MONITORING TOOL WEAR PROCESS IN TURNING MACHINE USING ACOUSTIC EMISSION TECHNIQUE

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MONITORING TOOL WEAR PROCESS IN TURNING MACHINE USING ACOUSTIC EMISSION TECHNIQUE

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I certify that the thesis entitled “Monitoring Tool Wear Process In Turning Machine Using Acoustic Emission Technique” is written by Azlan Bin Mohd Saini. I have examined the final copy of this thesis and in my opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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DEDICATION

Dedicated to my beloved

parents and friends

for their support and motivation that they gave

while working on this thesis

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ABSTRACT

This project have been conducted in an attempt to monitor the changing of tool wear caused by increasing the cutting speed, through the variation of acoustic emission in turning process, under different feed and depth of cut. The signal-processing analysis was done on the raw signal, on the Acoustic Emission, signal filtered using a high bandpass and on the Acoustic Emission signal filtered using a smaller bandpass. The relationship among several parameters of Acoustic Emission such as zero crossing rate and standard deviation of Acoustic Emission was established. The material machined was mild steel and uncoated carbide cutting tool. The cutting force was also monitored. The results show that acoustic emission can be a good way to monitor on line the growth of tool wear in turning process and therefore can be useful for establishing the end of tool life in these operations. Based on the results obtained pointing out the best Acoustic Emission parameters to monitor tool wear, a set-up is proposed to reach to this goal of project.

ABSTRAK

Projek ini telah dilakukan dalam usaha untuk memantau perubahan kehausan alat yang disebabkan oleh peningkatan kelajuan pemotongan, melalui variasi pembebasan akustik dalam proses melarik, serta nilai suapan yang berbeza dan kedalaman pemotongan. Analisis isyarat pemprosesan dilakukan pada isyarat asal pembebasan akustik, isyarat yang diterima disaring menggunakan bandpass tinggi manakala pada isyarat pembebasan akustik pula disaring menggunakan bandpass lebih kecil. Hubungan antara beberapa parameter pembebasan akustik seperti tahap sifar persimpangan dan deviasi standard pembebasan akustik ditubuhkan. Benda kerja yang digunakan dalam eksperimen ini adalah “mild steel” dan alat pemotong jenis karbida yang tidak dilapisi. Daya pemotongan juga dipantau. Keputusan eksperimen menunjukkan bahawa pembebasan akustik boleh menjadi cara yang baik untuk memantau pada pertumbuhan kehausan alat pemotong dalam mengubah proses dan oleh kerana itu bisa bermanfaat untuk membina jangka hayat alat pemotong dalam operasi ini. Berdasarkan keputusan yang diperolehi menunjukkan parameter pembebasan akustik terbaik untuk memantau kehausan alat pemotong, satu set-up yang dicadangkan untuk mencapai matlamat projek.

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LIST OF ABBREVIATIONS

AE	Acoustic Emission
Al_2O_3	Aluminium Oxide
cBN	Cubic Boron Nitride
CNC	Computer Numerical Control
CS	Cutting Speed
CVD	Chemical Vapour
D	Diameter
FYP	Final Year Project
GRP	Glass Reinforced Plastic
HP	Horse Power
HSS	High Speed Steel
IPM	Inches per Minute
IPR	Inches per Revolution
IPT	Inches per Tooth
LPG	Liquid Petroleum Gas
PCD	Polycrystalline Diamond
PVD	Physical Vapour Deposition
RMS	Root Mean Square
RPM	Revolutions per Minute
SFM	Surface Feet per Minute
Si_3N_4	Silicon Nitride
SiC	Silicon Carbide
SMA	Shape Memory Alloys
TiC	Titanium Carbide
ZrO_2	Zirconium Oxide

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The basic mechanisms of wear of tools and different types of wear produced at the tip of the tool can be realized several years ago. Based on experimental measurements of the tool are different, and application of appropriate statistical techniques, it is possible to predict the tool life and hence the intervals of changing tools.

At the same time, the poor prospects were provided for the cutting process because of higher energy waste and economic inefficiency. However, recent developments in machine tools, computer control, automation, combined with improvements related to contingencies when cutting materials and their protective coatings with geometric tools, make such a prediction completely invalid. In addition, the percentage of use of machining operations has actually increased significantly today.

New cutting materials costs to increase efficiency of the tool machining operations of interpretation and also very increase the reliability and cutting quality. All machining problems these changes pose new challenges amazing and tasks for users of tools. If we were able to predict the life of a tool based on measurements of flank wear and crater of the tool, due to changing circumstances with new tools and all related appearances would require us to be unknown consider that the tool wear as a collection of different kinds of door located at the tool tip, difficult to separate form from the usual places.

The study of the dynamics of the machine tool is by "tracking", which is to monitor and improve the functions of the machine. Signals collected by sensors are processed by a computer and the data obtained are used to associate the state with the current operation of a class from a set of classes called the treatment conditions. Process tool wear is a vital aspect of machining and head of the tool is the term generally refers to a non rotary cutting tool used in metal lathes, shapers and planers. One of machining processes using a small machine tool tower is shooting process.

This study focuses on monitoring tool wear in turning machine using acoustic emission technique. By applying this technique to laboratory experiments the maximum level of performance in the transformation process of the tool head is identified, the inability of the head of the tool before breaking surveillance. Acoustic emission technique is the most valuable with respect to the acquisition of information, much of this is achieved by careful monitoring of electronic filtering data received by acoustic emission, but also best practices in order to identify the sustainability of the head of the tool and remove all sources of noise as possible.

1.2 PROBLEM STATEMENT

In many production processes, the processes mean shifts during production. For example, in metal machining operations, the cutting tool is subject to wear and random shocks. If adjustments are not made during a longer production period, the risk of tool failure increases and the quality of the product decreases, resulting in a large proportion of nonconforming items.

The problem often faced is the breakage of tool during cutting, which if not detected in time may lead to various problems associated with spoiled jobs, particularly in unmanned machining shifts. Hence it is necessary to have systems which can detect the breakage of tools through some means. The force drops since the tool may lose contact because of tool breakage.

1.3 RESEARCH OBJECTIVE

In the case of tool monitoring systems, the tool has to be continuously monitored while it is cutting. This would allow for continuously looking for tool wear, as well as the times when the tool breaks because of unforeseen conditions in the machining system. The main objective is monitoring tool wear process in turning machine using effective technique i.e. Acoustic Emission.

This type of system is simple, but can detect tool breakages before the maximum durability achieved. Any tool breakage during cutting remains unnoticed can reduce the process effectiveness caused by broken tools. Tool wear is a phenomenon whose behaviour can be explained qualitatively but not quantitatively. Though some tool life equations do exist, their universal adaptability or their utilisation even in restricted work tool material zones for all parameter ranges are doubtful. Further, direct in process measurement of tool wear is difficult in view of the location of the wear and the measurement techniques employed.

1.4 SCOPES

i. Turning process using the mild steel material for workpiece.
ii. Turning process using uncoated carbides cutting tool.
iii. Capture the Acoustic Emission signal technique during machining process.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW OF ACOUSTIC EMISSION

Acoustic emission is the technical term for the noise emitted by materials and structures when they are subjected to stress. Types of stresses can be mechanical, thermal or chemical. This emission is caused by the rapid release of energy within a material due to events such as crack formation, and the subsequent extension occurring under an applied stress, generating transient elastic waves which can be detected by suitable transducers. Hence, acoustic emission may be described as the *"sound"* emanating from regions of localized deformation within a material.

Acoustic emission is a passive listening technique which is extremely sensitive and can detect defects such as a few atom movements. AE can thus provide the early information on defect or deformation in any material or structure. If the atomic bonds break during an integrity test, the energy released propagates through the material according to the laws of acoustics. While this level of sensitivity is important in laboratory research, a less sensitive monitoring system is often used in industry to allow the technique to concentrate on growing defects rather than original deformation.

In both instances very sensitive transducers detect the propagating wave and the detected waveform can then be subjected to a series of analysis techniques which can be used to detect, locate and identify defects activated by the test program. AE techniques can provide a most sophisticated monitoring test and can generally be done with the plant or pressure equipment operating at or near, normal conditions. A typical acoustic emission pulse and the more interesting associated parameters are as follows.

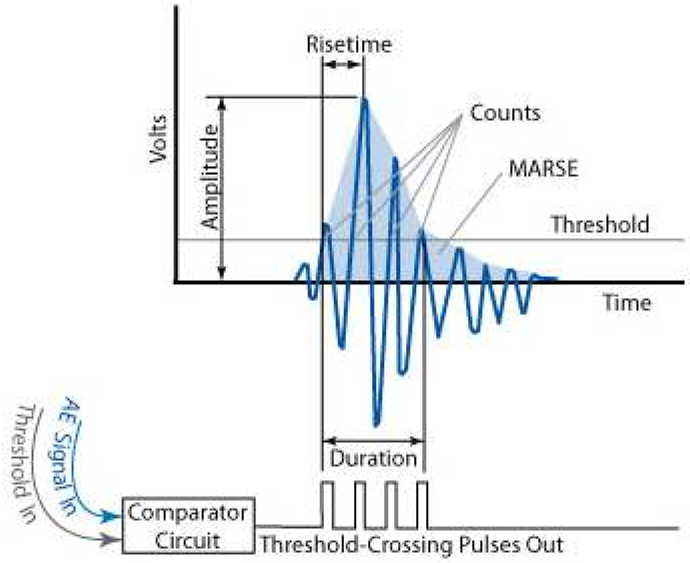


Figure 2.1: Acoustic Emission signal features

Source: Hartmunt Vallen 2006

When a load is applied to a solid structure (e.g. by internal pressure or by external mechanical means), it begins to deform elastically. Associated with this elastic deformation are changes in the structure's stress distribution and storage of elastic strain energy. As the load increases further, some permanent microscopic deformation may occur, which is accompanied by a release of stored energy, partly in the form of propagating elastic waves termed 'Acoustic Emission' (AE). If these emissions are above a certain threshold level they can be detected and converted to voltage signals by sensitive piezoelectric transducers mounted on the structure's surface.

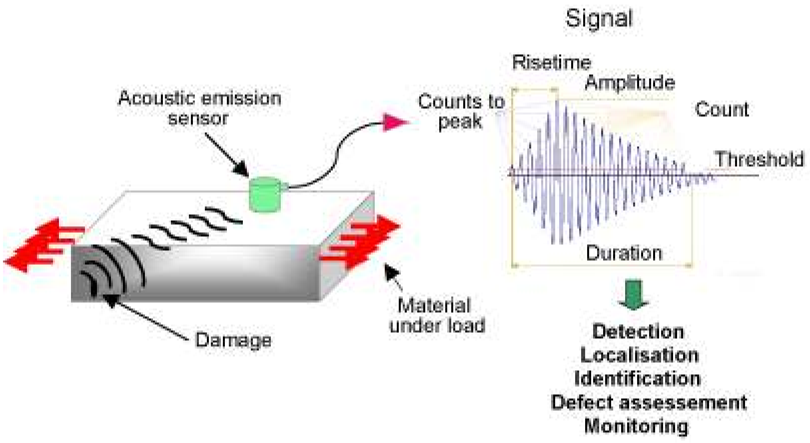


Figure 2.2: System of Acoustic Emission

Source: Hartmunt Vallen 2006

A typical AE system consists of signal detection, amplification, data acquisition, processing and analysis. Various parameters are used in AE to identify the nature of the source, including: count, duration, amplitude, rise-time, energy, frequency and RMS (Root Mean Square).An important aspect of AE testing is signal processing. There is a need to separate genuine stress wave emissions, originating from within the material, from external signals, such as environmental noise (rain, wind with sand particles), mechanical noise (movement of the component during testing), electric noise, etc. Much of this is achieved by careful electronic filtering of the received AE data but best practice is still to identify and remove as many sources of extraneous noise as possible prior to testing.

The frequency of the stress waves emitted is normally in the range 30 kHz to 1 MHz. Triangulation and other techniques can give positional information and localize the sources of the emissions. Some European standards and codes of practice exist for AE testing: Acoustic Emission Terminology (EN1330-9); General Principles (EN 13544); Equipment Description (EN 13477-1); Equipment Characterization (EN 13477-2); and Examination of Metallic Pressure Equipment during Proof Testing (prEN14584). Sources of acoustic emission are:

i. Plastic deformations, dislocation motion, rupture of the inclusion, phase transformation, twin or slip deformation.
ii. Different stages of crack propagation (static, fatigue, stress corrosion). AE is sensitive enough to detect newly formed crack surface down to a few hundred square micrometers and less.
iii. The weld defects: lack of penetration and fusion, cracks, inclusion and porosity.
iv. Corrosion: localized corrosion or pitting corrosion. Detecting and monitoring of active corrosion, hydrogen embrittlement, corrosion fatigue, and intergranular stress corrosion cracking. Hydrogen embrittlement, dissolution of metal, hydrogen gas evolution, the breakdown of thick surface-oxide films.
v. Friction, mechanical impact, leaks (liquid or gas) and external noise (mechanical, electrical, and environmental).

2.1.1 Implementation of Acoustic Emission

Acoustic Emission method could be applied in a variety of material and it is not limited to only a specific type of material. Acoustic emission can be used in nondestructive monitoring of different kinds of materials such as:

i. Metals: steels, stainless steel, carbon steel, alloy, ferritic steel, aluminium, aluminium alloys, magnesium alloys, and others (e.g., copper and its alloys, uranium alloys, titanium, and zirconium alloys).
ii. Composite materials and polymer: sandwich composite, glass-reinforced plastic (GRP) and carbon fibre.
iii. Concrete, reinforced concrete, rocks and woods.

The passive listening technique from Acoustic Emission which is extremely sensitive and can detect defects such as a few atom movements can utilize in various of engineering fields such as:

i. Pressure equipment: Fundamental research and development efforts in the control of the damage in materials by acoustic emission have grown in the last twenty years. This technique has become a reliable and standard method of nondestructive testing for pressure vessels. AE is used to monitor flaws, corrosion, and leakage in pressure vessels, LPG, tanks, piping systems, steam generators.

ii. Aircraft and aerospace: Aerospace structures, wings, bulkhead, fuel tanks, Rocket engine, real time monitoring.
iii. Petrochemical and chemical: Storage tanks, reactor vessels, offshore and onshore platforms, drill pipe, pipeline.
iv. Marine: Corrosion, composite shell, engine and power plant.
v. Civil engineering: Bridges, dams, suspension cable bridges, concrete structure reinforced by composite.
vi. Research and development: Acoustic emission is a good technique to monitor and study the damage in materials and their mechanical properties (new materials, smart materials, Shape memory alloys (SMA)).

2.2 TURNING PROCESS

Turning machines typically referred to as lathes, can be found in a variety of sizes and designs. While most lathes are horizontal turning machines, vertical machines are sometimes used, typically for large diameter workpieces. Turning machines can also be classified by the type of control that is offered. A manual lathe requires the operator to control the motion of the cutting tool during the turning operation. Turning machines are also able to be computer controlled, in which case they are referred to as a computer numerical control (CNC) lathe. CNC lathes rotate the workpiece and move the cutting tool based on commands that are preprogrammed and offer very high precision. In this variety of turning machines, the main components that enable the workpiece to be rotated and the cutting tool to be fed into the workpiece remain the same.

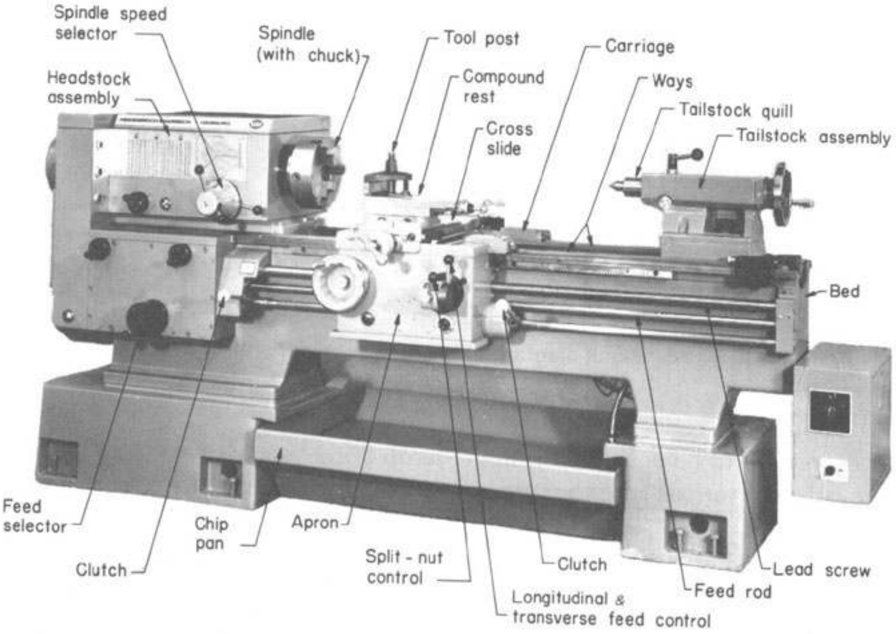


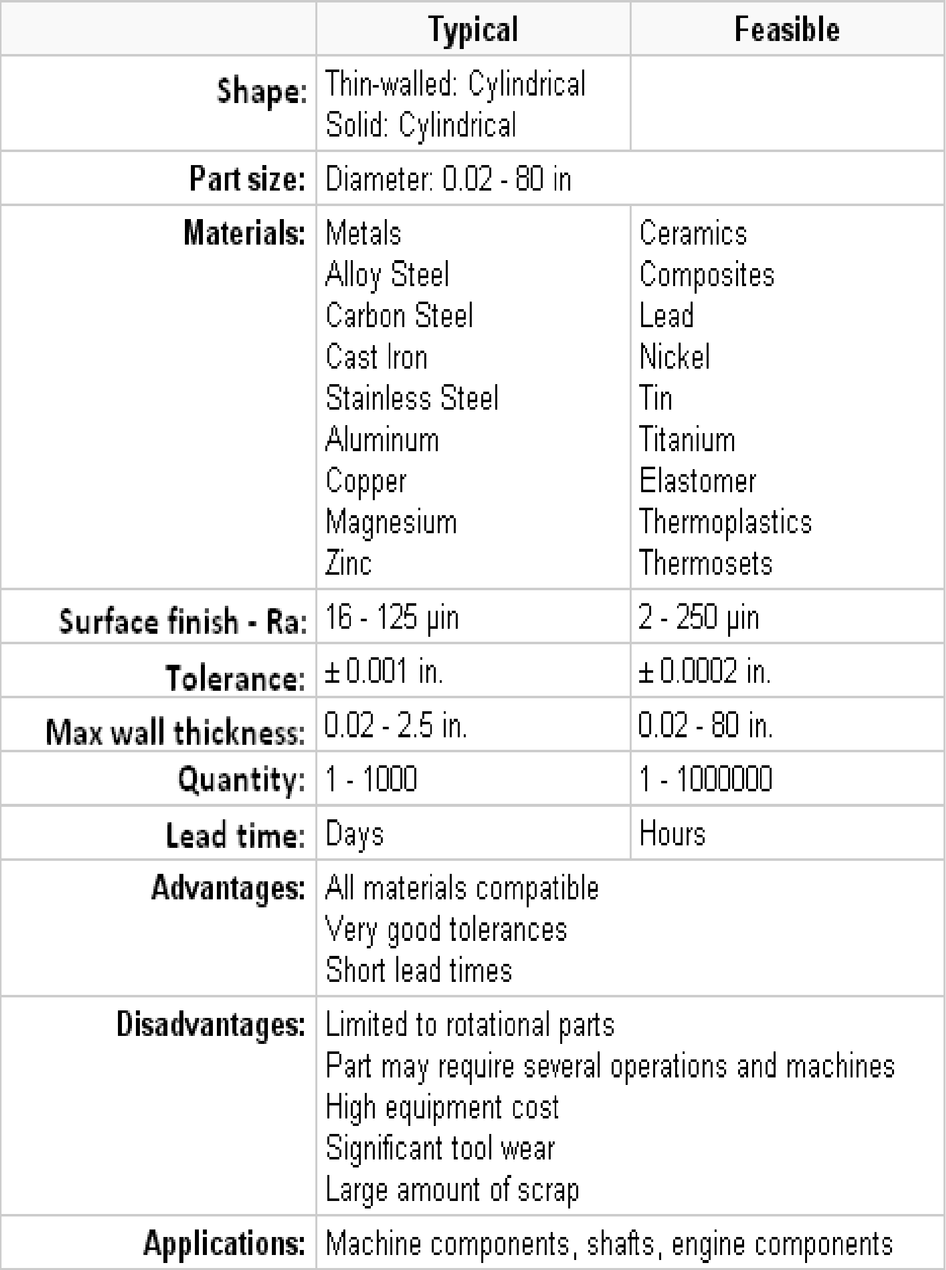
Figure 2.3: Manual lathe machine

Source: Chiles et.al 1996

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, workpiece, fixture, and cutting tool. The workpiece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating workpiece and cuts away material in the form of small chips to create the desired shape.

Turning is used to produce rotational, typically axi symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Parts that are fabricated completely through turning often include components that are used in limited quantities, perhaps for prototypes, such as custom designed shafts and fasteners. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that turning can offer, it is ideal for adding precision rotational features to a part whose basic shape has already been formed. According to Table 2.1 there is standard specification for capability of tuning machine.

Table 2.1: Capability of turning.



	Typical	Feasible
Shape:	Thin-walled: Cylindrical Solid: Cylindrical	
Part size:	Diameter: 0.02 - 80 in	
Materials:	Metals Alloy Steel Carbon Steel Cast Iron Stainless Steel Aluminum Copper Magnesium Zinc	Ceramics Composites Lead Nickel Tin Titanium Elastomer Thermoplastics Thermosets
Surface finish - Ra:	16 - 125 μin	2 - 250 μin
Tolerance:	± 0.001 in.	± 0.0002 in.
Max wall thickness:	0.02 - 2.5 in.	0.02 - 80 in.
Quantity:	1 - 1000	1 - 1000000
Lead time:	Days	Hours
Advantages:	All materials compatible Very good tolerances Short lead times	
Disadvantages:	Limited to rotational parts Part may require several operations and machines High equipment cost Significant tool wear Large amount of scrap	
Applications:	Machine components, shafts, engine components	

Source: Chiles et.al (1996)

2.2.1 Process Cycle

The time required to produce a given quantity of parts includes the initial setup time and the cycle time for each part. The setup time is composed of the time to setup the turning machine, plan the tool movements (whether performed manually or by machine), and install the fixture device into the turning machine. The cycle time can be divided into the following four times:

i. Load/Unload time: The time required to load the workpiece into the turning machine and secure it to the fixture, as well as the time to unload the finished part. The load time can depend on the size, weight, and complexity of the workpiece, as well as the type of fixture.

ii. Cut time: The time required for the cutting tool to make all the necessary cuts in the workpiece for each operation. The cut time for any given operation is calculated by dividing the total cut length for that operation by the feed rate, which is the speed of the tool relative to the workpiece.

iii. Idle time: Also referred to as non-productive time, this is the time required for any tasks that occur during the process cycle that do not engage the workpiece and therefore remove material. This idle time includes the tool approaching and retracting from the workpiece, tool movements between features, adjusting machine settings, and changing tools.

iv. Tool replacement time: The time required to replace a tool that has exceeded its lifetime and therefore become to worn to cut effectively. This time is typically not performed in every cycle, but rather only after the lifetime of the tool has been reached. In determining the cycle time, the tool replacement time is adjusted for the production of a single part by multiplying by the frequency of a tool replacement, which is the cut time divided by the tool lifetime.

Following the turning process cycle, there is no post processing that is required. However, secondary processes may be used to improve the surface finish of the part if it is required. The scrap material, in the form of small material chips cut from the workpiece, is propelled away from the workpiece by the motion of the cutting tool and the spraying of lubricant. Therefore, no process cycle step is required to remove the scrap material, which can be collected and discarded after the production.

2.2.2 Cutting Parameters

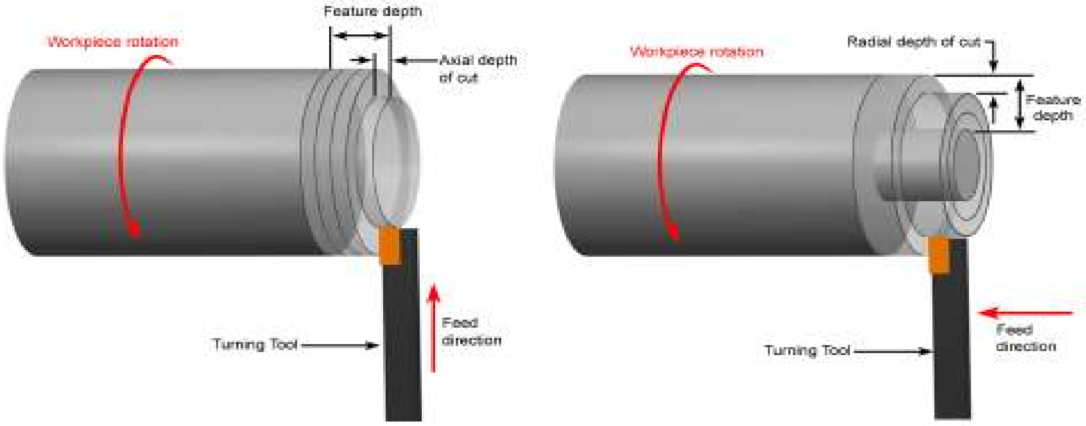
In turning, the speed and motion of the cutting tool is specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size, and etc.

i. Cutting feed: The distance that the cutting tool or workpiece advances during one revolution of the spindle, measured in inches per revolution (IPR). In some operations the tool feeds into the workpiece and in others the workpiece feeds into the tool. For a multi-point tool, the cutting feed is also equal to the feed per tooth, measured in inches per tooth (IPT), multiplied by the number of teeth on the cutting tool.

ii. Cutting speed: The speed of the workpiece surface relative to the edge of the cutting tool during a cut, measured in surface feet per minute (SFM).

iii. Spindle speed: The rotational speed of the spindle and the workpiece in revolutions per minute (RPM). The spindle speed is equal to the cutting speed divided by the circumference of the workpiece where the cut is being made. In order to maintain a constant cutting speed, the spindle speed must vary based on the diameter of the cut. If the spindle speed is held constant, then the cutting speed will vary.

iv. Feed rate: The speed of the cutting tool's movement relative to the workpiece as the tool makes a cut. The feed rate is measured in inches per minute (IPM) and is the product of the cutting feed (IPR) and the spindle speed (RPM).



(a) (b)

Figure 2.4: (a) Axial depth of cut, (b) Radial depth of cut.

Source: Chiles et.al 1996

v. Axial depth of cut: The depth of the tool along the axis of the workpiece as it makes a cut, as in a facing operation. A large axial depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is typically machined in several passes as the tool moves to the specified axial depth of cut for each pass.

vi. Radial depth of cut: The depth of the tool along the radius of the workpiece as it makes a cut, as in a turning or boring operation. A large radial depth of cut will require a low feed rate, or else it will result in a high load on the tool and reduce the tool life. Therefore, a feature is often machined in several steps as the tool moves over at the radial depth of cut.

2.2.3 Operations

During the process cycle, a variety of operations may be performed to the workpiece to yield the desired part shape. These operations may be classified as external or internal. External operations modify the outer diameter of the workpiece, while internal operations modify the inner diameter. The following operations are each defined by the type of cutter used and the path of that cutter to remove material from the workpiece.

2.2.3.1 External Operations

i. Turning: A single-point turning tool moves axially, along the side of the workpiece, removing material to form different features, including steps, tapers, chamfers, and contours. These features are typically machined at a small radial depth of cut and multiple passes are made until the end diameter is reached.
ii. Facing: A single-point turning tool moves radially, along the end of the workpiece, removing a thin layer of material to provide a smooth flat surface. The depth of the face, typically very small, may be machined in a single pass or may be reached by machining at a smaller axial depth of cut and making multiple passes.
iii. Grooving: A single-point turning tool moves radially, into the side of the workpiece, cutting a groove equal in width to the cutting tool. Multiple cuts can be made to form grooves larger than the tool width and special form tools can be used to create grooves of varying geometries.
iv. Cut-off (parting): Similar to grooving, a single-point cut-off tool moves radially, into the side of the workpiece, and continues until the center or inner diameter of the workpiece is reached, thus parting or cutting off a section of the workpiece.
v. Thread cutting: A single-point threading tool, typically with a 60 degree pointed nose, moves axially, along the side of the workpiece, cutting threads into the outer surface. The threads can be cut to a specified length and pitch and may require multiple passes to be formed.

2.2.3.2 Internal Operations

i. Drilling: A drill enters the workpiece axially through the end and cuts a hole with a diameter equal to that of the tool.
ii. Boring: A boring tool enters the workpiece axially and cuts along an internal surface to form different features, such as steps, tapers, chamfers, and contours. The boring tool is a single-point cutting tool, which can be set to cut the desired

diameter by using an adjustable boring head. Boring is commonly performed after drilling a hole in order to enlarge the diameter or obtain more precise dimensions.

iii. Reaming: A reamer enters the workpiece axially through the end and enlarges an existing hole to the diameter of the tool. Reaming removes a minimal amount of material and is often performed after drilling to obtain both a more accurate diameter and a smoother internal finish.
iv. Tapping: A tap enters the workpiece axially through the end and cuts internal threads into an existing hole. The existing hole is typically drilled by the required tap drill size that will accommodate the desired tap.

2.3 TOOL WEAR

Metal cutting tools are subjected to extremely arduous conditions, high surface loads, and high surface temperatures arise because the chip slides at high speed along the tool rake face while exerting very high normal pressures (and friction force) on this face. Tool wear describes the gradual failure of cutting tools due to regular operation. It is a term often associated with tipped tools, tool bits, or drill bits that are used with machine tools. The forces may be fluctuating due to the presence of hard particles in the component micro structure, or more extremely, when interrupted cutting is being carried out. Hence cutting tools need:

i. Strength at elevated temperatures.
ii. High toughness.
iii. High wear resistance.
iv. High hardness.

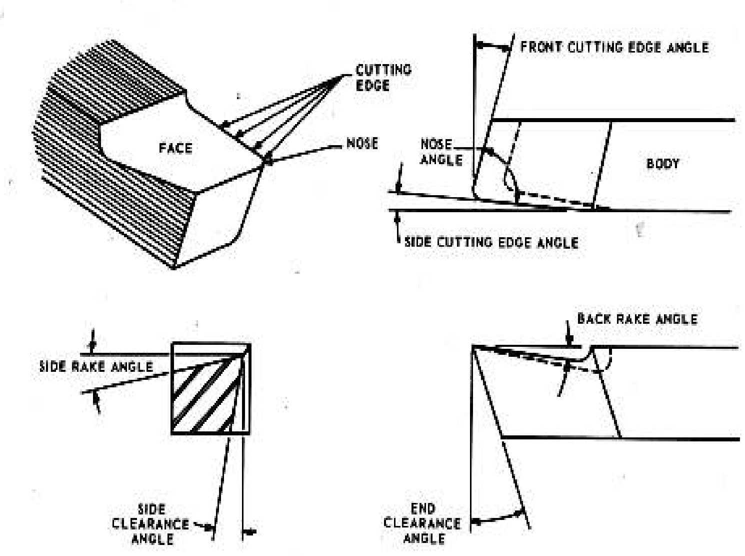


Figure 2.5: Cutting tool terminology

Source: Chiles et.al 1996

The Figure 2.5 shows a typical cutting tool and the terminology used to describe it. The actual geometry varies with the type of work to be done. The standard cutting tool shapes are shown below.

i. Facing tools are ground to provide clearance with a center.
ii. Roughing tools have a small side relief angle to leave more material to support the cutting edge during deep cuts.
iii. Finishing tools have a more rounded nose to provide a finer finish. Round nose tools are for lighter turning. They have no back or side rake to permit cutting in either didection.
iv. Left hand cutting tools are designed to cut best when traveling from left to right.
v. Aluminum is cut best by specially shaped cutting tools (not shown)that are used with the cutting edge slightly above center to reduce chatter.

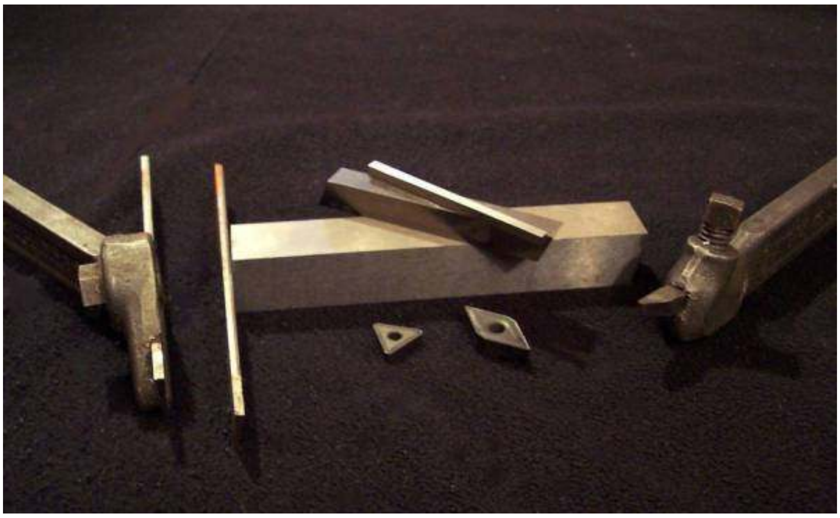


Figure 2.6: Various tool bits, carbide inserts and holders

Source: Chiles et.al 1996

There are various types of cutting tool material in the market, each according to his specifications workpiece to be cut. Cutting tool material consisting of:

i. Carbon Steel
ii. High speed steel (HSS)
iii. Cast Cobalt Alloys
iv. Carbides
v. Coating
vi. Cermets
vii. Cubic Boron Nitride (cBN).
viii. Diamond

2.3.1 Carbon Steels

Carbon steels have been used since the 1880s for cutting tools. However carbon steels start to soften at a temperature of about 180^{o}C. This limitation means that such tools are rarely used for metal cutting operations. Plain carbon steel tools, containing about 0.9% carbon and about 1% manganese, hardened to about 62 Rc, are widely used for woodworking and they can be used in a router to machine aluminium sheet up to about 3mm thick.

2.3.2 High Speed Steel (HSS)

HSS tools are so named because they were developed to cut at higher speeds. Developed around 1900 HSS are the most highly alloyed tool steels. The tungsten (T series) were developed first and typically contain 12 - 18% tungsten, plus about 4% chromium and 1 - 5% vanadium. Most grades contain about 0.5% molybdenum and most grades contain 4 - 12% cobalt.

It was soon discovered that molybdenum (smaller proportions)could be substituted for most of the tungsten resulting in a more economical formulation which had better abrasion resistance than the T series and undergoes less distortion during heat treatment. Consequently about 95% of all HSS tools are made from M series grades. These contain 5 - 10% molybdenum, 1.5 - 10% tungsten, 1 - 4% vanadium, 4% Chromium and many grades contain 5 - 10% cobalt.

HSS tools are tough and suitable for interrupted cutting and are used to manufacture tools of complex shape such as drills, reamers, taps, dies and gear cutters. Tools may also be coated to improve wear resistance. HSS accounts for the largest tonnage of tool materials currently used. Typical cutting speeds: 10 - 60 m/min.

2.3.3 Cast Cobalt Alloys

Introduced in early 1900s these alloys have compositions of about 40 - 55% cobalt, 30% chromium and 10 - 20% tungsten and are not heat treatable. Maximum hardness values of 55 - 64 Rc. They have good wear resistance but are not as tough as HSS but can be used at somewhat higher speeds than HSS. Now only in limited use.

2.3.4 Carbides

Also known as cemented carbides or sintered carbides were introduced in the 1930s and have high hardness over a wide range of temperatures, high thermal conductivity, high Young's modulus making them effective tool and die materials for a range of applications.

The two groups used for machining are tungsten carbide and titanium carbide, both types may be coated or uncoated. Tungsten carbide particles (1 to 5 micro-m) are are bonded together in a cobalt matrix using powder metallurgy. The powder is pressed and sintered to the required insert shape. titanium and niobium carbides may also be included to impart special properties.

A wide range of grades are available for different applications. Sintered carbide tips are the dominant type of material used in metal cutting. The proportion of cobalt (the usual matrix material) present has a significant effect on the properties of carbide tools. 3 - 6% matrix of cobalt gives greater hardness while 6 - 15% matrix of cobalt gives a greater toughness while decreasing the hardness, wear resistance and strength. Tungsten carbide tools are commonly used for machining steels, cast irons and abrasive non-ferrous materials.

Titanium carbide has a higher wear resistance than tungsten but is not as tough. With a nickel-molybdenum alloy as the matrix, TiC is suitable for machining at higher speeds than those which can be used for tungsten carbide. Typical cutting speeds are: 30 - 150 m/min or 100 - 250 when coated.

2.3.5 Coatings

Coatings are frequently applied to carbide tool tips to improve tool life or to enable higher cutting speeds. Coated tips typically have lives 10 times greater than uncoated tips. Common coating materials include titanium nitride, titanium carbide and aluminium oxide, usually 2 - 15 micro-m thick. Often several different layers may be applied, one on top of another, depending upon the intended application of the tip. The techniques used for applying coatings include chemical vapour deposition (CVD) plasma assisted CVD and physical vapour deposition (PVD). Diamond coatings are also in use and being further developed.

2.3.6 Cermets

Developed in the 1960s, these typically contain 70% aluminium oxide and 30% titanium carbide. Some formulation contain molybdenum carbide, niobium carbide and tantalum carbide. Their performance is between those of carbides and ceramics and coatings seem to offer few benefits. Typical cutting speeds: 150 - 350 m/min.

2.3.7 Ceramics

Alumina introduced in the early 1950s, two classes are used for cutting tools: fine grained high purity aluminium oxide (Al_2O_3) and silicon nitride (Si_3N_4) are pressed into insert tip shapes and sintered at high temperatures. Additions of titanium carbide and zirconium oxide (ZrO_2) may be made to improve properties. But while ZrO_2 improves the fracture toughness, it reduces the hardness and thermal conductivity. Silicon carbide (SiC) whiskers may be added to give better toughness and improved thermal shock resistance.

The tips have high abrasion resistance and hot hardness and their superior chemical stability compared to HSS and carbides means they are less likely to adhere to the metals during cutting and consequently have a lower tendency to form a built up edge. Their main weakness is low toughness and negative rake angles are often used to avoid chipping due to their low tensile strengths. Stiff machine tools and work set ups should be used when machining with ceramic tips as otherwise vibration is likely to lead to premature failure of the tip. Typical cutting speeds: 150 - 650 m/min.

Silicon Nitride-In the 1970s a tool material based on silicon nitride was developed, these may also contain aluminium oxide, yttrium oxide and titanium carbide. SiN has an affinity for iron and is not suitable for machining steels. A specific type is 'Sialon', containing the elements: silicon, aluminium, oxygen and nitrogen. This has higher thermal shock resistance than silicon nitride and is recommended for machining cast irons and nickel based superalloys at intermediate cutting speeds.

2.3.8 Cubic Boron Nitride (cBN)

Introduced in the early 1960s, this is the second hardest material available after diamond. cBN tools may be used either in the form of small solid tips or or as a 0.5 to 1 mm thick layer of of polycrystalline boron nitride sintered onto a carbide substrate under pressure. In the latter case the carbide provides shock resistance and the cBN layer provides very high wear resistance and cutting edge strength. Cubic boron nitride is the standard choice for machining alloy and tool steels with a hardness of 50 Rc or higher. Typical cutting speeds: 30 - 310 m/min.

2.3.9 Diamond

The hardest known substance is diamond. Although single crystal diamond has been used as a tool, they are brittle and need to be mounted at the correct crystal orientation to obtain optimal tool life. Single crystal diamond tools have been mainly replaced by polycrystalline diamond (PCD). This consists of very small synthetic crystals fused by a high temperature high pressure process to a thickness of between 0.5 and 1mm and bonded to a carbide substrate.

The result is similar to cBN tools. The random orientation of the diamond crystals prevents the propagation of cracks, improving toughness. Because of its reactivity, PCD is not suitable for machining plain carbon steels or nickel, titanium and cobalt based alloys.

PCD is most suited to light uninterrupted finishing cuts at almost any speed and is mainly used for very high speed machining of aluminium - silicon alloys, composites and other non - metallic materials. Typical cutting speeds: 200 - 2000 m/min.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, process and methodology for experiment will be discussed. Methodology is vital aspect for doing analysis or experimental so that process flow according the right planning. Every process that will be discussed their own importance obey the experiment. Start from find the article, journal and books, the idea of thesis or another experiment process which is related with the project can be use.

The idea from this literature review will be compare to make the best conclusion for the project process get the successfully result. Many type of monitoring project had be done but in different methodology, equipment and materials also.

The suitable material or techniques choose for suitable process is necessary to get the better and correct result. The arrangement of the process also importance to make sure any mistake or error will not affect the final result after doing the experimental.

3.2 PROJECT METHODOLOGY FLOWCHART

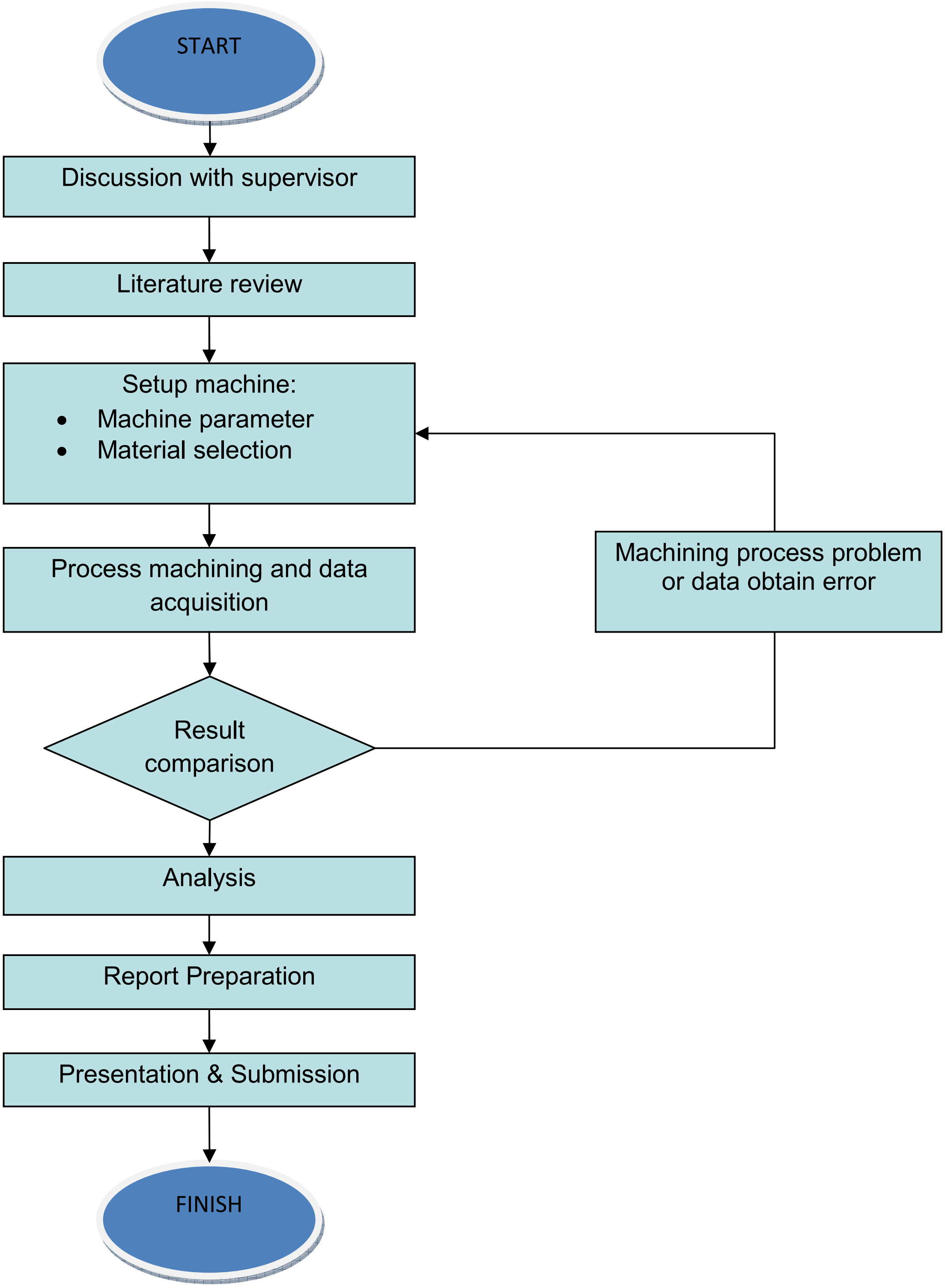
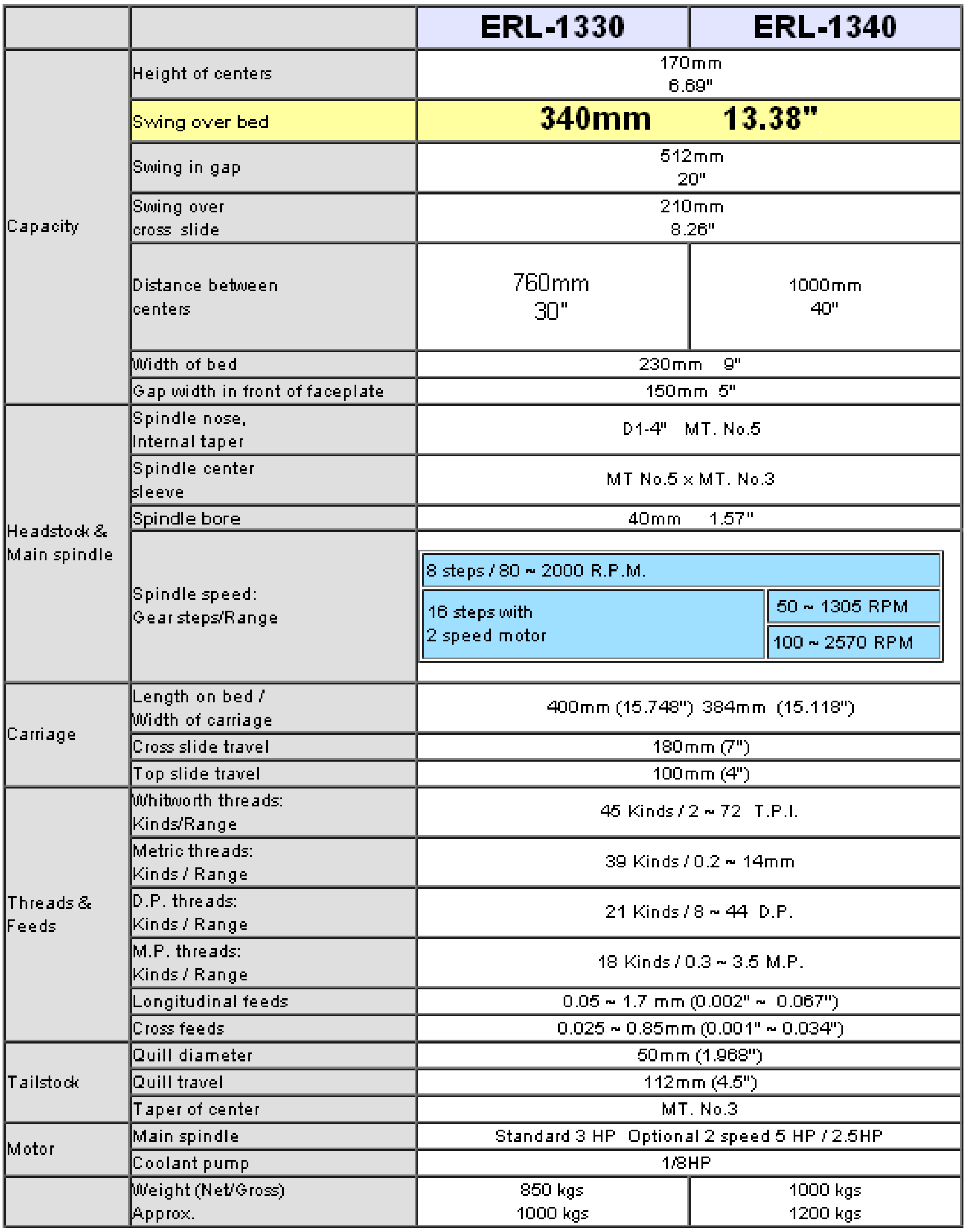


Figure 3.1: Flowchart for monitoring tool wear process

Table 3.1: Machine specification



		ERL-1330	ERL-1340
Capacity	Height of centers	170mm 6.69"	
	Swing over bed	**340mm 13.38"**	
	Swing in gap	512mm 20"	
	Swing over cross slide	210mm 8.26"	
	Distance between centers	760mm 30"	1000mm 40"
	Width of bed	230mm 9"	
	Gap width in front of faceplate	150mm 5"	
Headstock & Main spindle	Spindle nose, Internal taper	D1-4" MT. No.5	
	Spindle center sleeve	MT No.5 x MT. No.3	
	Spindle bore	40mm 1.57"	
	Spindle speed: Gear steps/Range	8 steps / 80 ~ 2000 R.P.M. 16 steps with 2 speed motor 50 ~ 1305 RPM 100 ~ 2570 RPM	
Carriage	Length on bed / Width of carriage	400mm (15.748") 384mm (15.118")	
	Cross slide travel	180mm (7")	
	Top slide travel	100mm (4")	
Threads & Feeds	Whitworth threads: Kinds/Range	45 Kinds / 2 ~ 72 T.P.I.	
	Metric threads: Kinds / Range	39 Kinds / 0.2 ~ 14mm	
	D.P. threads: Kinds / Range	21 Kinds / 8 ~ 44 D.P.	
	M.P. threads: Kinds / Range	18 Kinds / 0.3 ~ 3.5 M.P.	
	Longitudinal feeds	0.05 ~ 1.7 mm (0.002" ~ 0.067")	
	Cross feeds	0.025 ~ 0.85mm (0.001" ~ 0.034")	
Tailstock	Quill diameter	50mm (1.968")	
	Quill travel	112mm (4.5")	
	Taper of center	MT. No.3	
Motor	Main spindle	Standard 3 HP Optional 2 speed 5 HP / 2.5HP	
	Coolant pump	1/8HP	
	Weight (Net/Gross) Approx.	850 kgs 1000 kgs	1000 kgs 1200 kgs

Source: http://www.hhrobertsmachinery.com

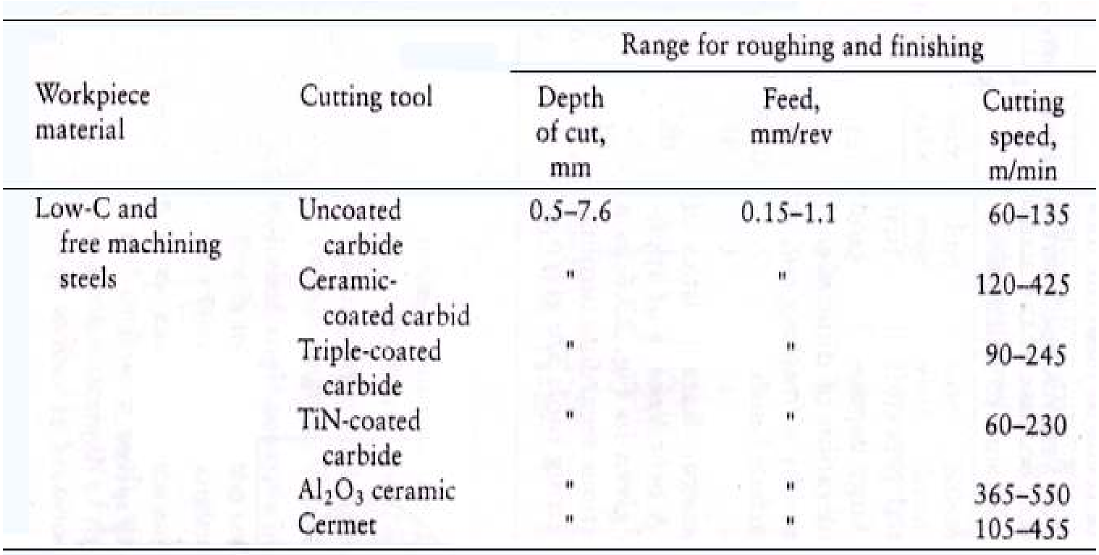
Important things that need to be initiated to begin a process is the machine setup, many fail is because the process experiment inaccuracy in the machining set-up as a result of the data collected have errors. ERL1330 conventional lathe machine are used in this machining process. Very large works with swing dimensions beyond the capacity of a horizontal machine are turned on vertical lathes that can accept work two to six feet in diameter.

Figure 3.2: Experiment set-up

Raw stock is brought to the lathe in several ways. Long lengths can be fed through the head stock, short lengths or "slugs" can be manually or automatically chucked. Gantry systems are used to handle large, heavy pieces of stock. Production lathes bring tools and arrangements of tools to the work by the use of turrets on larger machines and slide mounted "gang tooling" on smaller, more compact lathes. Regardless of the type of lathe, three key parameters determine productivity and part quality. The main parameters are: the cutting speed, feed and depth of cut. According the recommendation of turning operation Table 3.2, the parameter used for the experiment is:

i. Cutting speed: 60m/min, 100m/min, 135m/min
ii. Feed: 0.22mm/rev, 0.28mm/rev
iii. Depth of cut: 0.50mm, 0.55mm, 0.60mm

Table 3.2: Turning operation recommendation



Workpiece material	Cutting tool	Range for roughing and finishing		
		Depth of cut, mm	Feed, mm/rev	Cutting speed, m/min
Low-C and free machining steels	Uncoated carbide	0.5–7.6	0.15–1.1	60–135
	Ceramic-coated carbid	"	"	120–425
	Triple-coated carbide	"	"	90–245
	TiN-coated carbide	"	"	60–230
	Al_2O_3 ceramic	"	"	365–550
	Cermet	"	"	105–455

Source: Serope Kalpakjan et.al (2006)

3.3 CUTTING SPEED CALCULATION

Lower:

$$\text{RPM, N} = \frac{CS \times 1000}{\pi D}$$

$$= \frac{60\text{mm/rev x } 1000}{\pi(80\text{mm})}$$

$$= 238.73 \text{ rpm} \approx 265\text{rpm}$$

Medium:

$$\text{RPM, N} = \frac{CS \times 1000}{\pi D}$$

$$= \frac{100\text{mm/rev x } 1000}{\pi(80\text{mm})}$$

$$= 397.89 \text{ rpm} \approx 425\text{rpm}$$

High:

$$\text{RPM, N} = \frac{CS \times 1000}{\pi D}$$

$$= \frac{135\text{mm/rev} \times 1000}{\pi(80\text{mm})}$$

$$= 537.15\text{rpm} \approx 625\text{rpm}$$

3.4 MATERIAL SELECTION

For this experiment the mild steel are used as a workpiece material. Mild steel is a type of steel alloy, that contains a high amount of carbon as a major constituent. An alloy is a mixture of metals and non-metals, designed to have specific properties. Alloys make it possible to compensate for the shortcomings of a pure metal by adding other elements.

Steel is any alloy of iron, consisting of 0.2% to 2.1% of carbon, as a hardening agent. Besides carbon, there are many metal elements that are a part of steel alloys. The elements other than iron and carbon, used in steel are chromium, manganese, tungsten and vanadium. All these elements along with carbon, act as hardening agents. That is, they prevent dislocations from occurring inside the iron crystals and prevent the lattice layers from sliding past each other. This is what makes steel harder than iron. Varying the amounts of these hardening agents, creates different grades of steel.

Triangle insert of uncoated carbide are used as a cutting tool in this experiment. Machining with carbide can be difficult, as carbide is more brittle than other tool materials, making it susceptible to chipping and breaking. To offset this, many manufacturers sell carbide inserts and matching insert holders. With this setup, the small carbide insert is held in place by a larger tool made of a less brittle material (usually steel). This gives the benefit of using carbide without the high cost of making the entire tool out of carbide. The dimension of workpiece, type material selected for cutting tool and workpiece in this experiment is:

1. Cutting tool material: uncoated carbide
2. Workpiece material: mild steel
3. Workpiece diameter: 80mm
4. Workpiece length: 100mm

Everising S-300HB Bandsaw are used to cut to the desired size of the workpiece is to meet the prescribed size. Figure 3.3 shows the process cutting of material.

Figure 3.3: Cutting material process

3.5 PROCESS DATA ACQUISITION

Vibrations below 20 Hz are normally referred to as low frequency vibrations. The range from 20 Hz to 20 kHz covers the audible range of vibrations. Vibrations exceeding 20 kHz are not audible and for this reason are called Ultrasonic. The cutting tool, made of carbide is attached to the tool post of the machine tool and the work is displaced against the tool by table feed. An AE wide band sensor mounted on the tool holder to detects the AE activity.

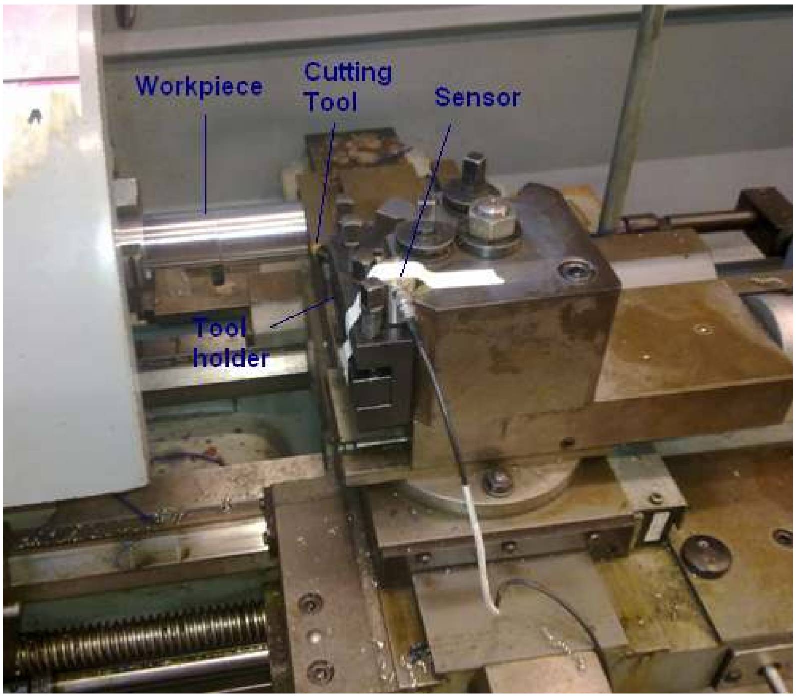


Figure 3.4: Position of sensor

Ensure the sensor is fixed onto a structure with an adequate coupling media. The location of the AE sensor should ensure a transmission path to the machine component under observation. This path can include surface discontinuities however, these surfaces should be in contact either directly or across a couplant. In addition, the surface onto which the sensor is placed shall be clean. The AE signal, preamplified (P.A.C. 1220A preamplifier) and filtered (100-300 kHz band pass), is sampled through an analog to digital (A/D) board (National Instruments NB A2000). The sampling frequency is 1 Ms/s. An Apple Quadra 950 computer reads the AE digital signal from the board and stores the data on hard disk in Figure 3.5.

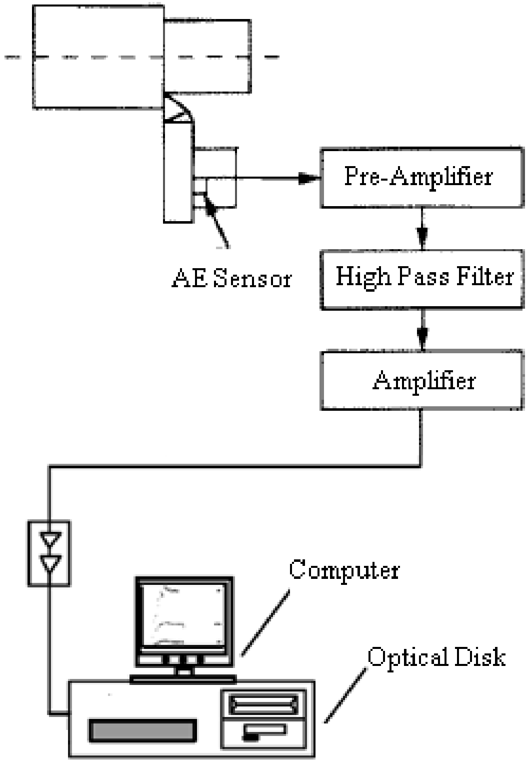


Figure 3.5: Scheme of the monitoring system

Source: Dornfeld 1984

Next, the signal is relayed to a bandpass filter for elimination of low frequencies (common to background noise) and high frequencies. Following completion of this process, the signal travels to the acoustic system mainframe and eventually to a computer or similar device for analysis and storage. Depending on noise conditions, further filtering or amplification at the mainframe may still be necessary.

After passing the AE system mainframe, the signal comes to a detection or measurement circuit. At the measurement circuitry, the shape of the conditioned signal is compared with a threshold voltage value that has been programmed. Signals are either continuous (analogous to Gaussian, random noise with amplitudes varying according to the magnitude of the AE events) or burst-type. Each time the threshold voltage is exceeded, the measurement circuit releases a digital pulse.

The first pulse is used to signify the beginning of a hit. (A hit is used to describe the AE event that is detected by a particular sensor. One AE event can cause a system with numerous channels to record multiple hits.) Pulses will continue to be generated while the signal exceeds the threshold voltage.

Once this process has stopped for a predetermined amount of time, the hit is finished (as far as the circuitry is concerned). The data from the hit is then read into a microcomputer and the measurement circuit is reset. An experiment was finished when the tool wear due to the increase in tool wear reached a value ≈ 300μm and after all experiment done, the MEIJI Techno IM7200 microscope are used for capture the structure of tool wear.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will discuss the result obtained from the experiment conducted turning. Parameters of machining such as cutting speed, feed, depth of cut and parameters of AE as frequency, rms, amplitude will be discussed briefly.

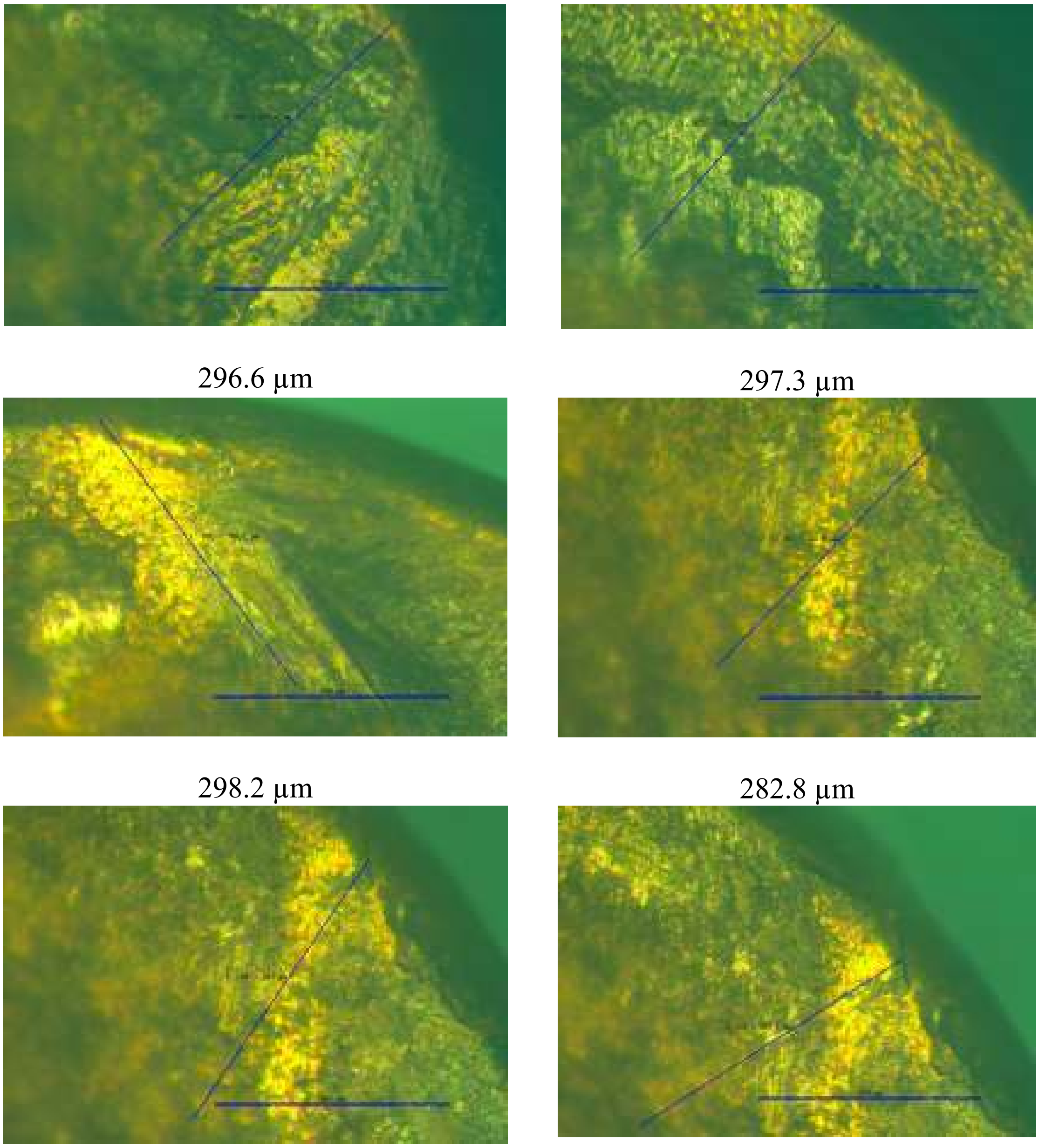
4.2 LOW CUTTING SPEED

Table 4.1 shows the data obtained from the experiment carried out using a low cutting speed of 60m/min. Two different feed values were used 0.22mm/rev and 0.28mm/rev while the depth of cut of 0.50mm, 0.55mm and 0.60mm are used which aims to provide the difference force and friction on workpiece.

Table 4.1: Data experiment for lower cutting speed

Spindle Speed(rpm)	Cutting Speed(m/min)	Feed (mm/rev)	Depth of Cut (mm)	Wear (µm)
265	60	0.22	0.50	296.6
265	60	0.22	0.55	297.3
265	60	0.22	0.60	298.2
265	60	0.28	0.50	282.8
265	60	0.28	0.55	283.0
265	60	0.28	0.60	284.2

Figure 4.1 shows the crater wear occur on the tool insert after during 40 times cutting experiment. It can see that the experiment with 0.22mm/rev feed and 0.60mm depth of cut achieved a higher crater wear 298.2 µm when the lowest wear 282.8 µm achieved at experiment with 0.28mm/rev feed and 0.50mm depth of cut.



296.6 µm

297.3 µm

298.2 µm

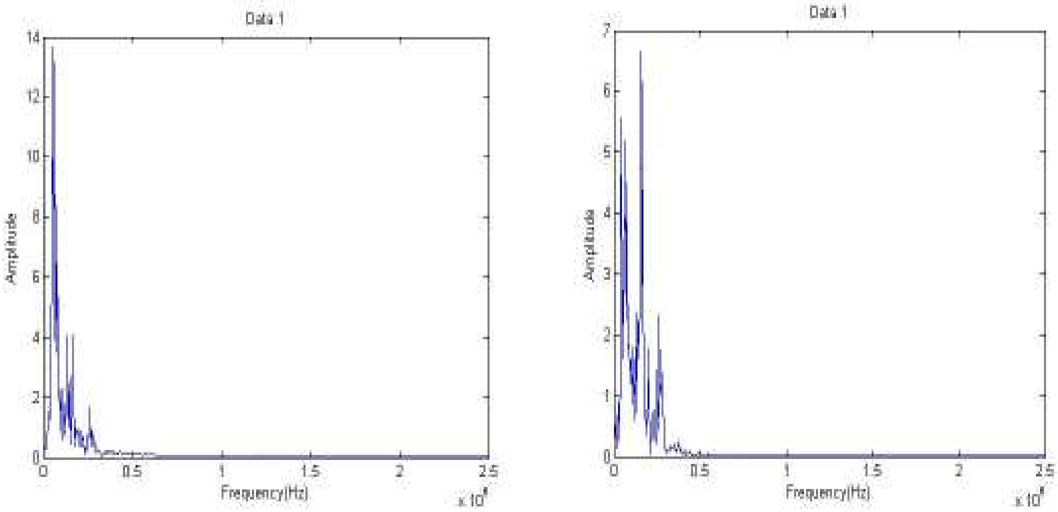
282.8 µm

283.0 µm

284.2 µm

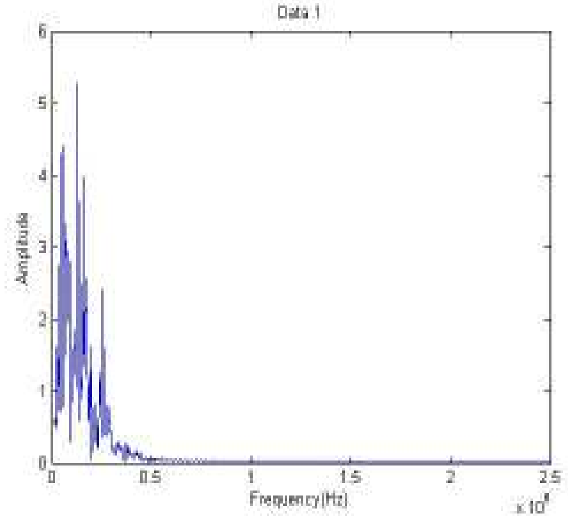
Figure 4.1: Crater wear on cutting tool with lower cutting speed condition

Figure 4.2 shows the data distribution Amplitude against the Frequency for the 60m/min cutting speed and 0.22mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 156 kHz with 0.60mm depth of cut as shown on Figure 4.2(c), while the lowest wear occurs on 151 kHz with 0.50mm depth of cut as shown on Figure 4.2(a).



(a) 0.50mm depth of cut

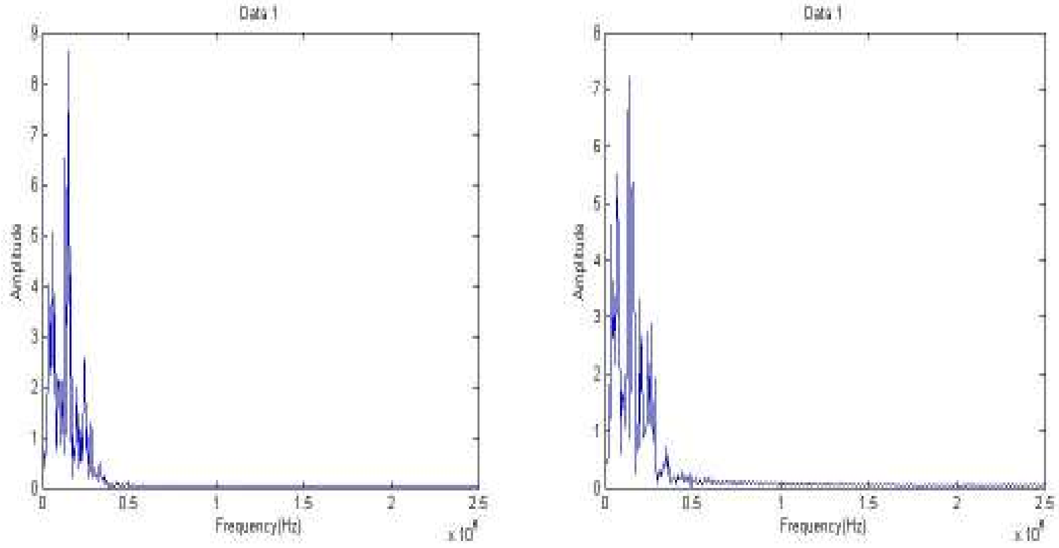
(b) 0.55mm depth of cut



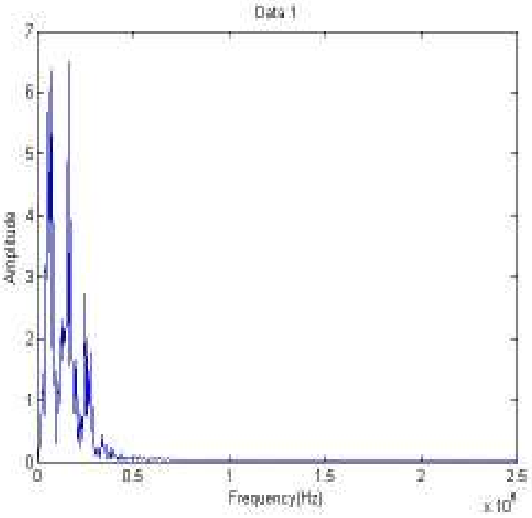
(c) 0.60mm depth of cut

Figure 4.2: Amplitude against frequency for feed 0.22mm/rev

Figure 4.3 shows the data distribution Amplitude against the Frequency for the 60m/min cutting speed and 0.28mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 152 kHz with 0.60mm depth of cut as shown on Figure 4.3(c), while the lowest wear occurs on 150 kHz with 0.50mm depth of cut as shown on Figure 4.3(a).



(a) 0.50mm depth of cut (b) 0.55mm depth of cut



(c) 0.60mm depth of cut

Figure 4.3: Amplitude against frequency for feed 0.28mm/rev

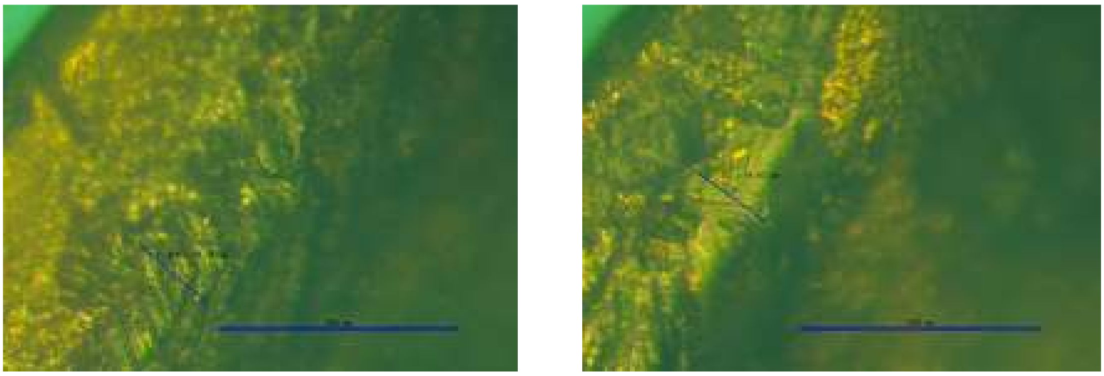
4.3 MEDIUM CUTTING SPEED

Table 4.2 shows the data obtained from the experiment carried out using a low cutting speed of 100m/min. Two different feed values were used 0.22mm/rev and 0.28mm/rev while the depth of cut of 0.50mm, 0.55mm and 0.60mm are used which aims to provide the difference force and friction on workpiece.

Table 4.2: Data experiment for medium cutting speed

Spindle Speed(rpm)	Cutting Speed(m/min)	Feed (mm/rev)	Depth of Cut (mm)	Wear (µm)
425	100	0.22	0.50	70.76
425	100	0.22	0.55	76.62
425	100	0.22	0.60	82.06
425	100	0.28	0.50	63.69
425	100	0.28	0.55	64.62
425	100	0.28	0.60	68.99

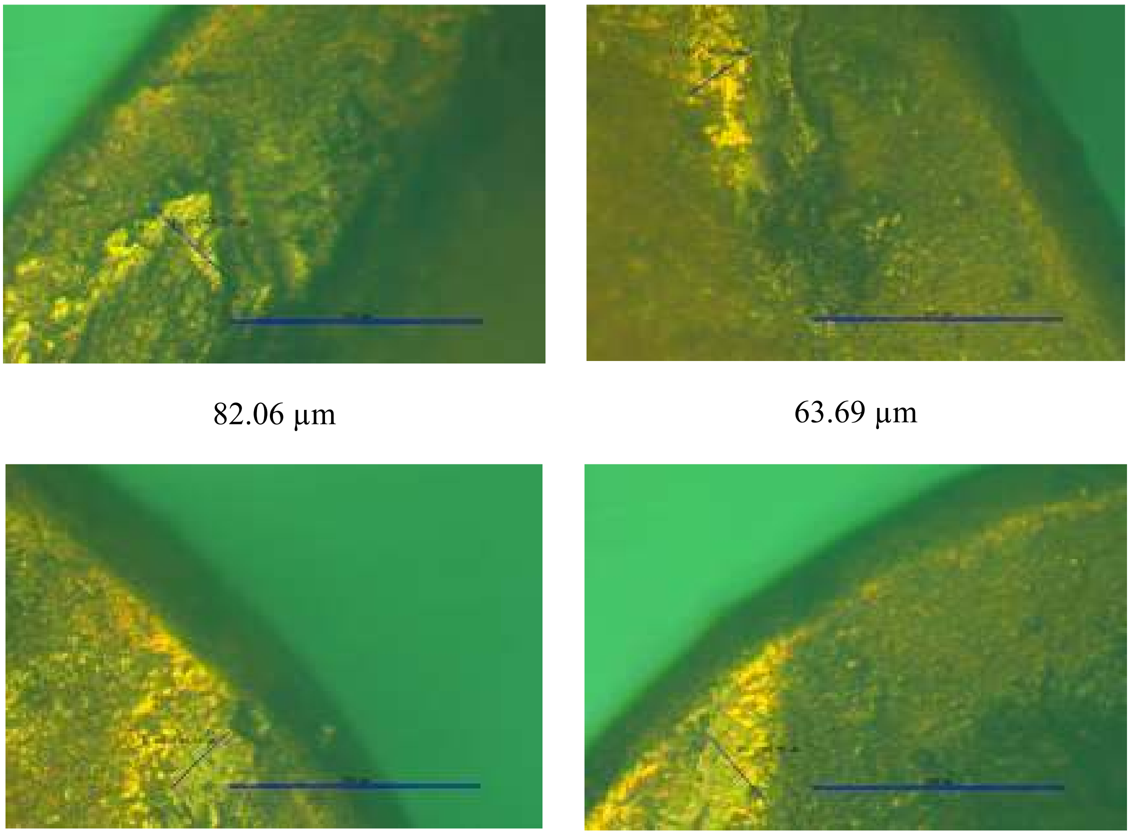
Figure 4.4 shows the crater wear occur on the tool insert after during 40 times cutting experiment. It can see that the experiment with 0.22mm/rev feed and 0.60mm depth of cut achieved a higher crater wear 82.06 µm when the lowest wear 63.69 µm achieved at experiment with 0.28mm/rev feed and 0.50mm depth of cut.



70.76 µm

76.62 µm

Figure 4.4: Crater wear on cutting tool with medium cutting speed condition



82.06 µm

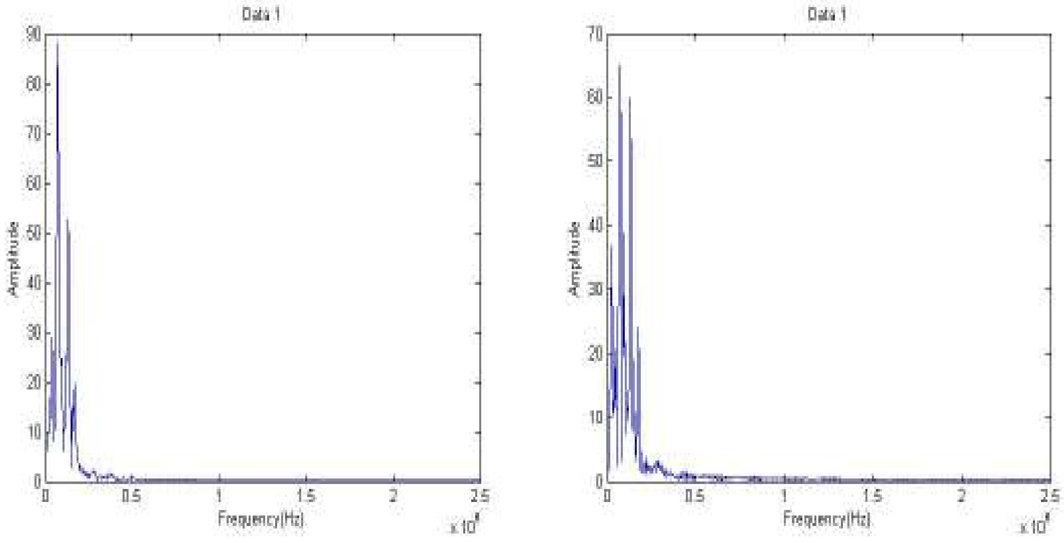
63.69 µm

64.62 µm

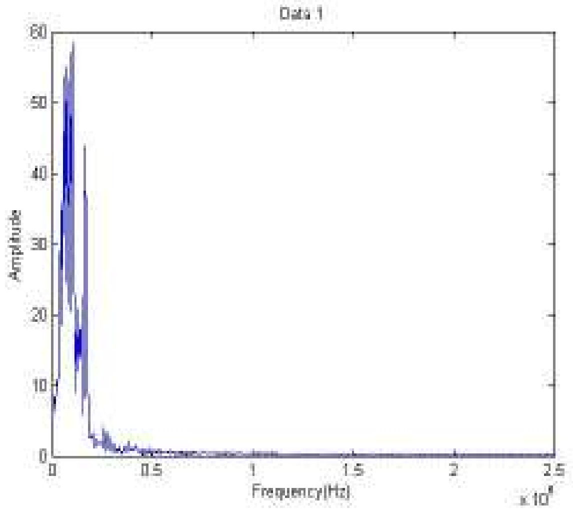
68.99 µm

Figure 4.4: Continued

Figure 4.5 below shows the data distribution Amplitude against the Frequency for the 100m/min cutting speed and 0.22mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 106 kHz with 0.60mm depth of cut as shown on Figure 4.5(c), while the lowest wear occurs on 100 kHz with 0.50mm depth of cut as shown on Figure 4.2(a).



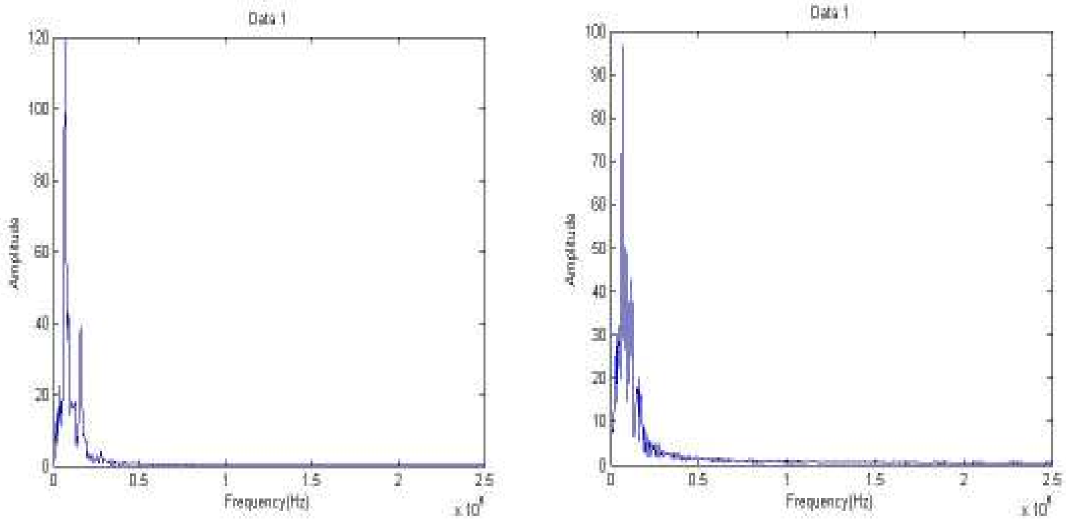
(a) 0.50mm depth of cut (b) 0.55mm depth of cut



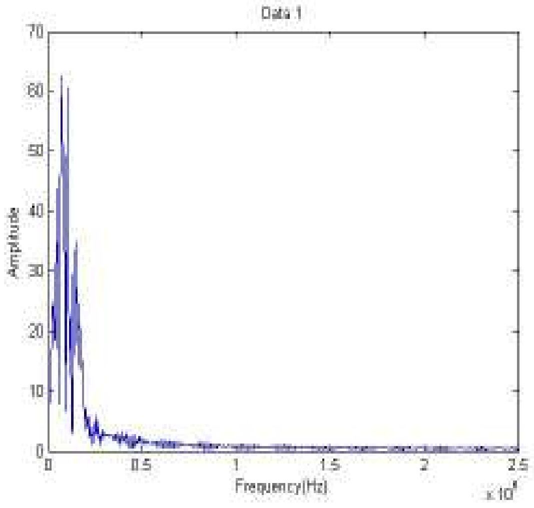
(c) 0.60mm depth of cut

Figure 4.5: Amplitude against frequency for feed 0.22mm/rev

Figure 4.6 below shows the data distribution Amplitude against the Frequency for the 100m/min cutting speed and 0.28mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 68.4 kHz with 0.60mm depth of cut as shown on Figure 4.6(c), while the lowest wear occurs on 63.5 kHz with 0.50mm depth of cut as shown on Figure 4.6(a).



(a) 0.50mm depth of cut (b) 0.55mm depth of cut



(c) 0.60mm depth of cut

Figure 4.6: Amplitude against frequency for feed 0.28mm/rev

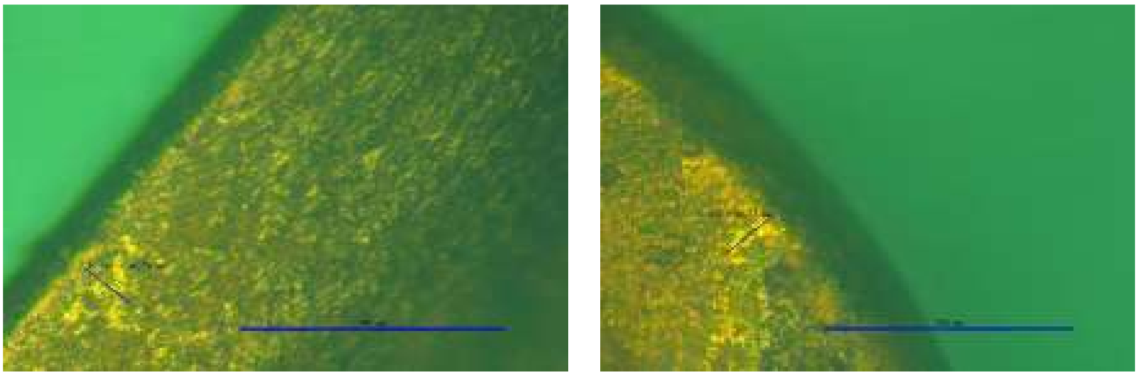
4.4 HIGH CUTTING SPEED

Table 4.3 shows the data obtained from the experiment carried out using a low cutting speed of 135m/min. Two different feed values were used 0.22mm/rev and 0.28mm/rev while the depth of cut of 0.50mm, 0.55mm and 0.60mm are used which aims to provide the difference force and friction on workpiece.

Table 4.3: Data experiment for high cutting speed

Spindle Speed(rpm)	Cutting Speed(m/min)	Feed (mm/rev)	Depth of Cut (mm)	Wear (µm)
625	135	0.22	0.50	46.78
625	135	0.22	0.55	50.72
625	135	0.22	0.60	59.89
625	135	0.28	0.50	40.69
625	135	0.28	0.55	43.45
625	135	0.28	0.60	43.56

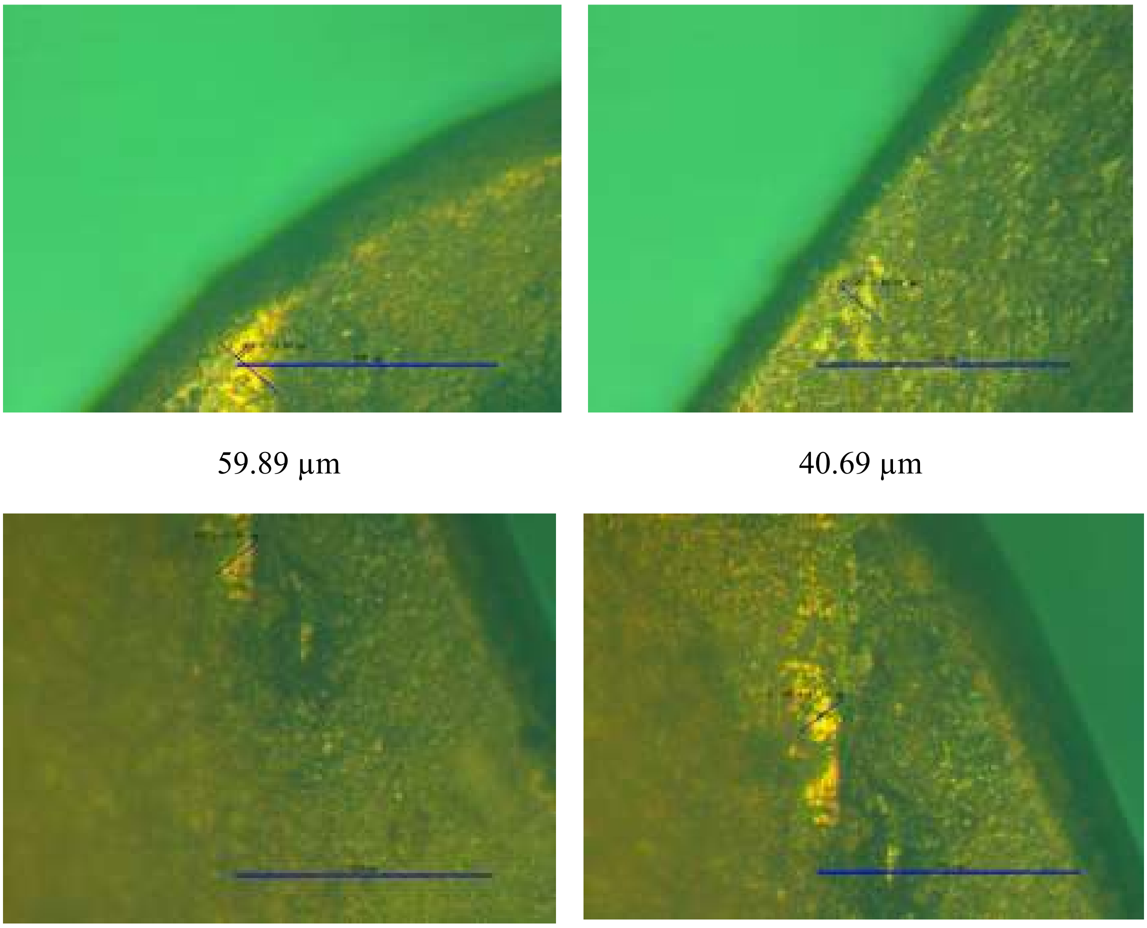
Figure 4.7 shows the crater wear occur on the tool insert after during 40 times cutting experiment. It can see that the experiment with 0.22mm/rev feed and 0.60mm depth of cut achieved a higher crater wear 59.89 µm when the lowest wear 40.69 µm achieved at experiment with 0.28mm/rev feed and 0.50mm depth of cut.



46.78 µm

50.72 µm

Figure 4.7: Crater wear on cutting tool with high cutting speed condition



59.89 µm

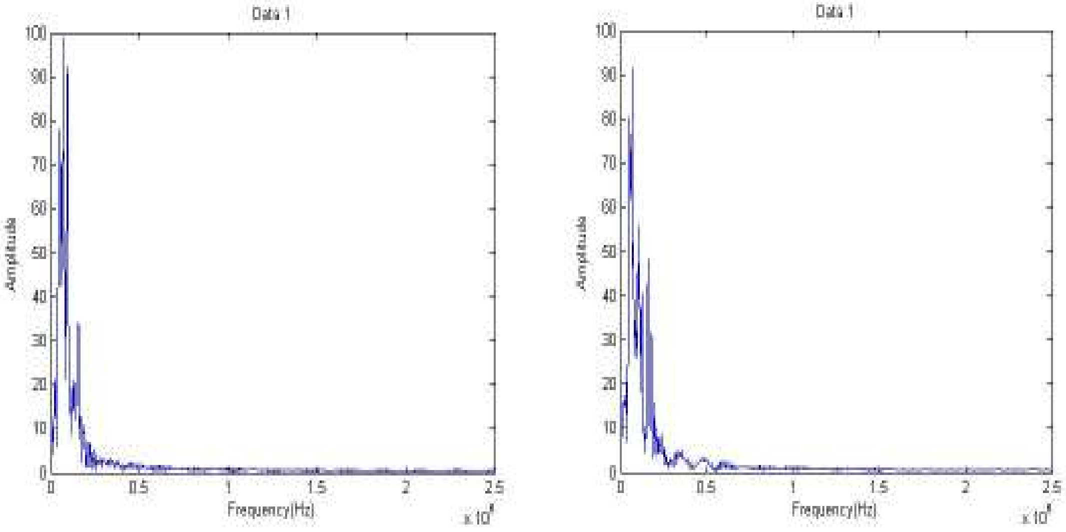
40.69 µm

43.45 µm

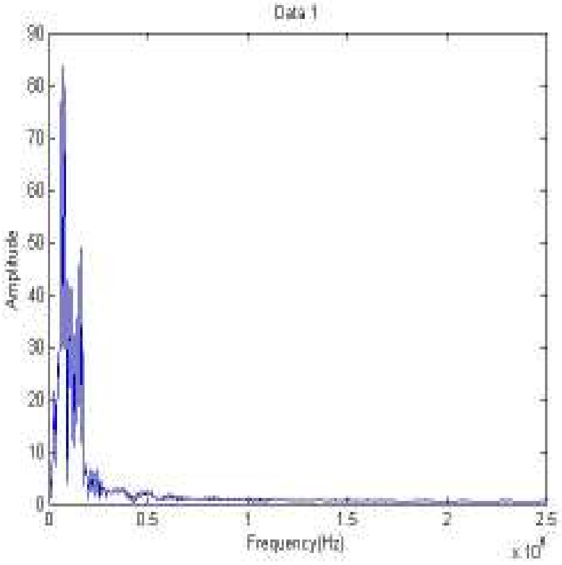
43.56 µm

Figure 4.7: Continued

Figure 4.8 below shows the data distribution Amplitude against the Frequency for the 135m/min cutting speed and 0.22mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 61.5 kHz with 0.60mm depth of cut as shown on Figure 4.8(c), while the lowest wear occurs on 59.1 kHz with 0.50mm depth of cut as shown on Figure 4.8(a)



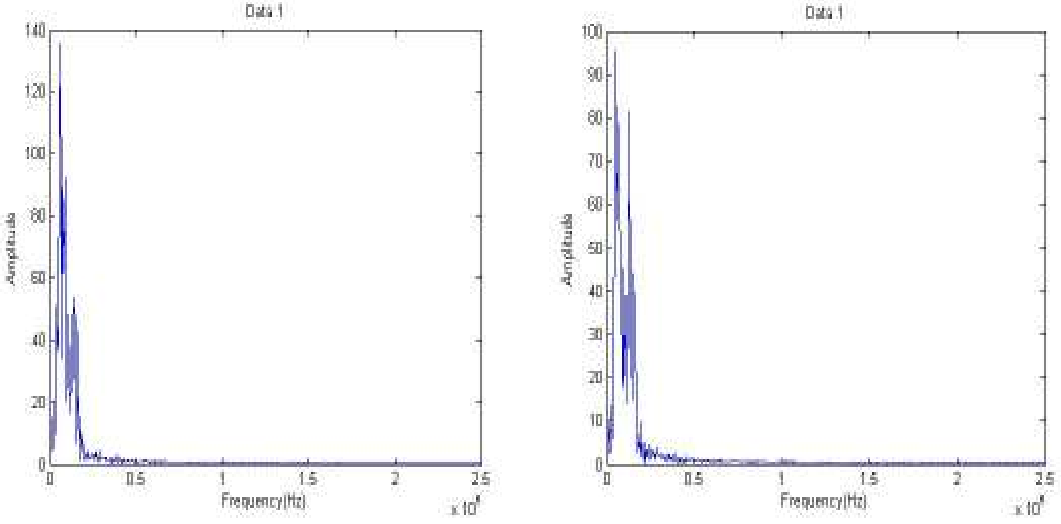
(a) 0.50mm depth of cut (b) 0.55mm depth of cut



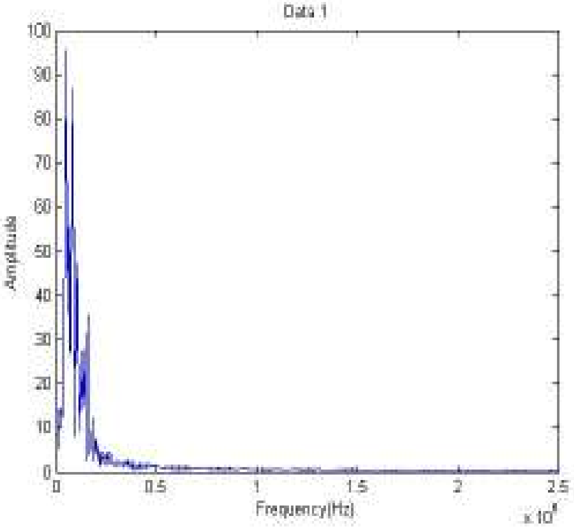
(c) 0.60mm depth of cut

Figure 4.8: Amplitude against frequency for feed 0.22mm/rev

Figure 4.9 below shows the data distribution Amplitude against the Frequency for the 135m/min cutting speed and 0.28mm/rev feed. The figure shows with three difference of depth of cut which is each of one representative one value of wear. The highest wear occurs on 58.6 kHz with 0.60mm depth of cut as shown on Figure 4.9(c), while the lowest wear occurs on 47.9 kHz with 0.50mm depth of cut as shown on Figure 4.9(a).



(a) 0.50mm depth of cut (b) 0.55mm depth of cut



(c) 0.60mm depth of cut

Figure 4.9: Amplitude against frequency for feed 0.28mm/rev

4.5 DISCUSSION

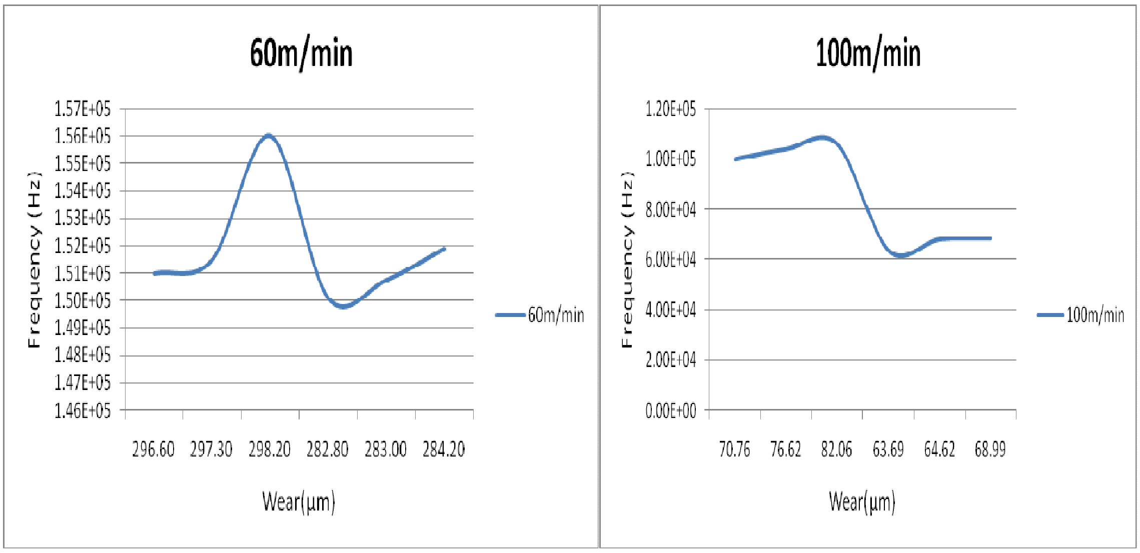
An experiment was finished when the tool wear due to the achieved or close to value 300µm. The cutting experiments took place in a conventional lathe with a 3 hp spindle motor and the tool microphotographs were taken in a scanning electronic microscope (SEM) model MEIJI Techno IM7200.The recorded raw signal was digitized using a filter with a high bandpass (SO-500kHz). After some analysis of these data the 200-300 kHz frequency band was chosen as the best frequency range to obtain the Acoustic Emission signal. Thus signal processing was done with three different approaches: first, analysis of the raw signal was done, then Acoustic Emission was analyzed with the data filtered in a SO-500 kHz band and a 20&300 kHz band.

Figure 4.10 below shows the distribution of data Frequency against Wear involving three different cutting speeds of 60m/min, 100m/min, and 135 m / min. In the distribution of this data, feed value 0.28mm/rev and 0.22mm/rev used in this experiment. The distribution of the highest value achieved in the frequency 156 kHz which is derived from the value of the lowest cutting speed and feed values 0.22mm/rev at Figure 4.10 (a). Distribution while the lowest value achieved at frequency of 47.9 kHz which is the value derived from the most high speed cutting with the feed 0.28mm/rev at Figure 4.10 (c).

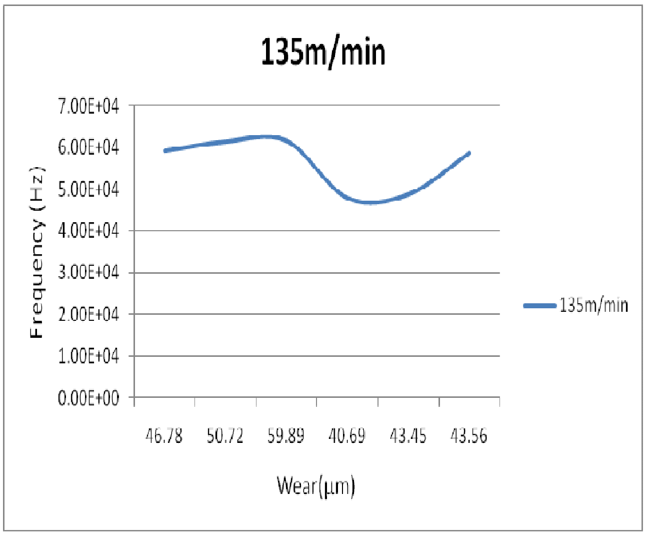
Its can be conclude that at 160 kHz frequency result obtained is greater wear of 290µm-300µm while frequency 40 kHz instead of the wear is where the value range of 40µm-60µm. Depends on the result is obtained, monitoring can be done when data from the Acoustic Emission analysis showed that the frequencies are in the 160kHz and above, the tool wear is at the level of maximum, this way of life tool wear can be known. When doing the machining work especially in turning process, appropriate cutting speed should be taken because the high speed cutting speed is good to extend the life of cutting tool.

Table 4.4: Acquisition data from difference cutting speed

Cutting Speed(m/min)	Feed (mm/rev)	Depth of Cut(mm)	Wear(µm)	Frequency (Hz)	Time Domain		
					RMS	Max. Amp. (v)	Energy
60.00	0.22	0.50	296.60	1.51E+05	6.27E-04	0.0668	17.1388
60.00	0.22	0.55	297.30	1.52E+05	5.03E-04	0.0601	14.1029
60.00	0.22	0.60	298.20	1.56E+05	4.76E-04	0.0549	11.1140
60.00	0.28	0.50	282.80	1.50E+05	6.93E-04	0.0888	20.5753
60.00	0.28	0.55	283.00	1.51E+05	6.84E-04	0.0793	19.8865
60.00	0.28	0.60	284.20	1.52E+05	6.64E-04	0.0742	18.9479
100.00	0.22	0.50	70.76	1.00E+05	5.90E-03	0.7330	150.0631
100.00	0.22	0.55	76.62	1.04E+05	5.80E-03	0.6915	149.9443
100.00	0.22	0.60	82.06	1.06E+05	2.50E-03	0.6485	134.9251
100.00	0.28	0.50	63.69	6.35E+04	7.88E-03	0.9885	172.8879
100.00	0.28	0.55	64.62	6.81E+04	7.80E-03	0.8807	166.4549
100.00	0.28	0.60	68.99	6.84E+04	5.93E-03	0.8517	150.4047
135.00	0.22	0.50	46.78	5.91E+04	1.32E-02	1.3072	185.7786
135.00	0.22	0.55	50.72	6.13E+04	1.31E-02	1.2601	183.3239
135.00	0.22	0.60	59.89	6.15E+04	1.10E-02	1.1035	179.5852
135.00	0.28	0.50	40.69	4.79E+04	1.62E-02	1.3940	276.9824
135.00	0.28	0.55	43.45	4.88E+04	1.59E-02	1.3296	269.0338
135.00	0.28	0.60	43.56	5.86E+04	1.51E-02	1.3173	249.4615



(a) Lower cutting speed (b) Medium cutting speed



(c) High cutting speed

Figure 4.10: Frequency against tool wear

Figure 4.11 shows the distribution of data RMS against Cutting Speed involving two different feed i.e. 0.22mm/rev and 0.28mm/rev. The value of RMS increases proportional with the cutting speed. The distribution of the highest value achieved in the RMS 0.0188 which is derived from the value of the highest cutting speed and feed values 0.28mm/rev. Distribution of the lowest value achieved at RMS 0.00047594 which is the value derived from the most lower speed cutting with the feed 0.22mm/rev. At RMS 0.00047594 result obtained is greater wear of 290µm-300µm while RMS 0.0188 instead of the wear is where the value range of 40µm -60µm.

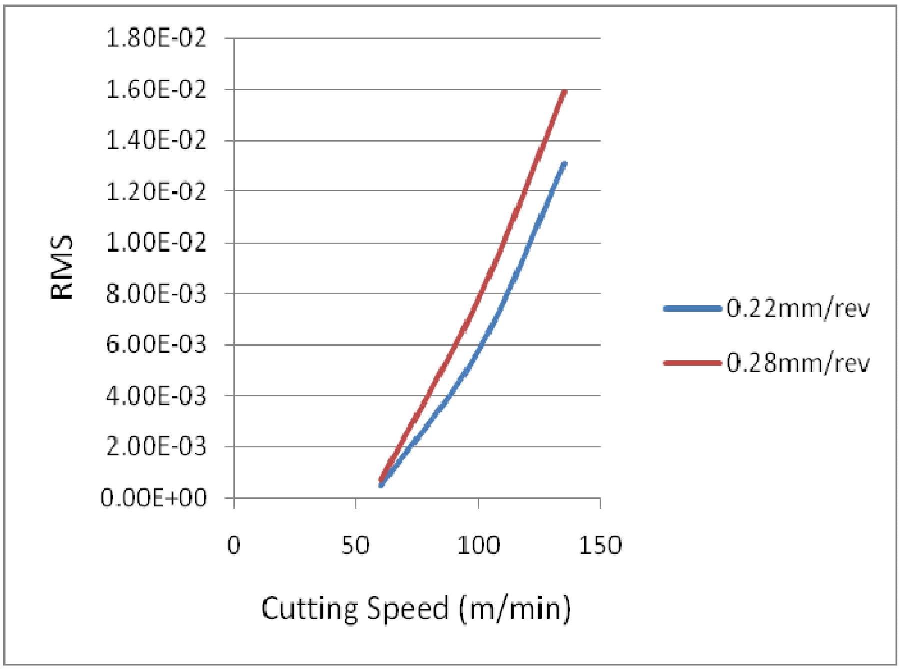


Figure 4.11: RMS against cutting speed

Figure 4.12 shows the distribution of data Energy against Cutting Speed involving two different feed i.e. 0.22mm/rev and 0.28mm/rev. The value of energy increases proportional with the cutting speed. The distribution of the highest energy value achieved at 276.9824 which is derived from the value of the highest cutting speed and feed values 0.28mm/rev. Distribution of the lowest energy value achieved at 11.1140 which is the value derived from the most lower speed cutting with the feed 0.22mm/rev. At energy 11.1140 result obtained is greater wear of 290µm-300µm while energy 276.9824 instead of the wear is where the value range of 40µm -60µm.

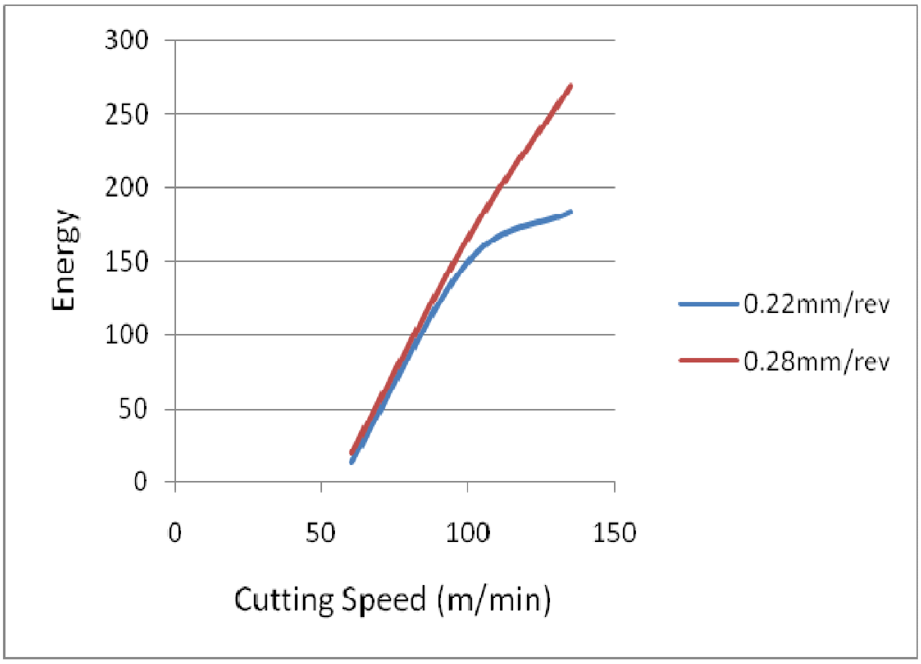


Figure 4.12: Energy against cutting speed

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

According to the experiment data obtained its can be conclude that the Acoustic Emission monitoring system was developed to investigate the sensitivity of a broad Acoustic Emission signal parameters as surface damage and the corresponding tool wear. The results show that Acoustic Emission signals can be used to monitor surface integrity factors, specifically. Acoustic Emission RMS, frequency, and amplitude are sensitive to the existence of vibration and corresponding tool wear. From the experiment data obtained, the tool wear can be monitoring when the frequency value about 160kHz and above, where the wear is highly achievable.

5.2 RECOMMENDATION

This case of study was considered succesfully achieve the objective by using the Acoustic Emission technique but some improvement will be make in order to get the better result. The improvement that must be taken on consideration for the next study area:

i. Acoustic Emission should be used in accordance with all happened to the environment in which temperature affects the component of Acoustic Emission.

ii. Acquisition of data analysis of the Acoustic Emission from conventional lathe machine to be controlled by assistants for data acquisition will be more accurate.

iii. Monitoring of turning process using Acoustic Emission is still new and experimental that more needs to be done again for identify the effectiveness of the cutting tool.

Hopefully, all of the recommendation can help to improve the fonding of this project in the future.

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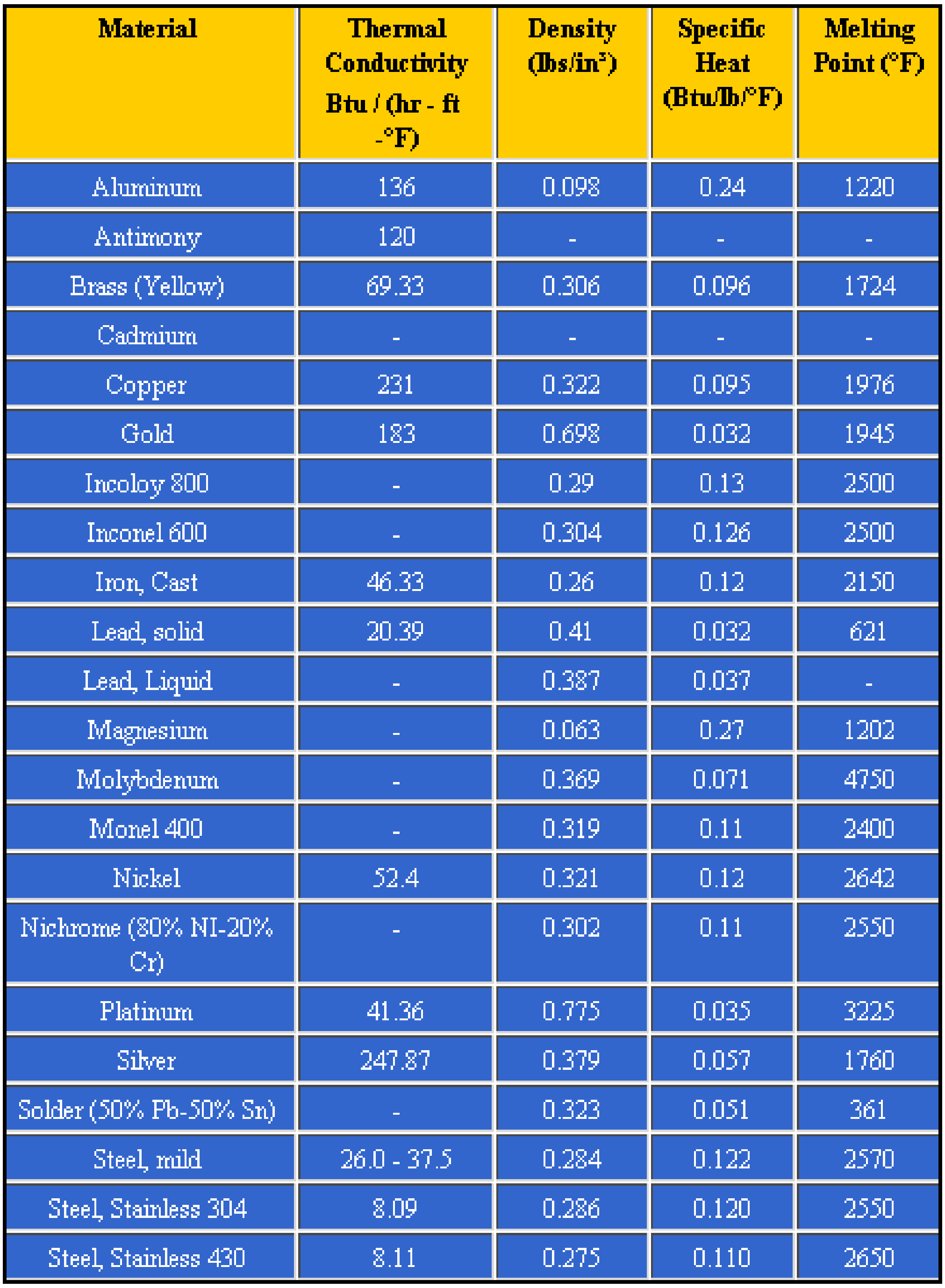
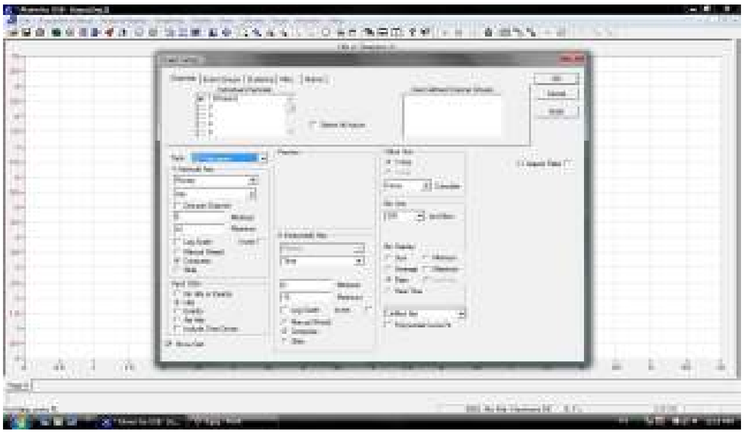
APPENDIX A

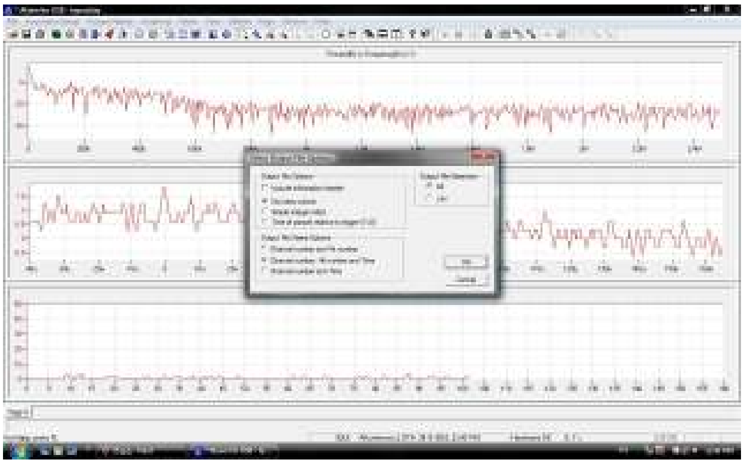
TABLE WITH DIFFERENCE MATERIALS COMPLETE WITH PROPERTIES

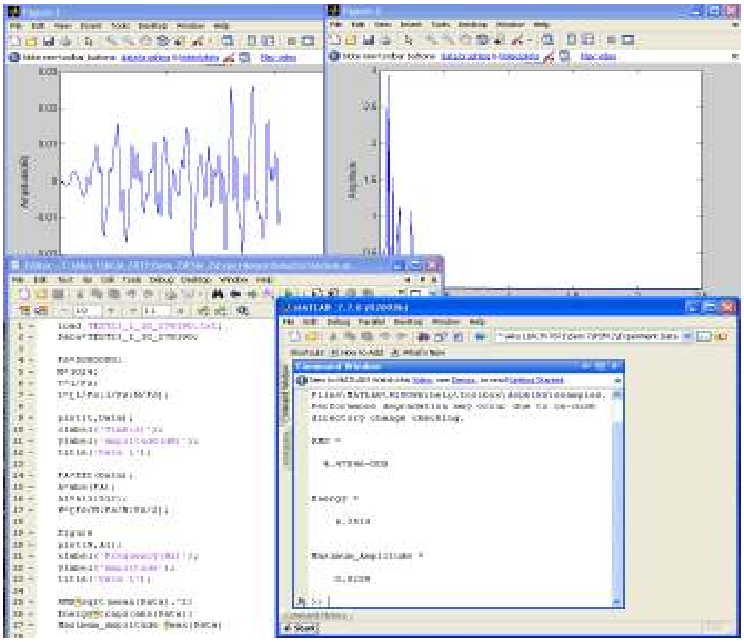


Material	Thermal Conductivity Btu / (hr - ft -°F)	Density (lbs/in^3)	Specific Heat (Btu/lb/°F)	Melting Point (°F)
Aluminum	136	0.098	0.24	1220
Antimony	120	-	-	-
Brass (Yellow)	69.33	0.306	0.096	1724
Cadmium	-	-	-	-
Copper	231	0.322	0.095	1976
Gold	183	0.698	0.032	1945
Incoloy 800	-	0.29	0.13	2500
Inconel 600	-	0.304	0.126	2500
Iron, Cast	46.33	0.26	0.12	2150
Lead, solid	20.39	0.41	0.032	621
Lead, Liquid	-	0.387	0.037	-
Magnesium	-	0.063	0.27	1202
Molybdenum	-	0.369	0.071	4750
Monel 400	-	0.319	0.11	2400
Nickel	52.4	0.321	0.12	2642
Nichrome (80% NI-20% Cr)	-	0.302	0.11	2550
Platinum	41.36	0.775	0.035	3225
Silver	247.87	0.379	0.057	1760
Solder (50% Pb-50% Sn)	-	0.323	0.051	361
Steel, mild	26.0 - 37.5	0.284	0.122	2570
Steel, Stainless 304	8.09	0.286	0.120	2550
Steel, Stainless 430	8.11	0.275	0.110	2650

APPENDIX B
DATA ACQUISITION AND ANALYSIS







APPENDIX C1

CHIPS FORM LATHE MACHINING

APPENDIX C2

MACHINES AND EQUIPMENTS


V
SHUN CHUAN MACHINERY IND. CO., LTD.
NO. 5, Lin 1, Shan Kan Li, Yuan Li Town, Maoli County, Taiwan
MODEL
CAPACITY
MOTOR
MFG. NO.
DATE
MADE IN TAIWAN R.O.C.
TEL:886-37-741591 FAX:886-37-741593


ERL-1330


H L
A 625 315
B 2570 1305
C 1600 815
D 990 505
100 50 A
425 215 B
265 135 C
160 80 D
C B A D

EVERISING

MODEL [illegible]

SERIAL NO [illegible] DATE [illegible]

VOLTAGE [illegible] PHASE 3 HERTZ [illegible]

BLADE SIZE [illegible]

TEL:886-4-23505300 e-mail:evers @ms13.hinet.net

FAX:886-4-23505420 web site:www.everising.com