ISLAMIC UNIVERSITY OF TECHNOLOGY

ORGANIZATION OF ISLAMIC CO-OPERATION

SURFACE ROUGHNESS ANALYSIS USING SOUND SIGNAL IN TURNING OF MILD STEEL AND THEIR COMPARISON IN NORMAL AND HOT CONDITION

BSc Engineering (Mechanical) Thesis

Authored by

ANAS AZMAYEEN ZAMEE
Student ID: 151452

MEHEDI HASAN BHUIYAN
Student ID: 151410

SULTAN MAHMUD SAKIB
Student ID: 151451

Supervised by

PROF. DR. MD. ANAYET ULLAH PATWARI

Head of the Department
Department of Business, Technology and Management
Islamic University of Technology (IUT)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING (MPE)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

NOVEMBER 2019

CERTIFICATE OF RESEARCH

This thesis titled **"SURFACE ROUGHNESS ANALYSIS USING SOUND SIGNAL IN TURNING OF MILD STEEL AND THEIR COMPARISON IN NORMAL AND HOT CONDITION"** submitted by **ANAS AZMAYEEN ZAMEE** (Student ID: 151452), **MEHEDI HASAN BHUIYAN** (Student ID: 151410) and **SULTAN MAHMUD SAKIB** (Student ID: 151451) has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering on November 2019.

Supervisor

PROF. DR. MD. ANAYET ULLAH PATWARI

Head of the Department

Department of Business, Technology and Management

Islamic University of Technology (IUT)

DECLARATION

It is hereby declared that, their thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the Candidates'

ANAS AZMAYEEN ZAMEE
Student ID: 151452

MEHEDI HASAN BHUIYAN
Student ID: 151410

SULTAN MAHMUD SAKIB
Student ID: 151451

Department of Mechanical and Production Engineering (MPE)
Islamic University of Technology (IUT)
Board Bazar, Gazipur, Dhaka, Bangladesh

Signature of the Supervisor

PROF. DR. MD. ANAYET ULLAH PATWARI

Head of the Department

Department of Business, Technology and Management

Islamic University of Technology (IUT))

ACKNOWLEDGEMENTS

Firstly, we would like to thank Almighty Allah for giving us opportunity, determination and strength to complete our research within time. Then, we would like to express our sincere gratitude to our thesis supervisor Prof. Dr. Md. Anayet Ullah Patwari, Head of the Department of Business, Technology and Management, Islamic University of Technology (IUT) for his enormous, support, guidance and inspiration in every single step towards the completion of the thesis. The door to his office was always open whenever we ran into a trouble spot or had a question about our research or writing. He consistently motivated us and steered us in the right direction whenever he thought we needed it.

We would also like to thank the lab instructors of the workshop who were involved in the machining process required for the thesis. Without their passionate participation and input, the operation could not have been successfully conducted.

Finally, we must express very profound gratitude to our parents for providing us with unfailing support and continuous encouragement throughout our years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

ABSTRACT

Among every other parameters of production process, surface roughness holds its ground as one of the most crucial factor for quality analysis. Good surface finish is a major criterion in almost every machining process. If the surfaces aren't smooth, many kinds of mechanical, thermal, frictional, vibrational problems may occur. So minimizing surface roughness should be top priority. Surface roughness depends on many factors. But it has a direct relation with the tool conditions and overhang length of the tool. With the variations of tool conditions and overhang length the machining sound level also varies. In this present work, an analysis has been made based on captured sound signal to correlate the surface roughness parameters with sound level at different tool and overhang length conditions. As the cutting tool wears out due to continuous usage, surface roughness also develops on the tool surface. It has been observed that with the increase of overhang length the sound generated level within the cutting zone varied and surface roughness in the job also varied due to the effect of vibration and friction. A correlation factor has been investigated with the sound level variation to analyze the surface roughness condition with different tool wear and overhang length.

KEY WORDS: *Surface roughness, Overhang length, Lathe, Turning, Facing, Profilometer, Sound wave*

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

OVERVIEW OF THE THESIS

For many years' considerable research work has been carried out in industrial and academic perspective to understand various aspects of surface roughness. The surface finish of machined parts is known to have considerable effect on some properties such as wear resistance and fatigue strength. Thus, the quality of the surface is significantly important for evaluating the productivity of machine tools, and mechanical parts.

Lathes are one of the most widely used metal shaping machines for cylindrical job pieces. For effective and multipurpose uses they are being used in almost every workshop. In spite of their versatility there are also some disadvantages. The type of cutter is used usually for normal operations like turning, facing, threading, chamfering, grooving is called single point cutting tool because it cuts at a single point. So, during the whole operation only one point gets in contact with job piece. Eventually the surface of the single point cutting tool gets blunt and wears out which results in poor surface finish. As the time goes on, surface roughness increases drastically hampering the desired quality which results in a great economic loss. Hence its essential to optimize the tool life to increase it as much as possible.

With a view to increasing the tool life of the single point cutting tool, generally an insert is used which is mechanically clamped to the single point cutting tool. The idea of using an insert is to compare the surface finish of using different parts of the same insert having different wear.

OBJECTIVES OF THE THESIS

From the beginning of the experiment, we set some objectives which we have to achieve after finishing the experiment. At First, we tried to determine the effect of temperature in improving the surface roughness. That's why we have done the experiment in both normal and hot condition (Temperature: 410°C) to check the effect of temperature in improving surface roughness. Next, we measured the effect of overhang length in machining. To achieve that, we did the experiment for different overhang length (160mm, 170mm and 180mm) to check the effect of overhang length on the surface roughness. Then, we have to investigate different kind of chip formation. For that reason, different types of inserts (No wear, Moderate wear & High wear) were used for varying overhang length to check the chips that were produced during the turning operation. Finally, we have to analyze sound intensity in terms of variable parameters.

OUTLINE OF SURFACE ROUGHNESS

Surface roughness is one of the most important quality control parameter to ensure that functional surfaces of manufactured parts to maintain specified standards. Surface finish of parts can significantly affect their friction, wear, fatigue, corrosion, tightness of contact joints, positioning accuracy etc. Surface finish is a significant factor for manufacturing process monitoring and quality control inspection. A change in any part of the production process will result in a change in one or more measurable parameters of the component. Surface finish in particular is very sensitive to changes in production, even modification in the composition of the material or hardness of surface will be reflected as a change in the texture of the machined component.

The application of surface roughness is crucial in medical and aircraft components because people's lives are dependent on it. It affects parts performance and durability. Moreover, defect analysis in production process is done for better manufacturing and quality inspection. Better visibility and customer satisfaction is also a factor.

LITERATURE REVIEW

Many research works have already been conducted to improve the surface roughness of machined work-piece in turning operations using different types of process parameters, coolant, hot machining, cryogenic machining etc. G.M. Sayeed Ahmed et al [1] conducted an experiment using AISI 1050 material of different diameters of 20, 30, and 40 mm in which the surface roughness of the work piece was determined through experiments using constant cutting speed and feed rates with different depth of cuts (DOCs) and tool overhang lengths. Safeen Y. Kassab et al. [2] experimented to find relation between surface roughness and cutting tool vibration in lathe dry turning of medium carbon steel. They found that vibration of cutting tool depends strongly on cutting tool overhang length and with the increasing feed rate the surface roughness of work piece increase. H.H. Habeeb et al. [3] conducted machining of nickel based alloys 242 included using four different cutting tool materials under wet condition. Flank wear modes are noticed as acceptable results at lowest cutting depth with high cutting speed and moderate feed rate. Optimum surface roughness results were also recorded with decreasing of cutting depth. In a similar type of experiment by Anayet U. Patwari et al. [4] investigated the effects on overhang length on surface roughness, chip morphology to determine the suitability of over-hang length with coated carbide inserts so that with the proper selection of the overhang length the productivity will increase with the increased process parameters. Vladimir Aleksandrovich Rogov et. al. [5] used the Taguchi method to optimize the surface roughness with vibration in turning of Aluminum AA2040 under dry condition where Spindle speed, feed rate, depth of cut and tool overhang were chosen as cutting parameters. Kong Lingguo et al. [6] in their study found that within a certain range, the cutting speeds increased will first make the amount of vibration and surface roughness increase, then decreased, and more than this range, the surface roughness goes up along with the vibration increase. The cutting edge of the worn tool acting like un-uniformly larger nose radius which produced better surface was found in an experiment by S. Thamizhmanii et al. [7]. In this present study, several experiments have been conducted with different types of tool wear and overhang length and generated sound were captured at different cutting conditions in turning process. The captured sound level was analyzed to correlate the surface profile with the sound level in machining process and find out the relationship with sound level, surface roughness, tool wear and overhang length for conventional turning processes.

METHODOLOGY

PROCESS BLOCK DIAGRAM

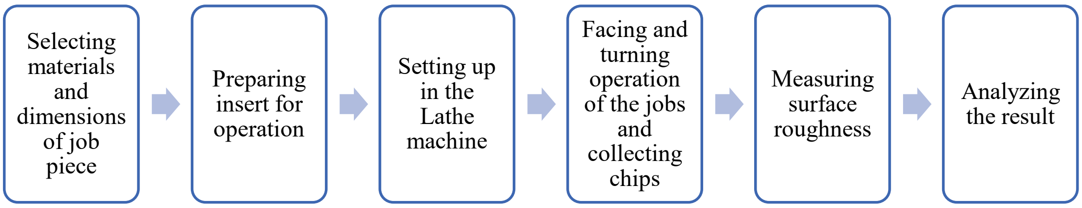


Figure 1: Process Block Diagram

For this experiment first we have to select the material (Mild Steel) where the length of the job piece is 200mm and the diameter of the job piece is 32mm. After selecting the job piece material, power saw was used to cut the job piece according to the required dimension. After cutting the job piece, the job piece was positioned in the lathe for facing and turning process. An insert of (12mm x 12mm x 4mm) was used as cutting tool for this operation where the insert was constructed which had no, medium and high wear in its three sides. Then the machining was conducted using the same condition for different overhang lengths. 3 types of flank wear (no wear, moderate wear, high wear) were used for a single insert in its three sides in three different work piece. During the machining, both facing and turning operation were done on the lathe where facing was done to remove the metal from the end of a job piece to produce flat surface and turning was done to remove the metal from the outer diameter of a rotating cylindrical job piece, it was basically done to reduce the diameter of the job piece and to produce a smooth finish on the metal. For hot air condition, a heat gun was used to raise the temperature of the work piece to get better surface roughness. During the turning operation various types of chips were produced for using different types of insert having (No wear, Moderate wear & High wear) varying overhang length. We collected the chips according to the work piece and varying overhang length and wear. An audio recorder was also used to capture the sound produced during the operation. Profilometer was used to measure the surface roughness. To measure the roughness, we held the tip of the profilometer on the outer surface of the job piece at different points. We collected the surface roughness value which we got from the experiment and analyzed the value to select the best one. After that we compared the value of normal and hot condition.

EQUIPMENTS USED

POWER SAW

Sawing machine is a device for cutting up bars of material or for cutting out shapes. The cutting tools of sawing machines may be thin metallic disks with teeth on their edges, thin metal blades or flexible bands with teeth on one edge, or thin grinding wheels. The tools may use any of three actions in sawing: true cutting, grinding or friction-created melting.

Figure 2: Power saw (LET LHM-280)

The power hacksaw machine provides a vise for clamping the work and means for reciprocating a U-shaped frame on which is mounted a straight steel hacksaw blade that cuts when moving in one direction only. The saw presses down on the work during the cutting stroke but is raised clear of the work during the return stroke. [10]

LATHE

A lathe is a machine tool that rotates a work piece about an axis of rotation to perform various operations such as cutting, sanding, knurling, drilling, deformation, facing, and turning, with tools that are applied to the work piece to create an object with symmetry about that axis. [8]

Figure 3: Horizontal Central Lathe (Gate Pinacho Mod. L-1/180)

WORKING PRINCIPLE OF LATHE

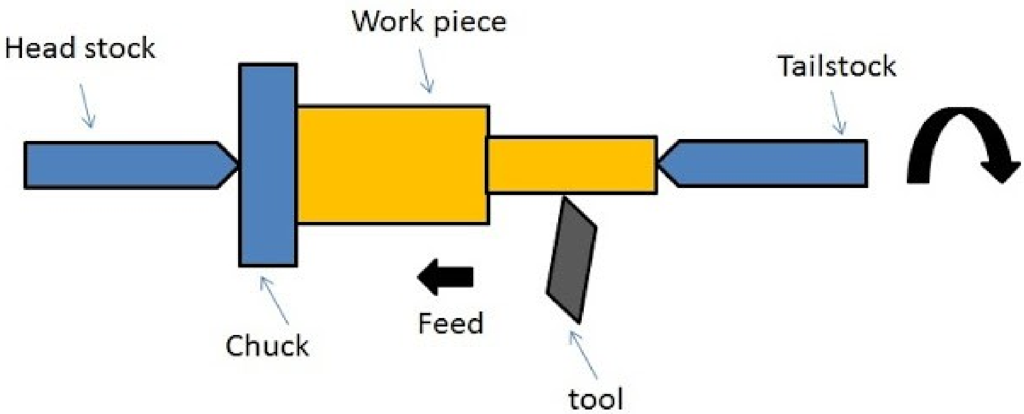


Figure 4: Main Components of a Lathe [8]

The function of lathe is to remove metal from a piece of work to give it a desired shape and size. In a lathe, the work piece rotates against the tool. The tool is used to remove material from the work piece. The direction of motion of tool is called feed. [8]

MAIN PARTS OF A LATHE

1. Headstock

It is present at the left hand side of the lathe. It holds the gear train, main spindle, chuck, gear speed control levers and feed controllers. It is aligned with the tailstock. The head stock is made up of cast iron. [8]

(i) Chuck

It is that part of lathe machine which is used to hold the work piece. It is attached to the main spindle of the headstock. It rotates with the spindle and also rotates the work piece. In the lathe machine we generally use three jaw or four jaw check. The jaws of the three jaw chuck are made to move simultaneously but the jaws of the four jaw chuck move independently. [8]

(ii) Main Spindle

This part of the lathe machine is used to hold cylindrical work piece within it. It is a hollow shaft on which the chuck is mounted. [8]

(iii) Feed Selector

It is used to select the direction of the feed i.e. whether we want to move the tool from left to right or right to left. Feed selector is present on the headstock. [8]

2. Tailstock

It is present at right hand side of the lathe. It is used to provide supports to the work piece. It supports the work piece from one end i.e. right end. [8]

3. Bed

It is the main part of the lathe. All the parts of the lathe are bolted on the bed. It comprises of headstock, tailstock, carriage guide ways and other parts. It is made of cast iron. [8]

Guide ways

Guide ways are present on the bed. As its name indicates it is used to guide the tail stock and carriage. The tailstock and carriage, slides over the guide ways. It is an inverted V. [8]

4. Carriage

The carriage is present in between the headstock and tailstock. It carries apron, saddle, compound rest, cross slide and tool post.

(i) Tool Post: It is used to hold the tool. It has T-slot for holding the tool. Tool post is bolted on the carriage.

(ii) Compound Rest: It is used to set the tool at desired angle for taper turning and other operations.

(iii) Cross Slide: The cross slide is used to move the tool perpendicular to the axis of the lathe.

(iv) Saddle: The top portion of the carriage is called saddle. Cross slide is mounted on the saddle.

(v) Apron: The front portion of the carriage is called apron. It contains all the moving and control mechanism of the carriage. [8]

5. Lead Screw

Lead screw is used to move the carriage automatically during threading. [8]

6. Feed Rod

It is used to move the carriage from left to right and vice versa. [8]

7. Chip Pan

Chip pan is used to collect the chips that are produced during the lathe operation. It is present at the bottom of the lathe. [8]

8. Hand Wheel

It is the wheel which is operated by hand to move cross slide, carriage, tailstock and other parts which has hand wheel. [8]

LATHE OPERATIONS

The various operations that we performed on the lathe are:

Facing

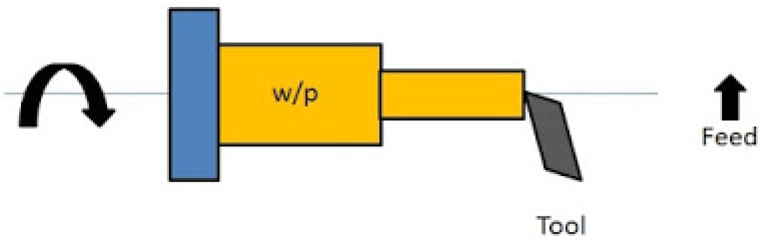


Figure 5: Facing Operation on lathe [8]

It is the first operation that is done on the work piece. It is a machining operation which is done to produce flat surfaces at the ends of the work piece. This operation is performed by feeding the tool perpendicular to the axis of rotation of the chuck. [8]

Turning

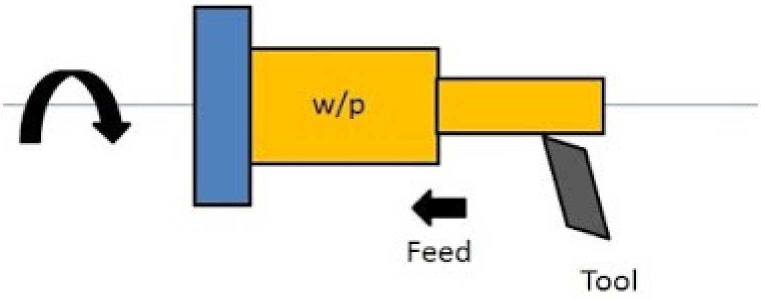


Figure 6: Turning operation on lathe [8]

In turning operation, the excess material is removed from the surface of the work piece to produce a cylindrical surface of desired shape and size. During the turning operation, the feed is moved along the axis of rotation of the chuck. It reduces the diameter of the cylindrical work piece. [8]

PROFILOMETER

A profilometer is a measuring instrument used to measure a surface's profile, in order to quantify its roughness. Critical dimensions as step, curvature, flatness are computed from the surface topography. [11]

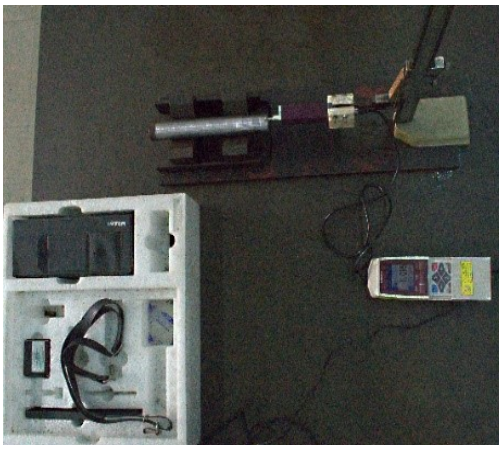


Figure 7: Profilometer setup for measuring surface roughness (Mitutoyo Surftest SJ-210-Portable Surface Roughness Tester)

HOW A PROFILOMETER WORKS

All profilometers are consist of at least two parts – a detector and a sample stage. The detector is what determines where the points on the sample are and the sample stage is what holds the sample. In some systems, the sample stage moves to allow for measurement, in others the detector moves and in some both move.

There are two types of profilometers: stylus vs optical. Stylus profilometers use a probe to detect the surface, physically moving a probe along the surface in order to acquire the surface height. This is done mechanically with a feedback loop that monitors the force from the sample pushing up against the probe as it scans along the surface. A feedback system is used to keep the arm with a specific amount of torque on it, known as the 'set point'. The changes in the Z position of the arm holder can then be used to reconstruct the surface. [11]

STYLUS PROFILOMETRY

Stylus profilometry requires force feedback and physically touching the surface, so while it is extremely sensitive and provides high Z resolution, it is sensitive to soft surfaces and the probe can become contaminated by the surface. This technique can also be destructive to some surfaces.

Because a stylus profilometer involves physical movements in X, Y and Z while maintaining contact with the surface, it is slower than non-contact techniques. The stylus tip size and shape can influence the measurements and limit the lateral resolution. [11]

OPTICAL PROFILOMETRY

Optical profilometry uses light instead of a physical probe. This can be done a number of ways. The key component to this technique is directing the light in a way that it can detect the surface in 3D. Examples include optical interference, using a confocal aperture, focus and phase detection, and projecting a pattern onto the optical image. [11]

SOUND RECORDER

Digital recording converts the analog sound signal picked up by the microphone to a digital form by the process of sampling. This lets the audio data be stored and transmitted by a wider variety of media. Digital recording stores audio as a series of binary numbers (zeros and ones) representing samples of the amplitude of the audio signal at equal time intervals, at a sample rate high enough to convey all sounds capable of being heard. [12]

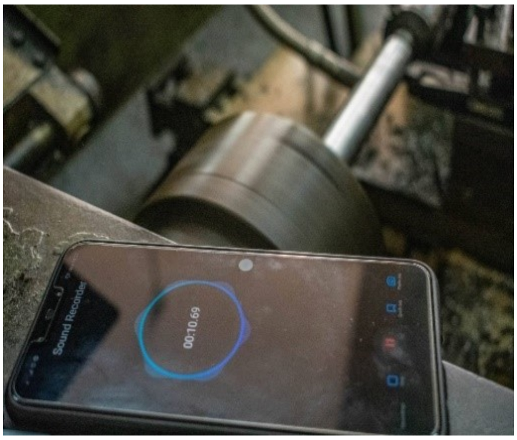


Figure 8: Audio recorder (Huawei nova 3i)

HEAT GUN

A heat gun is a device used to emit a stream of hot air, usually at temperatures between 100 °C and 550 °C (200-1000 °F), with some hotter models running around 760 °C (1400 °F), which can be held by hand. Heat guns usually have the form of an elongated body pointing at what is to be heated, with a handle fixed to it at right angles and a trigger, in the same general layout as a handgun, hence the name. A lighter duty heat gun is similar to a portable hair dryer. [13]

Figure 9: Rita Hot Air Gun

INSERT DETAILS

During machining, coated carbide tools ensure higher wear resistance, lower heat generation and lower cutting forces, thus enabling them to per-form better at higher cutting conditions.

INSERT

A tipped tool is any cutting tool in which the cutting edge consists of a separate piece of material that is brazed, welded, or clamped onto a body made of another material. In the types in which the cutter portion is an indexable part clamped by a screw, the cutters are called inserts (because they are inserted into the tool body). Tipped tools allow each part of the tool, the shank and the cutter(s), to be made of the material with the best properties for its job. Common materials for the cutters (brazed tips or clamped inserts) include cemented carbide, polycrystalline diamond, and cubic boron nitride. Tools that are commonly tipped include milling cutters (such as end mills, face mills, and fly cutters), tool bits, router bits, and saw blades (especially the metal-cutting ones).

WIPER INSERT

A wiper insert is an insert used in a milling machine or a lathe. It is designed for finished cutting, to give a smooth surface on the surface being cut. It uses special geometry to give a good finish on the work piece at a higher-than-normal feed rate. Wiper inserts generally have a larger area in contact with the work piece, so they exert higher force on the work piece. This makes them unsuitable for fragile work pieces.

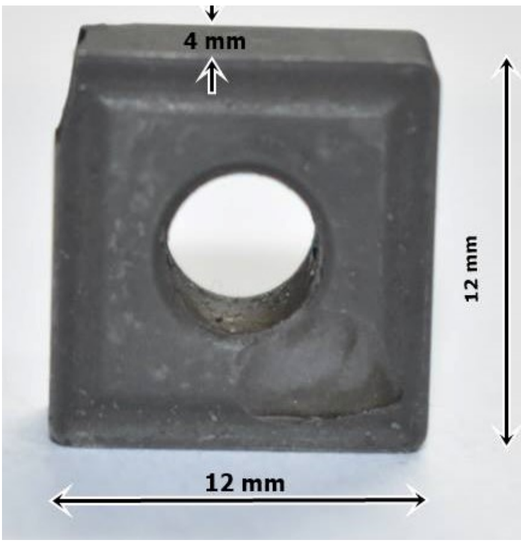


Figure 10: Dimensions of Wiper Insert

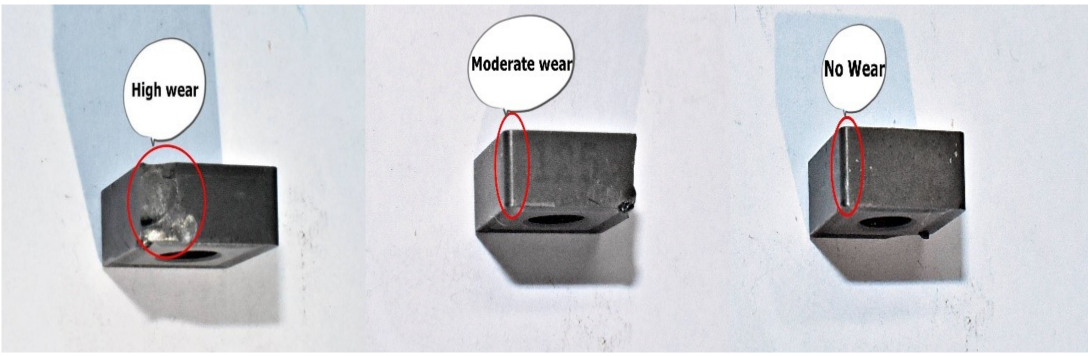


Figure 11: High wear, Moderate wear and No wear sides of a wiper insert

For this experiment, an insert was constructed which had no, medium and high wear in its three sides. Then the machining was conducted using the same condition for different overhang lengths. 3 types of flank wear (no wear, moderate wear, high wear) were used for a single insert in its three sides in three different work piece in various overhang length such as:

- In 1st work piece, high wear insert for 1st 10mm, Moderate wear insert for 2nd 10mm, no wear insert for 3rd 10 mm were used.
- In 2nd work piece, no wear insert for 1st 10mm, high wear insert for 2nd 10mm, moderate wear insert for 3rd 10 mm were used.
- In 3rd work piece, moderate wear insert for 1st 10mm, no wear insert for 2nd 10mm, high wear insert for 3rd 10 mm were used

EXPERIMENTAL CONDITIONS

A proper cutting condition is extremely important task because these determine surface quality of manufactured parts. This experiment was conducted by using lathe machine where 3 types of (no wear, moderate wear, high wear) insert were used for machining. In the machining process following parameters were applied.

Constant Parameters (Hot & Normal Condition)	Cutting Speed	875 rpm
	Depth of Cut	1 mm
	Feed Rate	0.19 mm/rev
Constant Parameter (Hot Condition)	Temperature	410℃
Variable Parameter (Hot & Normal Condition)	Overhang Length	160 mm 170 mm 180 mm

Table 1: Constant and Variable parameters during machining for both normal and hot conditions

Cutting speed, Depth of cut, Feed rate was kept constant throughout the whole experiment while overhang length became variable for both normal and hot condition.

HOT CONDITION PARAMETERS

A hot air gun was used to raise the temperature of the work piece. The air gun was pointed at the job pieces for 90 seconds and the temperature value was taken at 10 seconds interval. Atmospheric temperature =25℃. After 50 seconds, temperature rises up to 410℃ and it doesn't change much for the next 40 seconds.

Figure 12: Heating Work piece with a Hot Air Gun

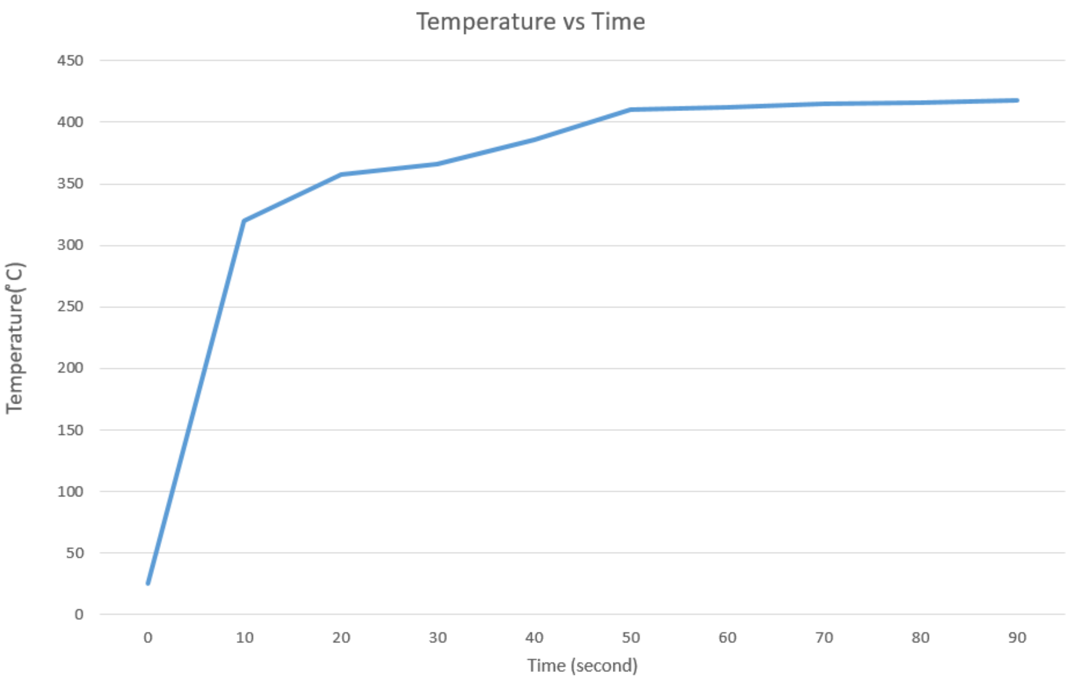


Figure 13: Temperature of work piece vs Time of heating graph

WORK PIECE DETAILS

A figure is illustrated below showing all the three job pieces with their dimensions and cutting conditions along with different wear inserts

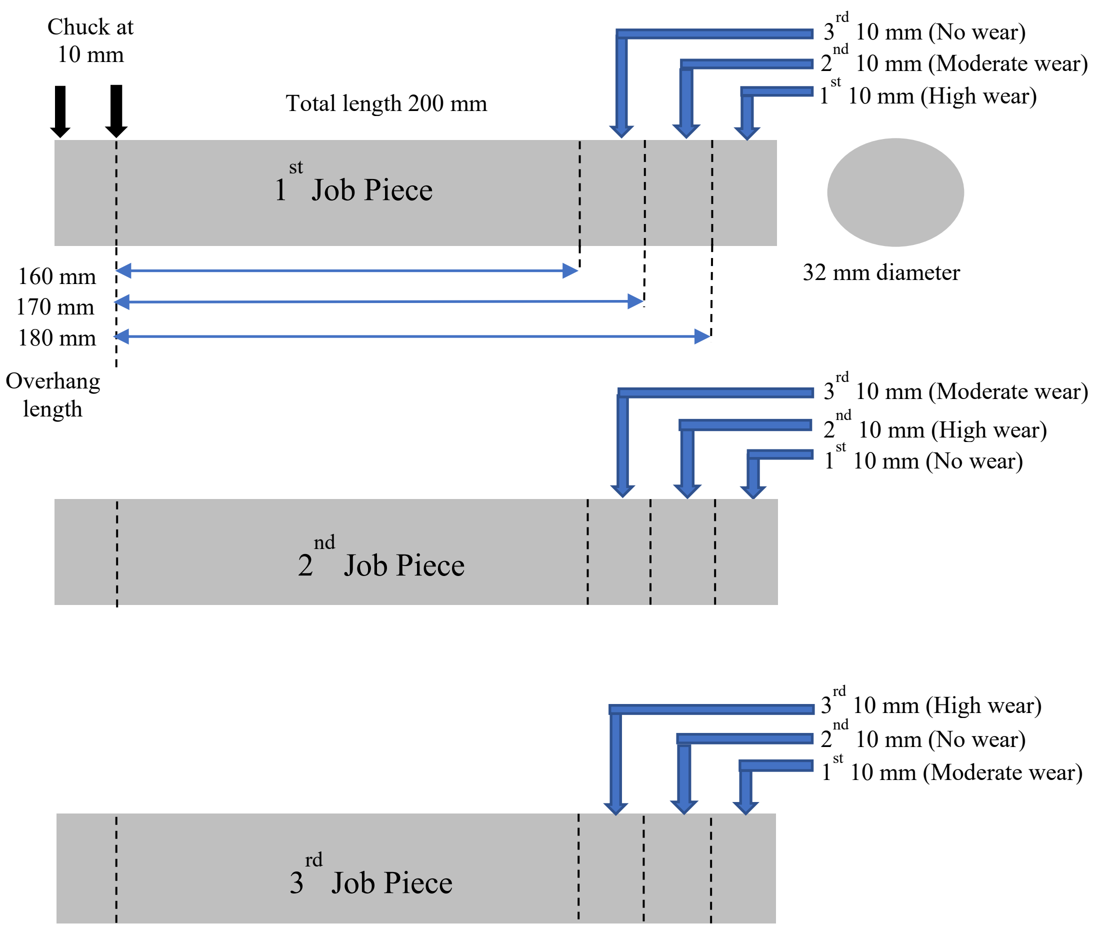


Figure 14: Job pieces with their dimensions and cutting conditions along with different wear inserts

In 1st work piece, high wear insert for 1st 10mm, Moderate wear insert for 2nd 10mm, no wear insert for 3rd 10 mm were used.

In 2nd work piece, no wear insert for 1st 10mm, high wear insert for 2nd 10mm, moderate wear insert for 3rd 10 mm were used.

In 3rd work piece, moderate wear insert for 1st 10mm, no wear insert for 2nd 10mm, high wear insert for 3rd 10 mm were used.

CHIP FORMATION

During the machining process of the work piece, to give it a desired shape, metal chips are produced. These metal chips may be of different types. The chips formed depend upon the types of materials used and other factors too. The chips formed may be of continuous, discontinuous and continuous with built up edge type.

TYPES OF CHIPS

The various types of chips in metal cutting are:

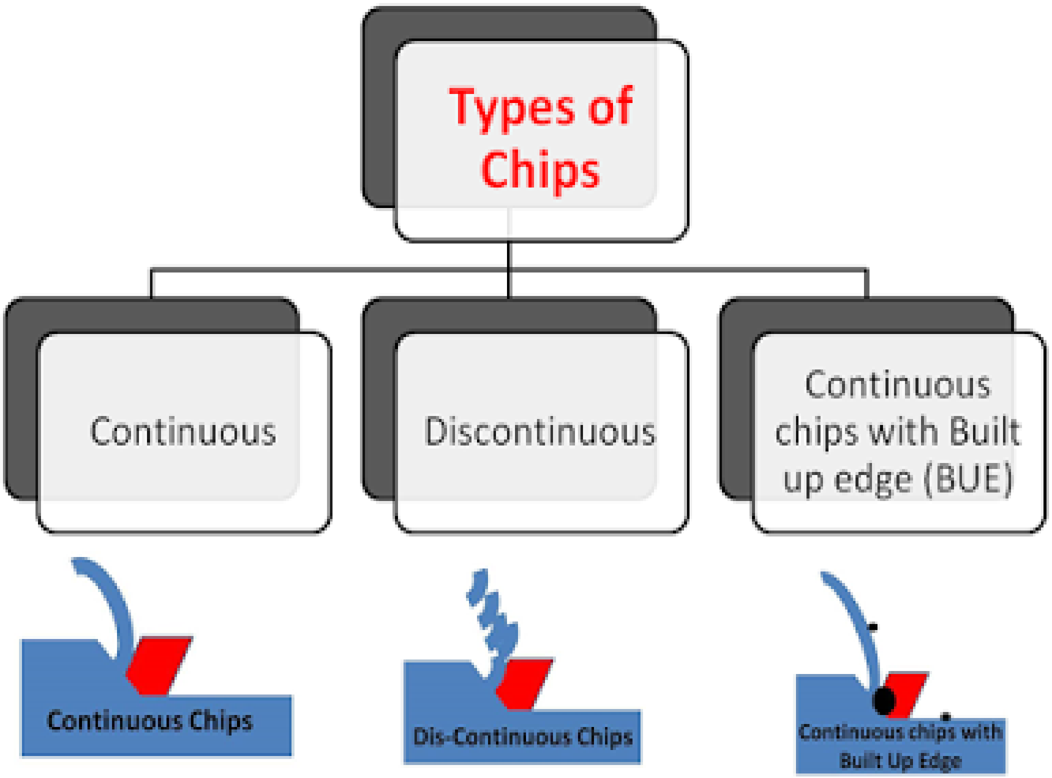


Figure 15: Classification of Chips [9]

1. **Continuous Chips**

If the metal chips formed during machining is without segments i.e. without breakage, then it is called as continuous types of chips.

Continuous chips are formed when the ductile material is machined with high cutting speed and minimum friction between the chip and tool face.

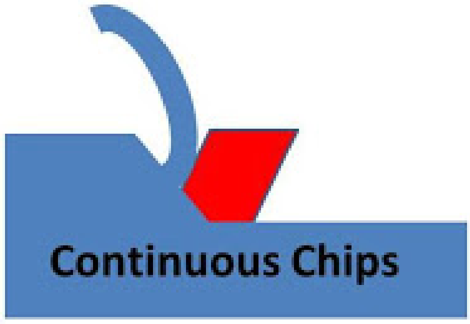


Figure 16: Schematic Diagram of Continuous Chips [9]

2. **Discontinuous Chips**

If the chips formed during machining process is not continuous i.e. formed with breakage is called discontinuous chips.

Discontinuous types of chips are formed when hard and brittle metals like brass, bronze and cast iron is machined.

Figure 17: Schematic Diagram of Discontinuous Chips [9]

3. **Continuous Chips with Built Up Edge**

Continuous chips with built up edge is formed by machining ductile material with high friction at the chip-tool interface.

It is similar to the continuous types of chips but it is of less smoothness due to the built up edge.

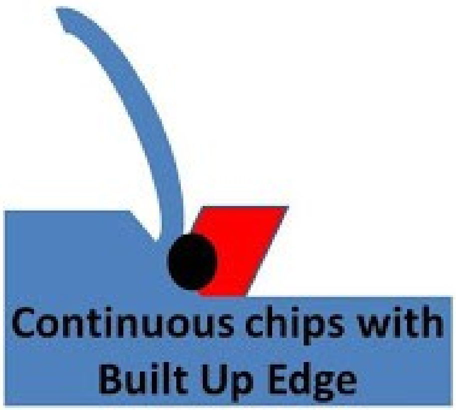


Figure 18: Schematic Diagram of Continuous Chips with Built Up Edges [9]

RESULTS & DISCUSSIONS

NORMAL CONDITION

While measuring the surface roughness, different surface roughness was found using different insert for each work piece. Comparing work pieces, insert 3 (no wear insert) had the best surface finish at various overhang length as shown below:

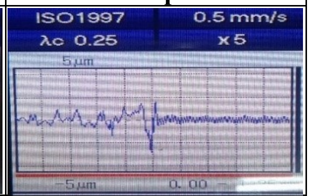
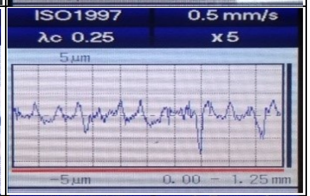
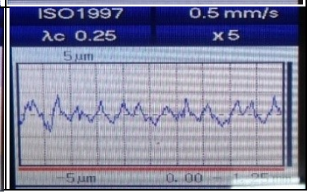
Condition	Surface Roughness	Surface Roughness Graph
For work piece 1: • 160 mm Overhang length • No wear insert		
For work piece 2: • 180 mm overhang length • No wear insert		
For work piece 3: • 170 mm overhang length • No wear insert		

Table 2: Surface roughness values and graphs of insert 3 (no wear insert) at various overhang length

In this experiment, using different insert for each job piece while varying the overhang length, it is found that 3rd insert (No wear) has the better surface finish for conventional machining. For job piece 1, in 160 mm overhang length for insert 3 (No wear) has the better surface finish of 0.360 micro-m. Similarly, for job piece 2 & 3 better surface finish is obtained using 3rd insert that has no wear for varying overhang length 180 mm & 170 mm as shown in Table 2.

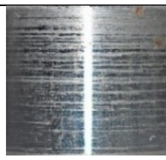
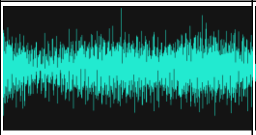
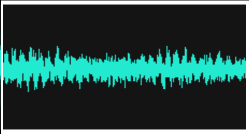
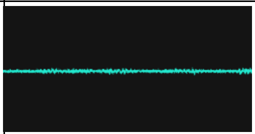
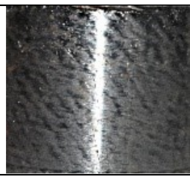
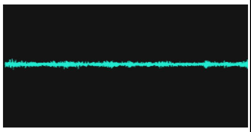
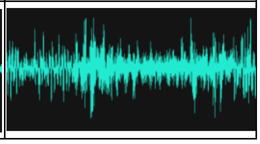
	Overhang Length		
	180 mm (High wear)	170 mm (Moderate wear)	160 mm (No wear)
Job Piece 1			
Surface Roughness	3.263 µm	2.474 µm	0.360 µm
Sound Analysis			
	180 mm (No wear)	170 mm (High wear)	160 mm (Moderate wear)
Job Piece 2			
Surface Roughness	0.609 µm	1.743 µm	0.859 µm
Sound Analysis			
	180 mm (Moderate wear)	170 mm(No wear)	160 mm (High wear)
Job Piece 3			
Surface Roughness	1.781 µm	0.570 µm	2.825 µm
Sound Analysis			

Table 3: Comparison of Various Parameters for Normal Condition

It is clearly observed that with the increase of overhang length, the surface roughness increased in case of no wear insert. In case of sound level analysis, it is also found that no wear insert generated less sound level compared to other two inserts. It is also observed that at overhang length 170 mm and 180 mm for moderate and high wear insert the surface roughness varied considering the frictional and vibration effect.

While machining the job piece, different types of chips were formed as shown in table 4 using different insert for varying overhang length:

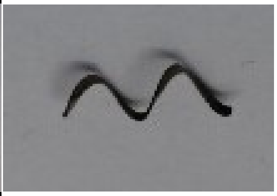
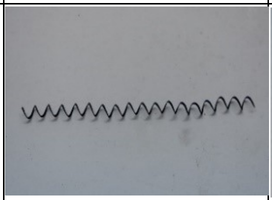
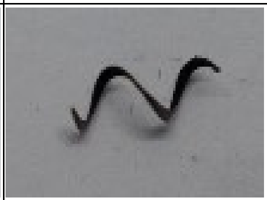
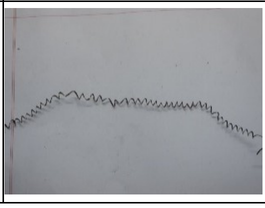
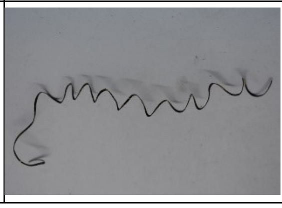
	Overhang Length		
	180 mm(High wear)	170 mm(Moderate wear)	160 mm(No wear)
Job Piece 1			
	180mm (No wear)	170 mm(High wear)	160 mm (Moderate wear)
Job Piece 2			
	180mm (Moderate wear)	170 mm(No wear)	160 mm (High wear)
Job Piece 3			

Table 4: Different types of chip formed in machining processes in Normal Condition

For 1st job piece, using high wear insert for 180 mm overhang length discontinuous chip was formed which was black in color (because of high friction between tool and job piece). For 1st job piece, during machining discontinuous chips were formed for other insert (Moderate & No wear) for varying overhang length (170 mm & 160 mm). But the chips which were formed during machining became blueish (because of friction between tool and job piece it slightly burnt) for insert 2 (Moderate wear) and silver for insert 3(No wear). For 2nd job piece continuous chip was formed using insert 3(No wear) where overhang length was 180 mm and using insert 1(High wear) with overhang length 170 mm formed continuous chips with buildup edge due to excessive friction and vibrational effect between tool and job piece and it was coil type shape. For overhang length of 160 mm insert 2 (moderate wear) formed discontinuous chip which was brownish in color. For job piece 3, continuous chips were formed using 2nd (Moderate wear) & 3rd insert (No wear) for varying overhang length at 170 mm. But the chips which were formed during machining became bronze type color (because of friction between tool and job piece it slightly burnt) for insert 2 (Moderate wear) and silver for insert 3 (No wear). Beside this continuous chips with buildup edge was formed using insert 1(High wear) (overhang length 160mm) due to excessive friction between tool and job piece.

HOT CONDITION

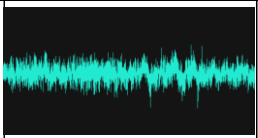
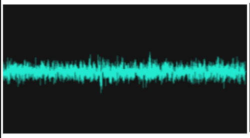
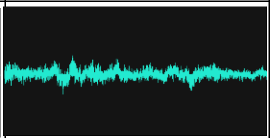
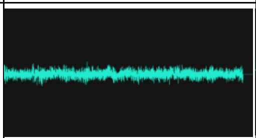
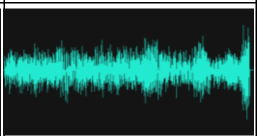
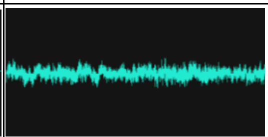
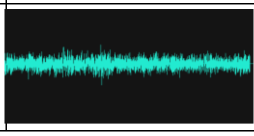
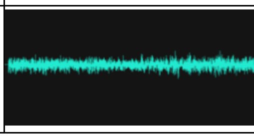
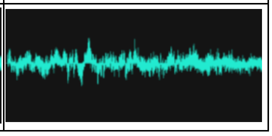
	Overhang Length		
	180 mm (High wear)	170 mm (Moderate wear)	160 mm (No wear)
Job Piece 1			
Surface Roughness	2.980 µm	1.130 µm	0.896 µm
Sound Analysis			
	180 mm (No wear)	170 mm (High wear)	160 mm (Moderate wear)
Job Piece 2			
Surface Roughness	1.132 µm	2.865 µm	1.038 µm
Sound Analysis			
	180 mm (Moderate wear)	170 mm(No wear)	160 mm (High wear)
Job Piece 3			
Surface Roughness	1.240 µm	1.288 µm	2.844 µm
Sound Analysis			

Table 5: Surface profile with average roughness and sound level variation at different overhang length in hot condition

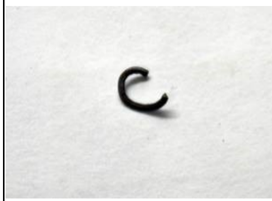
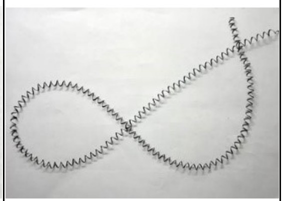
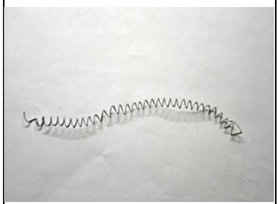
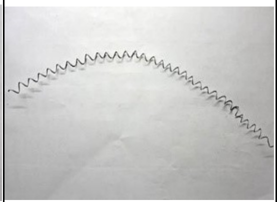
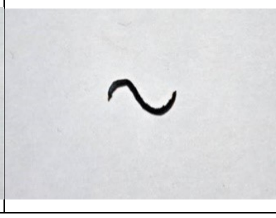
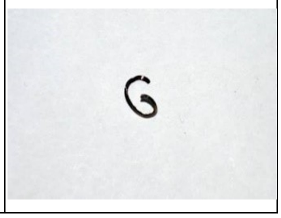
	Overhang Length		
	180 mm(High wear)	170 mm(Moderate wear)	160 mm(No wear)
Job Piece 1			
	180mm (No wear)	170 mm(High wear)	160 mm (Moderate wear)
Job Piece 2			
	180mm (Moderate wear)	170 mm(No wear)	160 mm (High wear)
Job Piece 3			

Table 6: : Different types of chip formed in machining processes in hot condition

In case of hot condition, the job piece was heated up to 410℃. So, in case of no wear insert the color of the chips are bronze rather than its normal silver color as the chips are slightly burnt. When moderate wear insert is used, the chips burn more as there is more friction and there is bluish texture around the bronze chips. Lastly, the chips turn black when high wear insert is used. There is the most friction in this case so the chips burn more and turn black in color.

NORMAL CONDITION VS HOT CONDITION

SOUND LEVEL COMPARISON WITH OVERHANG LENGTH

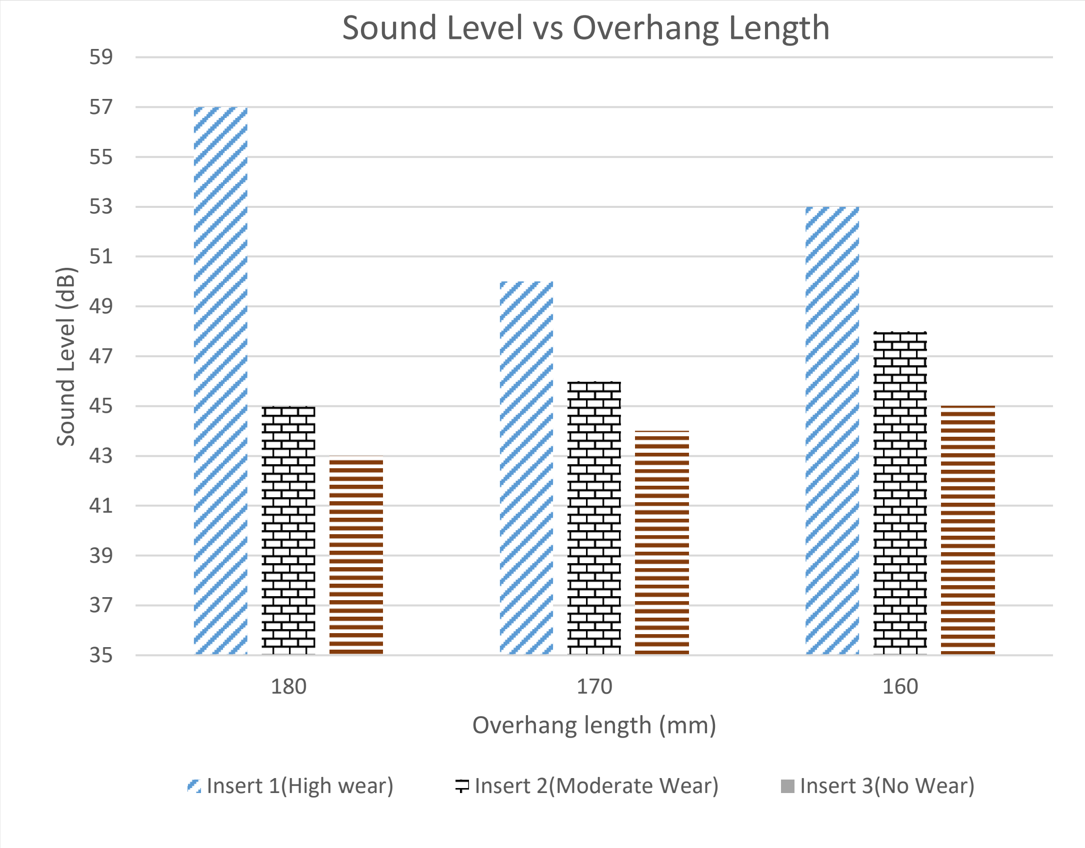


Figure 19: Sound level vs Overhang length for Normal Condition

This figure is the visual demonstration of sound analysis vs. overhang length, where machining is done under same feed rate, depth of cut and cutting speed but overhang length is variable for each insert. From this bar graph it can be seen that sound level is decreasing with overhang length. When overhang length is decreasing less vibration occurs, that's why sound level decreases.

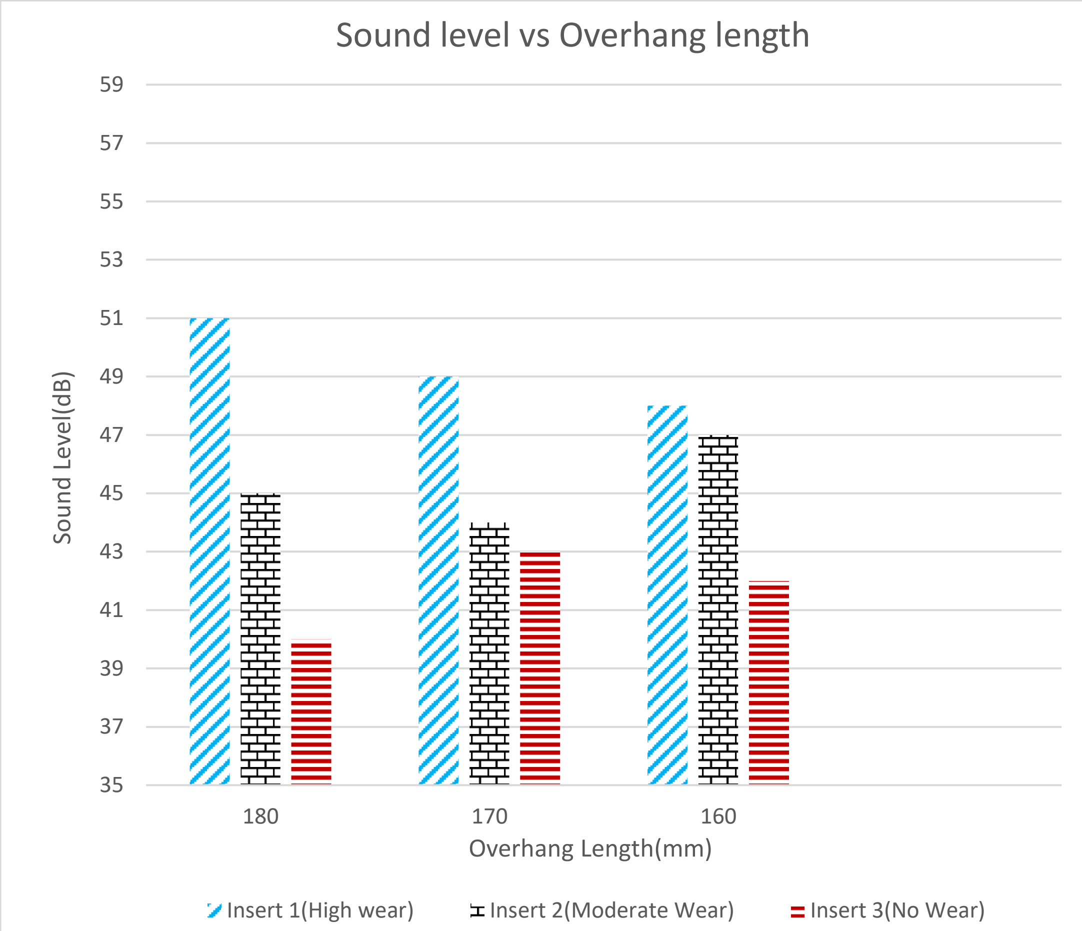


Figure 20: Sound level vs Overhang length for Hot Condition

In case of hot condition, sound level is less in most of the cases than the normal condition. Sound level indicates surface smoothness. Less sound level means more smooth surface. So, surface is more smooth in the hot condition

SURFACE ROUGHNESS COMPARISON WITH OVERHANG LENGTH

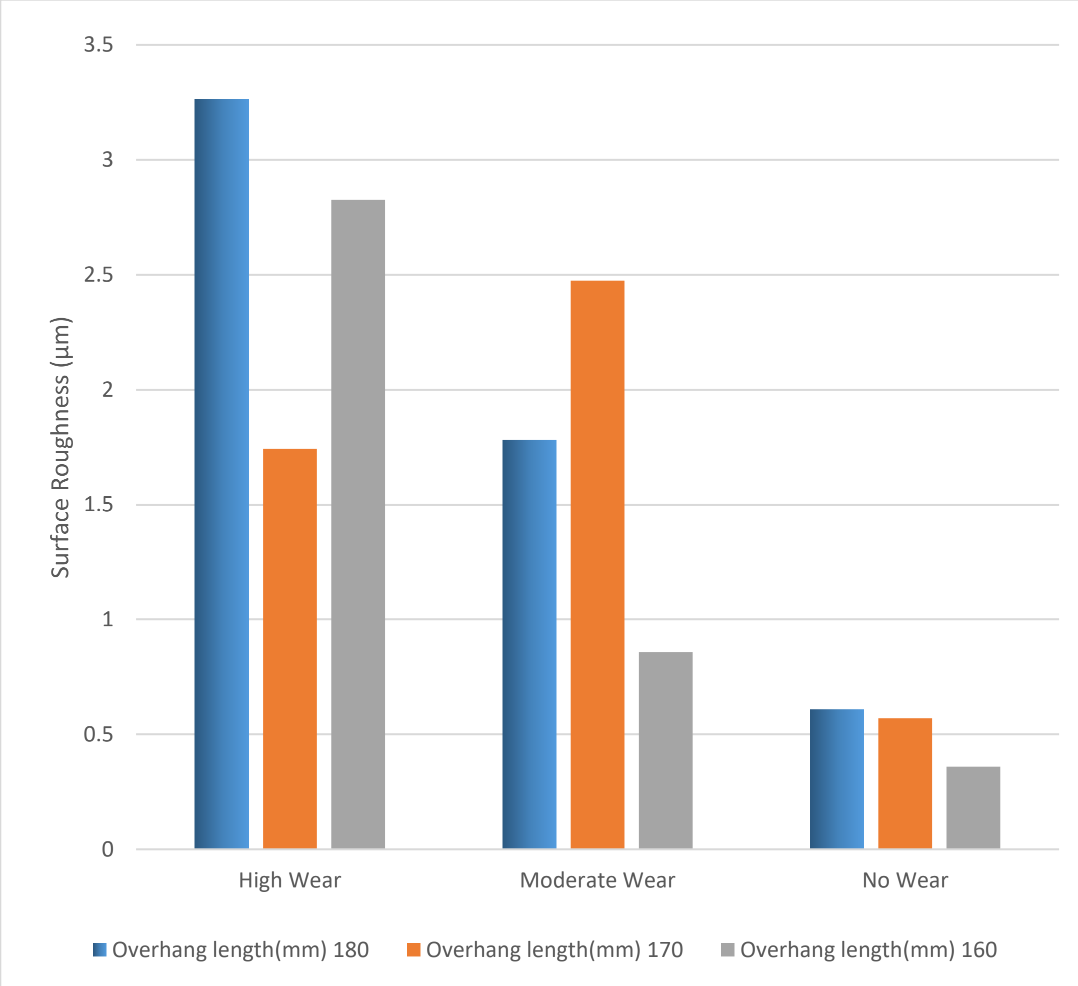


Figure 21: Surface Roughness Vs Overhang Length for normal condition

In this graphical illustration, we can see that surface roughness decreases as overhang length decreases. In the normal condition, there is some changes in case of high wear and moderate wear condition. Surface roughness was supposed to be less in overhang length of 160 mm than 170 mm in high wear.

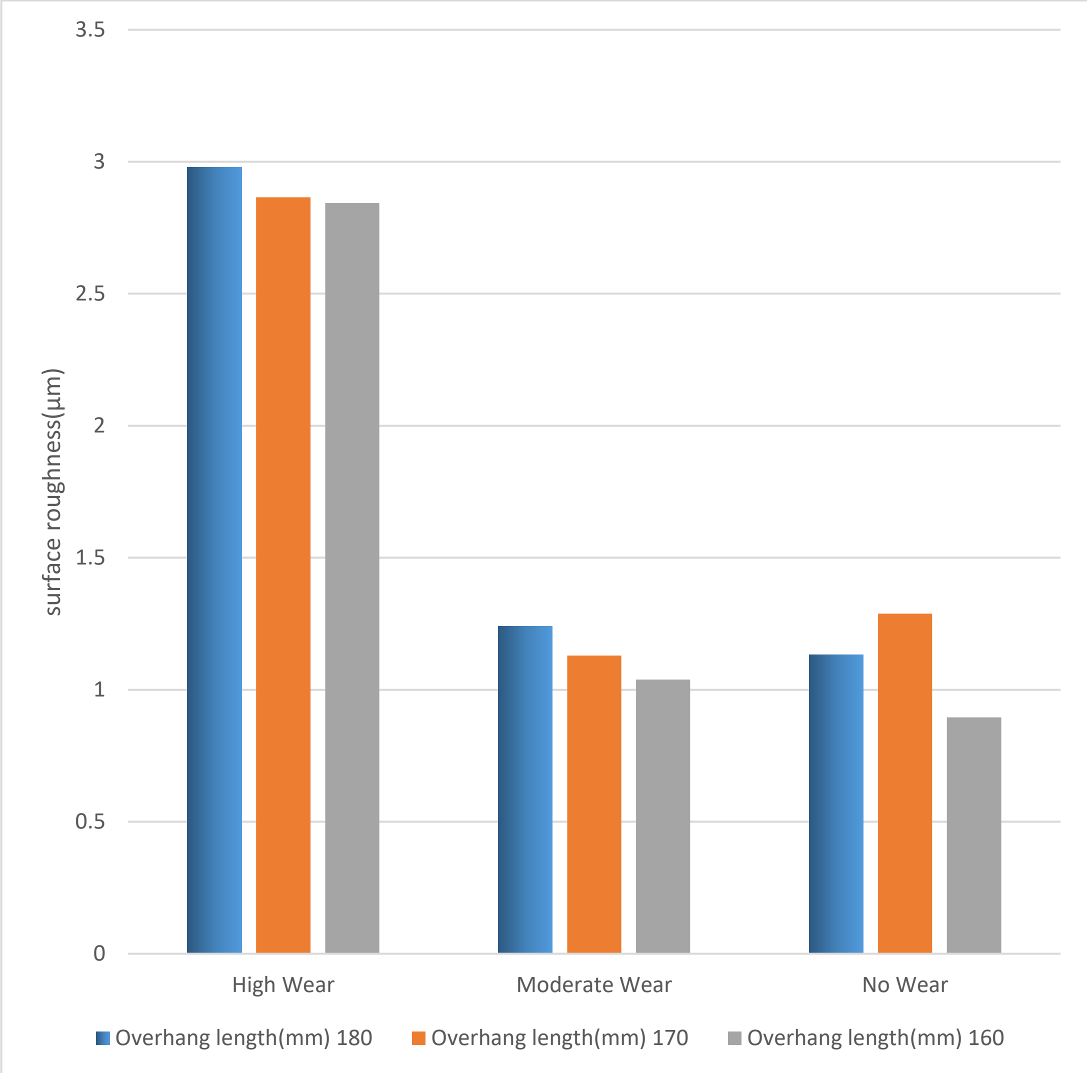
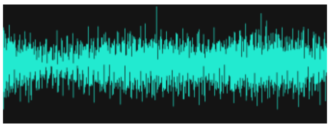
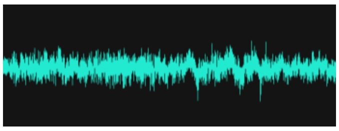
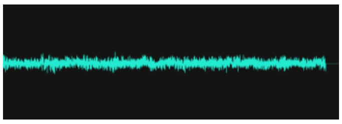
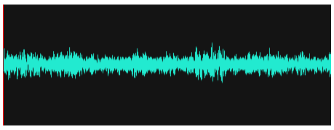
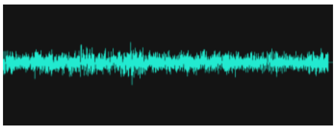


Figure 22: Surface Roughness Vs Overhang Length for Hot Condition

We notice similar type of problem in case of hot condition as well. Surface roughness was supposed to be less in 170 mm from 180 mm in the no wear condition.

SOUND WAVE COMPARISON

Condition	Normal Condition	Hot Condition
Job Piece: 1 High wear		
Job Piece: 2 High wear		
Job Piece: 3 High wear		

Here, we compared how sound wave differs in one condition in each job piece for normal and hot condition. Normal condition shows more distortion from the hot condition.

DISCUSSIONS

During the experiment, we experienced some problems while machining such as vibrational, mechanical, frictional, thermal etc. While the job piece is rotating at high rpm, it experienced high mechanical and frictional error. Beside this, the higher the overhang length, the higher vibrational error. That's why the job piece which had higher overhang length had more surface roughness value. Thermal error may have occurred during the experiment of hot air condition. We clamped the job piece into the headstock, it might not perfectly clamp at 10mm from the headstock due to the parallax error. Though noise reduction and sound filtering was done, it wasn't possible to remove all the background sounds. For that reason, there will be some change occurred in the sound wave that we got during the experiment.

CONCLUSION

In this study, surface roughness has been compared with the sound level variation at different overhang length for three different types of insert. Generally, it has been observed that with the increase of overhang length the average surface roughness value is going to be increased. Overhang length variation results the cutting process stability and insert status reflects the frictional behaviour in between the tool and the work-piece. The performance of machining is related with the stated factors and sound captured during machining will be varied at various combinations of the process and system parameters. So, in this experiment, an attempt was made to investigate and correlate the output response in terms of average surface roughness and generated sound signal during cutting process. Surface profile response, tool life, vibration may be predicted from the sound level variation. From the comparison between normal and hot condition, it was observed that, experiment which was done in hot condition had better surface roughness value and the sound wave that we got from the experiment was smoother for hot condition than normal condition. From the observation of the chips that were formed due to machining, we could say that the chips that were formed in hot condition were more continuous than normal condition.

REFERENCES

[1] G M Sayeed Ahmed, Hakeemuddin Ahmed, Syed Safiuddin Samad Experimental Investigation of Effect of Tool Length on Surface Roughness during Turning Operation and its Optimization *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),* e-ISSN:2278-1684, p-ISSN: 2320-334X Volume 7 (May. - Jun. 2013)

[2] Safeen Y Kassab, Younis K Khoshnaw 2007 The Effect of Cutting Tool Vibration on Surface Roughness of Work piece in Dry Turning Operation *Eng. & Technology* Vol 25

[3] H H Habeeb, K A Abou El Hossein, Bashir Mohamad, Jahara A Ghani and K Kadirgama 2008 Investigating of Tool Wear, Tool Life and Surface Roughness When Machining of Nickel Alloy 242 with Using of Different Cutting Tools. *Asian Journal of Scientific Research*, **1:** 222-230

[4] Anayet U Patwari, Yahya Mohammad Alfakih, Ibrahim Bamnjo Investigation of tool overhang length effects on machining responses during turning operation Annals of Faculty Engineering Hunedoara, *International Journal of Engineering* Tome XVI 2018 (Fascicule 2 May)

[5] Vladimir Aleksandrovich Rogov, Ghorbani Siamak 2013 Optimization of Surface Roughness and Vibration in Turning of Aluminum Alloy AA2024 Using Taguchi Technique World Academy of Science, Engineering and Technology; *International Journal of Mechanical and Mechatronics* Engineering Vol 7

[6] Kong Lingguo, Chen Guangjun, Wang Liang, Wang Dingwen, Chen Weidong, Zhang Ting Research on Vibration and Surface Roughness in Hard Cutting Process of Hardened Steel, *Key Engineering Materials*, ISSN: 1662-9795 Vol. 693 pp 878-883.

[7] S Thamizhmanii, K. Kamarudn, E A Rahim, A Saparudin, S Hassan Tool Wear and Surface Roughness in Turning AISI 8620 using Coated Ceramic Tool Proceedings of the World Congress on Engineering 2007 Vol 2

[8] https://www.mechanicalbooster.com/2016/11/what-is-lathe-machine-main-parts-operations-working.html

[9] https://www.mechanicalbooster.com/2016/12/types-of-chips.html

[10] https://www.britannica.com/technology/hydrometer

[11] https://www.nanoscience.com/techniques/optical-profilometry/#how

[12] https://en.wikipedia.org/wiki/Sound_recording_and_reproduction

[13] https://en.wikipedia.org/wiki/Heat_gun