EFFECT OF ALUMINIUM OXIDE AND SILICON CARBIDE ABRASIVE TYPE ON MILD STEEL SURFACE TEMPERATURE

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UNIVERSITI MALAYSIA PAHANG

2010

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: **EFFECT OF ALUMINIUM OXIDE AND SILICON CARBIDE ABRASIVE TYPE ON MILD STEEL SURFACE TEMPERATURE**

SESI PENGAJIAN: 2010/2011

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

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DECEMBER 2010

SUPERVISOR 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 Mechanical Engineering.

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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 concurently submitted for award of other degree.

Signature	: ………………………………
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DEDICATION

To my beloved mother and father

En. Mohd Noor bin Md Lazim

Pn. Halimah Binti Che Hassan

ACKNOWLEDGEMENTS

First of all I am grateful to ALLAH S.W.T for blessing me in finishing my final year project (PSM) with success in achieving my objectives to complete this project. Secondly I want to thank my family for giving morale support and encouragement in completing my project and also throughout my study in UMP as they are my inspiration to success. I also would like to thank to my supervisor Dr Mahadzir bin Ishak @ Muhammad for guiding and supervising my final year project throughout this semester. He has been very helpful to me in finishing my project and I appreciate every advice that he gave me in correcting my mistakes.

I apologize to my supervisor for any mistakes and things that I done wrong while doing my project. The credits also goes to all lecturers, tutors, teaching engineers (JP) especially En. Aziha and assistant teaching engineers (PJP) for their cooperation and guide in helping me finishing my final year project. Last but not least I want to thank all my friends that have given me advice and encouragement in completing my project. Thank you very much to all and may ALLAH bless you.

ABSTRACT

Surface grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat surfaces by removing a small amount of material. The phenomena of removing process actually will lead to the thermal damage to work piece and wheel grinder. As a result, this study tends to investigate the optimum parameter on mild steel grinding process by using conventional grinding machine through understanding the thermal effect and temperature distribution in the process and to investigate the thermal process of the mild steel grinding process for different parameter by using aluminum oxide and silicon carbide as a wheel grinder by running the experiment in dry grinding. A method of capturing the increasing temperature value is by using infrared thermometer. Depth of cut and table speed are the variables parameter used in this experiment and spindle speed and mode of dressing are the parameter that constant along the experiment are running. Furthermore, by using Taguchi approached, design of experiment (DOE) will be attained and Minitab software is used to design the DOE. Two way ANOVA methods then used to make an analysis of the data attained. The temperature value are analyzed to make the conformation that table speed and silicon carbide wheel grinder will give high impact to temperature rising. This research proved that by using silicon carbide as a grinding wheel, it will give higher thermal effect to the workpiece instead using aluminium oxide grinding wheel. Silicon carbide wheel grinder, that have rough grain will produce high friction force during grinding process occur. This friction force then will produce heat and will produce higher value of temperature instead using aluminium oxide. Aluminium oxide that have smaller grain, will also produce heat but the value of the temperature are smaller than using silicon carbide. After that, table speed is most significant factor that effect thermal on mild steel grinding process with silicon carbide as wheel grinder but for aluminium oxide wheel grinder, thermal effect are very low when using variables parameter.

ABSTRAK

Giling permukaan merupakan proses pengakhiran yang digunakan untuk memperbaiki permukaan akhir, mengelupas bahan keras, dan ketatkan toleransi pada permukaan datar dengan pengikisan sejumlah kecil material. Fenomena pengikisan ini akan menyebabkan kerosakan terma untuk bahan kerja dan roda penggiling. Oleh itu, kajian ini cenderung untuk menyiasat parameter optimum pada proses penggilingan besi karbon dengan menggunakan mesin penggiling konvensional melalui pemahaman kesan terma dan pengedaran suhu pada proses dan untuk menyiasat proses terma daripada proses penggilingan besi karbon untuk parameter yang berbeza dengan menggunakan aluminium oksida dan silikon karbida sebagai roda penggiling dengan menjalankan percubaan di penggilingan kering. Sebuah kaedah menangkap nilai peningkatan suhu adalah dengan menggunakan termometer IR. Kedalaman potong dan kelajuan meja parameter pembolehubah yang digunakan dalam percubaan ini dan spindel kelajuan dan cara berpakaian adalah parameter yang malar di sepanjang percubaan berjalan. Selain itu, dengan menggunakan kaedah Taguchi, penyusunan eksperimen (DOE) akan digunakan dan software Minitab digunakan untuk desain DOE. Kaedah ANOVA dua arah kemudian digunakan untuk melakukan analisis data tercapai. Nilai suhu dianalisis untuk membuat konformasi yang jadual kelajuan dan silikon karbida roda penggiling akan memberikan kesan kenaikan suhu tinggi. Penelitian ini membuktikan bahawa dengan menggunakan silikon karbida sebagai roda penggiling, maka akan memberikan kesan terma yang lebih tinggi kepada benda kerja berbanding menggunakan aluminium oksida roda penggiling. Roda penggiling silicon karbida, yang mengandungi butir kasar akan menghasilkan gaya gesekan tinggi selama proses grinding berlaku. Geseran ini kemudian akan menghasilkan suhu panas dan akan menghasilkan nilai yang lebih tinggi daripada suhu dariapada menggunakan aluminium oksida. Aluminium oksida yang mengandungi butir yang lebih kecil, juga akan menghasilkan panas tapi nilai suhu lebih kecil daripada menggunakan silikon karbida. Setelah itu, kelajuan meja faktor paling penting yang mempengaruhi panas pada proses penggilingan baja ringan dengan silikon karbida sebagai penggiling roda tetapi untuk penggiling roda aluminium oksida, kesan terma yang sangat rendah apabila menggunakan parameter pembolehubah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material.

In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes. The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary. Grinding process is indeed given priority to do the surface finish on the material because of some particular reasons :

1. The material is too hard to be machined economically. (The material may have been hardened in order to produce a low-wear finish, such as that in a bearing raceway.
2. Tolerances required preclude machining. Grinding can produce flatness tolerances of less than ±0.0025 mm (±0.0001 in) on a 127 x 127 mm (5 x 5 in) steel surface if the surface is adequately supported.
3. Machining removes excessive material.

In industry, grinding usually used in automotive production. Grinding is used to make surface finished on car body

1.2 PROJECT BACKGROUND

The grinding machine consists of a power driven grinding wheel spinning at the required speed (which is determined by the wheel's diameter and manufacturer's rating, usually by a formula) and a bed with a fixture to guide and hold the work-piece. The grinding head can be controlled to travel across a fixed work piece or the workpiece can be moved whilst the grind head stays in a fixed position. Very fine control of the grinding head or tables position is possible using a vernier calibrated hand wheel, or using the features of numerical controls. Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat; they therefore incorporate a coolant to cool the workpiece so that it does not overheat and go outside its tolerance. The coolant also benefits the machinist as the heat generated may cause burns in some cases. In very high-precision grinding machines (most cylindrical and surface grinders) the final grinding stages are usually set up so that they remove about 200nm (less than 1/100000 in) per pass - this generates so little heat that even with no coolant, the temperature rise is negligible.

Table 1.0 : Type of grinding machine

Grinding machine	Applications
Belt grinder	Finishing, deburring, and stock removal
Bench grinder	Shaping tool bits or various tools that need to be made or repaired. Bench grinders are manually operated.
Cylindrical grinder	Make precision rods
Surface grinder	To clean the surface of workpiece. Can be manually operated or have CNC controls.
Tool and cutter grinder and the D-bit grinder	These usually can perform the minor function of the drill bit grinder, or other specialist toolroom grinding operations
Jig grinder	Its primary function is in the realm of grinding holes and pins. It can also be used for complex surface grinding to finish work started on a mill.

1.3 PROBLEM STATEMENT

During grinding, a number of physical phenomena occur ; cutting, sliding, material removal, heat generation, deformation, fluid flow, etc. When grinding process is started, frictional force between grinding tool and workpiece will generate heat that can effect the quality of workpiece and also damage the tool. A central problem during the grinding process is especially the thermal stress on the tools. If the process temperatures are too high, certain application properties can be modified and lasting damage to the tools can possibly result, such as, e.g microstructures change or micro cracks. The influence exerted on the cutting tool material becomes especially clear when grinding cermets. Here high temperature, temperature gradients and thermo mechanical stresses can arise, leading to the damage such as appearance of cracks. When the tool is used later, these cracks can cause lasting detrimental effects on application and wear behavior.

1.4 OBJECTIVES

- To do the thermal analysis on mild steel grinding process by using conventional grinding machine
- To determine the significant parameter that effect on tool and workpiece by using different parameter
- To investigate the thermal process of the mild steel grinding process for different parameter by using aluminum oxide and silicon carbide as a wheel grinder.

1.5 SCOPE OF PROJECTS

- Using mild steel as a workpiece study
- Using aluminium oxide and silicon carbide as a wheel grinder in dry grinding
- Using thermometer infrared to measure temperatures in the workpiece surface during grinding
- The wheel speed will remain constant until experiment are completed

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF GRINDING

There are several processes of manufacturing that are important for the conversion of raw materials into finished goods. Most of these processes deal with giving a new shape and form to the raw materials either by changing their state or shape [2]. One such important process is grinding, and it is very useful technique for metal removal at fast rates and for the high level finishing of final products.

2.1.1 Grinding

Basically grinding is nothing but removal of metal at a much faster rate than was earlier done with single edge tools such as chisels. Of course, grinding can be compared to a cutting tool such as a file having multiple edges rather than a chisel with a single edge, but with a much greater speed, material removal, accuracy, and surface finish. However, at the same time it must be noted that it is more appropriate to link grinding to a finishing process rather than a manufacturing process, in the true sense of the word, though these terms are used alternatively in common usage. Apart from being used as material removal process, it is also used to sharpen the cutting edges of cutting tools and sharp objects such as knives, although the underlying process of material removal is the same, but with a different purpose - to produce a sharp edge rather than to reduce size [10].

The grinding wheel consists of several abrasive particles which act as minute cutting edges, and these particles are bonded with the help of bonding material. The advantage of using such a process over conventional metal removal processes are as follows

- The rate of removal of material is much higher than a traditional file
- The surface finish obtained is obviously much better than can be obtained through a chisel or a file
- It is very difficult to remove metal from a surface when it is hardened, and grinding is one of the most practical solutions in such cases
- The pressure required for the grinding process is very small, which means that it is easier to hold the metal even during automated process though use of simple techniques such as magnetic chucks

It is very important that we choose the correct grinding wheel for the exact type of cutting required. The manner of cutting should also be proper, as otherwise the grains may get over-worn resulting in less cutting action or the chips getting embedded in the wheel itself. In the next article we will take a look at various types of abrasive materials which are used for the manufacture of cutting particles in the grinding wheels and the use of both natural as well as artificial materials for the same.

2.1.2 Surface grinding

In this research, surface grinding is used because it is the most common operation of grinding for the flat surfaces. Workpiece is secured on a magnetic chuck attached to the work table of the grinder and for nonmangetic material, vises, vacuum chucks or some other fixtures is used to hold the workpiece [1]. Surface grinding methods include: horizontal-spindle, vertical-spindle, vertical-spindle rotary grinding, horizontal spindle single disk, and vertical swivel head grinding. Parts may require surface grinding for several reasons. The following are a few of the more common reasons:

- Produce a very flat surface.
- Very accurate thickness tolerance specified.
- A very smooth surface roughness Ra is specified/required.

- Cutting tool sharpening

Surface grinding machines and processes where first developed to manufacture very tight tolerances, smooth surface finishes, and removing material from very hard materials.

Figure 2.0 and 2.1 showed model of flat surface grinding machine avaiable at FKM lab.

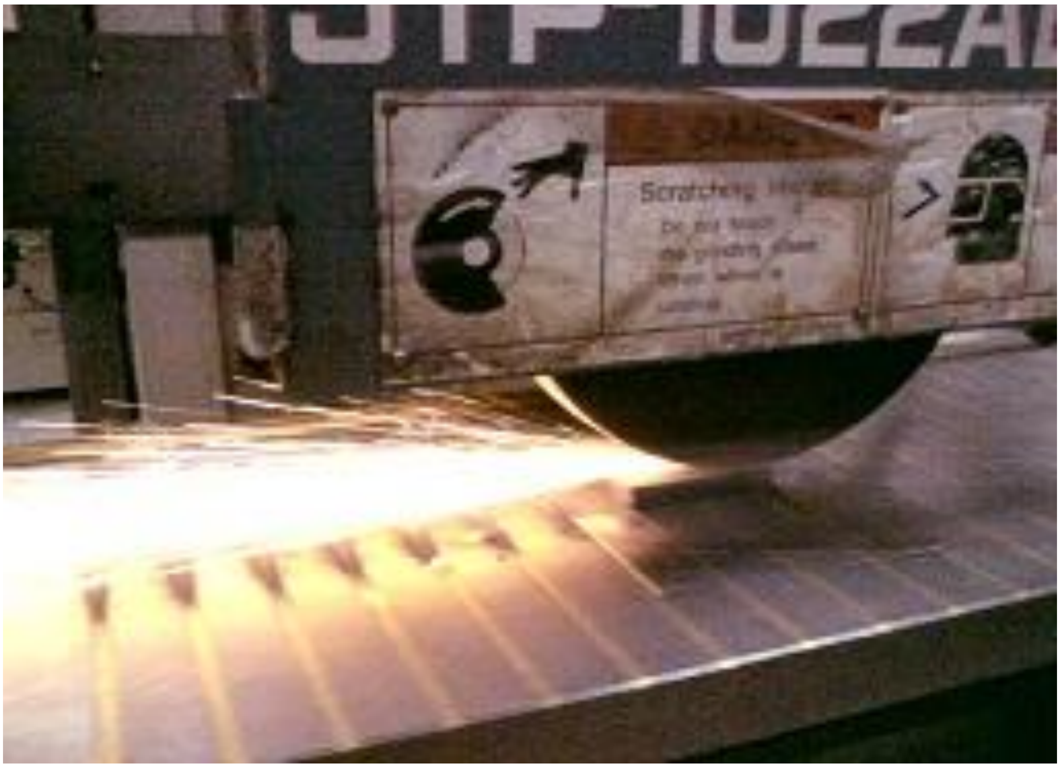


Figure 2.0: Horizontal-spindle reciprocating table surface grinding

Figure 2.1 : Surface grinding machine

2.1.3 Grinding machine

The grinder is a machine that is used for fine surface finishing and the amount of material removed rarely exceeds a few thousands of an inch. These machines have been developed over the years to satisfy specific needs of the industry it serves, so grinding has become specialized, as has turning and milling. The most common types of grinders are the surface grinder, the universal tool and cutter grinder, and the cylindrical grinder [11].

Figure 2.2 : Surface grinder

Figure 2.3 : Cylindrical grinder

Table 2.0 : Grinding machine specification [1]

Process	Characteristics	Typical maximum dimensions,length and diametet,m
Surface	Flats surfaces on most materials;production rate depends on the table size and level of automation;labor skill depends on part complexity;production rate is high on vertical – spindle rotary – table machines	Reciprocating table L:6 Rotary table D: 3
Cylindrical	Round workpieces with stepped diameter ; low production rate unless automated;	Workpiece D: 0.8, roll grinder D: 1.8, universal grinder D: 2.5
Centerless	Round and slender workpieces; high production rate; low to medium labor skill	Workpiece D: 0.8
Internal	Holes in workpiece; low production rates; low to medium labor skill	Hole D: 2
Honing	Holes in workpiece; low production rates; low labor skill	Spindle D: 2
Lapping	Flat, cylindrical or curved; high production rate; low labor skill	Table D: 1.2 -

2.1.4 Grinding wheel

Grinding wheels use several types of abrasive grains. Aluminum oxide, the most common industrial mineral in use today, is used either individually or with other materials to form ceramic grains. Silicon carbine, a synthetic abrasive that is harder than aluminum oxide, is typically used with nonferrous materials such as brass, aluminum, and titanium. Alumina-zirconia grains fuse aluminum oxide and zirconium oxide and are used to improve grinding performance on materials such as stainless steel. Synthetic diamond superabrasives are used for grinding nonferrous metals, ceramics, glass, stone, and building materials. Cubic boron nitride (CBN), another type of superabrasive, provides superior grinding performance on carbon and alloy steels. CBN is second only to diamond in terms of hardness.

Crushed tungsten carbide grits are used in metal-bonded products to abrade tough materials such as composites, fiberglass, reinforced plastics, and rubber [12].

2.1.4.1 Aluminium Oxide

As an angular, durable blasting abrasive, aluminum oxide (or aluminium oxide) can be recycled many times. It is the most widely used abrasive grain in sand blast finishing and surface preparation because of its cost, longevity and hardness. Harder than other commonly used blasting materials, aluminum oxide grit powder penetrates and cuts even the hardest metals and sintered carbide.

Approximately 50% lighter than metallic media, aluminum oxide abrasive grain has twice as many particles per pound. The fast-cutting action minimizes damage to thin materials by eliminating surface stresses caused by heavier, slower cutting media.

Aluminum oxide grit powder has a wide variety of applications, from cleaning engine heads, valves, pistons and turbine blades in the aircraft industry to lettering in monument and marker inscriptions. It is also commonly used for matte finishing, as well as cleaning and preparing parts for metalizing, plating and welding.

Aluminum oxide abrasive grain is the best choice for an abrasive sand blasting and polishing grain as well as for preparing a surface for painting.

Figure 2.4 : Aluminium oxide wheel grinding

Table 2.1 : Aluminium oxide grinding wheel types

Name	Colouration	Al_2O_3 contents	Machined materials
Aluminium oxide 95A	grey-blue or brown	ca. 94,5%	carbon steels C< 0,5%; cast steels, malleable cast irons, and some non-iron materials.
Aluminium oxide 97A	grey-brown or grey-blue	ca. 97,5%	alloy and carbon steels with 0,5% contents of carbon and hardness up to 60HRC
Aluminium oxide 99A (38A)	white	more than 98%	alloy and carbon steels with more than 0,5% contents of carbon and hardness above 62HRC.
Microcrystalline aluminium oxide 32A	bright pink	more than 98%	alloy and carbon steels with more than 0,5% contents of carbon and hardness above 62HRC.

Table 2.1: Aluminium oxide grinding wheel types (cont...)

Microcrystalline aluminium oxide - Cubitron SG	blue	ca. 95%	stainless steels, titan, chrome and nickel alloys.
Microcrystalline aluminium oxide - Cerpass XTL	white	ca. 99,6%	stainless steels, titan, chrome and nickel alloys.

In this researh, the aluminium oxide type that has been used in mild steel grinding process is microcrystalline aluminium oxide 32A.

2.1.4.2 Silicon Carbide

Silicon carbide is the hardest blasting media available. High-quality silicon carbide media is manufactured to a blocky grain shape that splinters. The resulting silicon carbide abrasives have sharp edges for blasting. Silicon carbide has a very fast cutting speed and can be recycled and reused many more times than sand. The hardness of silicon carbide allows for much shorter blast times relative to softer blast media.

Silicon carbide grit is the ideal media for use on glass and stone in both suction or siphon and direct pressure blast systems. The ability to be recycled multiple times results in a cost-effective silicon carbide grit blast media with optimal etching results. Since silicon carbide grit is harder than aluminum oxide, it can be used efficiently for glass engraving and stone etching. Silicon carbide grit blast media has no free silica, does not generate static electricity and is manufactured to contain minimal magnetic content.

Figure 2.5 : Silicon Carbide wheel grinding

Table 2.2 : Silicon carbide grinding wheel types

Name	Colouration	SiC contents	Machined materials
Green silicon carbide 99C	dark green	99,66%	HSS cutting tools, cemented carbides, ceramics and for truing and dressing.
Black silicon carbide 98C	black	98,26%	hardened and grey cast iron, cemented carbides, non-ferrous materials, glass, plastics, leather and rubber.

In this researh, the silicon carbide type that has been used in mild steel grinding process is green silicon carbide 99C.

Table 2.3 : Types of wheel grinder [12]

Types of grinding wheels	Description
Straight Grinding wheels	Straight wheel are the most common mode of wheel that is found on pedestal or bench grinders. This is the one widely used for centreless & cylindrical surface grinding operations. As it is used only on the periphery, it forms a little concave surface on the piece. This is used to gain on several tools like chisels. The size of these wheels differs to a great extent, width & diameter of its face obviously depends on the category of its work, machines grinding power.
Cylinder or wheel ring	A cylinder wheel has no center mounting support but has a long & wide surface. Their width is up to 12" and is used purely in horizontal or vertical spindle grinders. This is used to produce flat surface, here we do grinding with the ending face of the wheel.
Tapered Grinding wheels	Tapered Grinding wheel is a straight wheel that tapers externally towards the midpoint of the wheel. As this pact is stronger than straight wheels, it accepts advanced lateral loads. Straight wheel with tapered face is chiefly used for gear teeth, grinding thread, etc.

Table 2.3 : Types of wheel grinder (cont...)

Straight cup	This Straight cup wheels forms an option for cup wheels in cutter and tool grinders, having an extra radial surface of grinding is favorable.
Dish cup	In fact this is used primarily in jig grinding and cutter grinding. It is a very thin cup-style grinding wheel which permits grinding in crevices and slot.
Saucer Grinding Wheels	Saucer Grinding Wheel is an exceptional grinding profile used for grinding twist drills and milling cutters. This finds wide usage in non-machining areas.
Diamond Grinding Wheels	In diamond wheels industrial diamonds remain bonded to the edge. This is used to grind hard materials like concrete, gemstones & carbide tips. A slitting saw is designed for slicing gemstones like hard materials.

2.1.5 Mild steel

Mild steel is a type of steel alloy, that contains a high amount of carbon as a major constituent. An alloy is a mixture of metals and non-metals, designed to have specific properties. Alloys make it possible to compensate for the shortcomings of a pure metal by adding other elements. To get what mild steel is, one must know what are the alloys that are combined to make steel. So, let us see what we mean by steel, which will help us in understanding what mild steel is and also in understanding the properties of mild steel.

Steel is any alloy of iron, consisting of 0.2% to 2.1% of carbon, as a hardening agent. Besides carbon, there are many metal elements that are a part of steel alloys. The elements other than iron and carbon, used in steel are chromium, manganese, tungsten and vanadium. All these elements along with carbon, act as hardening agents. That is, they prevent dislocations from occurring inside the iron crystals and prevent the lattice layers from sliding past each other. This is what makes steel harder than iron. Varying the amounts of these hardening agents, creates different grades of steel. The ductility, hardness and mild steel tensile strength is a function of the amount of carbon and other hardening agents, present in the alloy. The amount of carbon is a deciding factor, which decides hardness of the steel alloy. A steel alloy with a high carbon content is mild steel, which is in fact much more harder and stronger than iron. Though, increased carbon content increases the hardness of the steel alloy, it causes a decrease in its ductility. Mild steel can also be described as steel which is not stainless steel. Mild steel differs from stainless steel in its chromium content. Stainless steel contains a lot more chromium than ordinary carbon or mild steel.

2.1.5.1 Mild Steel Properties and Uses

Figure 2.6 : Mild Steel

Here is a compilation of mild steel properties and its uses in various fields of technology.

- Let us see, what makes the mild steel composition. Other than maximum limit of 2 % carbon in the manufacture of carbon steel, the proportions of manganese (1.65%), copper (0.6%) and silicon (0.6%) are fixed, while the proportions of cobalt, chromium, niobium, molybdenum, titanium, nickel, tungsten, vanadium and zirconium are not.
- A high amount of carbon makes mild steel different from other types of steel. Carbon makes mild steel stronger and stiffer than other type of steel. However, the hardness comes at the price of a decrease in the ductility of this alloy. Carbon atoms get affixed in the interstitial sites of the iron lattice and make it stronger.

- What is called as mildest grade of carbon steel or 'mild steel' is typically carbon steel, with a comparatively mild amount of carbon (0.16% to 0.19%). It has ferromagnetic properties, which make it ideal for manufacture of electrical devices and motors.
- The calculated average industry grade mild steel density is 7.85 gm/cm^3. Its Young's modulus, which is a measure of its stiffness is around 210,000 Mpa.
- Mild steel is the cheapest and most versatile form of steel and serves every application which requires a bulk amount of steel.
- The high amount of carbon, also makes mild steel vulnerable to rust. Naturally, people prefer stainless steel over mild steel, when they want a rust free technology. Mild steel is also used in construction as structural steel. It is also widely used in the car manufacturing industry.

Table 2.4 : Properties of Mild Steel AISI 1020

Properties of Mild Steel AISI 1020	
Density (×1000 kg/m^3)	7.7 -8.03
Elastic Modulus (GPa)	190 - 210
Tensile Strength (Mpa)	394.7
Yield Strength (Mpa)	294.8
Elongation (%)	36.5
Reduction in Area (%)	66.0
Hardness (HB)	111

2.2 INFRARED THERMOMETER

Infrared thermometers are devices used to remotely measure temperature in situations where it is not possible to be in physical contact with the object being measured. This includes objects that are very hot, very small or very far away. Infrared thermometers are also well suited for measuring objects that are especially prone to minute changes in temperature, or which cover vast areas making use of conventional thermometers impractical.

Variable in design and size - ranging from something that would fit in your palm to a 200 lbs. telescope-shaped device - infrared thermometers take advantage of the fact that, above absolute zero, all objects emit electromagnetic radiation or energy. By measuring the energy given off by objects in two different wavelength regions of the infrared portion of the spectrum, infrared thermometers internally compare the different readings in a ratio which corresponds to a known set of values linking energy distribution with wavelength to temperature.

Infrared temperature measurements were made as early as the mid-19th century, but they proved less-than-reliable. Accuracy did not improve until physicist Max Planck (1858-1947) speculated around the turn of the century that radiation was not emitted in a continuous wave across the spectrum, as had been widely assumed. Instead, he found it was emitted in whole number multiples of 6.625 x 10-34 joule-sec - now referred to as "Planck's Constant" - making it necessary to revise the technique of measuring. Two readings are required because certain properties like reflectivity, texture and wavelength sensitivity can degrade accuracy.

In taking an infrared temperature reading of the moon, a simplified example would use a telescope hooked up to an infrared detector, which converts infrared radiation into an electrical current or voltage. As two different infrared filters are placed sequentially over the lens, the detector registers two different readings. One reading is then divided into the other, and the number that results corresponds to a temperature that can be found in existing tables of values for Planck's Equation. It should be noted that in trying to ascertain the temperature of a large, distant body like the moon, one must take care to ensure that its entire image fills the area of infrared detector's sensor, lest the cold void of space influence the reading.

2.21 Handheld Infrared Thermometers

Infrared thermometers use infrared energy to detect temperatures. Since they are detecting actual energy levels, the physical thermometer does not need to actually touch the surface for an accurate temperature measurement. They don’t even send out any information or infrared rays themselves, they merely detect them from a distance, sometimes miles away. Some are used for weather forecasting and research and are able to tell the temperature of clouds at high altitudes. They are also used in many manufacturing processes that have temperature requirements and especially useful for monitoring products on a movable production line.

Infrared thermometers work by focusing infrared heat onto a sensor that can convert infrared energy into temperature units. To do this it has to take into account the regular ambient temperature and calculate the difference. This takes up a minor amount of space, but makes an infrared thermometer much larger than one that only uses mercury. They are often configured into a pistol shape and some offer a laser pointer so specific areas can be pinpointed. The temperature is often indicated on a small digital readout and temperature readings are almost instant which makes them useful for comparing multiple temperatures in an area and for finding hot spots in electrical equipment.

They are also used to calibrate many heating devices, from furnaces to ovens used for cooking. Since they can detect temperature differences from a distance they are especially useful for tasks that prevent direct temperature readings to be made such as in large electrical components and arrays and the inside of car engines where parts are blocked from contact by other mechanical and hydraulic devices.

Emissivity plays a key role in infrared temperature detection. It is defined as the ratio of energy emitted by a material in comparison to how much infrared energy it emits. Something that is black is closer to the emissivity of infrared than something that is very reflective such as chrome or silver. Knowing the emissivity is essential to calculate temperature, and many of these types of thermometers have different settings depending on the shininess of the surface, one for chrome and shiny materials and a separate one for dark absorbent materials.

There are a few different types of infrared thermometers which are all useful in different ways. A pinpoint or spot thermometer detects temperatures in very small areas, sometimes less than a millimeter. They can be aimed around other pieces to allow for accurate temperature detection on hard to reach and see parts. Another type of infrared thermometer scans a larger area and is used in manufacturing processes, especially in the metal and glass manufacturing sectors with large automated production lines.

The third type of infrared thermometer is actually a video camera, translating heat signatures into easy to view color coded pictures that instead of displaying light, display heat. These are used by hunters, in law enforcement and by the military for various applications, usually the detection of people, animals and enemy vehicles. They can expose any warm object even if hidden very well.

Figure 2.7 : Handheld Infrared Thermometers

Table 2.5 : Handheld Infrared Thermometer specifications

EXTECH 42500 Infrared Thermometer Specifications	
Range / Resolution	-4 to 500°F (-20 to 260°C), 1°C/F
Accuracy	± 3% of reading or ± 6°F (3°C) whichever is greater.
Note	Accuracy is specified for the following ambient temperature range: 64 to 82°F (18 to 28°C)
Emissivity	0.95 fixed value
Field of View	D/S = Approx. 6:1 ratio (D = distance, S = spot)
Laser power	Less than 1mW
Spectral response	6 to 14 µm (wavelength)
General Specifications	
Display	2000 count, backlit LCD display with function indicators
Display rate	1 second approx.
Operating Temperature	32°F to 122°F (0°C to 50°C)
Operating Humidity	Max. 80% RH
Power Supply	9V battery
Automatic Power Off	Meter shuts off automatically after 6 seconds
Weight	4.9 oz. / 140g
Dimensions	6.7 x 1.7 x 1.6” (170 x 44 x 40mm)

In this research, handheld infrared thermometer was using to measured the temperature value just after the grinding process is finished. Temperature is measured by pointing the handheld infrared thermometer to the workpiece after grinding process is finished and the reading is taken. Then this step is same for other variables. During the measurement process, it must to make sure that no other factors that can effect the reading like fan, or something else.

2.3 BAND SAW MACHINE

A bandsaw is a power tool which uses a blade consisting of a continuous band of metal with teeth along one edge to cut various workpieces. The band usually rides on two wheels rotating in the same plane, although some small bandsaws have three wheels. The saw may be powered by wind, water, steam, electrical motor or animal power. Bandsawing produces uniform cutting action as a result of an evenly distributed tooth load. Bandsaws are used forwoodworking, metalworking, or for cutting a variety of other materials, and are particularly useful for cutting irregular or curved shapes, but can also be used to produce straight cuts. The radius of a curve that can be cut on a particular saw is determined by the width of the band and its lateral flexibility. There are some featuring of S-300HB band saw that used in this experiment :

- Unitized frame construction of saw and index assures max. rigidity and eliminates inaccuracies of bolt on bar feed machines.
- Band wheels (17.32" dia.) are cast ductile iron for superior wheel life.
- A combination of roller bearings and carbide blade guides increase blade life while providing greater accuracy and squareness (+/- 0.002" per inch).
- Height control bar senses work height and programs the machine to eliminate operator guessing. This device also controls the transition from rapid approach to feed rate, reducing lost time "cutting air".
- Vertical rollers assist in the building of bundles and proper alignment of longer sections. Vertical alignment rollers are installed on the infeed rollers on the saw bed as well as on both ends of the free standing roller table.
- State of the art PLC controls the logic sequence of the saw and safety protection.Length settings are set by a hand wheel with a digital read out calibrated in thousands of an inch.
- Hydraulic down feed is dual controlled allowing precise, independent regulation of both feed pressure and feed rate.
- 30,000 psi tension is hydraulically applied and maintained. A pressure gage confirms proper blade tension.
- Infinitely variable blade speeds with tachometer.
- Split front vices hold material on both entry and exit sides to minimize drop off and twist burrs.

- Automatic shuttle feed with 16" single stroke. Multi index capability allows automatic cutting up of pieces up to 144".
- Repeatability of +/- 0.005"Motion detector stops the machine in case the blade breaks or wedge in the material without breakin

Figure 2.8: Material Cutting Machine (Bandsaw Machine)

Table 2.6 : Specification of S-300HB Band Saw Machine

Specification		**Dimension**
Capacity	●	300mm
	■	300x250mm
Bundle Cutting	Width	145 to 230mm
	Height	30 to 130mm
Blade Speed	50Hz	20 to 100 m/min
	60Hz	(INTERVAL)
Blade Size		3820x34x1.1 mm
Blade Tension		Hydraulic

2.4 THERMAL EFFECT

Grinding occurs by the interaction of discrete abrasive g27ains on the wheel surface with the workpiece. It has been shown that the total grinding energy due to the interaction between the wheel and the workpiece can be considered to consist of chip formation, plowing, and sliding components. Peak 'flash' temperatures are generated which approach the melting point of the material being ground [3,7]. However, these peak temperatures are of extremely short duration and highly localized on the shear planes of microscopic grinding chips.

Just beneath the surface, the workpiece 'feels' nearly continuous heating owing to the multiplicity of interactions with the abrasive grits passing quickly through the grinding zone. Therefore, the temperature associated with 'continuous' heating over the grinding zone, rather than the peak 'flash' temperature, is found to be responsible for most thermal damage. This temperature is often referred to as the ‘grinding zone’ or ‘background’ temperature [6]. Also of interest is the much smaller bulk temperature rise of the workpiece, which causes thermal expansion possibly leading to distortions and dimensional inaccuracies [8]. The grinding process requires an extremely high energy expenditure per unit volume of material removed.

Virtually all of this energy is converted to heat which is concentrate within the grinding zone. The high temperatures produces cause various types of thermal damage to workpiece, such as burning, phase transformation, softening (tempering) of the surface layer with possible rehardening, unfavorable residual tensile stresses, cracks, and reduce fatigue strength. Furtermore , thermal expansion of the workpiece during grinding contributes ti inaccuracies and distortions in the final prosuct. The production rates which can be achieved by grinding are often limited by grinding temperatures and their deleterious influence on workpiece quality.

2.5 PARAMETER

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

2.51 Depth of Cut

The depth of cut may be define as how far into the workpiece a grinding wheel plunges. It is usually measured in milimeters or inches. Dept of cut significantly effect the tool life. Increasing the depth of cut will result in increasing of temperature at grinding zone. In this research, depth of cut will be manupulate to see the change of temperature.

2.52 Table Speed

Like depth of cut, table speed also will effect the tool life. Table speed is directly propotional to temperature effect when increasing table speed aslo will increase temperature. Table speed is measured in metre per second and in some grinding machine it only have low, medium and high for its scales.

2.6 ANALYSIS OF VARIANCE (ANOVA) USING MINITAB

Frequently, scientists are concerned with detecting differences in means (averages) between various levels of a factor, or between different groups. What follows is an example of the ANOVA (Analysis of Variance) procedure using the popular statistical software package, Minitab. ANOVA was developed by the English statistician, R.A. Fisher (1890-1962). Though initially dealing with agricultural data**[13]**, this methodology has been applied to a vast array of other fields for data analysis. Despite its widespread use, some practitioners fail to recognize the need to check the validity of several key assumptions before applying an ANOVA to their data. It is the hope that this article may provide certain useful guidelines for performing basic analysis using such a software package.

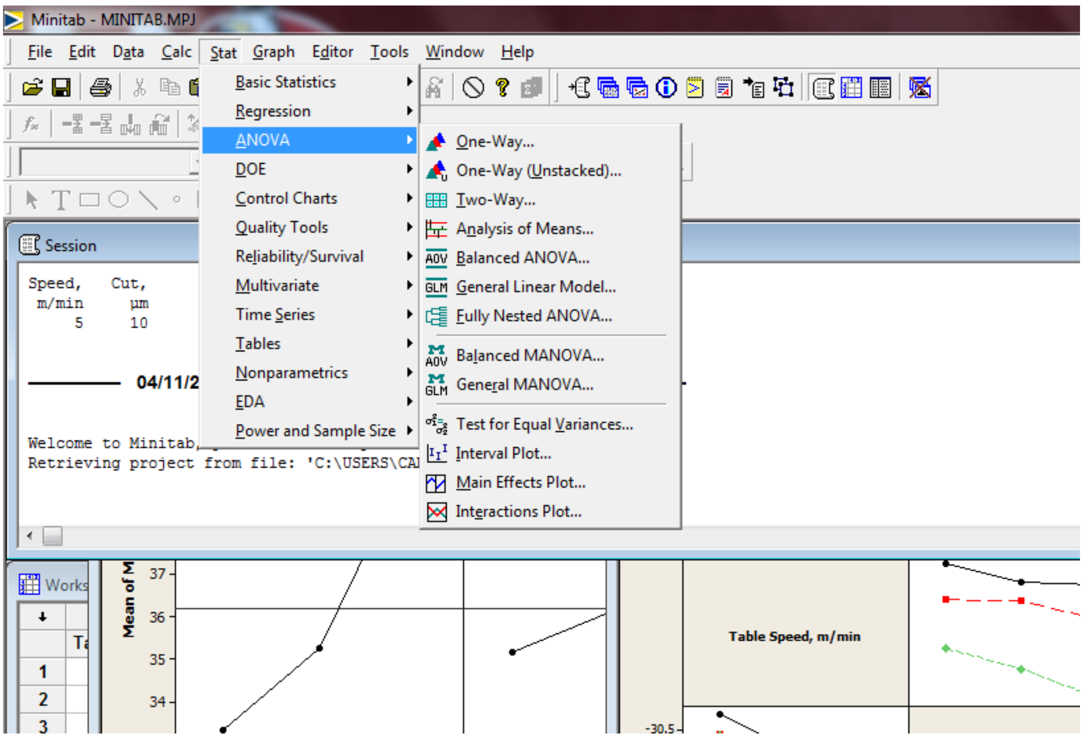


Figure 2.9 : Analysis of Variance (ANOVA) using Minitab software

For this example we shall consider a set of data from the Journal of the Electrochemical Society**[14]**. This data originated from an experiment performed to investigate the low-pressure vapor deposition of polysilicon. Four wafer positions have been chosen and our goal is to detect whether there are any statistically significant differences between the means of these levels. As is discussed by Hogg and Ledolter**[15]**, assumptions that underpin the ANOVA procedure are:

- The values for each level follow a Normal (a.k.a. Gaussian) distribution, and
- The variances are the same for each level (Homogeneity of Variance).

Traditionally, Normality has been investigated using Normal probability plots. However as is discussed by Ryan and Joiner**[16]** inexperienced practitioners have difficulty in their interpretation, and considerable practice is sometimes necessary. With the advent of computer technology, statistical tests may be easily performed to investigate an assumed distributional form, e.g. the Anderson-Darling test. As this dataset is so small (only three observations for each level) it would be unusual to reject the null hypothesis of Normality.

2.7 PREVIOUS RESEARCH

Table 2.7 : Previous research of thermal analysis of grinding

Authors (Year)	Title	Description
S. Malkin, C. Guo2 (2007)	Thermal Analysis of Grinding	Overview of analytical methods to calculate grinding temperatures and their effect on thermal damage. The general analytical approach consists of modeling the grinding zone as a heat source which moves along the workpiece surface.
C.C Chang, A.Z Szeri (1997)	A Thermal Analysis of Grinding	This paper presents about analysis of grinding zone by using different type of coolant (water and oil).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will describe about the overall process methodology in this research from beginning until the end of my research. There are 4 main processes that start with determine material, method and machining parameters and end with data discussion and conclusion of project. Those processes will be explained in this chapter according to the flow chart. In this part, each data and information will be gathered together and concluded according to the objective and scope of this project.

The methods are basicly refers to the design of experiment (DOE) methodology and its procedure. The DOE is not a simple one – step process but actually a series which must follow a certain sequence for the experiment to produce an improvement understanding of product or process performance.

3.2 FLOW CHART

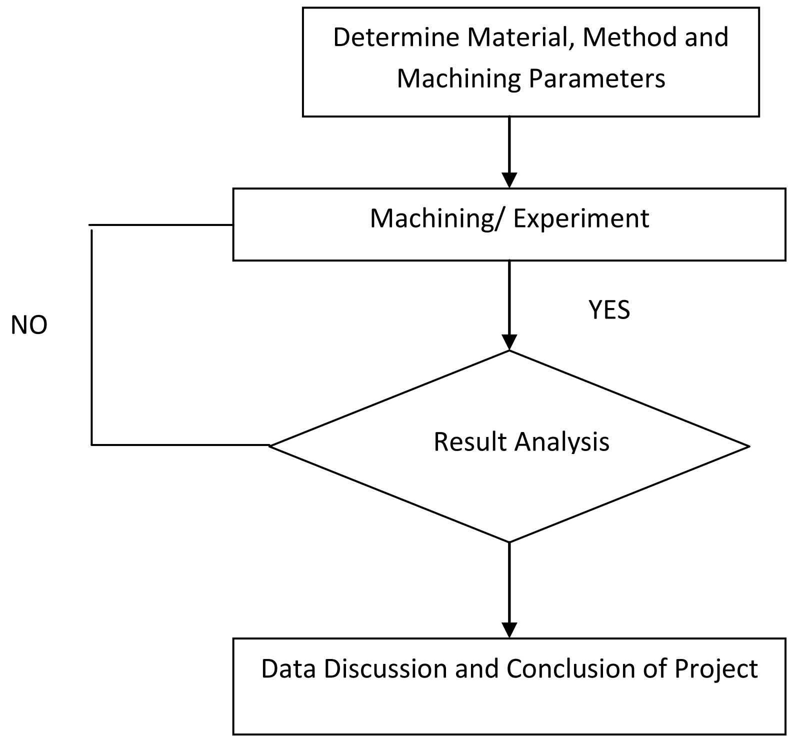


Figure 3.0: Procedure Flow Diagram

3.3 PROJECT DESIGN

In this project, grinding process will be executed on mild steel workpiece by using aluminium oxide and silicon carbide as a grinding wheel. In order to measure the optimal value of temperature, so the condition of this grinding is dry grinding. Then after that, critical temperature on workpiece and wheel will be measured by using infrared thermometer but in this case, the temperature on the surface of workpiece and wheel grinder are the same because the contact always occur. So, the only value of temperature from workpiece surface will be taken. Figure 3.1 shown indicated a design layout on how this experiment will be carried out.

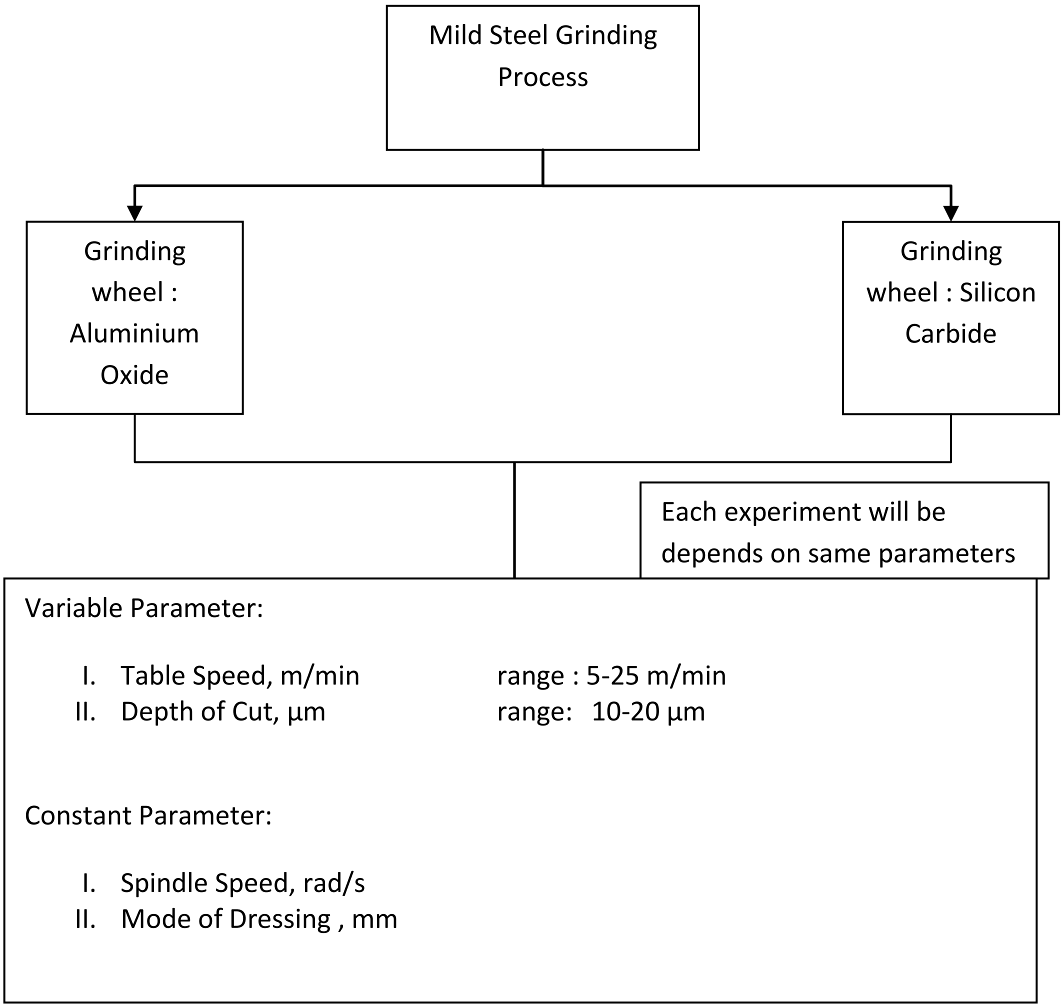


Figure 3.1: Design Layout Mild Steel Grinding Process

3.3.1 Determine Material

This section provided information on how all requirements have been determined. In process to determine workpiece and wheel of grinding, the first thing factor should be consider is suitability of workpiece and wheel of grinding. In thermal analysis, dry grinding is used to optimize the result. So some material need to use lubricant to avoid damage to workpiece and wheel. So mild steel grinding for silicon carbide and aluminium oxide are the most suitable to use in dry grinding. After that, some tool or workpiece hard to find or the price is too expensive. So to determine the workpiece or wheel that want to be used in this project, availability of material in FKM lab must be consider.

3.3.2 Grinding Machine

The type of grinding machine that will use in my project is conventional grinding machine. Conventional grinding machine is most suitable to use in this project instead using CNC machine because we can fully setting the parameter of this machine. Figure 3.3 show the conventional grinding machine.

Figure 3.2: Conventional Grinding Machine

3.4 DESIGN OF EXPERIMENT

In identifying the effects of machining parameters to the specific energy in grinding process, the Design of Experiment (DOE) is applicable to determine the possible effect of the variable during machining. This method also can be developed for experiment a ranges from uncontrollable factor, which will be introduced randomly to carefully controlled parameters. The factor consists of quantitative and qualitative. The range of value for quantitative factor must be decide on how they are going to be measured and the level at which they will controlled during this experiment. In the meantime, the qualitative factors are parameter that will be determined unconnectedly.

This method has found to be applied in many orders activities, where new products are produced and the some improvement in a production. Some application of experimental design in engineering are comprise the evaluation of basic design parameter, hence the product will work under a wide variety of machining conditions and finally is determination of the solution of design parameters that effect performance. In this mild steel grinding experiment, mild steel wild be grinded for a four round by using aluminium oxide or silicon carbide. Then just after the grinding process is finished, infrared temperature will be used to measure the temperature on the workpiece surface. In this experiment, we assume that the temperature on the wheel grinder and workpiece surface is same. As a result, the only value of temperature on the workpiece surface is needed.

3.5 DETAIL EXPERIMENT DESIGN

The Taguchi method will be applied as a tool for design of experiment and data analysis. This section will provide the detail information of DOE which is the Taguchi method and the variables that must be considered for this experimental study.

3.5.1 Variables

Machining parameters and machining characteristics are the group of variables that are going to study. Machining parameters are the classified as the data or measurable quantity that belongs to such machines involve for this experimental study. Machining parameters are grouped into two types of variables which are dependent and independent variables. During this experimental study, the independent variables will be depth of cut and table of speed. The dependent variable will be the specific energy and surface finish of the workpiece.

3.5.2 Machining Parameters

Previous on the literature review, some factors that are significant are found that related to the specific energy in grinding process. The factors are workpiece material, surface topography, grinding parameters, cutting fluids and many other parameters of the machining system. This experimental study will be focused to the machining parameter that influenced to the specific energy and surface finish. The grinding parameter used is taken from the journal and compare to the reliability of machining that available in FKM Lab. The grinding machine manual also referred to get the appropriate level of machining. Below is the machining parameters and it's level respectively.

3.5.3 Taguchi Method

Taguchi's orthogonal arrays are highly fractional orthogonal designs proposed by Dr. Genichi Taguchi, a Japanese industrialist. These designs can be used to estimate main effects using only a few experimental runs. These designs are not only applicable to two level factorial experiments, but also can investigate main effects when factors have more than two levels. Designs are also available to investigate main effects for certain *mixed level* experiments where the factors included do not have the same number of levels. As in the case of Plackett-Burman designs, these designs require the experimenter to assume that interaction effects are unimportant and can be ignored. For this experiment, Minitab software is used to make design of Taguchi method. Using software is a easy way and probability to make mistake during the design can be reduced instead using manual method that sometimes mistake can happen without realized.

Table 3.0: Table of Taguchi Orthogonal Array Design

No of Experiment	Types of Wheel	Factors		Temperature, °C
		Depth of Cut, µm	Table Speed, m/min	
1	A	a	a	
2	A	a	b	
3	A	a	c	
4	A	b	a	
5	A	b	b	
6	A	b	c	
.	.	.	.	
.	.	.	.	
.	.	.	.	
17	B	c	b	
18	B	c	c	

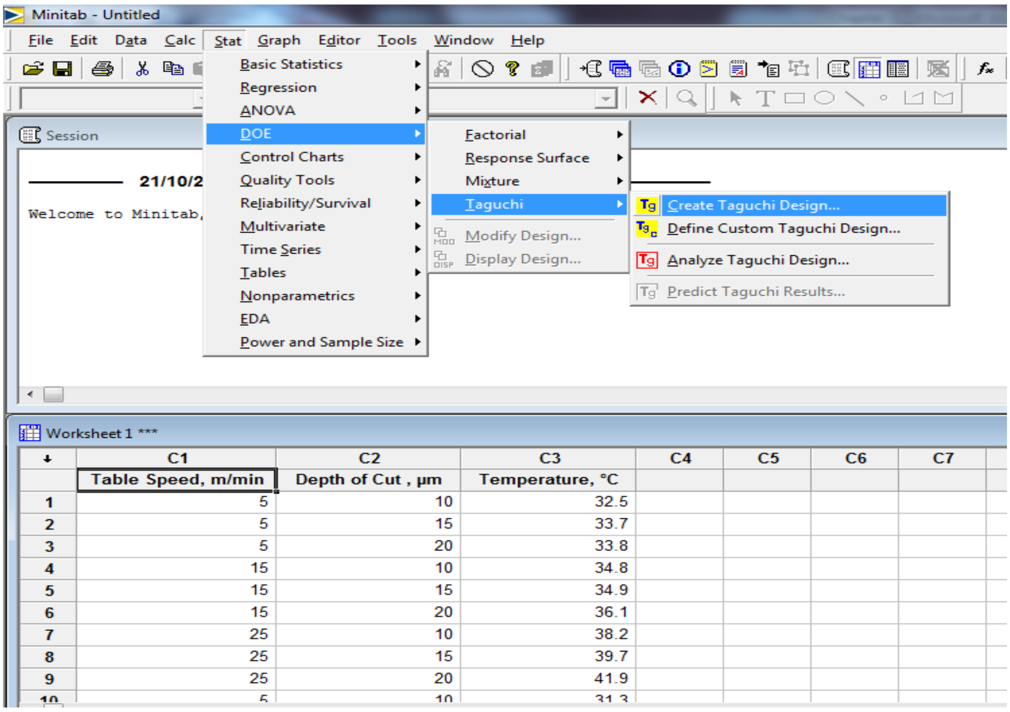


Figure 3.3 : Taguchi method with Minitab software

3.6 WORKPIECE PREPARATION

To do the preparation of workpiece, the material type and dimension must be identifying. The material that use as workpiece in this research is mild steel. The dimension of the workpiece are 50mm x 30mm x 20mm.

Figure 3.4 : Mild steel as a workpiece in this research

Table 3.1: Properties of Mild Steel AISI 1020

Properties of Mild Steel AISI 1020	
Density (×1000 kg/m^3)	7.7 -8.03
Elastic Modulus (GPa)	190 - 210
Tensile Strength (Mpa)	394.7
Yield Strength (Mpa)	294.8
Elongation (%)	36.5
Reduction in Area (%)	66.0
Hardness (HB)	111

3.6.1 Workpiece Cutting Process

The horizontal band saw in Figure 3.2 will use to prepare workpieces. The type of band saw that is S-300HB. The specification of this machine as show in table 3.3.

Figure 3.5: Material Cutting Machine

Table 3.2: Specification of S-300HB Band Saw Machine

Specification		**Dimension**
Capacity	●	300mm
	■	300x250mm
Bundle Cutting	Width	145 to 230mm
	Height	30 to 130mm
Blade Speed	50Hz	20 to 100 m/min (INTERVAL)
	60Hz	
Blade Size		3820x34x1.1 mm
Blade Tension		Hydraulic

The mild steel 50mm width enables to be clamp by vise. The material was cut into a 30mm length size by using the horizontal band saw machine. In this process, the cutting speed and feed rate must be set depends on the material.

3.6.2 Milling process

After cutting material using band saw machine are done, the next process before grinding process can be running is milling process. Milling process is removal process that remove part or layer from workpiece. Before grinding process can be done, rust or unwanted layer on worpiece must be removed. This removal process are very important to avoid wheel grinder faced risk of damage and to make grinding process smoothly done.

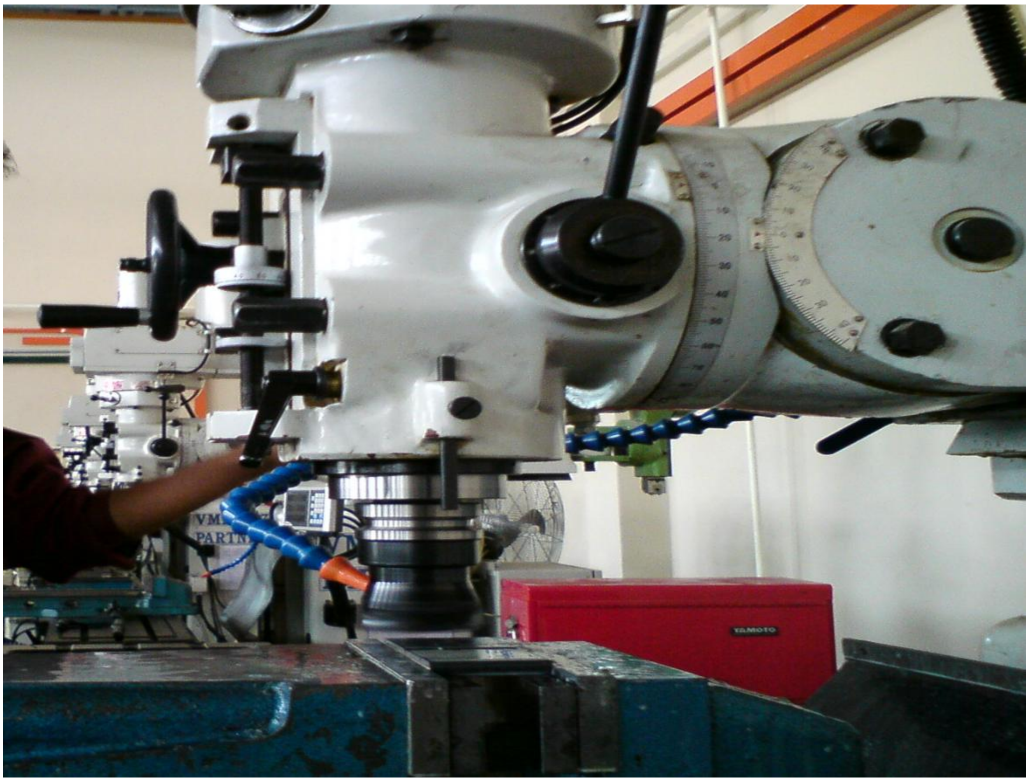


Figure 3.6 : Milling machine

3.7 DATA ANALYSIS

Analysis of variance (ANOVA) is the statistical treatment most commonly applied to the result of experiment to determine the percentage contribution of each factor. ANOVA was carried out to find the dependent variables that effect the machining parameter and machining characteristics by using Minitab software. The software will then calculate the relations of two factors to response supported by ANOVA.

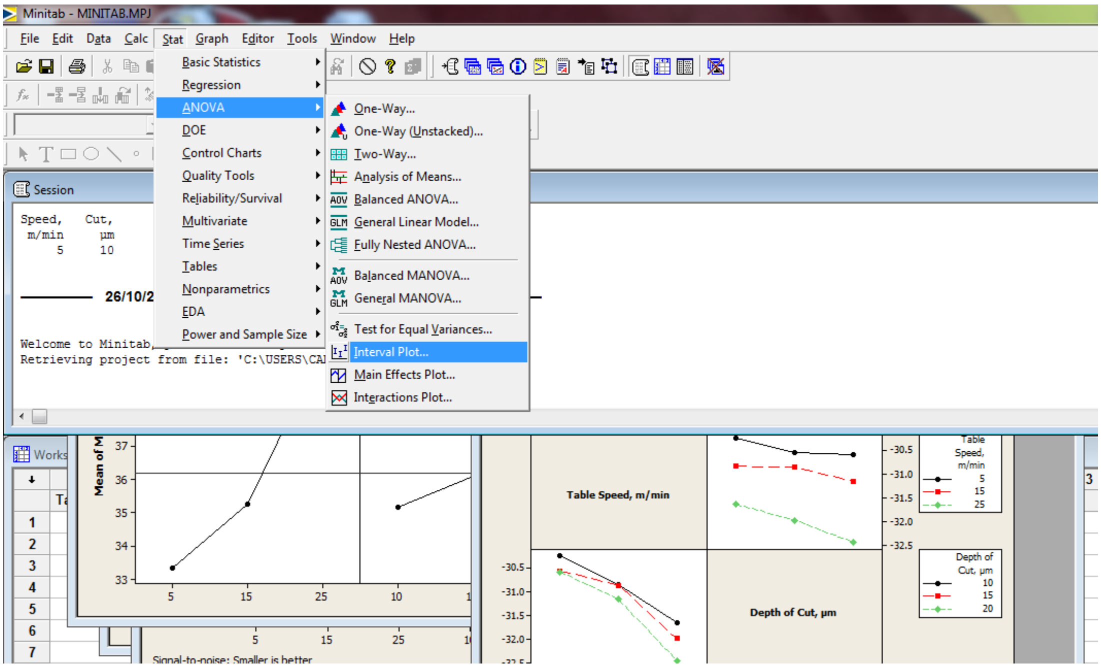


Figure 3.7 : ANOVA with Minitab software

Table 3.3 : ANOVA table

Source	SS	df	MS	F	p
A		1			
B		1			
AxB		1			
Within		16			
Total		19			

Table 3.4 : Example of ANOVA table

(Source)	Sum of Squares, SS	Degree of Freedom, DF	Mean square, MS	F-test
Table Speed				
Treatment		2		
Error		24		
Total		26		
Depth of Cut				
Treatment		2		
Error		24		
Total		26		

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

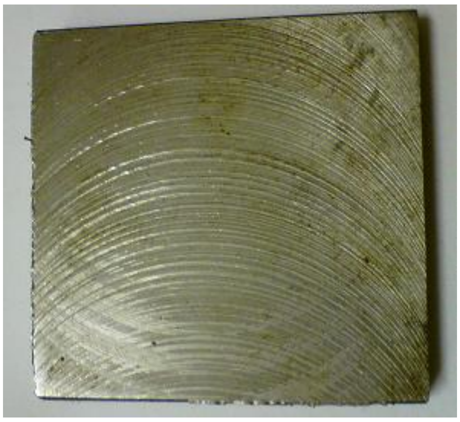
This chapter presents about the final results of temperature value obtained from the previous experiments. The process involved in attaining those results has been discussed thoroughly by the prior chapter. The objective of this chapter is to determine the significant factor and non-significant factor among the machining parameters using the analysis of variance (ANOVA). From those analyses, stable and optimum combination of table speed and depth of cut can be identified. With these main finding, it is possible for machinists and engineers to use as a guideline which result in minimiza thermal effect on workpiece and wheel grinder. The outcome of this research will be discussed in detail by the next topic.

4.2 PRELIMINARY FINDING OF RESEARCH

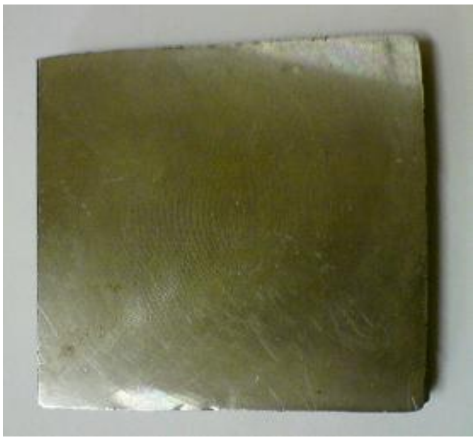
During the grinding process is running, the rough surface of the wheel will produce a frictional force on the surface of the wheel and work pieces. Work piece surface will burn and damage the quality of the work piece. Because of silicon carbide has a grain that are harder than aluminum oxide, crude at a more gentle and refined, the process involves grinding the silicon carbide grinding wheel will produce a higher temperature. From the experiment, the aluminum oxide is recommended for use in mild steel grinding wheel surface due process is more subtle.

4.3 RESULT OF TEMPERATURES

This topic are focusing in analyzing obtained results from experiments before, which have been acquired by using thermomether infrared to measured the temperature on the workpiece during mild steel grinding proces. The results gained from the experiment which have 2 factors and 3 level came in the table 4.1. Taguchi method was apply to obtained the design of experiment. This experiment ran with two different wheel grinding, aluminium oxide and silicon carbide. The following graph will show the data gained when used the different wheel grinding and parameter. Analysis of variance (ANOVA) method has been selected as main medium to find the significant factor in chatter occurrence. Figure 4.0 shown the condition of workpiece before and after grinding process is done.



Before



After

Figure 4.0 : Condition of mild steel before and after grinding process

4.3.1 Silicon Carbide

Silicon carbide is known as the hardest blasting media available. Silicon carbide have rough grain on the wheel surface compare to the aluminium oxide. From the experiment, because of the roughness of the surface grain, temperature produced form the grinding using this wheel type will give higher reading of temperature instead of using Aluminium oxide. The Table 4.0 below showed the data taken after using this type of grinding wheel with different parameter.

Table 4.0 : Result of temperature using Silicon Carbide griding wheel

No of experiment	Type of parameter		Temperature, °C
	Table Speed, m/min	Depth of Cut, µm	
1	5	10	32.5
2	5	15	33.7
3	5	20	33.8
4	15	10	34.8
5	15	15	34.9
6	15	20	36.1
7	25	10	38.2
8	25	15	39.7
9	25	20	41.9

Table 4.0 shown the result of temperature obtain when using silicon carbide as wheel grinder on mild steel grinding process. Then after that, data obtained will put into graph by using Minitab software. Figure 4.1 and 4.2 show a plotted graph with variable parameters.

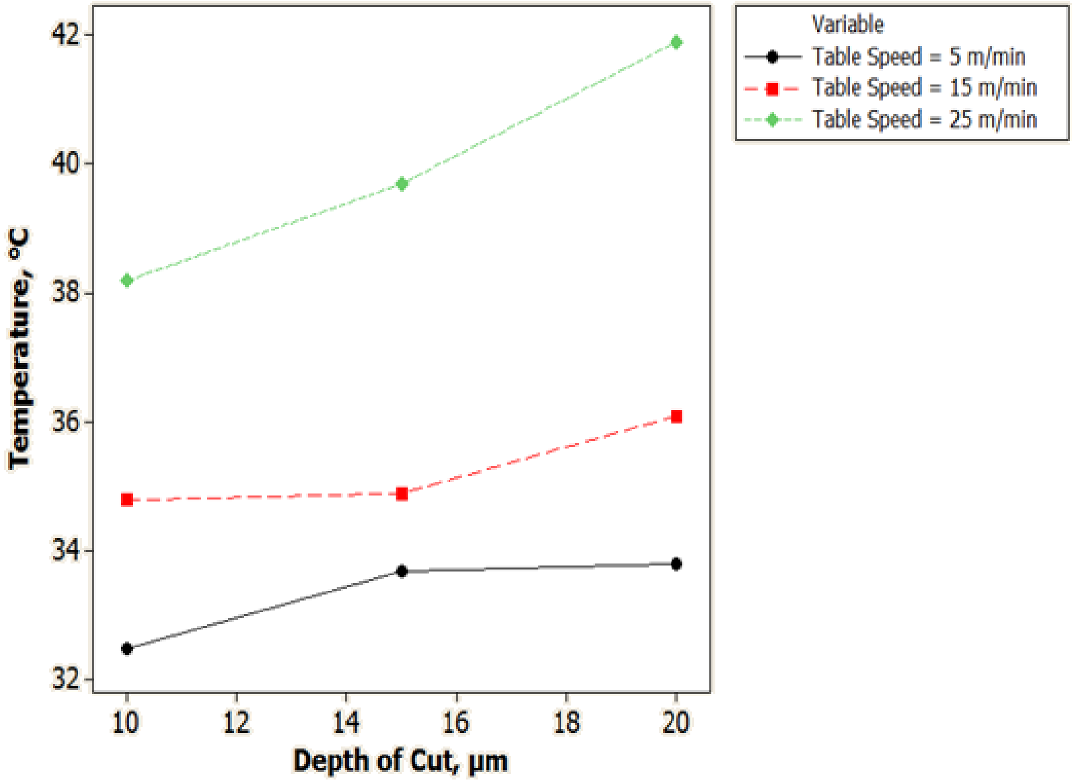


Figure 4.1 : Temperature versus Depth of Cut

From the Figure 4.1, the graph showed that the gradiant of the line is quite small for table speed 5 m/min and 15 m/min. It can say that the parameter, depth of cut was not give effect so much to the rising of temperature in mild steel grinding process but for table speed, the range among the lines of this graph quite far each other. As a result, table speed will give more effect to the rising temperature in mild steel grinding process by using silicon carbide as grinding wheel in this experiment.

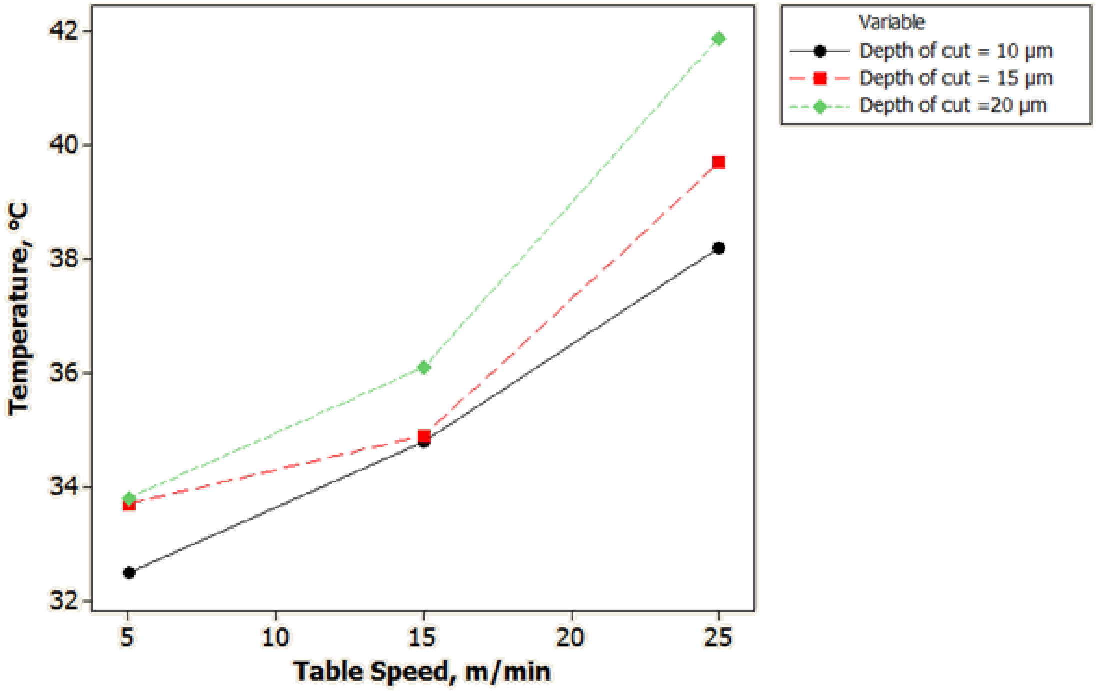


Figure 4.2: Temperature versus Table Speed

From the Figure 4.2, the graph showed that the gradiant of the line is so big for the all depth of cut value. It can say that the parameter, table speed gave effect so much to the rising of temperature in mild steel grinding process but depth of cut, the range among the lines of this graph quite small each other. As a result, depth of cut give less effect to the rising temperature in mild steel grinding process by using silicon carbide as grinding wheel in this experiment.

4.3.2 Aluminium Oxide

Aluminium oxide is the famous grinding wheel used in industry. It has been used widely because of its characteristic. Compare to the silicon carbide, aluminium oxide have more small grain. As a result, grinding process using this type of wheel will produce less thermal effect compare to the silicon carbide grinding wheel.

Table 4.1 : Result of temperature using Aluminium Oxide griding wheel

No of experiment	Type of parameter		Temperature, °C
	Table Speed, m/min	Depth of Cut, µm	
1	5	10	31.3
2	5	15	31.9
3	5	20	32.1
4	15	10	32.1
5	15	15	32.9
6	15	20	33.4
7	25	10	32.7
8	25	15	35.2
9	25	20	38.7

Table 4.1 shown the result of temperature obtain when using aluminium oxide as wheel grinder on mild steel grinding process. Then after that, data obtained will put into graph by using Minitab software. Figure 4.3 and 4.4 show a plotted graph with variable parameters.

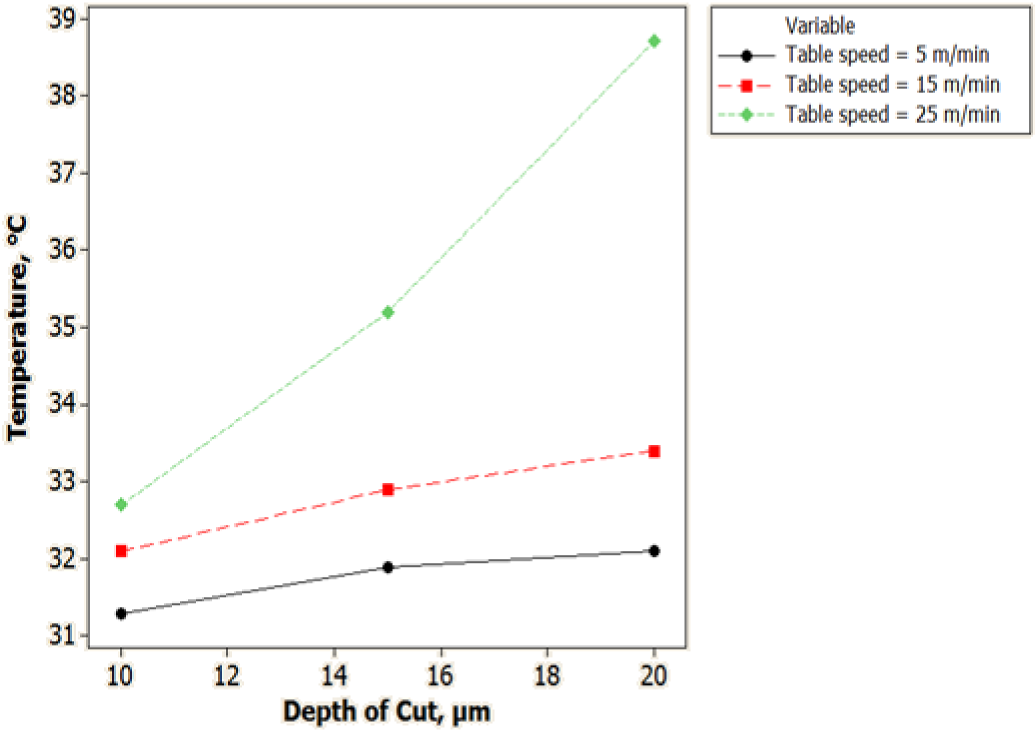


Figure 4.3 : Temperature versus Depth of Cut.

From the Figure 4.3, the graph showed that the gradiant of the line is quite small for table speed 5 m/min and 15 m/min. It can say that the parameter, depth of cut was not give effect so much to the rising of temperature in mild steel grinding process but for table speed, the range among the lines of this graph quite far each other. As a result, table speed will give more effect to the rising temperature in mild steel grinding process by using aluminium oxide as grinding wheel in this experiment.

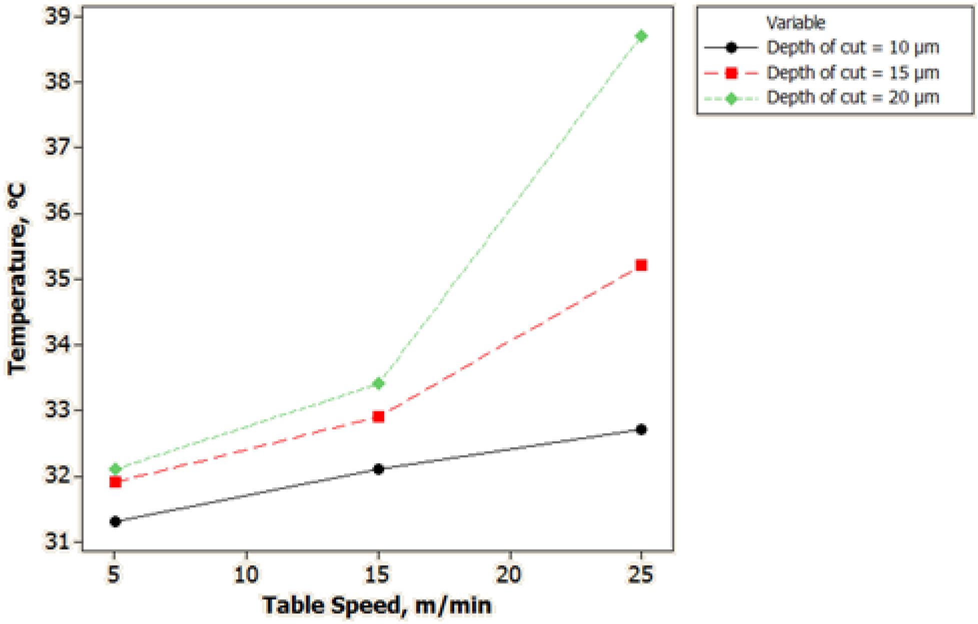


Figure 4.4 : Temperature versus Table Speed

From the Figure 4.4, the graph showed that the gradiant of the line is so big for the all depth of cut value. It can say that the parameter, table speed gave effect so much to the rising of temperature in mild steel grinding process but depth of cut, the range among the lines of this graph quite small each other. As a result, depth of cut give less effect to the rising temperature in mild steel grinding process by using aluminium oxide as grinding wheel in this experiment.

4.4 ANALYSIS OF SILICON CARBIDE AND ALUMINIUM OXIDE

From the Figure 4.1 to 4.4, it has been prove that by using silicon carbide as a grinding wheel, it will give higher thermal effect to the workpiece instead using aluminium oxide grinding wheel. Silicon carbide wheel grinder, that have rough grain will produce high friction force during grinding process occur. This friction force then will produce heat and will produce higher value of temperature instead using aluminium oxide. Aluminium oxide that have smaller grain, will also produce heat but the value of the temperature are smaller than using silicon carbide. Figure 4.5 to 4.11 will show detail about comparison between effect of using silicon carbide and aluminium oxide as wheel grinder.

4.41 Temperature versus Depth of Cut

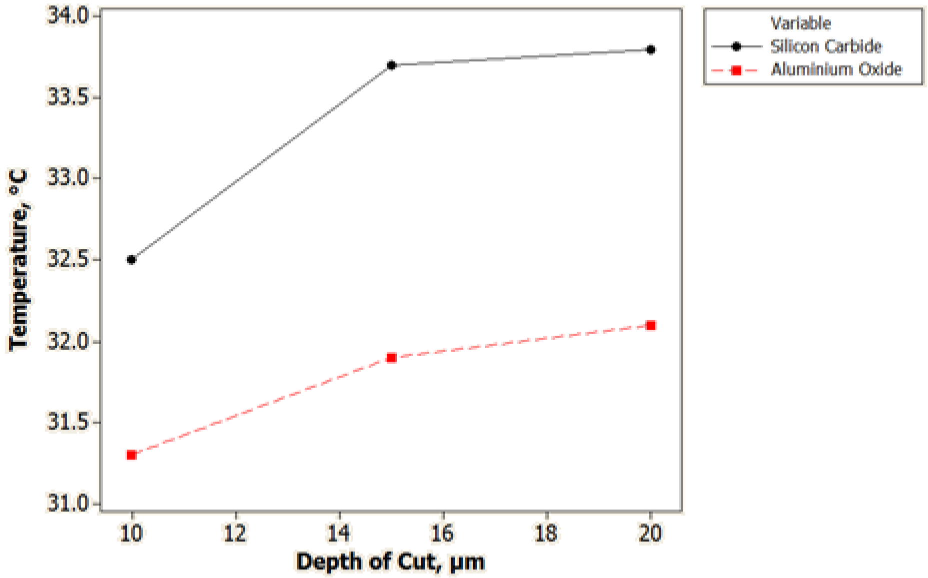


Figure 4.5 : For Table Speed = 5 m/min

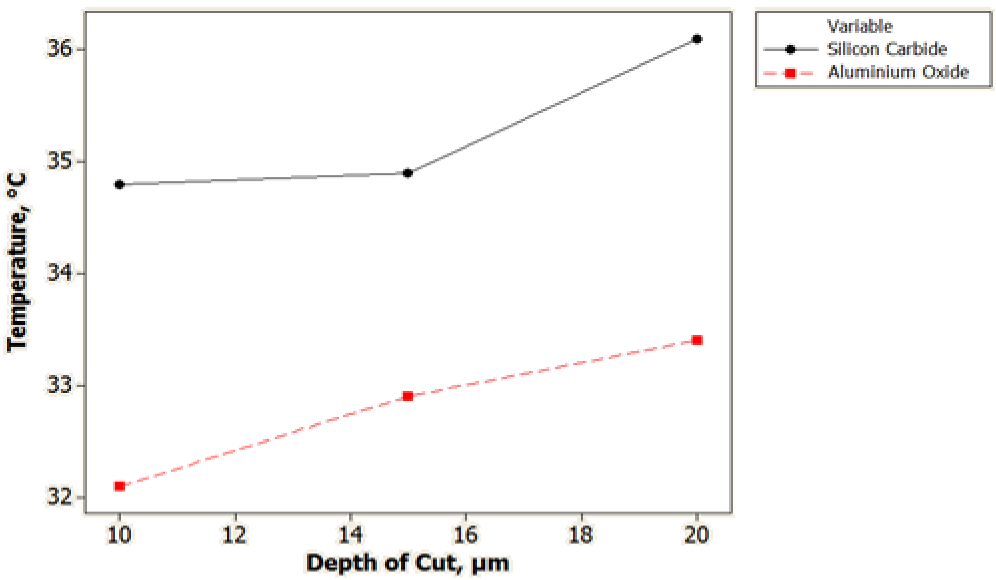


Figure 4.6 : For Table Speed = 15m/min

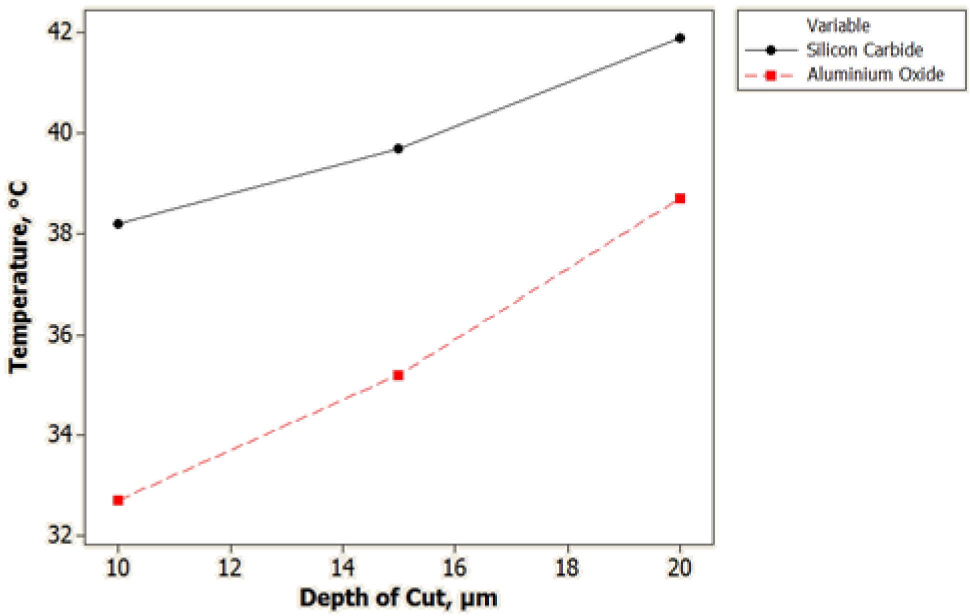


Figure 4.7 : For Table Speed = 25m/min

4.42 Temperature versus Table Speed

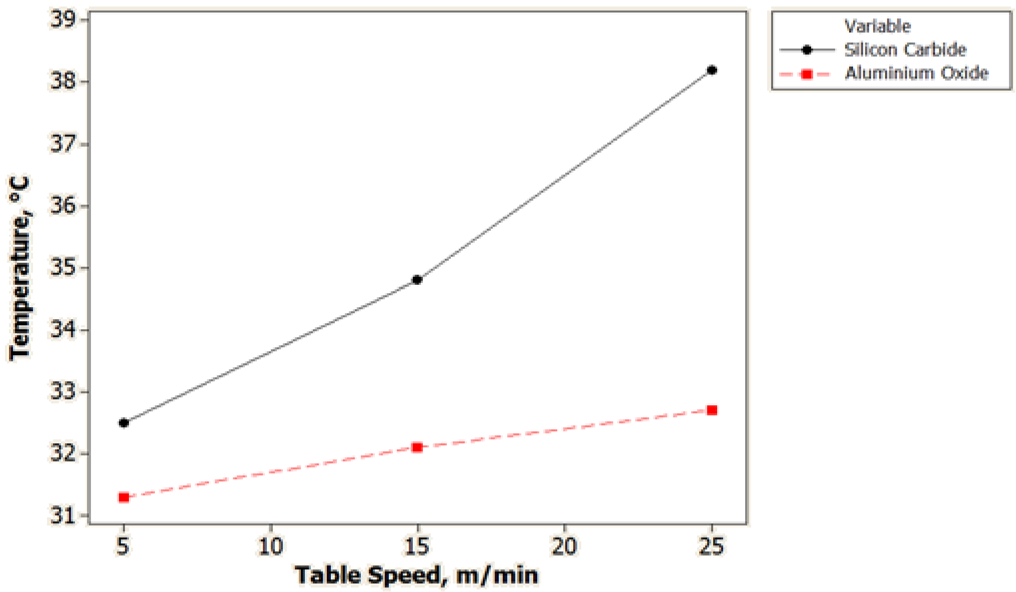


Figure 4.8 : For Depth of Cut = 10 µm

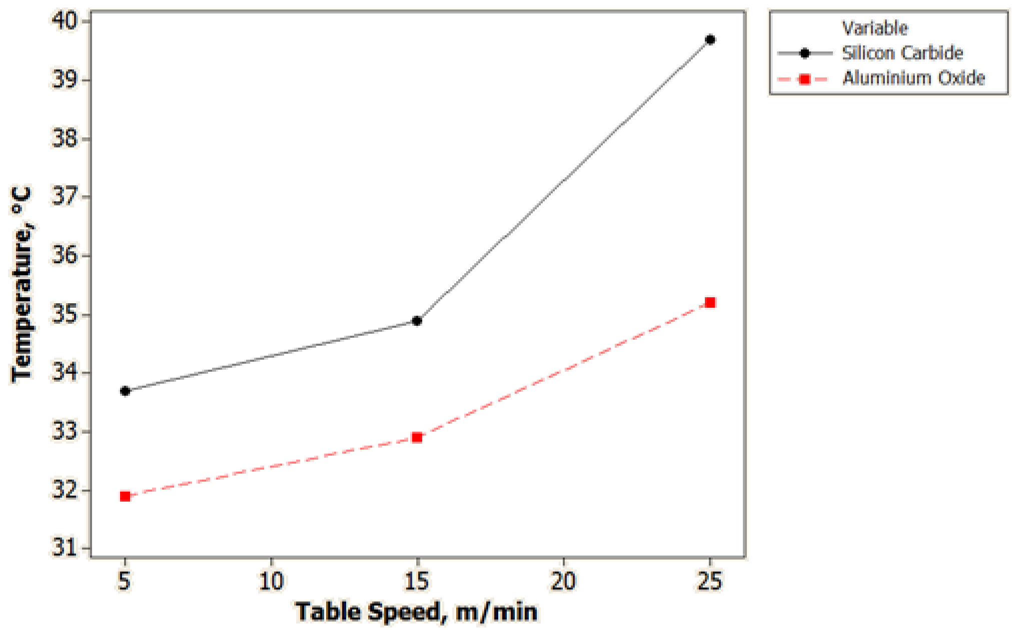


Figure 4.9 : For Depth of Cut = 15µm

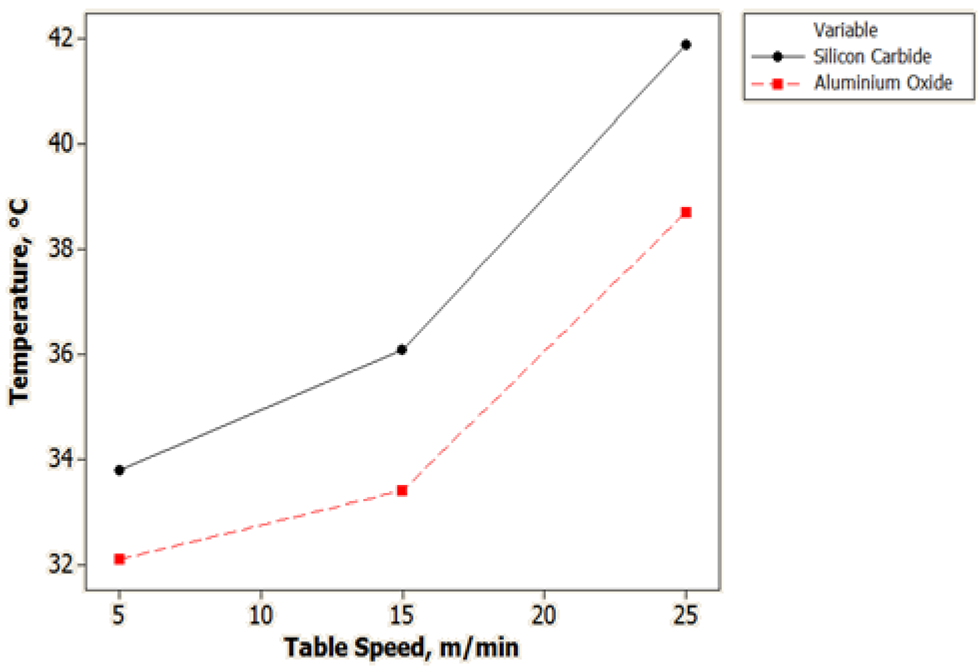


Figure 4.10 : For Depth of Cut = 10 µm

4.4.3 Overall Chart

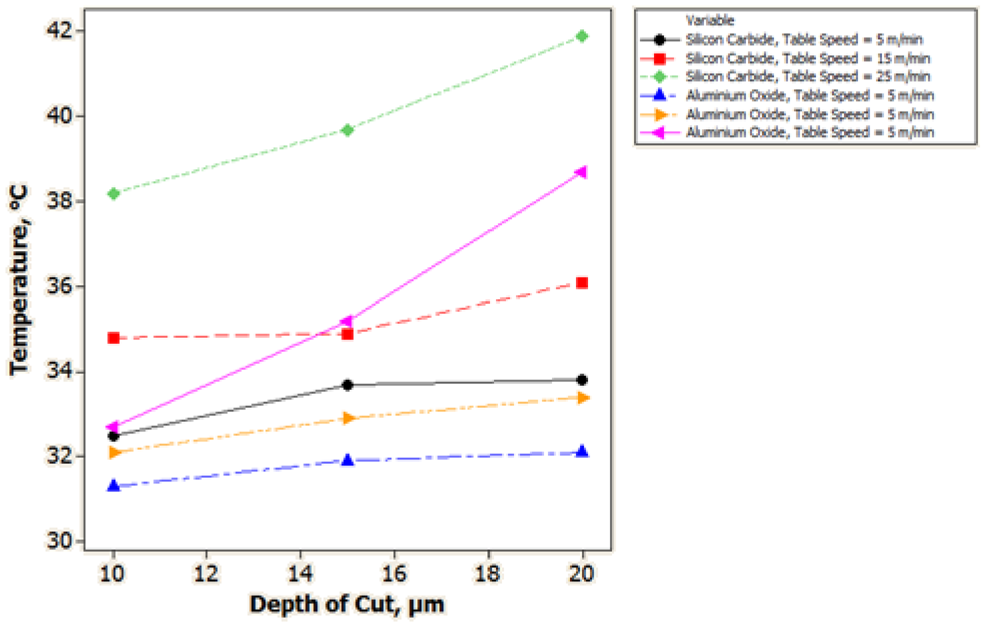


Figure 4.11 : Temperature versus Depth of Cut

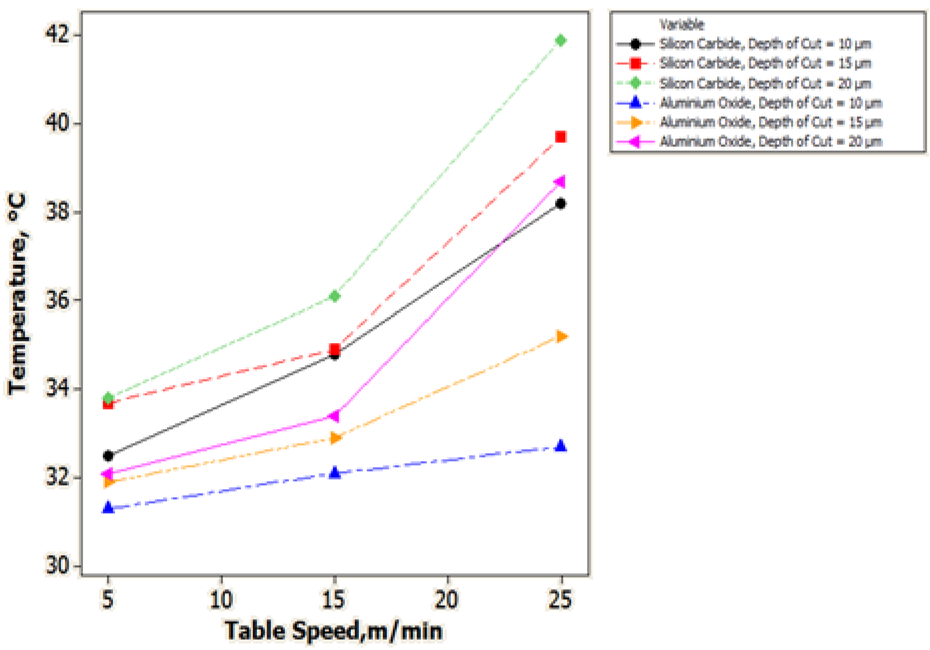


Figure 4.12 : Temperature versus Table Speed

4.5 ANOVA APPROACH

4.5.1 Silicon Carbide

Table 4.2 : ANOVA for Silicon Carbide wheel grinder

Source	DF	SS	MS	F	P
Table Speed, m/min	2	69.0756	34.5378	58.10	0.001
Depth of Cut, µm	2	6.6422	3.3211	5.59	0.069
Error	4	2.3778	0.5944		
Total	8	78.0956			

S = 0.7710   R-Sq = 96.96%   R-Sq(adj) = 93.91

4.5.2 Aluminium Oxide

Table 4.3 : ANOVA for Aluminium Oxide wheel grinder

Source	DF	SS	MS	F	P
Table Speed, m/min	2	22.7267	11.3633	5.39	0.073
Depth of Cut, µm	2	10.9400	5.4700	2.59	0.189
Error	4	8.4333	2.1083		
Total	8	42.1000			

S = 1.452   R-Sq = 79.97%   R-Sq(adj) = 59.94%

From the table 4.2, the p-value for table speed is equal to 0.001 and this mean this value fulfill the condition that p-value must lower than 0.005 to make sure the parameter is really significant to the ginding process but for depth of cut, p-value is higher than 0.005, that the value is 0.069. This means, the depth of cut parameter for silicon carbide wheel grinder is not effected much the thermal occur during grinding process but for aluminium oxide wheel grinder, the different situation occur when both p-value for table speed and depth of cut give the value higher than 0.005.

From the point of optimum parameter, the all the graph above showed that the smaller value of parameter used will give smaller effect of thermal damage. So, the hypotesis that can be proved is smaller value of depth of cut and table speed will lead to less thermal damage on workpiece and grinding wheel. Unfortunately, in industry, smaller parameter will effect the production rate of the company. If production process too slow because of the value of parameter too small, it will not give any advantages to company. So, this hypotesis not relevant to used in industry because it will make lost to company. As a result, the most suitable parameter that should be used is the mid value of this experimet that are 15 m/min for table speed and 15 µm for depth of cut.

As a conclusion, table speed is most significant factor that effect thermal on mild steel grinding process with silicon carbide as wheel grinder but for aluminium oxide wheel grinder, thermal effect are very low when using variables parameter. This mean, aluminium oxide is most suitable wheel grinder for mild steel because its will give lowest effect on temperature on workpiece and tool.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

At the beginning of this research, there was an uncertainty on how an optimum performance of parameter could be attained and the most suitable wheel grinder for mild steel grinding process. Then, an experimental approach on measurement of temperature on work piece has been suggested by using aluminium oxide and silicon carbide as a wheel grinder in this research. By using Taguchi method, several experiments then have been executed on this work piece with varying machining parameters and wheel grinder. The parameters involved in studying the subject matter are depth-of-cut and table speed. Then the desired temperatures are attained by using thermometer infrared as a measured tool.

The research continued by analyzing process in purpose to determine the significant parameter and insignificant parameter in by using ANOVA method. Significant parameters and type of wheel grinder then will be deduced as the most contributing factor to be reference for next experiment. In addition, a specific combination of depth-of-cut and table speed for optimum performance for mild steel grinding process also will be identified. After go through of all this experimental process and analysis, thermal problem can be reduced and be controlled

5.2 CONCLUSION

This project is successfully completed and all of the notified objectives already been achieved which are to investigate thermal effect occurrence on mild steel grinding process via experimental. The value of temperatures was successfully obtained by using infrared thermometer and then analyzes the data using ANOVA technique. It obviously showed from the finding that, the most significant factor for the producing higher temperature is table speed. In ANOVA method, the result clearly showed that p-value for table speed is below than 0.005.

That was mean table speed factor give high effect on thermal problem of grinding process. Depth of cut aslo will give thermal effect to workpiece and grinding wheel but it effect very low and small. Besides that, type of grinding wheel also gives effect on grinding process. Between aluminium oxide and silicon carbide wheel grinder, silicon carbide will produce more heat instead of using aluminium oxide as wheel grinder. Silicon carbide has rough grain, hard and running experimet by using silicon carbide as grinding wheel on mild steel will give high impact to thermal damage. As a result, in mild steel grinding process, aluminium oxide is preferred as grinding wheel because it grain more soft, small and suitable for most material. By applying these results in mild steel grinding process, the thermal damage on the workpiece and wheel grinder can be predicted and be controlled and thus, elongates the tool lifespan and reduce defect on product or workpiece.

5.3 SUGGESTION FOR IMPROVEMENT

From the previous experiment, there are several suggestions that could be implanted as to improve results and obtained more accurate finding. The recommendations are as enlisted below:

1. *Experiment repetitions are necessary*: the data of cutting force should be taken repeatedly in order to gain a more accurate ANOVA table.
2. *Advanced technology provides better*: A CNC grinding machine are much better to control thermal effect instead of a conventional grinding machine as the conventional grinding machine has less performance in term of poor accuracy and poor stability compared to a CNC grinding machine.
3. *Vary cutter tools for each experiment*: the cutting tool use in the experiment should be change for each experiment as to maintain a constant performance reading and avoid tool wear which can influence the reading of the data.
4. *Cutting fluid* : cutting fluid is the most important factor that can dramatically reduce thermal damage on workpiece and wheel grinder. With a variation type

of cutting fluid that widely used in industry, it can reduce almost of the heat that produce during grinding process occur.

5. *Thermocouple* : thermocouple is the most suitable tool to measure heat change during grinding process because thermocouple will measure the temperature from the beginning of the experiment. So although the small change of temperature will be detected by thermocouple instead using infrared thermometer that must be measured the temperature manually and risk of error is high.

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APPENDIX A

Gantt Chart for PSM 2

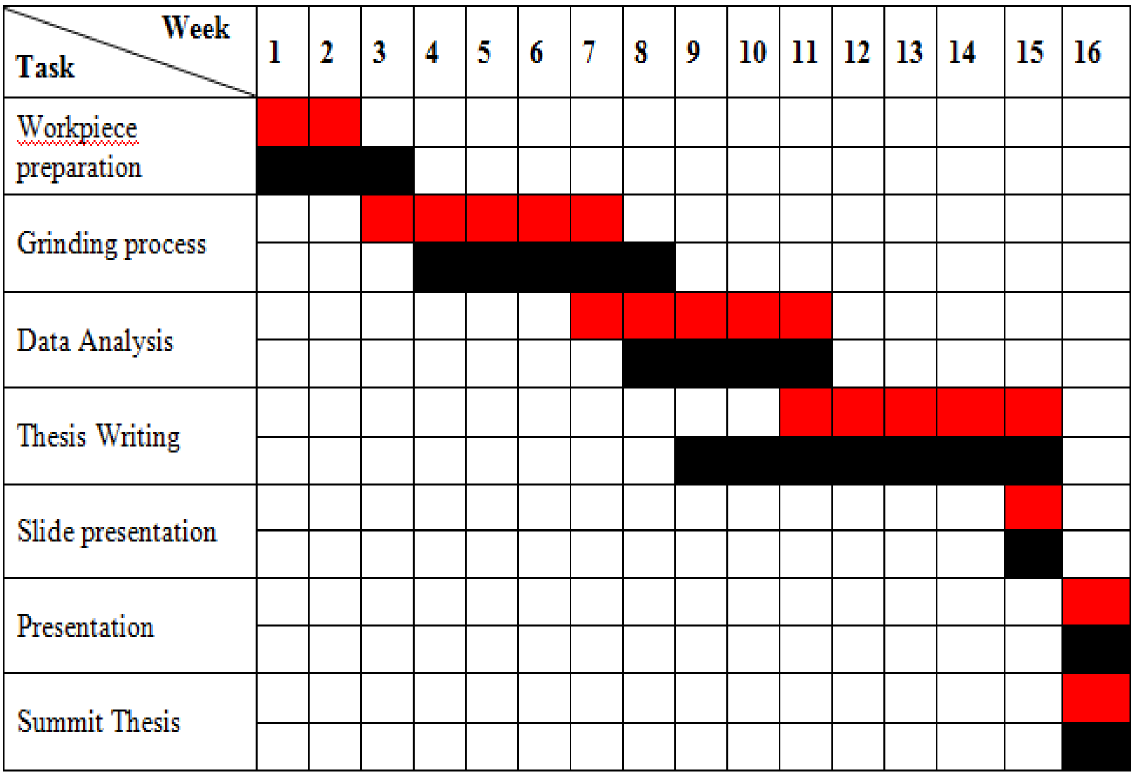
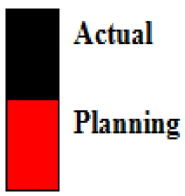


Table 3.1b: Gantt Chart for Final Year Project 2



APPENDIX B

Machining procces

Figure B-1 : Band Saw machine

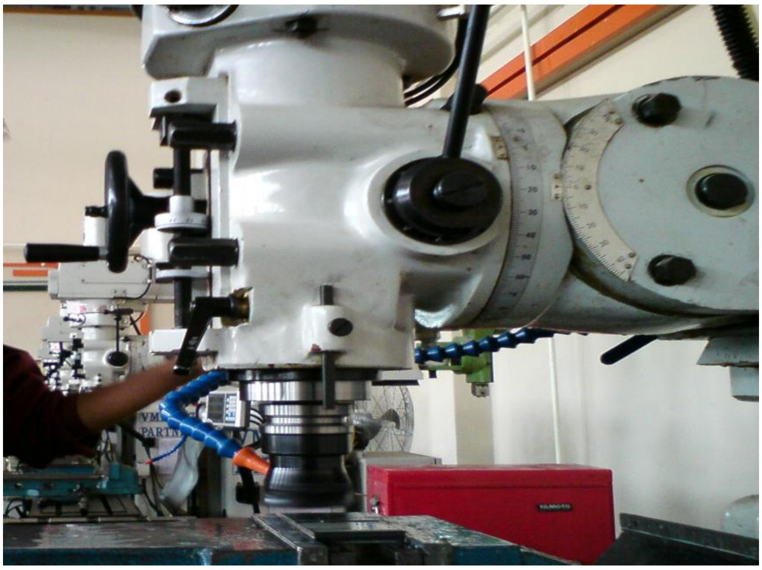


Figure B-2 : Milling machine

Figure B-3 : Surface grinding machine

Figure B-4 : Mild steel grinding process

APPENDIX C

Machine/ tool and material specification

Table C-1 : Specification of S-300HB Band Saw Machine

Specification		Dimension
Capacity	●	300mm
	■	300x250mm
Bundle Cutting	Width	145 to 230mm
	Height	30 to 130mm
Blade Speed	50Hz 60Hz	20 to 100 m/min (INTERVAL)
Blade Size		3820x34x1.1 mm
Blade Tension		Hydraulic

Table C-2 : Properties of Mild Steel AISI 1020

Properties of Mild Steel AISI 1020	
Density (×1000 kg/m^3)	7.7 -8.03
Elastic Modulus (GPa)	190 - 210
Tensile Strength (Mpa)	394.7
Yield Strength (Mpa)	294.8
Elongation (%)	36.5
Reduction in Area (%)	66.0
Hardness (HB)	111

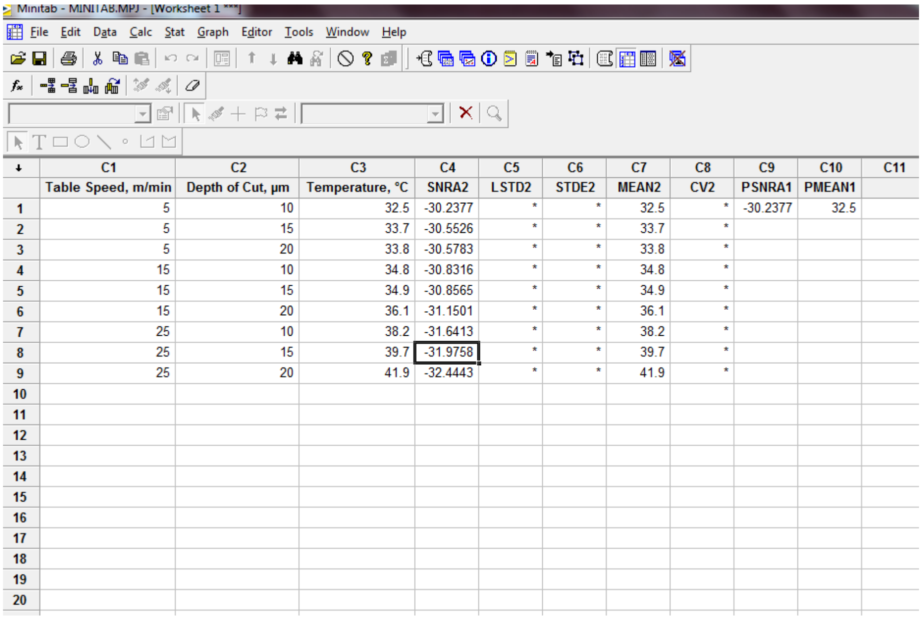
Table C-3 : Handheld Infrared Thermometers specifications

EXTECH 42500 Infrared Thermometer Specifications	
Range / Resolution	-4 to 500°F (-20 to 260°C), 1°C/F
Accuracy	± 3% of reading or ± 6°F (3°C) whichever is greater.
Note	Accuracy is specified for the following ambient temperature range: 64 to 82°F (18 to 28°C)
Emissivity	0.95 fixed value
Field of View	D/S = Approx. 6:1 ratio (D = distance, S = spot)
Laser power	Less than 1mW
Spectral response	6 to 14 µm (wavelength)

General Specifications	
Display	2000 count, backlit LCD display with function indicators
Display rate	1 second approx.
Operating Temperature	32°F to 122°F (0°C to 50°C)
Operating Humidity	Max. 80% RH
Power Supply	9V battery
Automatic Power Off	Meter shuts off automatically after 6 seconds
Weight	4.9 oz. / 140g
Dimensions	6.7 x 1.7 x 1.6” (170 x 44 x 40mm)

APPENDIX D

Minitab software



↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
	Table Speed, m/min	Depth of Cut, µm	Temperature, °C	SNRA2	LSTD2	STDE2	MEAN2	CV2	PSNRA1	PMEAN1	
1	5	10	32.5	-30.2377	*	*	32.5	*	-30.2377	32.5	
2	5	15	33.7	-30.5526	*	*	33.7	*			
3	5	20	33.8	-30.5783	*	*	33.8	*			
4	15	10	34.8	-30.8316	*	*	34.8	*			
5	15	15	34.9	-30.8565	*	*	34.9	*			
6	15	20	36.1	-31.1501	*	*	36.1	*			
7	25	10	38.2	-31.6413	*	*	38.2	*			
8	25	15	39.7	-31.9758	*	*	39.7	*			
9	25	20	41.9	-32.4443	*	*	41.9	*			

Figure D-1 : Data key-in

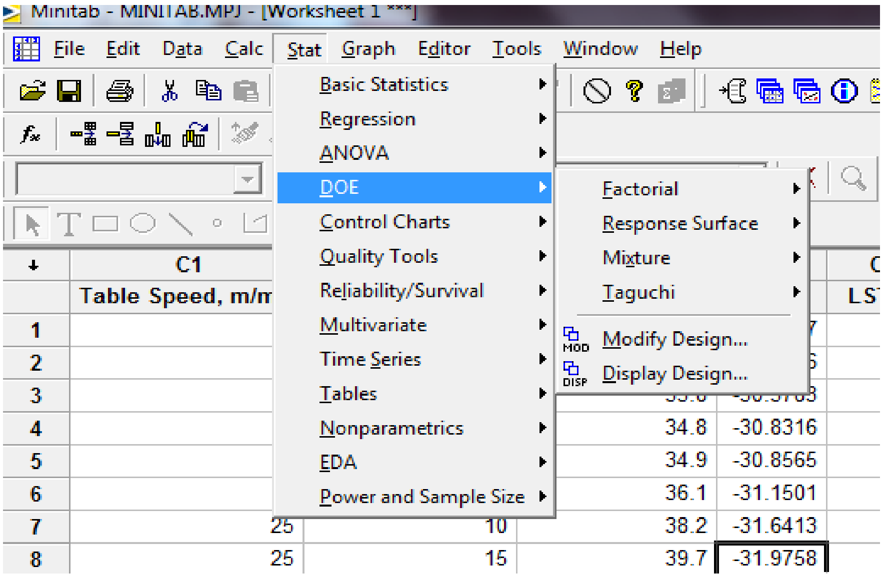


Figure D-2 : DOE types

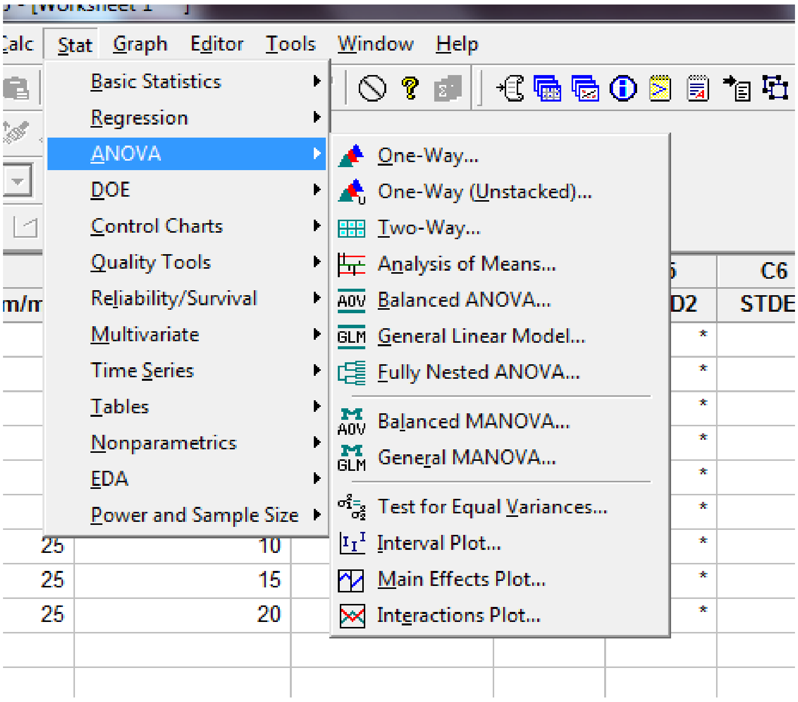


Figure D-3 : ANOVA approached

APPENDIX E

Mild Steel

Figure E-1 : Raw material cutted by band saw machine

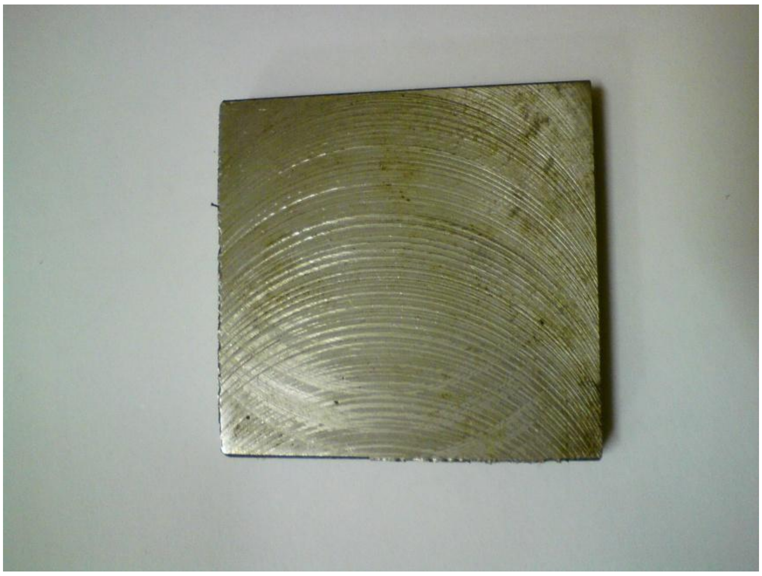


Figure E-2 : After milling process

Figure E-3 : After go through grinding process