PERFORMANCE OF COATED CARBIDE CUTTING TOOL WHILE MACHINING ALUMINIUM ALLOY AND MILD STEEL

ISMAIL BIN AB.LLAH

BACHELOR OF ENGINEERING
UNIVERSITI MALAYSIA PAHANG
2010

UNIVERSITI MALAYSIA PAHANG

FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled "Performance of Coated Carbide Cutting Tool while Machining Aluminium Alloy and Mild Steel" is written by Ismail Bin Ab.llah. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

(Muhammad Hatifi Bin Haji Mansor)

Examiner Signature

PERFORMANCE OF COATED CARBIDE CUTTING TOOL WHILE MACHINING ALUMINIUM ALLOY AND MILD STEEL

ISMAIL BIN AB.LLAH

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature

Name of Supervisor: Dr Kumaran Kadirgama

Position: Lecturer

Date: 6 December 2010

STUDENT'S DECLARATION

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

Signature
Name: Ismail Bin Ab.llah
ID Number: MA07008
Date: 6 December 2010

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Dr Kumaran Kadirgama for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his progressive vision about my training in science, his tolerance of my naïve mistakes, and his commitment to my future career.

My sincere thanks go to all my members who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

ABSTRACT

This paper discuss of the performance of coated carbide cutting tools in milling by investigating through the surface roughness. Response Surface Methodology (RSM) is implemented to model the face milling process that are using four insert of coated carbide TiNC as the cutting tool and mild steel AISI1020 and aluminium alloy AA6061 as materials due to predict the resulting of surface roughness. Data is collected from HAAS CNC milling machines were run by 15 samples of experiments for each material using DOE approach that generate by Box-Behnkin method due to table design in MINITAB packages. The inputs of the model consist of feed, cutting speed and depth of cut while the output from the model is surface roughness. Predictive value of surface roughness was analyzed by the method of RSM. The model is validated through a comparison of the experimental values with their predicted counterparts. A good agreement is found where from the RSM approaches show the 81.76% accuracy for mild steel and 80.09% accuracy for aluminium alloy which reliable to be use in Ra prediction and state the feed parameter is the most significant parameter followed by depth of cut and cutting speed influence the surface roughness. For Aluminium Alloy AA6061, the performance of coated carbide cutting tool is better than Mild Steel AISI1020. This project also identified that the increasing of surface roughness, Ra is proportional to the increasing of depth of cut and feed but inversely proportional to the increasing of cutting speed for both of the Aluminum Alloy (AA6061) and Mild Steel (AISI1020). The proved technique opens the door for a new, simple and efficient approach that could be applied to the calibration of other empirical models of machining

ABSTRAK

Kertas kajian ini membincangkan tentang prestasi alat pemotong karbida tidak bersalut dengan menyiasat melalui kekasaran permukaan dalam proses pengilingan. Pendekatan RSM digunakan dalam menganalisis nilai kekasaran permukaan mild steel AISI1020 dan aluminium aloi AA6061 iaitu bahan eksperimen yang di potong oleh empat sisipan karbida yang tidak bersalut titanium karbida (TiC). Data dikumpul dari 15 sample eksperimen untuk setiap bahan yang direka dari kaedah Box-Behnkin di dalam perisian MINITAB mengunakan pendekatan DOE dan mesin pengiling HAAS CNC. Data masuk adalah kelajuan memotong,kedalaman memotong dan kadar pergerakan pemotong dan data yang dinilai adalah kekasaran permukaannya. Nilai ramalan kekasaran permukaan dianalisis oleh kaedah RSM. Kemudian nilai analisis terbabit akan dibandingkan dengan nilai eksperimen. Pendekatan RSM menunjukan ketepatan ramalan sebanyak 81.76% untuk mild steel dan 80.09% untuk aluminium aloi yang boleh diguna pakai dalam ramalan kekasaran permukaan dan kadar pergerakan pemotong memainkan peranan yang penting dalam mempengaruhi nilai kekasaran permukaan di ikuti oleh kedalaman dan kelajuan pemotongan. Prestasi mata pemotong bersadur karbida ketika memotong paduan Aluminium AA6061 adalah lebih baik daripada keluli lembut AISI1020. Projek ini juga mengenalpasti bahawa peningkatan kekasaran permukaan, Ra selari dengan peningkatan kedalaman potong dan pakan tetapi berkadar songsang dengan peningkatan kelajuan pemotongan untuk kedua-dua paduan Aluminium (AA6061) dan keluli lembut (AISI1020). Teknik dan pendekatan ini terbukti membuka pintu untuk pendekatan baru, mudah dan efisien yang boleh diterapkan dalam mendapatkan nilai kekasaran permukaan yang diperlukan.

`TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Manufacturing in general term is the use of machine, tools and labor to produce things for sale. It was a wide field that involves human activity from handicraft to high tech for process raw material into finished good and also process finished good into more complex product. Manufacturing usually occur in large scale that involve mass of production. In order to improve the traditional manufacturing, many technologies are developed and it’s cause many machine are created as well as tool itself.

There are many types of machine and tool that are use to process the material in manufacturing process. Some of them may involve high cost to operate the process such as cost of machine, cost of maintained, energy consumption, labor and so on. So in mass production, there is important to consider the economic aspect due to make the industry profitable and growth. Many method and machine are developed to make the manufacturing process more effective and decrease the cost of production.

One of the solutions is by reducing cost of maintained of the machine. It’s meant, create new machine that can stand longer than the old machine and not easily broken or fail. An ultimate machine required ultimate tool to operate at full of performance. We can use high quality of material to created better tool for example by using TiN-coated carbide cutting tool as it can stand at high temperature, high cutting-speed and it was prove that can improve the tool life. However, the performance of that cutting tool is depending on many variable of cutting condition.

In this project i will investigate the performance of TiN-coated carbide cutting tool while machining aluminum and mild steel by using milling machine in variety value of cutting speed, feed rate and depth of cut.

1.2 PROBLEM STATEMENT

Performance of milling machine almost depending in how fast the machine can cut the work piece, its meant more faster the milling machine process material more finish product are produce in a period of time and the productivity of the machine are high. High productivity needed high rate of metal removal, so it will reduce manufacturing cost and operation time. Although the faster process is needed, it did not guarantee the quality of the produce good in term of surface roughness. Customer always prefer to a quality product and the quality of work piece machined surface and its integrity are most depend on tool wear and it directly depend on life of the tool. Moreover, despite having the target of achieving optimum superficial finishing with the shortest possible time one must take into account the consideration the quality of surface roughness, so that the complete finishing operation can be carried out with just one tool, avoiding the intermediate stops in order to change the tool due to its wear. Eventually, sudden failure of cutting tools lead to loss of productivity, rejection of parts and consequential economic losses. Selection of cutting tools and cutting conditions represents. Plus tool wear/tool life is an important aspect commonly considered in evaluating the performance of a machining process.

In this research, the main objective is to determine the optimum machining parameters in order to get the best quality of work piece surface roughness while using milling machine. Selection of cutting conditions represents an essential element in process planning for machining. This task is traditionally carried out on the basis of the experience of process planners with the help of data from machining handbooks and tool catalogs.

1.3 OBJECTIVE

(i) The main objective of this research is to determine actual parameter and condition while machining aluminum alloy and mild steel due to get the optimum performance of coated carbide cutting tool.

(ii) This project also to determine performance of coated carbide cutting tool by focusing on surface finish.

1.4 PROJECT SCOPE

(i) Use Response Surface Method to design the experiment and analyze the data from experiment. Run the experiment base on Response Surface Method (RSM).

(ii) Use CNC milling machine to operate the end milling on aluminium alloy and mild steel under wet condition.

(iii) Use Mpi Mhar Perthometer to analyze the surface roughness of work piece.

(iv) Use Minitab software to construct contour and surface graph and determine the relationship between cutting parameter and the surface roughness.

(v) Construct a graph of comparison between Aluminium Alloy and Mild Steel in term of the performance of cutting tool.

CHAPTER 2

LITERITURE REVIEW

2.1 INTRODUCTION

In this chapter will discuss about milling machine and information about the operation of this machine. It also contains the information of coated carbide cutting tool.

2.2 MILLING MACHINE

Milling is the process of machining flat, curved, or irregular surfaces by feeding the work piece against a rotating cutter containing a number of cutting edges. The usual Mill consists basically of a motor driven spindle, which mounts and revolves the milling cutter, and a reciprocating adjustable worktable, which mounts and feeds the work piece.

Milling machine are among the most versatile and usefull machine tool. The first milling machine was built in 1820 by Eli Whitney (1765 – 1825) . Milling machines are basically classified as vertical or horizontal. These machines are also classified as knee-type, ram-type, manufacturing or bed type, and planer-type. Most milling machines have self-contained electric drive motors, coolant systems, variable spindle speeds, and power-operated table feeds

In general the milling machine removes metal with a revolving cutting tool called a milling cutter. With various attachments, milling machines can be used for boring, slotting, circular milling dividing, and drilling. This machine can also be used for cutting keyways, racks and gears and for fluting taps and reamers. (Boothroyd et al, 1989)

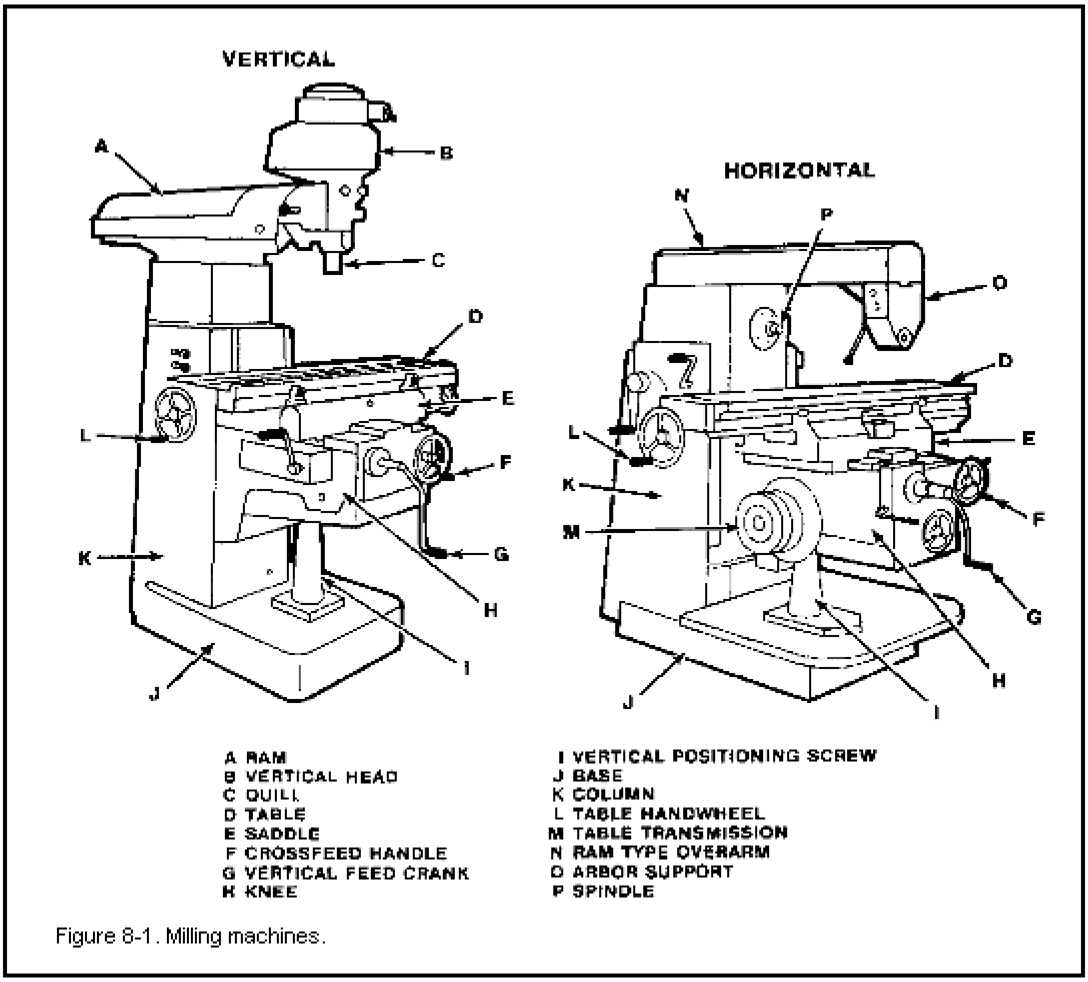

Figure 2.1: Vertical and horizontal milling machine

Source: Huynh et al, 1992

2.3 TYPE OF MILLING MACHINE

Milling machines are basically classified as being horizontal or vertical to indicate the axis of the milling machine spindle. These machines are also classified as knee-type, ram-type, manufacturing or bed-type, and planer-type milling machines.

2.3.1 Knee-type Milling Machine

Knee-type milling machines are characterized by a vertical adjustable worktable resting on a saddle supported by a knee. The knee is a massive casting that rides vertically on the milling machine column and can be clamped rigidly to the column in a position where the milling head and the milling machine spindle are properly adjusted vertically for operation. (David, 2005)

2.3.1.1 Floor-mounted Horizontal Milling Machine

The floor-mounted plain horizontal milling machine's column contains the drive motor and, gearing and a fixed-position horizontal milling machine spindle. An adjustable overhead arm, containing one or more arbor supports, projects forward from the top of the column. The arm and arbor supports are used to stabilize long arbors, upon which the milling cutters are fixed. The arbor supports can be moved along the overhead arm to support the arbor wherever support is desired. This support will depend on the location of the milling cutter or cutters on the arbor.

The knee of the machine rides up or down the column on a rigid track. A heavy, vertical positioned screw beneath the knee is used for raising and lowering. The saddle rests upon the knee and supports the worktable. The saddle moves in and out on a dovetail to control the crossfeed. of the worktable. The worktable traverses to the right or left upon the saddle, feeding the work piece past the milling cutter. The table may be manually controlled or power fed.

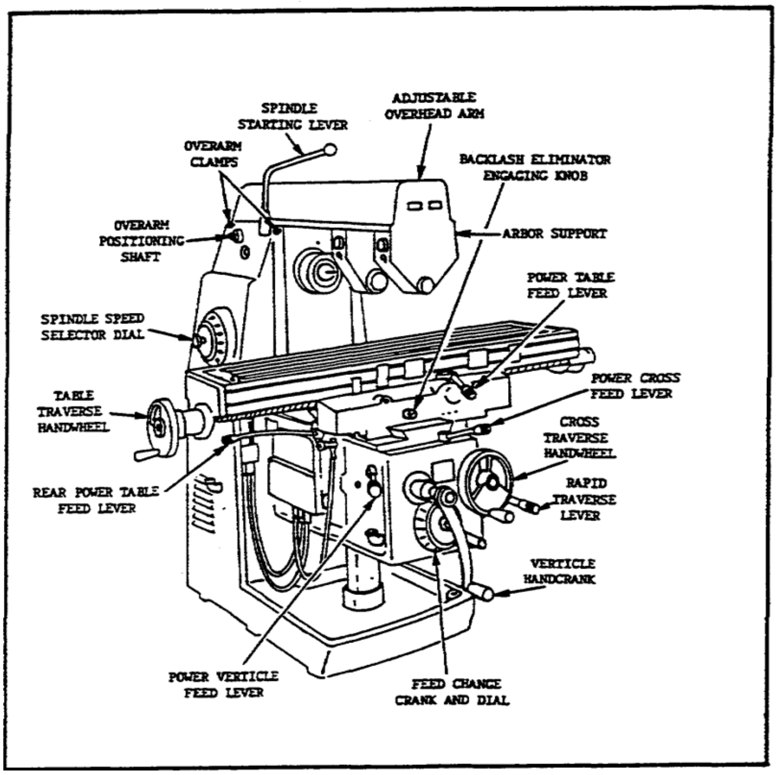

Figure 2.2: Component of milling machine

Source: Huynh et al, 1992

2.3.1.2 Bench-type Plain Horizontal Milling Machine

The bench-type plain horizontal milling machine is a small version of the floor-mounted plain horizontal milling machine; it is mounted to a bench or a pedestal instead of directly to the floor. The milling machine spindle is horizontal and fixed in position. An adjustable overhead arm and support are provided. The worktable is generally not power fed on this size machine. The saddle slides on a dovetail on the knee providing crossfeed adjustment. The knee moves vertically up or down the column to position the worktable in relation to the spindle.

2.3.1.3 Floor-mounted Universal Milling Machine

The basic difference between a universal horizontal milling machine and a plain horizontal milling machine is in the adjustment of the worktable, and in the number of attachments and accessories available for performing various special milling operations. The universal horizontal milling machine has a worktable that can swivel on the saddle with respect to the axis of the milling machine spindle, permitting workpieces to be adjusted in relation to the milling cutter.

The universal horizontal milling machine also differs from the plain horizontal milling machine in that it is of the ram type; i.e., the milling machine spindle is in a swivel cutter head mounted on a ram at the top of the column. The ram can be moved in or out to provide different positions for milling operations.

2.3.2 Ram-type Milling Machines.

The ram-type milling machine is characterized by a spindle mounted to a movable housing on the column, permitting positioning the milling cutter forward or rearward in a horizontal plane. Two widely used ram-type milling machines are the floor-mounted universal milling machine and the swivel cutter head ram-type milling machine. (David, 2005)

2.4 TYPE OF TEETH

The teeth of milling cutters may be made for right-hand or left-hand rotation, and with either right-hand or left-hand helix. Determine the hand of the cutter by looking at the face of the cutter when mounted on the spindle. A right-hand cutter must rotate counterclockwise; a left-hand cutter must rotate clockwise. The right-hand helix is shown by the flutes leading to the right; a left-hand helix is shown by the flutes leading to the left. The direction of the helix does not affect the cutting ability of the cutter, but take care to see that the direction of rotation is correct for the hand of the cutter. (Figure 2.3)

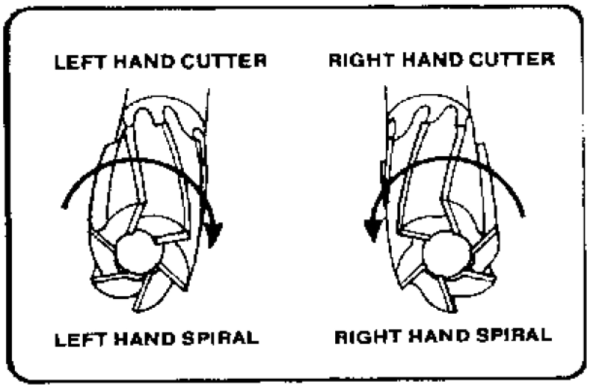

Figure 2.3: Left and right cutters

Source: Huynh et al, 1992

2.4.1 Saw Teeth

Saw teeth similar to those shown in Figure 2.4 are either straight or helical in the smaller sizes of plain milling cutters, metal slitting saw milling cutters, and end milling cutters. The cutting edge is usually given about 5 degrees primary clearance. Sometimes the teeth are provided with off-set nicks which break up chips and make coarser feeds possible.

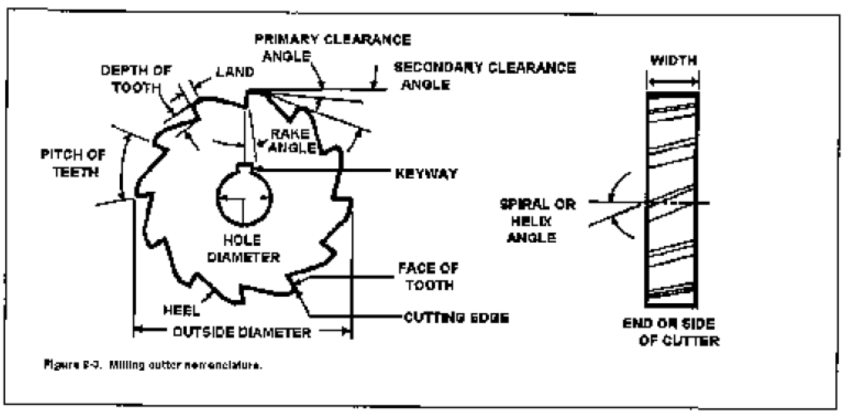

Figure 2.4: Primary Clearance

Source: Huynh et al, 1992

2.4.2 Helical Milling Cutters

The helical milling cutter is similar, to the plain milling cutter, but the teeth have a helix angle of 45° to 60°. The steep helix produces a shearing action that results in smooth, vibration-free cuts. They are available for arbor mounting, or with an integral shank with or without a pilot. This type of helical cutter is particularly useful for milling elongated slots and for light cuts on soft metal. See Figure 8-5

.

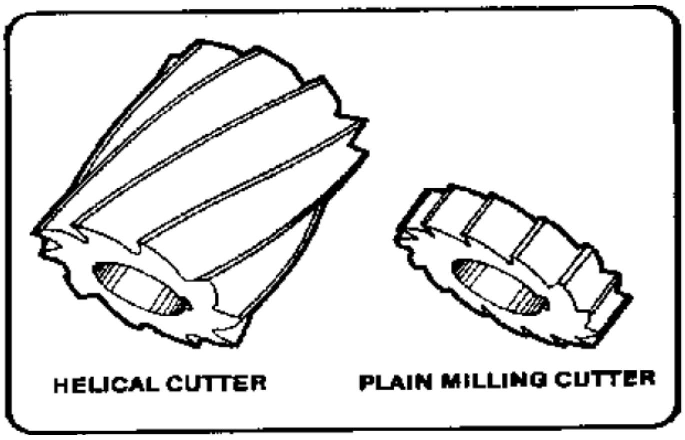

Figure 2.5: Plain and helical milling cutter

Source: Huynh et al, 1992

2.4.3 Metal Slitting Saw Milling Cutter

The metal slitting saw milling cutter is essentially a very thin plain milling cutter. It is ground slightly thinner toward the center to provide side clearance. These cutters are used for cutoff operations and for milling deep, narrow slots, and are made in widths from 1/32 to 3/16 inch.

2.4.4 Side Milling Cutters

Side milling cutters are essentially plain milling cutters with the addition of teeth on one or both sides. A plain side milling cutter has teeth on both sides and on the periphery. When teeth are added to one side only, the cutter is called a half-side milling cutter and is identified as being either a right-hand or left-hand cutter. Side milling cutters are generally used for slotting and straddle milling.

Interlocking tooth side milling cutters and staggered tooth side milling cutters are used for cutting relatively wide slots with accuracy (Figure 2.6). Interlocking tooth side milling cutters can be repeatedly sharpened without changing the width of the slot they will machine.

After sharpening, a washer is placed between the two cutters to compensate for the ground off metal. The staggered tooth cutter is the most washers is placed between the two cutters to compensate for efficient type for milling slots where the depth exceeds the width.

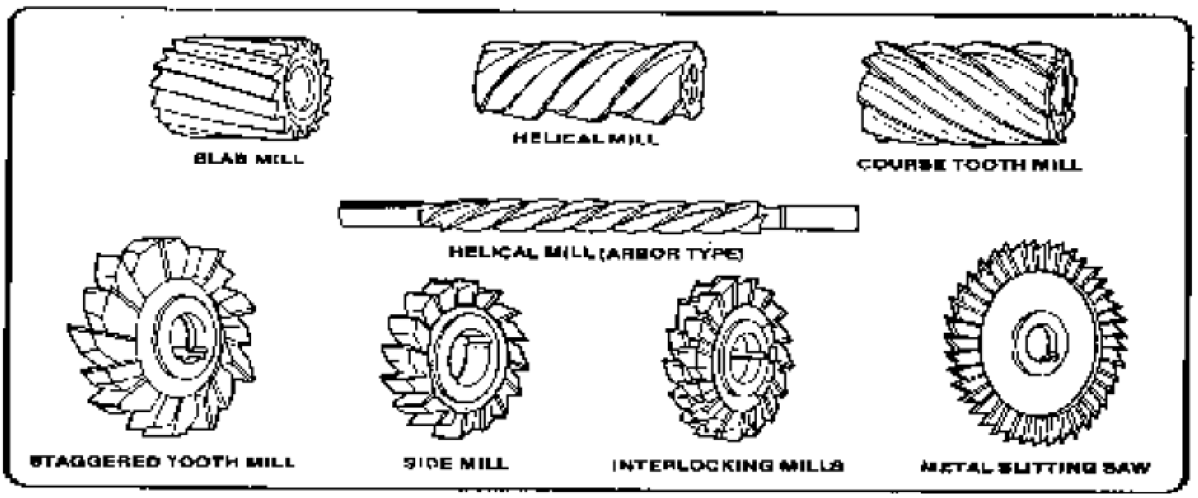

Figure 2.6: Variable type of cutter

Source: Huynh et al, 1992

2.4.5 End Milling Cutters

The end milling cutter, also called an end mill, has teeth on the end as well as the periphery. The smaller end milling cutters have shanks for chuck mounting or direct spindle mounting. End milling cutters may have straight or spiral flutes. Spiral flute end milling cutters are classified as left-hand or right-hand cutters depending on the direction of rotation of the flutes. If they are small cutters, they may have either a straight or tapered shank.

The most common end milling cutter is the spiral flute cutter containing four flutes. Two-flute end milling cutters, sometimes referred to as two-lip end mill cutters, are used for milling slots and keyways where no drilled hole is provided for starting the cut. These cutters drill their own starting holes. Straight flute end milling cutters are generally used for milling both soft or tough materials, while spiral flute cutters are used mostly for cutting steel.

Large end milling cutters (normally over 2 inches in diameter) (Figure 2.7) are called shell end mills and are recessed on the face to receive a screw or nut for mounting on a separate shank or mounting on an arbor, like plain milling cutters. The teeth are usually helical and the cutter is used particularly for face milling operations requiring the facing of two surfaces at right angles to each other.

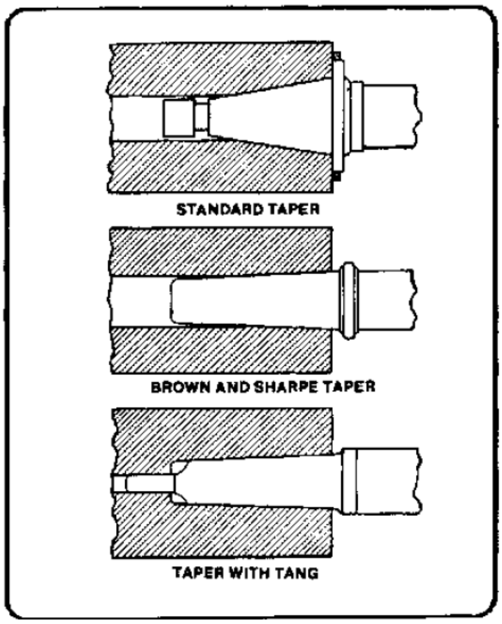

Figure 2.7: Tapers used for milling machine absorber

Source: Huynh et al, 1992

2.4.6 T-Slot Milling Cutter

The T-slot milling cutter is used to machine T-slot grooves in worktables, fixtures, and other holding devices. The cutter has a plain or side milling cutter mounted to the end of a narrow shank. The throat of the T-slot is first milled with a side or end milling cutter and the headspace is then milled with the T-slot milling cutter.

2.4.7 Woodruff Keyslot Milling Cutters

The Woodruff keyslot milling cutter is made in straight, tapered-shank, and arbor-mounted types. See Figure 8-7. The most common cutters of this type, under 1 1/2 inches in diameter, are provided with a shank. They have teeth on the periphery and slightly concave sides to provide clearance. These cutters are used for milling semi cylindrical keyways in shafts.

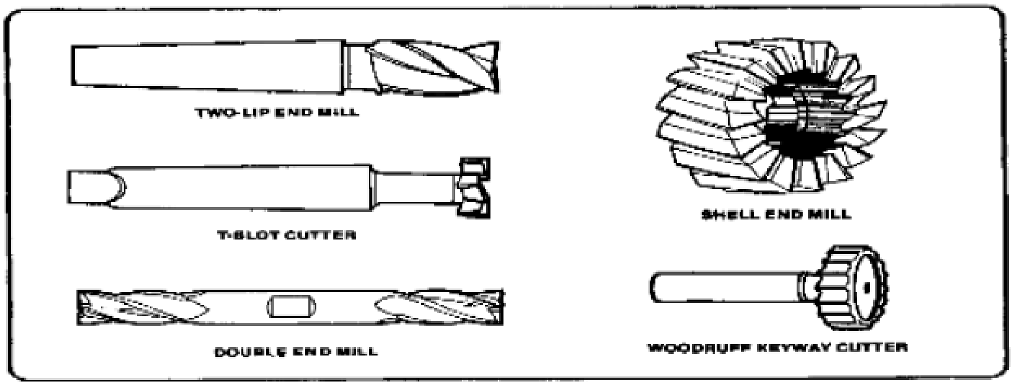

Figure 2.8: End mill, T- slot, and Woodruff keyslot milling cutter

Source: Huynh et al, 1992

2.4.8 Angle Milling Cutters

The angle milling cutter has peripheral teeth which are neither parallel nor perpendicular to the cutter axis. See Figure 2.9. Common operations performed with angle cutters are cutting V-notches and serrations. Angle cutters may be single-angle milling cutters or double-angle milling cutters. The single-angle cutter contains side-cutting teeth on the flat side of the cutter. The angle of the cutter edge is usually 30°, 45°, or 60°, both right and left. Double-angle cutters have included angles of 45, 60, and 90 degrees.

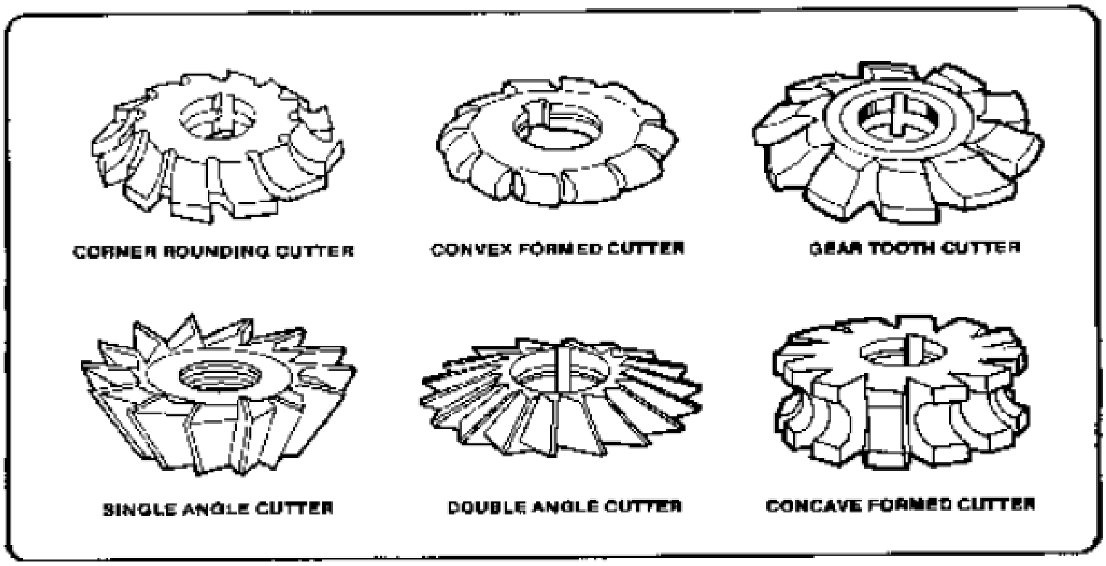

Figure 2.9.: Angle, concave, convex, corner and gear cutter.

Source: Huynh et al, 1992

2.4.9 Gear Hob

The gear hob is a formed tooth milling cutter with helical teeth arranged like the thread on a screw. These teeth- are fluted to produce the required cutting edges. Hobs are generally used for such work as finishing spur gears, spiral gears, and worm gears. They may also be used to cut ratchets and spline shafts.

2.4.10 Concave and Convex Milling Cutters

Concave and convex milling cutters are formed tooth cutters shaped to produce concave and convex contours of 1/2 circle or less. The size of the cutter is specified by the diameter of the circular form the cutter produces.

2.4.11 Corner Rounding Milling Cutter

The corner-rounding milling cutter is a formed tooth cutter used for milling rounded corners on work pieces up to and including one-quarter of a circle. The size of the cutter is specified by the radius of the circular form the cutter produces, such as concave and convex cutters generally used for such work as finishing spur gears, spiral gears, and worm wheels. They may also be used to cut ratchets and spline shafts.

2.4.12 Special Shaped-Formed Milling Cutter

Formed milling cutters have the advantage of being adaptable to any specific shape for special operations. The cutter is made especially for each specific job. In the field, a fly cutter is formed by grinding a single point lathe cutter bit for mounting in a bar, holder, or fly cutter arbor. The cutter can be sharpened many times without destroying its shape. (S. Kalpakjian et al, 2006)

2.5 CUTTING TOOL MATERIAL

There are many type cutting tool material use in industry for difference purpose. The type of cutting tool material will discuss further under this topic.

2.5.1 PVD TiN-coated carbide cutting tool

Titanium-nitride coating have low friction coefficients, high hardness, resistance to high temperature, and good adhesion to the substrate. Consequently, they greatly improve the life of high-speed steel tools, as well as the lives of carbide tools, drill bits, and cutters. Titanium-nitride coated tools perform well at higher cutting speeds and feeds. Flank wear is significantly lower than that of uncoated tools, and the flank surfaces can be reground after use, since regrinding the tool does not remove the coating on the rake face of the tool. However, coated tools do not perform as well at low cutting speeds because the coating can be worn off by chip adhesion. Therefore, the use of appropriate cutting fluids to discourage adhesion is important. (S. Kalpakjian et al, 2006)

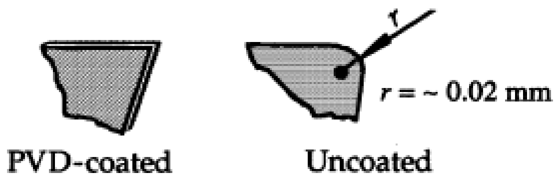

Figure 2.10: PVD-coated and uncoated cutting tool

Table 2.1: Physical properties of PVD TiN-coated carbide cutting tool

Coating (PVD-ion plating)	TiN
Thickness (μm)	2–3.5
Hardness (HV)	2200
Hot hardness	800
Adhesion strength (indent, kg)	45
Thermal conductivity (W/mK)	25
Thermal experimental coefficient (10^{-6}/K)	9.35

2.5.2 High-Speed Steel

High-speed steel (HSS) tools were developed to machine at higher speeds than was previously possible. It is the most highly alloyed of the tool steels so they can be hardened to various depths, have good wear resistance, and are relatively inexpensive. High speed steels are suitable especially for (a) high, positive rake-angle tools, (b) interrupted cuts, (c) machine tools with low stiffness that are subject to vibration and chatter, and (d) complex and single-piece tools, such as drills, reamers, taps, and gear cutters. (S. Kalpakjian et al, 2006)

2.5.3 Cast-Cobalt Alloys

Cast-cobalt alloy have good wear resistance and can maintain their hardness at elevated temperatures. They are not as tough as high-speed steels and are sensitive to force impact forces. Consequently, they are less suitable than high-speed steels for interrupted cutting operation. Commonly known as Satellite tools, these alloys are cast and ground into relatively simple shapes. They now are used only for special applications that involve deep, continuous roughing cuts at relatively high feeds and speeds. (S. Kalpakjian et al, 2006)

2.5.4 Alumina-Based Ceramics

Alumina-based ceramic tools have very high abrasion resistance and hot hardness. Chemically, they are more stable than high-speed steels and carbides, so they tendency to form a built-up edge. Consequently, in cutting cast irons and steels, goods surface finish is obtained with ceramic tools. However, ceramics lack roughness, and their use may result in premature tool failure by chipping or catastrophic failure.

2.5.5 Cubic Boron Nitride

Cubic boron nitride (cBN) provides very high wear resistance and cutting edge strength. cBN tools are also made in small sizes without a substrate. At elevated temperatures cBN is chemically inert to iron and nickel. Its resistance to oxidation is high and, thus, is particularly suitable for cutting hardened ferrous and high-temperature alloys. It’s also is used as abrasive because of cBN tools are brittle, stiffness of the machine tool and the featuring is important to avoid vibration and chatter.

2.5.6 Silicon-Nitride-Based Ceramics

These tools have toughness, hot hardness, and good thermal-shock resistance and are recommended for machining cast irons and nickel-based super alloys at intermediate cutting speed.

2.5.7 Diamond

As cutting tools, it has high desirable properties, such as low friction, high wear resistance, the ability to maintain a sharp cutting edge. Diamond is used when good surface finish and dimensional accuracy are required, particularly with soft nonferrous alloys, and abrasive nonmetallic and metallic materials.

2.6 WORK PIECE MATERIAL

Two type of material are used in this project to determine the different of performance of cutting tool for each material.

2.6.1 Aluminum alloys

Aluminum is a silverfish white metal that has a strong resistance to corrosion and like gold, is rather malleable. It is a relatively light metal compared to metals such as steel, nickel, brass, and copper with a specific gravity of 2.7. Aluminum is easily machinable and can have a wide variety of surface finishes. It also has good electrical and thermal conductivities and is highly reflective to heat and light.

2.6.1.1 Characteristic

At extremely high temperatures (200-250°C) aluminum alloys tend to lose some of their strength. However, at subzero temperatures, their strength increases while retaining their ductility, making aluminum an extremely useful low-temperature alloy.

Aluminum alloys have a strong resistance to corrosion which is a result of an oxide skin that forms as a result of reactions with the atmosphere. This corrosive skin protects aluminum from most chemicals, weathering conditions, and even many acids, however alkaline substances are known to penetrate the protective skin and corrode the metal.

Aluminum also has a rather high electrical conductivity, making it useful as a conductor. Copper is the more widely used conductor, having a conductivity of approximately 161% that of aluminum. Aluminum connectors have a tendency to become loosened after repeated usage leading to arcing and fire, which requires extra precaution and special design when using aluminum wiring in buildings.

Aluminum is a very versatile metal and can be cast in any form known. It can be rolled, stamped, drawn, spun, roll-formed, hammered and forged. The metal can be extruded into a variety of shapes, and can be turned, milled, and bored in the machining process. Aluminum can riveted, welded, brazed, or resin bonded. For most applications, aluminum needs no protective coating as it can be finished to look good, however it is often anodized to improve color and strength. (S. Kalpakjian et al, 2006)

Table 2.2: Mechanical properties of Aluminum alloy T6061

Properties	Value
Density (× 1000 kg/m^3)	2.7
Poisson's Ratio	0.33
Elastic Modulus (GPa)	70-80
Tensile Strength (MPa)	115
Yield Strength (MPa)	48
Elongation (%)	25
Hardness (HB500)	30
Shear Strength (MPa)	83
Fatique Strength (MPa)	62

2.6.2 Mild steel (AISI 1020)

Carbon steel is sometimes referred to as 'mild steel' or 'plain carbon steel'. The American Iron and Steel Institute defines a carbon steel as having no more than 2 % carbon and no other appreciable alloying element. Carbon steel makes up the largest part of steel production and is used in a vast range of applications.

Typically carbon steels are stiff and strong. They also exhibit ferromagnetism (i.e. they are magnetic). This means they are extensively used in motors and electrical appliances. Welding carbon steels with a carbon content greater than 0.3 % requires that special precautions be taken. However, welding carbon steel presents far fewer problems than welding stainless steels. The corrosion resistance of carbon steels is poor (i.e. they rust) and so they should not be used in a corrosive environment unless some form of protective coating is used. (S. Kalpakjian et al, 2006)

Table 2.3: Mechanical properties of mild steel (AISI 1020)

Properties	Value
Density (× 1000 kg/m^3)	7.7-8.03
Poisson's Ratio	0.27-0.30
Elastic Modulus (GPa)	190-210
Tensile Strength (MPa)	393
Yield Strength (MPa)	294
Elongation (%)	36
Hardness (HB500)	66
Shear Strength (MPa)	111
Impact Strength (J)	123.4

2.7 RESPONSE SURFACE METHOD (RSM)

Response Surface Methodology (RSM) is a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes. The most extensive applications of RSM are in the particular situations where several input variables potentially influence some performance measure or quality characteristic of the process. Thus performance measure or quality characteristic is called the response. The input variables are sometimes called independent variables, and they are subject to the control of the scientist or engineer. The field of response surface methodology consists of the experimental strategy for exploring the space of the process or independent variables, empirical statistical modeling to develop an appropriate approximating relationship between the yield and the process variables, and optimization methods for finding the values of the process variables that produce desirable values of the response. In this report we will concentrate on the second strategy statistical modeling to develop an appropriate approximating model between the response y and independent variable $\xi_1, \xi_2, ..., \xi_k$.

In general, the relationship is

$$y = f(\xi_1, \xi_2, ..., \xi_k) + \varepsilon \; ; \qquad (1.1)$$

Where the form of the true response function f is unknown and perhaps very complicated, and ε is a term that represents other sources of variability not accounted for in f. Usually ε includes effects such as measurement error on the response, background noise, the effect of other variables, and so on. Usually ε is treated as a statistical error, often assuming it to have a normal distribution with mean zero and variance σ^2. Then

$$E(y) = \eta = E[f(\xi_1, \xi_2, \ldots, \xi_k)] + E(\varepsilon) = f(\xi_1, \xi_2, \ldots, \xi_k); \quad (1.2)$$

The variables $\xi_1, \xi_2, \ldots, \xi_k$ in Equation (1.2) are usually called the natural variables, because they are expressed in the natural units of measurement, such as degrees Celsius, pounds per square inch, etc. In much RSM work it is convenient to transform the natural variables to coded variables $x_1, x_2, \ldots, x_k$, which are usually defined to be dimensionless with mean zero and the same standard deviation. In terms of the coded variables, the response function (1.2) will be written as

$$\eta = f(x_1, x_2, \ldots, x_k); \quad (1.3)$$

Because the form of the true response function f is unknown, we must approximate it. In fact, successful use of RSM is critically dependent upon the experimenter's ability to develop a suitable approximation for f. Usually, a low-order polynomial in some relatively small region of the independent variable space is appropriate. In many cases, either a first-order or a second-order model is used. (Khaider, 2010)

The first-order model is likely to be appropriate when the experimenter is interested in approximating the true response surface over a relatively small region of the independent variable space in a location where there is little curvature in f. For the case of two independent variables, the first-order model in terms of the coded variables is

$$\eta = \beta_o + \beta_1 x_1 + \beta_2 x_2; \quad (1.4)$$

The form of the first-order model in Equation (1.4) is sometimes called a main effects model, because it includes only the main effects of the two variables x_1 and x_2. If there is an interaction between these variables, it can be added to the model easily as follows:

$$\eta = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 \; ; \qquad (1.5)$$

This is the first-order model with interaction. Adding the interaction term introduces curvature into the response function.

Often the curvature in the true response surface is strong enough that the first-order model (even with the interaction term included) is inadequate. A second-order model will likely be required in these situations. This model would likely be useful as an approximation to the true response surface in a relatively small region. The second-order model is widely used in response surface methodology for several reasons:

1. The second-order model is very flexible. It can take on a wide variety of functional forms, so it will often work well as an approximation to the true response surface.
2. It is easy to estimate the parameters (the β's) in the second-order model. The method of least squares can be used for this purpose.
3. There is considerable practical experience indicating that second-order models work well in solving real response surface problems.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss further the study of performance of coated carbide cutting tool in term of surface roughness and tool life. In this chapter contain description of any process that is involved while run this project. This methodology is important because to ensure this project run smoothly and the objective will achieve. In order to make sure this methodology success, it is necessary to follow the entire step.

3.2 WORK PIECE PREPARATION

This project starts with preparation of material. Two type of material are cut into exact parameter before it's can be used for milling.

3.2.1 Type of work piece

There are two type of material use in this project which are aluminum alloy and mild steel. Their properties are state below.

Table 3.1: Aluminum alloy and mild steel properties

Properties	Aluminum alloy	Mild steel
Density (×1000 kg/m^2)	2.7	7.7-8.03
Poisson's Ratio	0.33	0.27-0.30
Elastic Modulus (GPa)	70-80	190-210
Tensile Strength (Mpa)	115	393
Yield Strength (MPa)	48	294
Hardness (HB)	30	111

3.2.2 Material parameter

Both of aluminum and mild steel use same size as below.

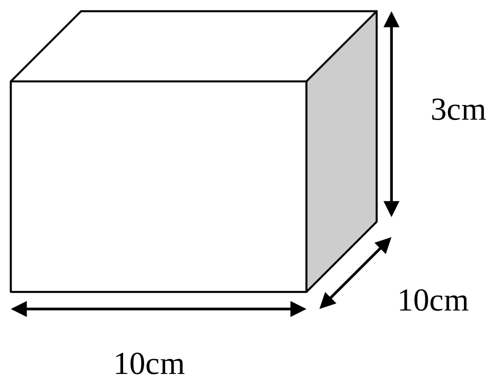

Figure 3.1: Size of material

3.3 EXPERIMENT PARAMETER

Cutting parameter can determined after generate by Minitab software. The cutting parameter that used in this experiment are cutting speed, feed rate and depth of cut. The value of all the parameter show as Table 3.2.

Table 3.2: Cutting parameter

Factor	Aluminum Alloy (T6061)	Mild Steel (AISI1020)
A-speed (m/min)	140~250	90~150
B-feed (mm/tooth)	0.02~0.10	0.02~0.10
C-depth cut (mm)	1.0~2.0	1.0~2.0

3.4 DESIGN OF EXPERIMENT

The design of experiment used in this project is Response surface methodology, it can be simplified huge number of experiments where it saves time and the cost of the experiments. Response surface methodology (RSM) is a combination of experimental and regression analysis and statistical inferences. BBD, Box-Behnken Design is used that do not have axial points, thus can be sure that all design points fall within the safe operating. The Box-Behnken Design method has been done with using Minitab software . Preliminary tests were carried out to find the suitable cutting speed, feed and depth of cut.

MINITAB software can be used determine the prediction data that we want to optimize. Minitab 15 is statistical software used for Six Sigma and other data-driven quality improvement programs, as well as statistics education. The package features comprehensive and powerful statistical methods with the ability to assign formulas to columns in the worksheet. From the minitab software also, linear graph, contour plot, surface plot and full quadratic graph are generated. The parameter that we generate from minitab software are illustrate as table 3.3 and table 3.4.

Table 3.3: Cutting parameter of Mild Steel (AISI1020)

No of Experiment	Cutting Speed (m/min)	Feed (mm/tooth)	Depth of cut (mm)	Surface Roughness (Ra)
1	120	0.1	1	
2	120	0.06	1.5	
3	120	0.06	1.5	
4	120	0.1	2	
5	90	0.06	2	
6	150	0.1	1.5	
7	150	0.06	2	
8	120	0.06	1.5	
9	90	0.02	1.5	
10	150	0.06	1	
11	120	0.02	2	
12	150	0.02	1.5	
13	90	0.1	1.5	

14	120	0.02	1	
15	90	0.06	1	

Table 3.4: Cutting parameter of Aluminium Alloy (AA6061)

No of Experiment	Cutting Speed (m/min)	Feed (mm/tooth)	Depth of cut (mm)	Surface Roughness (Ra)
1	195	0.1	1	
2	195	0.06	1.5	
3	195	0.06	1.5	
4	195	0.1	2	
5	140	0.06	2	
6	250	0.1	1.5	
7	250	0.06	2	
8	195	0.06	1.5	
9	140	0.02	1.5	
10	250	0.06	1	
11	195	0.02	2	
12	250	0.02	1.5	
13	140	0.1	1.5	
14	195	0.02	1	
15	140	0.06	1	

3.5 MACHINING PROCES

After collected enough information about work piece and CNC machine, the project continues with preparing aluminium and mild steel work piece. In this part, band saw machine had been used for purpose to cut the raw work piece into three pieces of each aluminium alloy and mild steel with dimension 100x100x30mm each. The surface finished are rough and wavy, it will affected the result of the experiment so its need to flat so it will underdo one more machining process. The process is face milling in purpose to get rid rough and wavy surface.

Figure 3.2: Cut the material into pieces by using band saw Machine

Figure 3.4: Face milling used to rid out rough and wavy surface

After the preparations of work piece are completed, the progress will proceed into most important part of this project which is machining process. In this project, end milling is chosen because it important application in industry, after clamps the work piece properly into the CNC milling machine, the experiment was started with specific combination of cutting speed, feed and depth of cut. We run four different combination of machining parameter at one surface because of the size of end milling cutting tool just around 15mm so number of work piece can be reduce. After end milling process was completed, the surface finished are going to test by using Mpi Mhar Perthometer and the data was collected to analyze.

Figure 3.5: Experiment is running by using CNC milling machine

Figure 3.6: Finished product and ready to test

Figure 3.7: Test surface roughness by using Mpi Mhar Perthometer

3.6 RESULT ANALYSIS

The surface roughness, Ra data obtained from the experiment are going to analyze by using minitab software. The significant factors can be determined and several contour and surface graph will generate as consequent from the analysis . then, from the graph, the relationship between those parameter and the surface roughness can be determined. Also a graph of comparison the performance of the cutting between Aluminium Alloy AA6061 and Mild Steel AISI1020 will be construc to help identified the difference of their performance.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter present about the final results of surface roughness, Ra collected from the experiment. The detail of the experiment from the beginning until obtained those result have been discussed thoroughly by the previous chapter. The main objective of this chapter is to determine the best machining parameter in order to get the better surface roughness. The machining parameters are cutting speed, feed and depth of cut. The significant factor and non-significant factor of the machining factor also can be determined using the analysis of variance (ANOVA).

4.2 RESULTS OF SURFACES ROUGHNESS, Ra

Under this topic, it will focus in analyzing the results that obtained from the experiments before. The experiment data gained from the Mpi Mahr Perthometer came in many types of data such as Ra, Rz, Rmax but only Ra was considered the focus value of output and used in analysis. The reading was taken three times and the mean value was calculated to ensure the data is accurate. Obtained data from 15 experiments of both Mild Steel (AISI1020) and Aluminum Alloy (AA6061) are illustrated in table 4.1 and 4.2 below.

Table 4.1: Surface roughness, Ra of Aluminum Alloy (AA6061)

No of Experiment	Cutting Speed (mm/min)	Feed (mm/tooth)	Depth of Cut (mm)	Surface Roughness, Ra
1	195	0.1	1	0.255
2	195	0.06	1.5	0.25
3	195	0.06	1.5	0.253
4	195	0.1	2	0.579
5	140	0.06	2	0.415
6	250	0.1	1.5	0.394
7	250	0.06	2	0.368
8	195	0.06	1.5	0.278
9	140	0.02	1.5	0.216
10	250	0.06	1	0.221
11	195	0.02	2	0.187
12	250	0.02	1.5	0.18
13	140	0.1	1.5	0.49
14	195	0.02	1	0.191
15	140	0.06	1	0.324

Table 4.2: Surface Roughness, Ra of Mild Steel (AISI1020)

No of Experiment	Cutting Speed (mm/min)	Feed (mm/tooth)	Depth of Cut (mm)	Surface Roughness, Ra
1	120	0.1	1	0.455
2	120	0.06	1.5	0.34
3	120	0.06	1.5	0.336
4	120	0.1	2	0.56
5	90	0.06	2	0.501
6	150	0.1	1.5	0.45
7	150	0.06	2	0.435
8	120	0.06	1.5	0.403
9	90	0.02	1.5	0.339
10	150	0.06	1	0.376
11	120	0.02	2	0.26
12	150	0.02	1.5	0.233
13	90	0.1	1.5	0.478
14	120	0.02	1	0.286
15	90	0.06	1	0.34

4.3 ANALYSIS IN IDENTIFYING THE SIGNIFICANT FACTOR

There are several methods can be used to identifying significant factor that mostly contribute to the surface roughness. In this project, analysis of variance (ANOVA) has been used to determine the significant factor. Several graph and table will be constructed as the result from this analysis. The table analysis of variance for both Mild Steel (AISI1020) and Aluminum Alloy (AA6061) are illustrated as shows below.

Tabled 4.3: Estimated Regression Coefficients for Ra of Aluminum Alloy (AA6061)

Term	Coef	SE Coef	T	P
Constant	**0.04546**	**0.104995**	**0.433**	**0.673**
cutting speed	-0.00064	0.000387	-1.657	0.126
feed	2.95000	0.531894	5.546	0.000
depth of cut	0.13950	0.042552	3.278	0.007

Base from table 4.3, the P value for each term below is list as below;

P(cutting speed) = 0.126 > 0.05 insignificant

P(feed) = 0.000 < 0.05 significant

P(depth of cut) = 0.007 < 0.05 significant

Values of P less than 0.005 indicate model terms are significant, in this case feed and depth of cut are significant.

Table 4.4: Analysis of Variance for Ra of Aluminum Alloy (AA6061)

Source	Degree of Freedom	Seq SS	Adj SS	Adj MS	F	P
Regression	3	0.160253	0.160253	0.053418	14.75	0.000
Linear	3	0.160253	0.160253	0.053418	14.75	0.000
Residual Error	11	0.039834	0.039834	0.003621		
Lack-of-Fit	9	0.039361	0.039361	.004373	18.51	0.052
Pure Error	2	0.000473	0.000473	0.000236		
Total	14	0.200087				

S = 0.0601770 PRESS = 0.0784203

R-Sq = 80.09% R-Squared(pred) = 60.81% R-Squared(adj) = 74.66%

The "R-Squared(pred)" of 60.81% is in reasonable agreement with the "R-Squared(adj)" of 74.66%. The "Lack of Fit P-value" of 0.052 implies the Lack of Fit is not significant relative to the pure error but non-significant of lack of fit is good.

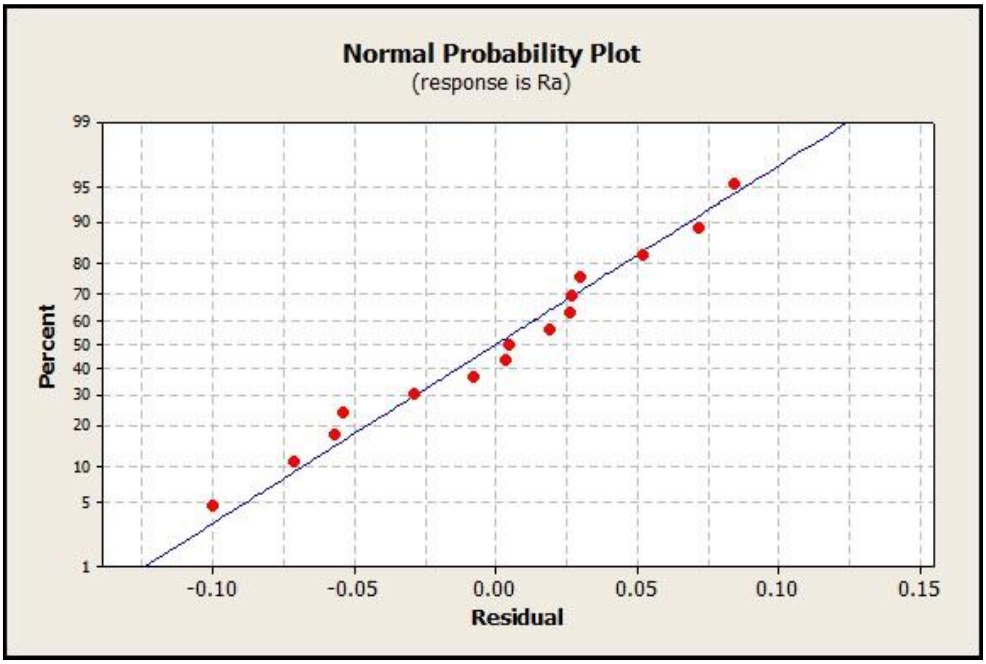

Figure 4.1: Normal Probability Plot of Aluminum Alloy (AA6061)

Table 4.5: Estimated Regression Coefficients for Ra of Mild Steel (AISI1020)

Term	Coef	SE Coef	T	P
Constant	0.20132	0.083762	2.403	0.035
cutting speed	-0.00068	0.000530	-1.290	0.224
feed	2.57813	0.397278	6.489	0.000
depth of cut	0.07475	0.031782	2.352	0.038

Base from table 4.5, the P value for each term below is list as below;

P(cutting speed) = 0.224 > 0.05 insignificant

P(feed) = 0.000 < 0.05 significant

P(depth of cut)= 0.038 < 0.05 significant

Values of P less than 0.005 indicate model terms are significant, in this case feed and depth of cut are significant.

Table 4.6: Analysis of Variance for ra for Mild Steel (AISI1020)

Source	Degree of Freedom	Seq SS	Adj SS	Adj MS	F	P
Regression	3	0.099615	0.099615	0.053418	16.44	0.000
Linear	3	0.099615	0.099615	0.053418	16.44	0.000
Residual Error	11	0.022222	0.022222	0.003621		
Lack-of-Fit	9	0.019398	0.019398	.004373	1.53	0.458
Pure Error	2	0.002825	0.002825	0.000236		
Total	14	0.121838				

S = 0.0449469 PRESS = 0.0426966

R-Sq = 81.76% R-Sq(pred) = 64.96% R-Sq(adj) = 76.79%

The "R-Squared(pred)" of 64.96% is in reasonable agreement with the "R-Squared(adj)" of 76.79%. The "Lack of Fit P-value" of 0.458 implies the Lack of Fit is not significant relative to the pure error but non-significant of lack of fit is good.

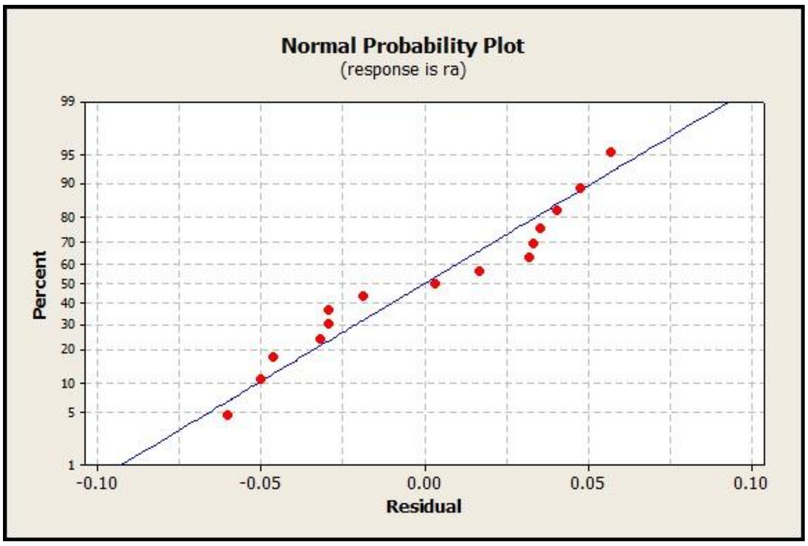

Figure 4.2: Normal Probability Plot of Mild Steel (AISI1020)

4.4 COMPARISON OF SURFACE ROUGHNESS OF MILD STEEL AND ALUMINIUM ALLOY

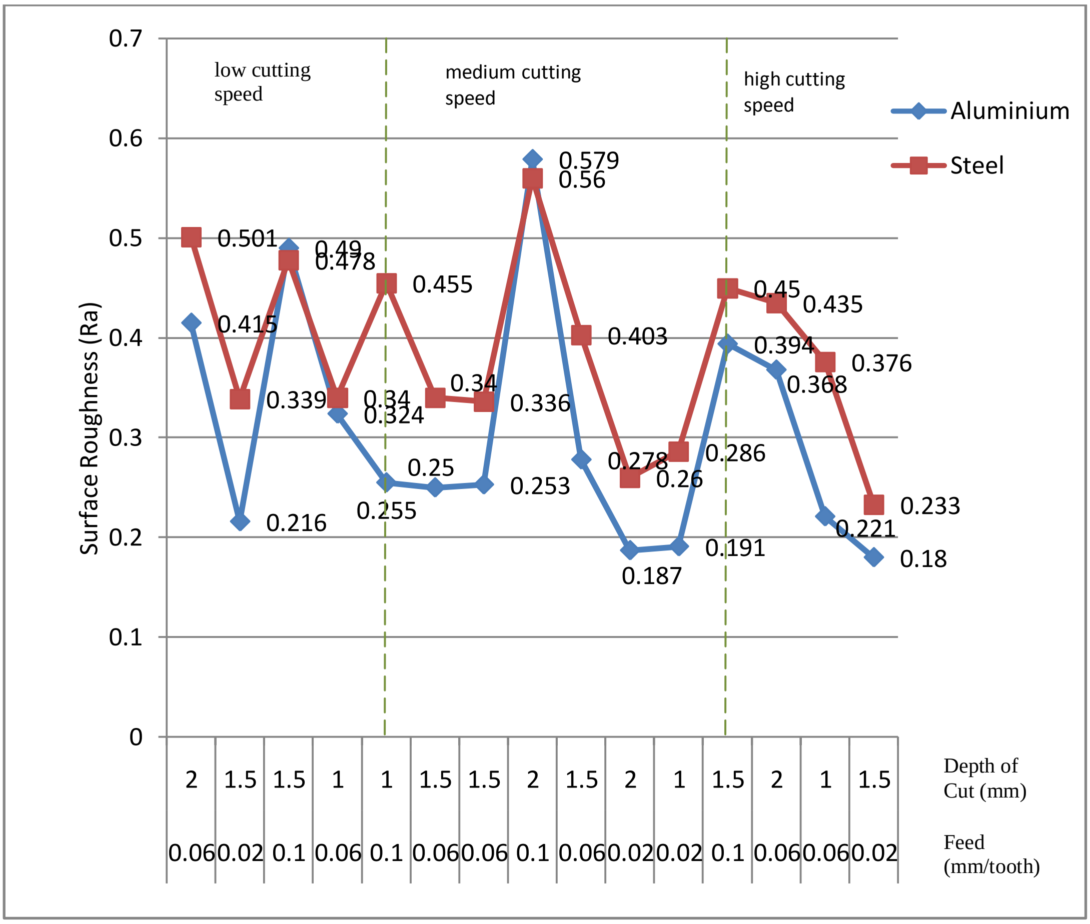

Figure 4.3: Comparison of Surface Roughness for Mild Steel and Aluminum Alloy

Figure 4.3 represent the comparison of experimental data of surface roughness between Aluminum Alloy T6061 and Mild Steel AISI1020 which has been prepared in accordance with the level of cutting speed. From the graph, it obviously show the Aluminium AA6061 has the better surface finish than Mild Steel AISI1020 in overall except for only two experiment data, when the depth of cut is 1.5mm and feed is 0.1mm/tooth also when the depth is 2mm and feed is 0.1 mm/tooth, the surface roughness of Aluminum is slightly higher than Mild Steel. As the result, the cutting tool performs better when it's machining Aluminum Alloy AA6061 than Mild Steel AISI 1020.

As state previously, depth of cut and feed are significant factor, giving the greatest effect to the surface roughness, Ra. Base on the figure, the finest surface roughness, Ra for Aluminum Alloy (AA6061) happened when the depth of cut was 1.5 mm , feed at 0.02 mm/tooth and cutting speed at 250 mm/min, and the worst surface roughness, Ra for Aluminum Alloy (AA6061) happened when the depth of cut 2 mm, feed at 0.1 mm/tooth and cutting speed at 195 mm/min. Meanwhile, the optimum parameter in order to get the finest surface roughness, Ra for Mild Steel (AISI1020) happened when the depth of cut was 1.5 mm, feed at 0.02 mm/tooth and cutting speed at 150 mm/min, and the worst surface roughness, Ra for Mild Steel (AISI1020) occurred when the depth of cut was 2 mm, feed at 0.1 mm/tooth and cutting speed at 120 mm/min.

4.5 SURFACE PLOT AND CONTOUR PLOT

In this topic, surface plot and contour plot are illustrated to show the effects of every parameter that causes the condition of surface roughness, Ra. These effects are further explained with help of response surface plot as shown in figure 4.4 to figure 4.22.

4.5.1 Surface Plot and Contour for Aluminum Alloy T6061

Based on figure 4.4(a), the dark blue colour indicate the finest surface finish and the dark green colour indicate the worst surface finish for hold values depth of cut is 2 mm and for the figure 4.4(b), the highest position in the graph represent the highest value of surface roughness and otherwise. From the pattern of the contour graph show value of surface roughness increase when the value of feed is increase. It’s also happen with the decreasing value of cutting speed. This conclusion also can be applied to figure 4.5 and figure 4.6.

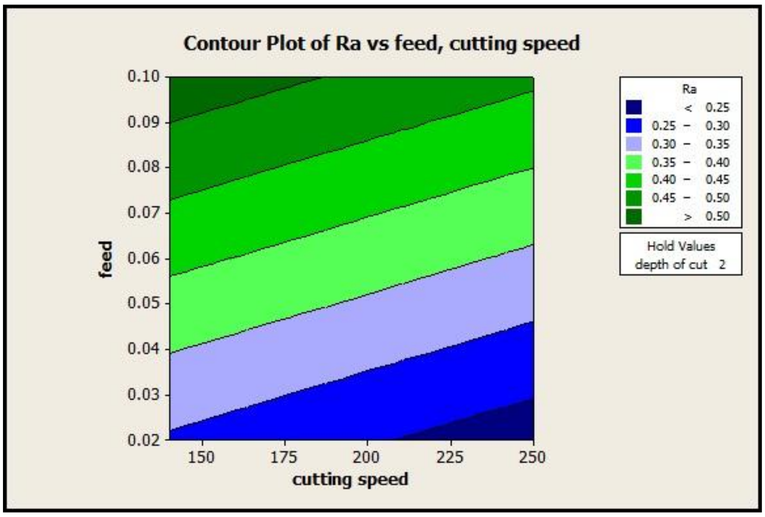

Figure 4.4(a): Contour Plot of hold extra factor at high setting of Ra vs feed, cutting speed

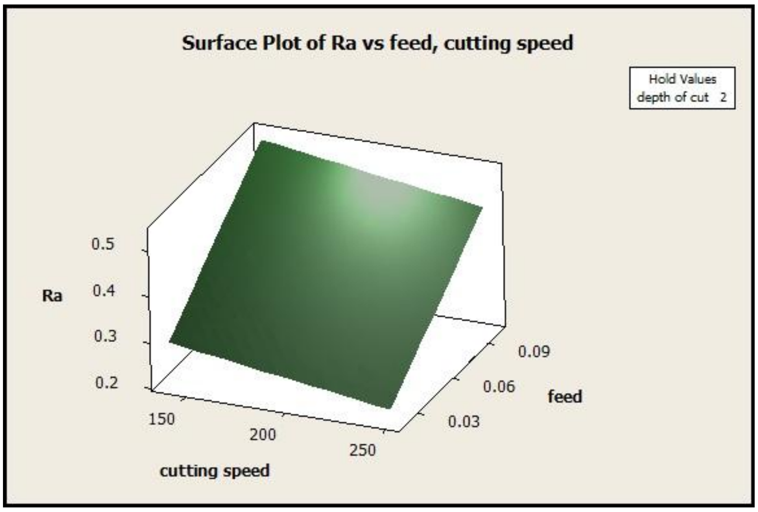

Figure 4.4(b): Surface Plot for hold extra factor at high setting of Ra vs feed, cutting speed

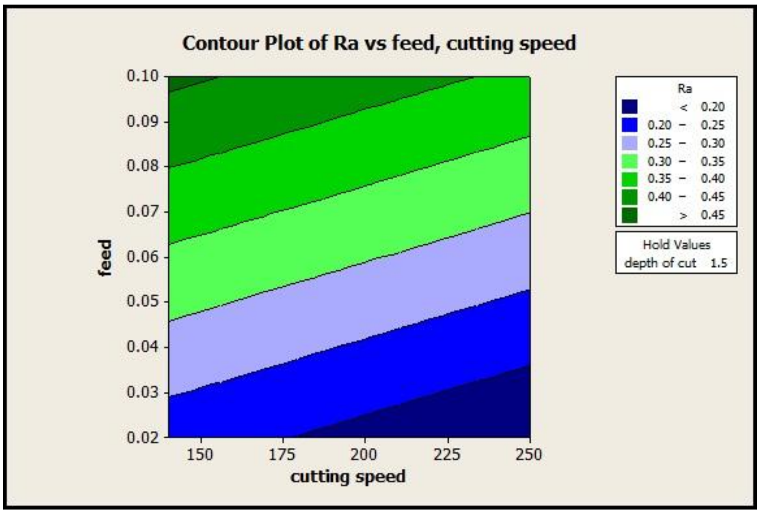

Figure 4.5(a): Contour Plot for hold extra factor at middle setting of Ra vs feed, cutting speed

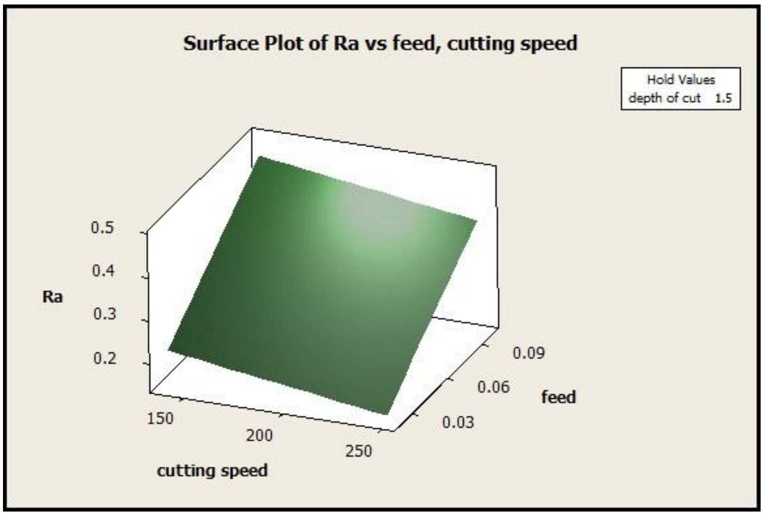

Figure 4.5(b): Surface Plot for hold extra factor at middle setting of Ra vs feed, cutting speed

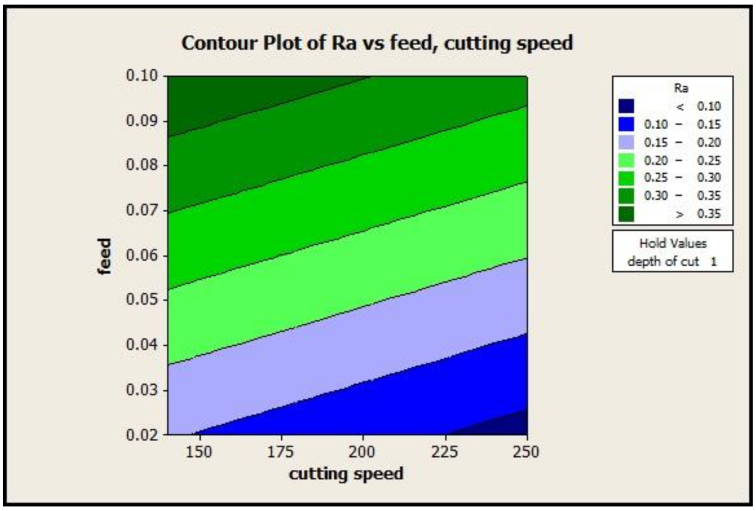

Figure 4.6(a): Contour Plot for hold extra factor at low setting of Ra vs feed, cutting speed

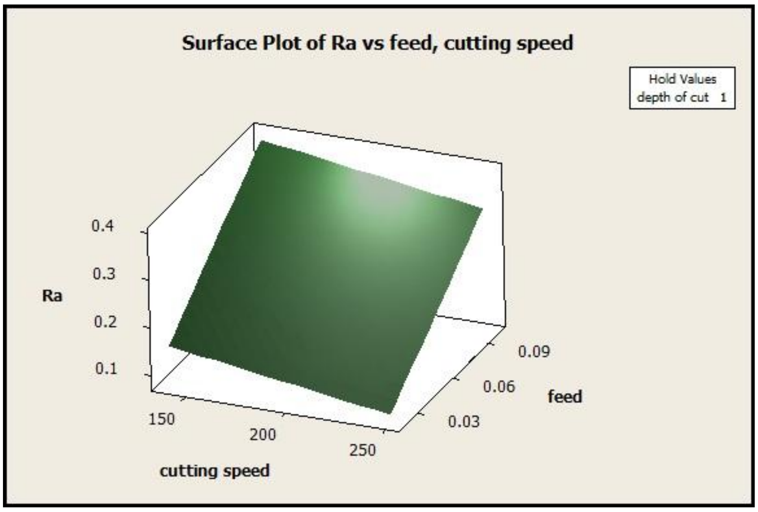

Figure 4.6(b): Surface Plot for hold extra factor at low setting of Ra vs feed, cutting speed

From figure 4.7 until figure 4.9, value of surface roughness are illustrate by colour difference, brighter the green colour means smoother the surface finish. It show when the depth of cut increase, the value of surface roughness also increase but the value of surface roughness is decrease with the decreasing of value of cutting speed.

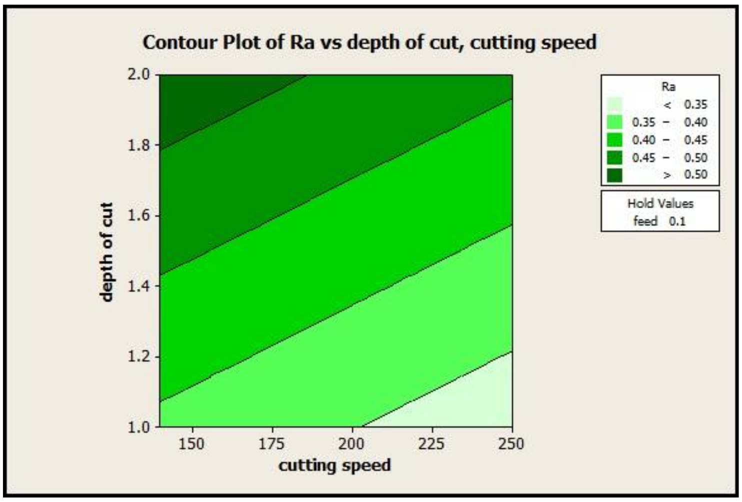

Figure 4.7(a): Contour Plot for hold extra factor at high setting of Ra vs depth of cut, cutting speed

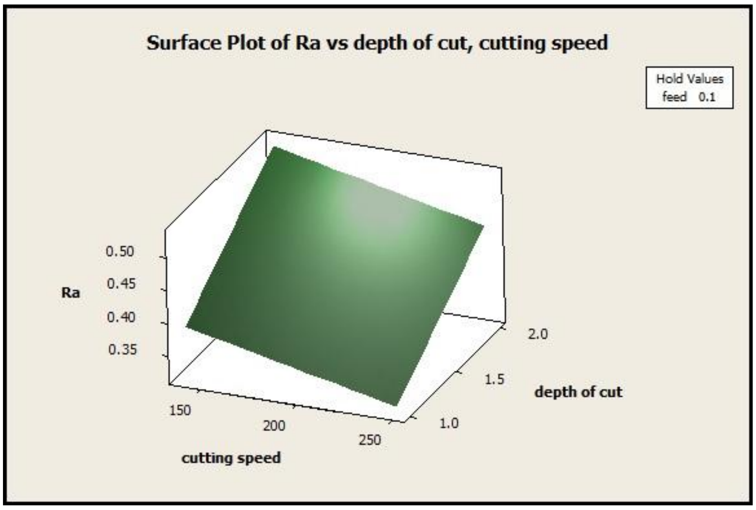

Figure 4.7(b): Surface Plot for hold extra factor at high setting of Ra vs depth of cut, cutting speed

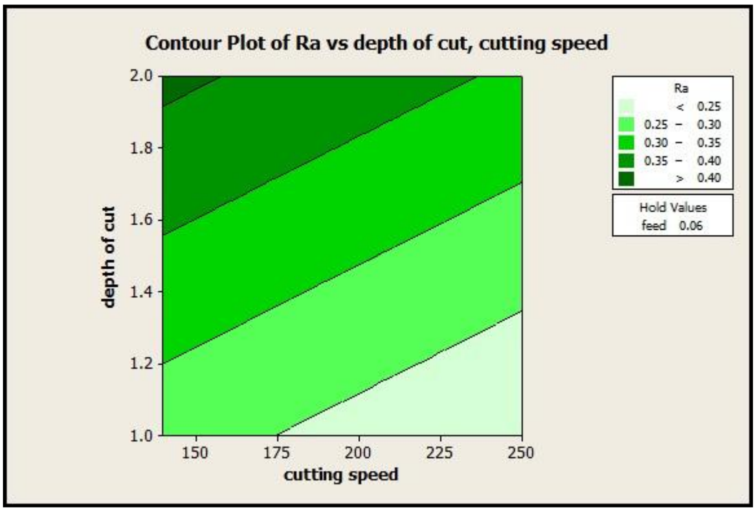

Figure 4.8(a): Contour Plot for hold extra factor at middle setting of Ra vs depth of cut, cutting speed

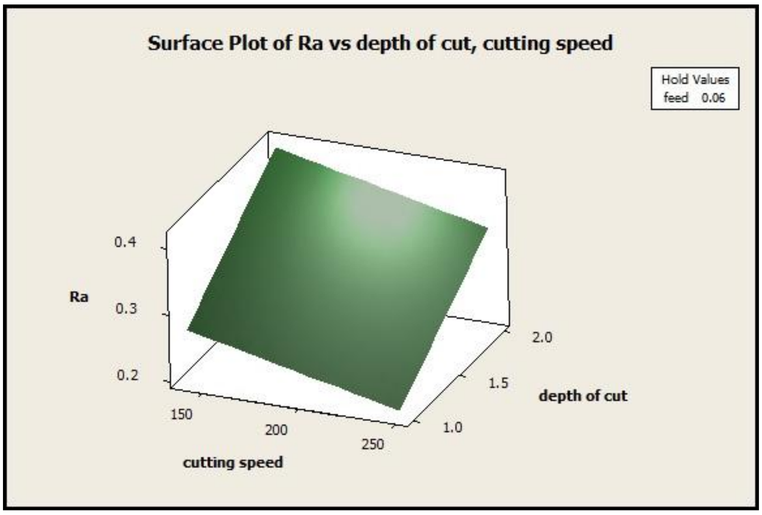

Figure 4.8(b): Surface Plot for hold extra factor at middle setting of Ra vs depth of cut, cutting speed

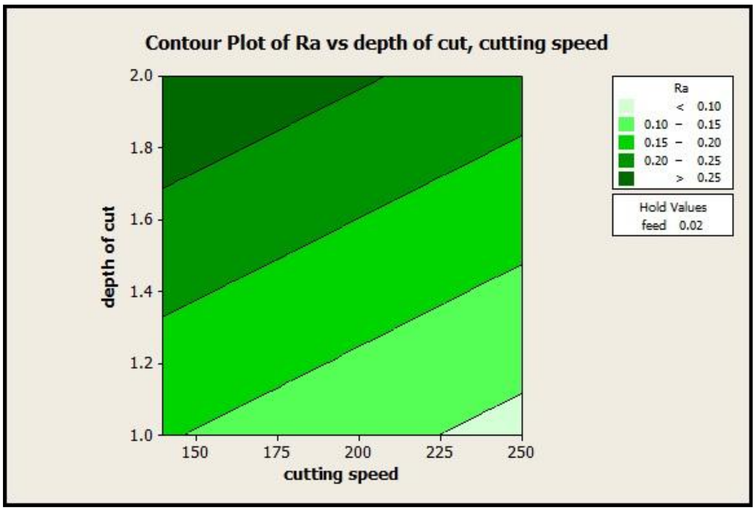

Figure 4.9(a): Contour Plot for hold extra factor at low setting of Ra vs depth of cut, cutting speed

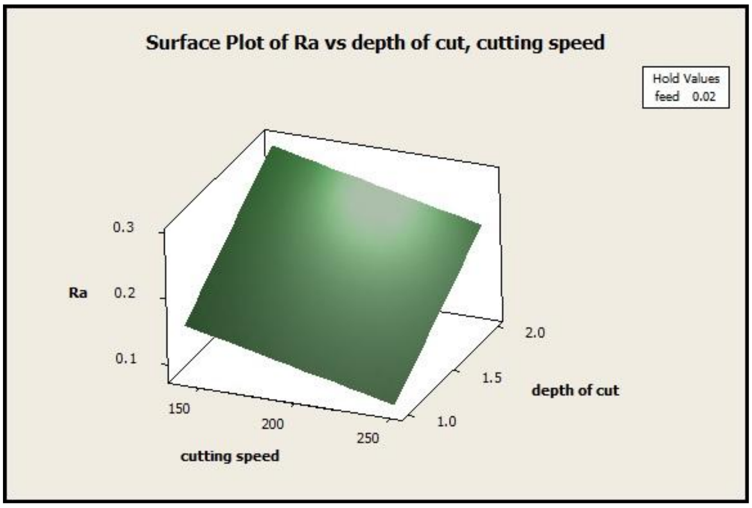

Figure 4.9(b): Surface Plot for hold extra factor at low setting of Ra vs depth of cut, cutting speed

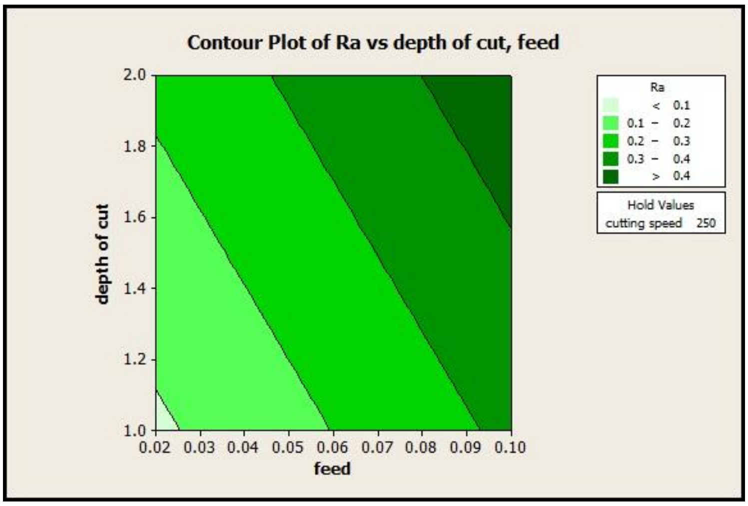

Figure 4.10(a): Contour Plot for hold extra factor at high setting of Ra vs depth of cut, feed

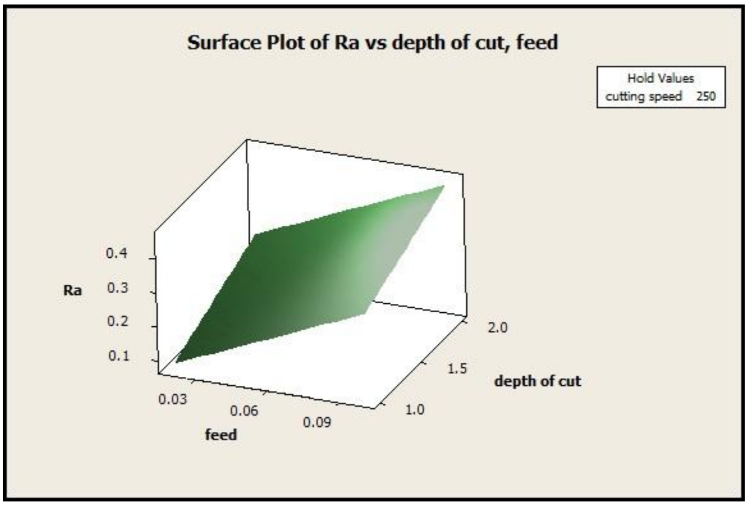

Figure 4.10(a): Contour Plot for hold extra factor at high setting of Ra vs depth of cut, feed

Based on figure 4.11 until figure 4.13, the finest surface finish is show by the darkest blue contour colour and the most rough surface represent by dark green colour. From the contour pattern, its show that the increasing of feed and depth of cut value will also increase the surface roughness value.

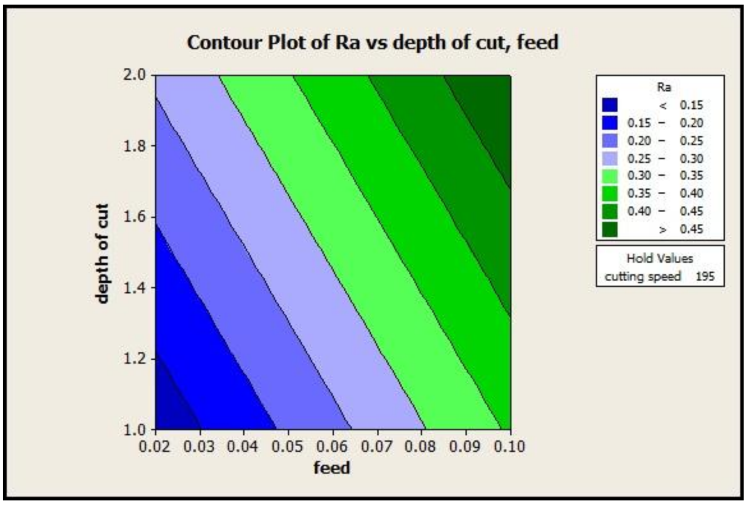

Figure 4.11(a): Contour Plot for hold extra factor at middle setting of Ra vs depth of cut, feed

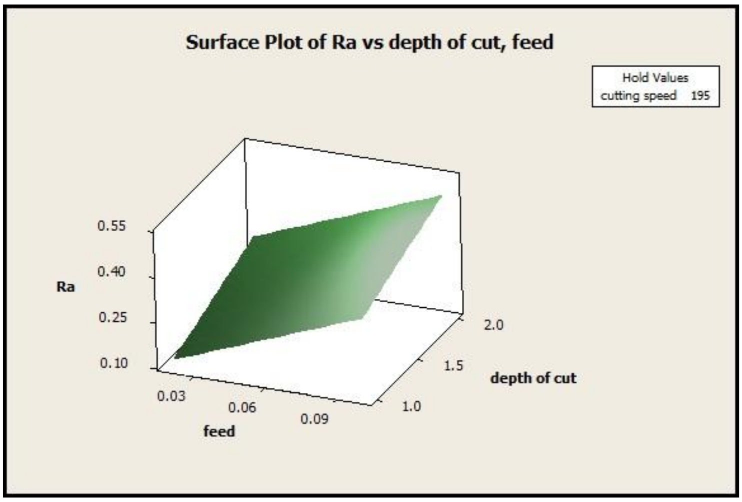

Figure 4.11(b): Surface Plot for hold extra factor at middle setting of Ra vs depth of cut, feed

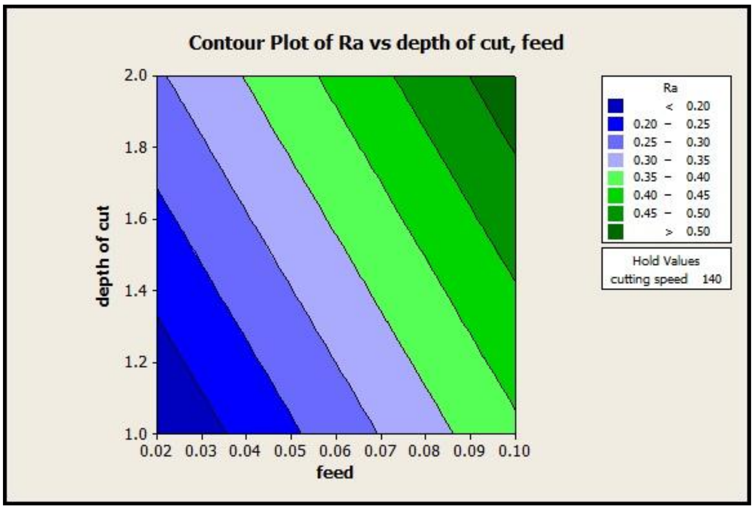

Figure 4.12(a): Contour Plot for hold extra factor at low setting of Ra vs depth of cut, feed

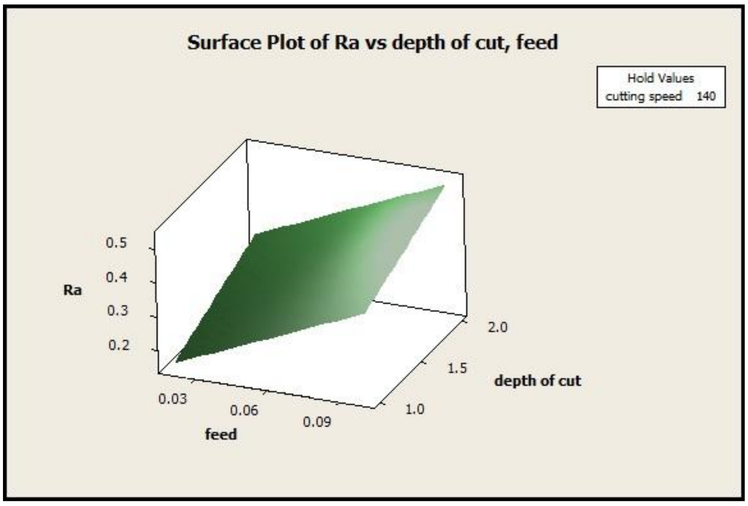

Figure 4.12(b): Surface Plot for hold extra factor at low setting of Ra vs depth of cut, feed

4.5.2 Surface plot and Contour plot for Mild Steel (AISI1020)

Figure 4.13 till figure 4.15 represent the graph of surface roughness versus feed and cutting speed. The brighter the green colour the smoother the surface finishes. It means when the feed is increase, the surface roughness also increase but it's opposite to the cutting speed.

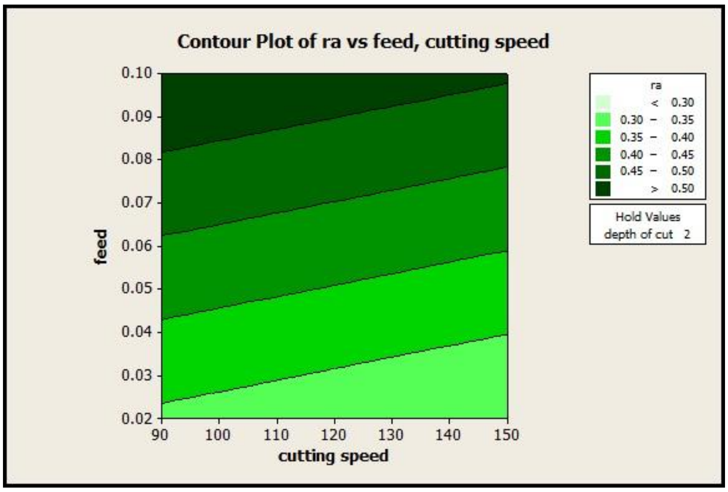

Figure 4.13(a): Contour Plot for hold extra factor at high setting of Ra vs feed, cutting speed

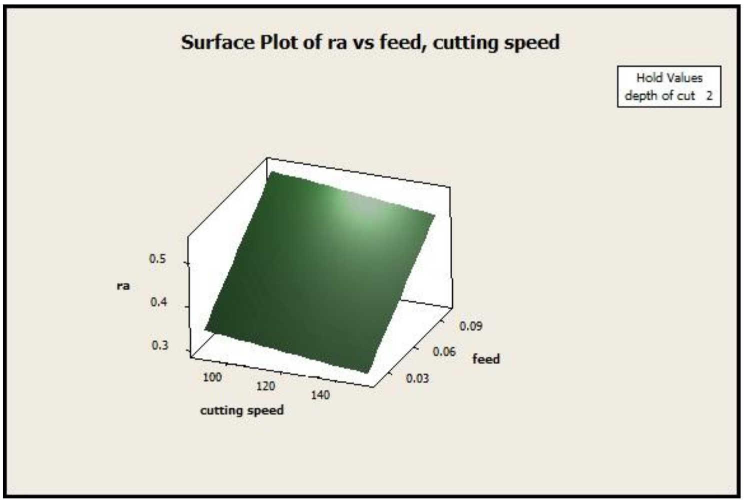

Figure 4.13(b): Contour Plot for hold extra factor at high setting of Ra vs feed, cutting speed

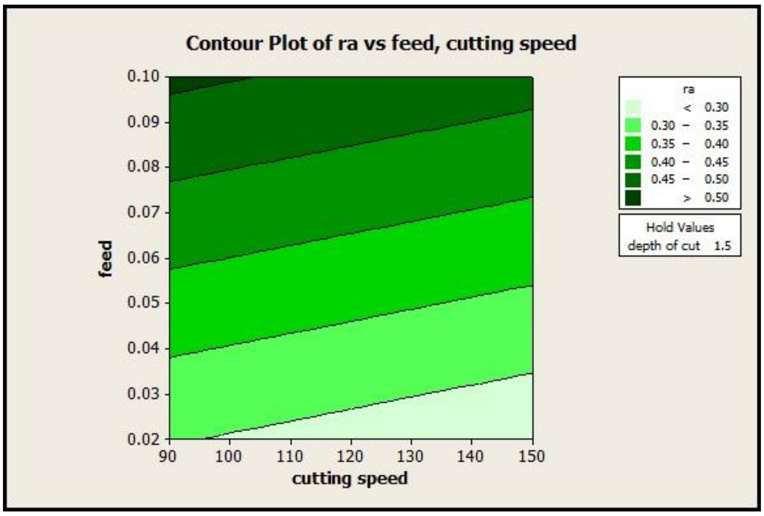

Figure 4.14(a): Contour Plot for hold extra factor at middle setting of Ra vs feed, cutting speed

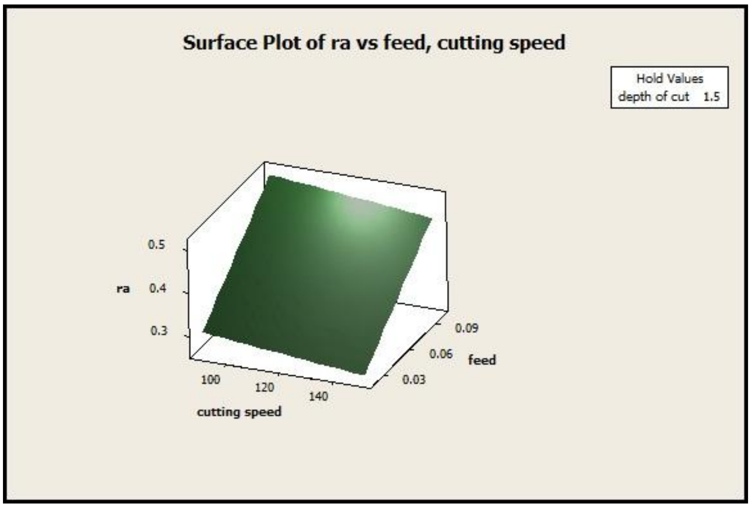

Figure 4.14(b): Surface Plot for hold extra factor at middle setting of Ra vs feed, cutting speed

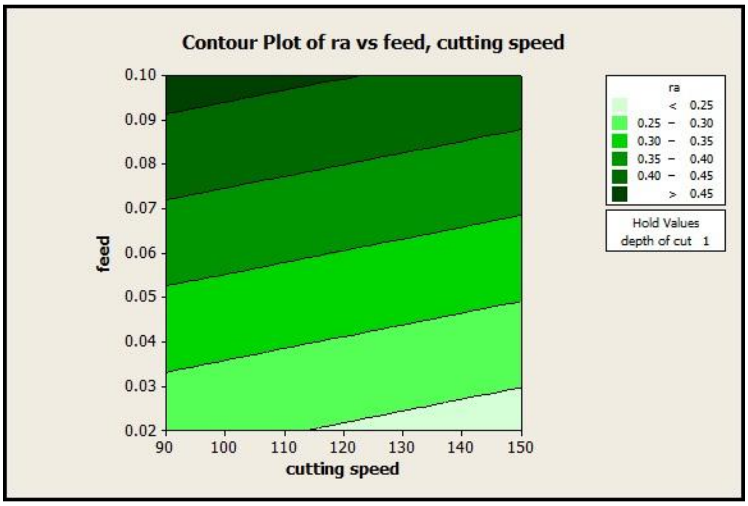

Figure 4.15(a): Contour Plot for hold extra factor at low setting of Ra vs feed, cutting speed

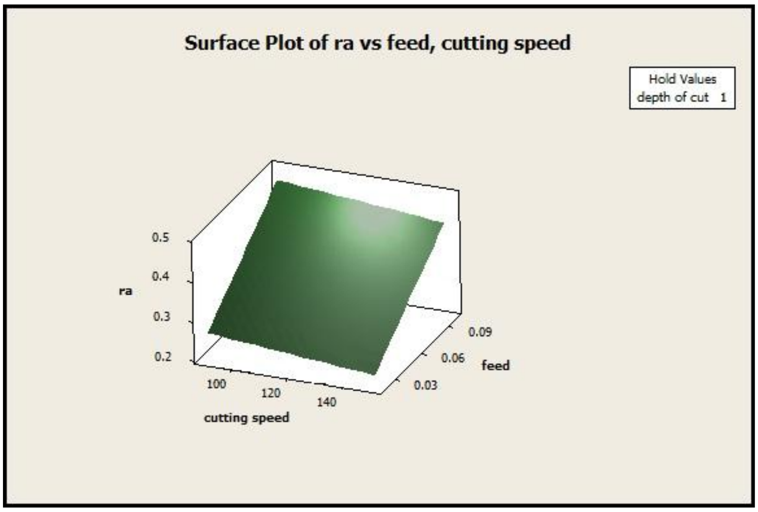

Figure 4.15(b): Surface Plot for hold extra factor at low setting of Ra vs feed, cutting speed

Figure 4.16 till figure 4.18 represent the surface roughness versus depth of cut and cutting speed. The darkest green is the higher value of surface rouhness and the darkest blue indicate as the finest surface finish. From the graph, the value of surface roughness increase with the increasing of depth of cut and decreasing of cutting speed.

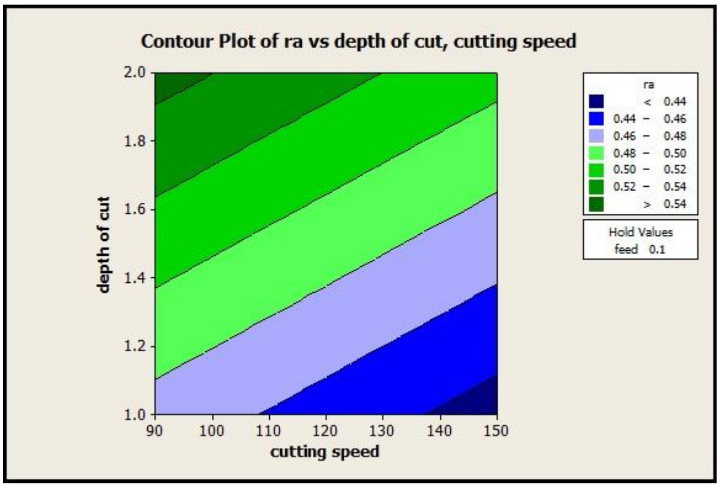

Figure 4.16(a): Contour Plot for hold extra factor at high setting of Ra vs depth of cut, cutting speed

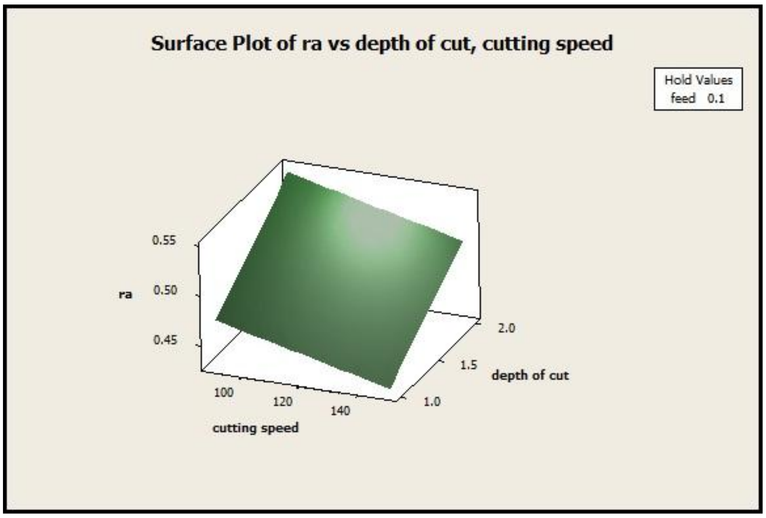

Figure 4.16(b): Surface Plot for hold extra factor at high setting of Ra vs depth of cut, cutting speed

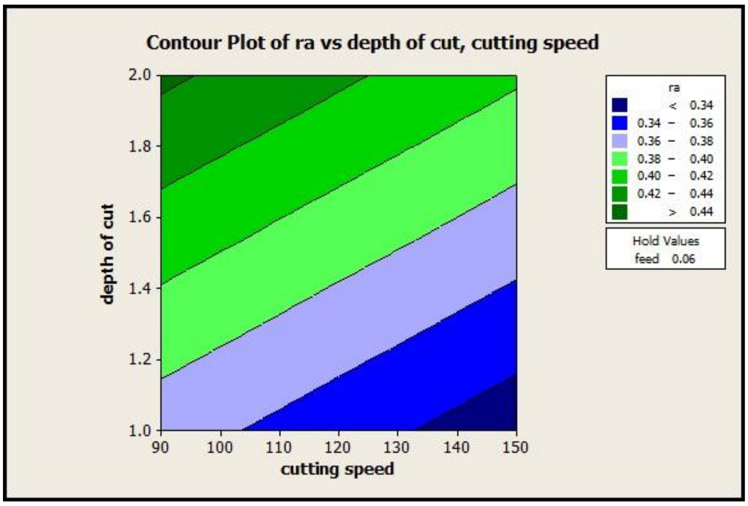

Figure 4.17(a): Contour Plot for hold extra factor at middle setting of Ra vs depth of cut, cutting speed

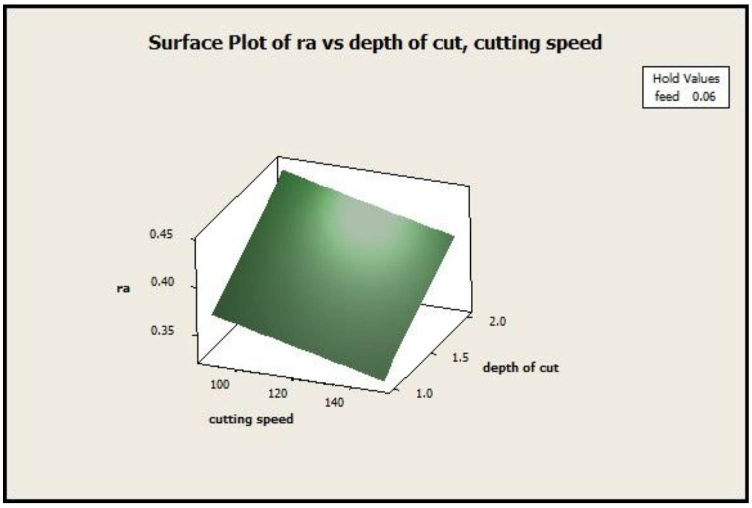

Figure 4.17(b): Surface Plot for hold extra factor at middle setting of Ra vs depth of cut, cutting speed

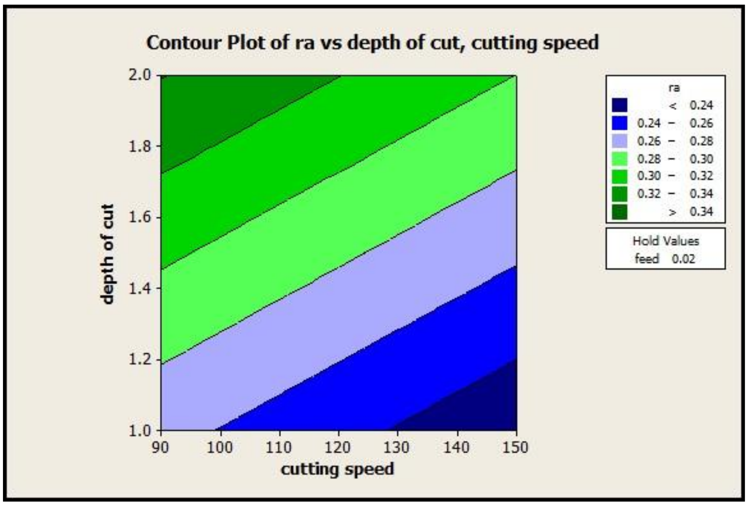

Figure 4.18(a): Contour Plot for hold extra factor at low setting of Ra vs depth of cut, cutting speed

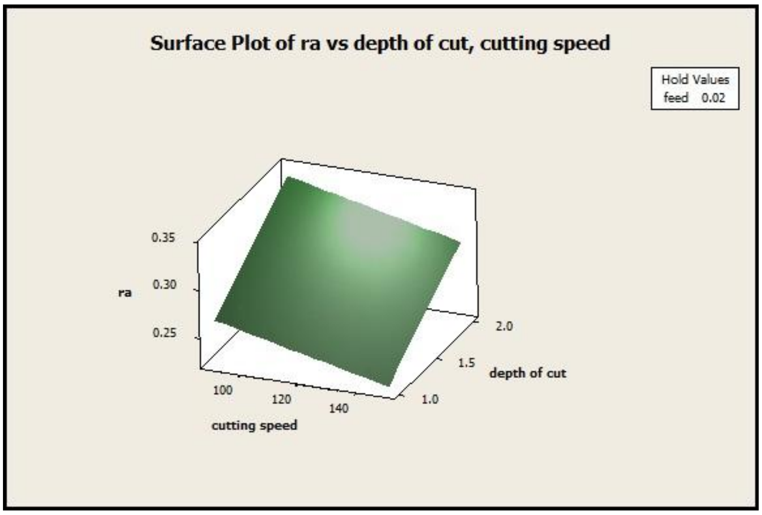

Figure 4.18(b): Surface Plot for hold extra factor at low setting of Ra vs depth of cut, cutting speed

Graph from figure 4.19 until figure 4.21 show the value of surface roughness is increase when the value of depth of cut and feed are increase. It prove by the changing colour of contour and the tendency of surface plot graph.

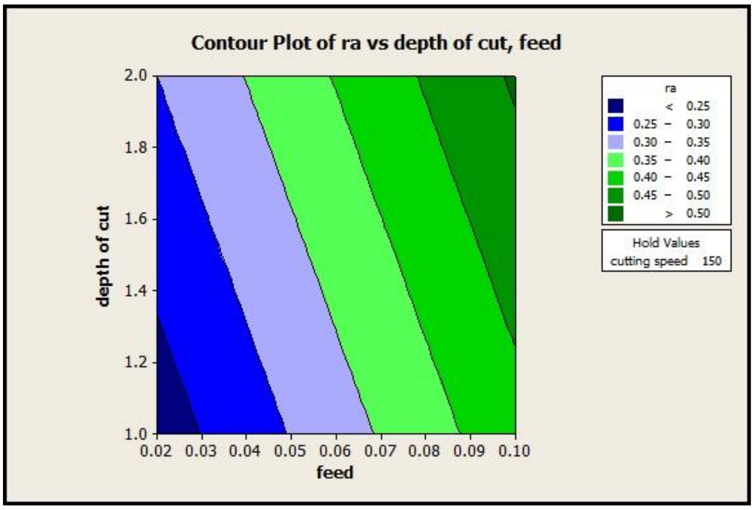

Figure 4.19(a): Contour Plot for hold extra factor at high setting of Ra vs depth of cut, feed

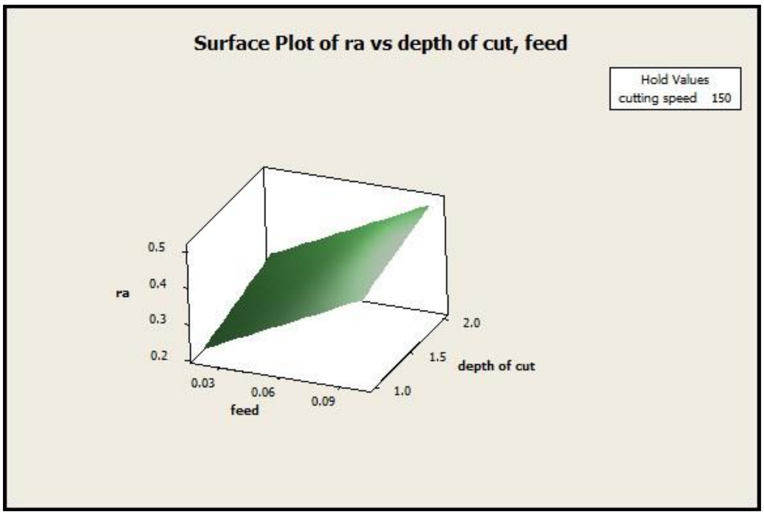

Figure 4.19(b): Surface Plot for hold extra factor at high setting of Ra vs depth of cut, feed

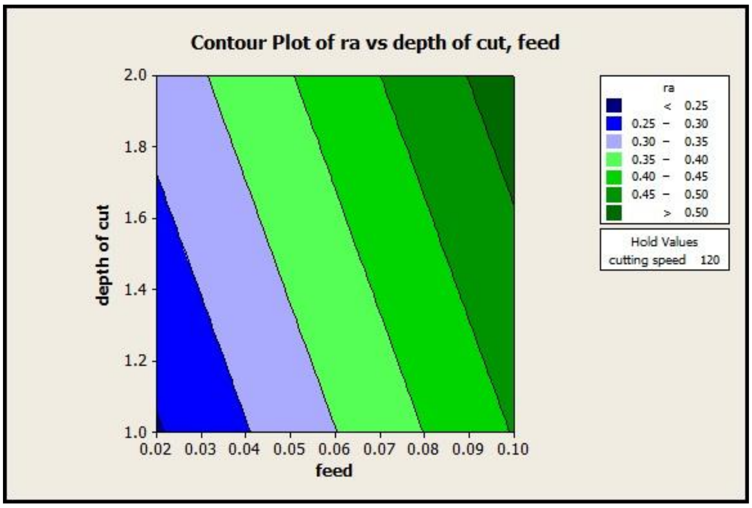

Figure 4.20(a): Contour Plot for hold extra factor at middle setting of Ra vs depth of cut, feed

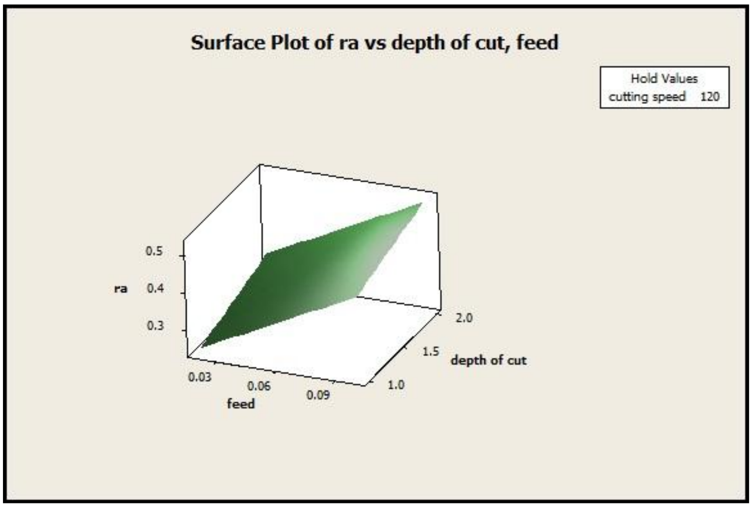

Figure 4.20(b): Surface Plot for hold extra factor at middle setting of Ra vs depth of cut, feed

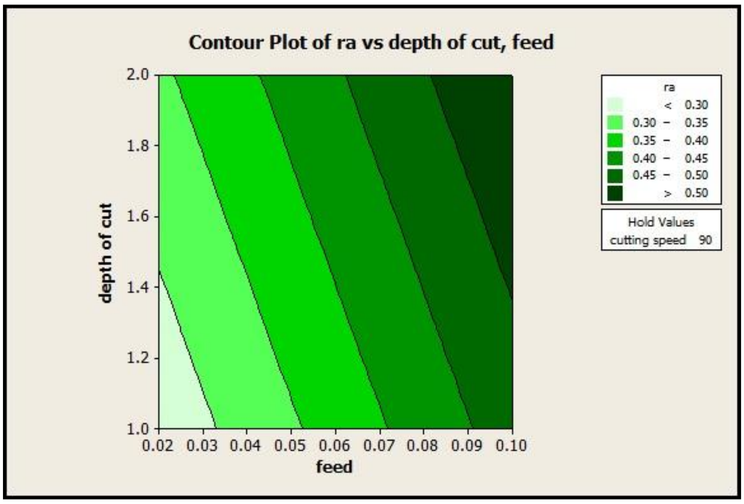

Figure 4.21(a): Contour Plot for hold extra factor at low setting of Ra vs depth of cut, feed

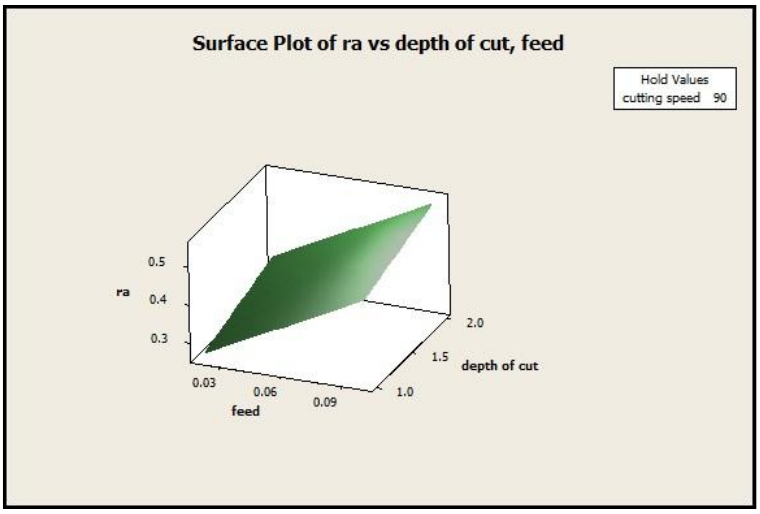

Figure 4.21(b): Surface Plot for hold extra factor at low setting of Ra vs depth of cut, feed

4.6 CONCLUSION

As illustrated in the figure 4.4 till figure 4.21, a clear formation of pattern can be seen through all of the setting of parameter. It obviously showed that the increasing of surface roughness, Ra is proportional to increase of depth of cut and feed but inversely proportional to increase of cutting speed for both of the Aluminum Alloy (AA6061) and

Mild Steel (AISI1020). The performance of cutting tool while machining Aluminium Alloy AA6061 is better than Mild Steel AISI1020 because of their finest surface finish, it prove by the figure 4.3.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This last chapter contain conclusion of the finding for this project and the recommendation base on the outcome of this project and the result as well for future reference. This chapter also contained the summarization by of overall progress taken and discussion of the project.

5.2 SUMMARY

Before this research have been done, there was problem to obtained optimum performance during milling operation, so an experimental approach on predicting surface roughness has been held by using Aluminum Alloy (AA6061) and Mild Steel (AISI1020) as the medium of this research. By using response surface method (RSM), several experiments then have been executed on this work piece with varying machining parameters which are cutting speed, feed and depth of cut. Then the data obtained at the end of machining process by sing Mpi Mhar Perthometer. This research continued with the analyzing process in purpose to determine the significant parameter by using ANOVA method and relationship between those factors by using contour graph. The analysis was run by using Minitab software. The specific combination of cutting speed, feed and depth of cut will be identified.

5.3 RECOMMENDATION

In order to get better improvement of experiment analysis in this project, there is several approaches can be done;

1. Analyze the others variable or criteria of performance such as tool life, force and torque so, we can fully understand the effect of machining parameter to the work piece.
2. Make sure the value of Rsquered is close to 100% or more than 70% to ensure the data obtained from experiment are relevant and the analysis more accurate.
3. At least one term or more got “P” value (from the table Estimated Regression Coefficients for Ra) less than 0.05 but more is better.
4. Use different insert for every experiment so the condition of cutting tool is constant and data more accurate.
5. Use liquid coolant in every experiment to prolong tool life of the insert.

5.4 CONCLUSION

This project can be classified as successfully completed and all of the objectives already been achieved which are to determine the performance of coated carbide cutting tool while machining Aluminum Alloy and Mild steel. The surface roughness finished surface after end milling was successfully obtained by Mpi Mhar Perthometer and analyze data by using Minitab 1.5 version also successful. It obviously showed from the analysis that the significant factors for producing fine surface roughness are depth of cut and feed for both of Aluminum Alloy (AA6061) and Mild Steel (AISI10120). From the analysis also show that depth of cut and feed are proportionally to the surface roughness and cutting speed is inversely proportional to the surface roughness. The ideal setting of depth of cut and feed are 1.5mm and 0.02mm/tooth for both of material. The ideal cutting speeds are 250m/min for Aluminum Alloy (AA6061) and 150m/min for Mild steel (AISI1020). The performance of coated carbide cutting tool while machining Aluminium Alloy AA6061 is better than it’s performance while machining Mild Steel AISI1020.

REFERENCES

C.H Che Haron, A. Ginting, J.HGoh. 2001. Wear The Coated and Uncoated Carbide tool in turning steel *Jourmal of Material Processing Technology* **116**:49-54

G.Jayaram, L.D. Marks, M.R. Hilton, (1995) Surf, Soat, Technol. **76/77** 393-399

G. Santhanakrishnan, 1994 Tribological aspect in composite machine, Ph.D. Dissertation, Indian Institute of Technology, Madras, India

N. Narutaki, Y. Yamane, S. Tashima, H.Kuroki, (1997) A new advanced ceramic for dry machining, Ann. CIRP 46(1)

P.S. Sreejith*, B.K.A Ngoi, Dry machining, 1999, School of Mechanical and Production Engineering , Nanyang Technological University, Nanyang Avenue Singapore 639798, Singapore

P P.S. Sreejith .S Sreejith, 2007. Machining of 6061 aluminium alloy with MQL, dry and flooded lubricant conditions, Department of Mechanical Engineering Cochin University of Science and Technolody, Kochi- 682022, Kerala, India

R.Horsfall, R. Fontana, (1993) TiAin coatings beat the heat , Cutting Tool Eng. February 37-42

Serope Kalpakjian and Steven Schmid, Manufacturing Engineering and Technology, Tool Life: wear and failure, 5th edition in SI unit

S.Sharif, E.A. Rahim , 2007, Performance of coated and uncoated carbide tool when drilling titanium alloy- Ti-6AI4V, Journal of Materials Processing Technology 185: 72-76

T.Kurimoto, G.Barrow, (1982), The influence of aqueous Fluid on the wear charecteristics and life of carbide cutting tools, Ann. CIRP 31 (1)

Lou, M. S. & Chen, J. C., (1999), “Inprocess surface roughness recognition system in end-milling operations”, *International Journal of Advanced Manufacturing Technology*, 15, p. 200-209.

Fidan, I., Kraft, R. P., Ruff, L. E. &Derby, S. J., (1998), “Designed experiments to investigate the solderjoint quality output of a prototype automated surface mount replacementsystem”, *Components. Packaging, and Manufacturing Technology Part C: Manufacturing*, IEEE Transactions, V.21, No. 3, p. 172-181.

Lou, S. J., (1997), “Development of four in-process surface recognition systems to predict surface roughness in end milling”, *Dissertation*, Iowa State University, p.1.

Boothroyd, G. and Knight, W. A., (1989), Fundamentals of Machining and Machine Tools, Second Edition, Marcel Dekker Inc., New York.

Huynh, V. M. and Fan, Y., (1992), “Surface-Texture Measurement and Characterization With Applications To Machine-Tool Monitoring”, The International Journal of Advanced Manufacturing Technology, 7, pp.2-10.

David A. Stephenson (2005), Metal *Cutting Theory and Practice*, Taylor & Francis Group 2nd Edition.

S. Kalpakjian & S. Schmid, 2006, Manufacturing Engineering and Technology Book.

Khaider B., Mohamed A. Y., Tarek M and Jean-F.R., Statistical analysis of surface roughness and cutting forces using response surface methodology in hard turning of AISI 52100 bearing steel with CBN tool, International Journal of Refractory Metals and Hard Materials Volume 28, Issue 3, May 2010, Pages 349-361

Kumaran K., Mohd.Mat.N., Zuki.N.M., Rahman M., Mohd Ruzaimi M. R., Rosli D., Abou-El-Hossein K. A., Optimization of Surface Roughness in End Milling on Mould Aluminium Alloys (AA6061-T6) Using Response Surface Method and Radian Basis Function Network, ISSN 1995-6665 Pages 209- 214

APPENDIX

Appendix A: Project flow chart