Sudan University of Science and Technology

Collage of Engineering

School of Mechanical Engineering

Study The Effect of Cutting Parameters (Cutting Speed, Feed Rate and Depth of Cut) on Surfaces Roughness in Turning Operation

دراسة تأثير عوامل القطع (سرعة القطع ،التغذية وعمق القطع) على خشونة الأسطح باستخدام عملية الخراطة

A Project Submitted in Partial Fulfillment for the Requirement of the Degree of B.Sc. (Honor) In Mechanical Engineering (Production Department)

<u>Prepaid By:</u>

1- Mohammed Abdallah Mohammed Alhadi Abdallah

2- Musab Abdallah Algaylani Ahmed

3- Sohaib Hamad Alneel Hassan Abdallah

Supervisor:

Dr. Yaseen Mohammed Hamadan

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الآيـــــــــة

قَالَ تَعَالَىٰ:

﴿ وَأَنزَلْنَا ٱلْحَدِيدَ فِيهِ بَأْسٌ شَدِيدٌ وَمَنَٰفِعُ لِلنَّاسِ وَلِيَعْلَمَ ٱللَّهُ مَن يَنصُرُهُۥ وَرُسُلَهُۥ بِٱلْغَيْبِ ۚ إِنَّ ٱللَّهَ قَوِىٌّ عَزِيزٌ ﴾

صدق الله العظيم

سورة الحديد الآية 25

DEDICATION

For their countless sleepless nights filled with prayer and hopes for our Success in life, the least we could do is to dedicate the fruit of our Efforts to the two most influential people in our life mother and father.

…This is for you.

For providing us with constant encouragement to complete this journey, and for believing in our ability to always do our best, we would like to Dedication this project to our teachers who have been with us all the Step of the way.

We are truly blessed to have them by our side.

Experience also, we predict the effort to the kindness person, who provides us with his knowledge Experience studies tell this see the light. And the respectful college teachers who take our hands since our

Entrance to the college till this step.

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ABSTRACT

This project aims to study the effect of input variables (depth of cut, cutting speed and feed) on the surface roughness of mild steel by using high speed steel tool with cooling liquid. Nine cylinders' work-pieces from mild steel are used for straight turning them by using a turning traditional machine under different ranges of cutting condition (depth of cut (0.5,0.3, and 0.15) mm, cutting speed (350,500, and 800) rpm, and feed (0.5,0.3, and0.08) mm/rev. The surface roughness is then measured for all samples turned under these conditions. The result showed that the surface roughness generally increases with the increase of both feed and depth of cut, and when cutting speed increased the surface roughness decreases.

المستخلص

يهدف المشروع (دراسة تاثير المتغيرات الداخلة في عملية الخراطة باستخدام ماكينة الخراطة التقليدية) الي دراسة تاثير المتغيرات (سرعة القطع، عمق القطع والتغذية) على خشونة السطح للحديد منخفض الكربون باستخدام حديد السرعات العالية وباستخدام سائل التبريد.

تم استخدام تسع عينات اسطوانية من الحديد ممنخفض الكربون اجريت عليه عملية الخراطة الطولية باستخدام ماكينة القطع التقليدية عند ظروف قطع مختلفة حيث كان عمق القطع *mm*(٠,٥-٠,٣-٠,١٥) وسرعة القطع كانت *rpm*(٣٥٠-٥٠٠-٨٠٠) وبمعدل تغذية *mm/rev*(٠,٥-٠,٣-٠,٠٨) وبعدها تم قياس خشونة السطح لجميع العينات التي تم تشغيلها عند هذه الظروف.

اظهرت النتائج بان خشونة السطح تزداد عموما عند زيادة كل من عمق القطع والتغذية ولكن كلما زادت سرعة القطع قلت خشونة السطح.

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CHAPTER ONE

INTROUCTION

1.1Introduction

Turning is the removal of metal from the outer and inner diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the work piece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts. Today’s fast changing manufacturing environment requires the application of optimization techniques in metal cutting processes to effectively respond to severe competitiveness and to meet the increasing demand of customizable quality product (low cost, high quality, easily deliverable) in the market. Machining vibration is important in metal cutting operations which may affect the quality characteristics. The machine tool operators always face the problem in turning process. Machine tool condition, job clamping, tool and work piece geometry and cutting parameters are the major reasons for occurrence of this problem. Vibration in machine tool is directly affecting the surface finish of the work material in turning process. So vibration of a machine tool is one of the major factors limiting its performance. In machining, there has been recently and intensive computation focusing on surface roughness at international level. This computation can be observed in turning processes especially in plane and automotive industry by increasing the alternative solutions for obtaining more proper surface roughness. So it becomes important to study the effect of machining parameters on multiple quality characteristics like surface roughness and vibration etc.

A large number of engineering components, such as shafts gears bearing, clutches, cams, screw-nuts, etc. need reasonably high dimensional and form accuracy and good surface finish for serving their functional purposes. Performing the casting forging, rolling etc. generally cannot provide the desired accuracy and finish. For that, performed objects called blanks need semi finishing and finishing and this is done by machining and grinding. Therefore, briefly stated that the engineering components are essentially finished to accuracy and surface finish by machining to enable the product. Machining is an essential finishing process by which jobs of desired dimensions and surface finish are produced by gradually removing the excess material from the performed blank in the form of chips with the help of cutting tools moved past the work surfaces. Surface roughness indicates the state of a machined surface. Surface roughness plays an important role in defining the character of a surface. The surface irregularities of a component or material may be intentionally created by machining, but they can also be created by a wide range of factors such as tool wobbling caused by motor vibration during machining, the quality of the tool edge and the nature of the machined material. The form and size of irregularities vary, and are superimposed in multiple layers, so differences in those irregularities impact the quality and functions of the surface. The results of these irregularities can control the performance of the end product in aspects such as friction, durability, operating noise, energy consumption, and air tightness. If the products in question are printing paper or exterior panels, aspects of quality such as glossiness and adhesion of paint and ink can also be affected by surface roughness. The shape and size of irregularities on a machined surface have a major impact on the quality and performance of that surface, and on the performance of the end product. The quantification and management of fine irregularities on the surface, which is to say, measurement of surface roughness, is necessary to maintain high product performance.

1.2 Problem statement

In machining operation, the quality of surface finish is an important requirement for many turned work pieces. Thus, the choice of optimized cutting parameters is very important for controlling the required surface quality

1.3 Objective

What the effect of cutting parameters (cutting speed, feed rate and depth of cut) on surface roughness in turning?

1.4 Scope of study

- Literature review on surface roughness in turning
- Study on effect of three cutting parameter (cutting speed, feed rate and depth of cut).
- Turning operation is performed using traditional lathe machine. Turning operation will be done on mild steel based on three machining parameters. The three parameters that will be used are cutting speed, depth of cut (DOC) and Feed rate. The surface roughness of each of the specimen will be studied and compared.

1.5 Significant Study

The Quality and productivity play very important role in manufacturing technology. The quality of any product influences the extent or degree of satisfaction of the shoppers throughout its usage & therefore, quality becomes a significant concern for every manufacturing unit.

CHAPTER TWO

LETRETURE REVIEW

2.1 Introduction

In metal cutting and manufacturing industries, surface finish and strength of a product is very crucial in determining the quality. Good surface finish not only assures quality, but also reduces manufacturing cost. Surface finish is important in terms of tolerances, it reduces assembly time and avoids the need for secondary operation, thus reduces operation time and leads to overall cost reduction. Besides, good-quality turned surface is significant in improving fatigue strength, corrosion resistance, and creep life. It is well known that the final geometry of surface roughness is influenced by various machining conditions such as spindle speed, feed rate and depth of cut.

2.2 Turning

Turning is a machining process to produce parts round in shape by a single point tool on lathes. The tool is fed either linearly in the direction parallel or perpendicular to the axis of rotation of the work-piece, or along a specified path to produce complex rotational shapes as shown in figure (2.1). The primary motion of cutting in turning is the rotation of the work-piece, and the secondary motion of cutting is the feed motion.

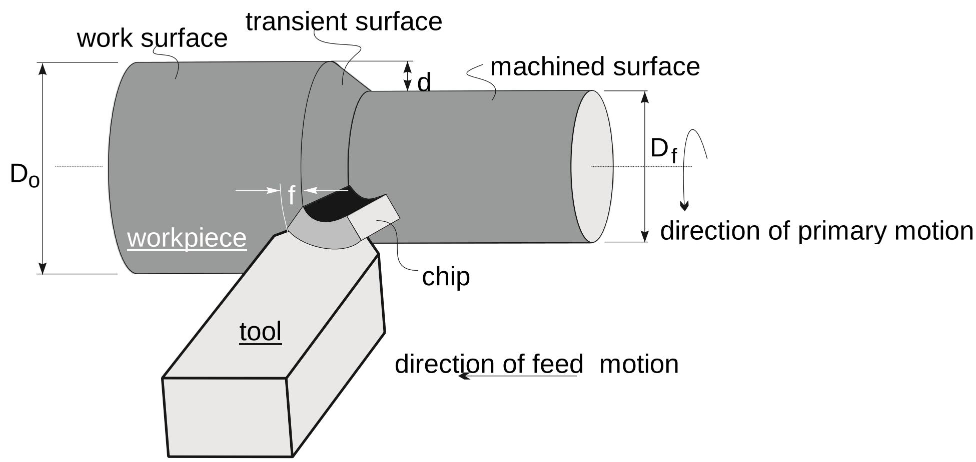


Figure (2.1) Turning operation

2.2.1 Cutting conditions in Turning

Cutting speed in turning V in m/s is related to the rotational speed of the work-piece by the equation:

$$V = \pi DN \qquad (2.1)$$

Where D is the diameter of the work-piece, mm;

N is the rotational speed of the work-piece, rev/min.

One should remember that cutting speed V is always a linear vector. In the process planning of a turning operation, cutting speed V is first selected from appropriate reference sources, and the rotational speed N is calculated taking into account the work-piece diameter D. Rotational speed, not cutting speed, is then used to adjust lathe setting levers.

The turning operation reduces the diameter of the work-piece from the initial diameter D_o to the final diameterD_f. The changes in diameter is actually two times *depth of cut*, d:

$$\boldsymbol{2d = d_o - d_f} \qquad (2.2)$$

The volumetric rate of material removal (so-called *material removal rate*, *MRR*) is defined by

$$mrr = v * f * d \qquad (2.3)$$

When using this equation, care must be exercised to assure that the units for V are consistent with those for f and d.

2.2.2 Operations in turning

Turning is not a single process but class of many and different operations performed on a lathe. Turning of cylindrical surfaces

The lathe can be used to reduce the diameter of a part to a desired dimension. The resulting machined surface is cylindrical as shown in figure (2.2).

straight turning

Figure (2.2): straight turning

2.2.2.1 Turning of flat surfaces

A lathe can be used to create a smooth, flat face very accurately perpendicular to the axis of a cylindrical part. Tool is fed radially or axially to create a flat machined surface as shown in figure (2.3).

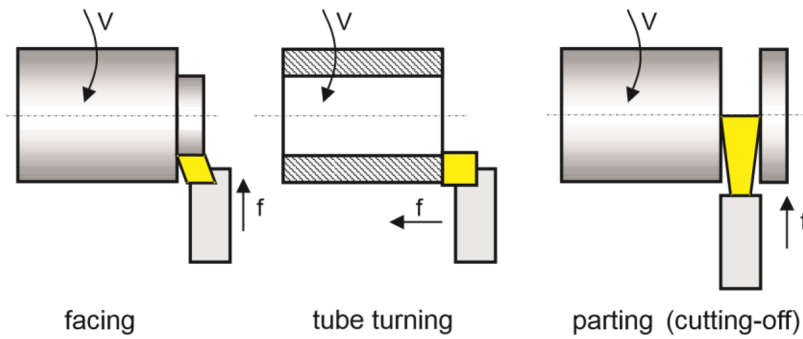


Figure (2.3): Turning of flat surfaces

2.2.2.2 Threading

Different possibilities are available to produce a thread on a lathe. Threads are cut using lathes by advancing the cutting tool at a feed exactly equal to the thread pitch. The single-point cutting tool cuts in a helical band, which is actually a thread. The procedure calls for correct settings of the machine, and also that the helix be restarted at the same location each time if multiple passes are required to cut the entire depth of thread. The tool point must be ground so that it has the same profile as the thread to be cut as shown in figure (2.4.a).

Another possibility is to cut threads by means of a thread die (external threads) as shown in figure (2.4.b), or a tap (internal threads) as shown figure (2.4.c). These operations are generally performed manually for small thread diameters.

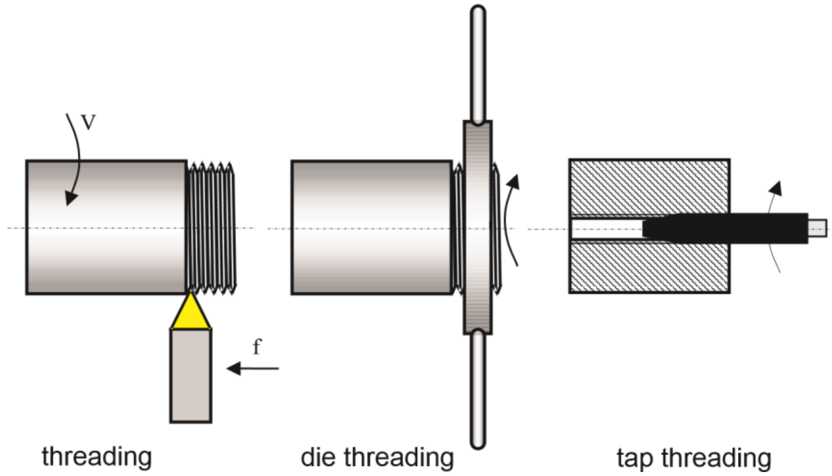


Figure (2.4) :

2.2.2.3 Form turning

Cutting tool has a shape that is imparted to the work piece by plunging the tool into the work-piece. In form turning, cutting tool is complex and expensive but feed is linear and does not require special machine tools or devices as shown in figure (2.5).

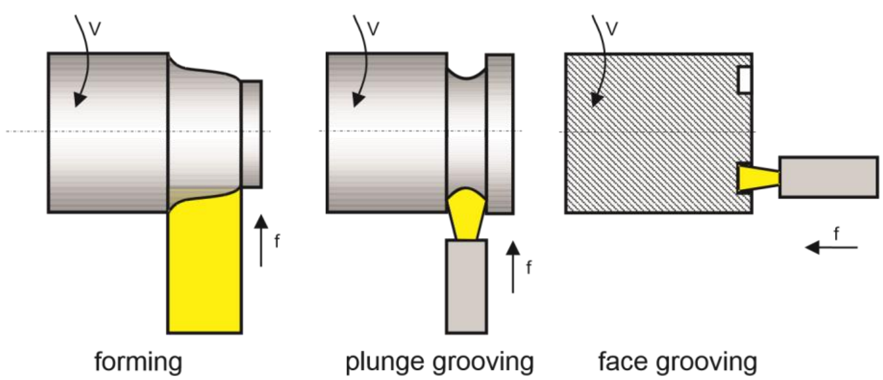


Figure (2.5): Form turning

2.2.2.4 Contour turning (profiling)

Cutting tool has a simple shape, but the feed motion is complex; cutting tool is fed along a contour thus creating a contoured shape on the work-piece. For profiling, special lathes or devices are required as shown in figure (2.6).

Figure (2.6): Contour turning

Producing tapers on a lathe is a specific task and contour turning is just one of the possible solutions.

2.2.2.5 Miscellaneous operations

Some other operations which do not use the single-point cutting tool can be performed on a lathe, making turning one of the most versatile machining processes as shown in figure (2.7).

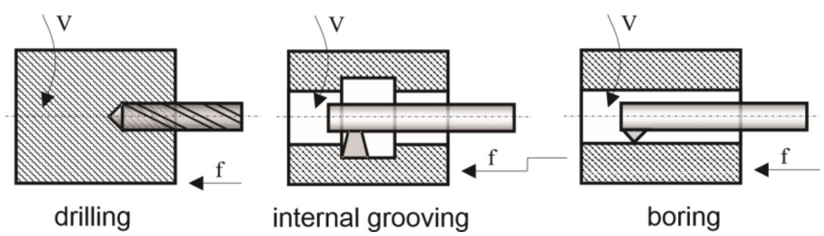
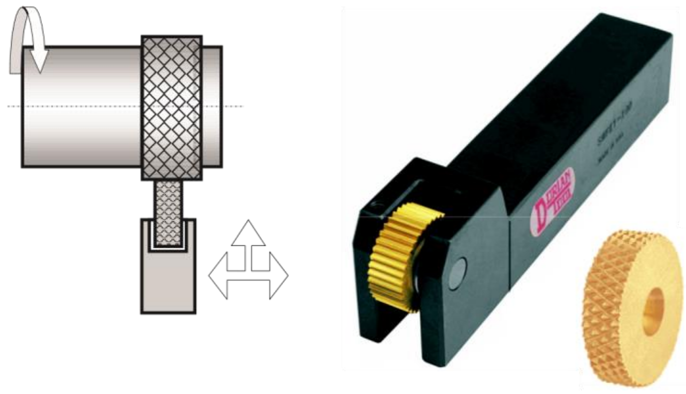


Figure (2.7): Miscellaneous operations

2.2.2.6 Knurling

This is not a machining operation at all, because it does not involve material removal. Instead, it is a metal forming operation used to produce a regular crosshatched pattern in the work surface as shown in figure (2.7).



(*Left*) Knurling operation; (*Right*) Knurling tool and knurling

Figure (2.8): tool Knurling

2.3 Cutting tools

The geometry and nomenclature of cutting tools used in turning is standardized by ISO3002/1-1982:

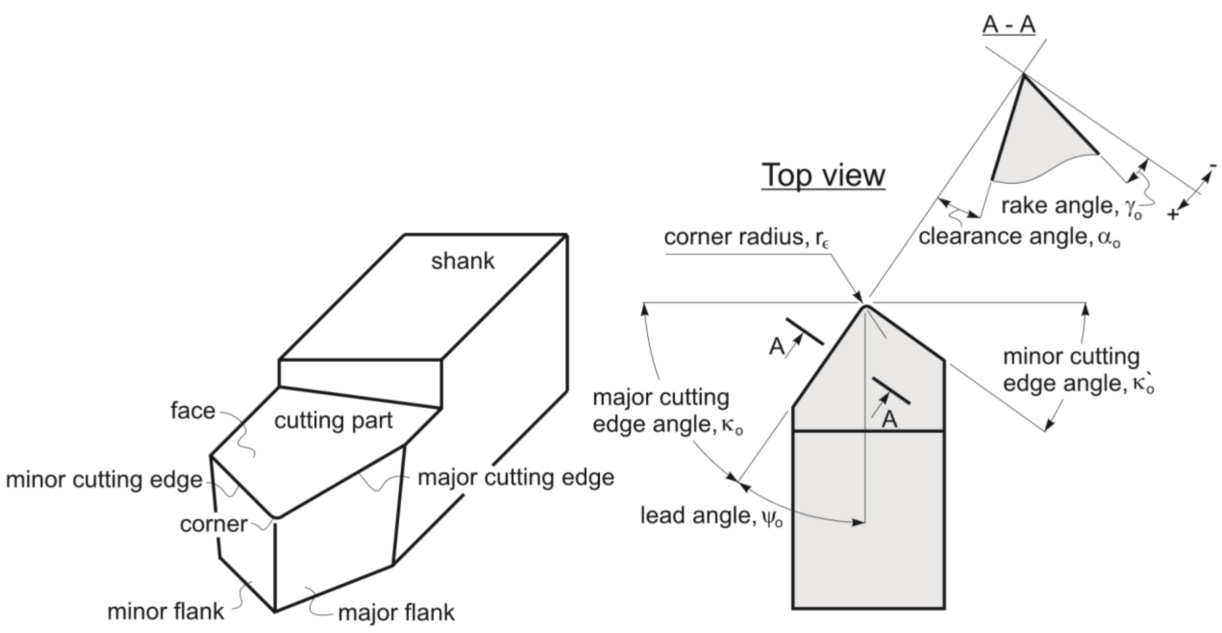


Figure (2.9): Cutting tools geometry

Cutting edges, surfaces and angles on the cutting part of a turning tool

The figure (2.8) shows only the most important geometrical features of a turning cutting tool. Recommendations for proper selection of the cutting tool geometry are available in the reference materials. [8]

2.4 Surface quality

The quality of surface finish is commonly specified along with linear and geometric dimension. This is becoming more common as product demands increase because surface quality often determine how will part performs. Heat exchanger tube transfer heat better when their surfaces are slightly rough rather highly finished. Brake drums and clutch plates work best with in some degree of surface roughness on the other hand, bearing surfaces for high speed engines wear excessively and fail sooner if not highly finished but still need certain surface texture to hold lubricants. Thus the need is to control all surface feature, not just roughness alone.

2.5 Surface Characteristics

The American national standard institute has provided a set of standard terms and symbols to define such basic surface Characteristics as profile, roughness, waviness, flaws, and lay. Profile is defined as the contour of any section through a surface roughness.

2.5.1 Roughness

Refer to relatively finely spaced surface irregularities such as might be produced by the action of a cutting tool or grinding wheel during a machining operation as shown in figure (2.9).

2.5.2 Waviness

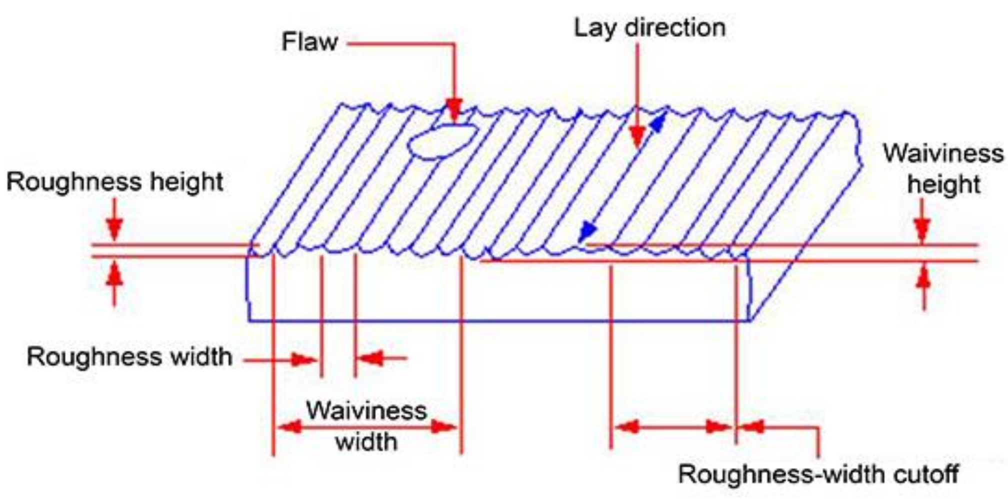
Consist of those surface irregularities which of greater spacing than roughness as shown in figure (2.9). Waviness may be caused by vibrations, machine or work deflection, warping, etc.

2.5.3Flaws

Flaws are surface irregularities or imperfections which occur at infrequent intervals and at random location. Such imperfection as scratches, ridges, holes, crack, pits, checks, etc. are included in this category as shown in figure (2.9).

2.5.4 Lay

Lay is defined as the direction of the predominant surface pattern. These Characteristic are illustrated in figure (2.9). [1]



Surface characteristics (Courtesy, ANSI B46.1 - 1962)

Figure (2.10): surface characteristics (Courtesy, ANSI B46.1-1962)

2.6 Parameters that Affecting Surface Roughness in Turning Operation

There are many parameters effect in turning operation

2.6.1 Tool life/ Tool wear

Tool life/tool wear is the most meaningful criteria in machinability. It affects both the quality and cost of the machined part. Machinability is to increase when the tool wear rate decreases or tool life rate increases. As tool damage, by wear or fracture increases, the surface roughness and accuracy of the machined surface deteriorates. Ratings based on wear rates are generally applicable to a restricted range of cutting conditions. That is, when the cutting speed is substantially increased or decreased, the dominant tool wear mechanism and tool wear rate may change. However, the use of very low cutting speed and feed to prolong the life of tool is not economical, as it leads to low production rate. It is particularly relevant when ranking the machinability of a group of materials under different cutting conditions.

2.6.2 Achievable surface finish

Generally, roughness of surface is the common parameter used to assess surface quality. Surface roughness is affected by cutting speed, feed rate, and chip formation. Higher cutting speed and feed rate will produce smoother surface and vice versa. On the other hand, the formation of continuous chip that got entangled on work piece will scratch the surface of work piece. Thus, causes surface roughness.

2.6.3 Cutting force

Cutting force is often measured in machinability testing and research. Machinability increases as cutting forces and power consumption decrease for the cutting conditions of interest. Lower cutting forces generally imply lower tool wear rates, better dimensional accuracy due to decreased of deflection, and increased machine tool life due to reduced loads on bearings and ways.

2.6.4 Cutting Speed

Cutting speed is defined as the speed at which the work moves with respect to the tool (usually measured in feet per minute). According to National Maritime Research Institute, when the rotating speed is high, processing speed becomes quick, and a processing surface is finely finished.

Cutting speed is one of the parameters that control the surface roughness. At low cutting speed, build-up-edge (BUE) tends to build up at the edge of material during turning. BUE scratches the material surface and causes the roughness of surface to be not constant. This is because the vibrations produced lift the tool and snaps it back when the BUE fractures. As the cutting speed increases, the temperature rises and separates the BUE from tool. The repeating of buildup and removal of BUE will eventually ruins the cutting tool. On the other hand, higher cutting speed results in good surface roughness. However, it might also cause burn marks to appear on the surface of material turned.

2.6.5 Feed rate

The feed of lathe may be defined as the distance the cutting tool advances along the length of the work for every revolution of the spindle Check, for instance, if the feed is set to 0.15 mm, the cutting tool will travel along the length of the work for 0.15 mm. It is depending on the speed of lead screw or feed rod. Feed rate is one of the factors that leave its own characteristic marks on the surface of specimen being machined. Different feed rate used during turning operation somehow leaves impact on the surface roughness. When the feed rate is high, the processing speed becomes quick. When the feed rate is low, the surface is finished beautiful. Hence, an appropriate feed must be use to gives an acceptable surface finish. There are 'manual feeding' which turns and operates a handle, and 'automatic feeding' which advances a byte automatically (National Maritime Research Institute, undated). An equation had been derived in predicting the surface roughness result. The equations are as Eq. (2.3) and Eq. (2.4)

$$\mathrm{Ra} = 2.95\, f^{0.7}\, r^{-0.4}\, T^{0.3} \qquad (2.3)$$

Where;

Ra = surface roughness (μm)

f = feed rate (mm per revolution)

r = tool nose radius (mm)

T = cutting time (minutes)

Or

$$Ra = 1.22 * 105\mathrm{M} f^{1.004} v^{-1.252} \qquad (2.4)$$

Where; v = cutting speed (m/min)

$$M = r^{-0.714}(BHN)^{-0.323} \qquad (2.5)$$

BHN = material hardness on the Brinell scale

The equations above can only be computed when all other cutting parameters are known. Thus, it is very difficult to use. Most researchers agree that the main cause of surface roughness is due to feed tool marks.

2.6.6 Depth of Cut

Depth of cut is defined as the depth of chip remove by the cutting tool. It is half of the total amount removed from the work piece in one cut. Varies greatly with lathe condition, material hardness, speed, feed, amount of material to be removed, and whether it is to be roughing or finishing cut. The equation of depth of cut is shown in Eq. (2.6)

$$Depth\ of\ cut = \frac{D_1 - D_2}{2} \tag{2.6}$$

Where,

D1 = Initial diameter

D2 = Final diameter

2.6.7 Cutting Tool

The selection of cutting tool materials for particular application is among the most important factors in machining operations. Cutting tool is subjected to high temperatures, high contact-stress, and rubbing along the tool-chip interface and along the machined surface. Consequently, the cutting-tool material must possess the following characteristics:

I. Hot hardness: so that the hardness, strength and wear resistance of the tool are maintained at the temperatures encountered in machining operations. This characteristic ensures the tool does not undergo any plastic deformation and can retain its shape and sharpness.
II. Toughness and impact strength (mechanical shock): so that the impact forces on the tool encountered repeatedly in interrupted cutting operations do not chip or fracture the tool.

III. Thermal shock resistance: to withstand the rapid temperature cycling encountered in interrupted cutting.

IV. Wear resistance: so that an acceptable tool life is obtained before the tool has to be replaced.

V. Chemical stability and inertness: to avoid or minimize any adverse reactions, adhesion, and tool-chip diffusion that would contribute to tool wear.

2.6.8 Cutting Fluid

Cutting fluid is used to improve cutting conditions by applying it at the chip formation zone during machining operations. A cutting fluid is used to keep the tool cool to prevent it from heated to a temperature at which the hardness and resistance to abrasion are reduced; to keep the work piece cool preventing it from machined into inaccurate dimensions; by lubricating, the friction, tool wear and power consumption can be reduced. It often is found in liquid form. The improvements can take account on several forms, depending on the tool and work materials, the type of cutting fluid and to an extent the cutting conditions. There are 2 usages of cutting fluid, it can either acts as coolant or lubricant, or both. Most cutting fluids have a mineral- or vegetable-oil base, mineral oil being the more widely used. Cutting fluids are classified into 3 categories, which are emulsions, oil, and solutions, oil and water emulsions are used when cooling action is the most important requirement because these emulsions have much larger heat conducting capacity than neat oil. On the other hand, neat oil is used for operation which lubricating action is the most important consideration. [2]

I. The tool geometry

Some geometric factors which affect achieved Surface finish include:

a. Nose radius

b. Rake angle

c. Side cutting edge angle, and
d. Cutting edge.

Work piece and tool material combination and their mechanical properties

Quality and type of the machine tool used,

II. Auxiliary tooling, and lubricant used, and
III. Vibrations between the work piece, machine tool and cutting tool [3]

The effects of the machining parameters were evaluated on surface roughness, when step turning of Al Alloy under dry cutting condition were performed by using Taguchi methodology [5]. The following specific conclusions are achieved based on the results:

I. For machining Aluminum alloy feed rate is the most significant control factor.
II. Average surface roughness decreased with increasing cutting speed during machining using carbide tipped tool inserts.
III. For obtaining better surface finish for machining of material, the control parametric combinations are 3rd level spindle speed (425 rpm), 1st level feed rate (0.1 mm/rev) and 1st level depth of cut (0.4 mm).
IV. The ANOVA model can determine the surface roughness with accuracy depend on the correlation coefficients R-sq. = 96% [5].

Cutting Parameters Optimization for Surface Roughness in Turning Operation of Polyethylene (PE) Using Taguchi Method

This paper described the application of Taguchi method for optimization of cutting parameter settings for minimizing the average surface roughness in turning of polyethylene. Four cutting parameters, cutting speed, feed rate, depth of cut, and tool nose radius were considered and arranged in the L27 OA. (ANALISYS OF VARIANCE) results indicate that the feed rate is far the most Significant parameter, followed by tool nose radius, and cutting speed, whereas the influence of depth of cut is negligible. The ANOVA resulted in less than 10 % error indicating that the interaction effect of process parameters is small. The optimum levels of the process parameters for minimum surface roughness are as follows: cutting speed - 213.88 m/min, feed rate - 0.049 mm/rev, depth of cut - 2 mm, and tool nose radius - 0.8 mm.

The Taguchi method is relatively simple yet a powerful optimization approach that could be efficiently applied for machining optimization problems [3].

Optimization of Turning Parameters with Carbide Tool for Surface Roughness Analysis The present work shows the use of Taguchi method to find out optimal machining parameter. By using the Taguchi method, we determine the S/N ratio for all the experimental tests. Machining Parameters Namely Cutting Speed V, Feed rate f, depth of cut d were optimized to meet the objective [4]. As a result of the study the following conclusions are drawn:

I. The observation result shows that the primary factor affecting the surface roughness is depth of cut, subsequently followed by cutting speed and feed.
II. the optimized control factors for minimizing the Surface roughness Ra Were Cutting speed, V3=225m/min, Feed rate f1=0.1mm/rev, Depth of Cut d3=1.5mm
III. the optimized control factors for minimum Surface roughness R_z were Cutting speed, V_3=225m/min, Feed rate f_1=0.1mm/rev, Depth of Cut d_3=1.5mm
IV. From the Taguchi's analysis it was found that the depth of cut is the most dominant factor affecting the surface roughness, Ra and Rz [4].

In this study investigating the optimal cutting parameters for surface roughness in turning process Surface roughness has received great attention for many years. It has formulated an important design feature in many situations such as parts subject to fatigue loads, precision fits, fastener holes and aesthetic requirements. In addition to tolerances, surface roughness imposes one of the most critical constraints for the selection of machines and cutting parameters in process planning. The effect of feed rate is very high on the surface roughness. It is clearly observed from the graphics that surface roughness increases as feed rate increases, and this is generally considered to be a function of square of the feed rate. Decreasing the surface roughness will usually increase exponentially its manufacturing costs. In this study, the surface roughness resulted from finish turning of ferrous metals depended on machining parameters and material type in terms of hardness. The cutting speed and material type greatly influence the surface roughness. At low cutting speeds, the relationship between surface roughness and cutting speed is positive due to the formation of built-up edge, while at high cutting speeds, a contrary relationship occurs due to deterioration of a built-up edge. The effects of two factor-interactions of the work piece hardness and cutting speed on surface roughness are statistically significant in all types of material except the cast iron which shows very low correlation. High surface hardness and low cutting speed result in a better surface roughness (i.e. lower roughness) in machining carbon steel and cast iron in speed variation. The relationship between cutting speed and surface roughness in machining carbon steel is more significant than the case of alloy steel; this also makes it easier in prediction and better choice, particularly when it shows good surface quality [6].

In this study, the main objective is to study the effect of cutting speed and depth of cut on surface roughness of mild steel in turning operation. And MINITAB

15 software was used to predict the surface roughness. Both predicted and experimental results were then compared. Different cutting parameters have different influential on the surface finish. In the experiment conducted in this study, 3 cutting speed and 5 depth of cut were used. Using Taguchi Orthogonal Array as design of experiment, the total set of experiments carried out is 15 sets. At first, the mild steel was undergone chemical composition test using Arc Spectrometer, and was decide that it might be of grade AISI 1022. The cutting speed and depth of cut were decide using the suitable range recommended; which were 490rpm, 810rpm and 1400rpm for cutting speed, 0.1mm, 0.2mm, 0.3mm, 0.4mm, and 0.5mm for depth of cut. The specimen was turned under different level of parameters and was measured the surface roughness using a Pertho-meter. From the result, it is concluded that higher cutting speed or lower depth of cut produce better surface finish. The optimum cutting speed and depth of cut in this case were 1400rpm and 0.1mm, which produced average surface roughness 4.695µm. Response Surface Method (RSM) was used to predict the surface roughness. And from the result generated, the correlation for surface roughness with the cutting parameters satisfies a reasonable degree of approximation. Both cutting speed and depth of cut are a significant parameter in influencing the surface roughness. [2]

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the ways, methods and procedures used to conduct this experiment are discussed step by step. A clear and systematic planning of methodology is essential to keep the experiment run smoothly.

3.2 Methodology Flow Chart

The methodology flow chart is a visual representation of the sequence of the project. This flowchart organizes the topic and strategies done to ensure a smooth flow when running the project. Figure 3.1 is an illustration of a simple flow chart showing the process flow. As illustrated, the first step is doing literature study based on related topic. Machining work started by determining the grade of mild steel then using conventional lathe machine to do turning. Next step is determining the surface roughness by using Perth meter. The final step is comparison between results obtained with predicted result from using Response Surface Method (RSM) to decide the significance of parameters on surface roughness

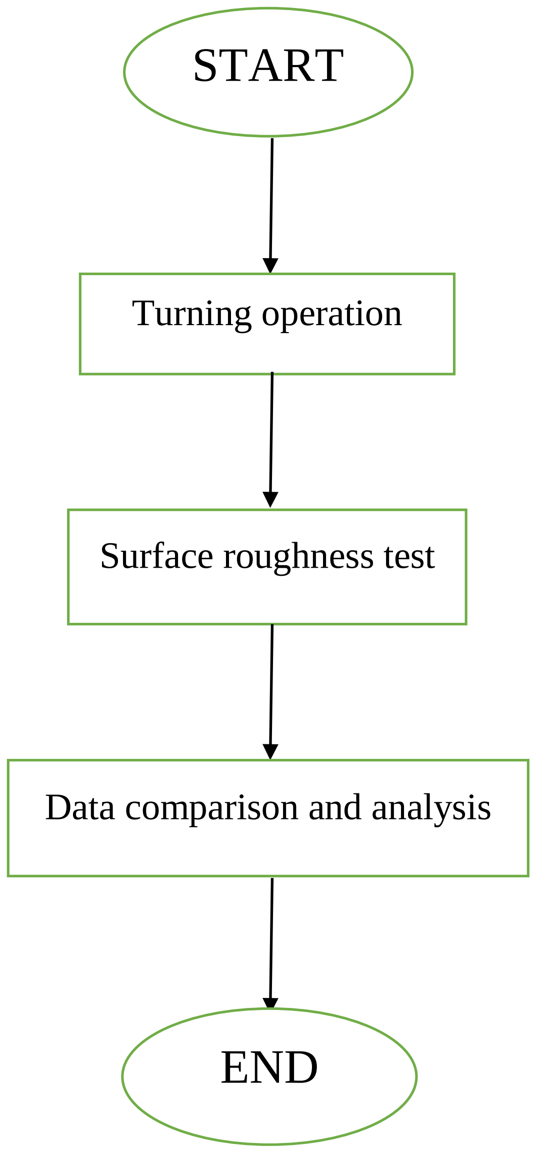


Figure (3.1): Methodology Flow Chart

3.3 Selection of the Three Parameters

The cutting speed, depth of cut and feed rate that is suitable to apply is selected based on as recommended in the reference book

3.4 Experimental Procedures

There are many steps in this experiments:

3.4.1 Machine Specification

TOS SN-50B Manual

Manufacturers: gate-pinacho

Model: L/200

Machine Type: Lathe

Print Code: MT200B

Contents: Operators Manual and Maintenance Manual

3.4.2 Material Selection

One specific types of plain carbon steel bar are chosen in this experiment, which is mild steel. The dimension of the round bar desired is 150 mm x 20 mm. That is 150 mm in length and 18 mm in diameter. The carbon steel bar is to take from available mild steel at Mechanical Laboratory. Carbon steel bar required in performing the turning process is 3 in quantity, each piece for each level of parameter. As the specification of mild steel is unknown.

Figure (3.2) Samples

3.4.3 Cutting tool material

The selection of cutting tool materials for particular application is among the most important factors in machining operations. Cutting tool is subjected to high temperatures, high contact-stress, and rubbing along the tool-chip interface and along the machined surface.

- **High Speed Steel**

1- An alloyed steel with 14-22% tungsten, as well as cobalt, molybdenum and chromium, vanadium.

2- Appropriate heat treating will improve the tool properties significantly (makers of these steels often provide instructions).

3- Can cut materials with tensile strengths up to 75 tons/sq.in. at speeds of 50-60 fpm.

4- Hardness is in the range of 63-65°C Rockwell.

5- The cobalt component gives the material a hot hardness value much greater than Carbon Steels.

6- Used in all type of cutters, single/multiple point tools, and rotary tools [8].

3.4.4 Machining conditions

High speed steel (HSS) Cutting tool is used, the range of rpm on the lathe machine is limited, so the cutting speed is selected based on the available rpm that are 350 rpm, 500 rpm and 800 rpm and depth of cut are 0.15mm, 0.3mm and 0.5mm and feed rate are 0.08, 0.3 and 0.5 and work piece material is mild steel.

The experimental procedure is carried out in the following three steps:

STEP1: The raw material (metal rods) is fed into traditional turning lathe machine.

STEP2: The metal rods are clamped in machine.

STEP3: The process of turning has been done in the following three cases

1. Varying speed while keeping the depth of cut and feed rate constant
2. Varying feed rate and keeping cutting speed and depth of cut constant
3. Varying depth of cut while keeping the cutting speed and feed rate constant.

Table (3.1): show various values of cutting speed and constant depth of cut and feed rate

NO.	Spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)
1	350	0.3	0.15
2	500	0.3	0.15
3	800	0.3	0.15

Table (3.2): show various values of feed rate and constant cutting speed depth of cut

NO.	Spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)
1	500	0.5	0.3
2	500	0.3	0.3
3	500	0.08	0.3

Table (3.3): show various values of depth of cut and constant cutting speed and feed rate

NO.	Spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)
1	350	0.5	0.5
2	350	0.5	0.3
3	350	0.5	0.15

3.5 Surface Roughness Test

Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. The surface roughness was measured by using roughness tester device, the surface roughness tester as shown in Figure (3.5). The value of surface roughness of the specimens in each level of parameter of turning operation are stated down for further analyze.

3.6 Measures of Roughness

A simple measure of roughness is the average area per unit length that is off the center line (mean). We will call this the Centre Line Average (CLA), or Arithmetic Average (R_a), the units are µm.

To calculate the roughness using samples at evenly spaced positions as shown in figure (3.3),

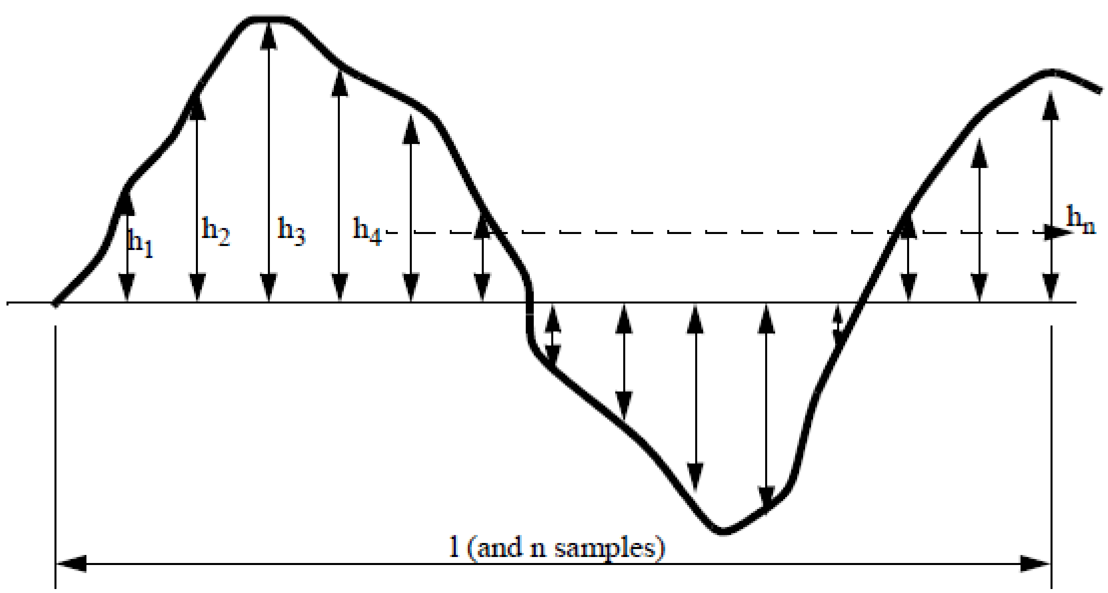


Figure (3.3): Magnified detail of a rough surface

$$CLA = R_a = \frac{\sum h}{n} = \frac{h_1+h_2+\cdots+h_n}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

The roughness can also be calculated by area as shown in figure (3.4),

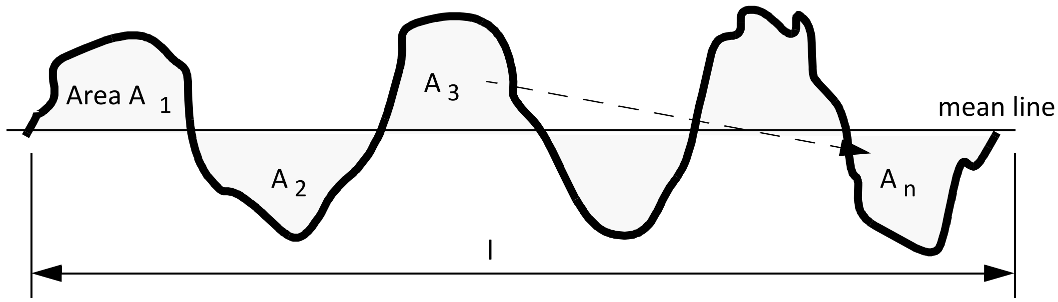


Figure (3.4): Magnified detail of a rough surface for Areas

$$CLA = R_a = \frac{\sum A}{l} = \frac{A_1 + A_2 + \cdots + A_n}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

In both cases the mean line is located so the sum of areas above the line is equal to the sum of areas bellow the line.

Note the results are the same with both methods. These numbers may vary significantly if the height method does not take enough samples for a rougher surface texture.

3.7 Methods of Measuring Surface Roughness

There are a number of useful techniques for measuring surface roughness,

1- observation and touch - the human finger is very perceptive to surface roughness
2- stylus based equipment - very common interferometry - uses light wave interference patterns (discussed later). [2]

Figure (3.5) measurement device

Figure (3.5) measurement device

The method of measuring based on the comparison in which a device has a samples indicates a specific degree of surface roughness which given in (Ra) and (R_z) units.

Measuring process accomplished by closing both the measuring device and the work piece, then by comparing the work piece surface with the samples surface of the measuring device through the hand touch and the seeing the surface roughness of the work piece are determined

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter is about the result and discussion on the experiment conducted. The results will be expressed in tables and graphs to provide the reader with a clearer view. The experimental result will then be analyzed and compared. Recommendation will be given for future improvements.

4.2 Results

4.2.1 Analysis of Surface Roughness Value when deferent cutting speed, and the depth of cut and feed rate are constant

Table 4.1 **show the results for vary cutting speed VS R_a**

NO.	spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)	Average Surface Roughness , Ra (μm)
1	350	0.3	0.15	3.2
2	500	0.3	0.15	1.6
3	800	0.3	0.15	0.8

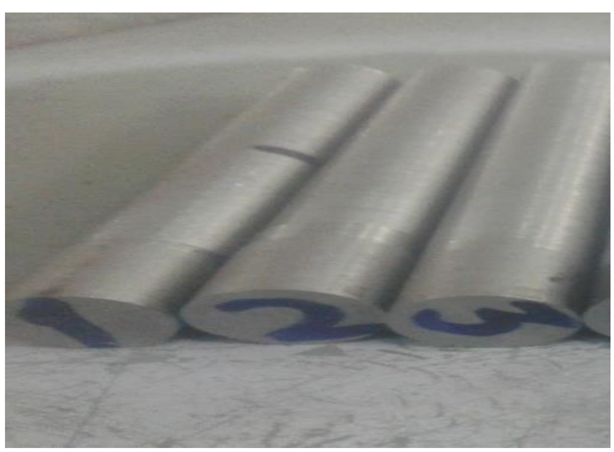


Figure (4.1) the Samples

4.2.2 Analysis of surface roughness value when deferent feed rate, and the depth of cut and cutting speed are constant

Table 4.2 **show the result for vary feed rate VS R_a**

NO.	Spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)	Average Surface Roughness , Ra (μm)
4	500	0.5	0.3	3.2
5	500	0.3	0.3	1.6
6	500	0.08	0.3	0.8

Figure (4.2) the Samples

4.2.3 Analysis of surface roughness value when deferent depth of cut, and feed rate and cutting speed are constant

Table 4.3 **show the result for vary depth of cut VS R_a**

NO.	Spindle speed(rpm)	Feed rate(mm/rev)	Depth of cut(mm)	Average Surface Roughness , Ra (μm)
7	350	0.5	0.5	6.3
8	350	0.5	0.3	6
9	350	0.5	0.15	1.6

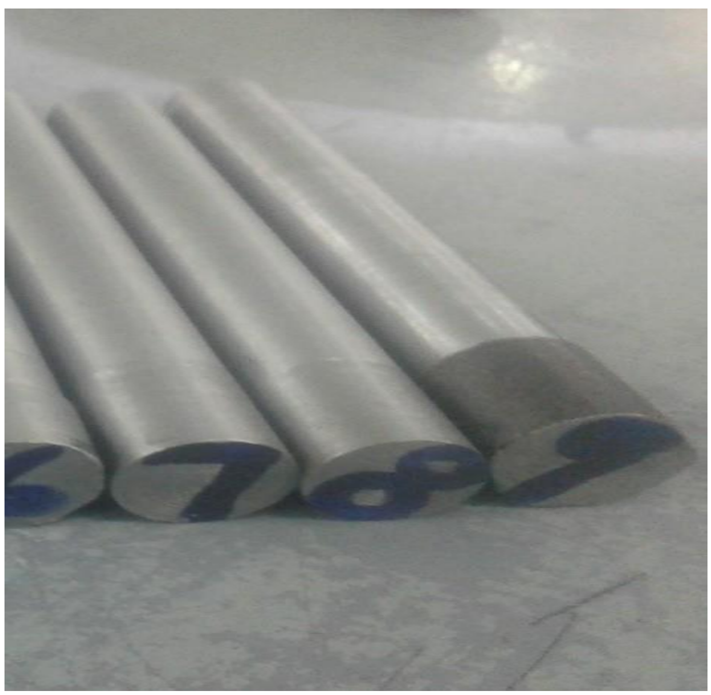


Figure (4.3) Samples

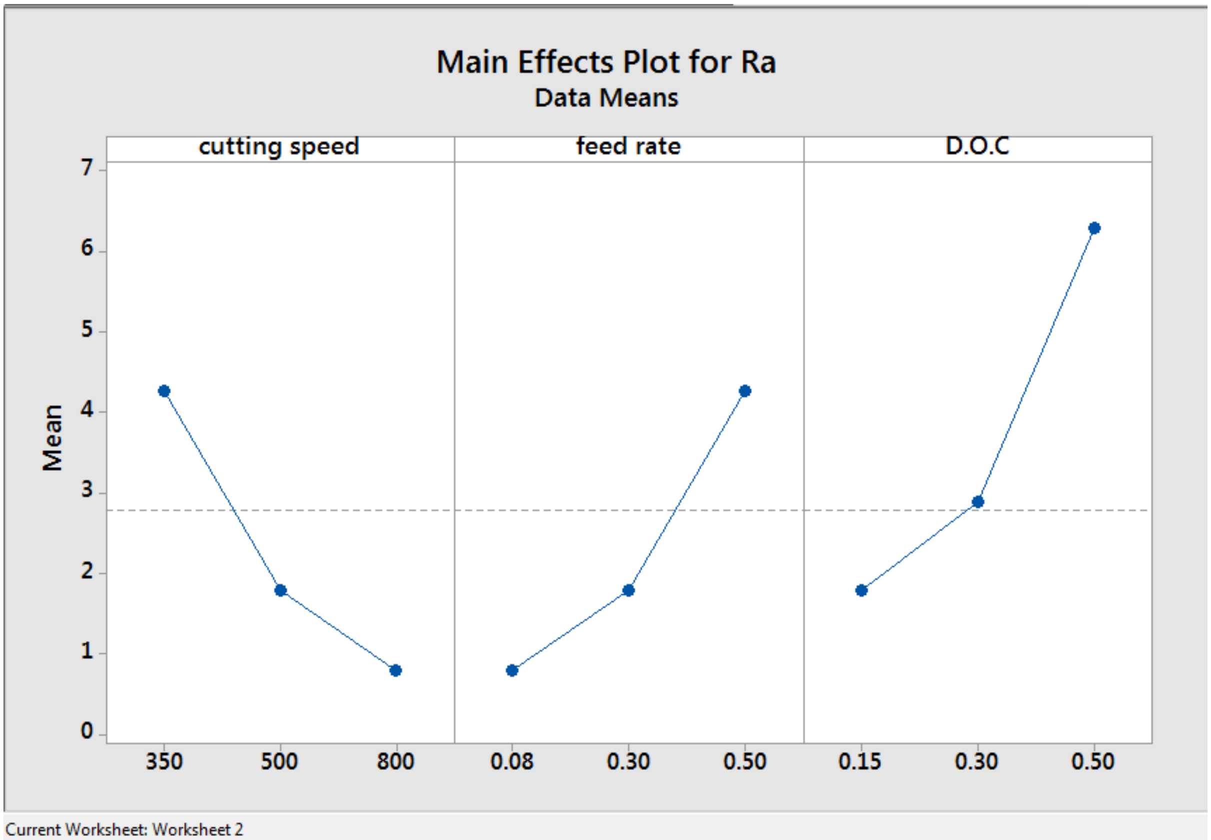


Figure (4.4) Main Effects Plot for R_a

Data Means

4.3 Discussion

Figure 4.1 above shows graph for surface roughness of 3 different speeds, which are 350 rpm, 500rpm, 800 rpm, which are approximately 19.792 mm/min, 28.274 mm/m**.** Then, and 45.239 mm/min respectively. The feed rate is set at 0.3 mm/rev and depth of cut is set at 0.15mm. The work piece diameter is reduced from 18 mm to 17.85 mm. The surface roughness value decreases from 3.2 μm to 0.8 μm. The graph obviously shows that the surface roughness value is decreasing significantly when the RPM is higher. In other words, the surface finish will be improved as the cutting speed increased.

The Tables 4.2 and Figure 4.1 above displays the surface roughness values for feed rate of 0.5 mm/rev, 0.3 mm, and 0.08 mm respectively. The spindle speed used was 500 rpm (which cutting speed is approximately 28.274 mm/min) and the depth of cut is set at 0.15 mm. The surface roughness is measured using a roughness tester. The average value for feed 0.5 mm/rev is 3.2 μm, feed rate 0.3 mm /rate is 1.6 μm, feed rate .08mm is 0.8 μm. According to the graph roughly, the surface roughness increases as the feed rate increases, which are from 0.08 μm to 3.2 μm. In other words, it means that the surface finish is better at smaller value of feed rate.

The Tables 4.3 and Figure 4.1 above displays the surface roughness values for depth of cut are 0.5 mm, 0.3 mm, and 0.15 mm respectively. The spindle speed used was 350 rpm (which cutting speed is approximately 19.792 mm/min) and the feed rate is set at 0.5 mm/rev. The surface roughness is measured using a roughness tester. The average value for depth of cut 0.5 mm is 6.3 μm, depth of cut 0.3 mm is 6 μm, depth of cut 0.15mm is 1.6 μm. According to the graph roughly, the surface roughness increases as the depth of cut increases, which are from6.3 μm to 1.6 μm.

In other words, it means that the surface finish is better at smaller value of Depth of cut.

Chapter five

Conclusion and Recommendations

5.1 Conclusion

- The surface roughness increases as the depth of cut increases, which are from6.3 µm to 1.6 µm. In other words, it means that the surface finish is better at smaller value of depth of cut.
- Surface roughness value is decreasing significantly when the RPM is higher. In other words, the surface finish will be improved as the cutting speed increased.
- The surface roughness increases as the feed rate increases, which are from 0.08 µm to 3.2 µm. In other words, it means that the surface finish is better at smaller value of feed rate.

5.2 Recommendations

- Study of effect of cutting parameters (cutting speed, feed rate, depth of cut) on the surface roughness using (milling, drilling…. etc.) operation.
- Machining several work-pieces materials such as (stainless steel, cast iron …. etc.) in turning operation and know their effect on surface roughness
- Study of effect of cutting parameters (cutting speed, feed rate, depth of cut) on the surface roughness using turning operation using other tool materials such as carbide tool…. etc.

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Appendices

TableA1: Cutting Speeds and Feed for Turning Operations

Work Material	Tool Material	Cutting Speeds			
		Depth of cut in mm			
		5 - 10	2.5 - 5	0.5 – 2.5	0.1 – 0.5
		Feeds in mm / rev.			
		0.5 – 0.6	0.3 – 0.5	0.25 – 0.35	0.05 – 0.25
Free Machining Steels	HSS Carbide	20 – 50 100-150	50 -70 125-175	40 – 50 150 - 250	50– 120 200 -500
Mild Steel	HSS Carbide	25 – 35 60 - 120	35 – 50 85- 150	40 – 60 120 - 200	45 – 80 150 - 450
Medium Carbon Steel	HSS Carbide	15 – 25 50 - 110	25 –45 60 - 120	25 – 50 100 - 150	35 – 70 120 - 300
Alloy Steels	HSS Carbide	15 – 20 30 - 65	15 – 25 40 - 80	15 – 36 65 - 100	120 – 300 80 - 180
Tool steel	HSS Carbide	15 – 20 50 - 110	20 –25 60 - 120	25 – 30 100 - 150	30 – 60 120 -300
Stainless Steel	HSS Carbide	15 – 20 35 - 60	20 – 25 40 - 70	20 – 30 50 - 80	25 – 50 50 - 90
Cast Irons Grey, ductile and malleable	HSS Carbide	20 – 25 60 - 90	25 – 30 70 - 100	30 – 45 85 - 110	40 – 60 80 - 120
Alluminium Alloys	HSS Carbide	40 – 75 60 - 150	75 – 100 90 - 180	90 – 120 90 - 450	100 – 120 150 - 600
Copper Alloys	HSS Carbide	40 – 60 50 - 110	60 – 100 60 - 150	90 – 120 100 - 180	120 – 200 120 - 310
Magnesium Alloys	HSS Carbide	40 – 75 60 - 150	70 – 100 90 – 180	90 – 120 90 - 450	100 – 200 150 - 600
Titanium Alloys	HSS Carbide	10 – 15 15 - 30	15 –30 30 - 90	30 – 60 60 - 90	60 – 90 60 - 120

Figure A2: Lathe during Experiment process

Figure A3: Lathe Machine of Experiment

Figure A4: Work-pieces and measurement device