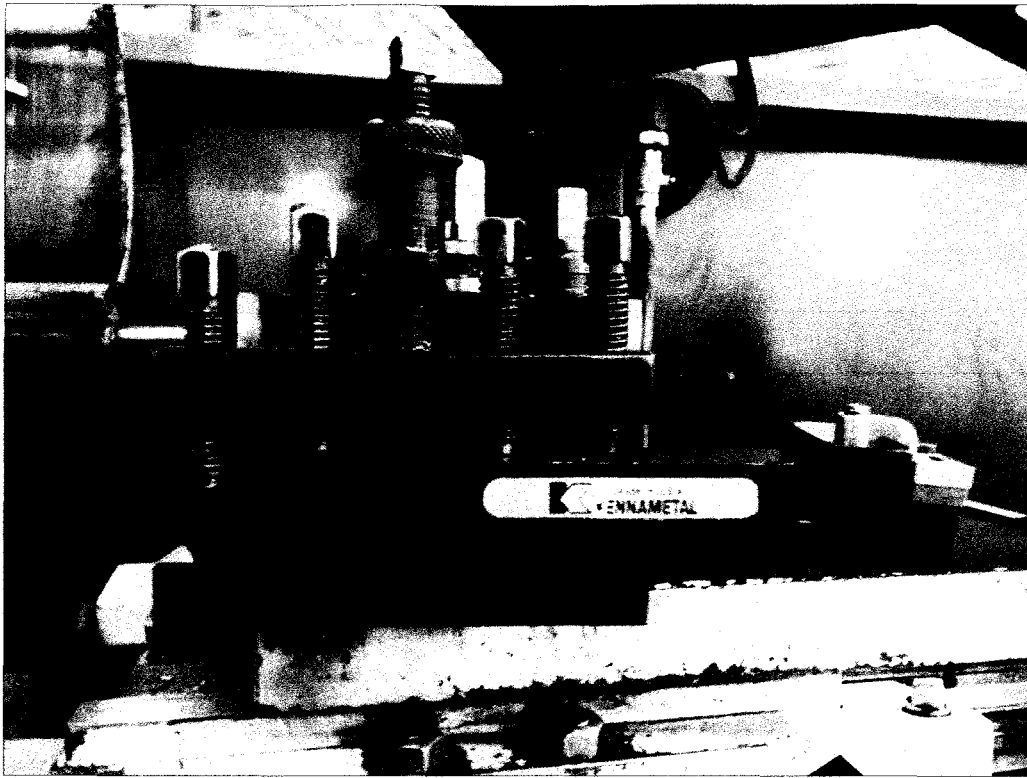


Figure 3.1: Tool holder without damping material.

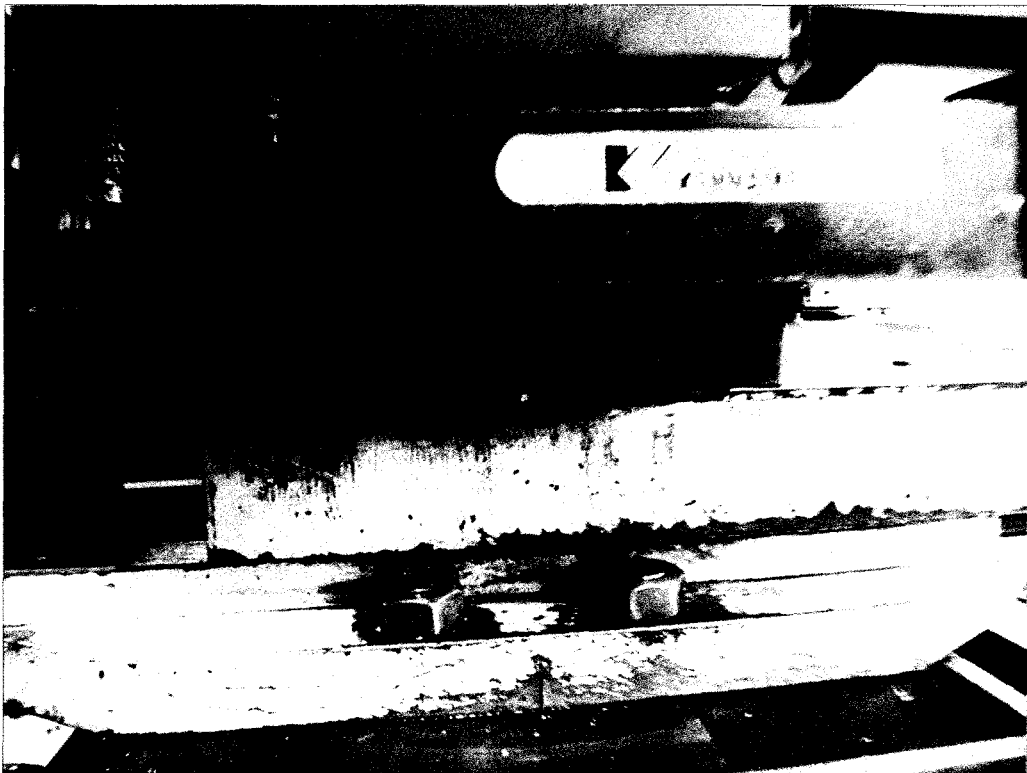


Figure 3.2: Tool holder with neoprene damping. (viscoelastic material)

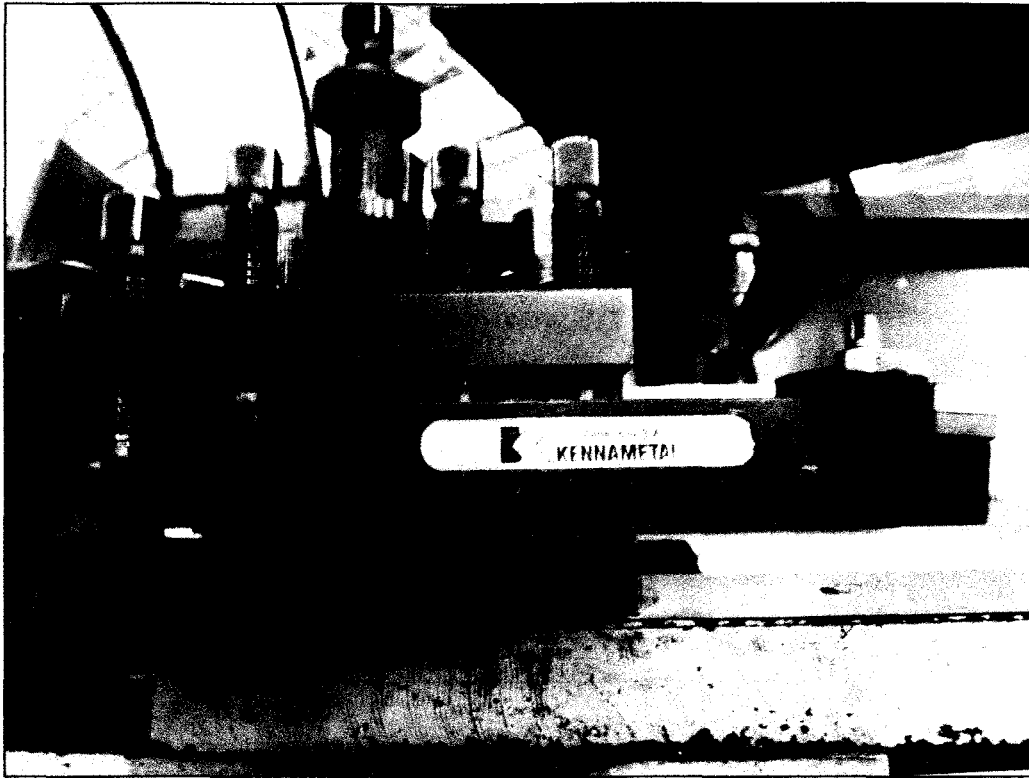


Figure 3.3: Tool holder with pine wood damping. (softwood material)

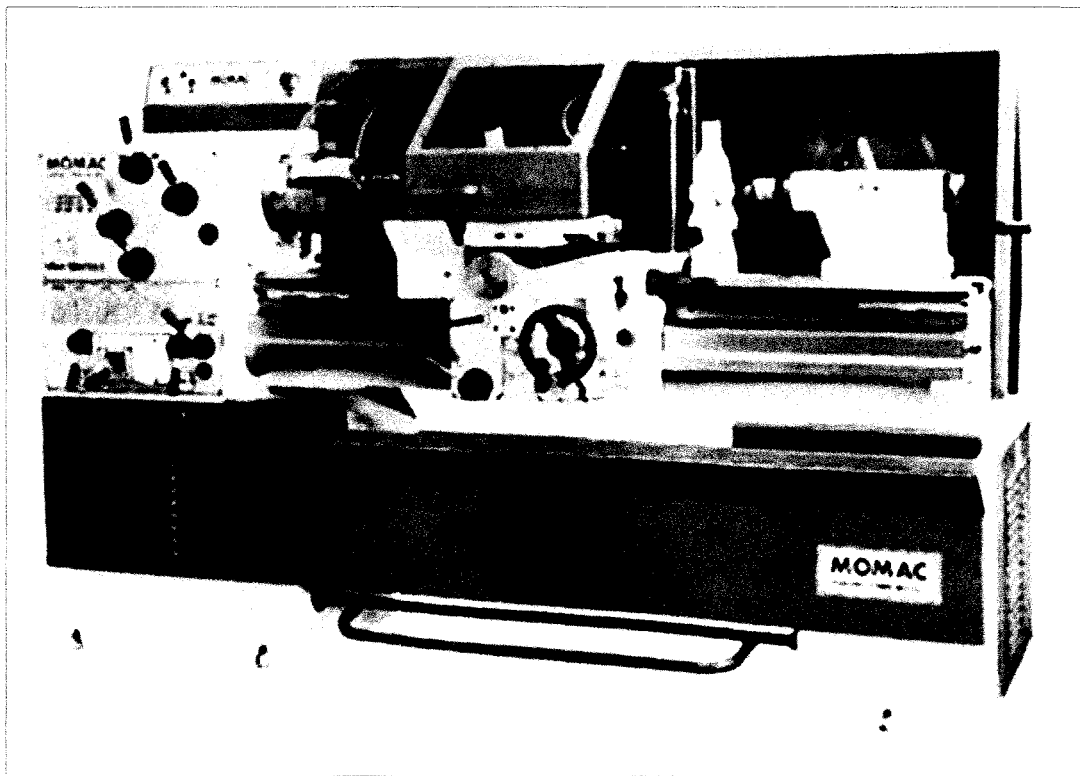


Figure 3.4: Momac SM200X1500 conventional lathe machine.

EVA-L	4.0mm
N	5
λc	0.8mm
λs	2.5 μ m
TILT--COMP.	ALL
M--SPEED	0.5mm/s
RANGE	AUTO
PRE/POST	ESC
	ON

Figure 3.5: Example of surface roughness tester setting.

Quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematics or computing techniques (Given and Lisa, 2008). The objective of quantitative research is to develop and apply mathematical models, theories and / or hypotheses pertaining to phenomena. The process of measurement is central to quantitative research because it provides the basic connection between empirical observation and mathematical expression of quantitative relationships. Quantitative data is anything data in numerical form such as statistics, percentage, etc. (Given and Lisa, 2008). Quantitative research widely used in the social sciences such as: psychology, economics, sociology, and political science, and information technology, and less frequently in anthropology and history. However, research in mathematical sciences such as physics is also 'quantitative' by definition, though this uses different terminology in context. Qualitative methods produce information only on the particular cases studied, and any more general conclusions are only hypotheses. Quantitative methods can be used to validate the hypothesis to be true.

Analysis of variance (ANOVA) is used to analyse the differences between group means and their associated procedures. EzANOVA is used to analyse the data obtained.

3.2.1 Data Measurement

3.2.1.1 Mixed Ceramic (Al₂O₃ + TiCN) Coated With TiN Insert Tool Wear

The wear of the insert is measured by using digital microscope at the Metrology Laboratory at Faculty of Manufacturing Engineering UTeM as shown in Figure 3.6. V.i.S version 2.90 Professional Edition from NK Measuring Instruments Sdn Bhd software is used to do the data collection (Appendix A). Magnification of 7x is used during the measurement.

3.2.1.2 Tool Vibration

Tool vibration is recorded during the machining process. VI-400Pro hand-held real time vibration analyser (Figure 3.7) from Ergonomic Laboratory of Faculty of Manufacturing Engineering UTeM is used to collect the data. Sensor attached at the lower side of the tool holder as shown in Figure 3.8.

3.2.1.3 Cold Work Tool Steel AISI D2 of 45 HRC Surface Roughness

The surface roughness of the work piece is measured by using portable surface roughness tester from Metrology Laboratory of Faculty of Manufacturing Engineering UTeM. Three random points is test for each of the work piece (Figure 3.9).

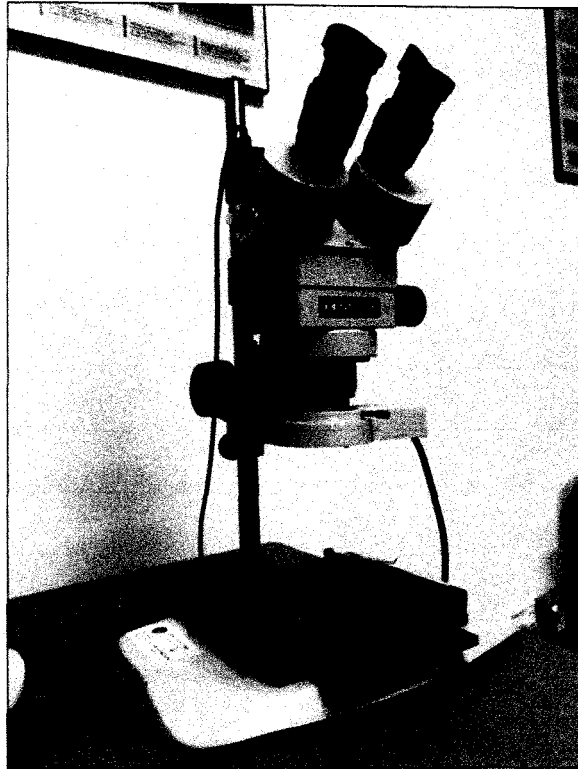


Figure 3.6: Digital microscope with V.i.S version 2.90 Professional Edition.

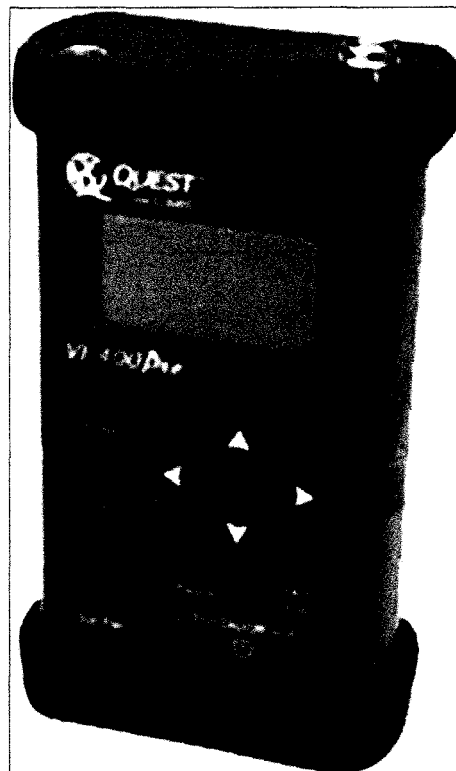


Figure 3.7: VI-400Pro hand-held real time vibration analyzer.