

# STUDY ON WEAR MECHANISM AND SURFACE INTEGRITY OF H13 TOOL STEEL UNDER DRY CUTTING CONDITIONS



# BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

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# Faculty Of Mechanical And Manufacturing Engineering Technology



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# Bachelor Of Manufacturing Engineering Technology (Process And Technology) With Honours

2022

# STUDY ON WEAR MECHANISM AND SURFACE INTEGRITY OF H13 TOOL STEEL UNDER DRY CUTTING CONDITIONS

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## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

#### DECLARATION

I declare that this project entitled "Study On Wear Mechanism And Surface Integrity Of H13 Tool Steel Under Dry Cutting Conditions" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



#### APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Of Manufacturing Engineering Technology (Process And Technology) With Honours.

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#### DEDICATION

This study is dedicated to my loving and respected parents, Shahmirul Hafiz Bin Abdullah and Roslinah Binti Abd. Hamid, who have served as an inspiration to me by providing me with a solid moral foundation and a respectable education. They have provided me with tremendous drive and discipline to tackle a work with enthusiasm and attention. I couldn't have done it without their passion and affection. I'd want to dedicate this to my renowned supervisor, Associate Professor Ts.Dr.Umar Al-Amani bin Haji Azlan, who has taught and mentored me during my Final Year Project and, more importantly, throughout my academic career. Finally, I'd want to dedicate this to all of my classmates and friends who have always been by my side no matter how difficult it has been to complete my studies and research.

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#### ABSTRACT

Surface roughness and tool wear are now essential factors in many sectors, particularly the manufacturing industry. In order to achieve the lowest possible surface roughness and tool wear, an ideal parameter is required for the machining process and its use in industry. Cutting speed, dept of cut, and feed rate all have an impact on getting a good surface finish with minimal tool wear. Aside from that, cutting circumstances play a vital influence in producing surface roughness. As a result, this research shows the result of an experimental examination into the influence of cutting speed and feed rate on the surface roughness of H13 tool steel. This experiment was carried out using an CNC (computer Numerical Control) turning machine in dry cutting mode. This project's input variables are cutting speed and feed rate, while the output variables are the surface roughness of the machine sample, tool wear, and surface integrity. The surface roughness of the sample was assessed using a surface roughness tester, and tool wear were quantified using an optical microscope. According yo the findings, cutting speed and feed rate have a significant impact on the surface roughness of H13 tool steel while machining in dry condition with CNC turning. The surface roughness value, Ra, was acquired at various cutting speed and feed rate parameters. It demonstrates that the lowest surface roughness value was attained at a lower cutting speed and feed rate. The findings of this experiment have the potential to assist the industrial industry in reducing production time and cost. It is critical to obtain the optimal cutting speed and feed rate since it can decrease tool wear and extend tool life.

#### ABSTRAK

Pada masa kini, kekasaran permukaan dan nilai kelusuhan alat adalah merupakan faktor yang penting di dalam industri-industri terutama industri pembuatan. Dalam usaha untuk mendapatkan kekasaran permukaan dan nilai kelusuhan alat yang minima, janya perlu mendapatkan nilai yang optimum dimana ianya adalah penting untuk proses pemesinan untuk digunakan di dalam industri. Perkara penting dalam mendapatkan permukaan yang baik dan nilai kelusuhan alat yang minima Yang dipengaruhi oleh kelajuan putaran, kedalaman memotong dan kadar suapan. Selain itu, jenis keadaan permotongan juga memainkan peranan yang penting dalam menghasilkan kekasaran permukaan. Oleh itu. projek in membentangkan eksperimen bag mengkaji kesan kelajuan putaran dan kadar suapan terhadap permukaan kekasaran H13. Eksperimen ini dijalankan menggunakan mesin pelarik CNC (dikawal oleh sistem komputer) dalam keadaan pemotongan kering. Input pembolehubah untuk projek adalah kelajuan putaran dan kadar suapan manakala untuk output pembolehubah adalah kekasaran permukaan setiap sampel and nilai kelusuhan alat selepas pemesinan. Menggunakan pengukur kekasaran permukaan untuk mengukur kekasaran permukaan setiap sampel dan optikal mikroskop untuk mengukur nilai kelusuhan alat. Dari analisis, kelajuan putaran dan kadar suapan memainkan peranan yang penting dalam mempengaruhi kekasaran permukaan H13 apabila pemesinan dilakukan dalam keadaan kering oleh mesin pelarik CNC. Nilai kadar kekasaran permukaan, memperoleh nilai yang berbeza untuk setiap parameter yang berbeza bagi kelajuan putaran dan kadar suapan. Keputusan eksperimen ini dapat membantu industri pembuatan dalam mengurangi masa dan kos produksi. lanya adalah penting untuk mendapatkan nilai optimum untuk kelajuan putaran dan kadar suapan untuk mengurangi nilai kelusuhan alat dan memanjangkan jangka hayat alat.

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# LIST OF SYMBOLS AND ABBREVIATIONS

fr	-	Feed Rate
μ	-	Micron
Vc	-	Cutting Speed
d	-	Diameter Of Workpiece, Depth Of Cut
n	-	Cutting speed
π	-	Pi
Do	-	Original Diameter
Df	-	Final Diameter



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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Project Background

The machining process is one of the oldest industrial processes, and it is the most widely utilized industrial manufacturing of work pieces, with an estimated 15% of all mechanical components manufactured via machining across the world (Calamaz et al, 2008). The lathe machine is one of the traditional machines that is still used in the manufacturing sectors to execute machining processes, but it has limitations in making intricate sections of goods and obtaining poor precision goods. As a result, CNC machines were first created to solve the problem of high-complexity machining of components in production, and therefore to boost productivity. Furthermore, the increased needs of precision goods, high cutting rates, and machining processes may be met by employing a CNC machine with adjustable processing duration.

Turning is a machining operation performed on a lathe, and it is a critical machining process in which a single point cutting tool eliminates junk material from the surface of a spinning cylindrical work piece. The cutting tool is fed in a straight line parallel to the axis of rotation. The quality of the surface has an impact on the performance of the turning operation. This is due to the fact that a high-quality turned surface considerably increases quality. There are several cutting factors involved in CNC turning operations that impact a product's surface roughness. Cutting speed, feed rate, and depth of cut, on the other hand, have the greatest influence on surface roughness (Lalwani et al, 2012).

The surface roughness of H13 Tool Steel will be investigated in this study. Cutting speed and feed rate are the cutting parameters of the CNC turning machine that will be employed. The surface of H13 Tool Steel will be affected by the cutting parameter of this machine operation. Machine operation may be used to determine the surface roughness and quality of H13 Tool Steel. Surface roughness testers and optical microscopes will be used to examine the characteristics of H13 Tool Steel.

The surface finish is governed by the four cutting parameters: cutting speed, feed rate, depth of cut, and tool nose. It has been observed that when a larger tool nose range is used, the surface roughness improves with increased depth of cut, rapid and high feed rate.



#### **1.2 Problem Statement**

The key problem statement in this project is the absence of research into machining parameters on H13 Tool Steel under dry cutting condition, which will affect wear mechanism and surface integrity of materials. The cutting settings will have an effect on the material's microstructure. Earlier SI research in the machining of H13 tool steel was primarily concerned with the experimental evaluation of the impacts of cutting process parameters, tool geometry, and tool wear on work piece surface roughness, residual stress, and subsurface modification, such as white layer development. In engineering, the quality of a material is determined by its surface roughness and microstructure, which determine whether the lifespan cycle fatigue can sustain over a longer or shorter length of time.



# **1.3** Research Objective

The study will examine the surface integrity and surface roughness of H13 Tool Steel under dry cutting conditions. As a result, the primary goals of this project are as follows:

- a) To investigate the impact of machining parameters on a CNC machine.
- b) To determine the wear mechanism and surface integrity under tungsten carbide cutting tool.



#### 1.4 Scope Of Research

The research study in this project will largely focus on numerous factors such as executing a machining process utilizing a CNC turning machine and a Tungsten Carbide cutting tool. H13 Tool Steel was utilized as the raw material for the machine. As dry cutting conditions will be employed in this case study, the turning process will be completed without the presence of lubrication or cutting fluid throughout the machining operation. The experiment will be carried out to study the influence of cutting parameters on the surface roughness of the supplied samples. A surface roughness tester and an optical microscope will be used to determine the surface roughness and wear mechanism of the H13 Tool Steel.



Figure 1.1 Flow process of experiment

#### 1.5 Significant Of Study

The findings of this study will have a significant influence on the CNC machine industry. In general, the use of CNC machines will improve the quality of creating more products while also allowing for more complicated designs to be created as technology advances. Furthermore, this study will provide an excellent chance to learn more precisely about the material H13 Tool Steel in the engineering sector. As a result, a new study on the CNC Machine for the material H13 Tool Steel will be given.



#### 1.6 Concluding Remarks

As a result of this chapter, three issues and constraints that industries face in their efforts to boost productivity are identified. Surface roughness is a major aspect that has a significant impact on the manufacturing process. Minimizing surface roughness is a crucial part of improving performance, maintaining material quality, and lowering material costs in machining. However, determining the appropriate parameters and cutting conditions of the machining process in order to achieve the desired product quality is challenging. The influence of cutting speed and feed rate parameters on the surface roughness of H13 Tool Steel is investigated utilizing a dry CNC turning process condition to determine the best

values.

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#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Turning Process

Turning is a machining operation that is the most often used in industrial production operations and is performed on lathes (Kumar., 2012). The turning operation is used to undertake a material removal procedure and is capable of producing a range of characteristics as well as a higher surface finish on circular items. The characteristics include holes, grooves, threads, tapers, different diameter 7steps, and even contoured surfaces. In a turning operation, numerous machining factors, such as cutting speed, feed rate, and depth of cut, have a substantial impact on the surface of the work piece. Obtaining the optimal parameter in a turning operation is a difficult problem to solve. A good quality work piece surface that has been turned will be able to increase fatigue strength, corrosion resistance, or creep life (Kumar., 2012).



Figure 2.1 Conventional turning machine

The turning operation is one of the most ancient and well-known processes of metal cutting. It is a procedure that employs a single-point cutting instrument. Turning is sometimes used as a secondary process for adding or refining features on pieces made using a separate method. It has even replaced grinding operations in many applications, resulting in shorter lead times and higher tolerances and surface finishes (Rao et al., 2013). It is connected to the essential features of turning operations, which include cutting forces and work-piece surface roughness. The study of cutting tools is critical in the turning process. Turning generates three types of cutting forces: feed force (FX), thrust force (FZ), and radial force (FY). The first is the primary cutting force, often known as thrust force (FZ). The thrust force is generated in the direction of the cutting speed. The second type of force is feed force (FX), which produces in the feed rate direction. Radial force is the third cutting force (FY). This sort of cutting force is generated in a radial direction. The cutting force (main force) is capable of forming around 70% to 80% of the total available force 'F', which is utilized to compute the power 'P' necessary to conduct the machining process (Harsh and Sanket, اونيوم سيتي تيكنيكل مليسيا ملاك

2014).

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#### 2.2 CNC Turning

CNC stands for Computer Numerical Controlled machines, and it is now widely employed in the industrial business all over the world. The CNC was primarily built to meet the growing demand for complicated components machining from client orders and to increase product production. CNC technology enables machining operations to achieve high material removal rates and excellent quality of manufactured components. The rising need for precise products of higher quality and higher productivity with shorter processing times has been the output adopted in recent years, with the most well-known example being the process on a CNC machine (Tillmann et al., 2010). The trial-and-error approach is frequently used to optimize the CNC turning process. It is not, however, a guarantee of high quality or machining economy. As a result, a general optimization strategy is necessary to avoid a large number of trial runs on the machine, which waste time and cause waste.

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#### 2.3 Machining Parameters

Setting up the settings is the first thing that must be done before operating a machine. The criteria for turning operations are the same as those for milling and drilling operations. Optimizing machining settings and selecting the kind of cutting tool are the most significant components in turning to boost productivity and efficiency, therefore reducing processing time and producing high-quality goods (Lee and Kwon, 2010). However, obtaining the optimization of machining settings is a difficult challenge to solve. Many researchers conducted study on this type of issue. To get the optimal machining settings, the try-and-error method must be used. Parameters such as cutting speed , feed rate, depth of cut, and tool geometry have the most influence on surface finish quality.



Figure 2.2 Ishikawa cause effect diagram of parameters that affect the quality parts (Ratnayake, 2014)

#### 2.4 Cutting speed

The rotating speed of the spindle and the work piece in revolutions per minute is referred to as cutting speed (RPM). The cutting speed is calculated by dividing the cutting speed by the circumference of the work piece. The cutting speed must change according to the size of the cut. Its purpose is to maintain a steady cutting speed. Cutting speed can also have a substantial impact on tool life, resulting in the production of tool wear. Excess heat generated by high cutting speed weakens the tool. As a result, the cutting tool's edge becomes dull, resulting in an inconsistent surface finish on the work piece. In some circumstances, however, high cutting speed provides a superior surface quality by taking into account the other factors during machining and obtaining the ideal settings. Furthermore, the higher the cutting speed , the more forces arise. As a result, this condition shows that vibrations are growing during tool performance (Agustina, 2013).

 $n = \frac{Vc(1000)}{\pi(d)}$ **UNIVERSITI TEKNIKAL MALAYSIA MELAKA** 

- n =Cutting speed (RPM)
- Vc =cutting speed (m/min)
- $\pi$  = Approximately value of 3.14 or 3.142
- d = Diameter of the work piece, (mm)

#### 2.5 Feed Rate

Feed rate defines the speed at which the cutting tool moves relative to the work piece when it produces a cut. The feed rate is measured in millimeters per rotation (RPM). When all other factors are constant, the feed rate is the most significant. A low feed rate is required to reduce surface roughness. Tool life reduced as cutting speed increased. However, when the feed rate grew, so did the tool life for dry cutting. Furthermore, when the feed rate increases, so does the surface roughness. As a result, the decreased feed rate gives a superior surface finish. It can also be shown that tensile strength has a substantial influence on feed rate. When the feed rate is increased, the ultimate tensile strength, UTS, decreases. Gómez



### 2.6 Depth of Cut

Depth of Cut is defined as the measurement on how deep the cutting tool contact with the surface of the work piece. Depth of cut (DOC) is the estimation typically in inches or millimeters of how wide and profound the apparatus cuts into the work piece. The units of DOC is expressed in mm/rev.

$$d=\frac{Do-Df}{2}$$

Detail : d = Depth of Cut , (mm/rev) Do = Original diameter of the workpiece in (mm) Df = Final diameter of the workpiece in (mm) LINIVERSITI TEKNIKAL MALAYSIA MELAKA

# 2.7 Cutting Tool

Various machining operations need different types of cutting tool materials. In a turning operation, a single-point cutting tool is utilized, with the cutting tool feeding parallel to the work piece's axis. During the machining process, cutting tools were exposed to high temperatures and pressures. The high temperature is caused by heat from the primary shear zone, secondary shear zone, and friction between the work piece and tool insert flank.



#### 2.7.1 Cutting Tool Material

The selection of a cutting tool is critical in machining. The cutting tool used in machining is determined by the technique. Face mill cutting tools, for example, are used to execute milling operations, whereas centre drill cutting tools are required to undertake drilling operations. Furthermore, the intended form of the result is critical in choosing the cutting tool selection. Because of cutting tool selection failure, an incorrect machining process outcome will ensue. Material properties must be considered in order to obtain the best cutting tool. The properties include being harder than the work to be machined, having superior temperature stability, being impact resistant, resisting wear and thermal stress, and being chemically inert to the work material and cutting 1415 fluid (Sayeed Ahmed, 2015). Cutting tool materials are classified as high speed steel (HSS), carbide, and diamond.



(a) High speed steel (HSS)

HSS stands for high speed steel, and it provides high machining speed as well as high wear resistance. It is, nevertheless, extremely affordable. HSS has a high alloy content, exceptional harden ability, and great cutting edge performance. Because of its capacity to resist softening at high temperatures, it may achieve good machining performance that produces desirable results. This sort of cutting tool material is ideal for machining soft materials such as aluminium, Teflon, and elastomer (Farizan, 2015).

(b) Carbide

Carbide encourages hardness, thermal conductivity, modulus elasticity, and low thermal expansion. From an economic standpoint, carbide has been discovered to be a costeffective tool. Tungsten carbide and titanium carbide are the two forms of carbide used in machining.

*siSis* (c) Diamond UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Diamonds are used to cut hard materials that are difficult to cut with other tool materials, as well as for light, high-speed cuts on softer materials where precision and surface polish are critical. It is commonly used to mill plastics and aluminium at high cutting speeds. (Kalpakjian., 2011).

#### 2.8 Cutting Tool Wear

During the machining process, the cutting tools are loaded with strong forces. The high force is caused by chip deformation and friction between the cutting tool and the work piece. Cutting temperature has a considerable impact on tool wear formation. When heat is created at deformation and friction zones, the temperature of the tool, chip, and some sections of the work piece rises. The contact surfaces are chemically reactive and have a clean surface. As a result, there must be a link between the cutting operations and the complicated physical-chemical processes. As a result of such procedures, tool wear develops. It is also seen in the gradual removal of particles from the tool surface.



Figure 2.4 Tool wear phenomenon (Usui et al., 1984)

Cutting tools are exposed to a harsh rubbing procedure. They are in metal-to-metal contact between the chip and the work piece and are subjected to extremely high stress at high temperatures. The issue is exacerbated further by the presence of high stress and temperature gradients at the tool's surface. Cutting tools remove material from the work piece during machining to produce the desired form, size, and surface roughness (Khaider et al., 2010). However, wear will develop throughout the cutting motion. As a result, it will eventually cause the cutting tool to fail. When tool wear reaches a specific point, the tool must be replaced to provide the correct cutting action. The following are the implications of tool wear:

- Increase in cutting force.
  The roughness of the surface increases.
  Reduced dimensional precision.
  Increased temperature.
  There is vibration.
  Reduce component production efficiency and quality.
- 7. Increase the price.

#### 2.9 Chip Formation

Three major variables contribute to the formation of a chip. The tool shape, tool materials, and work are the variables. Figure 2.5 depicts the tool geometry, which is determined by different angles and nose radius of the single-point tool.



Chips are divided into three varieties based on their edges: discontinuous, continuous, and build-up.
## a) Continuous

Continuous chip happens when a chip is constantly distorted and glides up the face of the tool without being fragmented throughout the machining process. The chip is often produced through the use of ductile materials. It tends to get twisted in the tool holder, fixtures, and work piece, as well as the chip-disposal system, and the process must be paused to remove the chips. Using coolant or improving machining parameters such as feed rate, cutting speed, or depth of cut can help to avoid continuous ship.

## b) Discontinuous

When machining is shattered into small fragments, a discontinuous chip is generated. It is often obtained by the cutting of ductile materials such as bronze and cast iron. It also has a high surface polish quality. Furthermore, a discontinuous chip was formed while milling brittle material without using adequate cutting conditions.

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## b) Discontinuous

When machining is shattered into small fragments, a discontinuous chip is generated. It is often obtained by the cutting of ductile materials such as bronze and cast iron. It also has a high surface polish quality. Furthermore, a discontinuous chip was formed while milling brittle material without using adequate cutting conditions.



## 2.10 Dry Cutting

There are two sorts of cutting conditions that may be employed in machining: dry cutting and wet cutting. Dry cutting does not require the use of cutting fluids like as water or oil. Cutting fluid is a coolant that also acts as a lubricant during the machining process. Dry cutting takes less electricity and is frequently associated with cheap cost, health difficulties, and environmental sustainability. However, 100% dry turning is not technologically viable because to the inability to decrease heat output or provide appropriate heat dissipation.

Nowadays, the usage of dry cutting conditions in machining processes is thought to be long-term and in high demand. It is due to environmental and human health concerns, as advised by environmental legislation. Dry cutting conditions are commonly used to provide finishing and clean machining systems that do not pose a risk to the environment. Furthermore, using dry cutting in machining can save production costs because cutting fluid prices account for a major portion of total machining expenses. There are a few limits or issues that arise when using it.

Cutting fluid difficulties may be avoided by machining in a dry environment, but it is not easy to install dry machining on an existing shop floor since it requires highly stiff machine tools and ultra-hard cutting tools (Leo Dev Wins and Varadarajan, 2011). To enable the application of dry cutting, robust, wear-resistant, low thermal diffusivity tool materials and coatings that can retain their qualities at higher machining temperatures are required (Raykar et al., 2014). Another issue with dry machining is the significantly greater temperature and, as a result, the resultant thermal expansion of the work piece, which contributes to geometrical errors of the machined item (Klockea., 2013). There are several aspects that might impact dry cutting in order to ensure costeffective manufacture of final components. Figure 2.7 depicts all of the variables.



Figure 2.7 Factors influencing economical manufacturing of finished parts by using

UNIVERSE dry machining condition (Klocke.F, 1997)

## 2.11 H13 Tool Steel

H13 Tool Steel is a chromium-containing hot-work steel. This steel is frequently utilized in engineering applications, particularly in hot work such as cutting, brazing, and soldering, as well as cold work such as rolling, extrusion, and riveting. When compared to other steels, H13 is well-known for its hardness and ability to resist cracking and fatigue. According to (José Outeiro.,2014), the machined material under consideration was H13 tool steel. It has strong thermal softening resistance, high harden ability, high strength, and high toughness. H13 tool steel is commonly used to make a variety of hot work dies, including forging dies, extrusion dies, die-casting dies, and so on. The hardness of H13 tool steel varies depending on its application for various types of dies.

H13 is composed of ten chemical components: chromium,Cr (4.75-5.50 percent ), molybdenum,Mo (1.10-1.75 percent ), silicon,Si (0.80-1.20 percent ), vanadium,V (0.80-1.20 percent ), carbon,C (0.32-0.45 percent ), nickel,Ni(0.3 percent ), copper,Cu(0.25 percent ), manganese,Mn (0.20-0.50 percent ), (0.03 percent ). This combination of chemical compositions demonstrates that H13 material has high strength, which is why it is suited for hot work dies. A work piece of H13 is seen in Figure 2.8 below:



Figure 2.8 Hardened H13 tool steel work piece

## 2.12 Surface Roughness

Nowadays, surface finish is a critical indication of quality and accuracy in manufacturing processes, and it is the most essential characteristic since it plays a key role in industry. The surface roughness of the product during the cutting process has a significant impact on its quality. The reduction of surface roughness might result in higher product quality. At the same time, a good surface roughness is accomplished by taking into account factors such as a faster cutting speed, a lower feed rate, and a shallower depth of cut (Basim A. Khidhir and Bashir Mohamed, 2011).

A good surface finish not only ensures quality, but it also decreases manufacturing costs because it is a significant component that influences manufacturing costs. Surface quality is significant in terms of tolerances because it decreases assembly time and minimizes the need for extra operations, which decreases operating time and contributes to overall cost savings. The effect of surface roughness is affected by a variety of factors, including material couple, manufacturing type, and cutting circumstances. At the same time, because of the direct relationship between surface roughness and cutting conditions, surface roughness is one of the most significant characteristic variables to monitor in cutting operations (Ilhan and Ali, 2010).

Surface roughness influences several functional properties of components, such as contact generating surface friction, wearing, light reflection, heat transfer, lubricant distribution and retention, load bearing capacity, coating, and fatigue resistance. As a result, the desired surface finish is generally defined, and the appropriate techniques are required to achieve high product quality (N. Satheesh Kumar, 2013). Surface roughness is also one of the most critical restrictions for selecting optimal cutting settings and machine tools during process development and to achieve the desired quality.

Surface roughness has a significant impact on the friction, wear, and lubrication of contacting bodies. Surface roughness is one of the characteristics that has a significant impact on friction under specific operating circumstances. During the forming process, the surface roughness of the contacting surfaces determines their frictional qualities. It is now obvious that the geometry of surface roughness has a significant impact on how the contacting surfaces interact. Furthermore, it is widely recognized that various machining circumstances such as cutting speed, feed rate, and depth of cut impact the final geometry of surface roughness.

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### 2.13 Surface Roughness Parameters

Because of the relationships between the factors, optimizing cutting settings for surface roughness is a tough task. It is regarded as a difficult problem to solve because many factors must be considered 23, such as machining expertise, empirical equations linking tool life, pressures, power, and surface polish. Problems relating to the increase of desired product quality and manufacturing efficiency capable of gaining client satisfaction may always be linked to optimization techniques (Suhail et al, 2010).

Surface roughness may be classified into several categories. Controlling the essential parameters was created in response to the rising demand in industry for optimal parameter sets for optimal roughness measurements with enhanced metal removal rate. The roughness average (Ra) is one of the surface roughness parameters utilized in this study to measure surface roughness. It is sometimes referred to as the arithmetic mean roughness value, the arithmetic average (AA), or the centre line average (CLA). The roughness average is positioned between the roughness profile and its centre line region, or the integral of the absolute value of the roughness profile height over the evaluation length, as illustrated in figure 3. Roughness average (Ra) is another effective measure for describing the quality of a machined surface.

## 2.14 Concluding Remarks

This chapter demonstrates that surface roughness is a critical element in determining the quality of a machined product. As a result, parameter optimization is required to attain a minimal surface finish. However, optimizing factors such as feed rate and cutting speed is challenging. The three most important parameters are feed rate, cutting speed, and depth of cut. Many researchers used these parameters in their research in order to optimize parameters. In this chapter, the dry cutting state is also discussed in terms of how it affects surface roughness during machining operations.



#### **CHAPTER 3**

#### METHODOLOGY

## 3.1 Experiment Design

The experiment will be carried out on H13 Tool Steel utilizing a CNC turning machine with dry cutting, where no cutting fluid or coolant will be present. Feed rate and cutting speed are two parameters to be investigated. The output sample will next be evaluated using a surface roughness tester and an optical microscope to acquire the findings. The preparation of raw materials and cutting tools is the first step in the process flow. The material will next be machined in a dry cutting state. The output of the sample will be analyse in terms of cutting speed and feed rate. The samples will next be examined using an optical microscope and surface roughness tester to assess surface roughness and tool wear.

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# 3.2 Prepare Material And Cutting Tool MALAYSIA MELAKA

At general, this cutting tool project will be carried out in the Advance Machining Lab utilizing H13 Tool Steel. The original raw material is already produced in the shape of a cylinder bar and must be cut to a length of 200 mm. The bandsaw available in the lab will be used to cut the material. The material will be skimmed once it has been cut. This tries to smooth the whole surface of the material whether it is rough or damaged. The following procedure will require CNC Lathe Machine operation and stages. Figure 3.1 depicts the experiment's Flow.

## 3.3 **Process Flow**



Figure 3.1 Flow chart of experiment

## 3.4 Cutting Tool

In Lathe Machining, there are several varieties of cutting tool material. The material that will be utilized to cut H13 Tool Steel in this project is tungsten carbide. Because the blade of a tungsten carbide is constructed of carbide, it may be used to cut any other hard metal, such as High Speed Steel (HSS), Cast Iron, Stainless Steel, or any other Non-Ferrous Metal. H13 Tool Steel will be the first material evaluated utilizing a Tungsten Carbide tool in the Advance Machining Lab.



Figure 3.3 Cutting tool holder

## 3.5 Machining Process

Several measures will be taken at this period. To acquire the proper outcome, the stages must be completed in the right order.

I. Skimming

Removal of a material from the surface is referred to as skimming. Removing a thin coating of H13 Tool Steel's surface with skimming gear is referred to as skimming. It may be defined as the process of cleaning or polishing the surface of a workpiece to restore it to its original state.

II. Facing

Before moving on to the next operation, the initial stage in the turning procedure is to face. Facing is the process of eliminating undesired metal or parts, generally near the material's end. This is intended to provide a nice or flat surface, particularly for a cylindrical shape. In general, this method is straightforward and straightforward, as it requires no parameters at all. Facing is usually done only once and never again since it is considered the first touch of the cutting tool against the material. The facing procedure will necessitate the use of a facing tool, which is attached to a tool holder on a standard lathe machine.

## III. Centre Drill

The technique of creating a 60 degree hole at the end of a work piece is known as centre drilling. It serves two purposes, the first of which is to provide a marking location for the drilling operation. This project's goal is to guarantee that the work piece receives adequate support from the tail stock 43 centre during the turning process. This method will necessitate the use of a drill bit tool, the size of which is determined by the diameter of H13 Tool Steel.



## IV. CNC Turning Operation

This procedure will necessitate advanced programming on the equipment. In order to accomplish so, a few manual adjustments must be made, much like on a traditional lathe machine. H13 Tool Steel has a length of 200 mm. The chuck will be held at 20 mm during the clamping process. The turning procedure will be marked at 170 mm, with a gap of 10 mm left as a safety precaution. The programming will be established based on the machining settings provided. This project has four cutting speeds and two feed rates. This procedure is carried out in a dry environment. This experiment will be carried out at the Advance Machining Lab. DMG MORI SEIKI, CTX 310 eco line, and a 3-axis machine are the CNC Turning Machine models.



Figure 3.4 CNC Lathe Machine (CTX 310 ECOLINE)

## 3.6 Machining Parameter

The primary goal of this experiment is to investigate the impact of cutting speed and feed rate on the surface roughness of H13 Tool Steel. These variables have a considerable impact on the material and cutting instruments utilized. In this experiment, several cutting variables, as given in Table 3.1, will be employed.

Cutting speed	Feed Rates	Feed Rates	Depth Of Cut
(m/min)	(mm/rev)	(mm/rev)	(mm)
100	0.05	0.10	0.5
140	0.05	0.10	0.5
170	0.05	0.10	0.5
200	0.05	0.10	0.5
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Table 3.1	Cutting	parameters
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## 3.7 Data Analysis

The processing data is the final step in order to gain the output results from the experiment. There are two important factors that need to be studied which are the tool wear of the cutting tool and the surface roughness of the material H13 Tool Steel. There are two machine and testing equipment for this project which are Surface Roughness Tester and Optical Microscope



## I. Surface Roughness Tester

Surface Roughness Tester is used to examine the surface roughness of the material, based on this experiment is H13 Tool Steel. Surface roughness is a very important process to do especially after the cutting operation involved towards the material. It will show the cycle time of the material whether it still in good condition or about to fatigue. Surface Roughness Tester will consist the measurement of roughness depth and the mean roughness and is measured in unit of microns ( $\mu$ m). The device will display the result of the material by the formation of graph through the screen of the tester. The brand type used in this lab is Mitutoyo Surface Test (SJ-401). The procedure of using Surface Roughness Tester as follow:

- Turn on the device until the menu is display.
- Choose the measurement condition correctly.
- Define the Standard ISO to the device.
- Select a proper profile, define roughness parameters and use a proper filter.
- Adjust the device parameter properly.
- The device will conduct the measurement by display the measured profile.



Figure 3.5 Surface Roughness Tester

## II. Optical Microscope

A device that is used to measure and observe the tool wear condition of the cutting tool, on this case is Tungsten Carbide. The model that will be used in Advance Machining Lab is Nikon Measuring Microscope MM-800. According to the ISO 3685 which is used in single point turning tools, the range of 0.3 mm and above is consider as fully wear out, which means the tool must be replaced with a new cutting tool. If the range is still below 0.3 mm, the condition of cutting tool is good. The procedure of using Optical Microscope are as follow :

- The sample test is placed on the sample stage on the objective lens.
- Adjust the light intensity and outer knob for a focus image of lens.
- The image of sample can be viewed on the ocular lens.
- The attached computer will display live image of the sample.



Figure 3.6 Optical Microscope

## III. Scanning Electron Microscope

Scanning Electron Microscope is a model of microscope that examines the surface of a material with a focused beam of electrons in order to produce a high-resolution image. SEM is more advance than the optical microscope. Generally, both instruments are used to examine the structure of a material, only SEM can reveal more detail about the microstructure. The model used in the lab is ZEISS EVO 18. The procedure of using SEM is as follow:

- Before beginning the scanning, the sample must be clean and dry.
- Mount or attach the sample at the aluminium stub using sticky tab.
- Make sure to run the vent process to let air into the vacuum chamber.
- Once it is completed, put the specimen into sample holder and close the chamber door.
- Run the pump process until the instrument reach full vacuum.
- Sample is ready to be examined.



Figure 3.7 Scanning Electron Microscope

## 3.8 Concluding Remarks

It may be deduced from this chapter that a CNC turning machine will be utilized to machine the H13 Tool Steel material in dry cutting state. Surface roughness and tool wear are measured using two instruments: a surface roughness tester and an optical microscope. Chips or scraps generated during machining have also been used as extra information data.



#### **CHAPTER 4**

## **RESULTS AND DISCUSSION**

### 4.1 Introduction

The results and discussion are provided in this chapter. Each outcome will be followed by an analysis and debate. Surface roughness is the subject of discussion in one section. This chapter also discusses tool wear and chip development. Throughout this chapter, the flow and processes of the analysis are discussed. The factors that influence each reaction are examined in turn.

## 4.2 Surface Roughness

Surface roughness is an important factor in determining cutting performance and plays an important role in the manufacturing process. A product's surface roughness is used to determine and evaluate its quality. Superior surface quality can also save assembly time and remove the need for additional processes. The surface quality has an impact on fatigue strength, corrosion resistance, and creep life (Satheesh et al.,2012). In this work, H13 tool steel is machined under dry circumstances to examine the surface roughness on the material surface with varied cutting speed. A surface roughness tester was used to calculate the Ra value. Ra is expressed in micrometers.

## 4.3 Machine Configuration

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H13 is the material used in this investigation. Four parameters are required by the machine: cutting speed, feed rate, depth of cut, and spindle speed. However, the cutting speed, depth of cut, and feed rate have already been defined. At first, speeds of 100, 140, 170, and 200 m/min will be lowered. Following that, two feed rates of 0.05 and 0.10 mm/rev were used, with a cut depth of 0.5 mm. The parameter to be calculated is spindle speed. The spindle speed is measured in revolutions per minute (rev/m).

 $n = \frac{Vc(1000)}{\pi(d)}$ 

Table 4.1 The values of spindle speed for first parameter at feed rate (0.05) mm/rev

ž.	>	
Cutting Speed (m/min)	Diameter (mm)	Spindle Speed Calculation (rev/min)
109	ک ملسب	Spindle speed = $\frac{100(1000)}{\pi(56)}$ = 568.41
140 UNIVEF	SITI TEKNIK	Spindle speed = $\frac{140(1000)}{\pi(55)}$ = 810.24
170	54	Spindle speed = $\frac{170(1000)}{\pi(54)} = 1002.09$
200	53	Spindle speed = $\frac{200(1000)}{\pi(53)} = 1201.17$

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Cutting Speed (m/min)	Diameter (mm)	Spindle Speed Calculation (rev/min)
100	52	Spindle speed = $\frac{100(1000)}{\pi(52)} = 612.13$
140	51	Spindle speed = $\frac{140(1000)}{\pi(51)} = 873.79$
170	50	Spindle speed = $\frac{170(1000)}{\pi(50)}$ = <b>1082</b> .25
200	49	Spindle speed = $\frac{200(1000)}{\pi(49)}$ = <b>1299.22</b>

Table 4.2 The values of spindle speed for first parameter at feed rate (0.05) mm/rev

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4.4 **Surface Roughness Results And Data Analysis** 

In this section, statistics on the profile of surface roughness for both feed rates of 0.05 and 0.10 mm/rev are shown. The graph was created using the Surface Roughness Tester model SJ Mitutoyo-410.

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## رسيتى تيكنيد 4.4.1 **First Parameter** UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The measurements of surface roughness levels obtained after the machining process are shown. The surface roughness quality is referred to as the surface roughness. A lower surface roughness rating results in better surface roughness quality. Surface roughness, Ra, were examined.

Details	Profile of surface roughness
Diameter: 56 mm	
Cutting Speed: 100 m/min	Manufan Marin Manufan Marina Marina
Ra: 1.656 μm	
Diameter: 55 mm	
Cutting Speed: 140 m/min	WWW WAR MANNAN MANAMANAN MANYA
Ra: 2.007 µm	
Diameter: 54 mm	
Cutting Speed: 170 m/min	I were and the transmer businessed and when a more thank the the second and the
Ra: 1.611 μm	
Diameter: 53 mm	
Cutting Speed: 200 m/min	Martun Man Martin Martin Martin Martin Martin
Ra: 1.852 µm	اونيۇسىتى تېكنىكل ملىسپا

Table 4.3 Profile of Surface Roughness at feed rate (0.05 mm/rev)

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Cutting speed (m/min)	Surface	Standard
	Roughness, <i>Ra</i>	deviation
	(µm)	
100	1.656	0.003
140	2.007	0.390
170	1.611	0.003
200	1.852	0.060

Table 4.4 Cutting speed and surface roughness, Ra values at 0.05 mm/rev

Table 4.3 shows the readings of the surface roughness with the given cutting speed values at a constant feed rate and depth of cut. There were four readings of the surface roughness observed in this experiment. Surface roughness tester was used to obtain the Ra values of the workpiece according to different cutting speed parameters that have been set while conducting dry CNC turning machining process.

Cutting speed parameter of 100 m/min contributed to a surface roughness of 1.656µm while an increased cutting speed of 140 m/min, 170 m/min and 200 m/min yielded surface roughness readings of 2.007µm, 1.611µm, and 1.852µm respectively. Based on the table, when the cutting speed was set to 100 and 140 m/min, it is found that the surface roughness values of H13 tool steel increased slightly from 1.656 to 2.007µm. A sudden decrease in surface roughness is observed for cutting speed at 170 m/min at 1.611µm followed by a slight increase from that at cutting speed of 200 m/min yielding a surface roughness of 1.852µm.

The lowest value of the surface roughness was  $1.611\mu m$  which obtained when the cutting speed was 170 m/min while the highest value of surface roughness was  $2.007\mu m$  when a cutting speed of 140 m/min was applied. According to Kumar et al., (2012) The surface roughness decreased with increased cutting speed. The range of surface roughness had a slight increase at lower cutting speed s, a sudden rise in moderate cutting speed s, and a sudden decline with higher cutting speed.

Standard deviation values of  $\pm 0.003$ ,  $\pm 0.390$ ,  $\pm 0.003$ , and  $\pm 0.060 \mu m$  were calculated for surface roughness at cutting speed s of 100, 140, 170 and 200 m/min respectively, for a feed rate of 0.05 mm/rev. A smaller standard deviation reflects greater data accuracy. Data collected for cutting speed of 100 and 170 m/min yielded the greatest machining accuracy with the smallest standard deviation of  $\pm 0.003 \mu m$  while data collected for cutting speed of 140 m/min yielded the greatest standard deviation at  $\pm 0.390 \mu m$ , therefore making the data less accurate in comparison.

Therefore, the most suitable cutting speed for optimization of dry CNC machining process is 170 m/min shown by smallest surface roughness and tool wear average as well as standard deviation value yielded by carbide insert under these machining conditions. This means dry cutting processes that do not utilize fluids or coolants are best carried out with a cutting speed of 170 m/min for a feed rate of 0.05 mm/rev to ensure greater tool shelf life. According to Debnath et al., (2016) it is important the application of cutting fluid effectively reduce the tool wear and consequently improve the surface finish.



Figure 4.1 Graph of Surface Roughness (µm) against Cutting speed (m/min) at

0.05 mm/rev Feed Rate

Based on Figures 4.1, it was discovered that cutting speed had the greatest influence on surface roughness. The surface roughness of the workpiece examined increased as the cutting speed values of the H13 tool steel material rose. Cutting speed refers to the rotating speed of the workpiece during the machining process, which is used to anticipate surface quality in advance (Torres et al., 2015). When the cutting speed was increased, the surface removal of the workpiece encountered a poor finishing process, resulting in greater surface roughness values. The surface roughness is maximum at 140 m/min cutting speed because the cutting speed is increased by 40 m/min, as opposed to other increments of 30 m/min. When compared to other components produced at lesser cutting speed increments, the surface of the workpiece at 140 m/min was the roughest. Surface roughness would be higher on the workpiece with the roughest surface.

# 4.4.2 Second Parameter

Details	Profile of surface roughness
Diameter: 52 mm	
Cutting Speed: 100 m/min	and month and the second and the second with the second with the second se
Ra: 1.243 µm	
Diameter: 51 mm	
Cutting Speed: 140 m/min	mon Management month ANN ANNA MENDALAWA MANAMANA MANA
Ra: 1.314 μm	LAYSIA
Diameter: 50 mm	
Cutting Speed: 170 m/min	Annonin Man Mun Mun Mun Mun Mun Mun Mun Mun Mun Mu
Ra: 1.252 µm	
Diameter: 49 mm	اونوم ست تتكنيك ملسنا
Cutting Speed: 200 m/min	when my har
Ra: 0.976 μm	RSITI TEKNIKAL MALAYSIA MELAKA

Table 4.5 Profile of Surface Roughness at feed rate (0.10 mm/rev)

Table 4.6 Cutting speed, surface roughness, Ra and standard deviation values at 0.10

Cutting speed (m/min)	Surface roughness, <i>Ra</i> (μm)	Standard deviation
100	1.243	0.005
140	1.314	0.071
170	1.252	0.006
200	0.976	0.274

## mm/rev

The feed rate was increased to 0.10 mm/rev and the variables are cutting speed starting from 100, 140, 170 until 200 m/min. The first cutting speed value was set to 100 m/min resulting in a surface roughness of 1.243µm. When the cutting speed was increased to 140, 170, and 200 m/min, the surface roughness rose to 1.314µm and then continued to decline to 1.252µm and 0.976µm respectively.

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The highest value for surface roughness was 1.314µm while the lowest one was 0.976µm with cutting speed of 140 m/min and 200 m/min respectively. The overall readings show a steady increase of the surface roughness of H13 tool steel material from cutting speed s of 100 m/min and 140 m/min and a slight decrease in surface roughness after cutting speed s of 170 m/min.

Standard deviation values of  $\pm 0.005$ ,  $\pm 0.071$ ,  $\pm 0.006$ , and  $\pm 0.274\mu m$  were calculated for surface roughness at spindles speeds of 100, 140, 170 and 200 m/min respectively, for a feed rate of 0.10 mm/rev. A smaller standard deviation reflects greater data accuracy. Data collected for cutting speed of 100 m/min yielded the greatest machining accuracy with the smallest standard deviation of  $\pm 0.005\mu m$  while data collected for cutting speed of 200 m/min yielded the greatest standard deviation at  $\pm 0.274\mu m$ , therefore making the data less accurate in comparison. It is suggested that mechanical vibration due to greater cutting speed s may have contributed to a greater standard deviation within data collected.

Therefore, based on surface roughness and tool wear average for a feed rate of 0.10 mm/rev, the most optimized cutting speed for machining under dry cutting conditions is 200 m/min, since the smallest average for both surface roughness and tool wear parameters were attained with said cutting speed.

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Figure 4.2 Graph of Surface Roughness (µm) against Cutting speed (m/min) at

0.10 mm/rev Feed Rate

The surface roughness levels rose as the feed rate increased. Based on the graphs in Figures 4.2, this investigation method confirmed that the values of the surface roughness of H13 tool steel were influenced by feed rate. As a result, understanding and regulating the influence of machining parameters on the surface roughness of the manufactured product is crucial (Asil Turk & Ankus, 2011). As the feed rate increased, the surface roughness increased. In order to give a better product quality, a slower feed rate should be recommended to generate lower surface roughness values with a greater surface polish of the item under consideration. The interaction between feed rate and depth of cut has a significant influence on surface roughness; however, because the depth of cut value was fixed to a constant number, the effect on depth of cut was not explored in this work.

## 4.5 Cutting Tool Results And Data Analysis

In this section, statistics on the profile of surface roughness for both feed rates of 0.05 and 0.10 mm/rev are shown. The graph was created using the Surface Roughness Tester model SJ Mitutoyo-410.

## 4.5.1 First Parameter

Carbide inserts with ISO number ZP 352 TNMG 160404-MB were being used for this project. Using an optical microscope, tool wear on surface of the carbide inserts was recorded. Table 4.1 shows the value of tool wear obtained for the variables cutting speed values applied at 0.05 mm/rev feed rate.

Table 4.7 Cutting speed, tool wear, and standard deviation values at 0.05 mm/rev

	1 1 1 1	*
Cutting speed (m/min)	Tool wear (mm)	Standard
UNIVERSITI 1	EKNIKAL MALAYSI	deviation MELAKA
100	0.137	0.012
140	0.162	0.001
170	0.089	0.002
200	0.126	0.001

Based on the Table above, it shows the trend of tool wear reading in which the tool wear on the inserts had gone through dry CNC turning cutting process. The unit for tool wear was measured in millimeters. Starting with a cutting speed of 100 m/min, the tool wear stated a value of 0.137mm. When the cutting speed values were increased to 140 m/min, the value of tool wear produced also increased to 0.162mm. Next, at a cutting speed of 170 m/min, the tool wear subjected onto workpiece decreased drastically to 0.089mmand increased drastically to 0.126mmagain at a cutting speed of 200 m/min.

The highest tool wear value recorded was 0.162mm while the lowest one was 8.934 mm for cutting speed values of 140 and 170 m/min respectively. The range for tool wear readings occurred on carbide insert that had gone through dry CNC machining process which was without the presence of any fluids or coolants is from0.089mmto 0.162mm. The trend of reading shows a slight increase in tool wear for the first increase in cutting speed followed by a sharp decline in moderate cutting speed s and a slight increase at the end as the cutting speed increases. According to Suresh et al., (2014) stated that tool wear is increased with the increased of cutting parameters. From that, the experimental result is achieved with specification studied which is cutting speed and feed rate increased, the feed rate also increased.

Standard deviation values of  $\pm 0.012$ ,  $\pm 0.001$ ,  $\pm 0.002$ , and  $\pm 0.001$ mm were calculated for tool wear at spindles speeds of 100, 140, 170 and 200 m/min respectively, for a feed rate of 0.05 mm/rev. A smaller standard deviation reflects greater data accuracy. Data collected for cutting speed of 140 m/min yielded the greatest machining accuracy with the smallest standard deviation of  $\pm 0.001$ mm while data collected for

cutting speed of 100 m/min yielded the greatest standard deviation at  $\pm 0.012$ mm, therefore making the data less accurate in comparison.

Therefore, the most suitable cutting speed for optimization of dry CNC machining process is 170 m/min shown by smallest surface roughness and tool wear average as well as standard deviation value yielded by carbide insert under these machining conditions. This means dry cutting processes that do not utilize fluids or coolants are best carried out with a cutting speed of 170 m/min for a feed rate of 0.05 mm/rev to ensure greater tool shelf life.





Figure 4.3 Graph of Tool Wear (mm) against Cutting speed (m/min) at 0.05 mm/rev



Tool wear is one of the key characteristics used to evaluate tool life, therefore decreasing tool wear is critical for maximizing tool life and improving production performance. According to Figures 4.3, tool wear increased in tandem with surface roughness, resulting in a poor surface quality. Furthermore, cutting speed had a part in raising the material removal rate by creating several difficulties such as poor tolerances and tool wear on carbide inserts. Higher cutting speed s would result in greater tool wear. As the feed rate increased, so did tool wear (Imran et al., 2014). When a faster feed rate was employed, the workpiece created more heat due to friction generated during the machining process. These parameters have a substantial impact on the surface of machined components, increasing the value of roughness with a poor surface quality.
#### 4.5.2 Second Parameter

Cutting speed (m/min)	Tool wear (mm)	Standard					
Cutting speed (m/mm)	1001 wear, (mm)	deviation					
100	0.106	0.001					
140	0.108	0.0003					
170	0.104	0.002					
200	0.088	0.002					

Table 4.8 Cutting speed, tool wear and standard deviation values at 0.10 mm/rev

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Four tool wear readings were taken with different cutting speed values keeping a constant feed rate of 0.10 mm/rev and depth of cut of 1 mm. Based on Table 4.7, a steady increase for the first two readings were achieved followed by a steady decline. The peak value, that is the highest tool wear reading attained, was achieved with cutting speed of 140 m/min at 0.108 mm. When the cutting speed was set to 100 m/min, the tool wear gave reading of 0.106 mm. Then, the cutting speed was increased to 140 m/min and 170 m/min resulting in tool wear values of 0.108 mm and 0.104 mm respectively. The average tool wear for highest cutting speed 200 m/min is the lowest among four readings at 0.088 mm. The trend of graph shows a slight incline followed by a slight decline for cutting speed s between the first and second repetitions that are between 100 m/min and 140 m/min, and the third and fourth repetitions that are between 170 m/min and 200 m/min.

Standard deviation values of  $\pm 0.001$ ,  $\pm 0.0003$ ,  $\pm 0.002$ , and 0.002mm were calculated for tool wear at spindles speeds of 100, 140, 170 and 200 m/min respectively, for a feed rate of 0.10 mm/rev. A smaller standard deviation reflects greater data accuracy. Data collected for cutting speed of 140 m/min yielded the greatest machining accuracy with the smallest standard deviation of  $\pm 0.0003$  mm while data collected for cutting speed of 170 m/min yielded the greatest standard deviation at  $\pm 0.002$  mm, therefore making the data less accurate in comparison.

Therefore, based on surface roughness and tool wear average for a feed rate of 0.10 mm/rev, the most optimized cutting speed for machining under dry cutting conditions is 200 m/min, since the smallest average for both surface roughness and tool wear parameters were attained with said cutting speed .

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Figure 4.4 Graph of Tool Wear (mm) against Cutting speed (m/min) at 0.10 mm/rev

#### Feed Rate

According to Figures 4.4, tool wear increased in tandem with surface roughness, resulting in a poor surface quality. Furthermore, cutting speed had a part in raising the material removal rate by creating several difficulties such as poor tolerances and tool wear on carbide inserts. Higher cutting speed s would result in greater tool wear. As the feed rate increased, so did tool wear (Imran et al., 2014). When a faster feed rate was employed, the workpiece created more heat due to friction generated during the machining process. These parameters have a substantial impact on the surface of machined components, increasing the value of roughness with a poor surface quality.

# 4.6 Surface Integrity

In this section, the microstructure of the surface condition after the machining process will be displayed at a magnification of 500x to make it clearer, and it will vary with each cutting speed and feed rate.

# 4.6.1 Material H13 Tool Steel



Figure 4.5 Comparison of microstructure of surface roughness at cutting speed (100 m/min) at two different feed rate

The diagram in figure demonstrates that at a cutting speed of 100 m/min, the difference in feed rate between diagrams a and b is 0.05 mm/rev and 0.10 mm/rev. Both diagrams are wonderful when zoomed in by 500 times. Diagram a has a surface roughness of 1.656  $\mu$ m. At a magnification of 500, the microstructure reveals that the tool path cannot be seen clearly. Second, there are several oval-shaped spots attached to the material's surface. This is triggered by H13 grain hitting with the HP of the tool's eye during the cutting process, causing melting to occur above the surface. The feed rate is 0.05 mm/rev, and the Ra is 1.243

 $\mu$ m, according to diagram b. It has the lowest surface roughness for the second parameter, which is less than 0.10 mm/rev. The microstructure demonstrates that the grain at H13 is dragged out and melted as a result of the machining operation.



Figure 4.6 Comparison of microstructure of surface roughness at cutting speed (140 m/min) at two different feed rate

The cutting speed is shown in the diagram above at 140 mm/min. The feed rate for diagram a is 0.10 mm/rev, the surface roughness is  $1.314 \,\mu$ m, and the tool wear is 0.108 mm. The surface roughness in diagram b is 2.007  $\mu$ m, and the tool wear is 0.162 mm. When compared to the other figures, diagram b has the most surface roughness. The microstructure reveals that the surface is relatively smooth, with an oval shape forming on the material's surface. In diagram a, there are large patches on the surface. When we look at surface pieces, we can see that their surfaces have a complicated structure made up of a succession of peaks and troughs with varied heights, depths, and spacing.



Figure 4.7 Comparison of microstructure of surface roughness at cutting speed (170 m/min) at two different feed rate

Both figures above were created at the cutting speed of 170 m/min of both diagrams. Figure a shows that the surface roughness, Ra, is  $1.252 \mu m$  formed and 0.104 mm at tool wear. Surface roughness in figure b is  $1.611 \mu m$ , and tool wear is 0.089 mm. In both pictures, the round spot is clearly generated by the same fault, which is a melted chip at the material's surface. This is most likely because the chip became stuck between the substance H13 and the edge cutting tool. When the stylus or cutting tool moves and collides with the material, the chip has the potential to melt at all places.



Figure 4.8 Microstructure of surface roughness at cutting speed (200 m/min) at (0.05 mm/rev)

The graphic above depicts the microstructure of surface roughness at 200 m/min and 0.05 mm/rev. Ra denotes the surface roughness. According to the first parameter, the fourth cutting speed has a surface roughness of Ra,1.852  $\mu$ m. As indicated in the diagram, the surface is quite rough, and there are few imperfections along the surface.

# 4.6.2 Carbide Cutting Tools

Tool wear can also be using a scanning electron microscope. The development of tool wear varies based on the cutting parameter. As cutting speed and feed rate rose, so did tool wear. The surface integrity (SI) of a component is crucial to its functional performance (Outeiro, 2014). Tables 4.2 and 4.3 show the development of tool wear during dry cutting.



Table 4.9 Tool wear formation at feed rate 0.05 mm/rev



Table 4.10 Tool wear formation at feed rate 0.10 mm/rev

As the experiment progressed through the dry CNC cutting process, many problems on carbides inserts, such as flank wear and crater wear, were identified. High temperatures may occur on the carbide during a dry cutting condition, which is defined by the absence of fluids or coolant, the main objective of the problem is to minimize the surface roughness (Debnath et al., 2016). Furthermore, under the same conditions, if the cutting speed was too high and the feed rate was too low, the temperature may rise. You may see a visible shift in the color of the inserts as the temperature rises. Shear tension had then developed, causing friction between the workpiece and the cutting tool. The surface of the carbide insert acquired flank wear and crater wear as a result of the strong shear.

Flank wear generally occurs when the cutting speed is too fast. Flank wear may also result in a poor surface polish and out of range hole tolerances. Tool wears are less at 0.10 mm/rev feed rate than at 0.05 mm/rev feed rate. The tool wear values increased as the cutting speed increased. The formation of wear has also resulted in increased degrees of surface roughness. At the same time, environmental factors such as high temperatures led to the production of wear. Because the cutting conditions used was dry CNC machining, the production of flank wear and crater wear was easier to achieve than in wet CNC machining conditions with the presence of cutting fluids or coolant that works as a temperature reducer. To counteract this type of wear production, an ideal parameter and proper cutting condition were required to be used throughout the machining process.

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In general, feed rate has a significant impact on chip formation. Tool wear will build on the carbide insert as the cutting speed and feed rate rise, whereas crater wear will generally form on the rake face. Notch wear is often produced by high temperature because heat in the workpiece chips causes cemented carbide components to disintegrate and diffuse into the chip. The crater chip then developed on the surface of the carbide implant. Surface roughness is directly influenced by the cutting speed and feed rate (Kumar et al., 2012). Crater wear may result in a poor surface polish, a nasty chip, and edge fracture. Flank and end clearance wear are most likely caused by both abrasive and adhesive wear processes, with abrasive wear being the primary source of material removal since tool flank temperatures are lower than rake face temperatures.



# 4.6.3 Tool Wear Under Optical Microscope

The optical microscope is used to assess and monitor tool wear. The photos of tool wear from the Front View will be provided in this chapter based on the cutting speed and feed rate of 0.05 and 0.10 mm/rev.



Table 4.11Diagram of tool wear at feed rate (0.05 mm/rev)

Cutting Speed M/Min	Feed Rate Mm/Rev	Diagram
100	0.10	
140	0.10	
170 171	NALAYSIA 0.10	
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Table 4.12Diagram of tool wear at feed rate (0.05 mm/rev)

# 4.6.4 Tool Wear Under SEM

The scanning electron microscope (SEM) is commonly used to examine the microstructure and composition of various materials. An electron source is one of its key components. In this chapter, samples of tool wear at 0.05 and 0.10 mm/rev feed rates will be given at a 20x magnification.

Parameter	Top View	Front View
Cutting Speed: 100 m/min Feed Rate : 0.05 mm/rev Magnification : 20 x	Minimum	
Cutting Speed: 140 m/min Feed Rate : 0.05 mm/rev Magnification : 20 x	TANK AND	LAYSIA MELAKA
Cutting Speed: 170 m/min Feed Rate : 0.05 mm/rev Magnification : 20 x	The second secon	Mar Mar Ar PC 18 M We stam Bor Bar Bar Bar Bar Bar Bar Bar Bar Bar Ba

Table 4.13 SEM diagram at (0.05 mm/rev)



Table 4.14 SEM diagram at (0.05 mm/rev)

Parameter	Top View	Front View
Cutting Speed: 100 m/min Feed Rate : 0.10 mm/rev Magnification : 20 x		NA MAR TOTESTATI TOTESTATI
Cutting Speed: 140 m/min Feed Rate : 0.10 mm/rev Magnification : 20 x	A Martin Andrew An	AVSIA MELAKA NAVSIA MELAKAKA MELAKA MELAKA MELAKA MELAKA MELAKA MELAKA MELAKA MELAKA
Cutting Speed: 170 m/min Feed Rate : 0.10 mm/rev Magnification : 20 x	TO GO THE MARK THE	THE MAY BUT BAT BUT ADDRESS AND ADDRESS AN





# 4.7 Concluding Remarks

This chapter concludes that there are three findings in this study, which are surface roughness, tool wear, and surface integration. In order to analyse the influence of H13 tool steel , the machining parameters cutting speed and feed rate are chosen. At a fixed depth of cut, different values of cutting speed and feed rate lead to varied levels of surface roughness. According to the findings, feed rate and cutting speed have a significant impact on the surface roughness of the material studied, H13 tool steel. Lower surface roughness levels with greater surface finish are obtained at lower feed rate rates. It has been discovered that when cutting speed increases, surface roughness increases. The machining settings also have an impact on the tool wear that occurs on the carbide insert used throughout the dry cutting process. Flanking and crater wear are two types of tool wear. As conclusion to this chapter, it is discovered that the optimal machining parameters are extremely necessary in order to generate lowest surface roughness of H13 tool steel, hence increasing the surface finish of the product with a great quality.

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#### **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATIONS**

#### 5.1 Conclusion

This chapter discusses the project's findings and recommendations. This section contains recommendations and suggestions for future work on the continued enhancement of this project. This project displays the results of an experiment to measure the surface roughness of H13 Tool Steel utilising dry cutting CNC turning. Several conclusions may be drawn from the machining data gathered;

- This research contributes to a better knowledge of the influence of parameters on the surface roughness of H13 tool steel under dry cutting conditions.
- This research aids in the identification of optimal parameters for reducing surface roughness and tool wear on H13 tool steel.
- The roughness of the surface has a significant impact on the final product's quality. As a result, the surface roughness of any material must be carefully regulated throughout any machining operation. The advantages of regulated surface roughness include cost savings and improved quality control.

### 5.2 Recommendations

There are a few recommendations provided to extend understanding of fundamentals in surface roughness, as well as to enhance the machining process in order to gain a greater surface finish and gather more knowledge about surface roughness with the different conditions used while machining, which are as follows:

- The material chosen to be machined in this project work is H13 tool steel. In the future, it is proposed that various sorts of materials, such as brass, be included to studies and comparisons of experimental results between two distinct types of materials.
- ii) The most essential factor influencing surface roughness quality is the machining settings. Only feed rate and cutting speed are considered in this project scope, while depth of cut remains fixed. It is advised that the depth of cut be specified as a variable value in the next step.
- Carbide inserts are utilized as the cutting tool in the machining process to investigate the effects of surface roughness, and tool wear. Inserts come in a variety of materials, including uncoated carbide and High Speed Steel (HSS). These inserts are advised for researching the effects on surface roughness, and tool wear.
- It is suggested that cutting force and surface hardness be taken into account in future studies.

# 5.3 **Project Potential**

Because H13 material is an uncommon substance, the research might provide valuable and novel information to a corporation involved in the CNC turning industry. After the project is completed, it can provide useful feedback to industrial workers and regarding H13.



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# APPENDICES

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# APPENDIX A Gantt Chart Final Year Project 1

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