# Experimental Investigation and Optimization of Machining Parameters during CNC dry turning of AISI4340/En24 Steel

**Abraham Mulugeta Desta**

**A Thesis Submitted to**

**The Department of Mechanical Engineering**

**School of Mechanical, Chemical, And Material Engineering**

**Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Mechanical Engineering (Manufacturing Engineering)**

**OFFICE OF GRADUATE STUDIES**

**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**

**June, 2023**

**Adama, Ethiopia**

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**Advisor:**

Dr. Guteta Kabeta (Assistant Professor)

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# Declaration

I hereby declare that this grasp Thesis entitled "Experimental research and Optimization of Machining Parameters at some stage in CNC turning of AIS14340/En24 metal" is my original work. that is, it has no longer been submitted for the award of any educational degree, degree, or certificate in every other university. All sources of substances which might be used for this thesis had been duly recounted thru citation.

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# Recommendation of Advisors

I/we, the guide(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled "Experimental investigation and Optimization of Machining Parameters at some stage in CNC turning of AIS14340/En24 metal" organized underneath my/ our steerage through Abreham Mulugeta Desta submitted in partial achievement of the requirements for the diploma of master of technology in manufacturing Engineering. consequently, I/we endorse the submission of a revised version of the thesis to the branch following the applicable procedures.

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| **Major Advisor** | **Signature** | **Date** |
| __________________________ | _______________________ | ________________ |
| Co**-advisor** | **Signature** | **Date** |

Dedicated to

My Father

Mulugeta Desta Wendimu

Who was pass away on 2014.

# Approval page

I/we, the advisors of the thesis entitled "Experimental research and Optimization of Machining Parameters all through CNC turning of AIS14340/En24 metal" and evolved by Abreham Mulugeta Desta here by using certify that the recommendation and tips made via the board of examiners are appropriately included into the final model of the thesis.

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| Co-advisor | Signature | Date |

We, the undersigned, contributors of the Board of Examiners of the thesis through Abreham Mulugeta Desta have examine and evaluated the thesis entitled "Experimental investigation and optimization of parameters through CNC turning of AISI4340/EN24 steel " and tested the candidate at some point of an open defense. that is, consequently, to certify that the thesis is ordinary for partial success of the requirement of the diploma of grasp of science in manufacturing Engineering.

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Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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| School Dean | Signature | Date |
| Office of Postgraduate Studies, Dean | Signature | Date |

# Acknowledgment

I would really like to explicit my maximum fullsize gratitude to almighty God for giving me a hazard to finish my thesis with all his blessings. I would really like to thank my thesis advisors Guteta Kabeta (Ph.D.) and Moera Gutu (Ph.D.) for their integral in offering assist and precious help through steerage, corrections, and pointers giant contribution to doing this thesis. without their braveness and staying power, this work would no longer be possible. it has been a privilege for me to work underneath their steerage. thanks to Engineer Mr Shewa Taddese, supervisor of CNC precision branch at Hibret machine constructing and manufacturing industry for their type guide and for offering the workshop facility to performed the experimental machining. I specific the maximum and unique way thanks to my father Mulugeta Desta who gave me his aid to whole through my thesis. I want express my inner most thanks to my spouse Yemisrach Woretaw and wishes to offer my love to my young children, Makida Abreham and Seanan Abreham.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AISI | American Iron and metallic Institute |
| ASTM | American Society for trying out and materials |
| ANOVA | Analysis of Variance |
| CBN | Cubic Boron Nitride |
| CNC | Computer Numerical manipulate |
| CVD | Chemical Vapor Deposition |
| DOE | Design of experiment DOF degree of Freedom |
| EN | European numerous ISO international trend company |
| JIS | Japanese industrial standard |
| HSS | High pace steel HV Vickers Hardness |
| HRC | Rockwell Hardness C- scale |
| MQL | Minimum quantity Lubrication |
| MSS | Suggest Sum of square |
| MRR | Material removal rate |
| OA | Orthogonal Array |
| S/N | Signal to Noise Ratio |
| SST | Total Sum of Squares |
| SSE | Sum of Squares Error |

# LIST OF ACRONYMS

| | |
|---|---|
| d1 | Primary depth of cut |
| et al. | And others |
| f | Feed |
| Ra | Average surface roughness |
| Rt | Highest peak to the deepest valley |
| Rz | Average height profile |
| Rq | Root mean square roughness |
| Rpm | Revolutions per minute |
| RSM | Response Surface Methodology |
| Vc | Cutting speed |
| Za | Highest peak of surface roughness |
| Zp | Deepest valley of surface roughness |

# CHAPTER-1

# INTRODUCTION

## 1.1. CNC Machining

CNC turning is the most broadly used system for generating diametric shape work piece in less time and at a decrease value, with an excessive floor polish and correct measurements. It is particularly proper that a product with a tremendous floor end be produced in a short time period. The measured floor roughness is used to determine the floor finish excellent of a product. Surface roughness is normally affected by slicing factors inclusive of cutting speed, feed r ate, and depth of cut. The proper selection of management para meters for the experiment is critical if you want to produce elements with smart surface ends and excessive tolerance in a timely way. Good deal effort has been expended in current many years to enhance the high quality of merchandise and machining performance. But, other areas of this paper have nevertheless to be investigated. CNC slicing and turning gear are subjected to noticeably harsh rubbing under high strain and temperature, with in steel to steel contact among the chip and the workpiece. The presence of sizeable stress and temperature gradients on the device's surface exacerbates the problem (Wahida et al., 2012).

Device wear is commonly a slow process as a result of consistent use. Device wear is similar to the wear at the tip of ordinary pencil. Tool put on, consistent with Australian trend,described as the change in form of the tool from its unique form all through slicing, caused by the sluggish lack of tool fabric (Viktor P. 2004).

Tool wear depends upon following parameters tool and work piece material.

i. Tool shape.
ii. Cutting Speed.
iii. Feed.
iv. Depth of cut.
v. Cutting fluid used.
vi. Machine Tool characteristics etc.

Main aims of the present study are to investigate on tool wear during turning operation done on a CNC machine, to study the cutting tool wear rate of different work cutting tool combinations and finally present the analysis/comparison results to reflect the objectives stated in the abstract.

In today’s competitive manufacturing environment, the manufacturing systems should be designed not only to increase the production rate and quality of the component but also to decrease time and cost involved in manufacturing. So, there is a need to develop a system that can ensure the quality of the component at minimum machining time. Dry machining is environmentally desirable to manufacturing industries. Dry turning can also reduce cost of manufacturer by eliminating use coolants (Sampath et al., 2016).

## 1.2 AISI 4340

AISI 4340 this is a warmth-treatable low alloy medium carbon steel this is normally utilized in programs requiring high power and put on resistance. Whilst swiftly cooled, the excessive carbon content material of AISI4340 causes the manufacturing of martensite, specifically in milling techniques. As a result of the adjustments in the micro structure and residual stresses all through machining, diverse modifications at the floor or subsurface of the machined item are observed (Pereira et.al., 2017). Crankshafts, cam shafts, touchdown gears, and high tensile screws are commonplace programs for these materials in car and aerospace (Citti et al., 201 8).

## 1.3 Turning operation

Turning is a technique of constructing an axisymmetric floor by doing away with unwanted cloth from a workpiece with a view to produce a desired shape, in which the tool movements in a perpendicular p lane and the workpiece is hung on a spindle and rotated (Groover, M. P America, 2010). Cutting, feed, and depth of cut were the maximum thrilling traits related with the turning system (Astakhov et al., 201 1).

The cutting speed is defined as the workpiece is relative surface pace with regard to the device liable for fabric removal. Feed is the relative motion of the tool with appreciate to the workings in a perpendicular direction to the cutting speed on the way to attain an unmachined surface (Davim,J. P. 201 1). The intensity of reduce, which is the radial distance in turning from the unmachined floor of the activity to the tool tip, is the penetration of the slicing device into the work, this is under the working surface (Dixit, P. M., Dixit, U. S 2008). Turning is a completing operation carried out on additives to generate the final form of the factor with suited measurement and tolerances (Kalpakjian, S. et al.,2001). The procedure of putting off fabric from a revolving workpiece with a single factor reducing device to create a cylindrical shape.

## 1 .3.1. Step Turning

Step turning is a turning procedure that pro duces a series of steps of varying diameter s on a work piece. A step is formed by the workpiece's final feature.

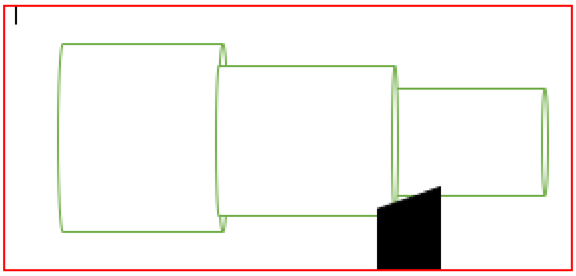

Figure1.1 Schematic representation of step turning

## 1.3.2. Contour turning

The cutting tool in this form of turning operation follows an axial route with a preset shape. Multiple passes of a contouring tool are necessary to generate desirable curves in a workpiece. However, it is possible to create the same contour shape with form tools in a single pass.

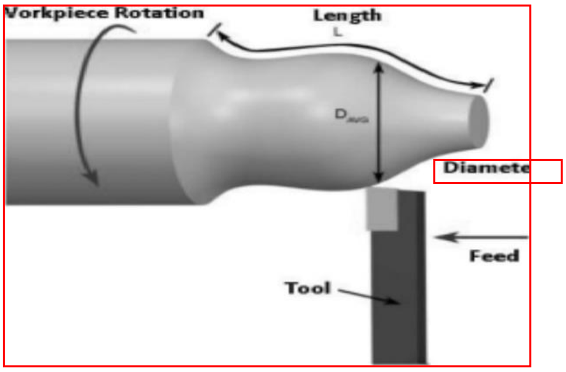


Figure1.2 Schematic representation of contour turning

## 1.3.3. Chamfering

Chamfering, like step turning, is the process of beveling the extreme end of a workpiece. After thread cutting, this step is required so that the nut can freely move over the threaded workpiece. Chamfering also removes sharp edges, lowering the likelihood of cuts.

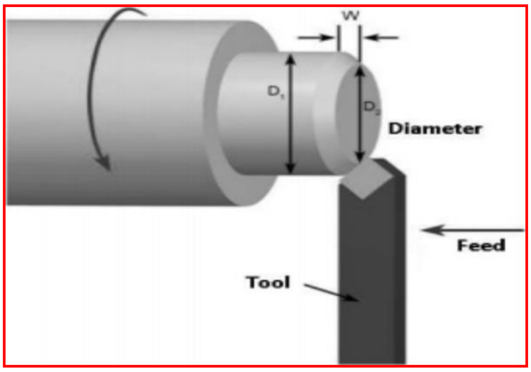


Figure 1.3 Schematic representation of chamfering

## 1.4 Turning parameter

Cutting speed, feed, depth of cut, tool angle, coolant intake, and different variables all have an effect on machining overall performance. Cutting speed, feed, and depth of cut are the three maximum crucial traits in every machining operation. These traits, in particular, are without problems managed during the machining process.

### 1.4.1 Cutting Speed

Cutting speed refers to the speed at which the slicing device or workpiece movements relative to every other in the course of a machining operation. It is generally measured in surface ft per minute (SFM) or meters in line with minute (m/ min). Reducing velocity is a vital parameter in machining because it directly impacts the price of cloth removal, device put on, and surface end. In trend, higher cutting speeds bring about higher fabric elimination quotes but additionally increase the threat of device wear and warmth technology. The top-rated cutting speed for a given machining operation relies upon at the particular material being machined, the tool cloth and geometry, and the preferred final results. To determine the perfect cutting speed, machinists frequently consult cutting speed charts or use cutting speed calculators. These tools do not forget the material and tool properties and provide advocated slicing speeds primarily based at the machining operation and desired effects. It is critical to note that cutting speed is simply certainly one of numerous parameters that need to be considered in machining, at the side of feed rate, depth of cut, coolant type and flow rate. collectively, the parameters decide the general machining overall performance and the quality of the finished part.

### 1.4.2 Feed Rate

Feed charge is a machining parameter that refers to the velocity at which a cutting device actions via a workpiece at some stage in a machining operation. It is normally expressed in gadgets of distance per unit of time, which includes millimeters in keeping with minute or inches in line with minute. The feed fee is a crucial machining parameter because it at once influences the material removal fee, reducing forces, tool existence, and surface finish of the workpiece. A higher feed rate will bring about a higher material removal price, however it can also generate higher reducing forces and reason expanded tool wear. Conversely, a decrease feed fee will bring about a decrease cloth elimination price, however it can also produce a higher floor end and lessen cutting forces and device wear. An appropriate feed fee for a specific machining operation relies upon on numerous elements, including the material being machined, the form of reducing device, the machine tool's tension and strength, and the preferred surface finish. In well known, softer materials can tolerate a better feed charge than harder materials. in addition, a highspeed metal tool can generally handle a better feed rate than a carbide tool. To determine the ideal feed fee for a selected machining operation, a machinist might also carry out a sequence of test cuts at unique feed fees and compare the effects. In trend, the goal is to locate the most feed charge that lets in for efficient fabric removal without causing immoderate slicing forces or device wear, whilst additionally producing the favored surface finish. It is important to word that the feed charge should be decided on together with the intensity of reduce and cutting velocity to ensure finest machining effects. The cutting speed is the speed at which the reducing tool rotates and is typically expressed in devices of surface feet in line with minute or meters in step with minute. The intensity of cut is the space among the pinnacle surface of the workpiece and the reducing fringe of the device for the duration of a reducing operation. In precis, feed rate is a critical parameter within the machining technique, and it have to be cautiously decided on to make certain top-quality effects. Machinists must keep in mind different factors when deciding on the best feed rate, and they will need to perform check cuts to decide the most effective fee for a specific software.

### 1.4.3 Depth of cut

Depth of cut is a machining parameter that refers to the distance between the top surface of a workpiece and the cutting edge of a tool during a cutting operation. It is an important parameter because it directly affects the material removal rate, cutting forces, tool life, and surface finish of the workpiece. In general, the depth of cut is specified as the axial depth that a cutting tool penetrates into the workpiece during a single pass. The depth of cut is typically measured in millimeters or inches and can be adjusted by changing the position of the cutting tool relative to the workpiece. The depth of cut can have a significant impact on the machining process. If the depth of cut is too shallow, the cutting tool may not be able to remove the desired amount of material, resulting in poor productivity. On the other hand, if the depth of cut is too deep, it can lead to excessive cutting forces, tool wear, and poor surface finish. The appropriate depth of cut depends on several factors, including the material being machined, the type of cutting tool, the machine tool's rigidity and power, and the desired surface finish. In general, softer materials like aluminum can tolerate a deeper depth of cut than harder materials like steel. Similarly, a high-speed steel tool can typically handle a deeper depth of cut than a carbide tool. To determine the appropriate depth of cut for a particular machining operation, a machinist may perform a series of test cuts at different depths and evaluate the results. In general, the goal is to find the maximum depth of cut that allows for efficient material removal without causing excessive cutting forces or tool wear.

In summary, depth of cut is a critical parameter in the machining process, and it must be carefully selected to ensure optimal results. Machinists must consider various factors when selecting the appropriate depth of cut, and they may need to perform test cuts to determine the optimal value for a particular application.

## 1.5 Dry Machining

The usage of reducing fluids at some point of the cutting procedure is removed with dry machining. Most problems linked with the usage of cutting fluids can for that reason be avoided. Imposing dry machining also can keep manufacturers money by means of putting off the want for coolants. Furthermore, decreasing exposure to risk us slicing fluids offers a safe working environment, growing worker process satisfaction and pro ductility. Dry machining is likewise environmentally pleasant and according with relevant exertions and environmental regulation. With these benefits and favorable effect s, groups may additionally broaden a fine rapport with society and depart a high-quality company influence on human beings. accelerated feed rate and depth of reduce in dry slicing can increase touch vicinity and cutting temperature within the cutting area, accelerating tool wear and deteriorating workpiece floor exceptional (Sampath et al., 201 6).

Excessive warmth and mechanical loading during machining may also additionally pressure the workpiece floor, ensuing in massive fatigue strain at the product (Sarnobat et al.,201 9). Overcome these troubles, progressed tooling substances, such as CBN, PCBN, PCB, inserting ceramics and special coatings, have been used together with dry machining (Goindi et.aI.,2017). These coating technologies amplify tool existence through reducing the device thermal surprise and temperature variation at the tool tip particularly for the duration of milling operations.

## 1.6 Statement of the Problem

In many research reviews selection of in correct reducing parameters ended in poor floor end of AIS14340/EN 24 steels which additionally affects slicing tool existence. Improper selection of slicing parameters (cutting speed, feed, and depth of reduce) additionally influence s machining productivity including cloth elimination charge (MRR). Due to the fact this metal has high industrial application, much less research become carried out to optimize cutting parameters.

## 1.7. General objective

The principle goal of this thesis research to investigate the effect of cutting parameters on surface finish and optimization of machining parameters in the course of CNC turning of AIS14340/En24 low alloy metal.

## 1.8. Specific objective

To attain the main goal of this thesis, the following precise goals are designed:

1. To study the effect of cutting parameters on floor first-rate the use of DOE.
2. To investigate cloth removal rate at most advantageous situation.
3. To investigate chip morphology for different reducing parameters.

## 1.9. Delimitation of scope

This study is on the CNC slicing and turning system device, that found in Hibret gadget constructing and manufacturing industry. The studies are executed for this enterprise so, this is one of the barriers of the studies, even though the final out put can enforce for different companies too. The second difficulty of this studies is limited on a specific type of device, which is on slight metallic device of CNC cutting and turning system.

## 1.10. Significance of study

This look at is tremendous in its very own proper, it can be implemented to other organizations to enhance their product satisfactory and production time, reduce waste, and boom output. It also has the benefit of improving the CNC reducing and turning device characteristics, that could face up to excessive fluctuation masses without deformation or immoderate put on for a longer time frame, in addition to excessive tool erosion. In general, it has the significance of improving material characteristics.

## 1.11. Organization of the thesis research

This thesis consists of five chapters;

Chapter one: - Mentioned advent of the observe, CNC turning operation, effect of turning parameters, dry turning, assertion of the trouble, significance of the observe unique and preferred goals.

Chapter two: Under this chapter the studies literature s finished with the aid of other exclusive researchers which is associated with this look at or experimental research and optimization of parameters on special steels kind are mentioned. ultimately, the Research gab is discussed.

Chapter three: - In chapter 3 the followings: studies technique, material and strategies selection of material, experimental method, experimental setup, Taguchi technique, surface roughness measurements, profilometer, machining parameters and their ranges are mentioned.

Chapter four: - Experimental results, analysis of machining parameters, Taguchi methodology, confirmation test, and ANOVA meth od are discussed.

Chapter five; - Discussed the conclusion and recommendation of the research.

# CHAPTER-2

# LITERATURE REVIEW

## 2.1 Introduction

A literature review is a critical analysis and summary of scholarly research on a particular topic. It is an essential component of academic writing, as it helps researchers to identify gaps in the existing knowledge and provides a framework for their research. In this essay, we will discuss the purpose, benefits, and steps involved in conducting a literature review. A literature review is an essential component of academic research, providing a comprehensive overview of existing research on a particular topic. It helps researchers to identify gaps in the existing knowledge, develop research questions and hypotheses, and select appropriate research methods and data sources. Conducting a literature review involves several steps, including defining the research question, conducting a comprehensive search, evaluating the literature, synthesizing the findings, and writing the review. By following these steps, researchers can ensure that their literature review provides a solid foundation for their research, and makes a valuable contribution to the field.

This survey on research papers require to deliberate in this chapter connected towards CNC Turning Machine. From the readings out in these papers and thesis is mostly concerned through the CNC Lathe settings such as the feed, depth of cut, cooling medium, spindle speed etc. and in what way these parameters will affect like MRR and productivity, Chip morphology, surface finish. Reviewing research journal mean not criticize their job but find the research gap if any. This literature part reviewed different journals about experimental investigation and optimization of machining parameters during CNC turning of AISI4340/EN24 mild steel. This survey reviewed different conducted journals.

- The effect of Cutting parameters
- Temperature and Tool wear and mild steel CNC turning
- Chip morphology
- MRR and productivity

## 2.2. The effect of Cutting parameters

When cutting AISI 4340 with different cutting modes (CM and HSM), it was noticed that the force produced during the process was different. Machining in the high-speed mode is twice as fast as that in the conventional mode under dry and minimum quantity lubrication conditions. The article is about improving the simplicity of a text by using easier words and language. Saw like cuts that appear on chips made during machining show that more strength is needed when cutting in the HSM mode. Al Ghamdi et al., (2015) studied how much force is needed to cut through AISI4340 without using any liquids or coolants. The conditions of MQL+C02. The MQL and C02 nozzles were put in different spots on the rake and flank. As a result, using MQL on the cutting edge and C02 on the side reduces the force applied the most. In a study conducted by Saini et al., (2014) adjusted the way machines cut materials how changing the speed of the cutting tool and the rate at which the material is fed into the machine would affect the results. Effects on the force needed to cut AISI 4340 (39 HRC) when machining it.

The researchers did their work in dry and MQL conditions using carbide inserts that were coated with CVD and PVD. The team is working on a new project that aims to improve customer satisfaction and increase sales. The MQL settings stayed the same, but we changed the pressure, flow rate and nozzle distance to 4 bars and 300 units. ml/ h means milliliters per hour. This is a unit used to measure how fast a liquid is flowing. On the other hand, 35 mm stands for 35 millimeters, which is a measurement used to describe the length or size of something. discovered that the amount of force needed decreased as the cutting speed increased. A comparable A study noticed something interesting while cutting without using any liquid. found that the faster the cutting speed, the more energy and stress were involved in the process that made temperature higher. In the meantime, the material became softer because it was very hot. Making the force needed to cut something smaller. The temperature and cutting force levels were measured in the MQL condition. Much less than the ones when the cutting is done without using any liquid or lubrication.

Arun et al. (2018) looked at how cutting forces are affected by different cooling methods. And discovered that using cryogenic coolant can greatly reduce friction between the tool and the material being cut, which is better than using a flood cooling method. When the cutting speed was enhanced to 100, 150, and 200 m/min, the cutting forces were much lower in all the cryogenic coolant conditions compared to the flood coolant conditions. The reduction in cutting forces was 18%,14.03%, and 11% for the respective speeds. Furthermore, cryogenic machining used less power than flood machining. Even though the power used increase along with the cutting speed, it was still lower compared to flood machining at all cutting speeds.

Natasha et al., (2016) and (muhamed et al.201 9) was found same conditions that Cryogenic machining is better than dry machining because it reduces cutting force and feed force. The chips made by cryogenic machining looked like saw teeth and were more likely to curl. This suggests that cryogenic cooling can make the chips become brittle and harder. In this situation, it takes less energy to cut the metal, which means less force is needed. The process of cutting goes faster, make smoother surfaces However, when the feed rate is increased, the surface quality gets worse, besides comparing MQL with dry cutting.

Das et al., (2018) conducted a study to how certain settings of a machine can affect how rough a surface is. At the range of feed rate between O. 04 mm/rev to O. 16 mm/rev, the findings discovered that the surface roughness values got higher when it was dry and conditions that use MQL. Using a minimal quantity of lubricant (MQL) in machining results in a smoother surface compared to machining without any lubricant. In short, when the feed rate increases, it affects the surface roughness values.

Cryogenic machining can make a surface smoother than other types of machining. The study conducted by Arun Kumar et al., (2018) compared how smooth the surface was after using cryogenic, dry, and flood machining methods to turn hardened AISI 4340. At a fast cutting speed, a feed rate of 0.1 mm per revolution, and a depth of cut of 0.5 mm, cryogenic machining produced a low surface roughness value of 0.432 m, which was the same as the value obtained from grinding processes dry machining doesn't offer any significant advantages compared to using flood in terms of surface roughness atl.0.89 and 0.979 m respectively. The rough surface was caused by a tool that broke and fell off, which happened where the rake and flank areas meet and were being cooled with flood Muhamad et al., (2019) tested both dry milling and cryogenic milling of AIS14340 metal and found that cryogenic milling gave a better surface finish. A 24% increase in area. Noticed that the task was completed using a cutting speed of 180 m/s, a feed rate of 0.1 mm/ tooth, and a depth of cut of 0.3 mm, even the speed of cut is increased the improvement in surface finished decline by 14%.

## 2.3. Temperature and Tool wear

In dry cutting, making the cutting tool move faster and cutting deeper can make the cutting area bigger. The heat can cause the tools to wear down faster and make the surface of the object being worked on worse. Too much heat and pressure from the machine can cause even more stress to the surface of the workpiece, leading to significant damage. The study found the more stressed can affect how well a product works (Sarnobat et al, 2009).

Goindi et al., (2017) advanced materials like CBN, PCBN, PCB, cermet, ceramics, and others were used as coating agent for better tools life. Using coatings in combination with dry machining helps prolong the lifespan of too Is. These coatings treatments help prevent damage to the tools Reducing sudden changes in temperature and heat at the tool tip especially when milling.

Xavior et al. (2015) conducted a study that compare how easily AISI 4340 steel can be milled using different types of tools coated and uncoated carbide in a dry environment and found that the coated tool wears out more slowly than the uncoated tool because of the layer of TiN material used for the coating. This stop work material from sticking to the edge of the tool. When using tools without a protective coating, It wear out faster, particularly when the cutting speeds are fast. The study found that the cutting speed and feed were important factors. The speed of wearing out of a tool is mainly caused by the rate of use.

Li et al., (2019) studied how well different coatings on cutting tools worked when milling AISI 4340 without using any lubrication. In HSM, it was found that using a tool with multiple coatings of TiN, TiCN, and TiAIN reduces the force required for cutting pieces and the cutting tool generates heat. This heat can cause the temperature of the TiCN + NbC and AITiN coated tools to increase. When cutting fluid is not used, the friction between the workpieces and the cutting tool creates heat, which can make the TiCN + NbC and AITiN coated tools hotter. The object being cut and the tool used to cut it create a lot of heat in the area where the cutting is happening. In this case, during the machining process, the energy is used to get rid of extra heat and lubricant from the cutting area. This helps the tool last longer and makes the surface better. Manufacturers now use environmentally friendly methods for machining. Technologies like MQL are used to get rid of the need for cutting fluid, this way of machining is also called near dry machining. With a large amount of air from 30,000 to 60,000 ml/h form a mist or spray that is directed at the cutting area of a machine tool. From 05 mL/h to 500 ml/h instead of flood coolant, which uses. In simple terms, air is pushed at a high force to make a mist. This mist is then sprayed on the area where cutting needs to be done. M QL offers a wide range of functions and tools, making it accessible for both beginner and experienced manufacturer. This process is a method that uses only a little bit of liquid to cut material s, making production cheaper by 4%. Greenhouse gas emissions decreased by 21 % according to ( Ginting et al.,201 5).

It has been shown that using vegetable based cutting fluids, especially palm oil, makes a very stable lubricant. The protective layer with oxide helps make the tools last longer (Rahim and Sasahara 2011; Lawal et al.,2014; Shankar et al.,2017; Norfazillah et al., 2018). The fat acids in these oils are structured in a complicated way, so it doesn’t easily spoil when exposed to high temperatures. This is important for using It in machining operations at high temperatures and for making sure the oil stays effective throughout the entire machining process (Lawal et al.,2014 and Shankar et al., 2017) keeping the qualities of oil the same during the entire cutting process.

## 2.4. Chip morphology

Li et al., (2019) examined the shape of the chips that were formed when AISI4340 was milled without using any liquids with HSM. All the chips made are a serrated shape is created and the material becomes softer because of the strong force applied to it. Cutting temperature refers to the temperature at which a material is effectively and efficiently cut through with a tool. However, the amount of roughness on the cutting tool can change depending on what type of material is used to coat it. These changes show MQL's ability to minimize cutting region temperature during machining and suggest that a high cutting temperature is generated in the absence of cutting fluid. When MQL is used, helical shaped chips are created, whereas dry cutting produces helical and ribbon shaped chips.

Berlin et al., (2015) looked at how MQL and dry cutting conditions affects the thickness of chips and how long the tool comes into contact with the chips. Because the cutting is very low when using MQL instead of dry machining, the temperature created was lower and the chips produced were thinner made between the surfaces. Also found at the tool tip, the amount of material removed by the tool is 3% to 0.9% less when using minimum
quantity lubrication (MQL) compared to dry cutting. These larger and longer chips indicate that a strong cutting process is happening, which requires a lot of pressure and power. Cryogenic cooling is often used in industries such as metal working, where high temperatures can cause damage to the cutting tools and impact the quality of the final product. Overall, cryogenic cooling is a widely used technique for enhancing the performance and lifespan of cutting tools in machining operations, the heat in the area where something is being cut. When the cutting temperature is lowered in very cold conditions; the chip can become brittle. This means that if decrease how long the tool chip touches the material during milling, it will make the chip break more easily. Cold temperature can affect how chips are formed and the temperature of the tool tip, using a process called dry machining, working on AISI 4340 (Natasha et al.,201 6).

## .2.5 MRR and productivity

Metal cutting efficiency is mainly determined by how well the machining and tooling processes work together. Getting rid of extra stuff as quickly as possible. speed, a milling machine can produce a smoother surface finish on a workpiece. By increasing the cutting speed and depth of cut, more metals can be removed without using a lot of energy. The amount of tool damage in areas with a lot of contact during machining need to consider the cost of tooling is not important to the manufacturer, it can finish the metal removal process using more advanced standards and can achieve better productivity (Iqbal et al., 2015).

According to other researchers (Gidi et al.,201 5) Choosing the right cutting tools is really important to Make machining work better overall and can reduce manufacturing costs by 15% and make workers more productive by 20%. Ginting et al., (2018) studied how well two different ty pes of coated tools, PVD and CVD, worked for dry machining. The study looked which one was better at getting work done quickly,working with machines in a place without any water or moisture is very challenging due to the hot condition and the wearing out of tools. However, not using cutting fluid, it might encourage people to use dry machining.

The volume of material removed (VMR) and material removal rate (MRR) should be included while calculating productivity.

$$VMR = MRR \times T = (v.\ f.\ a) \times T \tag{2.1}$$

$VMR$ = Volume of material removal (cm3)

$MRR$ = material removal rate (cm3 / min)

$V, f, a$ = Cutting speed (m/min), feed rate (mm/rev), depth of cut (mm) and = Tool life (min)

Al Ghamdi et al., (2015) studied how efficient and powerful a type of steel called AISI 4340 is when used in different situations. measured its productivity and energy usage to better understand its performance. Machine settings refers to the specific configurations and adjustments made to a machine in order to carry out a particular task or operation. In simpler terms, researchers used the method mentioned above to calculate MRR (mean recurrence rate) and measure specific energy. The average amount of force used to cut something was measured in the experiments and was calculated using the MRR. Al Ghamdi et al., found out that the When combine MQL and C02 on the rake and flank face, can achieve the best value for the desired goal by using fuzzy logic. Researchers use logic to make optimization technique better and also aim to minimize VB and specific energy. These results show that when compared to using wet, dry, or isolated coolant methods separately, using a combination of all of them together is more effective. Using environmentally friendly cutting techniques can be a good way to increase productivity in machining.

## 2.6. Influence of cutting parameters

The speed, feed, and depth of cutting during the turning process directly impact how fast and well the task can be finished. Tool life is the amount of time a tool can be used before it breaks or stops working well. Machine parameters are the specific requirements or conditions that a machine must have in order to work properly. It is important to choose these conditions very carefully for each task. When deciding how to cut metal, the desired result (rough or finished) affects the choice of cutting conditions. The words speeds and feeds or feeds and speeds are used to describe two different speeds used in machine tools for cutting. Cutting speed is the speed at which a tool or machine cuts through a material. Simply speed refers to the difference in speed between the cutting tool and the surface of the work piece. It is usually measured in units of distance per time, like m/min. The feed rate is how fast something is being fed or moved.

Feed is the speed at which the cutter moves along the workpiece. Its direction is represented by a vector. To put it simply, "perpendicular" means at a right angle to workpiece. So, when we say "perpendicular to the vector of cutting speed," it means that it is at a right angle to the direction in which the cutting tool is moving. The abbreviation for inches per revolution is in/ rev or ipr. The abbreviation for millimeters per revolution is mm/rev. fit properly or is not aligned correctly, it can lead to errors and issues in the final product. This can happen because the work piece is either too big or too small for the intended purpose, or it may not be positioned correctly. These problems can cause damage to the work piece or result in a product that doesn't function as it should. When something rotates, like in milling, the units used to measure it are usually distance per time. This is represented as inches per minute or millimeters.

Komson et al., (2012) conducted to see how changing parameters can affect the roundness and hardness of stainless Steel. Steel commonly referred to as SUS 303. Stainless steel JIS: SUS 303 is commonly used for car parts. However, changing certain factors may impact the smoothness and toughness of the objects being worked on. The aim of this study was to investigate the factors that influenced the roundness and hardness of stainless steel.

Steel turning is the process of shaping steel into a desired size. A special cutting tool was used, which had a coating made of carbide called TiCN, Al 203, and TiN. This tool was made by depositing polycrystalline material through a process involving vapor. PVD cutting tools are tools that are used to cut materials. The study was set up with two things being tested, and each thing had three options at cutting speed was at 100, 150, and 200 m/min. The feed rate was set at 0.08, 012, and 016 mm/rev. Additionally, the test was conducted by using both cooling and non-cooling methods. The findings showed that only one of cooling condition was the factor that affected the roundness. However, the roundness was not influenced by the cutting speed and feed rate. In addition, the level of hardness is being referred to. The number of specimens did not go up after they were turned. The parameters were studied did not change the hardness after turning in a big way (Puneet Kumar et al., 2016). The paper is called "optimization of process parameters for machining of mild steel EN 18 by Response surface methodology". This study looks at how to make CNC max mill machines work better when machining mild steel (EN 8) with a Cemented Carbide cutting tool. The machine should always have a constant flow of coolant. The speed, rate, and depth at which a machine cuts a material are adjusted to achieve both a high level of material removed and a smooth surface. The response surface method used the data from the experiment with the help of the design of the experiment. The ANOVA analysis helps to identify the parameters that have a significant impact on the surface roughness and material removal rate values. The best answer for Material Removal Rate (MRR) and Roughness (SR) can be found when using a cutting speed of 41.86 rounds per minute(rpm)and a feed rate of l .8 millimeters per minute (mm/ min) and cutting 0. 60mm.Wahida et al., (2016) conducted "Improving turning of mild steel by adjusting the process parameters while using a small amount of lubrication. In this experiment, trying to find the best settings for cutting mild steel during the turning process. The foundation of how rough or smooth a surface is and how hot or cold it feels. Getting the best cutting results requires optimizing the cutting parameters. having a smooth surface and preventing heat from rising. Minimum Quantity Lubrication (MQL) is a technique where a s mall amount of oil or lubricant is used during industrial processes. (MQL) was created to prevent using too much cutting fluid.

Taguchi experimental method to measure performance. To understand how well something works when it turns, we used a method called Analysis of Variance (ANOVA). The speed and force of cutting have a big impact on how rough the surface feels and how hot it gets. (Carmita et al.,2013) conducted a study titled "Reducing energy usage in turning of a specific material by optimizing cutting settings Rephrase using the Taguchi method and ANOVA. " Machine tools use a lot of energy, which can harm the environment. cutting parameters need to be optimized and made changes to the settings of the cutting machine to reduce the amount of power it needs. However, response factors that to measure do not consider, the amount of energy needed to keep the machine tool ready. This paper describes a study that tested different ways to improve cutting in a process. Reducing the energy used by turning AISI 6061 T6 material during roughing.

A method called orthogonal array, along with signal to noise ratio and analysis of variance, was used to examine and analyses the data. A comparison is a way to find similarities and differences between response variables. This was done to show how important it is to choose the right thing to study. The values of certain things needed to be measured to make cutting better, like cutting power and energy used. In addition, the researchers studied how different settings for cutting can affect both energies used and the roughness of the surface. This research found that the speed at which feed is given is the most important factor in reducing energy taken. Using things and how rough they are on the outside. However, the amount of this factor required to reach the lowest energy level. Consuming something does not always lead to the minimum roughness on a surface. A higher feed rate means giving more food. Using less energy will cause the surface to become rougher. (K.ManiIvani et al., 2013) a research paper titled "Improving the Turning Process of a Specific Type of Steel using a Statistic al Method. " This paper studies the things that affect how rough a surface is during turn AISI-1016 Steel. experiment looked how different turning settings, like ho w fast to cut, how fast to move the tool, and how deep to cut, affect how rough the surface is. The findings from the machine tests on ASI-1016 were used to study the main factors that impact roughness of the surface using the Analysis of Variance method. The speed at which the feed was given that determined to be the most important factor.

Yacov Sahijpaul et al., (2013) looked at how different cutting settings affect the surface of a material. Wet CNC Turning of AISII 040 Medium Carbon Steel can cause roughness. The rea son for this test or study to conduct how different amounts of cutting fluid and two different types of cutting fluids made with different oils affect the roughness of a metallic surface called EN8. To improve the roughness of a surface while using AISI 1040 steel for turning, a design of experiments approach is applied. This involves using the JMP software to analyze the data and identify optimal conditions. Through custom design methods, variance analysis, leverage plots, and desirability profiling, the roughness during wet CNC turning operation can be optimized. The study discovered that how fast we feed the material has the biggest impact on the roughness of the surface. The type of cutting fluid used doesn't make much difference in the roughness of the surface.

Parshvam Jain et al., (2015) found the best way to adjust para meters when cutting of mild steel on a lathe machine improve the efficiency of the process. The process of planning and investigating to test a hypothesis or answer a research question. The values that deter mine how a material is cut) for laser cutting of E-Glass fiber reinforced epoxy composites using a pulsed laser are investigated. The effects of laser power, cutting speed, and pulse frequency on the quality of the cut are analyzed. The results show that by adjusting these cutting parameters, the cut quality can be improved, resulting in a smoother and more precise cut. The roughness of a surface when using a lathe is determined by the speed and depth of the cut. Improved surface finishing can have a positive impact. The effectiveness, how well work piece how easily it can be taken care of, and how much it costs to keep it in good condition for any type of moving mechanism and Surface roughness is a really important quality feature. Mathematical tools like the Taguchi method and ANOVA are used to find the best cutting parameters for getting a smooth surface finish. The rate at which feed is given to someone or something. The speed at which you cut something has the biggest effect on how rough the surface is. (Vijay Bhagora et al.,2015) a study was done on improving the process of turning on a CNC lathe. It focused on finding the best parameters for the machine to get the desired results. ASTM A242 Type-2 Alloy Steel is analyzed using regression analysis. The goal of this project is to use Regression. Analysis on a CNC lathe to find the best cutting conditions that will result in the smoothest surface finish when turning ASTM A242 type-2 alloy steel. Scientists and experts have studied the process of cutting metal for a long time. However, not much research has been done on cutting a specific type of alloy called ASTM A242 grade materials. This study, examine how different machining settings like cutting speed, feed rate, depth of cut and tool nose radius affect the roughness of the surface being worked on.

Basha et al., (2013) conduct research about improving the CNC turning process of aluminum 6061.Used a method called response surface methodology to find the best para meters for this process. This paper explains how different settings in a turning operation can affect the roughness of the surface being worked on. The use of CNC turning lathe for turning materials is very common in industry because it is very versatile and efficient. Surface roughness refers to the texture or unevenness of a surface. Surface roughness is a crucial thing that affects how good work piece is made. The main goal of this paper is to use a special tool called coated carbide to optimize the speed, rate, and depth of cuts in order to predict how rough the surface of aluminum 6061 will be optimized with a method called regression to create a mathematical equation. Then, use a process called optimization to improve the equation. Box-Behnken design is a kind of experimental de sign used in response surface methodology. The use of response surface methodology to find the best solution or setting for a problem. The parameters put into a machine, like how fast it spins, how fast it moves, and how deep it cuts, can be adjusted to make the surface of the work piece that making smoother while also being efficient. This study uses response surface methodology to find the best cutting conditions for reducing surface roughness. The researchers are using design expert 8.0 software to help with this process.

Mahendra Korat et al., (2019) conducted “Optimization of Different Machining Parameters of En24 Alloy Steel in CNC Turning by Use of Taguchi Method". The present paper outlines an experimental study to optimize the effects of cutting parameters on surface finish and MRR of EN24/AIS14340 work material by employing Taguchi techniques. The orthogonal array, signal to noise ratio and analysis of variance were employed to study the performance characteristics in turning operation. Five parameters were chosen as process variables: speed, feed, depth of cut, nose radius, cutting environment (wet and dry). The experimentation plan is designed using Taguchi's Ll 8 orthogonal Array (OA) and Minitab 16 statistical software is used. Optimal cutting parameters for, minimum surface roughness (SR) and maximum material removal rate were obtained. Thus, it is possible to increase machine utilization and decrease production cost in an automated manufacturing environment. (Jadhav JOS et al., 2014) presented paper on "Experimental study of Effect of Cutting Parameters on Cutting Force in Turning Process". The purpose of this paper is to study the effect of cutting parameters on cutting force (Fc) & feed force in turning Process. Experiments were conducted on a precision center lathe and the influence of cutting parameters was studied using analysis of variance (ANOVA) based on adjusted approach. Based on the main effects plots obtained through full factorial design, optimum level for surface roughness and cutting force were chosen depth of cut, and the interaction of feed and depth of cut significantly influenced the variance. In case of surface roughness, from the three levels of cutting parameters considered Linear regression equation of cutting force has revealed that feed, the influencing factors were found to be feed and the interaction of speed and feed. As turning of mild steel using HSS is one among the major machining operations in manufacturing industry, the revelation made in this research would significantly contribute to the cutting parameters optimization.

Dr. N. Lakshmana et al., 2012) presented “Optimizing Surface Roughness in Turning Operation Using Taguchi Technique and ANOVA". The objective of this paper is to obtain an optimal setting of Turning parameters (Cutting speed, Feed and Depth of Cut) which results in an optimal value of Surface Roughness while machining Al 6351-T6 alloy with Uncoated Carbide Inserts. Several statistical modelling techniques have been used to generate models including Genetic Algorithm, Response Surface Methodology. In our study, an attempt has been made to generate a model to predict Surface Roughness using Regression Technique. Also, an attempt has been made to optimize the process parameters using Taguchi Technique. S/N ratio and ANOVA analysis were also performed.

## 2.7. Research Gap

In CNC turning of mild steel materials there is limited research conducted on dry turning AISI 4340 steel on surface quality. In addition, optimization of cutting parameters during CNC turning low alloy steel also needed more investigation. Due to high application areas of AISI 4340 steel, research has to conducted to solve problems like tool wear which is caused by wrong selection of cutting parameters. Machining productivity also needs to be improved by effective utilization of resources such as raw material, selection of right cutting parameters such as feed, depth of cut and speed. The main aim of this thesis proposal is to investigate effect of cutting parameters on tool life, productivity and surface finish.

# CHAPTER -3

# MATERIALS AND METHODS

## 3.1 Introduction

In this section materials used was discussed with testing equipment, methods and procedures were discussed in detail.

## 3.2. Material selection

For the experiment CNC lathe machine model CK6140/1000 was used, and the workpiece material of AISI4340 steel, cutting tool of type cemented carbide cutter and AISI4340 steel chemical, mechanical properties and hardness were discussed.

## 3.3. Experimental procedure

In the experimental procedure the step of experimental investigation and optimization of machining parameters during CNC turning of AISI 4340 Steel, shown the Figure 3.1.

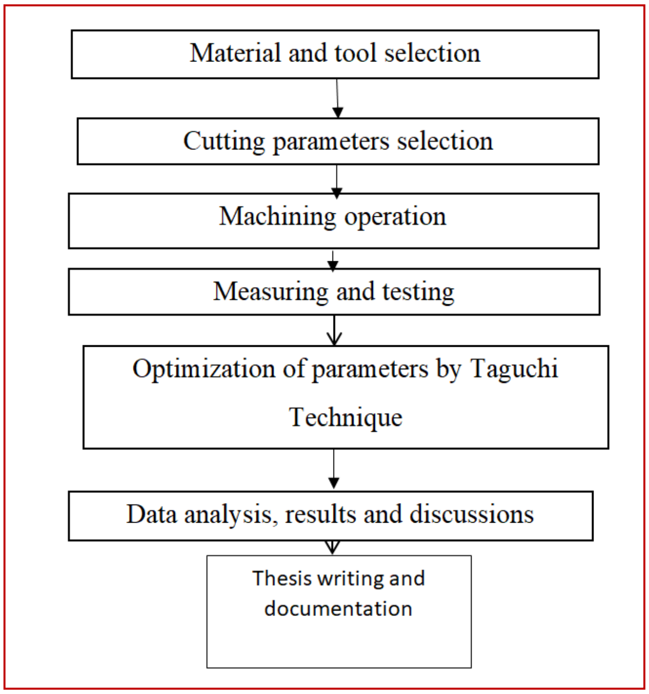


Figure 3.1 Experimental scheme

## 3.4. Equipment used

Model CK6140/1000 CNC lathe machine used for experimental study of cutting parameter on the machined workpiece AISI 4340 Steel. This machine used for turning operation. AISI 4340 steel was the selected workpiece material to the study. Profilometer used to measure surface roughness of the machined work piece. Generally, materials used for the research study is listed

- CNC lathe machine model CK6140/1000
- AISI 4340 round steel bar used as workpiece material
- Carbide cutter tool
- Profilometer to measure surface roughness of the machined workpiece.

## 3.5. Material selection and specification

In the material selection and specification part, specification of model CK6140/1000 CNC lathe machine, selection of workpiece material AISI 4340 steel, cutting tool and AISI 4340 steel chemical, mechanical properties and hardness of workpiece piece material are discussed.

### 3.5.1. CNC turning machine specification

The CNC lathe machine modelCK6140/1000 is a precision machining tool that is widely used in manufacturing industries for turning and milling operations. It is equipped with a computer numerical control (CNC) system that allows for precise and repeatable machining of complex parts and components. The CK6140/1000 CNC lathe has a maximum turning diameter of 400mm and a maximum turning length of 1000mm. It is capable of spindle speeds ranging from 50 to 2000 RPM, and has a spindle bore diameter of 52mm. The lathe is powered by a 7.5 kW motor that provides ample torque for heavy-duty cutting operations. The machine is equipped with a 6-position turret that allows for quick and easy tool changes, reducing downtime and increasing productivity. The turret is also capable of indexing to precise angles for complex machining operations. The lathe has a maximum X-axis travel of 220mm and a maximum Z-axis travel of 1 000mm, allowing for a wide range of machining operations. The CK6140/1000 CNC lathe is also equipped with a range of safety features, including an emergency stop button, a chuck guard, and a door interlock system. The machine is also designed for ease of use, with a user-friendly interface that allows for easy programming and operation.

Overall, the CK6140/1000 CNC lathe is a versatile and reliable machine that is ideal for a wide range of manufacturing applications, from small-scale prototyping to large-scale production runs. Its high precision and repeatability, combined with its user-friendly interface and range of safety features, make it an excellent choice for any machining operation. This data was obtained from the standard reference chart that used by Hibret machine building and manufacturing industry.

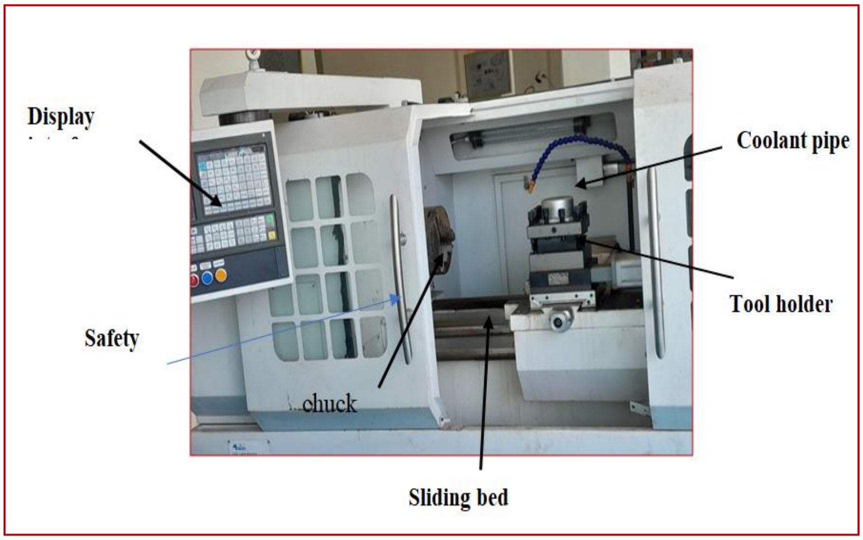


Figure 3.2. photo of CNC turning machine

### 3.5.2 Selection of workpiece material

AISI 4340 steel selected as workpiece material for the research. The selection criteria of this material are based on its tremendous application on manufacturing industries. AISI 4340 steel is mainly used in power transmission gear and shaft, aircraft landing gear and other structural pars. It has high strength, ductility, toughness, creep resistance and fatigue resistance relative to most other steel.

Figure 3.3. AISI 4340 workpiece material

**Table 3.1**. Experimental condition

| | |
|---|---|
| Machine | CNC Turning Machine |
| Workpiece material | AISI 4340 Steel |
| Hardness (HRC) | 280 |
| Environment | Dry turning |

### 3.5.3. AISI 4340 steel Grade equivalents

In this part grade equivalents and standards that are similar to AISI 4340 are discussed in table form.

**Table 3.2** AISI 4340 steel Grade equivalents

| Country | USA | Britain | Britain | Japan |
|---|---|---|---|---|
| Standard | ASTM A29 | EN10250 | BS970 | JIS G410 |
| Grade | 4340 | 36CrNiMo4/1.6511 | EN24/817M40 | SNCM439/SNCM |

### 3.5.6. Chemical composition of AISI 4340 steel

AISI 4340 steel is low alloy steel, the chemical composition of AISI 4340 steel listed in the Table 3.3. Addition of chromium, nickel, and molybdenum to the steel provides enhanced strength, toughness, and resistance to wear and fatigue. Manganese and silicon are added to improve the steers hardenability and machinability, while carbon provides hardness and strength. Phosphorus and sulfur are kept at low levels to avoid negative effects on the steel's properties. The chemical properties of AISI 4340 steel contribute to its excellent mechanical properties, including high tensile strength, yield strength, and impact strength. The steel is also known for its good wear resistance, low deformation under load, and high fatigue strength. However, the steel can be difficult to weld and requires special heat treatment processes to achieve optimal properties. In summary, AISI 4340 steel is a low-alloy steel with a specific chemical composition that provides it with unique mechanical properties. Its composition and properties make it suitable for use in a wide range of high-stress applications, including aircraft landing gear, crankshafts, and transmission gears.

**Table 3.3** Chemical composition of AISI 4340 steel (wt.%) (Anantha, Raman et-al 2019).

| Carbon | 0.372 |
|---|---|
| Silicon | 0,278 |
| Manganese | 0.570 |
| Phosphorous | 0.030 |
| Chromium | 1.106 |
| Sulphur | 0.026 |
| Molybdenum | 0.320 |
| Nickel | 1.467 |
| Aluminum | 0.023 |
| Copper | 0.14 |
| Niobium | 0.033 |
| Iron | 95.571 |

### 3.5.7. Mechanical properties of AISI 4340 steel

AISI 4340 is a low-alloy steel that is known for its toughness, strength, and high resistance to fatigue. It is commonly used in applications where high strength and durability are required, such as in the aerospace, automotive, and oil and gas industries. AISI 4340 steel has a high tensile strength of 745 MPa (108 ksi) in its normalized condition. When heat-treated, it can reach even higher tensile strengths, up to 200 ksi. The yield strength of AISI 4340 steel varies depending on its heat treatment condition. In its normalized condition, it has a yield strength of 470 MPa (68 ksi). When heat-treated, it can have a yield strength of up to 170 ksi. AISI 4340 steel has a relatively low elongation of 1 0-1 5% in its normalized condition. However, it can be improved to 25-30% when heat-treated. It has a hardness of 200-250 Brinell in its normalized condition. When heat-treated, it can have a hardness of up to 600 Brinell. It has a high fatigue strength, making it suitable for use in high-stress applications. Its fatigue strength can be improved through proper heat treatment. AISI 4340 steel has good impact strength, allowing it to withstand sudden shocks and impacts. In summary, AISI 4340 steel offers a combination of high tensile strength, yield strength, and toughness. Its mechanical properties can be further improved through proper heat treatment, making it suitable for a wide range of high-stress applications.

**Table 3.4**. Mechanical properties of AISI 4340 material listed in the table below; -

| | **Material properties** | **value** |
|---|---|---|
| 1 | Yield strength | 470 Mpa |
| 2 | Tensile strength | 745 Mpa |
| 3 | Modules elasticity | 205 Gpa |
| 4 | Poisson`s ratio | 0.258 |
| 5 | Mass density | 7850 kg/ m3 |

### 3.5.8. Specification of workpiece material

The total length to be machine AISI 4340 round bar with a diameter of 500mm and 20mm was turned on model CK6140/1000 CNC lathe machine with 50-2000.rpm of spindle speed. It has high strength, ductility, toughness, creep resistance and fatigue resistance relative to most other steel.

### 3.5.9. Selection of cutting tool

To be selected as a cutting tool material, it must be harder than workpiece material in order to remove metal from the workpiece. The tool must resist heat that generate during the removal of metal to metal contact to remove metal from workpiece.

### 3.5.9.1. Cemented Carbide tool cutter

Cemented carbide tool is a type of hard material that is used as an extension for cutting tools and in other industrial applications. It is made up of tiny carbide particles that are glued together in a composite by a binder metal. The cutting tool is extremely hard, strong, rugged, wear resistant, thermally stable, and chemically inert.

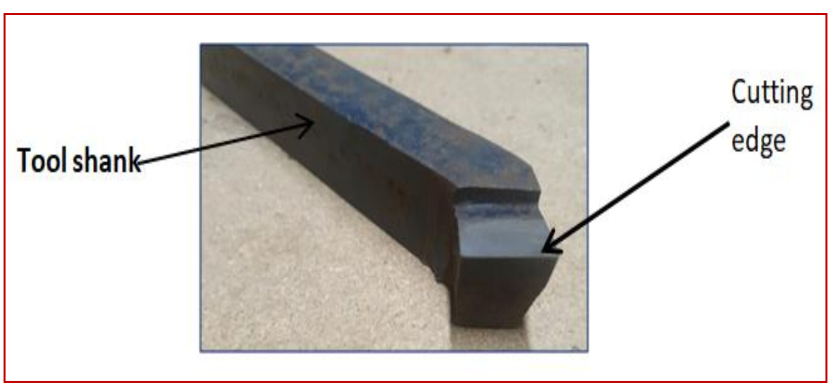


Figure 3.4. Cemented carbide cutting tool

## 3.6. Dry turning

The use of cutting fluids during the cutting process is eliminated with dry machining. Most difficulties linked with the use of cutting fluids can thus be avoided. Implementing dry machining can also save producers money by eliminating the need for coolants. Furthermore, reducing exposure to hazardous cutting fluids offers a safe working environment, increasing worker job satisfaction and productivity. Dry machining is also environmentally friendly and in accordance with applicable labor and environmental legislation. With these advantages and favorable effect s, businesses may develop a positive rapport with society and leave a positive corporate impression on people.

## 3.7. Surface roughness measurement

The vertical variations of a real surface from its ideal form are used to quantify it. The surface is rough if these variations are considerable; smooth if they are minimal. Surface roughness was measured using Model type 485321 17 in this paper. The surface test is a portable and magnetic surface roughness measurement tool that traces the surface of various machined components by attaching to the surface of the work piece, calculates surface roughness based on roughness standards, and displays the results in micrometer.

### 3.7.1 Profilometer

The Model type 485321 17 is used in this study. It has an evaluation length/ measuring distance of 1 .25 mm, a measurement range of Ra 0.05 -15.0µm, Rz 0.1 -50.01µm, and measuring precision of up to 0. 01 µm.

The roughness on average Ra was employed in this investigation. Ra is determined by employing a surface roughness testing apparatus with a probe on one end. During the measurement, 1 mm was set as the cut length. Whatever the production procedure, a flat and smooth surface cannot be obtained. The surface imperfections left behind from production are retained by the machine elements or parts. A part's surface is its exterior or boundary, and its surface imperfections are made up of many small valleys and wedges that dep art from a hypothetical nominal surface. These irregularities are more responsible for the look and appropriateness of a surface (Kumaran and Stephen, 2015). Roughness testers measure surface rough ness, which is represented as Ra.


Figure 3.5 Surface roughness tester profilometer contact type

## 3.8. Machining parameters selection

The study concentrated on the optimization of three cutting parameters that influence the surface roughness of the machined work piece material. These parameters are as follows: cut depth, cutting speed, and feed rate.

### 3.8.1. Cutting Speed

In the case of carbide tools, the minimum cutting speed should be maintained to avoid cutting tool failure due to build up edge development.

For easy chip removal, certain combination s of speed, feed, and depth of cut are commonly chosen, which are directly proportional to the kind of tool and work piece material.

$$v = \pi * Dm * n / 1000 (m/min \tag{3.1}$$

Where Dm (mm): Workpiece diameter n (minp1): Rpm of the cutter / Main Axis Spindle Speed v (m/min): Cutting Speed, π (3.14)

**Table 3.5.** cutting speed parameters and their levels

| **Factors** | **Symbol** | **Level 1** | **Level 2** | **Level 3** |
|---|---|---|---|---|
| Cutting speed (m/min) | V | 120 | 175 | 230 |

### 3.8.2. Feed

Feed rate has a bigger impact on machining time and surface roughness than depth of cut and cutting speed.

It is always possible to get significantly higher metal removal rates without sacrificing tool life by raising the feed and decreasing the cutting speed.

Low feed and high cutting speed are preferred for achieving a good surface finish. However, machining time significantly increases.

n: Insert number for cutting length per minute

$$f = l/n \text{ (mm/rev)} \quad (3.2)$$

where f (mm/rev): Feed per tooth

l (mm/min): Cutting Length per min

n: Insert number

**Table 3.6.** Feed rate parameters and their levels

| Factors | Symbol | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| Feed rate (mm/Rev.) | F | 0.1 | 0.2 | 0.3 |

### 3.8.3. Depth of cut

To achieve the maximum allowed level of depth of cut, the depth of cut should be chosen in a way that balances machining time and surface roughness.

$$d = (d1-d2) / 2 \quad (3.3)$$

d1 = diameter of the work surface before machining

d2 = diameter of the work surface after machining

**Table 3.7**. Depth of cut parameters and their levels

| Factors | Symbol | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| Depth of cut (mm) | D | 0.5 | 0.75 | 1 |

## 3.9. Taguchi orthogonal array

There are options for creating Taguchi arrays for the design of experiment, depending on how many times that chooses to test each level of each parameter. For instance, this study has 3 parameters and 3 levels of each parameters (P=3 and L=3), there for 9 run arrays is more desirable because for each level of any one parameter, all three level of the other parameters are tested. Orthogonal arrays are the best and most common type of Taguchi orthogonal array. By calculating degree of freedom (DOF) using the formula below in eq 3.4. The orthogonal array L9 is selected. This selection getting from the calculated value of degree of freedom. From calculation result degree of freedom (DOF) is 6. The total number of orthogonal arrays need to be greater than or equal to the calculated value that is why L9 orthogonal array is selected.

$$DOF=P^{*}\,(L-1) \tag{3.4}$$

Where, DOF= degree of freedom,

P = number of factors and,

L = number of levels

$$DOF= 3(3 – 1) = 6 \approx L9$$

**Table 3.8.** The experimental design of the cutting parameters

| No | Cutting speed m/min | Feed rate mm/min | Depth of cut mm | Surface roughness | | | Average Ra (µm) |
|---|---|---|---|---|---|---|---|
| | | | | Run 1 | Run 2 | Run 3 | |
| 1 | 120 | 0.1 | 0.5 | 2.89 | 3.22 | 3.75 | 3.29 |
| 2 | 120 | 0.2 | 0.75 | 2.88 | 3.06 | 3.51 | 3.15 |
| 3 | 120 | 0.3 | 1 | 4.15 | 3.07 | 3.77 | 3.66 |
| 4 | 175 | 0.1 | 0.75 | 3.67 | 3.73 | 4.05 | 3.81 |
| 5 | 175 | 0.2 | 1 | 3.47 | 4.11 | 4.62 | 4.07 |
| 6 | 175 | 0.3 | 0.5 | 4.28 | 3.26 | 3.00 | 3.51 |
| 7 | 230 | 0.1 | 1 | 3.23 | 3.46 | 3.49 | 3.39 |
| 8 | 230 | 0.2 | 0.5 | 3.10 | 2.54 | 2.94 | 2.86 |
| 9 | 230 | 0.3 | 0.75 | 2.57 | 2.23 | 3.04 | 2.61 |

## 3.10. Machining parameters and their levels

Machining parameters and the levels were selected based on the deep reviewing of different literatures and Hibret machine building manufacturing industry, manufacturers recommendation of their standard used for turning operation. This experimental investigation was evaluated the effect of the cutting parameters on surface roughness and material removal rate at three levels of study during CNC dry turning of AISI4340/EN 24 steels. This thesis uses the recommended cutting conditions for turning is appropriate and to select the possible cutting parameters from the Table3.9.

**Table 3.9.** Recommended Cutting Condition and Grades for turning (Mistu, 1994)

| Work Material | | | Recommended Cutting Condition and Grades | | | |
|---|---|---|---|---|---|---|
| | | | **Depth of cut (mm)** | **Feed rate (mm/min)** | **Coolant** | **Recommended Spindle Speed and Grades** |
| Mild Steel | ≤ 160 HB | *Light cutting* | ≤1.0 | ≤0.3 | Dry | 290 (235 - 335) |
| | | *Medium cutting* | 1 - 6 | 0.4 (0.2 – 0.6) | Dry | 350 (260 - 440) |
| Carbon Steel | 160 280 HB | *Light cutting* | ≤1.0 | ≤0.3 | Dry | 280 (210 - 355) |
| | | *Medium cutting* | 1 – 5 | 0.3 (0.1 – 0.5) | Dry | 330 (220 - 440) |
| Alloy Steel | 280 | *Light cutting* | ≤1.0 | ≤0.3 | Dry | 180 (120 - 230) |
| | 350 HB | *Medium cutting* | 1 – 4 | 0.3 (0.2 – 0.4) | Water Soluble Oil | 170 (120 - 210) |

**Table 3.10.** Indicates process parameters and their levels

| **Factors** | Symbol | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| Cutting speed (A) | V | 120 | 175 | 230 |
| Feed rate (B) | F | 0.1 | 0.2 | 0.3 |
| Depth of cut (C) | D | 0.5 | 0.75 | 1 |

Where Cutting speed (A) in m/min, feed rate (B) in mm/rev, Depth of cut(C) in mm Cutting parameters for AISI4340/EN 24 steels were selected depending on the recommended cutting parameters, which are given in Table 3-10, and the range was taken to get the accurate results since the maximum difference was at maximum range.

## 3.11. Experimental set up

An AISI 4340 round bar with a diameter of 20 mm and 500mm was turned on model CK6140/1000 CNC lathe machine with 50-2000.rpm of spindle speed. The surface roughness of the turned workpiece material measured by roughness tester machine called profilometer at cutting speed of 120,175,230m/mm with feed rate of 0.1,0.2,0.3 and depth of cut at 0.5,0.75,1 mm.

## 3.12. Experimentation

Turning is a common method of material removal. In comparison to conventional lathe machines, the use of CNC turning machines has a proven track record of greater surface quality, precise accuracy, shorter machining times, and higher production rates. However, the main issue that workers and researchers confront while executing turning g operations on such machines that demand a high initial investment is determining the appropriate parameter selection to get the intended outputs more efficiently. In this research, a set of basic parameters was chosen after doing pilot experiments with one factor at a time and then employing that set of studies.

## 3.13. Research methodology

Research methods can be defined as any method or technique utilized in the conduct of research. Thus, research methods or techniques relate to the procedures employed by researchers in carrying out research operations. In other words, research methods are any methods employed by the researcher while conducting research on a certain subject. The Taguchi approach is used in this study to optimize the cutting settings. To optimize machining settings, the Taguchi process is a powerful and cost-effective optimization technique.

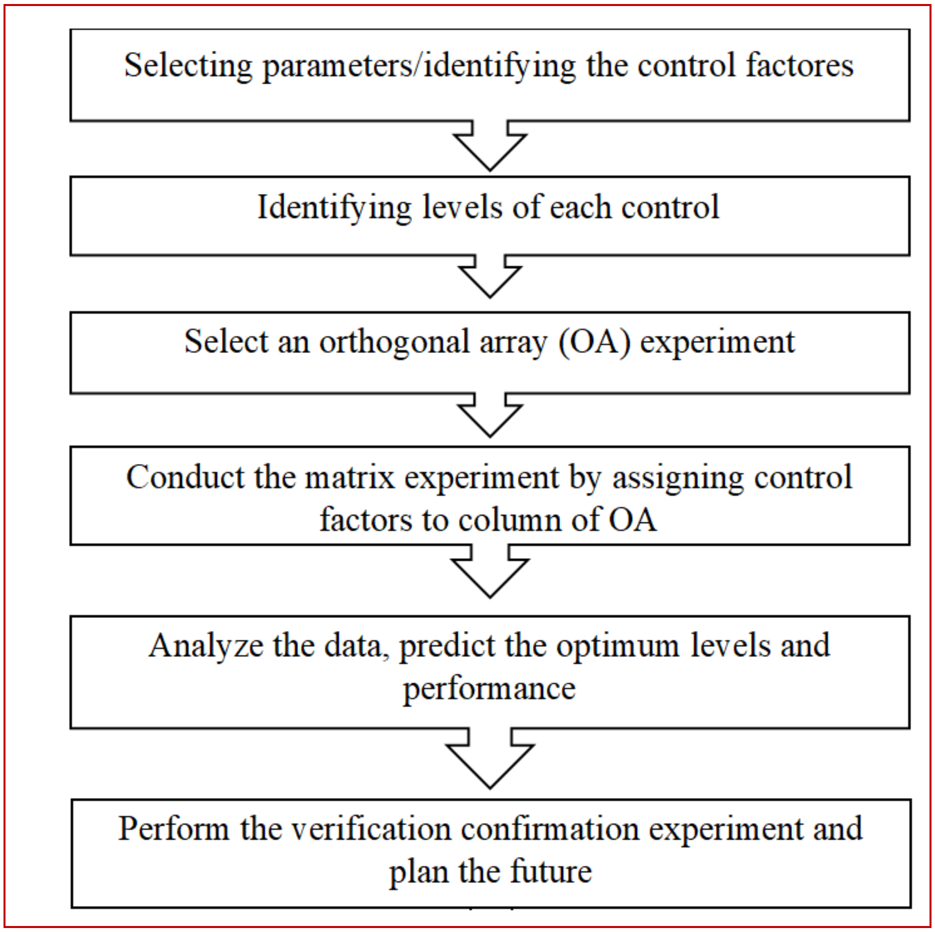

Figure 3.6. Taguchi methodology

### 3.13.1. ANOVA analysis for optimization of parameters by Taguchi method

The Taguchi approach is a type of design of experiments (DOE) with particular application principles for most industrial experiments. The difference between the DOE and the Taguchi approach is in the manner of app location. The Taguchi technique is an important tool for robust design in attaining the least sensitive process and product parameters to generate high quality goods at cheap manufacturing costs (Roy R.K. 1990 and 2001).It entails various steps such as planning, conducting, and evaluating the results of specially designed tables known as "orthogonal array" experiments to study the entire para meter space with the least number of trials in order to determine the optimum levels of control parameters (Noordin, M. Y., Venkat esh, V. C., Sharif, S., Elting, S., and Abdullah, A. 2004). A quality loss function is then created to analyze the difference between the experimental and desired values. The Taguchi technique integrates experiment design theory and the quality loss function. A quality loss function is then created to analyze the difference between the experimental and desired values. The Taguchi technique integrates experiment design theory and the quality loss function. The Taguchi method recommends the use of a loss function, which is then transformed into a S/N ratio to measure the performance characteristic deviating from the desired value, and then S/N ratio for each level of process parameters are evaluated based on average S/ N ratio response analysis, and greater S/ N ratio is corresponding to better quality characteristic irrespective of category. For the DOE, the following step-by step approach is used to identify the best combinations. Because this method proposes using the S/N ratio to measure quality parameters that deviate from the desired values. Depending on the sort of characteristics, there are different S/N ratios available: smaller is better, nominal is best, and greater is better.

$$\text{Smaller the better } N = -10 \text{ Log10} \tag{3.5}$$

mean of sum of squares of measured data

This is usually the chosen S/N ratio for all undesirable characteristics like "defects" etc. for which the ideal value is zero. Also, when an ideal value is finite and is maximum or minimum value is defined, then the difference between measured data and ideal value is expected to be as small as possible the generic form of S/N ratio then becomes, N = - 10 Log 10 [mean of sum of squares of {measured – ideal}]

### 3.13.2. Analysis of Variance (ANOVA)

ANOVA is used to evaluate the significance of a process element that is thought to be affecting product quality. The percentage contribution of variance of factors can be estimated by calculating the degree of freedom, f sum of squares, ss variance, v, and the percentage contribution for each factor. Using the Taguchi design approach, process parameters were optimized during CNC turning of AIS14340/En24 steel to improve surface finish, reduce tool wear, and increase productivity. ANOVA is an abbreviation for Analysis of Variance, which is a statistical approach used to assess whether or not there are significant differences in the means of two or more groups. ANOVA divides the total variance in the data into different sources of variation, such a s variation between groups and variation within groups. The ratio of between group variation to within group variation is used to compute an F statistic, which is then compared to a critic all value to assess whether the differences between the groups are statistically significant.

ANOVA is classified into two types: one-way ANOVA, which is used when there is only one independent variable, and two-way ANOVA, which is used when there are two independent variables. ANOVA can also be used in repeated measurements designs, which include measuring the same individuals many times under different settings. ANOVA is a strong data analysis tool that can provide important insights into the effects of various treatments or interventions. However, it is critical to carefully analyze the ANOVA assumptions, such as normality and variance homogeneity, and to interpret the results with caution, considering any potential confounding variables or alternative explanations for the observed effects.

## 3.14. Confirmation test

A confirmation test is a type of experiment or measurement designed to verify and validate the results of a previous test or study. Confirmation tests are often used in scientific research to confirm or refute the findings of a previous study or to address any concerns or limitations that may have been identified in the original study. In order to perform a confirmation test, researchers may use a variety of methods, such as repeating the original study with a larger sample size or using a different experimental design or methodology. The goal of a confirmation test is to provide additional evidence to support or refute the original findings, and to increase confidence in the validity and reliability of the results. Confirmation tests are an important part of the scientific process, as they help to ensure that research findings are accurate, reliable, and reproducible.

By replicating and verifying the results of previous confirmation test is a type of experiment or measurement designed to verify and validate the results of a previous test or study. Confirmation tests are often used in scientific research to confirm or refute the findings of a previous study or to address any concerns or limitations that may have been identified in the original study. In order to perform a confirmation test, researchers may use a variety of methods, such as repeating the original study with a larger sample size or using a different experimental design or methodology. The goal of a confirmation test is to provide additional evidence to support or refute the original findings, and to increase confidence in the validity and reliability of the results.

Confirmation tests are an important part of the scientific process, as they help to ensure that research findings are accurate, reliable, and reproducible. By replicating and verifying the results of previous studies, researchers can build a stronger foundation of knowledge and understanding in their field, and make more informed decisions based on the available evidence. Studies, researchers can build a stronger foundation of knowledge and understanding in their field, and make more informed decisions based on the available evidence. The confirmation test is used to verify the estimated result with the experiment results. If the optimal combination of parameters and their levels coincidently match with one of the experiments in the orthogonal array (OA), then the confirmatory much with one of the experiments in the OA, then the confirmatory test is not required.

## 3.15. MRR and productivity

Productivity in metal cutting is mostly controlled by the effectiveness of machining and tooling procedures in removing extra material in the smallest amount of time. An increased number of metals can be rem oved at a low energy cost by raising the fee d rate and properly selecting the cutting speed and depth of cut. The amount of tool wear in high contact areas during machining, on the other hand, is a concern. As a result, if the cost of tooling is insignificant to the manufacturer, the metal remove process can be completed with higher level parameters to obtain greater productivity (Iqbal et al., 201 5). The volume of material removed (VMR) an d material removal rate (MRR) should be included while calculating productivity.

$$VMR = MRR \times T = (v.\, f.\, a) \times T \tag{3.6}$$

$VMR$ = Volume of material removal (cm3)

$MRR$ = material removal rate (cm3 / min)

$V$, $f$, $a$ = Cutting speed (m/min), feed rate (mm/rev), depth of cut (mm)

$T$ = Tool life (min).

# CHAPTER-4

# RESULTS AND DISCUSSION

## 4.1. Introduction

Following the completion of the machining operation, the response parameter, surface roughness, was measured. The best outcome produced for achieving main effects was statistically analyzed. The purpose of the experiment was to determine the effect of cutting parameters such as cutting speed, feed rate, and depth of cut on the surface quality of AIS14340 steel during the turning process. This step evaluates the impact of various process parameters on the target surface roughness and material removal rate. This chapter discussed the outcomes of each experiment. Table 4-1 displays the design arrangement for the turning experiment as well as the response data obtained. To reduce errors, the experiment was carried out in a controlled environment. The experiment design was utilized to determine the best cutting parameters and the most influential parameters. All nine experiments were carried out using varying cutting parameters, but with a constant length of cut of 40mm and a diameter of the workpiece prepared for experimental investigation of 20mm. This experimental study on the double tool turning process of AISI 1 045 steel during dry and with cutting fluid machining operations was carried out at various spindle speeds (120m/min, 175m/min, 230m/ min), feed rates (0.1 mm/rev, 0.2mm/ rev, 0.3mm/ rev), and depth of cut (0.5mm, 0.75mm, 1mm,) using a cemented carbide cutting tool, optimize the cutting settings for dry turning. For surface roughness, a turning operation was performed on a model CK6140/1000 C NC lathe machine.

## 4.2. Surface roughness measurement

Ra data was measured at three (3) separate points on the machined surface, each 120 degree apart, using a surface roughness tester called a profilometer (Figure 3.5), and the average results were recorded. Table 4-1 shows the measured Ra. The maximum and minimum surface rough ness values for all three runs were found to be 4.62 µm and 2.23 µm, respectively.

**Table 4-1** Measured surface roughness at $L_9$ full factorial machining parameters

| No | Cutting speed m/min | Feed rate mm/min | Depth of cut mm | Surface roughness | | | Average Ra (μm) |
|---|---|---|---|---|---|---|---|
| | | | | Run 1 | Run 2 | Run 3 | |
| 1 | 120 | 0.1 | 0.5 | 2.89 | 3.22 | 3.75 | 3.29 |
| 2 | 120 | 0.2 | 0.75 | 2.88 | 3.06 | 3.51 | 3.15 |
| 3 | 120 | 0.3 | 1 | 4.15 | 3.07 | 3.77 | 3.66 |
| 4 | 175 | 0.1 | 0.75 | 3.67 | 3.73 | 4.05 | 3.81 |
| 5 | 175 | 0.2 | 1 | 3.47 | 4.11 | 4.62 | 4.07 |
| 6 | 175 | 0.3 | 0.5 | 4.28 | 3.26 | 3.00 | 3.51 |
| 7 | 230 | 0.1 | 1 | 3.23 | 3.46 | 3.49 | 3.39 |
| 8 | 230 | 0.2 | 0.5 | 3.10 | 2.54 | 2.94 | 2.86 |
| 9 | 230 | 0.3 | 0.75 | 2.57 | 2.23 | 3.04 | 2.61 |

## 4.3. Interaction effect

Figure 4.1 depicts the influence of cutting speed on surface roughness at different feed rates. As the cutting speed increased from 120m/min to 175m/ min, the surface roughness increased for b 0th constant feed rates of 0.1 mm/ rev and 0.2 mm/rev. However, at 0.3 mm/ rev feed, the surface roughness dropped when the cutting speed rose from 120 m/ min to 175 m/ min, and when the cutting speed is further increased to 175 m/ min, the surface roughness value decrease s at 0.3.

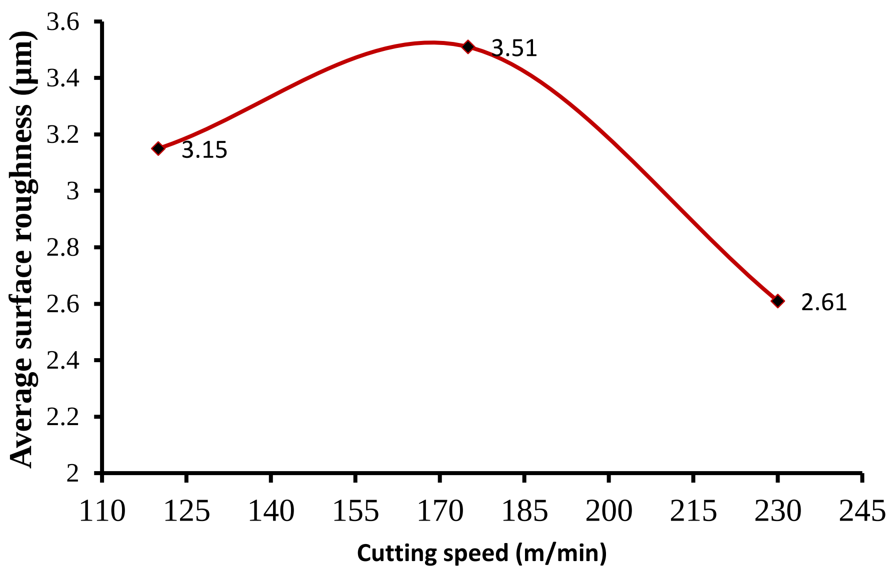


Figure.4.1 the effect of cutting speed on Surface roughness

From the above figure the optimum cutting speed was 230 m/min at which minimum surface roughness 2.61µm was achieved.  This was the parameter for sample 9.

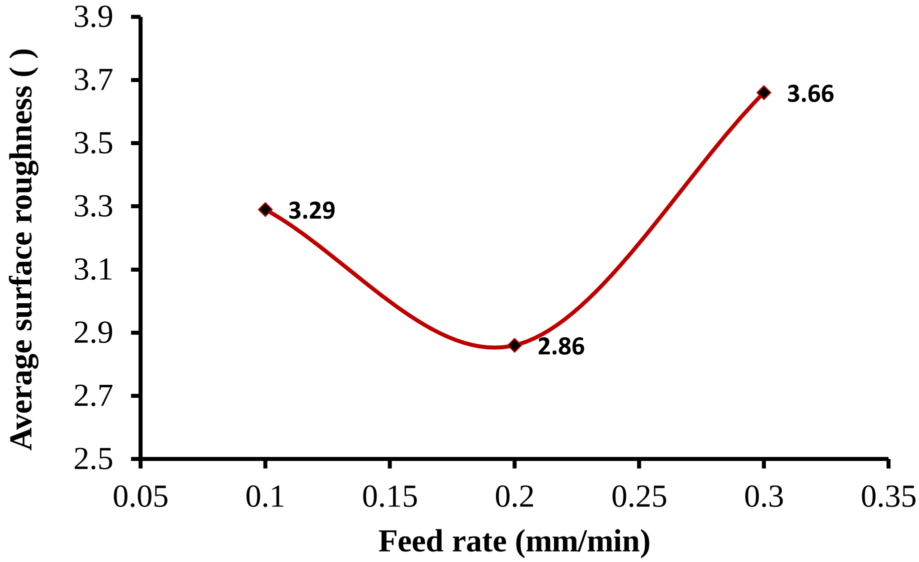


Figure 4.2 shows the effect of feed rate on average surface roughness

From Figure 4.2 shows the effect of feed rate on average surface roughness at optimum cutting speed 230 m/min. Fig.4.2 showed the optimum feed rate was at 0.2 mm/min since surface roughness of 2.86 µm. When feed rate increased beyond feed rate 0.2 mm/min the surface roughness also increased.

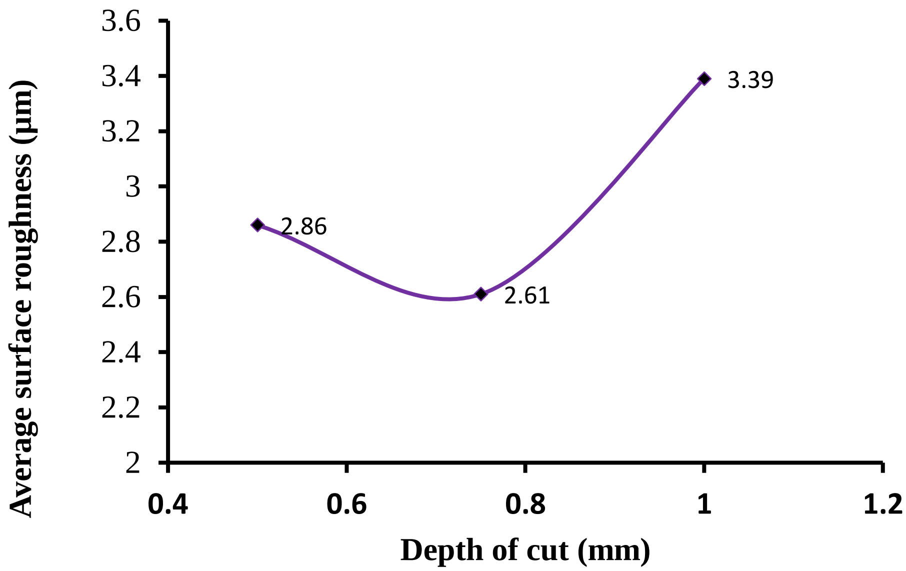


Figure 4.3 the effect of depth of cut on average surface roughness

The optimum cutting depth for this material was 0.75 mm where surface roughness was measured as 2.61 μm. It was not recommended to increase depth of cut beyond 0.75 mm since the graph shows increased surface roughness.

## 4.4. Optimization of cutting parameters in dry turning

The primary goal of the research was to conduct an experimental evaluation and optimization of cutting parameters during CNC turning of AIS14340 steel using the Taguchi L9 orthogonal array. Taguchi design approach was used to optimize process parameters of dry turning of AIS14340 steel material.

Total degree of freedom, f

$$f_T = N - 1 \tag{4.1}$$

Where N is the total number of results

For Factor A, f $\quad f_A = k_A - 1$ (4.2)

Where $k_A$ is the number of levels of factor A

For error, $f_e = f_T - (fa + fb + fc + fd + fe)$ (4.3)

a) Sum of squares, S

Total sum of squares,

$$S_T = (Z_{a1}^2 + Z_{a2}^2 + Z_{a3}^2 + \dots Z_{aN}^2) - \frac{(Z_{a1} + Z_{a1} \dots Z_{a1} + Z_{aN})^2}{N} \tag{4.4}$$

For factor A,

$\mathbf{S_A}$ **is**

$$S_A = \frac{(\Sigma A_1)^2}{K_A} + \frac{(\Sigma A_2)^2}{K_A} \dots \frac{(\Sigma A_N)^2}{K_A} - \frac{(Z_{a1} + Z_{a1} \dots Z_{a1} + Z_{aN})^2}{N} \tag{4.5}$$

For factor A, $\quad V_A = \frac{S_A}{f_A}$ (4.6)

For Error $\quad V_e = \frac{S_A}{f_e}$ (4.7)

## 4.5. Noise ratio

Noise ratio also called sign to noise ratio. This approach recommends the usage of s/ n ratio to degree the pleasant traits deviating from the favored values. There are several S/N ratios to be had depending at the kind of characteristics: smaller is higher, nominal is best and large is better.

(I) Smaller the better

N = -10 Log [mean of sum of squares of measured data] (4.8)

This is commonly the chosen S/N ratio for all undesirable characteristics like "defects" and many others. for which the best price is zero. also, while a super fee is finite and is maximum or minimal price is defined, then the difference among measured facts and best cost is predicted to be as small as possible the typical form of S/N ratio then turns into,

$$N = - 10 \text{ Log } 10[(\frac{1}{n}\sum_{n=1}^{1} yi^2 ) \tag{4.9}$$

(II) Larger -the -better

N = - Log 10 [mean of sum squares of reciprocal of measured data]

This case has been converted to smaller –the-better by taking the reciprocal of measured data and then taking the S/N ratio as in the smaller the better case.

(III) Nominal –the –best

$$S/_N = 10\log(\sum_{n=1}^{1} yi^2) \tag{4.10}$$

This case arises when a specified value is most desired, meaning that neither a smaller nor a larger value is desirable.

The logarithmic scale is used to express the SNR in decibels (dB), which provides a convenient way to compare the relative strengths of different signals and noise levels. A higher SNR in dB indicates a stronger signal relative to the noise, while a lower SNR in dB indicates a weaker signal that may be difficult to distinguish from the noise. In the context of ANOVA (Analysis of Variance), the noise ratio refers to the ratio of the variance of the error term to the variance of the treatment effect. The error term represents the variability in the response variable that is not explained by the treatment effect, and is assumed to be due to random variation or measurement error. The noise ratio is also known as the error mean square (EMS) to treatment mean square (TMS) ratio or the F-ratio. It is calculated by dividing the EMS by the TMS, and is used to test the null hypothesis that there is no significant difference between the means of the treatment groups. A high noise ratio indicates that the variability within the treatment groups is similar to or greater than the variability between the treatment groups, making it more difficult to detect a significant treatment effect. This can occur when there is a large amount of random variation or measurement error in the data. In contrast, a low noise ratio indicates that the variability between the treatment groups is much larger than the variability within the treatment groups, making it easier to detect a significant treatment effect.

In general, researchers aim to design experiments with a low noise ratio to maximize the power of the statistical test and increase the likelihood of detecting a significant treatment effect. One way to achieve this is to reduce the amount of random variation or measurement error in the data through careful experimental design and data collection techniques. The noise ratio, also known as the signal to-noise ratio (SNR), is a measure of the strength of a signal relative to the level of background noise present. It is commonly expressed in decibels (dB), which is a logarithmic scale. A higher SNR indicates a stronger signal relative to the noise, while a lower SNR indicates a weaker signal that may be difficult to distinguish from the noise. SNR is an important consideration in many fields, including telecommunications, audio engineering, and image processing. In general, a higher SNR is desirable as it allows for clearer communication, more accurate measurements, and better-quality output.

## 4.6. Experimental values of surface roughness

Experimental values suggest, the measuring values of floor roughness taken from AISI 4340 steel by way of the measuring device called profilometer. The measuring values taken at 3 specific location 120 degree from every different. The gadget information Rt, Rz, Rq and Ra values. For the study Ra cost is extra most desirable and show accurate end result approximately floor roughness than the values of the relaxation, due to this common price of floor roughness Ra is selected. The measured experimental result of imply values of surface roughness for each trial of experiment indexed in the table 4.2. For surface roughness evaluation the smaller the better overall performance characteristics had been decided on.

Average surface roughness and sign to noise ratio (S/N) is defined as:

$$\text{Ra}= \frac{R1+R2+R3}{3} \tag{4.11}$$

Where Ra is average surface roughness R1, R2 and R3 are the first, second and third trial test of surface roughness value.

$$\text{S/N} =-10\log\left(\frac{1}{n}\sum_{n=1}^{1} yi^{2}\right) \tag{4.12}$$

Where ή is the S/N ratio, n is the number of trial test in each experiment, Ri is the observed data and i is the number of trial test. Using equation (4.1 and 4.2) to calculate average surface roughness and S/N ratio for surface roughness. ANOVA 95% confidence level was chosen to determine the effect of cutting parameters on the surface roughness of turned material of AISI 4340 steel.

## 4.7. Response Table for Mean

A response table is generated for each response characteristics , such as mean and signal- noise ratio. The response table indicates which factors have the most influence on the response and which degree of the factor is associated with greater or lower response characteristic values. Procedures for generating a response Table 4.3

1. Calculates the chosen response function at each degree f or cutting velocity, feed, first intensity of cut, and second intensity of cut.
2. Following this, delta values are calculated, which are the variations between the very best and lowest average reaction feature values for that issue's stages.
3. The usage of the delta values, ranks are assigned from high to low. The aspect with the best delta cost is ranked first**.**

**Table 4.2**. Experimental result during dry turning of AISI 4340 steel

| | Cutting parameters | | | | |
|---|---|---|---|---|---|
| **No** | **Cutting speed** | **Feed rate** | **Depth of cut** | **Surface roughness Average** | **S/R** |
| 1 | 120 | 0.1 | 0.5 | 3.29 | -10.333351182 |
| 2 | 120 | 0.2 | 0.75 | 3.15 | -9.966211076 |
| 3 | 120 | 0.3 | 1 | 3.66 | -11.276738373 |
| 4 | 175 | 0.1 | 0.75 | 3.82 | -11.634443199 |
| 5 | 175 | 0.2 | 1 | 4.07 | -12.185483448 |
| 6 | 175 | 0.3 | 0.5 | 3.51 | -10.913562996 |
| 7 | 230 | 0.1 | 1 | 3.39 | -10.611677193 |
| 8 | 230 | 0.2 | 0.5 | 2.86 | -9.127320663 |
| 9 | 230 | 0.3 | 0.75 | 2.61 | -8.342788195 |

## 4.8. Analysis of parameters using Taguchi method

Data collected from Taguchi orthogonal array (OA) experiments can be analyzed using response graph method of analysis of variance (ANOVA). The response graph method is very easy to understand and apply. This method requires no statistical knowledge. for practical/ industrial application, this method may be sufficient. Analysis of variance (ANOVA) has already accounts the variation from average source including error sum. If error sum of square is large compared to the control factors in the experiments. ANOVA together with percent of contribution indicate that the selection of optimum condition may not be useful. Also, for statistically validating the results, ANOVA is required. In this study how, various types of data are analyzed is discussed.

### 4.8.1. Variable data with main factor only

The design of OA experiments was covered in the final section of Chapter 3. By carrying out the experiment and obtaining the response (output) from each experiment. Data is the response gained from all trials of an experiment. The data can be attribute or variable in nature. The response is measured with a suitable measurement equipment to obtain variable data. Assume that in an OA experiment, only the key components are present and the response is variable. The following image discusses the analysis of data from these types of experiments. An experiment was carried out to investigate the effect of three primary parameters (cutting speed, depth of cut, and feed rate), e ach at three levels, on L9 of OA. The table below shows the outcome response from one replication. The following section discusses the data analysis from this experiment.

### 4.8.2. Data analysis using response graph method

The following steps discus data analysis using response graph method.

Step 1. Development response total table for of factor effects [Table 4.3]

### 4.8.3 Calculation of S/N values using the following formula

$$S/_{N} = -10\log\left(\frac{1}{n}\sum_{n=1}^{1} yi^{2}\right) \quad (4.13)$$

Where y represents the observed data and n number of tests in one trial. The mean responses of S/N ratio for average surface roughhouse of AISI 4340 steel are calculated for all factors and are tabulated.

**Table 4.3.** Data for illustration of SN

| **Trial No** | **Cutting speed (A)** | **Feed rate (B)** | **Depth of cut (C)** | **Average surface roughness** | **Result of SN** |
|---|---|---|---|---|---|
| 1 | 120 | 0.1 | 0.5 | 3.29 | -10.333 |
| 2 | 120 | 0.2 | 0.75 | 3.15 | -9.966 |
| 3 | 120 | 0.3 | 1 | 3.66 | -11.276 |
| 4 | 175 | 0.1 | 0.75 | 3.82 | -11.634 |
| 5 | 175 | 0.2 | 1 | 4.07 | -12.185 |
| 6 | 175 | 0.3 | 0.5 | 3.51 | -10.9135 |
| 7 | 230 | 0.1 | 1 | 3.39 | -10.611 |
| 8 | 230 | 0.2 | 0.5 | 2.86 | -9.127 |
| 9 | 230 | 0.3 | 0.75 | 2.61 | -8.3427 |

From the table 4.3, the possible optimum condition of the experiment is selected. to select the optimum condition, make sure that the maximum values of SN/ noise to signal ratio value be selected from result properly. Based on this the optimum condition of experiment shown at trial 9 which is (A3, B3 C2).

**Table 4.4**. response totals for data illustration of SN

| **Factors** | **Cutting speed** | **Feed rate** | **Depth of cut** |
|---|---|---|---|
| Level 1 | -31.5763 | -32.5795 | -30.3742 |
| Level 2 | -34.7335 | -31.2790 | -29.9434 |
| Level 3 | -28.0818 | -30.5331 | -34.0786 |

**Table 4.4** is developed by adding the response values that corresponding to each level (level1 up to level3) for each factor. For instance, level1 totals of factors A is sum of the observation from trials (run). A sample calculation for one of factor (A) is shown below; -

A1= -10.333351182 +(-9.966211076) +(-11.276738373) (4.14)

A1 =-31.5765

Similarly, for level 2 and level 3 and for A2, A3, B1, B2, B3 and C1, C2, C3 Thus, there are 9 observations in each level. In a similar manner calculated mean for factor B, C, in each level.

### 4.8.4. Average S/N ratios for each factor

To develop Mean S/N Ratio Response Table for average surface roughness

$$Level1 = \frac{-10.333351182 + (-9.966211076) + (-11.276738373)}{3} = -10.5254\text{dB} \quad (4.15)$$

Do the above average SN formula similarly to other levels

S/N (V1) = -10.5254

SN (V2) = -11.5778

SN (V3) = -9.3606

SN (F1) = -10.8598

SN (F2) = -10.4263

SN (F3) = -10.1777

SN (D1) = -10.1247

SN (D2) = -9.9811

SN (D3) = -11.3784

The effect of this factor is calculated by determining the range

Δ = SN (Vmax)-SN (V m/min) ( 4.16)

-9.3606- (-11.5778) =2.2172

Δ=SN(F max)-SN (F mm/rev) (4.17)

-10.1777- (- 10.8598) = 0.6821

Δ=SN (D max)-SN (V m/min) =1.3784 (4.18)

After calculating the average S/N ratios for each factor, the delta value is calculated. Delta value calculated by subtracting minimum value from maximum. From Table 4.3 cutting speed (A) has the highest value so it is ranked first, depth of cut (C) has the second highest value and ranked second, Feed rate (B) is ranked third. At these cutting parameters level (A3, B3 C2) selected for dry machining environment. that means will be taken as a possible parameter combination for smaller is better values. Main effect plots for means helps adjust the mean on better value.

Step2: -Construction average response table and rank the level difference of each factors. The response totals are converted into average response and given in the table below. Each total value is divided by 9 to calculate average. The absolute difference in average response of three levels of each factor is also recorded. This difference represents the effect of the factors. These differences are ranked starting with the highest difference as rank 1, the next highest difference as rank 2 and the third difference as rank 3.

**Table 4.5.** Average response and ranking of factor effects

| **Factors** | **A** | **B** | **C** |
|---|---|---|---|
| Level 1 | -10.5254 | -10.8598 | -10.1247 |
| Level 2 | -11.5778 | -10.4263 | -9.9811 |
| Level 3 | -9.3606 | -10.1777 | -11.3595 |
| Δ (delta) | 2.2172 | 0.6821 | 1.3784 |
| Rank | 1 | 3 | 2 |

Where A is cutting speed, B is feed rate and C is depth of cut.
From the Table 4.5, it is observed that factor (cutting speed A) has the largest effect at rank 1. The optimal parameter combination is A3B2C2, for increasing the surface quality of AISI 4340 steel.

## 4.9. Predict optimum condition

Based on the objective of test this is whether minimization of reaction or maximization, the most reliable condition is selected. Assume in this test the objective is getting highest quality price, the most useful situation is selected. For maximization of response, the most efficient condition is decided on based on higher suggest cost of everything. Consequently, from the above discern and table the choicest condition is given below:
The optimum condition is A3, B3, C2 typically, all elements will now not contribute appreciably. As rule of thumb, it's far counseled to take the range of extensive effect identical to about one half the range of stages of freedom of the OA used for experiment. These are decided on within the order of their ranking starting from rank 1 For example, if we've three outcomes (rank 1, rank 2, and rank3) as sizable. Therefore, the optimal situation is A3, B3, C2.
The predict optimum response μ predict is given by

$$M = (A_3\text{-}T) + (B_3\text{-}T) + (C_3\text{-}T) + (D_1\text{-}T) + T \qquad (4.19)$$

where T= current grand average of S/N ratio
Data analysis using analysis of variance

First the correction factor (CF) is computed.

$$\text{CF} = \frac{T^2}{N} = \frac{\Sigma(T^2)}{N} \tag{4.20}$$

Where T= grand total and N is total number of observations

Ss total is computed using the individual observation (response) data as already discussed.

$$\text{Ss total} = \sum_{i=1}^{N} Yi^2 - CF \tag{4.21}$$

The factor (effect) sum of squares are computed using the level totals from above table: -

$$S_{SA} = \frac{A1^2}{nA1} + \frac{A2^2}{nA2} + \frac{A3^2}{nA3} - CF \tag{4.22}$$

Where A1= level 1 total of factor A

nA1= number of observations used in A1

A2 = level 2 total of factor A

nA2= number of observations used in A2

A3 = level 3 total of factor A

nA3= number of observations used in A3

ANOVA is used to determine the maximum tremendous aspect affecting the superior combination of method parameters on output quality and feature the usage of the quantities which includes diploma of freedom (f), sum of squares (SS), variance (V), percent contribution of each factor (F ratio) and then contribution ratio or contribution of variance had been decided. From the table4.6, it is determined that highest contribution ratio is for slicing pace (A) at the same time as Feed fee (B) is the bottom and depth of reduce (C) has moderate value between the opposite

Tables four.3 illustrate the common S/N ratio values for surface roughness. Tables 4.6 display the results of ANOVA. It is found that the cutting velocity (A) (59.899%) is most significantly affects the fabric, Feed fee (B) (5.1 8996%) that is the lowest impact and depth of reduce (C) has slight (30.896%) affects and reveals that the error of the manner parameters is likewise applicable.

**Table 4.6.** Result of ANOVA for surface roughness

| Factors | Ss | Dof | MS | F-ratio | (%) contribution |
|---|---|---|---|---|---|
| A | 8.356 | 2 | 4.178 | 14.921 | 59.899 |
| B | 0.724 | 2 | 0.362 | 1.293 | 5.18996 |
| C | 4.31 | 2 | 2.155 | 7.696 | 30.896 |
| Error | 0.56 | 2 | 0.28 | | 4.0143 |
| Total | 13.95 | 8 | | | 100 |

## 4.10. Confirmation Test for average surface roughness

The estimated S/N ratio using the optimal level of the process parameter is calculated using

$$M = (A_3\text{-}T) + (B_3\text{-}T) + (C_3\text{-}T) + (D_1\text{-}T) + T \qquad (4\text{-}23)$$

where T= current grand average of S/N ratio

A confidence interval (C.I) has to be evaluated on the for the M using the following expression; -

$$C.I = \sqrt{F_{\propto(1,Fe)*Ve*(\frac{1}{Nf}+\frac{1}{R})}} \qquad (4.24)$$

and R= number of trials to run confirmation test. The optimum conditions of SN of Ra are A3B3C2 then values of each levels listed

A3=-9.3606

B3=-10.1777

C2=-9.9811 then substitute these values in to the formula of equation 4.23, then the result become M=-8.5434 and A confidence interval (C.I) =**1.76.**

Using ANOVA table $v_e$= [0.28], $f_e$=2 and F (1, 2) =4.6 at 95% confidence level and tabulated. At the 95% confidence level, the predicted mean of the Surface roughness [Ra] was found to be in the range of [-6.7834] dB < Ra > [-10.3034] dB

**Table 4.7**. Comparisons of experimental and predicted result of MRR

| Particular | Predict | Experimental | Difference |
|---|---|---|---|
| levels | A3B3C2 | A3B3C2 | |
| S/N ratio in db. | -8.5434 | -8.342788195 | 0.2006 |

From Table 4.7 the result between the experimental result and the predicted results is very small. The values predicted by using the Taguchi approach are approximately near to the value which is experimentally obtained. This verifies that the experimental results of surface roughness are strongly correlated with the predicted results.

## 4.11. Material removal rate

MRR (material removal rate) is the key concern in the era of mass production, even in CNC machine manufacture.

In this research, the Taguchi method was used with a L9 orthogonal array to calculate three parameters: speed, feed, and depth of cut. Three levels for each of these characteristics have been established and used to conduct the turning parameters for maximum material removal rate.

### 4.11.1 Result and discussion of MRR

Taguchi technique result and discussion Taguchi technique is a powerful tool for identifying the effects of various process parameters based on orthogonal array (OA). The L9 orthogonal array was employed to carry out the experiment in this work, and the experimental results were analyzed using the Taguchi method.

The SN values of material removal rate are calculated using the formula bigger is better

(Il) The larger the better N = -Log 1 0 [mean of sum squares of measured data 4.

This instance was transformed to the smaller-the better case by getting the reciprocal of the measured data and then taking the S/N ratio, as in the smaller-the-better case. This instance was transformed to the small better case by getting the reciprocal of the measured data and then taking the S/ N ratio, as in the smaller-the-better case. The feasible optimum condition of the experiment is chosen from Table 4.8. N ratio, as in the smaller-the-better case. The feasible optimum condition of the experiment is chosen from Table 4.8.To pick the best condition, ensure that the highest values of SN/ noise to signal ratio are suitably selected from the results. Based on this, the ideal experimental condition is shown at trial 9, which is (A3, B2 C2)

**Table 4.8** Data for illustration of SN result of MRR

| Exp no | Cutting speed | Feed rate | Depth of cut | MRR | SN ratio |
|---|---|---|---|---|---|
| 1 | 120 | 0.1 | 0.5 | 100 | 44.771 |
| 2 | 120 | **0.2** | **0.75** | 300 | 54.313 |
| 3 | 120 | 0.3 | 1 | 600 | 60.334 |
| 4 | 175 | 0.1 | 0.75 | 218.75 | 51.540 |
| 5 | 175 | 0.2 | 1 | 583.3 | 60.089 |
| 6 | 175 | 0.3 | 0.5 | 437.5 | 52.819 |
| 7 | 230 | 0.1 | 1 | 383.3 | 51.670 |
| 8 | 230 | 0.2 | 0.5 | 383.3 | 51.670 |
| 9 | **230** | 0.3 | 0.75 | 862.5 | 63.486 |

### 4.11.2 Response Table for Mean

For maximization of MRR the SN the ratio turned into calculated the usage of large is the batter criteria. due to the fact that the experimental layout is orthogonal, it turned into possible to split out the effect of each parameter at special degree. The suggest S/N ratio for every level of the issue A, B and C changed into summarized and proven in the desk below. the total implies S/N ratio for the 9 experiments become also calculated and shown inside the desk below. The response table suggests the average of the chosen traits for each level of the elements. The reaction table also consists of ranks based totally at the data facts, which via comparing the relative extent of consequences. The statistics price is calculated because the distinction of the best average and the bottom common for each thing. Then the rank is assigned based totally on the delta values. A response table for every reaction function like suggest and sign-to-noise ratio is calculated. Steps to generate reaction table 4.9.

1. Calculates the chosen reaction feature for slicing velocity, feed, first depth of reduce, and second depth of cut at every level.
2. After this delta values are calculated, that [l]s the difference between th e best average reaction feature cost and the lowest common reaction function values for stages of that factor.

3. Via thinking about the delta values ranks are allocated from excessive to low. The element with the highest delta value is ranked one.

### 4.11.3. Average S/N ratios for each factor

To develop Mean S/N Ratio Response Table for average surface roughness

$$Level1 = \frac{-10.333351182 + (-9.966211076) + (-11.276738373)}{3} \quad (4.25)$$

**Table 4.9**. Average response and ranking of factor effects

| **Level** | **A** | **B** | **C** |
|---|---|---|---|
| Level 1 | 53.139 | 49.327 | 49.753 |
| Level 2 | 54.816 | **55.357** | 56.446 |
| Level 3 | 55.609 | 58.880 | 57.364 |
| Delta | 2.469 | 9.552 | 7.610 |
| **Rank** | **3** | **1** | **2** |

### 4.11.4. The total mean S/N ratio

ANOVA is a statistical approach that attracts foremost findings from the observe of experimental statistics. This technique is quite powerful for deter mining the level of significance of issue 'shave an effect on or interplay with some other factor on a selected reaction. ANOVA evaluation divides the total variability of the response into man or woman contribution s from each element and errors. The effects are summarized within the table below. Due to the fact this ratio is associated with the have an impact on of a component and variance because of the error term, ANOVA determines the variance ratio or F-ratio.

At the suitable importance stage, the ratio is used to quantify the importance of each of the parameters under inquiry in regards to the variance of all of the phrases contained inside the blunders time period. If the calculated F ratio is more than the tabulated F value, the component is large on the desired degree, and vice versa. In preferred, as the F fee rises, so does the significance of the particular parameter. The % contribution of each parameter is proven in ANOVA table 4.10.

**Table 4.10.** Results of ANOVA for MRR

| Source | Df | Ss | Ms | F | Contribution (%) |
|---|---|---|---|---|---|
| A | 2 | 6.264 | 3.132 | 0.19921 | 2.28 |
| B | 2 | 136.579 | 68.2895 | 4.3434 | **49.743** |
| C | 2 | 100.282 | 50.141 | 3.189 | 36.52 |
| Error | 2 | 31.4451 | 15.72255 | | 11.4525 |
| Total | 8 | 274.5701 | | | 100.00 |

## 4.12. ANOVA result of MRR

ANOVA is used to determine the most good-sized thing influencing the ultimate combination of manner parameters on output high quality and characteristics using quantities consisting of degree of freedom (f), sum of rectangular s (SS), variance (V), percent contribution of every component (F ratio), and contribution ratio or contribution of variance. in keeping with table 4.8, the biggest contribution ratio is for Feed fee (B), the bottom is f or slicing speed (A), and intensity of cut (C) has a moderate price between the alternative two. The common S/N ratio values for MRR (cloth elimination charge) are proven in Tables 4.3.

ANOVA findings are proven in Tables 4.6. it is determined that the Feed fee (B) (49. 743%) has the maximum impact at the material, the cutting velocity (A) (2.28%) has the leas t impact, and the depth of cut (C) has a moderate (36.52%) have an effect on, indicating that th e errors of the method parameters is also applicable.

## 4.13. Confirmation Test for MRR

The estimated S/N ratio using the ideal level of the process parameter is computed as; -

M = (A3-T) + (B2-T) + (C3- T) + + T (4.26), where T is the current grand average of the S/N ratio, which is -10.488. A confidence interval (C.I) must be calculated for the M using the formula

$$C.I = \sqrt{F_{\propto(1,Fe)*Ve*(\frac{1}{Nf}+\frac{1}{R})}} \quad (4.27)$$

and R= number of trials to run confirmation test. The optimum conditions of MRR are A3B3C2 then values of each levels listed here; -

A3=55.609

B3=58.88

C2=56.447 then substitute these values in to the formula of equation 4.27, then the result become M=61.89252 and A confidence interval (C. I) =**1.76.** Using ANOVA table $v_e$= (15.723), $f_e$=2 and F (1, 2) =18.513 at 95% confidence level and tabulated. A t the 95% confidence level, the predicted mean of the MRR was found to be in the range of (48.673) dB < MRR > (75.11) db.

**Table 4.11**. Comparisons of experimental and predicted result of MRR

| Particular | Predict | Experimental | Difference |
|---|---|---|---|
| levels | A3B2C2 | A3B2C2 | |
| S/N ratio db | 61.89252 | 63.4863 | **1.594** |

From Table 4.12 the result between the experimental result and the predicted results is very small. The values predicted by using the Taguchi approach are approximately near to the value which is experimentally obtained. This verifies that the experimental results of surface roughness are strongly correlated with the predicted results.

## 4.14. Analysis of Chip Morphology

The chips from the machining take a look at were accrued, hooked up, and measured. Chip morphology refers back to the form, length, and texture of the chips produced in the course of a machining operation. The observe of chip morphology is a vital factor of machining research as it provides insights into the cutting method and the cloth being machined. one of the earliest works on chip morphology changed into performed by way of Taylor in 1 938, who evolved a type gadget for chips based on their form and length. in keeping with Taylor's classification device, chips may be categorized as continuous, segmented, or discontinuous, depending on their duration and shape. Similarly, studies have proven that the chip morphology is inspired by using a selection of things, such as cutting pace, feed price, device geometry, and material houses. As an example, excessive reducing speeds and feed tend to supply longer and thinner chips, even as lower slicing speeds and feed rates produce shorter and thicker chips (Davim et al.,2008).

The texture of the chip surface is also an important aspect of chip morphology. A smooth chip floor might also imply that the slicing device is in appropriate condition and that the machining operation is proceeding easily. Alternatively, a rough or irregular chip floor may additionally indicate tool wear, unsuitable cutting conditions, or material defects (Klocke et al., 2017). The color and texture of the chips can also offer data about the fabric residences. For example, the shade of the chip can offer information approximately the temperature generated in the course of the machining system, even as the texture of the chip can offer statistics approximately the surface end of the fabric (Davim, 2008).

According to Table 4.12, the difference between the experimental and projected findings is quite modest. The Taguchi technique predicts values which might be kind of near the experimentally done fee. This demonstrates that the experimental surface roughness effects are particularly associated with the projected consequences. while the feed rate became increased from 0.1 mm/ rev to 0.3mm/ rev at some stage in dry machining situations at the cutting quarter, it become discovered that brief tabular and carefully curled thin chips had been fashioned due to higher reducing temperatures and more desirable chip segmentation. In dry surroundings, chip breakability was located to be better than in a wet environment, and dry machining produced thinner chips than wet machining, as shown. Furthermore, dry machining eliminates the want for chip cleaning. normal, chip morphology analysis is an important detail of the machining technique due to the fact it can help machinists optimize their reducing conditions, discover device put on or fabric issues, and improve the completed product exceptional.

Figure 4.4 Chips generated during dry machining

Table 12 confirmed that as the feed was reduced and the cutting speed extended, chip thickness decreased. that is due to a massive touch vicinity at the rake face and a small shear aircraft location at low slicing speeds, which results in thinner chips formation. In evaluation, upward thrust in chip thickness due to elevated feed resulting from big compressive stresses generated upstream of the tool rake resulted in plastic deformation of a massive extent of material, ensuing in a thick chip. the biggest chip thickness turned into reached at a most feed rate of 0.3 mm/ rev, and the bottom chip thickness became performed at a decrease feed charge of 0.1 mm/rev.

Moreover, the best and shortest chip lengths have been determined to be nine.4mm and 4.7mm, respectively. measure the maximum, minim al thickness, and duration of chips shaped by way of CNC dry turning operations of AISI 4340 metal materials in dry machining circumstances for each of the 9 experimental research. In line with the size outcomes, moist machining produces the longest and maximum non-stop curled chips, at the same time as dry machining produces the shortest and maximum dis non-stop chips. Additionally, at maximum feed and depth of cut, the maximum thickness of chips created all through wet machining conditions.

**Table 4.12**. Chip morphology average thickens and length

| **Exp no** | **Cutting speed** | **Feed rate** | **Depth of cut** | **Chip thickness t(mm)** | **Chip length l(mm)** |
|---|---|---|---|---|---|
| 1 | 120 | 0.1 | 0.5 | 0.6 | 4.7 |
| 2 | 120 | **0.2** | **0.75** | 0.9 | 5.3 |
| 3 | 120 | 0.3 | 1 | 0.11 | 5.4 |
| 4 | 175 | 0.1 | 0.75 | 0.23 | 6.5 |
| 5 | 175 | 0.2 | 1 | 0.14 | 5.2 |
| 6 | 175 | 0.3 | 0.5 | 0.33 | 7.8 |
| 7 | 230 | 0.1 | 1 | 0.34 | 6.6 |
| 8 | 230 | 0.2 | 0.5 | 0.39 | 5.6 |
| 9 | **230** | 0.3 | 0.75 | 0.41 | 9.4 |

# CHAPTER-5

## CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

This thesis main findings had been summarized as comply with: The investigation and optimization of cutting parameters completed at the CNC device to turn workpiece material of AISI 4340 metal with ceramics inserted reducing tools the use of CNC dry turning. Taguchi L9 orthogonal array and signal-to-noise ratio method changed into used for optimization of input parameters including reducing speed feed and depth of cut to research their impact on surface roughness.

- Within the dry turning; least floor roughness of 2.23 µm changed into achieved at the combinations of cutting parameters 230 m/ min reducing speed, 0.3mm/rev feed, depth of cut 0. 75mm.And feed price has evaluation of variance (ANOVA) shows slicing velocity changed into the maximum vast parameter for surface roughness observed by way of feed fee for dry and feed rate turned into the most massive parameter throughout material removal rate.
- Most suitable cutting situations for turning operation o AISI 4340 metallic for floor roughness of 2.23pm turned into determined to be 0.75mm, 230m/min, and 0.3mm/min for intensity of reduce, slicing speed and feed fee respectively.
- The best chip thickness which is 0.41 mm was finished at maximum feed price cost, 0.3 mm/rev, and the bottom chip thickness zero.6 mm become executed at decrease feed rat e price of 0.1 mm/rev. additionally, the most and minimum length of chips turned into recognized as the longest is nine.4mm and the smallest is four.7 mm respectively.

### 5.2. Recommendation

Based on the consequences and conclusions of this look at, forwards the subsequent pointers. In this paper dry turning of AISI 4340 metal on CNC turning machine has been used and this kind of optimization and research of cutting parameters may be further prolonged to different materials kinds to have a look at the effect of cutting parameters at the surface roughness underneath special machining surroundings. distinct industries of machining operations of AISI 4340 merchandise and system keep industries can use the optimized slicing parameters of slicing speed 230 m/min, feed of 0.3 mm/rev, first device depth of cut at 0.75mm turning of AISI 4340 steel to gain products with high quality of surface roughness. One of the parameters and their stages can enlarge the observe, and the mechanical and chemical houses research can also be accomplished.

## 5.3. Scope for Future Work

As a future studies work, the subsequent can be achieved for in addition look at: in this research, handiest three cutting parameters consisting of cutting g speed, feed and depth of cut have been studied, similarly researches can be analyzing the impact and analyses of reducing device geometry, cutting forces exerted and vibrational impact for the duration of tool put on rate throughout the cutting operation at some point of CNC turning with cemented carbide tool the on surface roughness. Observe and examine the differences in performance traits on the identical paintings sample after warmth remedy. within the present work cemented carbide cutting tool become used for turning operation, the future paintings may be prolonged to another one of a kind cutting-device with double or multi device machining method like triple reducing tool on turning operations.

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