CHATTER DETECTION ON THIN WALL MACHINING OF ALLUMINUM ALLOY UNDER MQL CONDITION

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SUPERVISOR'S DECLARATION

I hereby declare that I had read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the purpose of the granting of Bachelor Of Manufacturing Engineering.

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

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ABSTRACT

The purpose of this project was to analyze and study the chatter detection on thin wall machining of aluminum alloy under mql condition. Initially, 3 difference type of thin wall design are selected which is L shape, T shape and Pocket shape, then the chatter phenomenon during the cutting experiment were observed by using the accelerometer with a variable value of depth of cut. Three types of chatter detection method are applying in this experiment to achieve the accurate result which is by acceleration, time domain and surface roughness test. From the results, it was clear that the parameter depth of cut and the design of the thin wall manipulate the occurring of chatter or non-chatter in the machining process.

ABSTRAK

Tujuan dari projek ini adalah untuk menganalisis dan mengkaji getaran didalam pemesinan aluminium aloi dinding nipis di dalam keadaan MQL . Pada permulaan, 3 jenis reka bentuk dinding nipis yang berbeza dipilih seperti L, T dan poket, maka fenomena getaran semasa pemotongan dijalankan diperhati dengan menggunakan accelerometer dengan nilai kedalaman pemotongan yang berubah-ubah. Tiga jenis kaedah pengesanan getaran digunakan dalam percubaan ini untuk mencapai keputusan yang tepat seperti pecutan, domain masa dan uji kekasaran permukaan. Dari hasil keputusan , ianya jelas bahawa parameter kedalaman pemotongan dan reka bentuk dinding tipis memanipulasi terjadinya getaran atau non - getaran dalam proses pemesinan .

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LIST OF SYSMBOLS

Mm	milliliter
M	meter
Min	minute
Hp	horsepower
Rpm	revolution per minute
P	shorter length of two edges in the plate
H	plate thickness
δ	elastic deformation of the wall
T	allowed machining tolerance
MPa	megapascals
GPa	gigapascals
S	second
μm	micrometer

LIST OF ABBREVIATIONS

MQL	minimum quantity liquid
CATIA	computer aided three-dimensional interactive application
NC	numerical control
CNC	computer numerical control
HSM	high-speed milling
CAD	computer-aided design
CAM	computer aided manufacturing
CAE	computer aided engineering
UNS	unified numbering system
AL	aluminum
VOC	Volatile organic compounds
DAQ	data acquisition
DOC	depth of cut

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The technology that involved in the machining operation has been greatly advanced in recent decades and the machine has undergone significant changes such as the establishment of numerical control. Each year is possible to observe in promised, conferences and provide course in economic market, where production capacity has increased. This is due to development new concept, the appliance, device structure, materials, layers, etc. The accuracy, flexibility, and increased productivity continuous improvement with innovative solutions to meet the market demand or raise them to high-level. In the end, all of these improvements done thank you to knowledge generation.

Milling machine is one of the oldest machine that still commonly used in the manufacturing industry to produce parts (Elbestawi, M.A., and R.Sagherian, 1991). It is widely used in various manufacturing industries such as domestic appliances and automotive. Quality and accuracy of the surface of a workpiece play an important role in the milling machine as good quality of machine surface improve the fatigue strength and creep. The common issue that affects the quality and accuracy of the surface comes from the chatter and lubricant.

Chatter or machining vibration is a wave energy that occur during the machining process that result the quality of the machine surface. It is a very complex phenomenon because of the diversity of elements that can compose a dynamic system. Furthermore, the chatter can occur in various types of metal machining processes such as milling, turning, boring, broaching, grinding and drilling. Figure 1.1 show the diagnosis of chatter marks in milling machine (Planlauf, 2000). The occurrence of chatter has issued a number of negative effects such as excessive noise, poor quality of surface, waste of materials and energy and unacceptable inaccuracy. These effects are due to the workpiece is not in an optimum parameter when machining.

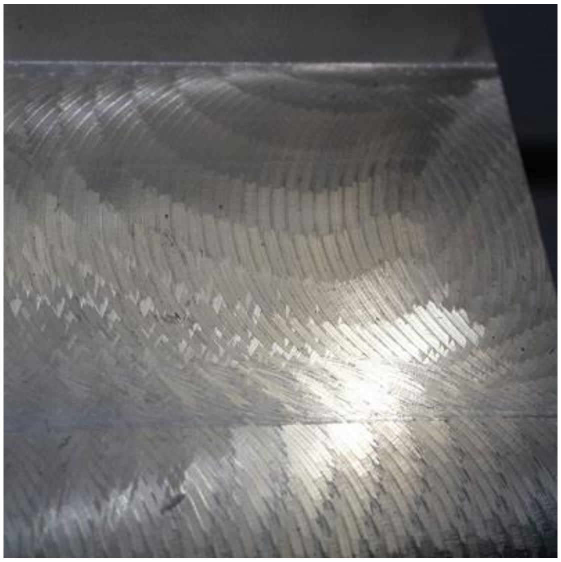


Figure 1.1 Diagnosis of chatter marks in milling machine

Source: Planlauf (2000)

In machining, manufacturing poses a major challenge for machining a workpiece which contains the characteristics of the thin walls. It is because of poor stiffness characteristics and deformation of the thin wall that easily occur during machining and cause error dimensional surface. Figure 1.2 show the deflection of thin wall in milling machining due to cutting forces (Raja Izamshah Raja Abdullah, 2011).

In the current industry practice, resulting surface errors is usually compensated by one or more of the following techniques : (i) an expensive and lengthy trial and error process of validation of numerical control (ii) manual calibration to determine ‘tolerable’ machining conditions (iii) using a repetitive feeding and final ‘float‘ cut to bring the machined surface within tolerance (Elbestawi, M.A., and R.Sagherian, 1991); and (iv) using a step machining approach, which alternately milling each side of the wall (Elbestawi, M.A., and R.Sagherian, 1991).

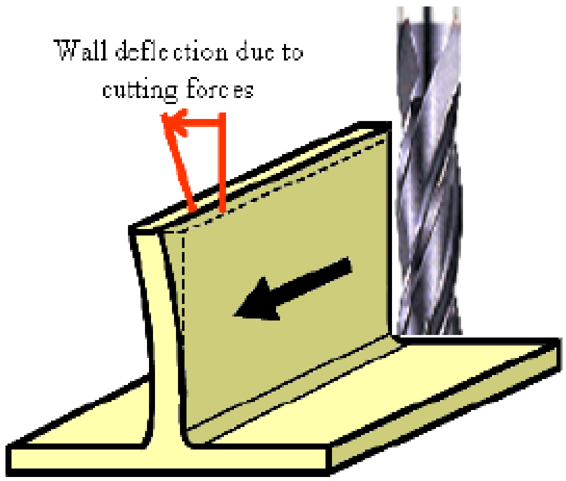


Figure 1.2 Deflection of thin wall in milling machining due to cutting forces

Source: Raja Izamshah Raja Abdullah (2011)

In this project, aluminum 7075 is used and the machining will be conducted using milling machine. This experiment will be based on thin wall machining. Besides, the minimum quantity liquid is use as the lubrication conditions. Depth of cut in a machining parameter will carried in this experiment. For finite element analysis, CATIA V5 is used to create and measure the 3D model of the work piece. Lastly, accelerometer and surface roughness test is used to observe the chatter condition in thin wall machining.

1.2 PROBLEM STATEMENT

To date, the challenge issued by manufacturing industries primarily focused on achieving the highest quality, in terms of the accuracy of the work-piece dimensions and surface finish, high production rates and cost savings (Quintana, Guillem, and Joaquim Ciurana, 2011). In the machining process, it is necessary to achieve the desired surface quality to produce parts or materials that provide the required functionality. When machining a thin wall part, the deformation always arises. The deformation in the thin wall machining occurs because of the parameter is not in a right optimum state. To get the optimum state in machining the thin wall, the accelerometer is used to detect the chatter in the machining process. By using data in the stability lobe graph as reference, the optimum parameter can be achieved. The right optimum cutting parameters will eliminate the chatter in machining and thus the deformation problem in the thin wall machining will be also solved.

1.3 OBJECTIVE

The objective of this experiment is:

- To conduct experiments for chatter detection by control machining parameter depth of cut of thin wall under MQL condition.
- To investigate the stable of chatter or non-chatter in different types of thin wall such as T shape, L shape and pocket shape components.

1.4 PROJECT SCOPE

To achieve results when researching about chatter measurement on thin wall machining of aluminum alloy under MQL condition, several experiment and test need to be conducted and calculated. To complete this project, these are the aspect that needs to be experimented and investigate:

- Milling operation is performed using milling machine.
- Chatter detection on the thin wall workpiece is analyzed by using accelerometer.
- Machining variable considered are lubrication condition, cutting speed, spindle speed and depth of cut of thin wall workpiece.
- Oil-mist is used as the lubrication in MQL.
- The effect of different lubrication condition on surface roughness of Aluminum 7075 is investigated
- Three different types of thin wall design are used which is a T - shape, L-shape, and pocket shape.

1.5 EXPECTED OUTCOME

- There are two expected outcomes of this project. The first expected outcome from this project is observation on chatter detection can be achieved by controlling depth of cut of machining parameter of thin wall under MQL condition. The other expected outcome from this project is the stable of chatter or non-chatter in different types of thin wall such as T shape, L shape and pocket shape components.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is discussing on some literature studies related to chatter detection on thin walled machining of aluminum alloy under minimum quantity liquid condition.

2.2 HIGH SPEED MACHINING

High-speed machining (HSM) is a modern technology, which in comparison with conventional cutting allows to improve the efficiency, accuracy and quality of work-piece. Besides, it is also to reduce the time and cost of machining. Practically, it can be noted that high-speed machining is not simply high cutting speed. It can be considered as a process in which the operation was carried out with very specific methods and production equipment. The term high speed is relative. As a general guide, an approximate range of cutting in speed may be defined as follows (Ashley. S., 1995):

i. High speed: 600-1800 m/min,
ii. Very high speed: 1800-18000 m/min,
iii. Ultra-high speed: > 18000 m/min.

Another definition of speed is it emphasizes higher production rates and reduced lead times. In this case, importance non-cutting factors come to play, such as high rapid traverse speeds and quick automatic tool changed. Another definition of high-speed machining is based on the ratio of horsepower to a maximum spindle speed, or HP / RPM ratio (Ashley, 1995). Conventional machine implements customarily have a higher HP/RPM ration than machines equipped for high speed machining.

2.3 CHATTER VIBRATIONS IN MACHINING

Chatter is a form of unstable self-excited vibration in dynamic metal cutting. It has been and is still considered a challenging task for manufacturing research. This can be shown with two principal factors: first the involution of the phenomenon makes its study and understanding nontrivial. Second, the negative effects of chatter stimulate interest in solving the problem (Quintana, G. And J. Ciurana, 2011). With regard to the first factor, chatter is a highly complex phenomenon considering the diversity of elements that composed of the dynamic system and its behavior: the work-piece material, the machine tool structure, the cutting tool, the tool holder and the cutting parameters. Predicting its occurrence is still the subject of much research, although the regenerative effect, the main cause of chatter, was identified and studied very early on (Tobias. S. A and W. Fishwick, 1958), (Hanna, N H and S A. Tobias, 1974). Moreover, chatter can occur in different metal removal processes, including turning and milling. Regarding the second factor, chatter occurrence has several negative effects (Quintana, G. And J. Ciurana, 2011):

- Costs of recycling.
- Environmental impact in terms of materials and energy.
- Poor surface quality.
- Waste of energy.
- Waste of materials.
- Unacceptable inaccuracy.
- Excessive noise.
- Reduced material removal rate.
- Disproportionate tool wear.
- Machine tool damage.
- Increased costs in terms of production time.

For these reasons, avoiding chatter is an issue of enormous interest. At the workshop, machine tool operators often choose conservative cutting parameters to avoid the chatter, and thus reduced production.

2.3.1 Chatter

Chatter (Mechanical Vibration) is defined as the movement back and forth of the mechanical components of a machine as a reaction of the internal force (the force generated by the machine) and external forces (the force comes from outside or around the machine) (Saleh, Khaled, 2013). Dominant case in machining vibration is caused by vibration of excitation force coming from the engine, which involves among others (Saleh, Khaled, 2013):

i. Unbalanced condition (unbalance) both static and dynamic on the machine.
ii. A defect that occurs in the rotating elements (bearing damage, jammed impeller, etc.).
iii. Imperfections parts / functions of the machine.

The ideal machine will not vibrate because of the energy it receives is used entirely for the functionality of the machine itself. In well-designed machine practice, the vibration is relatively low, but for long -term use will increase the vibration level due to the following:

i. Wear and tear on the machine elements.
ii. The process of consolidation of the foundation (base plate) such that deformation and result in misalignment on the shaft.
iii. Changes in the dynamic behavior of the machine for any changes resulting natural frequency.

Analysis of mechanical characteristics allows the use of the vibration signal to determine the condition of the engine without dismantling or stop an engine, so it can be used for further analysis in the repair of the damage caused. By observing vibration analysis on a regular basis, then something is not normal in a machine can be detected before greater damage occurs.

2.3.2 Mechanical Vibrations in Metal Cut

Metal cutting process can involve all three types of mechanical vibrations, which can be attributed to the lack of dynamic stiffness of one or more elements of a system consisting of a machine tool, cutting tool, tool holder and workpiece material. These three types of vibrations are known as free vibrations, forced vibrations and self-excited vibrations (Quintana, G. and J. Ciurana, 2011).

1. **Free vibrations**: Free vibration occurs when the mechanical system starts with the original style, and then allowed to vibrate freely. Examples of such vibrations are hitting a tuning fork and let it vibrate, or pendulum drawn from the equilibrium state and then released.

2. **Forced vibrations:** Forced vibration is a vibration caused by external forces acting on a system so that the system vibrates. The system tends to vibrate at its own frequency in addition to following the excitation force. With the movement of the friction retained by sinusoidal force gradually disappear. Thus, the system will vibrate at a natural frequency of the system. Part vibration continues the steady state vibration or steady state system response needed to analyze the effect of vibration due to ongoing care.

3. **Self-excited vibration:** Self-excited vibration in milling is also known as chatter. Chatter extract energy to start growing steadily, considering the interaction between the cutting tool and the workpiece during the machining process. Chatter further classified into conversation regenerative and non- regenerative conversation. Regenerative effect is caused by strains of consecutive cuts, which means that waste generated on the corrugated surface of the previous pass. Non regenerative vibration is maintained all cutting force fluctuations that are induced every tool-workpiece relative displacement of a periodic nature (shah, V., 2003).

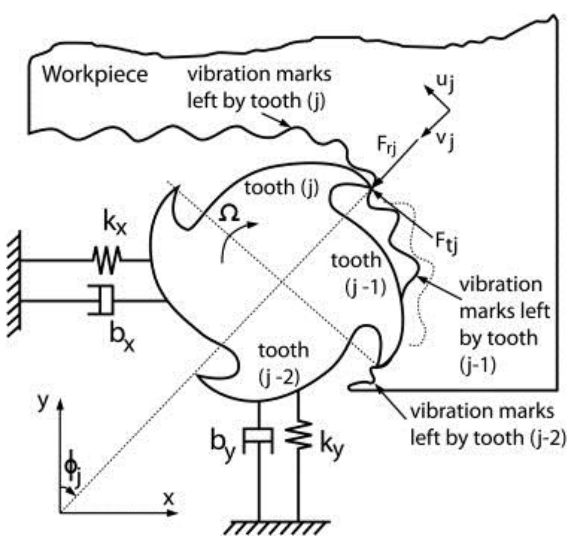


Figure 2.1 Regeneration of waviness in a milling model with two degrees of freedom

Source: Altintas, Y., and M. Weck (2004)

2.4 THIN-WALL COMPONENT

There are an amount definitions of characterizing thin-wall component. Fitzgerald (R. W. Fitzgerald, 1982) suggested a guide to differentiate between thin-wall and thick-wall cylinders predicated on the uniform stress distribution throughout the wall thic kness. The theory of thin-wall cylinders and spheres is predicated on this posit which be tokens a ratio of wall thickness to diameter of about 1/10 represents the dividing line between thin-wall and thick-wall cylinders. Figure 2.2 show the example of thin wall machining using milling machine.

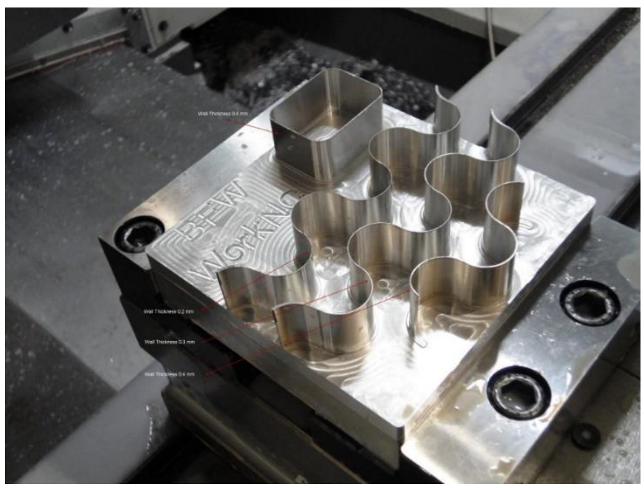


Figure 2.2 Thin wall machining using milling machine

Source: CA Jordan (2013)

Yang (G. Yang, 1980) gave a guide to differentiate between super-thin plates, thin plates and thick plates for approximation theory of plate bending as;

Super-thin plates = $h/p < (1/100)$
Thin plates = $(1/100) \leq h/p \leq (1/5)$
Thick plates = $h/p > (1/5)$

Where;

p = shorter length of two edges in the plate

h = plate thickness

The above definitions of thin-wall component perchance a general guideline to characterize thin-wall component. However, for the case about this project the thin-wall component is based on certainly the wall deflects sufficiently to affect machining accuracy. Subsequent specific, a thin-wall component is where the elastic deformation of the wall is beyond or efficient the allowed tolerance requirement and perhaps written as;

$\delta \geq T$

Where;

δ = elastic deformation of the wall

T = allowed machining tolerance

2.5 CUTTING FLUID

Cutting fluid has been used for centuries and their form has changed a little, though significant efforts have been made to improve their performance over the past several decades. These attempts at improvement have coincided with a better understanding of the adverse health impact that cutting fluids can have on people and the environment, which has in turn driven the development of environmentally adapted alternatives. It has been well perceived empirically that supply some fluid in the vicinity of the contact between the implement and the work-piece could facilitate the machining operation, so that the functions of cutting fluids have additionally been the consequential subject in machining process (Ghuge, Nilesh C., V. K. Dhatrak, and A. M. Mahalle, 2000).

At higher cutting speed, since the tool undergoes wear because of incremented temperature, it is consequent that the cutting fluid acts as the coolant. As cutting speed lower, the lubricating properties of the fluid become more prominent, facilitating the flow of the chip up the implement rake face. The main functions of cutting fluids are, cooling at relatively high cutting speeds and lubrication at relatively low cutting speed. Cutting fluids are a liquid added to reduce the friction coefficient between the grain and work-piece by way of cooling and lubrication the cutting side of tools by flooding or spraying. (Rao, 2007).

Most metal cutting processes need cutting fluid action. Very little (1 to 3 %) of the work of metal cutting is stored as residual stresses in work-piece or chip, more than 97% appearing as heat (siliman, 1992). Unfortunately, conventional cutting fluids cause the environment and health problems. The pollution caused during machining mainly come from waste cutting fluids. Recycling and disposal of liquid waste cut approximately 16-20 % of the cost of machining (Sreejith, 2000). As the costs of disposal and environmental effects of high machining processing, government regulations have been established to force manufacturers to reduce or eliminate the amount of waste.

Therefore, is seems anticipated a better option to eliminate using the cutting fluids. The health problem is caused every long-term exposure to cutting fluids. In order to eliminate the effect of cutting fluids, dry machining has become a reliable choice in machining of some materials. However, some engineering materials still require cutting fluid in their machining operations (Sreejith, 2000; Vierira, 2001; and Diniz, 2002). The base of specially prepared cutting fluids is commercially available mineral oil. The cutting fluid contains lubricant, coolant and additives such as stabilizer, surfactant and evaporator (Ramamoorthy, 2006).

2.5.1 MINIMUM QUANTITY LIQUID (MQL)

Minimum quantity liquid is also known as “Micro-lubrication” and “Near-Dry Machining” is the latest technique of distributing metal cutting fluid to the implements or work interface. By using of this technology, with a properly selected and applied of this little fluid, can make a substantial difference in how effective a tool performs. In conventional operations utilizing flood coolant, the cutting fluids are mainly selected based on their contributions to cutting performance. However, in minimum quantity liquid, the secondary of their characteristics is the most important.

These include their safety properties, (environment pollution and human contact), oxidation, biodegradability and storage stability.

This is important because the lubricant must be compatible with the environment and resistance to whole usage caused by low consumption (Ghuge, Nilesh C., V. K. Dhatrak, and A. M. Mahalle, 2000). In MQL, the lubrication obtained through the lubricant, while the minimum cooling action is achieved by the pressurized air reaches the working tool or interface. Furthermore, MQL reduces induced thermal shock and help improve the integrity of the work-piece surface in a situation of high pressure tools. Figure 2.3 show the schematic view of MQL system (Dhar, 2006)

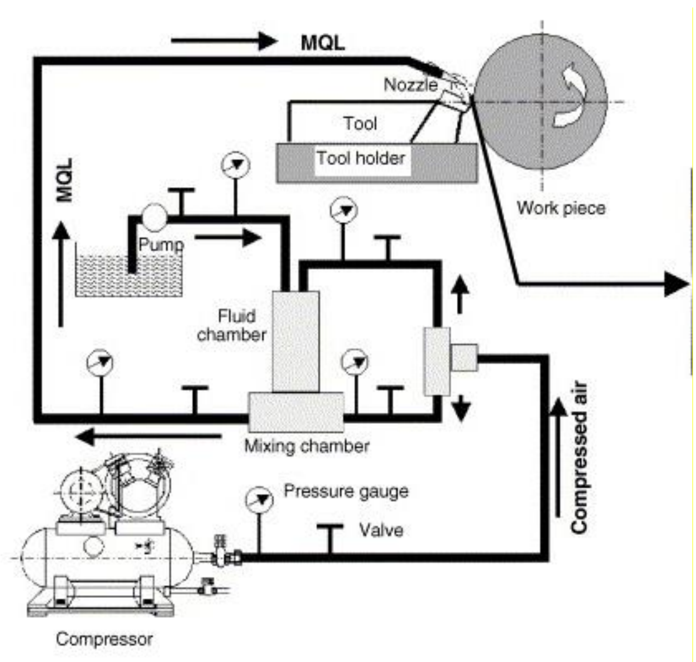


Figure 2.3 Schematic view of MQL system

Source: Dhar (2006)

2.5.2 OIL-MIST LUBRICATION

The Oil Mist principle was developed by a bearing manufacture in Europe during the 1930s. The problem that nurtured this development was the inability to satisfactorily lubricate high-speed spindle bearings on grinders and similar equipment. The speed of these bearings was too high for grease lubrication and liquid oil generated too much heat through fluid friction, necessitating an expensive recirculating system. Continuously thin-film lubrication with Oil Mist provided a solution. The purging and slight cooling effects of the carrier air gave additional benefits. The Oil Mist generator resulted later from the development and used a small amount of air to produce a dense concentration of small oil particles (Figure 2.6). About 97% of these particles could be transmitted to the bearings without condensing in the piping, regardless of the distance of the bearings from the Oil Mist generator itself (William, 1974).

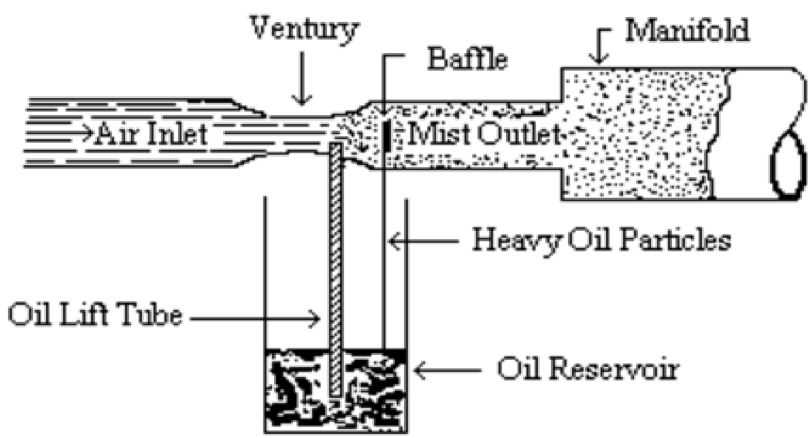


Figure 2.4 The principle of oil-mist generation

Source: William (1974)

2.6 SUMMARY

An experimental study of the chatter detection on thin wall machining of aluminum alloy under MQL condition need to be done. An optimum parameter should be used in machining the thin wall to eliminate the chatter and to avoid the thin wall from become deflection. A suitable MQL condition also require in machining to get a good surface finish.

CHAPTER 3

METHEDOLOGY

3.1 INTRODUCTION

The methodology describes the steps in conducting the project from the start until its finish and can be served as the guideline in managing the project. In developing a project report, methodology is the most important element to be considered to make sure that the development of the research is smooth in order to get the expected result. This chapter will discuss the method, the procedure and the process of this experiment.

3.2 PROCESSING PLANNING FLOW CHART

Process planning is important in this project to make sure this project completed on time. Process planning help to make sure all tasks run systematically. Figure 3.1 shows an overview of process in this research.

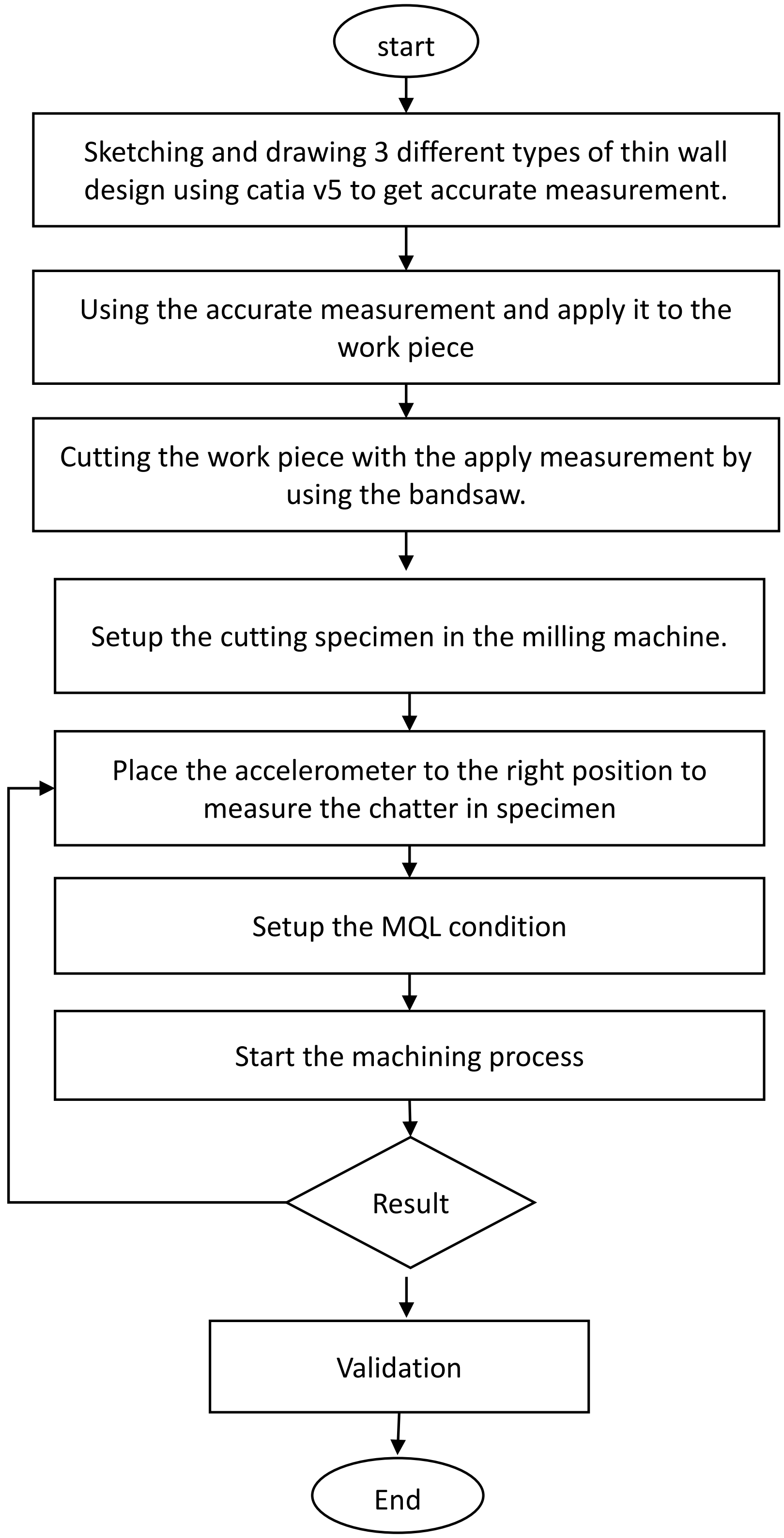


Figure 3.1 Process planning flow chart

3.3 MATERIAL, SOFTWARE AND MACHINE DATA

3.3.1 ALUMINUM 7075 ALLOY (UNS A97075)

An aluminum square block of aluminum 7075 is used in this experiment. Aluminum 7075 is an aluminum alloy with zinc as the primary alloying element.it is strong with strength comparable to many steels, and has good fatigue strength and average machinability, but has less resistance to corrosion than many other aluminum alloy. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.it has ultimate tensile strength 220 MPa and Modulus elasticity of 70-80 GPa.it have good chip formation and evacuation which are crucial for avoiding scratch marks on the surface of the specimen.

Figure 3.2 Aluminum 7075 square block

The following table shows the chemical composition of the aluminum 7075 alloy.

Element	Content (%)
Aluminum, Al	90
Zinc, Zn	5.6
Magnesium, Mg	2.5
Copper, Cu	1.6
Chromium, Cr	0.23

Table 3.1 Chemical composition of aluminum 7075 alloy

Source: Azo materials (2000)

The mechanical properties of aluminum 7075 alloy are outlined in the following table.

Properties	Metric	Imperial
Tensile strength	220 MPa	31909 psi
Yield strength	95 MPa	13779 psi
Shear strength	150 MPa	21756 psi
Fatigue strength	160 MPa	23206 psi
Elastic modulus	70-80 GPa	10153-11603 ksi
Poisson's ratio	0.33	0.33
Elongation at break	17%	17%
Hardness	60	60

Table 3.2 Mechanical Properties of aluminum 7075 alloy

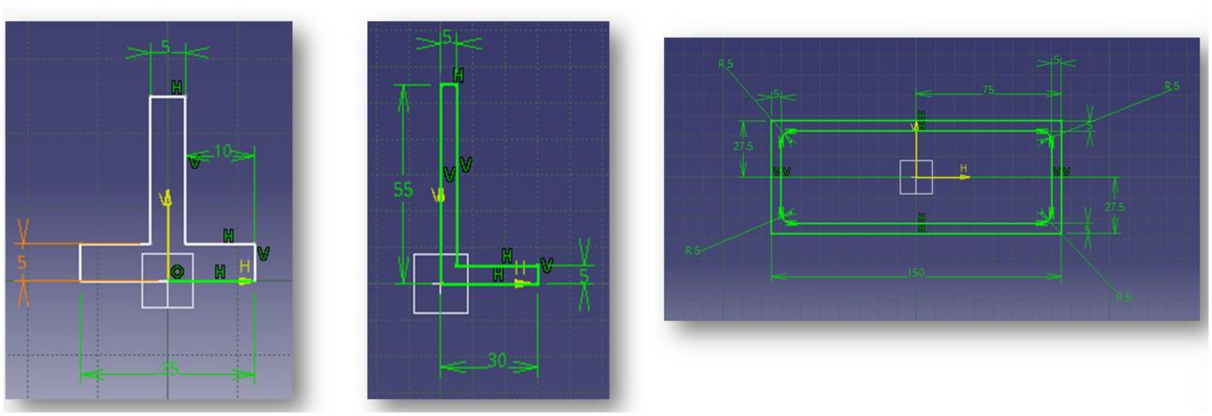
Source: Azo materials (2000)

3.3.2 3D DESIGN SOFTWARE: CATIA

CATIA (computer Aided Three-dimensional Interactive Application) is a multi-platform high-end CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. It is written in the C++ programming language. Commonly referred to as 3D product Lifecycle Management software suite, CATIA supports multiple stages of product development

(CAx), including conceptualization, design (CAD), manufacturing (CAM), and engineering (CAE).

CATIA provides a suite of surfacing, reverse engineering, and visualization solution to create, modify, and validate complex innovative shapes from subdivision, styling, and class A surface to mechanical functional surfaces. CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, molded, forged, or tooling parts up to the definition of mechanical assemblies. It provides tools to complete product definition, including functional tolerance as well as kinematics definition.



(a) T shape component (b) L shape component (c) Pocket shape component

Figure 3.3 sketching using CATIA.

CATIA can be applied to a wide variety of industries from aerospace and defense, automotive, industrial equipment, shipbuilding, consumer goods, plant design, process power and petroleum and services.

There is also other software that can be use other than CATIA which are Solid Work, Pro E, and Autodesk Inventor. The advantages by using CATIA is it have a simple effective machining simulation option which allow user to simulate the applied machining process to know the estimated process time, tool path, and thus generate the NC code for process.

3.3.3 MILLING MACHINE MAKINO KE-55

Makino KE-55 milling machine are choosing to be use in this experiment. It is because the machine is user friendly which is come with CNC and manual mode.it is specially design for next generation of operation, including oblique and circular cutting as well as tapping, can be executed accurately without using attachments or worrying about centering. The KE-55 also has an automatic lubricant supply system works to assure long hours of smooth operation. The machine proper continues Makino's proven ram and knee type design that allows superior accessibility. X and Y axis travels in the ram and Z axis travel in the knee provided by the innovative axis design. Because the tool moves exactly as indicated on the part drawing. Machining operation are easy to understand and operate.

Figure 3.4 Milling machine KE-55

Source: Faculty of manufacturing machining lab

Stock	Model	Age
2832	KE-55	1999

Specification	Description
Control	Fanuc Professional Jr. CNC Control
Table Size	31.5" x 14.76"
Machine Travels (X/Y)	21.6" x 12.6" (Y Axis Ram Travel)
Knee Travel	13.8" Programmable Z Travel
Spindle To Table Distance	4" - 17.7"
Spindle Center to Column Distance	2.95" - 15.55"
Rapid Travere Rate (X/Y/Z)	470 / 470 / 197 IPM
Max Table Load	550 Lbs.
Spindle Taper	Cat 40
Spindle Speeds	45-4,000 RPM
Spindle Drive	7.5 HP
Equipped with: Fanuc Pro Jr CNC Control, Handles for Manual Feed, Coolant System, Manuals.	

Table 3.3 The specification of milling machine KE-55

Source: Machines used (2015)

3.3.4 SURFACE ROUGHNESS TESTER

Perthometer or palpation cut equipment is a measuring instrument for the characteristic of the surface roughness, it is functions similarity as a sound recorder. With a palpation point one drives on the surface of a solid body long. The unevenness is led from the probe's tip into the equipment and converted into electrical signals. These signals serve for the determination of different characteristic values, which characterize the surface roughness.

Geometry of the palpation point has large influence on the determined characteristic values. Most frequency a palpation point radius is use of 5µm and an opening angle of the point tip of 60°. However, there are other radii used such as 2µm and 10µm, and the point tip angle of 90°

For this experiment, the type of the Perthometer used is the Mitutoyo surface roughness test SJ-201 series which have the display unit has IP53 protection level against dripping water and dust. The measurement results appear in large characters on the large LCD screen and results can be confirmed at a glance. Detailed set-ups, such as change of standards and cutoff lengths, can be made by pressing the relevant buttons after sliding back the top cover. The built-in battery if fully charged allows approximately 500 measurements to be taken even on a site with no access to power. A convenient carrying case is supplied as standard for protecting the instrument in the field.

Figure 3.5 Mitutoyo surface roughness test SJ-201 series

3.4 EXPERIMENT PROCEDURE

Below are the steps which how the experiment is conducted. The steps are listed using the points accordingly to its sequence.

3.4.1 DRAWING AND CUTTING THE SPECIMEN

In this project, catia v5 software is used to sketching and drawing 3 different types of thin wall which is L, T and pocket shapes. By using the catia v5, it makes the measurement reading more accurate. From the accurate measurement reading, it will be applying to the workpiece which is aluminum 7075 to get the shape of the specimen. The bandsaw is use to cut the workpiece with the applying measurement.

Figure 3.6 bandsaw for cutting the specimen

3.4.2 MILLING MACHINE DAN MQL SETUP

After the cutting process, milling machine is use to machining the workpiece to get the specimen shape and smooth the specimen surface. After this process finish, the specimen will be setup in the milling machine for chatter detection experiment. The parameter need to be setup before the experiment can be run such as the x, y and z axis, the spindle speed, the feed rate and the depth of cut. In this experiment the spindle speed use is 2754 rms, the feed rate is 100 mm/min and the depth of cut is 2mm, 4mm, 6mm, 8mm, 10mm.After setup the parameter, the MQl need to be setup for lubrication process in the machining. The air pipe from the MQL need to be connected to the air supply to get the air pressure. Coolube 2210AL is use in the MQl as the lubrication. Coolube 2210Al is derived from natural vegetable oils, is machinist and environmentally friendly and there are no VOC's. It is also being testing and it shows it provide exceptional lubricity and stability under load, which helps improve tool life.

Figure 3.7 setup mql on milling machine

3.4.3 DATA ACQUISITION (DAQ) AND ACCELEROMETER SENSOR SETUP

DAQ is a device that use to measuring an electrical or physical phenomenon such as temperature, vibration, sound or voltage with a computer. In this project experiment, daq from national instrument is use to detect a vibration in the machining. Installation software that have been provide from the national instrument need to be install first before using the daq. After finished installation, the accelerometer can be connected to the daq port by using a wire cable. Two accelerometer sensor are used in this project experiment which are 325C56 and 353B15.Both of the accelerometer have a different sensitivity. The accelerometer sensor is placed at the specimen when the machining process is run. Daisy lab software is use in this project experiment to take the data from the accelerometer sensor.

Figure 3.8 setup of data acquisition (DAQ)

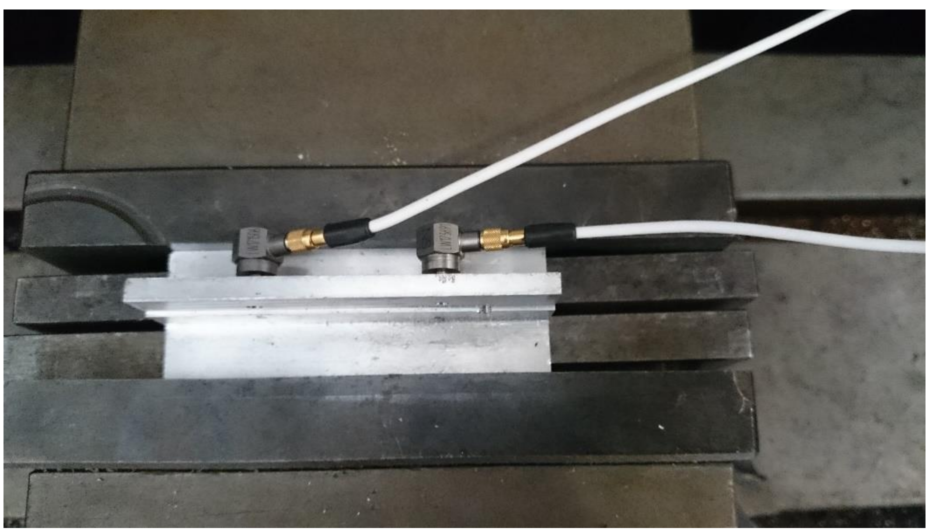


Figure 3.9 setup of accelerometer sensor on the specimen

3.4.4 MACHINING PROCESS IN EXPERIMENT PROJECT

The machining process in this experiment start after the daq and accelerometer sensor are setup as above. Three specimen are used in this experiment which is L shape, T shape and Pocket shape. End mill 5mm with 4 flutes is used as tool in this experiment for milling cutting process.0.3mm is set as a depth cutting parameter in this experiment at y axis. Each specimen is set with 10mm,8mm,6mm,4mm and 2mm as a depth of cut at z axis. The cutting of depth of cut need to be start with bigger to smaller diameter to make the cutting process easier. The spindle speed and the feed rate in this experiment are fixed which is 2753 rev/min and 100 mm/min. The cutting process will run for each depth of cut and repeated to other specimen with the same process.

Figure 4.0 the cutting process in the milling machine process

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the result that has been taken from the accelerometer sensor data by using daisy lab and matlab software and surface roughness test is analyzed by using Mitutoyo surface roughness test SJ-201 series, thus the graph is plotted for both set of data. The comparison between acceleration data from accelerometer, surface roughness and depth of cut is investigating in this project. Most of the discussion is based on the figure and data that have been collected.

4.2 ACCELERATION DATA

There are 2 accelerometer sensor that been use in this experiment which is 325c65 and 353b15.This type of sensors have same function but only different in their sensitivity. The data for the acceleration for both sensors came from the machining test and be converted into the matlab software. By using “rms (data for each parameter)” in the command function in the matlab it automatically calculate the average acceleration in each parameter in different specimen. From this result, the graph can be made for every types of specimen.

Specimen	DOC	325C65(AI0)	353B15 (AI1)
		ACCELERATION(m/s^{-2})	ACCELERATION(m/s^{-2})
L shapes	2	545.5039	5.97E+03
	4	5590.458	5.91E+03
	6	8.38E+03	5.82E+03
	8	5.24E+04	4.37E+03
	10	1.24E+05	4.79E+03
T shapes	2	512.2664	4.84E+03
	4	497.3336	4.69E+03
	6	2.09E+03	4.84E+03
	8	4.83E+03	4.54E+03
	10	8.81E+03	4.42E+03
Pocket shapes	2	461.5845	5.64E+03
	4	472.4873	5.98E+03
	6	470.8496	5.85E+03
	8	433.85	4.00E+04
	10	445.477	1.02E+05

Table 4.1 Acceleration data for L shape, T shape and Pocket shape.

From this Figure 4.2.1, it shows a type of line graph for L shape specimen which is for acceleration vs depth of cut data. In this graph there are two accelerometer sensor use in this experiment. For the first accelerometer sensor, it shows that from 2 mm to 6 mm depth of cut in the machining there is a constant increasing acceleration from 545.5039(m/s^{-2}) to 8.38E+03 (m/s^{-2}). The acceleration data increase dramatically from 8.38E+03 to 1.24E+05 (m/s^{-2}) at depth of cut 6 mm to 10 mm. The result show that there is chatter occur in that parameter. For the second accelerometer sensor, the data remain constant increase from 2 mm to 10 mm depth of cut. The data remain constant for second sensor probably there is an error from setting the sensor place. Therefore, the data from the first accelerometer is use in the comparison graph.

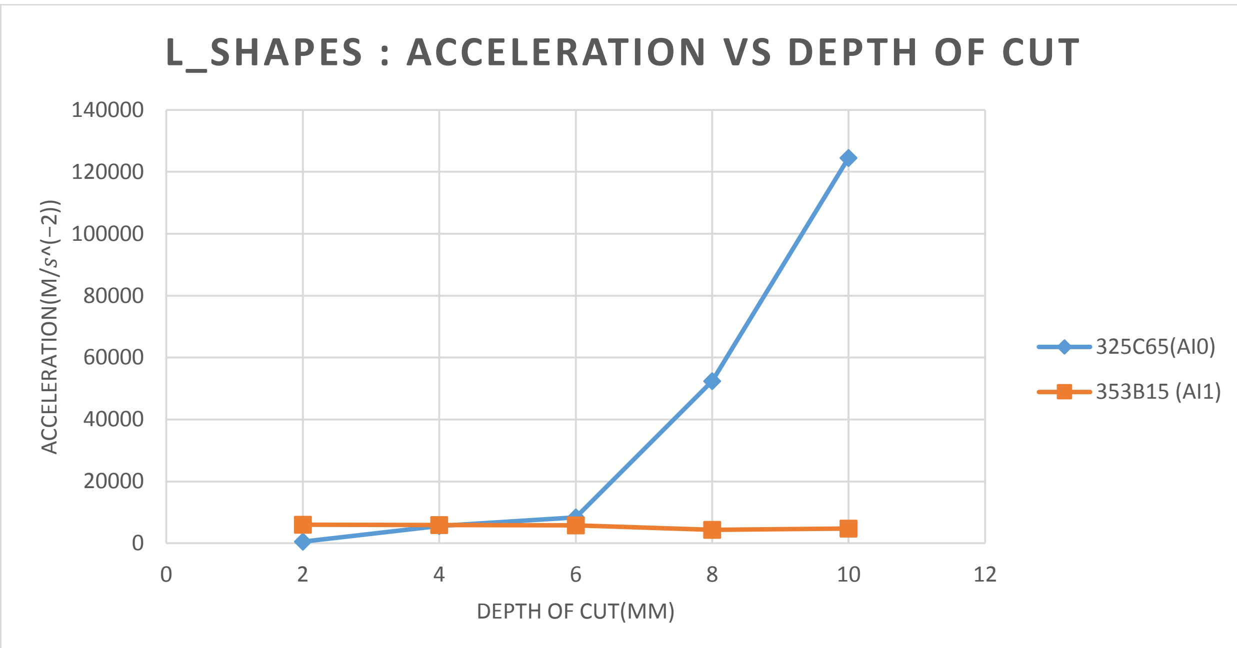


Figure 4.2.1 Acceleration VS Depth of cut graph (L shape).

From the Figure 4.2.2, it shows a type of line graph for T shape specimen which is for acceleration vs depth of cut data. In this graph there are two accelerometer sensor use in this experiment. For the first accelerometer sensor, it shows that from 2 mm to 10 mm depth of cut in the machining there is a steadily increasing data acceleration from 512.2664(m/s^{-2}) to 8.81E+03 (m/s^{-2}). From the first data result, it shows that there is no chatter occur in the experiment. While for the second accelerometer sensor, the data remain constant from 2 mm to 10 mm depth of cut. The same error occurs to the second accelerometer sensor as the L shape specimen experiment. Therefore, the data from the first accelerometer is use in the comparison graph.

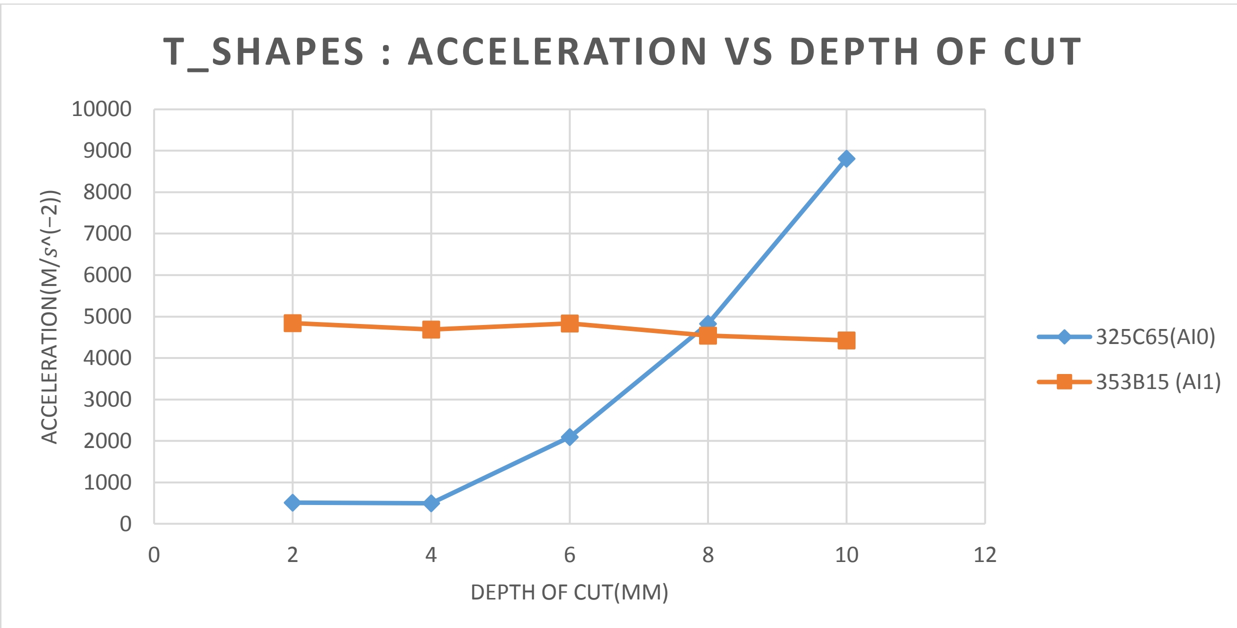


Figure 4.2.2 Acceleration VS Depth of cut graph (L shape).

From the Figure 4.2.3, it shows a type of line graph for Pocket shape specimen which is for acceleration vs depth of cut data. In this graph there are two accelerometer sensor use in this experiment. For the first accelerometer sensor, it shows that from 2 mm to 10 mm depth of cut in the machining data acceleration are not stable and decreasing. From the result data, it shows that there is error occur in this sensor due to the sensor positon. While for the second accelerometer sensor, the data slowly increasing constantly from 2 mm to 6 mm depth of cut and it start dramatically increasing from 6 mm to 10 mm. In that position, it shows that chatter start to occurred. Therefore, the data from the second accelerometer is use in the comparison graph.

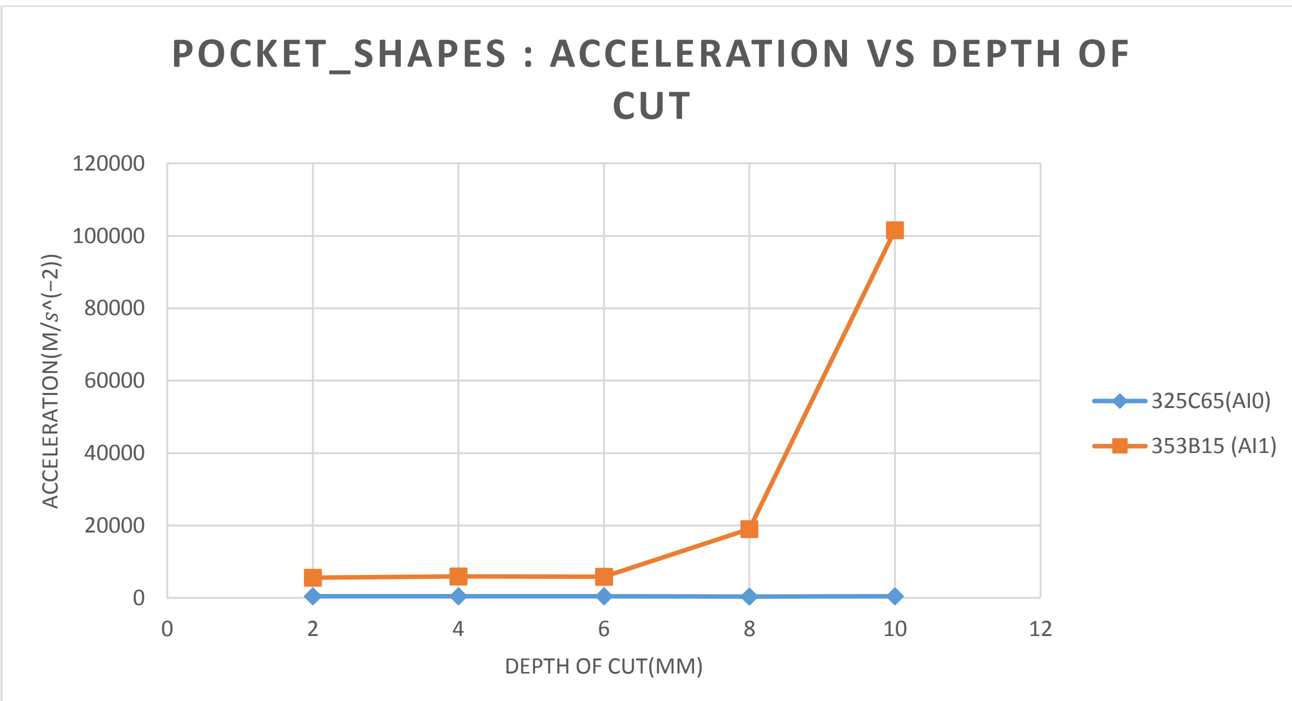


Figure 4.2.3 Acceleration VS Depth of cut graph (Pocket shape).

4.3 SURFACE ROUGHNESS DATA

The data from surface roughness test can be calculate by using a device which is Mitutoyo surface roughness test SJ-201 series. This device will calculate every surface roughness for each depth of cut in every different specimen. Four measurement are calculating for each depth of cut for each specimen and the average measurement will be taken from the four measurement.

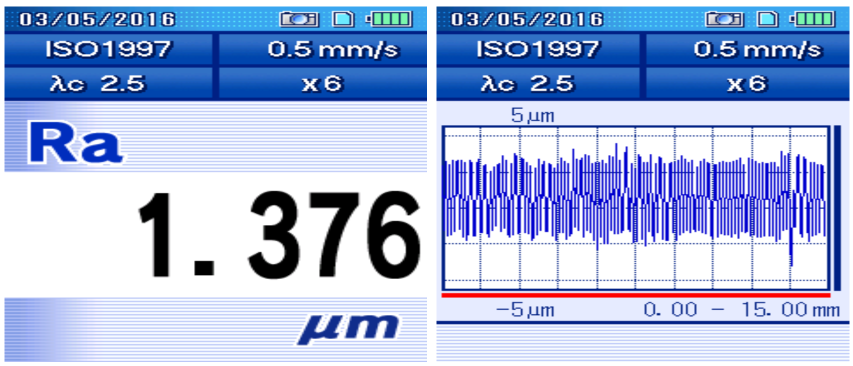


Figure 4.3 Example result by using the Mitutoyo surface roughness test device.

From the Figure 4.3.1 it shows the surface roughness vs depth of cut graph for L shape specimen. From this line graph, the data shows constantly increasing from 2mm to 8mm depth of cut with surface of roughness from 0.4255 µm to 0.62 µm. The percentage of increasing for each depth of cut from 2 mm to 8 mm is only about 6% while at the 10 mm depth of cut the percentage increasing 3 time than before which is 18%. From this changing of percentage, it shows that there is chatter occur in the machining at 10 mm depth of cut.

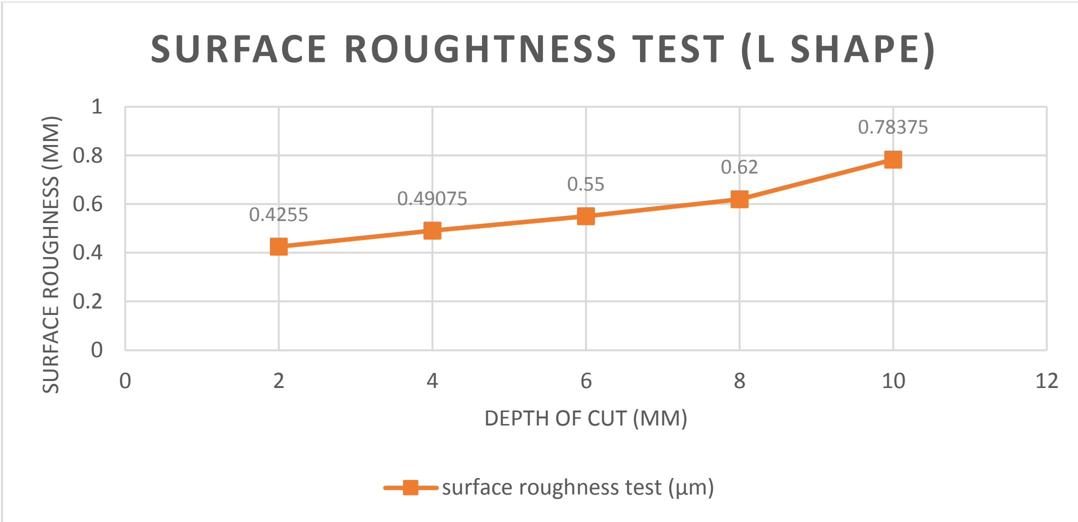


Figure 4.3.1 surface roughness VS Depth of cut graph (L shape).

From the Figure 4.3.2 it shows the surface roughness vs depth of cut graph for T shape specimen. From this line graph, the data shows constantly increasing from 2 mm to 10 mm depth of cut with surface of roughness from 0.55 mm to 0.75 mm. The percentage of increasing for each depth of cut from 2 mm to 10 mm is only about 6%. From the percentage, it shows that there is no chatter occur in the specimen.

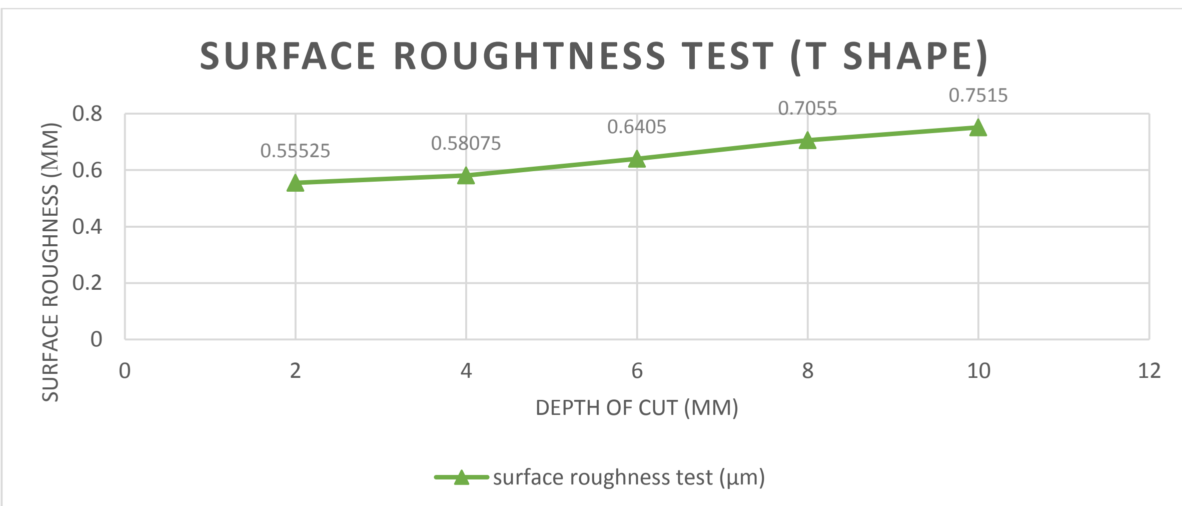


Figure 4.3.2 surface roughness VS Depth of cut graph (T shape).

From the Figure 4.3.3 it shows the surface roughness vs depth of cut graph for Pocket shape specimen. From this line graph, the data shows rapidly increasing from 2 mm to 8 mm depth of cut with surface of roughness from 0.501 µm to 1.09 µm. The percentage of increasing for each depth of cut from 2 mm to 8 mm is only about 20% while at the 10 mm depth of cut the percentage increasing up to 30%. From this changing of percentage, it shows that there is chatter occur in the machining at 10 mm depth of cut.

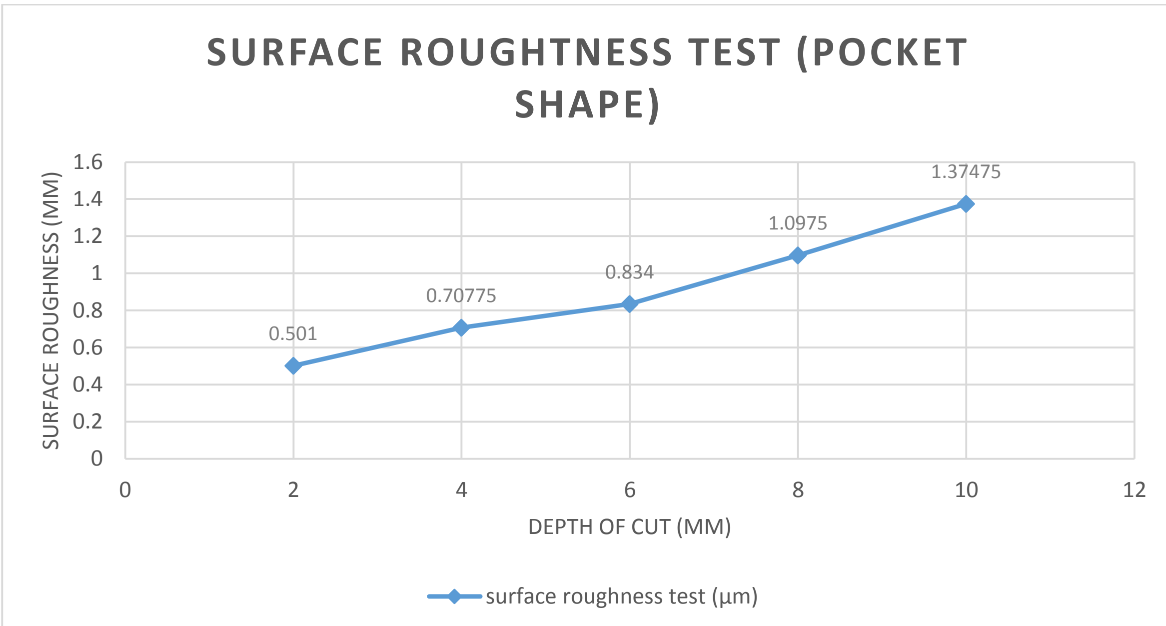


Figure 4.3.3 surface roughness VS Depth of cut graph (Pocket shape).

4.4 COMPARISON BETWEEN ACCELERATION, SURFACE ROUGHNESS VS DEPTH OF CUT

The comparison for acceleration, surface roughness vs depth of cut need to be done to make the data easier to read and to detect the chatter or non-chatter in the specimen at the different depth of cut parameter. From the two previous data which is acceleration and surface roughness data, the comparison result graph shows as below.

From the Figure 4.4.1 below it shows the comparison between acceleration, surface roughness vs depth of cut of L shape specimen. The two result shows the constantly increasing data at 2 mm to 6 mm of depth of cut. The data slowly increase rapidly at 6 mm and dramatically increase from 8 mm to 10 mm. From the result, it shows chatter occur in L shape specimen at 10mm because of the changing of two data result are the highest than others.

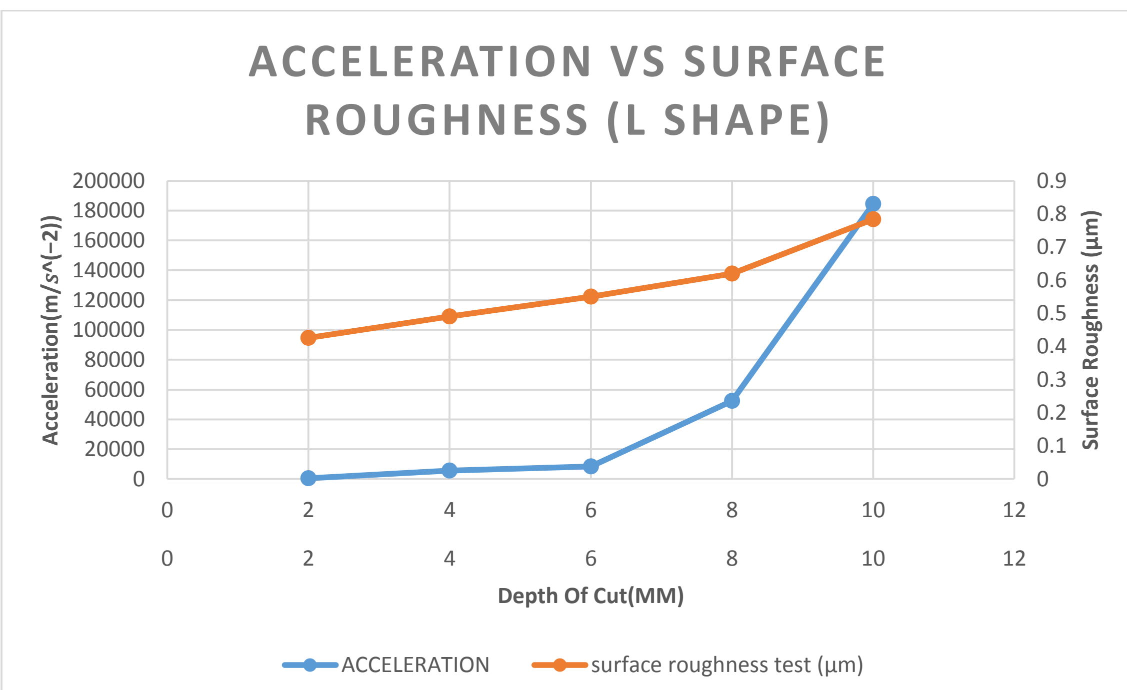


Figure 4.4.1 Acceleration, surface roughness vs depth of cut (L shape)

From the Figure 4.4.2 below it shows the comparison between acceleration, surface roughness vs depth of cut of T shape specimen. The surface roughness result shows the constantly increasing data from 2 mm to 10 mm of depth of cut while at the acceleration result it show that the constantly increasing data only start from depth of cut 2 mm to 4 mm. After that the data rapidly constant increasing from 4 mm to 10 mm. From the result, it shows that there is no chatter occur in T shape specimen because the two data result are increasing constantly.

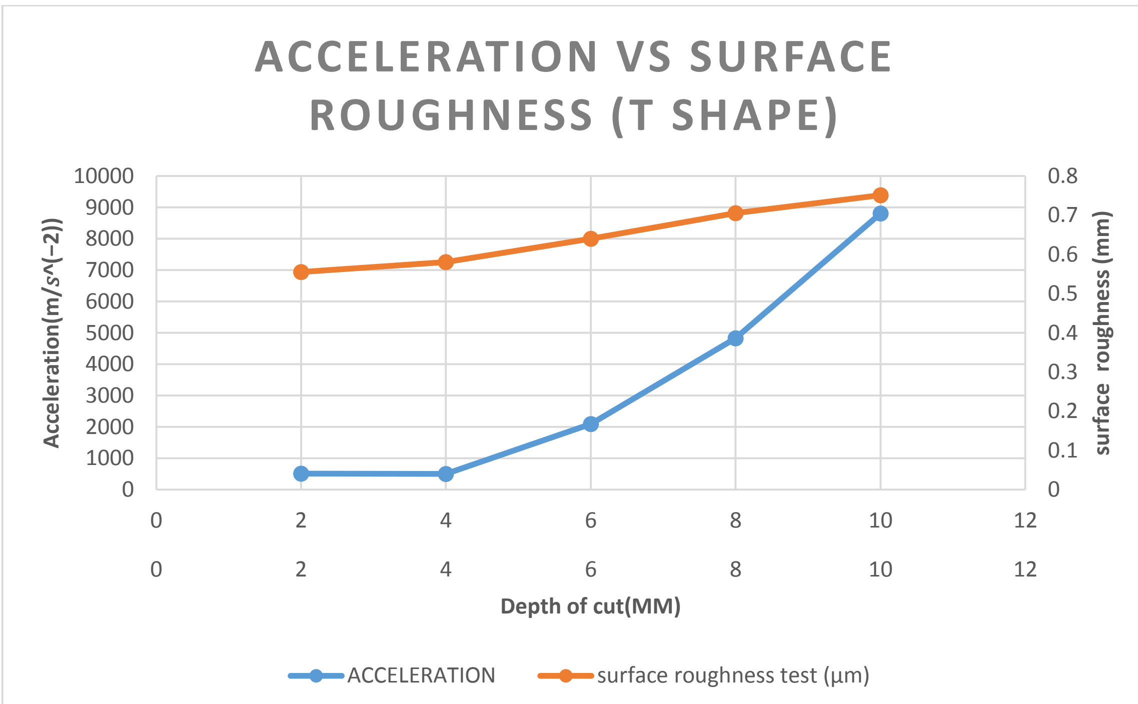


Figure 4.4.2 Acceleration, surface roughness vs depth of cut (T shape).

From the Figure 4.4.3 below it shows the comparison between acceleration, surface roughness vs depth of cut of Pocket shape specimen. The two result shows the constantly increasing data at 2 mm to 6 mm of depth of cut. The data start increasing rapidly from 6 mm to 8 mm of depth of cut and dramatically increase from 8 mm to10 mm. From the result, it shows chatter occur in Pocket shape specimen at 10 mm same as the L specimen because of the changing of two data result are the highest than others.

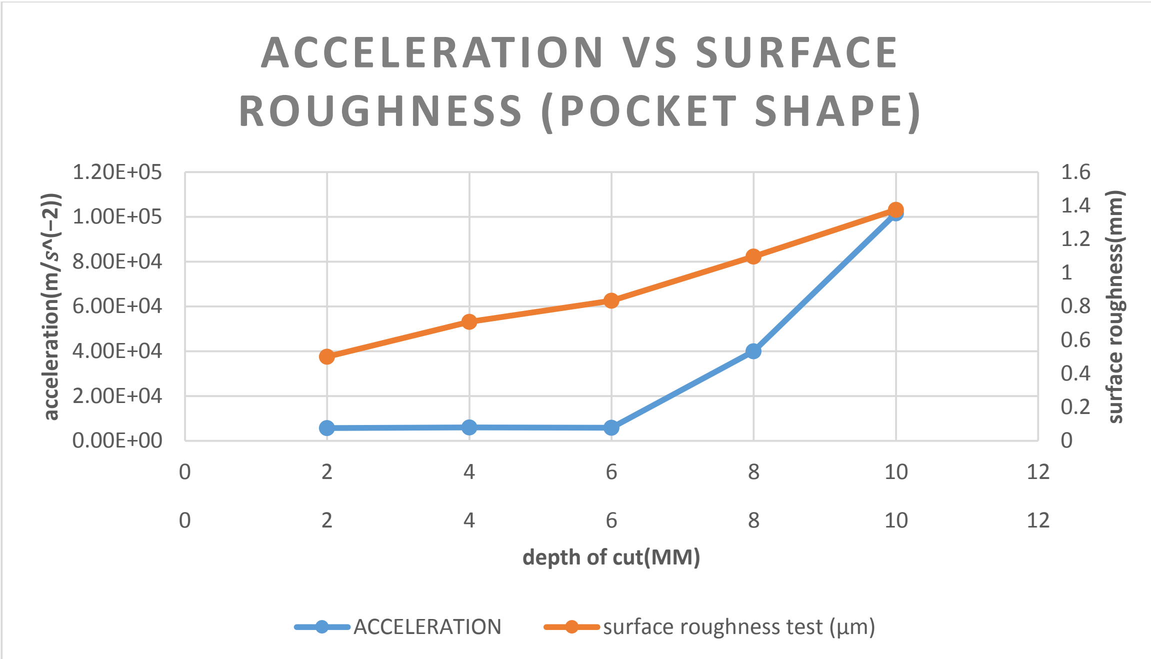


Figure 4.4.3 Acceleration, surface roughness vs depth of cut (Pocket shape).

4.5 TIME DOMAIN AND FFT RESULT

4.5.1 Time domain and FFT result for L shape.

For the 10 mm of depth of cut in L shape specimen, it can be clearly seen that there is a chatter occur in this parameter because of there is a certain of high frequency occur in a stable state of frequency signal.

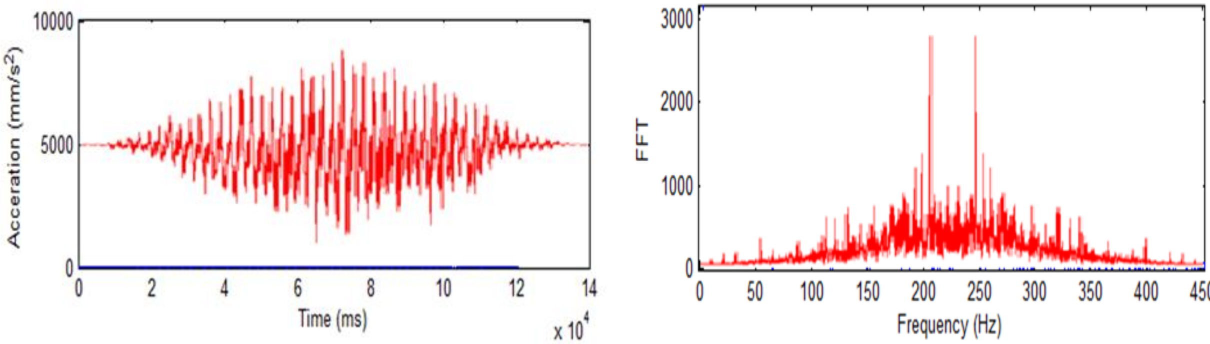


Figure 4.5.1.1 L shape specimen, 10 mm of depth of cut (chatter)

For the 8 mm of depth of cut in L shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

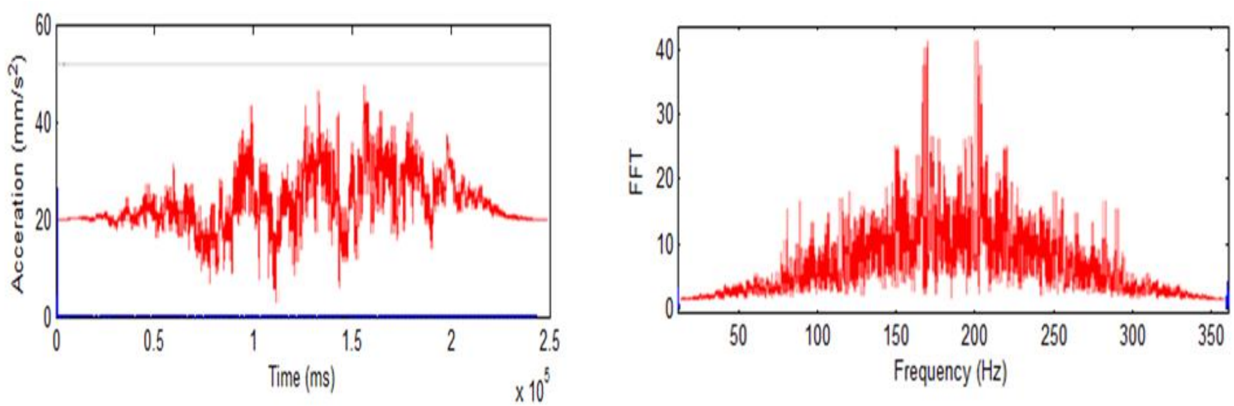


Figure 4.5.1.2 L shape specimen, 8 mm of depth of cut (no chatter)

For the 6 mm of depth of cut in L shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

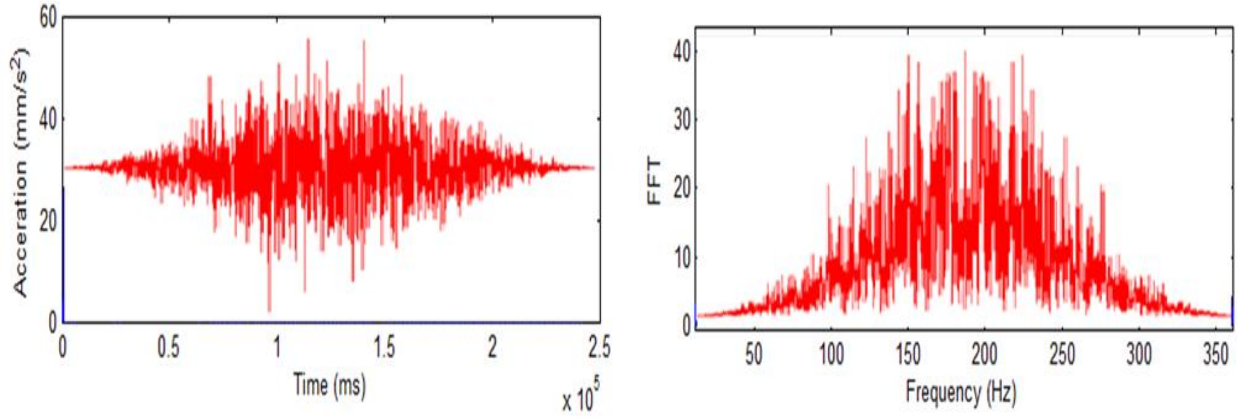


Figure 4.5.1.3 L shape specimen, 6 mm of depth of cut (no chatter)

For the 4 mm of depth of cut in L shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

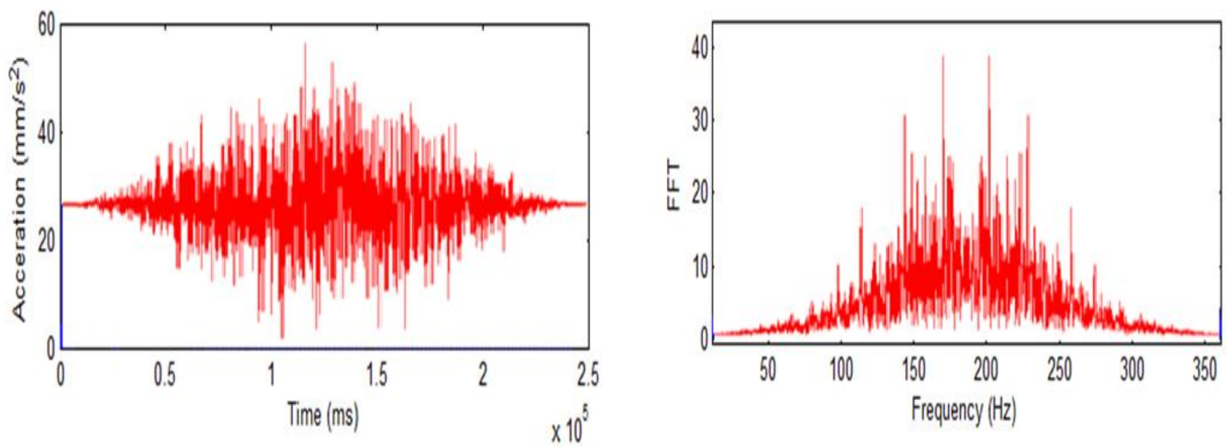


Figure 4.5.1.4 L shape specimen, 4 mm of depth of cut (no chatter)

For the 2 mm of depth of cut in L shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

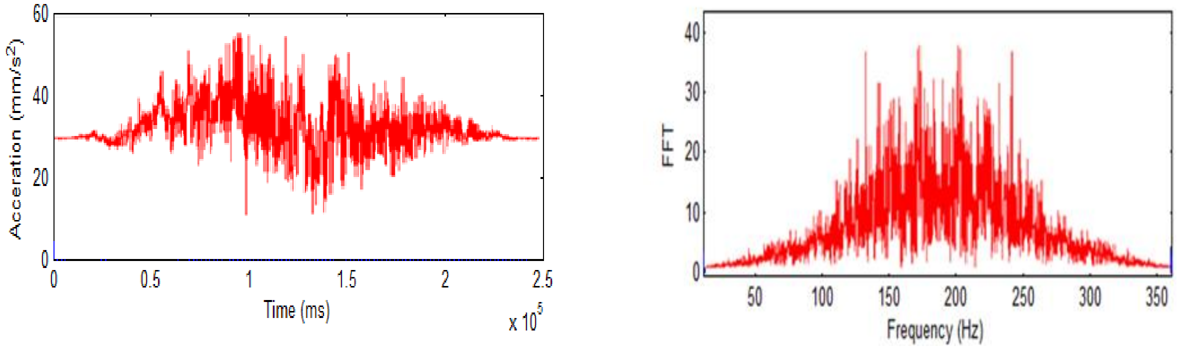


Figure 4.5.1.5 L shape specimen, 2 mm of depth of cut (no chatter)

4.5.2 Time domain and FFT result for T shape.

For the 10 mm of depth of cut in T shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

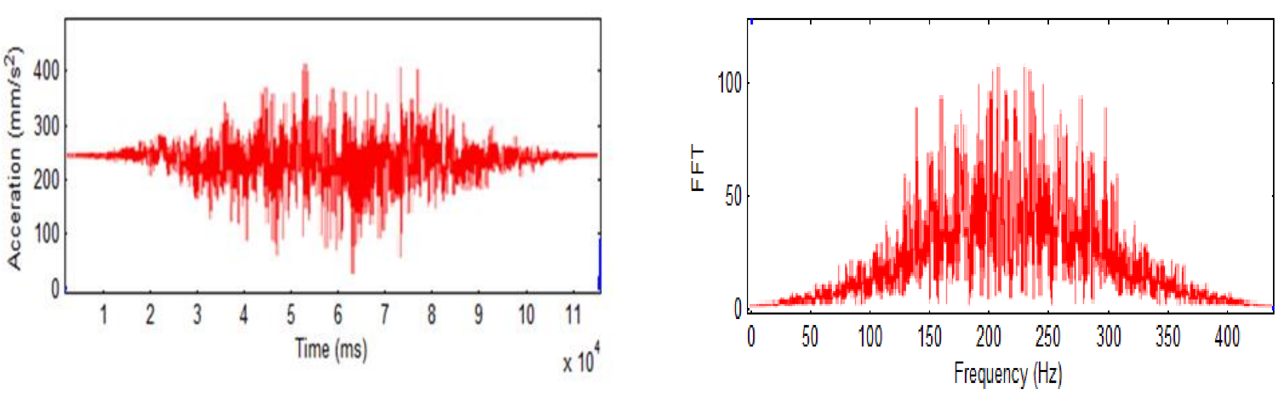


Figure 4.5.2.1 T shape specimen, 10 mm of depth of cut (no chatter)

For the 8 mm of depth of cut in T shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

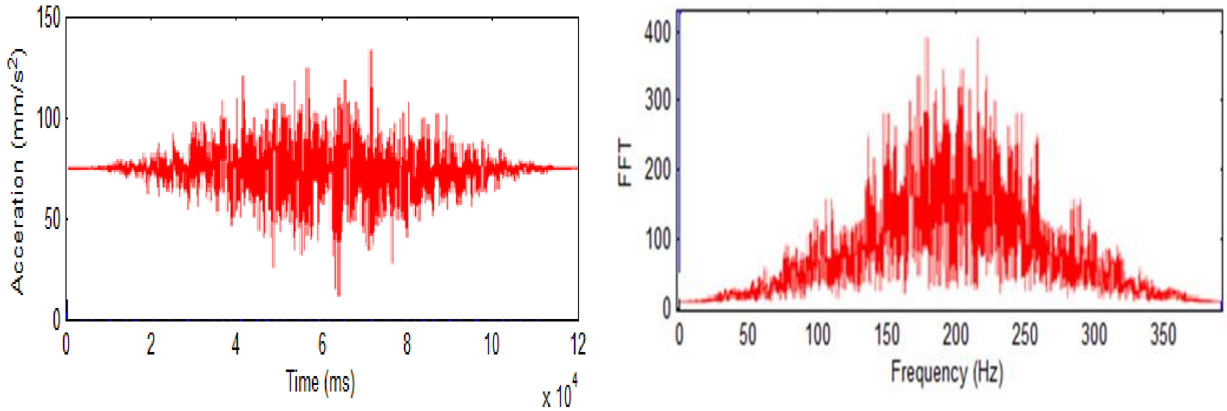


Figure 4.5.2.2 T shape specimen, 8 mm of depth of cut (no chatter)

For the 6 mm of depth of cut in T shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

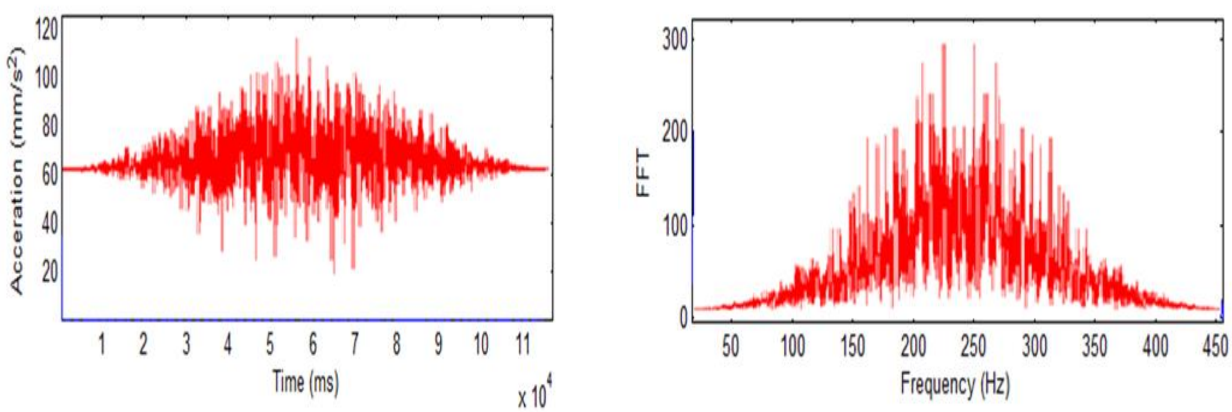


Figure 4.5.2.3 T shape specimen, 6 mm of depth of cut (no chatter)

For the 4 mm of depth of cut in T shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

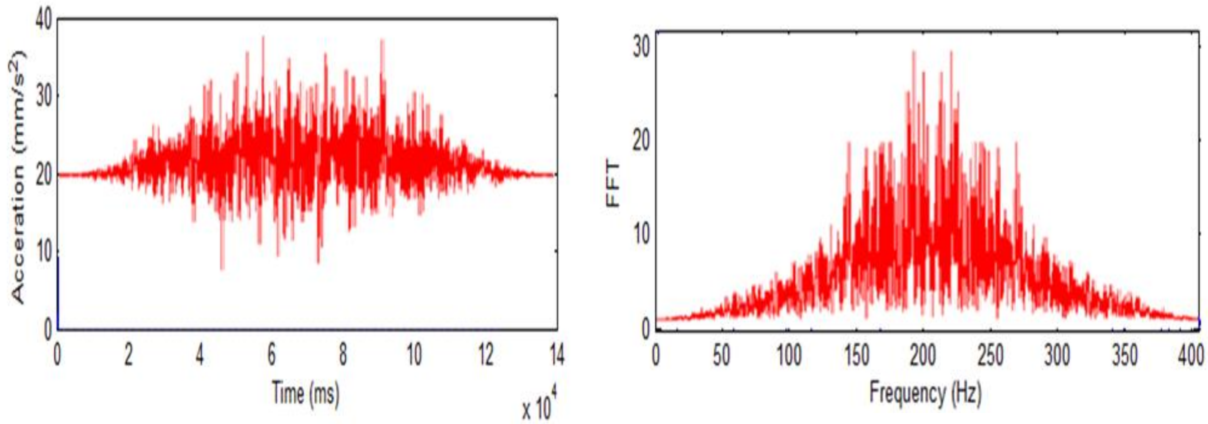


Figure 4.5.2.4 T shape specimen, 4 mm of depth of cut (no chatter)

For the 2 mm of depth of cut in T shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

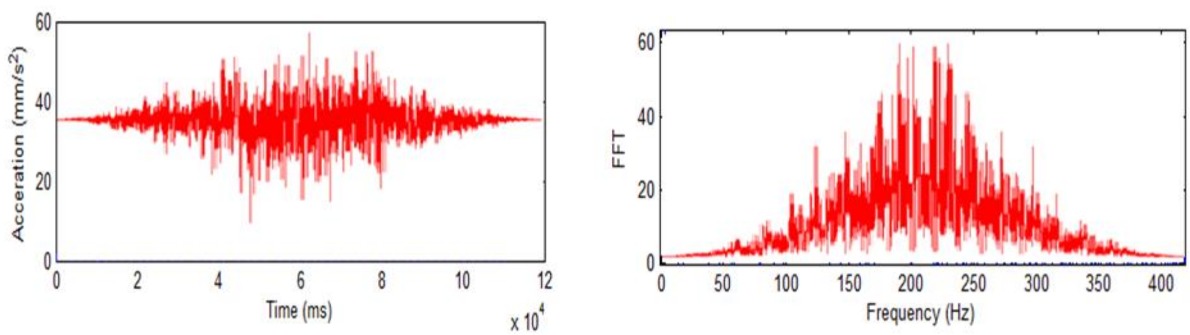


Figure 4.5.2.5 T shape specimen, 2 mm of depth of cut (no chatter)

4.5.3 Time domain and FFT result for Pocket shape.

For the 10 mm of depth of cut in Pocket shape specimen, it can be clearly seen that there is a chatter occur in this parameter because of there is a certain of high frequency occur in a stable state of frequency signal.

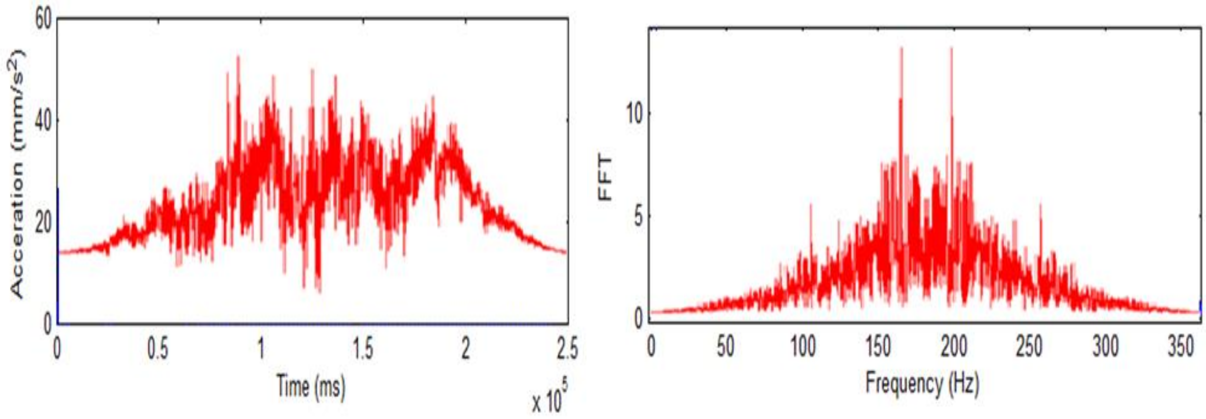


Figure 4.5.3.1 Pocket shape specimen, 10 mm of depth of cut (chatter)

For the 8 mm of depth of cut in pocket shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

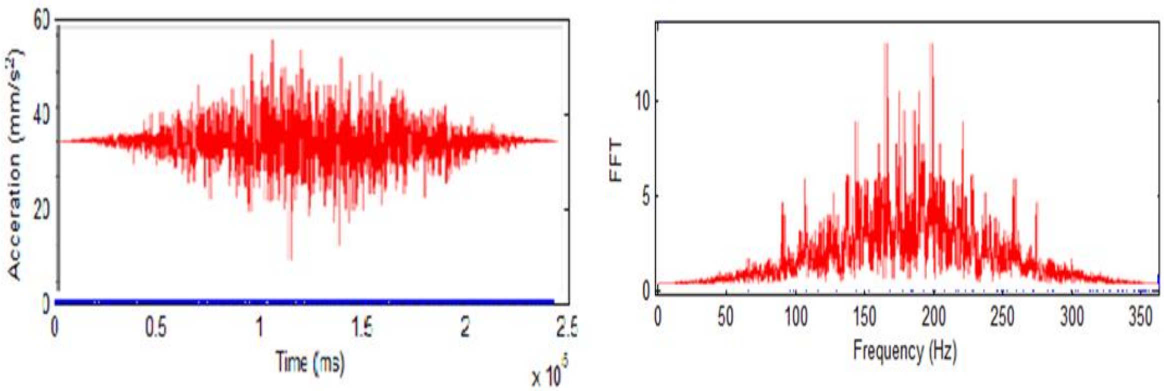


Figure 4.5.3.2 Pocket shape specimen, 8 mm of depth of cut (no chatter)

For the 6 mm of depth of cut in pocket shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

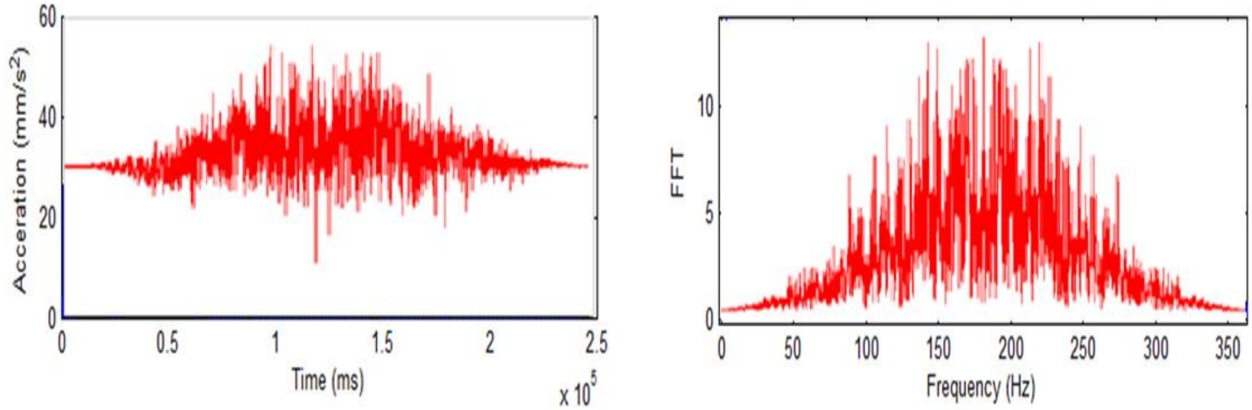


Figure 4.5.3.3 Pocket shape specimen, 6 mm of depth of cut (no chatter)

For the 4 mm of depth of cut in pocket shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

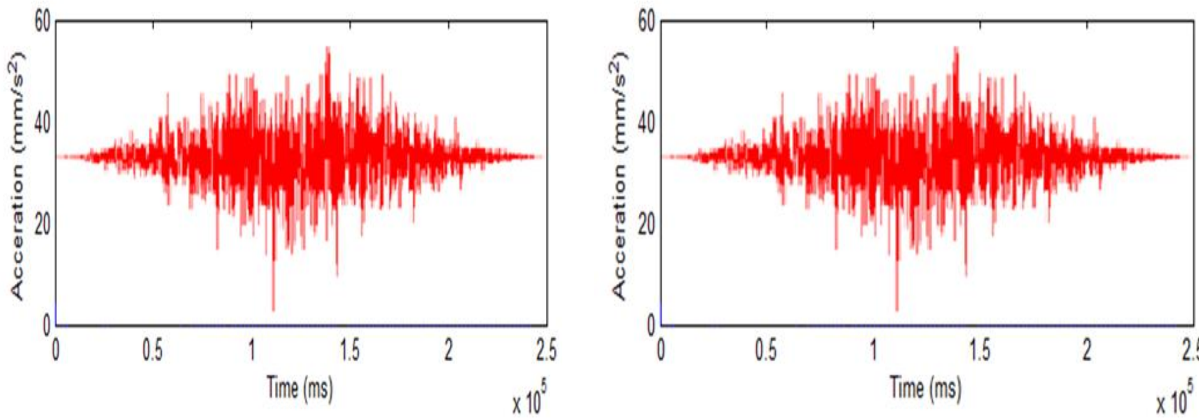


Figure 4.5.3.4 Pocket shape specimen, 4 mm of depth of cut (no chatter)

For the 2 mm of depth of cut in pocket shape specimen, it can be clearly seen that there is no chatter occur in this parameter because of the frequency reading shows transient and stable signal.

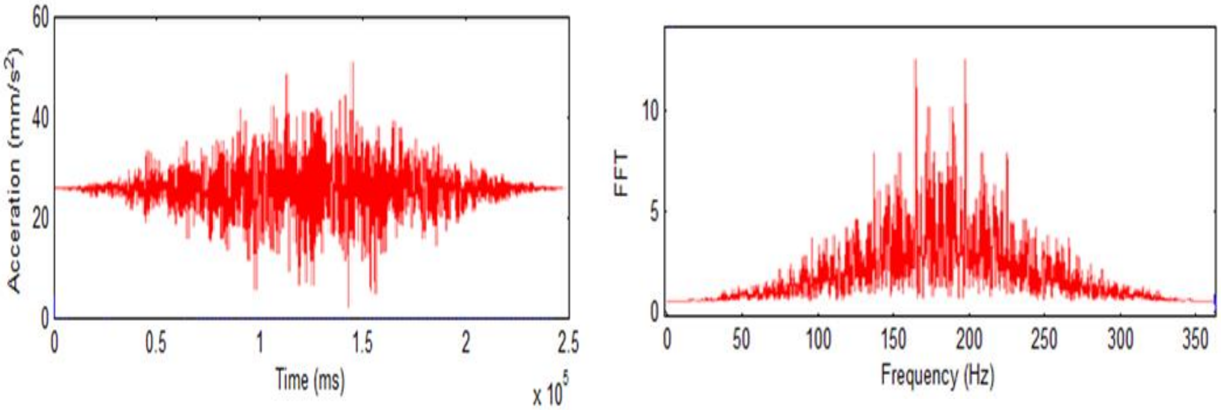
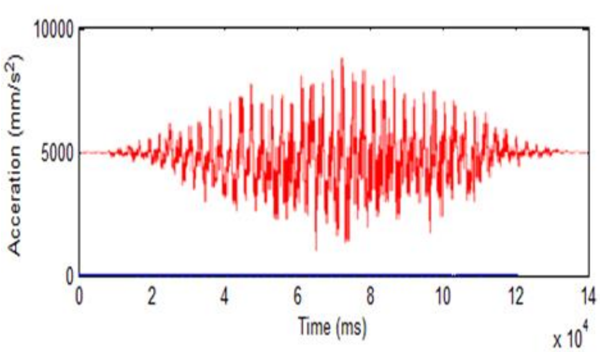
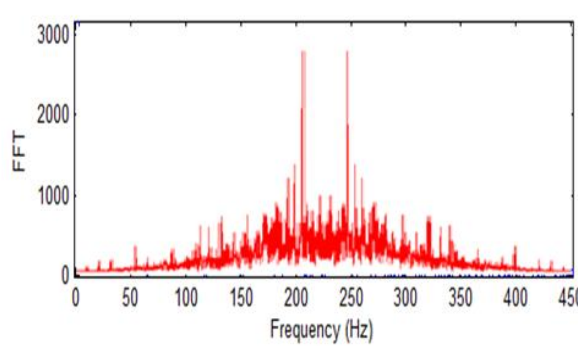
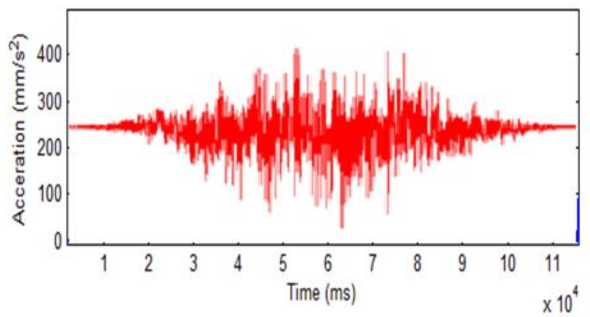
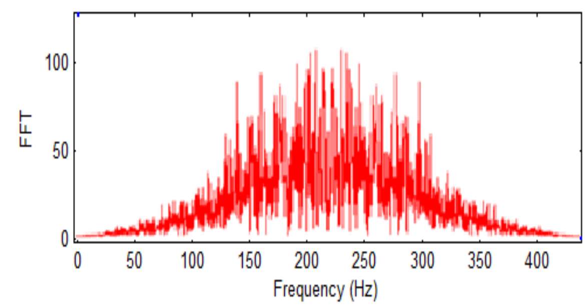
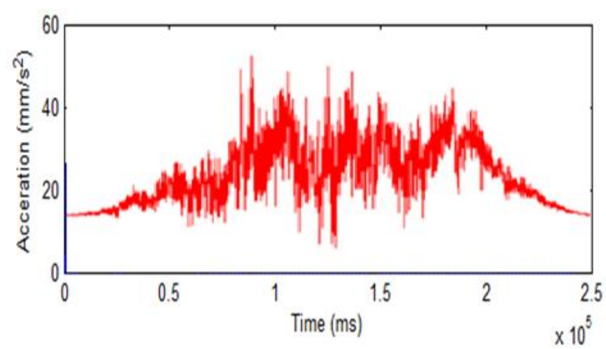
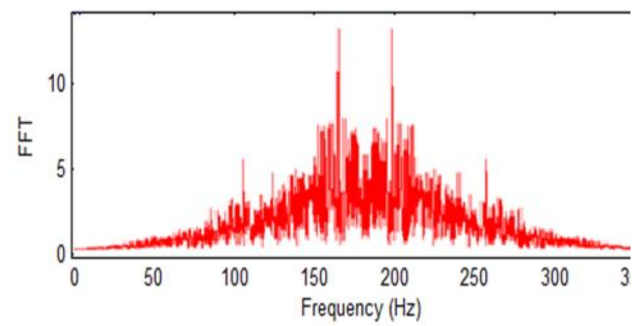


Figure 4.5.3.5 Pocket shape specimen, 2 mm of depth of cut (no chatter)

4.6 COMPARISON RESULT FOR TIME DOMAIN AND FFT GRAPH FOR DIFFERENT SPECIMEN

From the result below, it shows the result for L, T and Pocket shape for 10 mm of depth of cut. L and Pocket shape result shows that there is a chatter occur during the machining at 10 mm of depth of cut parameter while T shape in a stable or non-chatter condition. In this result, clearly seen that chatter occur at the high of parameter of depth of cut which is 10 mm.

TIME DOMAIN AND FFT GRAPH RESULT		
SPECIMEN	TIME DOMAIN GRAPH	FFT GRAPH
L shape		
	L-shape DOC 10 mm, RDOC 0.3 mm(CHATTER)	

T shape		
	T-shape DOC 10 mm, RDOC 0.3 mm(STABLE)	
Pocket shape		
	Pocket DOC 10 mm, RDC 0.3 mm(CHATTER)	

4.7 SUMMARY

Three type of chatter detection method are applying in this experiment which is by acceleration, time domain and surface roughness test. From the result, chatter occur only at L shape and Pocket shape at 10 mm of depth of cut while the other are stable or non-chatter.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION.

This chapter will conclude and summarize the study in various sections. For the first section gives a brief overview of the study and analysis, it covers the methodology and findings that related to the research questions and hypothesis. After that, based upon the Chapter 4 which is a discussion of the findings, the conclusions section puts all the research in the measurement of the quality of web-based library services. Finally, the recommendation for this analysis and guide for the future research.

5.2 CONCLUSIONS

In this experiment project, chatter can be detecting by changing or controlling the depth of cut in the thin wall. The result show that the increasing of depth of cut effect the occurring chatter in the machining. The types or shapes of the thin wall also effect the chatter occurring in this experiment. It is proven by the L and Pocket shape specimen at the 10 mm depth of cut have a chatter occur compare to the T shape specimen.

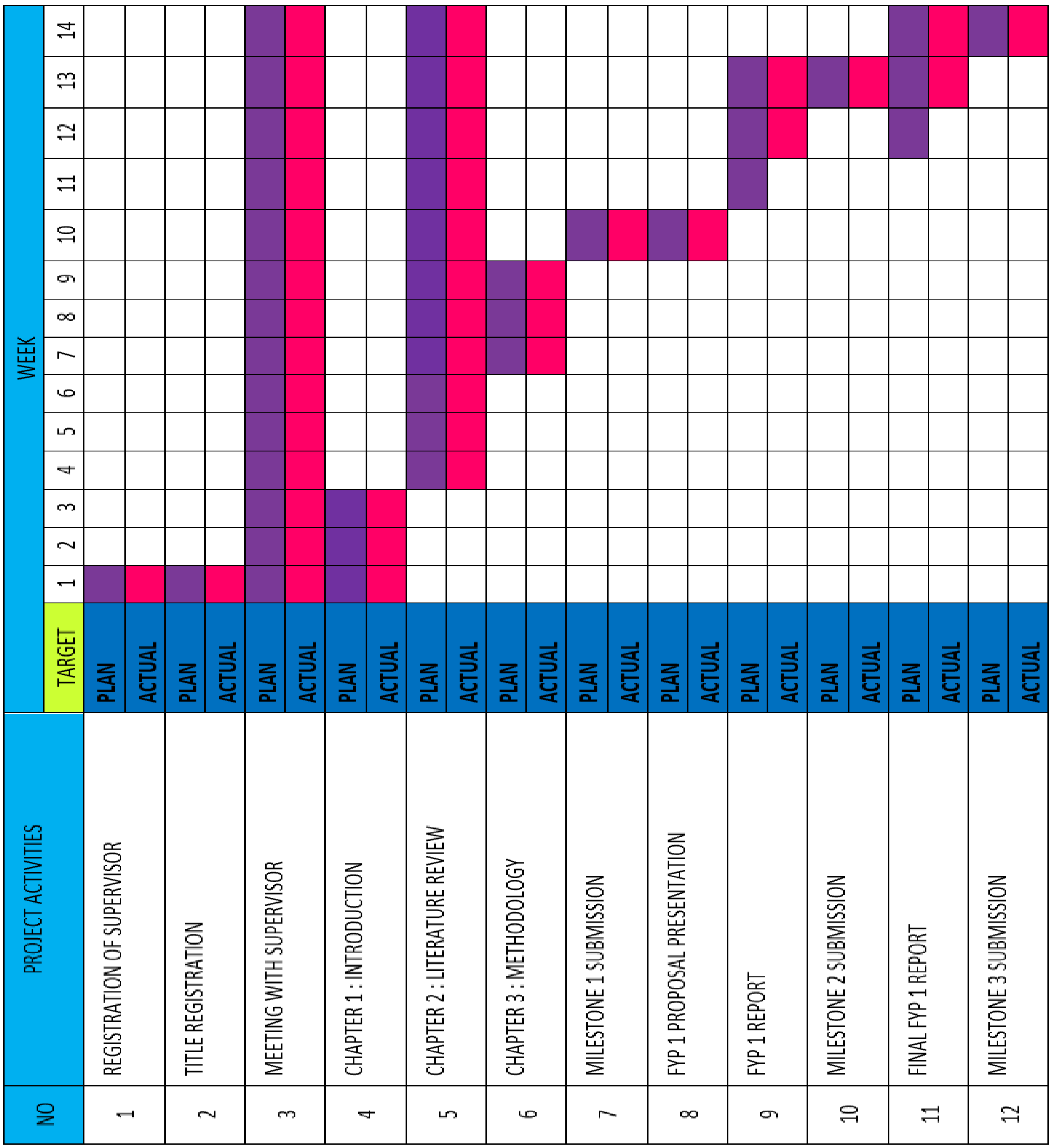
5.3 RECOMMANDATION

Therefore, from the analysis result that have been obtained in the previous chapter, the future analysis works can be recommended such as:

1. By adding the quantity of the accelerometer sensor to get a better result.
2. Using a high sensitivity of accelerometer sensor to get accurate data.
3. Adding the variable parameter for spindle speed and feed rate.
4. Using more complex of thin wall design.

APPENDICE

GANTT CHART FINAL YEAR PROJECT 1



GANNT CHART FINAL YEAR PROJECT 2

NO	PROJECT ACTIVITIES	WEEK														
		TARGET	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	MEETING WITH SUPERVISOR	PLAN														
		ACTUAL														
2	MACHINING THE SPECIMENT	PLAN														
		ACTUAL														
3	RUN THE EXPERIMENT AND COLLECTING DATA	PLAN														
		ACTUAL														
4	ANALYSIS DATA	PLAN														
		ACTUAL														
5	COMPLETE FYP 2 REPORT AND POSTER	PLAN														
		ACTUAL														
6	MILESTONE 3 SUBMISSION	PLAN														
		ACTUAL														
7	FYP 2 PRESENTATION	PLAN														
		ACTUAL														

REFERENCE

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