

**TO STUDY THE EFFECT OF DIFFERENT OPERATING
PARAMETERS ON NOISE DURING TURNING
OPERATION IN A CENTRE LATHE MACHINE**

**A
Thesis**

**Submitted in partial fulfillment of the requirement for the
award of degree of**

**MASTER OF ENGINEERING
IN
CAD/CAM & ROBOTICS
BY
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CERTIFICATE

This is to certify that the work which is being presented in this thesis entitled "*To study the effect of different operating parameters on noise during turning operation in a centre lathe machine*" in partial fulfillment of the requirement for the award of degree of *Master of Engineering in CAD/CAM & ROBOTICS* in the *Mechanical Engineering Department, Thapar University, Patiala* is an authentic record of my own work carried out under the supervision of *Mr. Paras Kumar, Assistant Professor, Mechanical Engineering Department, Thapar University, Patiala*. The matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

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ABSTRACT

In our modern world, rapidly expanding environment one of the developing problems is that of “Noise”. In India, the industrial sector is growing rapidly and number of industries increasing at very fast rate. This has lead to noise pollution. Machine tool noise is one of the major source of noise in industries.

So, it is necessary to study noise generated by machine tools. Machine tool which is most commonly used in factory/workshop is the lathe machine. In the present work the effect of different operating parameters like cutting speed, feed and depth of cut on noise during turning operation in a centre lathe machine have been considered. First of all to find out the location where the sound pressure level is maximum, the sound pressure level measured in dB(A) near the machine at five different locations at distance of 0.5 m from the centre of each side of an machine for different combination of operating parameters. Sound power is then calculated using rectangular parallelopiped method at different cutting speed, feed and depth of cut and also predict the most significant parameter using the Taguchi method.

Frequency spectrum analysis in 1-1 octave band has been carried out at the location where the sound pressure level is maximum.

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NOMENCLATURE

SYMBOLS	DESCRIPTION
TTS	Temporary threshold shift
PTS	Permanent threshold shift
Hz	Hertz
f_{upper}	Upper limit frequency
f_{lower}	Lower limit frequency
c_{centre}	Centre frequency
Pa	Pascal
SPL	Sound pressure level
dB	Decibel
L_{eq}	Equivalent continuous sound level
L_{10}	10 percentile exceeded sound level
L_{90}	90 percentile exceeded sound level
L_{50}	Median value of sound level
L_w	Acoustic power in dB(A) (ref. 10^{-12}W)
L_p	Average sound pressure level in dB(A)
S	Hypothetical surface area
S_o	Reference area
a	Length in m
b	Breadth in m
c	Height in m

CHAPTER 1

INTRODUCTION

1.1 Introduction to Noise

In our modern world, rapidly expanding environment one of the developing problems is that of noise. Apart from the pure annoyance factor of noise, exposure to an intense sound field over a long period of time presents the risk of permanent damage of hearing. This particular problem is becoming a source of serious concern to industrial corporations, trade unions and companies.

The object of this part is to discuss the concept of noise, problems of noise and its effect on man and environment both as annoyance and as a danger to health.

The major sources of noise are:

1. Industrial noise
2. Traffic noise
3. Community noise

Out of above three sources, the source that affects the most is industrial noise. In industrial noise, mainly the noise is contributing by machine tools and the machine tool which is most commonly used in factory/workshop is the lathe machine.

Noise: Noise is conveniently and concisely defined as “unwanted sound”.

Sound: Sound waves are pressure variations produced as a result of mechanical disturbance in a material medium.

Decibel: Decibel is the logarithm of a ratio of two quantities and therefore has no units.

Decibel is defined by expression as $10\log_{10}(P/P_0)^2$.

Where,

P is the sound pressure amplitude of the measured sound.

P_0 is a reference pressure, $20\mu\text{Pa}$.

Sound Pressure (N/m ²)	Sound Pressure Level (dB)	Environmental Conditions
10 ²	134 dB	Threshold of pain
10	114 dB	Loud automobile horn (distance 1m)
1	94 dB	Inside subway train
10 ⁻¹	74 dB	Average traffic on street corner
10 ⁻²	54 dB	Living room, Typical business office
10 ⁻³	34 dB	Library
10 ⁻⁴	14 dB	Broadcasting studio
2*10 ⁻⁵	0 dB	Threshold of hearing

Table 1.1 Environmental conditions at different SPL [Ref. 25]

1.2 Sound Sources

A distinction is made between three different types of sound sources:

- 1) Point source
- 2) Line source
- 3) Plane source

1.2.1 Point source: A sound source can be considered as a point source, if its dimensions are small in relation to the distance to the receiver and it radiates an equal amount of energy in all directions. Typical point sources are industrial plants, aircraft and individual road vehicles. The sound pressure level decreases 6 dB whenever the distance to a point source is doubled.

1.2.2 Line source: A line source may be continuous radiation, such as from a pipe carrying a turbulent fluid, or may be composed of a large number of point sources so closely spaced that their emission may be considered as emanating from a national line

connecting them. The sound pressure level decreases 3 dB, whenever the distance to a line source is doubled.

1.2.3 Plane source: A plane source can be described as follows. If a piston source is constrained by hard walls to radiate all its power into an elemental tube to produce a plane wave, the tube will contain a quantity of energy numerically equal to the power output of the source. In the ideal situation there will be no attenuation along the tube. Plane sources are very rare and only found in e.g. duct systems.

When two sources radiate sound energy, they will both contribute to the sound pressure level a distance away from the sources. If they radiate the same amount of energy and the distance from the point of measurement to the sources is the same, the level will increase by 3 dB compared with the level created by one source alone.

1.3 Physical Property of Sound

1.3.1 Sound power: When sound is produced, a transfer of energy from the source to the surrounding air molecules takes place. The rate of energy transfer is called sound power. The unit of sound power is W (Watt).

The audible range of sound power extends from 10^{-9} W to more than 1000 W. 10^{-9} W is the lowest level which can be heard by a listener close to the source, and 1000 W will create immediate hearing damage. Lower levels can also create hearing damage, if the listener is exposed for a long period of time.

1.3.2 Sound intensity: When a source produces sound power (P) it will create a certain Sound intensity (I) at a distance away from the source. The intensity is a measure for the amount of power through a certain area at this distance.

None of these units can be measured directly. Their values can, however, be calculated after measurement of the sound pressure level, knowing the area over which measurements are being made. The relationship between Sound Pressure (p), Intensity (I) and Sound Power (P) can be written as,

$$p^2 \propto I \propto P \quad (1.1)$$

1.3.3 Sound pressure level: Decibel (dB) is logarithmic ratio which defines the sound pressure level L_p as follows:

$$L_p = 20 \log_{10} \frac{P}{P_0} \quad (1.2)$$

Where,

P is the sound pressure measured.

P_0 is the reference sound pressure i.e. $20 \mu Pa$ (the threshold of hearing).

This logarithmic scale has several advantages over a linear scale. The most important advantages are:

1. A linear scale would lead to the use of some enormous and unwieldy numbers.
2. The ear responds not linearly, but logarithmically to stimulus.

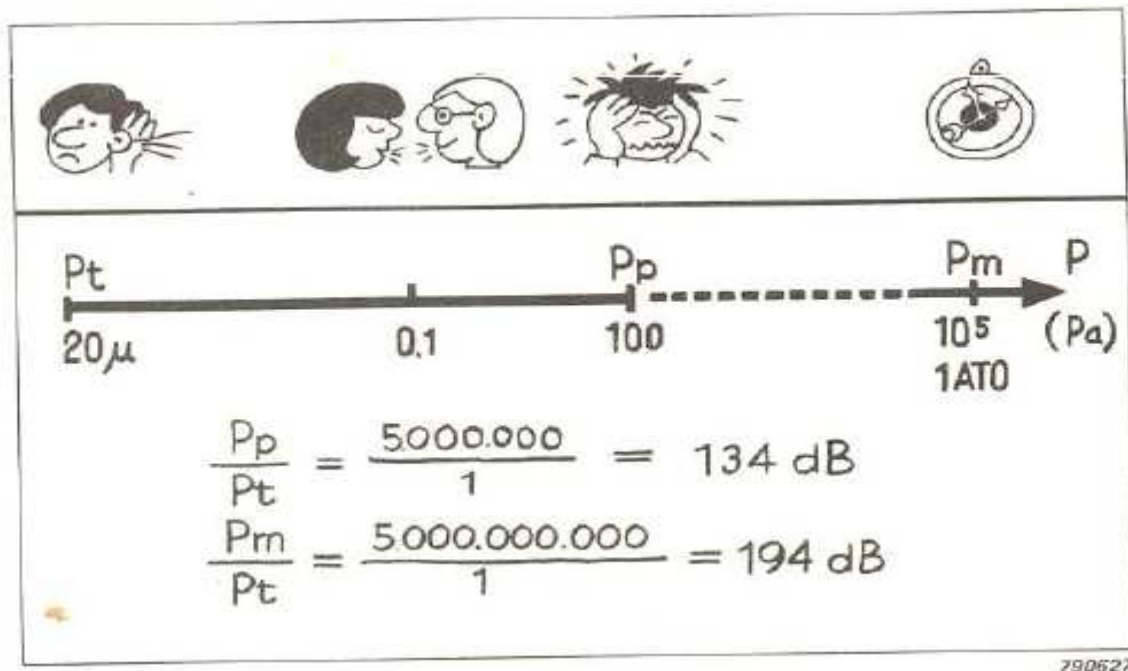


Fig. 1.1 Calculation of SPL [Ref. 25]

1.4 Characteristics of sound

1.4.1 Background Noise

When sound measurement for a machine is carried out, it is important that the background noise level is so low, that it does not have any influence on the result. This can be tested in the following manner. Measure the sound at the position where it should be measured with the source (machine) running. Switch off the machine and measure the sound level without the machine running.

If the difference is less than 3 dB measurements should be stopped until the background noise has been reduced. If the difference is between 3 and 10 dB use the curve to correct the measured value. If the difference is more than 10 dB, the background noise may be ignored.

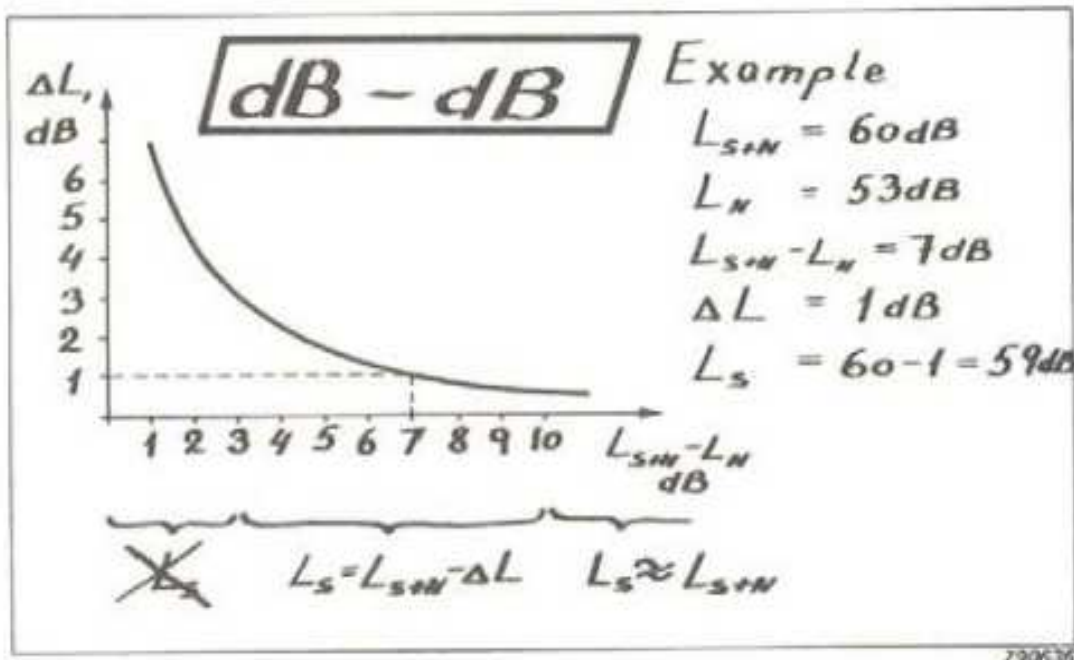


Fig. 1.2 Subtraction of background noise in dB [Ref. 25]

This is the curve for reducing the background noise. In this example, measurement without machine ON is 53 dB and with machine ON is 60 dB. So there is a difference of 7 dB and then from background noise curve, 1 dB of correction value is taken to get a corrected value. So the corrected sound pressure level is 59 dB.

1.4.2 Loudness

Loudness is a subjectively perceived attribute of sound which enables listener to order its magnitude on scale from soft to loud. It is defined as subjective intensity of sound. Based on these curves of equal loudness, the “phon” scale was logically conceived as a measure of loudness level. The loudness level of a sound in phon is the sound pressure level in dB is $2 \times 10^{-5} \text{ N/m}^2$ of a pure tone.

Non linear response of the ear:

- a) 1000 Hz tone of 40dB (40 phon) is of same loudness as
63 Hz tone of 58 dB

or

4000 Hz tone of 31dB

b) Increase in loudness for a corresponding increase in sound level depends upon frequency and on level also.

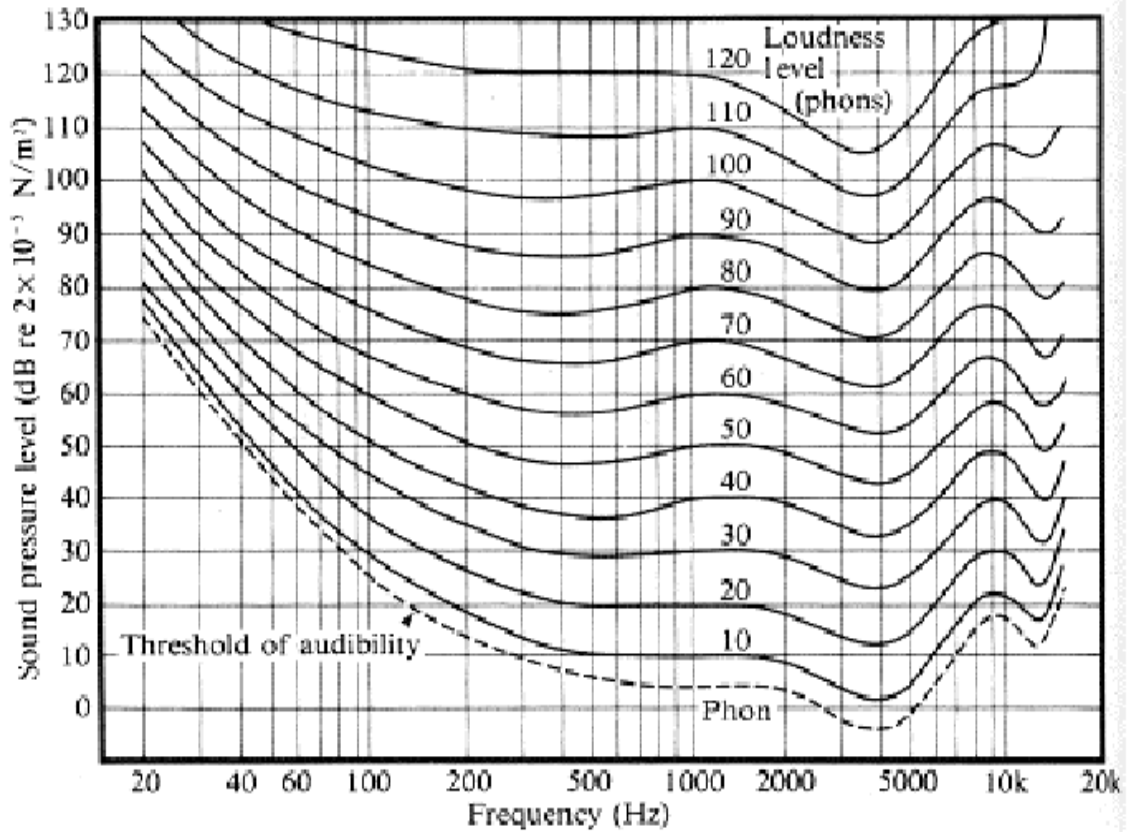


Fig. 1.3 Equal loudness contours [Ref. 25]

1.4.3 Weighting Curves

The non-linear response of the ear has led to the introduction of weighting filters, making it possible to carry out measurements, which correlate well with the response of the ear. The most commonly used of these curves is the A-weighting curve, because it gives the best correlation between the measured values and the annoyance and harmfulness of the sound signal. It follows approximately the 40phons curve in Fig.1.4. The B-weighting and C-weighting curve follow more or less than 70 phons and the 100 phons curves. The D-weighting curve follows a contour of perceived noisiness, and is used for aircraft noise measurement. Weighting filters can easily be built into portable Sound Level Meters, and the sound level measured is then given in dB(A) in case where an A-weighting filter has been used etc. Some sound level meters also have octave filters built in, or provision for connection of external filters.

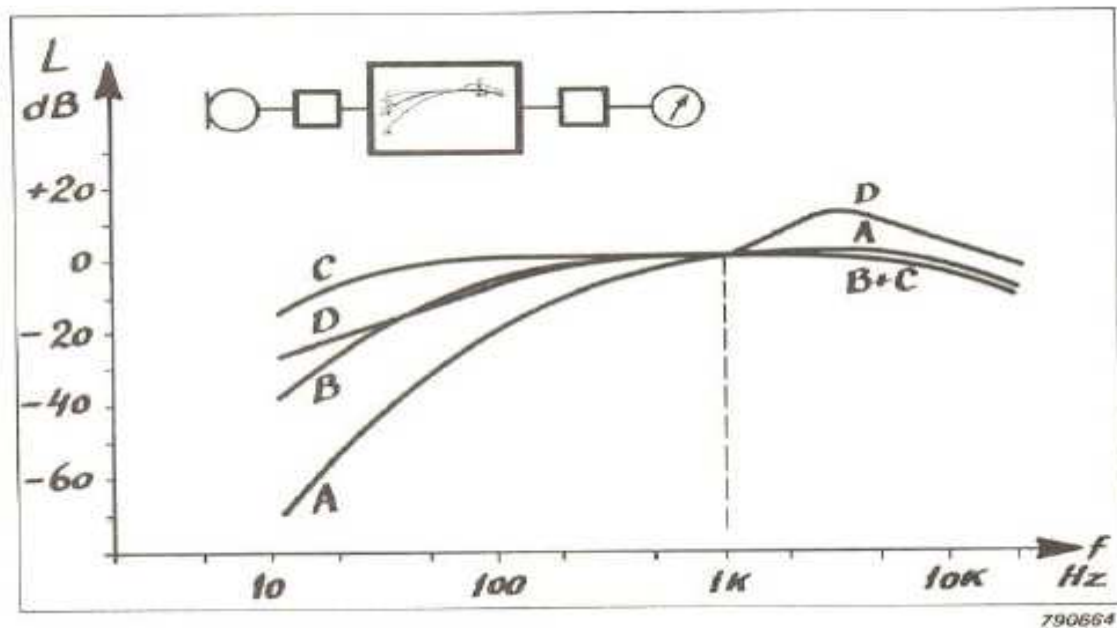


Fig. 1.4 Weighting Curves [Ref. 25]

1.4.4 Frequency Analyzer

All non-sinusoidal signals are composed of two or more sinusoidal signals. The non-sinusoidal signal can be represented in either the time domain as a function of time or in the frequency domain, where the individual frequency components are represented on a frequency scale. A noise signal will contain signals of all frequencies, or at least a broad spectrum of frequencies.

When a sound signal is investigated it is often desirable to investigate a limited part of the frequency spectrum. This can be done with the aid of a filter which will allow passage of only that part of the spectrum which lies inside the bandwidth (Δf) of the filter. A practical filter however will not have such a steep cut-off and the usual filter characteristic is together with the characteristic for an ideal filter.

The bandwidth (Δf) of the filter can be defined as the frequency range between the points, where the filter characteristic shows a reduction of 3dB, or the frequency range of an ideal filter, which would allow the same amount of power of a signal containing all frequencies to pass. The difference between the bandwidth found using these two definitions is for most filters very small.

It is common to classify a filter according to its bandwidth, and there are two classes of filters which may be encountered i.e. constant bandwidth filters and filters with a constant percentage bandwidth.

The constant band width filters have, as the name indicates, a constant band width filters have a constant ratio between bandwidth and center frequency. A special type of constant percentage bandwidth filters is the octave filters, where the upper limiting frequency is twice the lower limiting frequency $f_2 = 2 f_1$.

1.4.5 Equivalent Continuous Sound Level (L_{eq})

L_{eq} is the A-weighted energy mean of the noise level averaged over the measurement period. It can be considered as the continuous noise which would have the same total A-weighted acoustic energy as the real fluctuating noise measured over the same period of time and is defined as,

$$L_{eq} = 10 \log_{10} \left[\frac{1}{T} \int_0^T \left(\frac{P_A(t)}{P_0} \right)^2 dt \right] \quad (1.3)$$

Where, T is the total measurement time,

$P_A(t)$ is the A-weighted instantaneous acoustic pressure

P_0 is the reference acoustic pressure of 20 μ Pa.

1.5 Harmful effects of noise on human beings

The following are the various harmful effects of noise on human beings:

- 1) Reduces work efficiency.
- 2) Affects the speech communication.
- 3) May cause temporary threshold shift (TTS) / permanent threshold shift (PTS).
- 4) Induces loss of hearing ability.
- 5) Causes psychological strain and mental fatigue.
- 6) May damage the heart.
- 7) Increases the cholesterol level in the blood.
- 8) Dilates the blood vessels of the brain.
- 9) Upsets the chemical balance of the body.
- 10) Causes headache, nausea and general feeling of uneasiness.
- 11) Induces errors in “motor” performance.

12) Induces psychosis and acute mental agony.

1.6 Useful Applications of Noise

Noise is not only has harmful affects but sometimes it is very useful. Some of the examples when noise is useful:

1.6.1 Study of heart beats: Noise produced by the heart beats is very useful to diagnose the person's health accordingly.

1.6.2 Masking effects: Sometimes, it is necessary that nobody should hear the conversation between the two persons. For this, masking effect is used. For e.g., in the doctors chamber, doctor wants that nobody should hear his conversation with the patient so Dr. uses masking effect by putting a more noisy exhaust fan which make noise outside the room.

1.7 Noise Measuring Instrument

Noise measuring devices typically use a sensor to receive the noise signals emanating from a source. The sensor, however, not only detects the noise from the source, but also any ambient background noise. Thus, measuring the value of the detected noise is inaccurate, as it includes the ambient background noise. There are so many different types of instrument available to measure sound levels and the most widely used are sound level meters.

1.7.1 Elements of sound level meter

1.7.1.1 Microphone: Most measurement microphones generate a voltage that is proportional to the sound pressure at the microphone and is the electrical analog of sound waves impinging on the microphones diaphragm. The particular mechanism that converts the pressure variation into sound waves signal. Different types of microphones are:

- a) Capacitor (Condenser) Microphone
- b) Pre-polarized Microphone
- c) Piezoelectric Microphone

1.7.1.2 Amplifier: It amplifies the signal from microphone sufficiently to permit measurement of low SPL. It amplifies sound over a wide frequency range. It maintains the amplification constant.

1.7.1.3 Rectifier: It rectifies the signal from analog signal to digital signal.

1.7.1.4 Smoothing circuit: The circuit through which the sound waves are passes.

1.7.1.5 Meter: It is the part of sound level meter by which we can take observations.



Fig 1.5 Sound Level Meters

1.7.2 Steps for Measurement of Noise

(a) Calibration: Check the sensitivity (calibration) of the measuring instrument before and after each measurement.

(b) Measure the Acoustical Noise Level

1. Correction for back ground noise.
2. Correction for reflection of nearby surfaces.
3. Correction for ambient pressure.

(c) Out Door Measurement use of Windscreen

1. Wind effects can be minimized to protect microphone.
2. Wind generated noise can be reduced by fitting a wind screen.
3. Wind screen is a porous ball of open-cell plastic foam or some other porous material placed over the microphone.



Fig 1.6 Sound level meter with windscreen

1.8 Measurement of Sound Power

1.8.1 Sound power level measurement with sound pressure level: The sound power level of noise sources can be measured with the help of sound pressure level with following steps:

1. Surround the source with hypothetical surface of area S (either a hemisphere or a rectangular parallelepiped).
2. Calculate the area of this hypothetical surface if it is hemisphere, S is given by $2\pi r^2$ where r is radius of the hemisphere.
3. If it is rectangular, S is given by $ab+2(ac + bc)$, where a , b , c are its length, width and height.
4. Measure the sound pressure level at designated point on the hypothetical surface.
5. Obtain the average L_p of sound pressure level measured in the step 4.
6. Finally calculate the sound power level from the following equation.

$$L_w = L_p + 10\log(S/S_0) \quad (1.4)$$

Where,

S_0 is reference area, 1m^2 .

S is hypothetical surface area.

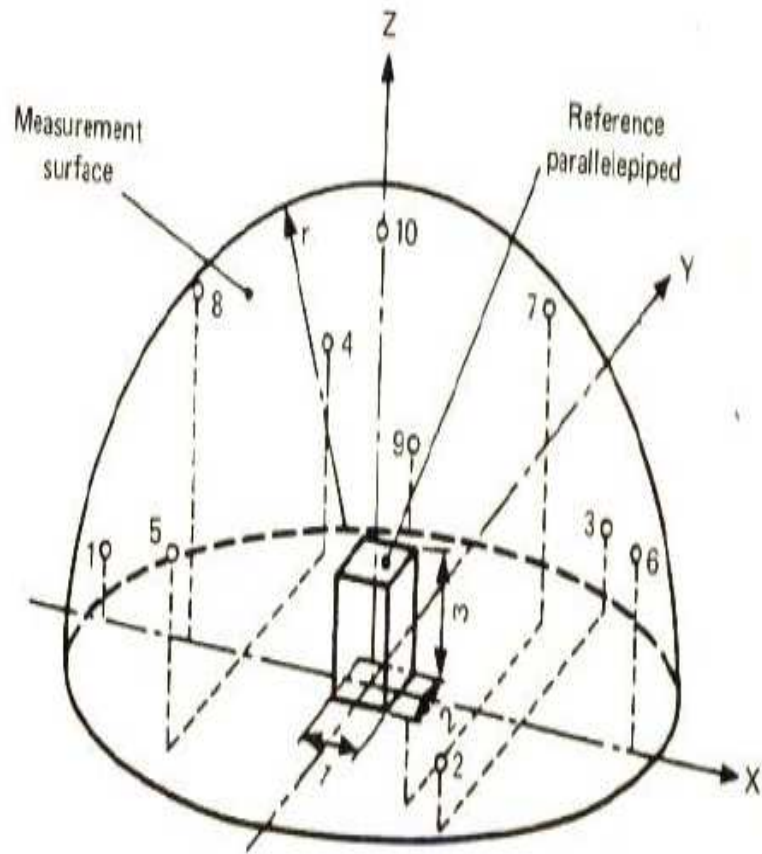


Fig.1.7 Graphical representation of micro phones position on an imaginary hemispherical surface surrounding a source [Ref. 25]

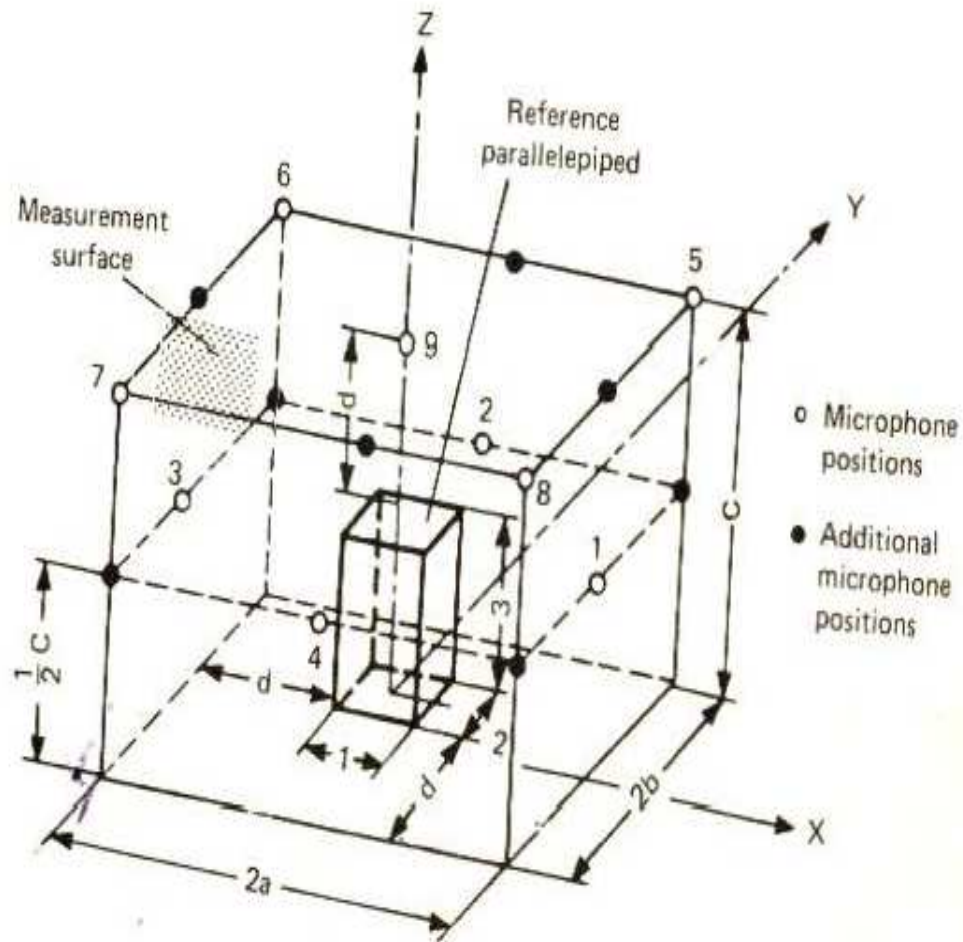


Fig.1.8 Array of microphone positions on an imaginary parallelepiped surface surrounding a source whose sound power is to be measured [Ref. 25]

1.8.2 Additional aspect of measurement correspond to the steps in the above Procedure

- 1) For the small sources whose largest dimension is significantly less than one meter. It is usually more convenient to use hemisphere than rectangular parallelepiped hypothetical measurement surface for large rectangular sources the rectangular parallelepiped surface is usually preferred.
- 2) The radius of hypothetical hemisphere should be equal to or greater than twice the major source dimension and not less than 1m for the rectangular parallelepiped, the measurement distance “d”, the perpendicular distance between the source and the measurement surface has a preferred value of 1 m.

- 3) For hemisphere the designated point of the microphone locations are shown in figure 5. The corresponding point for the rectangular parallelepiped is shown in figure 6. The sound pressure level at designated point is measured with A-weighting or in one-one octave or in one-third octave bands.
- 4) The average sound pressure level over the measurement surface, L_p is calculated from the measured sound pressure level L_p , after correction for background noise.

1.9 NOISE STANDARDS IN INDIA

Noise has been recognized as one of the unwanted by products of the industrialized society along with air, water and other pollutants. One of the earliest Noise standards available is due to the Occupational Safety and Health Act (OSHA) an acted in USA in 1971 which happens to be a land mark step in the direction of Environmental Noise Control.

In India, Noise figured only incidentally in general legislation of the Govt. of India as a Component in Indian Penal Code, Motor Vehicles Act (1939), and Industries Act(1951). Some of the states also had noise limits incorporated in certain manner in their legislation. In 1986, the Environment (Protection) Act was legislated.

A review of the status report indicates that noise Surveys were made in India in the sixties by the National Physical Laboratory, New Delhi. The findings of this survey clearly established the existence of high noise levels in Delhi, Bombay and Calcutta. An expert committee on noise Pollution was set up by the Ministry of Environment, Govt. of India, in early 1986 to look into the present status of Noise pollution in India Expert Committee submitted its report in June 1987.

The following have been identified as the Source of noise to which a man is exposed advertently or inadvertently on road, in the house, at work, in the factory, indoors or outdoors.

Group 1	Industrial Noise Automobiles Noise Domestic Appliances Noise Public Address System Noise
Group 2	Aircraft Noise Railway Noise Construction Noise Noise from Crackers

Table 1.2 Grouping of different types of noises in India [Ref. 25]

1.9.1 Permissible Sound Levels for machine tool industries in India

Sl. No.	Industry	Number of samples	Range L _p (dB(A))	Average L _p (dB(A))
1	Food Manufacture	79	85-111	92
2	Manufacture of textile	28	85-108	93
3	Sawmill and other wood mills	32	85-104	93
4	Manufacture of furniture	54	85-115	93
5	Manufacture of paper and paper products	29	85-102	92
6	Printing and Publishing	33	85-96	89
7	Manufacture of chemicals and chemical products	26	85-104	92
8	Manufacture of non metal products	22	85-110	94
9	Basic metal industry	24	85-100	92
10	Manufacture of structural metal products	82	85-108	93
11	Manufacture of metal cans and containers	83	85-118	94
12	Metal forging and stamping	45	85-105	93
13	Manufacture of fabrication metal products	139	85-115	92
14	Manufacture of machinery	96	85-120	93
15	Manufacture of electrical machinery, apparatus and appliances	38	85-108	91
16	Manufacture of electronic product and components	83	85-103	90
17	Building and repairing of ships	42	85-110	95
18	Manufacture and repair of motor vehicles	24	85-105	92
19	Manufacture of aircraft	43	85-105	92
20	Other manufactures industries	33	85-105	91
	Total Average			92

Table 1.3 Permissible Sound Levels for machine tool industries in India [Ref. 25]

1.9.2 Typical Noise Levels

- Areas with heavy industries or close to blaring loud speakers: 80-105 dB(A).
- Areas with over flying aircrafts: 90-100 dB(A).
- At railway stations, traffic junctions, busy markets: 70-90 dB(A).
- Residential areas close to traffic, industries and markets: 60-80 dB(A).
- Residential areas away from heavy traffic roads or other noisy Sources: 40-60 dB(A).

CHAPTER 2

LATHE MACHINE NOISE

2.1 INTRODUCTION OF LATHE MACHINE

A Lathe is an important and oldest known machine tool in any workshop. The job to be machined is held and rotated in a chuck, face plate, catch plate, between centres etc. A suitable cutting tool is advanced against rotating job. Since the cutting tool material is harder than the work piece, the metal is easily removed from the job in the form of chip. Cutting tool used is a single point cutting tool.

Some common operations performed are facing, turning, chamfering, parting off, drilling, knurling, boring, thread cutting etc.

2.2 THE PRINCIPAL PARTS OF LATHE MACHINE ARE SHOWN IN FIG. 2.1

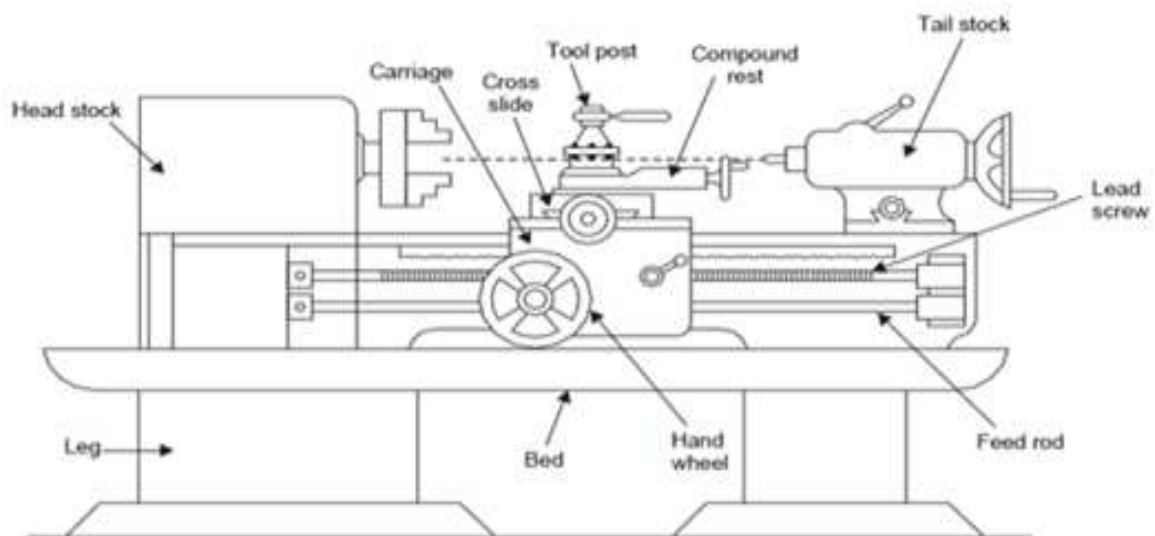


Fig.2.1 Parts of lathe machine

2.3 NOISE SOURCES

2.3.1 Gears noise: Any inaccuracies in gear profile cause unsteady forces acting on the whole transmission System. Also even if the profile is accurate, the periodic, loading of work gear tooth sets the gear wheels in resonant modes resulting in narrow frequency band vibration components. The spectrum of noise from a pair of meshing gear consists

of a Series of narrow band components at the rotational frequency of each gear and its harmonics. At tooth meshing frequency these two harmonic series coincide and the maximum noise generation usually occurs.

2.3.2 Bearing Noise: Journal bearings are very quiet provided sufficient lubrication is maintained and clearances are small. Instabilities arising principally out of shaft bending made can at times cause noise at frequencies half rotor speed. In roller and ball bearings the causes of vibration are departures from ideal profiles of inner and outer rings and of balls or rollers. Distortion through improper fitting procedures is a major cause of noisy bearings. The bearing noise is usually quite unrelated to any of the obvious modes of unsteady loadings.

2.3.3 Rotating parts noise: One of the principal cause of noise in rotating parts is the rotor imbalance. This is usually well below the frequency range of maximum structural excitation, but if the imbalance forces are sufficient to cause impacts within the bearing, significant noise may result.

2.3.4 Motor noise: The spectrum of this noise usually has large single frequency components superimposed on broadband noise, these single frequency components in the noise spectrum generated by (1) the periodic motion of its parts under the action of periodic forces, (2) the periodic interruption of the flow of cooling air, or the excitation of natural frequencies of components of the motor by magnetic forces.

2.3.5 Sliding Parts noise: In sliding parts like internal tail stock, compound rest etc. a lot of noise is produced. This noise is mainly due to the dirt, corrosion and improper fitting procedures.

2.4 DIFFERENT OPERATING PARAMETERS OF LATHE MACHINE

2.4.1 Cutting Speed: The cutting speed of a tool is the speed at which the metal is removed by the tool from the work piece. In a lathe it is the peripheral speed of the work past the cutting tool expressed in meters per minute.

$$\text{Cutting speed} = \frac{\pi dn}{1000} \text{ m/min.} \quad (3.1)$$

Where, d is the diameter of the work in mm,

and n is the r.p.m. of the spindle or work.

Here πd are constants, so the cutting speed depends on spindle speed.

2.4.2 Feed: The feed of a cutting tool in a lathe work is the distance the tool advances for each revolution of the work. Feed is expressed in millimeters per revolution.

2.4.3 Depth of cut: The depth of cut is the perpendicular distance measured from the machined surface to the uncut surface of the work piece. In a lathe the depth of cut is expressed as follows.

$$\text{Depth of cut} = \frac{d_1 - d_2}{2} \quad (3.2)$$

Where, d_1 is diameter of the work surface before machining

and d_2 is diameter of the machined surface.

Others factors remaining constant, the depth of cut varies inversely as the cutting speed.

For general purposes, the ratio of the depth of cut to the feed varies from 10:1.

2.5 CHANGE OF DIFFERENT OPERATING PARAMETERS IN LATHE MACHINE

2.5.1 Speed Selection: Main spindle RPM is selected through two shift levers situated at middle portion of head stock. Simplicity of control is an out-standing feature of this head stock. Eight distinct speeds both in the forward and reverse directions are achieved by the operation of two levers. The selections of the speeds are facilitated by an ergonomically designed speed plate as shown below. The circular speed plate has four principal segments with two zones. Turn the speed change lever (4) so that the segment containing the desired speed is brought to the top with zones dividing line in vertical position. Now shift the lever (3) towards right or left, to be in line with the zone of the desired speed.

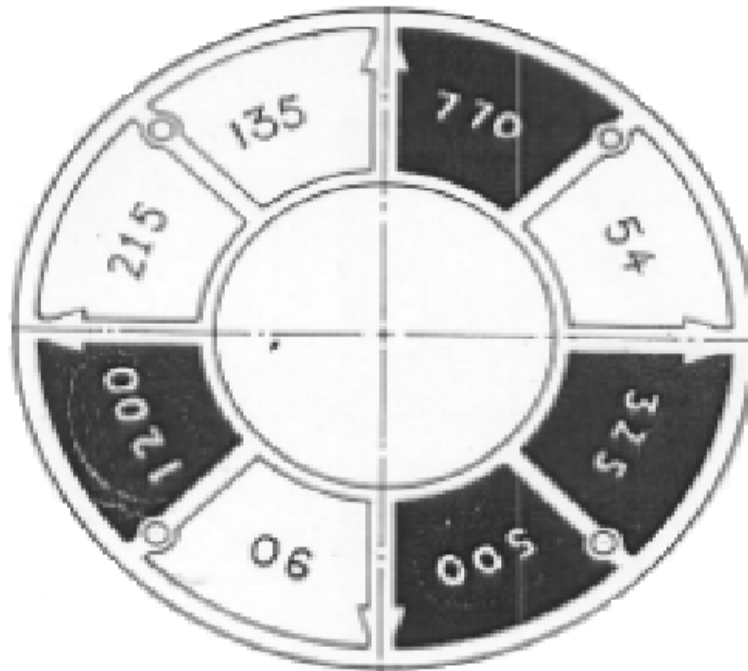


Fig. 2.2 Speed plate

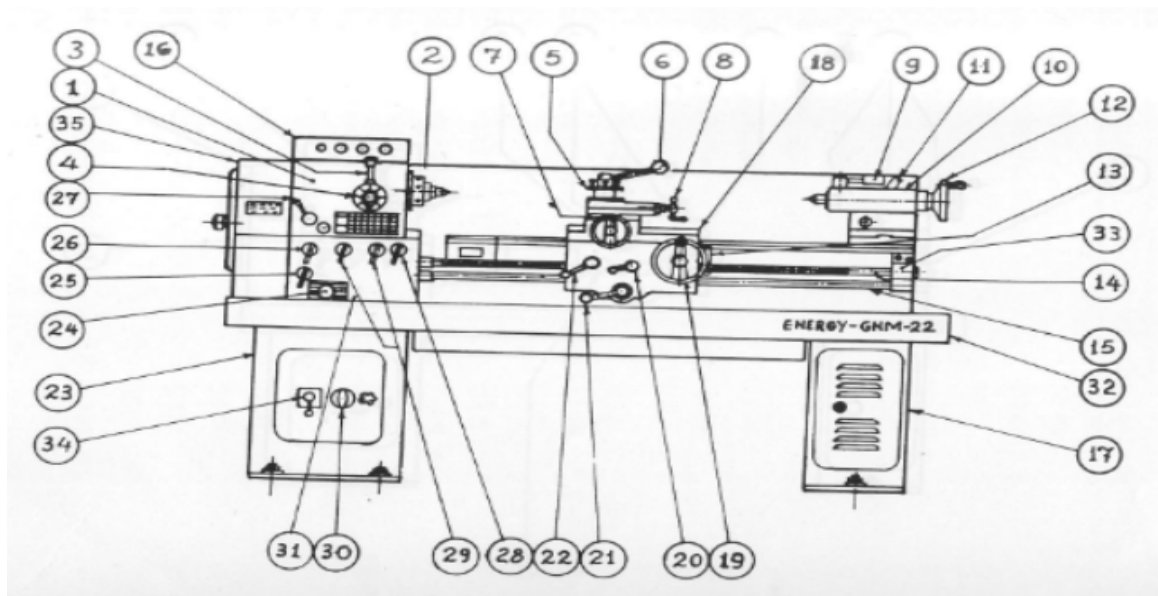


Fig. 2.3 Lathe controls (GNM-22)

The head stock pulley is directly driven by the motor through 'v' belts. The powers transmission inside the head stock to the main spindle is through an arrangement of gear, which can be shifted by the two afore mentioned levers. Do not move speed change levers 3 and 4 whilst the spindle is rotating. To free the spindle for hand rotation, bring the high/low lever (3) to middle position.

2.5.2 Feed selection: Feed motion direction is selected by lever (27) on headstock. Neutral position of this lever cuts off drive to feed train completely. GNM- 22 lathe is fitted with universal feed box permitting change from inch to metric and vice versa by flip of a lever on the feed box. Feeds directly available are given on the data plate fitted on the front of head stock with the settings of control levers, it should be noted that to operate feed selector knob (24) feed selector lock lever (25) should be brought to disengage position. After the knob has been moved to desired position the lever (25) should be turned back engage. Bring lever (27) in 'neutral' before shifting feed box levers.

2.5.3 Depth of cut: The cross-slide (7) rides on the carriage and has a feed screw that travels perpendicular to the main spindle axis. This permits facing operations to be performed, and the depth of cut to be adjusted. This feed screw can be engaged, through a gear train, to the feed shaft to provide automated 'power feed' movement to the cross-slide. On most lathes, only one direction can be engaged at a time as an interlock mechanism will shut out the second gear train.

In the whole experiment, the turning operation has done by only using the single point cutting tool (HSS). The different materials such as Aluminum (pure), Brass (yellow brass), Mild steel and Stainless steel (306) were used.

CHAPTER 3

LITERATURE REVIEW

A lot of research work has been carried out throughout the world to investigate and analyze the noise generated by centre lathe machine at different operating parameters as cutting speed, feed and depth of cut. A brief review of literature is being presented here.

R.A. Collacott [1] discussed the purpose of monitoring the condition of machine components there is evidence to suggest that the logging of sound spectra and comparison with a reference spectrum can aid in the formation of decisions regarding individual components of a machine. Since most machines operate in enclosures among other machinery, it is important to assess the problems involved in isolating individual sound sources under such conditions.

This investigation explored the response of six machine tools in a workshop when operating individually (solo) and together (simultaneously). Studies are made of the respective time-domain wave forms, decibel-frequency spectra (sound signatures) and power spectral density-frequency spectra. A comparison has been made between the resulting power spectral density spectra when all machines are working together and the computer-summed spectra of the machines when running individually. There is reason to believe that the discrete frequencies of separate components within a machine can be separated from the sound in a multiple-source sound environment. Results suggest that the greatest sensitivity is likely to be achieved within the frequency range 100 to 600 Hz and that higher frequency effects may be influenced by field reverberation effects of the enclosure.

E.J. Richards, M.E. Westcott and R.K. Jeyapalan [2] studied the introduction of legislation regarding the limits of noise in factories has led to the need for prediction of likely noise levels produced by a machine at its design stage. This paper, the first of a series, is concerned with the noise generated by impacting bodies due to the high surface accelerations during the contact period. An account is presented of the theoretical development and experimental validation of curves for the prediction of peak sound

pressure and radiated energy for collisions of compact bodies which are incapable of flexural motions. It is shown that acceleration noise energy is of the same order of magnitude as that due to ringing, that it cannot be greater than 1.5×10^{-4} times the kinetic energy input at impact, and that it falls off rapidly as the normalized contact time increases above a critical value.

Erkki Jantunen [3] presented a summary of the monitoring methods, signal analysis and diagnostic techniques for tool wear and failure monitoring in drilling that have been tested and reported in the literature. The paper covers only indirect monitoring methods such as force, vibration and current measurements, i.e. direct monitoring methods based on dimensional measurement etc. are not included. Signal analysis techniques cover all the methods that have been used with indirect measurements including e.g. statistical parameters and Fast Fourier and Wavelet Transform. Only a limited number of automatic diagnostic tools have been developed for diagnosis of the condition of the tool in drilling. All of these rather diverse approaches that have been available are covered in this study. In the reported material there are both success stories and also those that have not been so successful. Only in a few of the papers have attempts been made to compare the chosen approach with other methods. Many of the papers only present one approach and unfortunately quite often the test material of the study is limited especially in what comes to the cutting process parameter variation, i.e. variation of cutting speed, feed rate, drill diameter and material and also work piece material.

WimDesmet, Paul Sas, ReeneBoonon and Greg Pinte [4] studied about the noise pollution, caused by industrial activities, is an increasing environmental problem. Especially in machine halls with working machines such as punching machines, presses and, generating impact noise, the radiated noise level is too high to meet the regulations for noise emission. The objective of this project is to develop silent machine tools and taking measures over the machine structure, tools and components of punching machines and metal working presses. To attain this objective, innovative concepts in acoustic structural control (ASAC) and active noise control (ANC) will be used to develop new devices combining passive elements with active components.

The program started with the identification of the noise sources and transfer paths on the machines. This was carried out by means of measurements and FEM simulations. Once

the main noise sources were identified, the development of noise attenuation devices started. New algorithms, specific for transient noise, were developed to control the devices. The optimal spatial configuration of the chosen sensors and actuators, which has great influence on the efficiency of the control system, is determined. This work is carried out on a small scale representative demonstrator. Based on the obtained results, the devices will be redimensioned for the large scale machines and evaluated.

Kurasawahideo, Hanedayoshiaki and Miyaoyoshikazu [5] studied about recently environmental problem becomes important more and more in domestic and overseas. The region of this problem has the very wide field like global warming, deforestation, acid rain. Here, the noise in the environment was noticed, and also authors had the interest for the noise in the working environment. In this paper, the noise of machine tool in technology education center in our school was measured by the sound level meter. The results show that the noise level of the most machine tool does not exceed the working environment criteria for the noise.

Hingginson and R.F. [6] discussed the noise pollution caused by industrial activities is an environmental problem with increasing importance in Europe. Most mechanical machinery, specially machine tools, produce excessive noise and workers can suffer physical and psychological harm in the long term. Although a number of European directives regulate noise emissions, machinery makers have no guides for noise diagnosis and acoustic solutions to achieve these limits. Until now most of the work done to reduce noise levels is related to global machine enclosures (mainly by end users), which is not an efficient solution. In this project the problem is tackled by machine makers, defining appropriate strategies that combine simultaneously tool and structural modifications, and damping/absorbent devices. This way better result can be obtained with less cost than the traditional enclosures approach, increasing also manufacturer's competitiveness.

KarthikeyanSampath, Shiv G. Kapoor and Richard E. Devor [7] studied a cutting noise prediction model is developed to relate the cutter-work piece vibrations to the sound pressure field around the cutter in the high-speed face-milling process. The cutter-work piece vibration data are obtained from a dynamic mechanistic face-milling force simulation model. The total noise predicted, based on both cutting noise and aerodynamic noise prediction, compares well to the noise observed experimentally in the face-milling

process. Using the model, the effects of various machining and cutter geometry parameters are studied. It is shown that cutter geometry, machine dynamics, and cutting speed all play important roles in determining overall noise in face milling.

Desmons L. and Kergomard J. [8] studied the standard, together with the basic noise emission standards, describes the mechanical and acoustical specifications necessary for a reproducible test method for the determination of airborne noise emitted by woodworking machines. In normative annexes operating conditions, microphone positions and data sheets for the measurement of the noise emission of 19 types of woodworking machines are specified.

Lars Håkansson, Sven Johansson, Ingvar Claesson [9] studied a frequent problem in the manufacturing industry today is the vibrations or chatter induced by metal cutting, e.g. turning, milling and boring operations. Vibrations in boring operations or internal turning operations, for example, are inevitable and constitute a major problem for the manufacturing industry. Tool vibrations in metal cutting affect the result of machining, particularly the surface finish. Furthermore, tool life is correlated with the degree of vibration and acoustic noise introduced. Generally, tool vibrations are related to a low-order bending mode of, for example, the tool holder shank in external turning, the boring bar in internal turning, spindle-cutter assembly in milling, etc. Tool chatter or vibration problems in internal turning or milling may be reduced, for example, by using boring bars and milling adapters with passive tuned dampers. These are usually manually tuned to increase the dynamic stiffness of the boring bar or milling adapter at one of the eigen frequencies of its low-order bending modes. Active control approaches for the attenuation of the bending motion of boring bars, tool holder shanks and spindle-cutter assembly in milling have been developed; such approaches involve both adaptive and time-invariant feedback control. In addition, prediction and control methods for controlling cutting data to maintain stable cutting, i.e. to avoid cutting data resulting in chatter, have been developed.

Astrup Torben [10] studied the noise generation by impacting bodies due to the high surface accelerations during the contact period. An account is presented of the theoretical development and experimental validation of curves for the prediction of peak sound

pressure and radiated energy for collisions of compact bodies which are incapable of flexural motions. It is shown that acceleration noise energy is of the same order of magnitude as that due to ringing, that it cannot be greater than 1.5×10^4 times the kinetic energy input at impact and that it falls off rapidly as the normalized contact time increases above a critical value.

Cutler-Hammer [11] studied the most troublesome electrical noise source in industrial control systems, the "showering arc," and the resulting induced noise in adjacent lines is characterized by oscillograms and other measurements. It is shown that shunt capacitance due to wiring can increase the severity of this noise. Transient voltage peaks of 17 000 V have been observed; 2000 V peaks are common in 120-V ac systems. Malfunction of control systems due to these transients can be prevented by proper isolation shielding techniques or elimination of the noise at its source. A method to provide assistance in the selection of a capacitor quench circuit is presented, showing that capacitors of not more than 0.5 μF are adequate.

P.E. Gygax [12] discussed the cutting dynamics should not be restricted only to self-excited chatter vibrations. Transient disturbances are superimposed on stable working conditions and these dynamic components provide useful information on the real behavior of the whole machining process. Cutting dynamics therefore include the analysis of such signals in the entire frequency range. An introduction to the basic dynamics of milling processes is presented. Milling is a cutting operation during which the periodic sequence of cutting edges generates periodic time signals with discrete force and vibration spectra. A single cutting pulse from the series of successive cuts leads to a periodic time function and thus to a continuous spectrum. Since the dynamic behavior is known at all frequencies a study of the influence of various cutting conditions and the interactions between the cutting process and the machine tool structure is possible. The discrete spectrum of a real cut involving many teeth can be deduced from the corresponding single cutting pulse. A simple cutting force model was assumed in the theoretical analysis in order to give an initial rough idea of the fundamental properties of the milling pulses (frequency content of the spectra, spatial excitation locus and excitation ratio) as a function of the most important parameters (total cutting angle, up and down milling, symmetrical and asymmetrical cut and number of teeth). The computed results were compared with experimentally obtained data.

M.F. White and R.G. White [13] studied the current trend in dynamic testing is towards short duration, transient testing in the field followed by detailed computer analysis of the data at some later time. For many applications, tests must be carried out in a noisy environment, such as in frequency response studies of operating machinery and vibration tests on buildings or ships where the excitation power source is small and produces a low level response compared with ambient vibration levels. The use of time domain averaging is demonstrated and it is shown to be a suitable signal enhancement procedure for testing in poor signal to noise ratio conditions, when using a transient excitation technique. The limitations and accuracy of the technique are discussed and examples of practical application are given.

Kaminski T. and Wendeker M. [14] presented an overview of observations from almost 1.5 years of practical experience with acoustic intensity measurements. The often difficult working conditions of acoustic consultants mean that we tend to make demands on the measuring methods and the instrumentation that presently cannot easily be met. Therefore the instrumentation should be improved in order to increase both the dynamic and the frequency range. Further development of “real-time” control of measurement quality is also desirable, i.e. the possibility of surveying the quality of the result during or immediately after the measurement is performed.

S. Devos, B. Stallaert, G. Pinte, W. Symens, P. Sas and J. Swevers [15] studied this paper presents an active bearing for reducing the radiated noise of rotating machinery. This modular bearing uses piezo stacks for actuation and both force and acceleration measurements as sensing signal.

The bearing is tested on an experimental test bed comprising a rotating shaft, which is mounted in a frame. Noise is radiated by a plate that is attached to the frame. The set-up is designed such that in the frequency range of interest, up to 1 kHz, several plate resonances, frame resonances and the shaft resonance show up. To evaluate different control approaches, a simplified model of the setup was made. Based on the simulation results, a combination of feedback and repetitive controllers are implemented, using force and acceleration signals. This way, a noise reduction of more than 10 dB is achieved at the most important resonance frequencies of the system below 1 kHz. Experiments have also

shown that the shaft vibration is significantly reduced around its resonance frequency, which is also beneficial with respect to fatigue and failure of the machine.

E. Buckwar, R. Kuske, B. L. Esperance, and T. Soo [16] considered the effect of random variation in the material parameters in a model for machine tool vibrations, specially regenerative chatter. We show that fluctuations in these parameters appear as both multiplicative and additive noise in the model. We focus on the effect of additive noise in amplifying small vibrations which appear in subcritical regimes. Coherence resonance is demonstrated through computations, and is proposed as a route for transitions to larger vibrations. The dynamics also exhibit scaling laws observed in the analysis of general stochastic delay differential models.

Matti Rantatalo¹, Kouros Tatar and Peter Norman [17] studied of finding an optimum process window to avoid vibrations during machining is of great importance; especially when manufacturing parts with high accuracy and/or high productivity demands. In order to make more accurate predictions of the dynamic modal properties of a machining system in use, a non-contact method of measuring vibrations in the rotating spindle is required. Laser doppler vibrometry (LDV) is a non-contact method, which is commonly used for vibration measurements. The work presented consists of an investigation into the use of LDV to measure vibrations of a rotating tool in a milling machine, and the effects of speckle noise on measurement quality. The work demonstrates how the axial misalignment and the roundness of a polished shaft can be evaluated from LDV measurements.

Jonasson, H.G. [18] studied this project proposes the noise measurement and the operator's noise exposure evaluation for both traditional and NC (Numerical Control) machine tools. Six types of traditional machine tools, such as the lathe, mill machine, horizontal push cut shaper, surface grinder, drill machine, abrasive machine are considered as well as the NC lathe and NC machine center. One of the objectives of the project is to determine the sound power level of machine tools and so forth the machine noise level can be declared. Another is to determine the machine's exposure. The daily exposure of the operator can then be evaluated. The operating conditions of each machine tool, including both the work cycle and singular type conditions, are first defined. The A-weighted sound pressure level of the machine tool can then be measured at a defined

measurement point, so as to determine the sound power level. Both the time domain data will be recorded for further evaluation of machine tools noise. The machine noise level can also be declared. In order to determine the machine exposure, the microphone is positioned near the operator's ear. The A-weighted sound pressure level can then be measured for both work cycle and singular type operating conditions. The 5-dB equivalent sound pressure level is calculated for work cycle conditions, while the equivalent sound pressure level is determined for singular type conditions. The machine exposure can then be obtained based on the measurement result. The operator's daily exposure can then be further determined according to the actual operating conditions. The predicted exposure will also be compared with on-site measurement of a dose meter imposed on the operator for the verification of the prediction method. The proposed project can not only provide a systematic methodology for the evaluation of machine noise but also present the method for the prediction of the operator's exposure. The noise declaration technique of machine tools is very important and requirement for the manufacturers who intend to export their products to EC countries. Based on the measurement results, the factory noise can also be further evaluated. The developed evaluation technique can be applied to other types of machines and adopted for the legislation concern of worker's hearing damage.

Pichai Pamanikabud, Prakob Vivitjinda [19] discussed the Laser doppler vibrometry (LDV) is a well-established non-contact method, commonly used for vibration measurements on static objects. However, the method has limitations when applied to rotating objects. The LDV signal will contain periodically repeated speckle noise and a mix of vibration velocity components.

In this paper the crosstalk between vibration velocity components in laser vibrometry measurements of a rotating dummy tool in a milling machine spindle is studied. The spindle is excited by an adaptive magnetic bearing (AMB) and the response is measured by LDV in one direction and inductive displacement sensors in two orthogonal directions simultaneously. The work shows how the LDV crosstalk problem can be avoided if the measurement surface is optically smooth, hence the LDV technique can be used when measuring spindle dynamics.

C. H. Oppenheimer and S. Dubowsky [20] presented a methodology for predicting noise and vibration of machines and their support structures. Included is a heuristic energy-based criterion to assess the importance of dynamic coupling between a mechanism and its support structure based on a simplified analysis of a mechanism operating on a rigid base, which neglects the coupling. Also included is an analysis method that considers the coupling and to be used when the criterion reveals important coupling. The methodology is implemented using highly idealized closed form and more elaborates numerical descriptions and is checked against vibration and sound measurements of a plate subjected to periodic impacts by balls and a beam that rattles within a clearance bearing. The energy-based criterion is found to indicate situations in which mechanism-support coupling affects noise radiation. In some cases the coupling is observed to significantly affect vibration and noise radiation of the support structure, while having a relatively minor effect on mechanism response. Both the simple closed form and numerical descriptions are found to predict noise trends due to variations in machine speed and bearing clearance, and the numerical descriptions more accurately predict overall and band levels of noise radiation.

J. S. Sexton, R. D. Milne and B. J. Stone [21] studied the rate at which metal can be removed by a machine tool is often limited by the onset of an instability commonly called 'chatter'. It has been suggested that greater widths of cut could be achieved without chatter on a given machine by modulating the spindle speed continuously. A stability analysis is presented which gives, for any mean spindle rotation speed and degree of modulation, the limiting width of cut for chatter-free cutting. The machine tool is represented by a simple mass/spring/damper system, only the case of a single cutter is considered; however, extension of the analysis to more complex models is straightforward. The analysis indicates that a modest increase in useable width of cut is given by using spindle speed modulation. Results are compared with corresponding results obtained from an analogue computer simulation of the machine tool/cutter system.

The above literature survey gave an idea to take a problem on Lathe machine noise. The aim is to study the effect of different operating parameters like cutting speed, feed and depth of cut on lathe machine during turning operation. To find the effectiveness of these operating parameters on noise with different materials by measurements of acoustic power, sound pressure level and frequency spectrum.

CHAPTER 4

DESIGN OF EXPERIMENT

4.1 Introduction to design of experiment

Design of Experiment (DOE) is a structured, organized method that is used to determine the relationship between the different factors (Xs) affecting a process and the output of that process (Y). This method was first developed in the 1920s and 1930, by *Sir Ronald A. Fisher*, the renowned mathematician and geneticist.

Design of Experiment involves designing a set of experiments, in which all relevant factors are varied systematically. When the results of these experiments are analyzed, they help to identify optimal conditions, the factors that most influence the results, and those that do not, as well as details such as the existence of interactions and synergies between factors.

DOE methods require well-structured data matrices. When applied to a well-structured matrix, analysis of variance delivers accurate results, even when the matrix that is analyzed is quite small.

Experimental design is a strategy to gather empirical knowledge, i.e. knowledge based on the analysis of experimental data and not on theoretical models. It can be applied whenever you intend to investigate a phenomenon in order to gain understanding or improve performance.

Design of Experiments (DOE) is widely used in research and development, where a large proportion of the resources go towards solving optimization problems. The key to minimizing optimization costs is to conduct as few experiments as possible. DOE requires only a small set of experiments and thus helps to reduce costs.

There are many types of design of experiments applied in research and development but out of which the most efficient and commonly used method of design of experiment is “Taguchi”.

4.1.1 Taguchi method:

The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. Taguchi developed a method for designing experiments to investigate how different parameters affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies. Instead of having to test all possible combinations like the factorial design, the Taguchi method tests pairs of combinations. This allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources. The Taguchi method is best used when there are an intermediate number of variables (3 to 50), few interactions between variables, and when only a few variables contribute significantly.

4.1.1.1 Orthogonal arrays:

Taguchi’s orthogonal arrays are highly fractional designs, used to estimate main effects using only a few experimental runs. These designs are not only applicable to two level factorial experiments, but also can investigate main effects when factors have more than two levels.

An orthogonal array is a type of experiment where the columns for the independent variables are “orthogonal” to one another.

The Taguchi arrays can be derived or looked up. Small arrays can be drawn out manually; large arrays can be derived from deterministic algorithms. Generally, the arrays are selected by the number of parameters (variables) and the number of levels (states). Analysis of variance on the collected data from the Taguchi design of experiments can be used to select new parameter values to optimize the performance characteristic. The data

from the arrays can be analyzed by plotting the data and performing a visual analysis, ANOVA, bin yield and Fisher's exact test, or Chi-squared test to test significance.

4.1.1.2 Taguchi Method Design of Experiments

The general steps involved in the Taguchi Method are as follows:

- 1) Define the process objective, or more specifically, a target value for a performance measure of the process. This may be a flow rate, temperature, etc. The target of a process may also be a minimum or maximum.
- 2) Determine the design parameters affecting the process. Parameters are variables within the process that affect the performance measure such as temperatures, pressures, etc. that can be easily controlled. The number of levels that the parameters should be varied at must be specified.
- 3) Create orthogonal arrays for the parameter design indicating the number of and conditions for each experiment. The selection of orthogonal arrays is based on the number of parameters and the levels of variation for each parameter.
- 4) Conduct the experiments indicated in the completed array to collect data on the effect on the performance measure.
- 5) Complete data analysis to determine the effect of the different parameters on the performance measure.

4.1.1.3 Determining Parameter Design Orthogonal Array

The effect of many different parameters on the performance characteristic in a condensed set of experiments can be examined by using the orthogonal array experimental design proposed by Taguchi. Once the parameters affecting a process that can be controlled have been determined, the levels at which these parameters should be varied must be determined. Determining what levels of a variable to test requires an in-depth understanding of the process, including the minimum, maximum, and current value of the parameter. If the difference between the minimum and maximum value of a parameter is large, the values being tested can be further apart or more values can be tested. If the range of a parameter is small, then less values can be tested or the values tested can be closer together. For example, if the temperature of a reactor jacket can be varied between

20 and 80 degrees C and it is known that the current operating jacket temperature is 50 degrees C, three levels might be chosen at 20, 50, and 80 degrees C. Also, the cost of conducting experiments must be considered when determining the number of levels of a parameter to include in the experimental design. Typically, the number of levels for all parameters in the experimental design is chosen to be the same to aid in the selection of the proper orthogonal array.

Knowing the number of parameters and the number of levels, the proper orthogonal array can be selected. Using the array selector table shown below, the name of the appropriate array can be found by looking at the column and row corresponding to the number of parameters and number of levels. Once the name has been determined (the subscript represents the number of experiments that must be completed), the predefined array can be looked up. These arrays were created using an algorithm Taguchi developed, and allows for each variable and setting to be tested equally. For example, if we have three parameters (voltage, temperature, pressure) and two levels (high, low), it can be seen the proper array is L4. The levels designated as 1, 2, 3 etc. should be replaced in the array with the actual level values to be varied and P1, P2, P3 should be replaced with the actual parameters (i.e. voltage, temperature, etc.)

		Number of Parameters (P)																															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
Number of Levels	2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	
	3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36								
	4	L16	L16	L16	L16	L32	L32	L32	L32	L32																							
	5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50																					

Table 4.1 Array selector

In our experiment, the lathe sound pressure level of noise depends upon the different operating parameters such as depth of cut, feed and spindle speed. The possible values for each are as follows:

In the case of Aluminium & Brass:

Parameters	Levels			
	1	2	3	4
Depth of cut	1 mm	2 mm	3 mm	4 mm
Feed	0.089 mm/rev.	0.111 mm/rev.	0.133 mm/rev.	0.166 mm/rev.
Speed	54 RPM	135 RPM	500 RPM	1200 RPM

In the case of Mild steel & Stainless steel:

Parameters	Levels			
	1	2	3	4
Depth of cut	0.5 mm	1 mm	1.5 mm	2 mm
Feed	0.089 mm/rev.	0.095 mm/rev.	0.102 mm/rev.	0.111 mm/rev.
Speed	54 RPM	135 RPM	325 RPM	770 RPM

Table 4.2 Levels of parameters

In both cases there are 3 parameters, and each one has 4 levels. The highest number of levels is 4, so we will use a value of 4 when choosing our orthogonal array. Using the array selector above, we find that the appropriate orthogonal array is L16:

In the case of Aluminium & Brass

In the case of Mild steel & Stainless steel

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)
1	1	0.089	54
2	1	0.111	135
3	1	0.133	500
4	1	0.166	1200
5	2	0.089	135
6	2	0.111	54
7	2	0.133	1200
8	2	0.166	500
9	3	0.089	500
10	3	0.111	1200
11	3	0.133	54
12	3	0.166	135
13	4	0.089	1200
14	4	0.111	500
15	4	0.133	135
16	4	0.166	54

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)
1	0.5	0.089	54
2	0.5	0.095	135
3	0.5	0.102	325
4	0.5	0.111	770
5	1	0.089	135
6	1	0.095	54
7	1	0.102	770
8	1	0.111	325
9	1.5	0.089	325
10	1.5	0.095	770
11	1.5	0.102	54
12	1.5	0.111	135
13	2	0.089	770
14	2	0.095	325
15	2	0.102	135
16	2	0.111	54

Table 4.3 Orthogonal array

On the basis of above orthogonal arrays, conducted the experiment in both the cases. The collected data from the arrays can be analyzed by plotting the data and performing a visual analysis, ANOVA, bin yield and Fisher's exact test, or Chi-squared test to test significance.

4.2 Analysis of variance (ANOVA)

Analysis of Variance (ANOVA) is a statistical method used to compare two or more means. It may seem odd that the technique is called "Analysis of Variance" rather than "Analysis of Means". The name is appropriate because inferences about means are made by analyzing variance.

$$\text{Variance} = \frac{\text{Sum of squares of deviations}}{\text{Degree of freedom of factor}} \quad (4.1)$$

For analysis of variance of the collected data on the effect of operating parameters, first to determine the followings:

- 1) Sum of squares
- 2) Degree of freedom

4.2.1 Sum of squares:

In the experiment, calculate sum of squares for different parameters such as depth of cut, feed and speed. The formulae are as follows:

Factor Sum of Squares (SS_A) - Squared deviations of factor (A) averages from overall average.

$$SS_A = \left[\sum_{i=1}^{k_A} \left(\frac{A_i^2}{n_{Ai}} \right) \right] - \frac{T^2}{N} \quad (4.2)$$

Where,

A = Factor

A_i/n_{Ai} = Average of all observations under A_i level

T = Sum of all observations

\bar{T} = Average of all observations = T/N

n_{Ai} = Number of all observations under A_i level

Total sum of square: Sum of squares of observations from overall average.

$$SS_T = \sum_{i=1}^N (y_i - \bar{T})^2 \quad (4.3)$$

Where,

N = Number of response observations

\bar{T} is the mean of all observations

y_i is the i_{th} response

Error Sum of Squares: Squared deviations of observations from factor (A) averages.

$$SS_{(Error)} = SS_T - \sum_{i=1}^N (SS_{Ai}) \quad (4.4)$$

Where,

SS_{Ai} = Factor sum of square of i_{th} factor

4.2.2 Degree of freedom:

Rules:

- 1) The overall mean always uses one degree of freedom.
- 2) For each factor A, B, C.....; if the number of level are n_A , n_B , ..., for each factor, **the degree of freedom = number of levels – 1**; for example, **the degree of freedom for factor A = n_A-1 and B = n_B-1 .**
- 3) For any two factor interaction, for example, **AB** interaction, **the degree of freedom = $(n_A-1)*(n_B-1)$.**

In the experiment,

Number of experiment = 16

Number of factor = 3

Number of levels = 4

Now,

Total degree of freedom = $16 - 1 = 15$

Degree of freedom for each factor = $4 - 1 = 3$

Degree of freedom for all factors = $3 * 3 = 9$

Degree of freedom for error = $15 - 9 = 6$

4.2.3 F-Test: The F- test is most commonly used in Analysis of Variance (ANOVA). The formula is,

$$F = \frac{\text{variance of factor}}{\text{variance of error}} \quad (4.5)$$

4.2.4 T-Test: A statistical test comparing the distribution of two means or proportions for the purpose of determining whether they are significantly different.

4.2.5 F-critical value: It provides the significant status of the individual factor which affecting the measure, whether the factor is significant or not.

CHAPTER 5

EXPERIMENTAL SET-UP AND MEASUREMENTS

5.1 Experimental Set-up

To study the noise generated by an lathe machine, the parameters like sound pressure level are required to study in different operating conditions like cutting speed, feed and depth of cut. Experimental set up of centre lathe machine is shown in fig. 5.1.



Fig. 5.1 Centre Lathe Machine

The machine was manufactured by PADMINI LATHES (P) LTD. The modal name is ENERGY GNM-22. This lathe machine consists of various control panels to control feed, cutting speed and depth of cut.

The technical specifications of lathe machine are as follows:

BED

Length of bed : 1554 & 1800 mm

Width of bed : 240 mm

CAPACITY

Height of center : 175 mm

Distance between centers : 700 & 1000 mm

Swing over bed : 350 mm

Swing in gap : 510 mm

Swing over cross slide : 200 mm

HEAD STOCK

Hole through spindle : 40 mm

No. of spindle speeds : 8, 54-1200 RPM.

Types of spindle nose : taper nose

Taper bore in spindle sleeve : MT-3

THREADS & FEEDS

Metric : 48/ 0.25-15

Inch : 48/ 2-120

Longitudinal feeds : 24/ 0.03-2.0 mm/rev.

SADDLE & SLIDES

Cross slide travel : 225 mm

Top slide travel : 75 mm

TAIL SOCK

Maximum travel of sleeve : 110 mm

Morse taper of sleeve : MT-3

ELECTRICALS : 2 H.P. Motor, 50 Hz., 440 V-AC.

5.2 Measurements

Measurement procedure of different noise parameters contain calculation of sound power, measurement of sound pressure level at different locations (A, B, C, D & E) and measurement of sound pressure level for frequency spectrum in 1-1 octave band are discussed below:

5.2.1 Measurement of Sound Power: Calculation of sound power is done by two methods rectangular parallelepiped and hemisphere parallelepiped. In the present work, rectangular parallelepiped method is used because maximum dimension of a machine is greater than 1m. In this method, the first step is to make a grid according to the dimensions of machine. The grid is made by placing an machine at centre position and with the help of wire at required positions mark the different points. There are 17 Grid points for machine as shown in figure 5.2. Sound pressure level can be measured for every grid point for different cutting speed, feed & depth of cut. Value of Sound pressure level is measured in A-weighting at slow response and therefore by using the formula, calculate the sound power (L_w). The measured data for SPL is given from Table-1 to Table-4 in Appendix-A. The method for calculating the L_w from sound pressure level is given in Appendix-D.

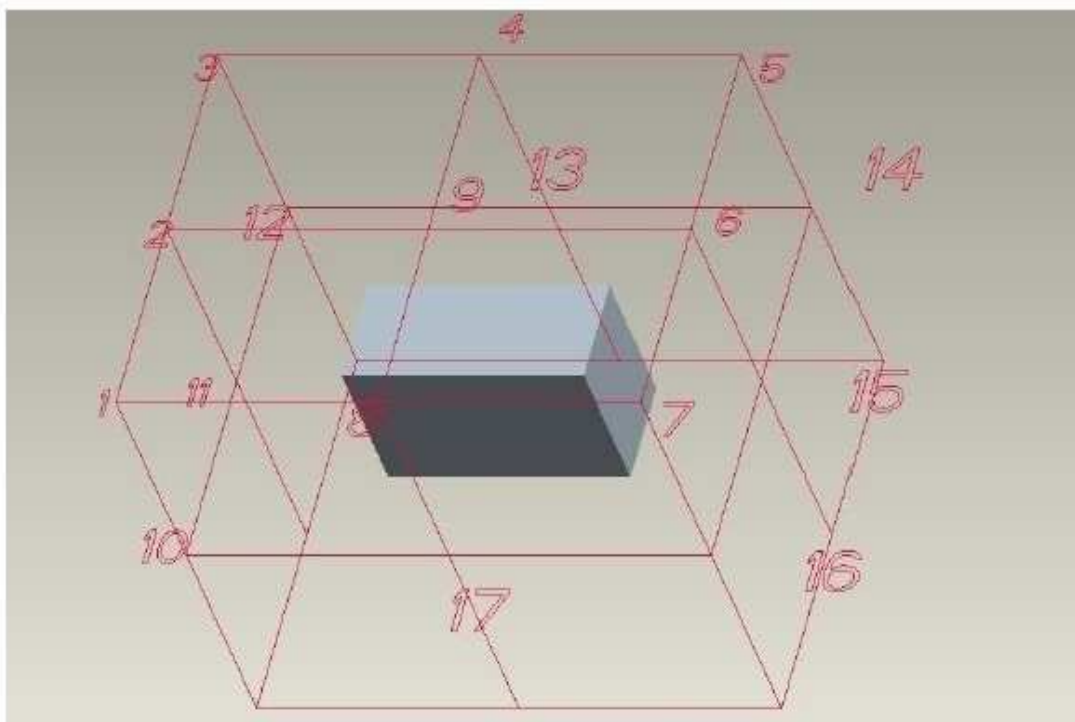


Fig. 5.2 Showing 17 grid points

5.2.2 Measurement of Sound Pressure Level at different points near machine: Sound pressure level is measured at four different locations and these four locations (A, B, C, D & E) are at a distance of 0.5 m from centre at each side of an machine as shown in figure 5.3. These measurements helped to find out that location where maximum Sound pressure level occurs. The measured data at five locations (A, B, C, D & E) are given from Table-1 to Table-8 in Appendix-B.

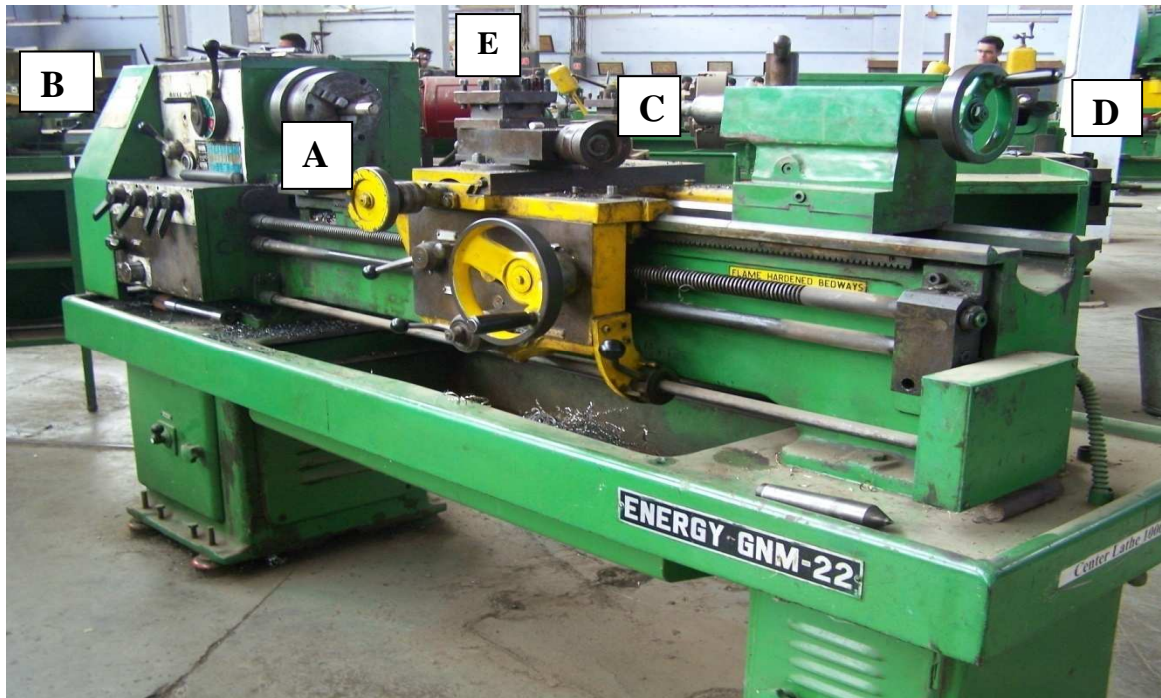


Fig. 5.3 Location of points A, B, C, D and E

5.2.3 Measurement of Sound Pressure Level for Frequency Spectrum in 1-1 Octave band: The value of sound pressure level at 1-1 octave band gives the maximum and minimum value at particular frequency.



Fig. 5.4 Sound level meter

Frequency spectrum analysis has been carried out at that location where sound pressure level is maximum for different cutting speed, feed and depth of cut. The data of SPL is recorded in software “CESVA CAPTURE STUDIO”. The measured data for frequency spectrum is given from Table-1 to Table-4 in Appendix-C.

CHAPTER 6

RESULTS AND DISCUSSIONS

After all the measurements, it is required to study the effect of different operating parameters for different materials during turning operation. Analysis have been done for acoustic power, sound pressure level at different locations (A, B, C, D & E) and sound pressure level for frequency spectrum in 1/1 octave band.

6.1 Analysis for Acoustic Power

Analysis for acoustic power was carried out for two different cases such as Aluminium & Brass and Mild steel & Stainless steel under the three varying parameters i.e. depth of cut, feed & spindle speed. For the case Aluminium & Brass, depth of cut varies from 1 mm to 4 mm, feed varies from 0.089 mm/rev. to 0.166 mm/rev. and spindle speed varies from 54 RPM to 1200RPM. For the another case Mild steel & Stainless steel, depth of cut varies from 0.5 mm to 2 mm, feed varies from 0.089 mm/rev. to 0.111 mm/rev. and spindle speed varies from 54 RPM to 770 RPM. Analysis shows the variation between acoustic power and varying parameters i.e. depth of cut, feed & spindle speed. The measured data is given from Table-1 to Table-4 in Appendix-A.

6.1.1 Acoustic power in the case of Aluminium & Brass:

For Aluminium: The values of acoustic power (L_w) under different parameters are shown below:

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)	L_w (dB(A)) (ref. 10^{-12} w)
1	1	0.089	54	82.7
2	1	0.111	135	82.6
3	1	0.133	500	85.3
4	1	0.166	1200	84.4
5	2	0.089	135	83
6	2	0.111	54	82.9
7	2	0.133	1200	87.1
8	2	0.166	500	85.6
9	3	0.089	500	88.1
10	3	0.111	1200	88
11	3	0.133	54	82.8
12	3	0.166	135	83.1
13	4	0.089	1200	88
14	4	0.111	500	85.6
15	4	0.133	135	83.5
16	4	0.166	54	83.1

Table 6.1 Acoustic power for Aluminium

Now, on the basis of Taguchi design of experiment, the analysis of variance and F-Test for Aluminium have been done. The values are shown below:

Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	6.8	3	2.3	3.5
Feed	3.8	3	1.3	2
Speed	51.6	3	17.2	27
Total	66.1	15	4.4	-
Error	3.8	6	0.6	-

Table 6.2 Analysis of variance for Aluminium

From the above values of the F-Test, the most effecting parameter on noise out of all the parameters is speed.

For Brass: The values of acoustic power (L_w) under different parameters are shown below:

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)	L_w (dB(A)) (ref. 10^{-12} w)
1	1	0.089	54	84.4
2	1	0.111	135	87.5
3	1	0.133	500	86.5
4	1	0.166	1200	90.2
5	2	0.089	135	84.3
6	2	0.111	54	83.9
7	2	0.133	1200	91
8	2	0.166	500	88.7
9	3	0.089	500	89
10	3	0.111	1200	93.7
11	3	0.133	54	84.7
12	3	0.166	135	85.6
13	4	0.089	1200	91.3
14	4	0.111	500	91.4
15	4	0.133	135	88.6
16	4	0.166	54	85.1

Table 6.3 Acoustic power for Brass

Now, on the basis of Taguchi design of experiment, the analysis of variance and F-Test for Brass have been done. The values are shown below:

Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	11.7	3	3.9	2.3
Feed	8.9	3	3	1.8
Speed	111.1	3	37	22.2
Total	141.7	15	9.4	-
Error	10.0	6	1.7	-

Table 6.4 Analysis of variance for Brass

From the above values of the F-Test, the most effecting parameter on noise out of all the parameters is speed.

6.1.2 Acoustic power in the case of Mild steel & Stainless steel:

For Mild steel: The values of acoustic power (L_w) under different parameters are shown below:

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)	L_w (dB(A)) (ref. 10^{-12} w)
1	0.5	0.089	54	83.3
2	0.5	0.095	135	83.4
3	0.5	0.102	325	85.8
4	0.5	0.111	770	91.3
5	1	0.089	135	83.7
6	1	0.095	54	83.1
7	1	0.102	770	91.5
8	1	0.111	325	84.7
9	1.5	0.089	325	83.8
10	1.5	0.095	770	88
11	1.5	0.102	54	83
12	1.5	0.111	135	83.2
13	2	0.089	770	88.7
14	2	0.095	325	83.9
15	2	0.102	135	83.3
16	2	0.111	54	82.9

Table 6.5 Acoustic power for Mild steel

Now, on the basis of Taguchi design of experiment, the analysis of variance and F-Test for Mild steel have done. The values are shown below:

Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	6.7	3	2.2	7.3
Feed	4.1	3	1.4	4.5
Speed	119.7	3	39.9	131.4
Total	132.2	15	8.8	-
Error	1.8	6	0.3	-

Table 6.6 Analysis of variance for Mild steel

From the above values of the F-Test, the most effecting parameter on noise out of all the parameters is speed.

For stainless steel: The values of acoustic power (L_w) under different parameters are shown below:

Exp. no.	Depth of cut (mm)	Feed (mm/rev.)	Speed (rpm)	L_w (dB(A)) (ref. 10^{-12} w)
1	0.5	0.089	54	82.6
2	0.5	0.095	135	83.1
3	0.5	0.102	325	83.4
4	0.5	0.111	770	87.7
5	1	0.089	135	85.6
6	1	0.095	54	83.8
7	1	0.102	770	90.1
8	1	0.111	325	86.7
9	1.5	0.089	325	90.3
10	1.5	0.095	770	91
11	1.5	0.102	54	85
12	1.5	0.111	135	85.7
13	2	0.089	770	87.1
14	2	0.095	325	89.5
15	2	0.102	135	88.8
16	2	0.111	54	89.2

Table 6.7 Acoustic power for Stainless steel

Now, on the basis of Taguchi design of experiment, the analysis of variance and F-Test for mild steel have been done. The values are shown below:

parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	46.7	3	15.6	2.9
Feed	1.6	3	0.5	0.1
Speed	35.5	3	11.8	2.2
Total	116.1	15	7.7	-
Error	32.3	6	5.4	-

Table 6.8 Analysis of variance for Stainless steel

From the above values of the F-Test, the most effecting parameter on noise out of all the parameters is speed.

After evaluating the acoustic power under different parameters, the T-test for both the above cases has been done. In all cases, the calculated acoustic power is given from Table-1 to Table-4 in Appendix-A.

6.1.3 T-test analysis for acoustic power: For comparing the acoustic power in both cases.

For the case of Aluminium & Brass:

Aluminium			Brass		
$X(Lw)$	$(X - \bar{X})$	$(X - \bar{X})^2$	$Y(Lw)$	$(Y - \bar{Y})$	$(Y - \bar{Y})^2$
82.7	-2	4	84.4	-3.5	12.3
82.6	-2.1	4.4	87.5	-0.4	0.2
85.3	0.6	0.4	86.5	-1.4	2
84.4	-0.3	0.1	90.2	2.3	5.3
83	-1.7	2.9	84.3	-3.6	13
82.9	-1.8	3.2	83.9	-4	16
87.1	2.4	5.8	91	3.1	9.6
85.6	0.9	0.8	88.7	0.8	0.6
88.1	3.4	11.6	89	1.1	1.2
88	3.3	10.9	93.7	5.8	33.6
82.8	-1.9	3.6	84.7	-3.2	10.2
83.1	-1.6	2.6	85.6	-2.3	5.3
88	3.3	10.9	91.3	3.4	11.6
85.6	0.9	0.8	91.4	3.5	12.3
83.5	-1.2	1.4	88.6	0.7	0.5
83.1	-1.6	2.6	85.1	-2.8	7.8
$\sum X$ =1355.8	$\sum(X - \bar{X})$ =0	$\sum(X - \bar{X})^2$ =65.9	$\sum Y$ =1405.8	$\sum(Y - \bar{Y})$ =0	$\sum(Y - \bar{Y})^2$ =141.4

Table 6.9 Calculation of T-test analysis for Aluminium and Brass

$$\bar{X} = \frac{1355.8}{16} = 84.7, \quad \bar{Y} = \frac{1405.8}{16} = 87.9 \quad (6.1)$$

Here $n_1 = 16$, $n_2 = 16$

$$S^2 = \frac{1}{n_1+n_2-2} \left[\sum(X - \bar{X})^2 + \sum(Y - \bar{Y})^2 \right] = 6.9 \quad (6.2)$$

Under null hypothesis (H_0):

$$T = \frac{\bar{X} - \bar{Y}}{\sqrt{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad (6.3)$$

$$T = \frac{84.7 - 87.9}{\sqrt{6.9^2 \left(\frac{1}{16} + \frac{1}{16} \right)}} = -1.32 \quad (6.4)$$

Tabulated $T_{0.05}$ for $(16+16-2) = 30$ degree of freedom is 2.04.

Since calculated 'T' is less than tabulated 'T', H_0 may be accepted at 5% level of significance and we may conclude that the two materials do not differ significantly as regards their effect on increase in acoustic power.

For the case of Mild steel & Stainless steel:

Mild steel			Stainless steel		
$X(Lw)$	$(X - \bar{X})$	$(X - \bar{X})^2$	$Y(Lw)$	$(Y - \bar{Y})$	$(Y - \bar{Y})^2$
83.3	-1.9	3.61	82.6	-4.3	18.5
83.4	-1.8	3.2	83.1	-3.8	14.4
85.8	0.6	0.4	83.4	-3.5	12
91.3	6.1	37.2	87.7	0.8	0.6
83.7	-1.5	2.3	85.6	-1.3	2
83.1	-2.1	4.4	83.8	-6.3	40
91.5	6.3	39.7	90.1	3.2	10.2
84.7	-0.5	0.3	86.7	-0.2	0
83.8	-1.4	2	90.3	3.4	11.6
88	2.8	7.8	91	4.1	16.8
83	-2.2	4.8	85	-1.9	3.6
83.2	-2	4	85.7	-1.2	1.4
88.7	3.5	12.3	87.1	0.2	0
83.9	-1.3	1.7	89.5	2.6	6.8
83.3	-1.9	3.6	88.8	1.9	3.6
82.9	-2.3	5.3	89.2	2.3	5.3
$\sum X$ =1363.4	$\sum (X - \bar{X})$ =0	$\sum (X - \bar{X})^2$ =132.5	$\sum Y$ =1389.6	$\sum (Y - \bar{Y})$ =0	$\sum (Y - \bar{Y})^2$ =146.6

Table 6.10 Calculation of T-test analysis for Mild steel and Stainless steel

$$\bar{X} = \frac{1363.4}{16} = 85.2, \quad \bar{Y} = \frac{1389.6}{16} = 86.9 \quad (6.5)$$

Here $n_1 = 16, n_2 = 16$

$$S^2 = \frac{1}{n_1 + n_2 - 2} \left[\sum (X - \bar{X})^2 + \sum (Y - \bar{Y})^2 \right] = 5.7 \quad (6.6)$$

Under null hypothesis (H_0):

$$T = \frac{\bar{X} - \bar{Y}}{\sqrt{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad (6.7)$$

$$T = \frac{85.2 - 86.9}{\sqrt{5.7^2 \left(\frac{1}{16} + \frac{1}{16} \right)}} = -0.42 \quad (6.8)$$

Tabulated $T_{0.05}$ for $(16+16-2) = 30$ degree of freedom is 2.04.

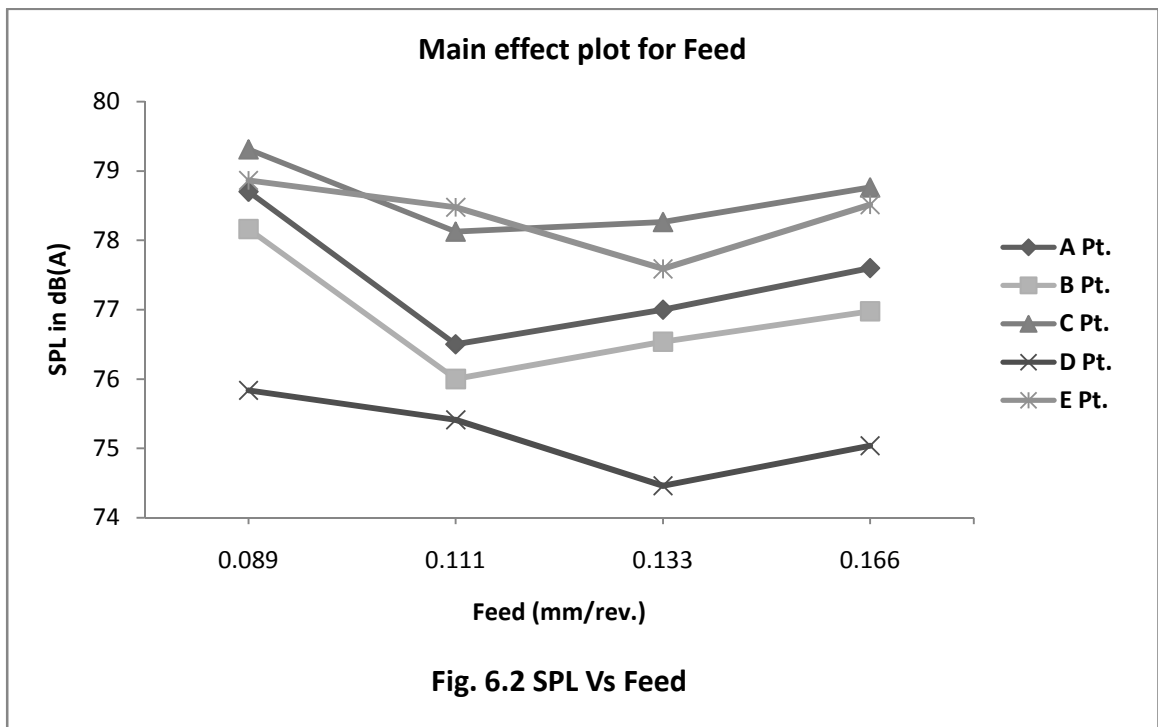
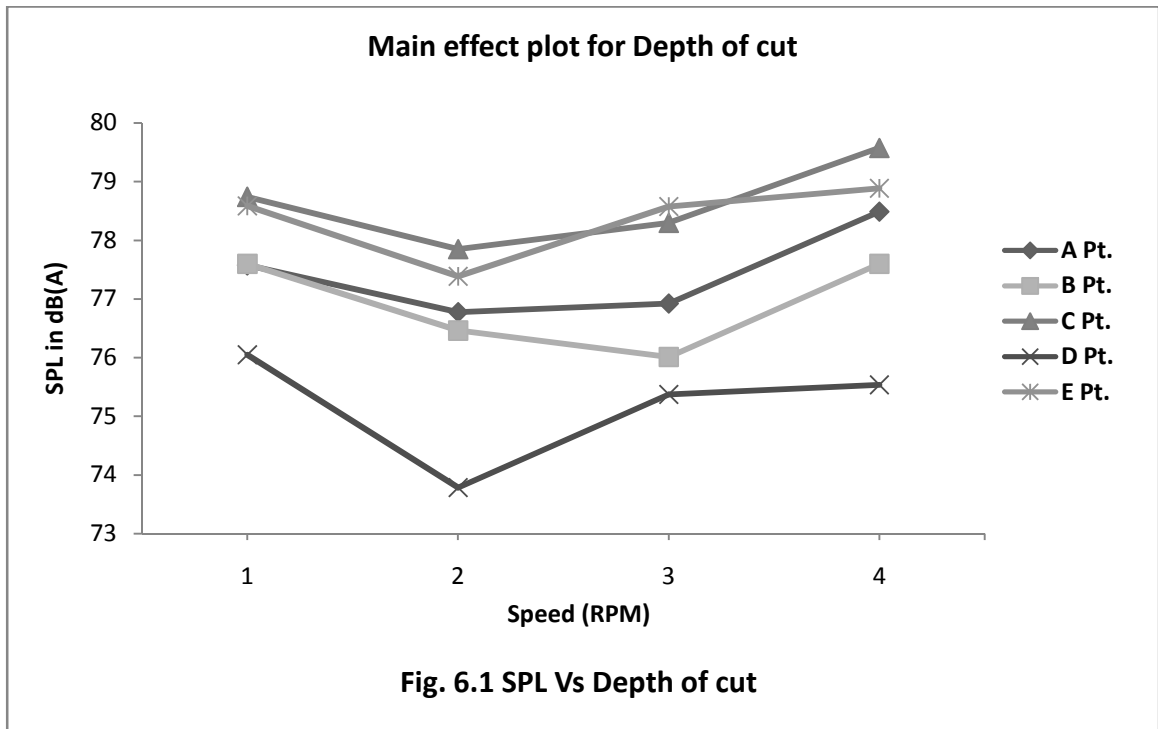
Since calculated 'T' is less than tabulated 'T', H_0 may be accepted at 5% level of significance and we may conclude that the two materials do not differ significantly as regards their effect on increase in acoustic power.

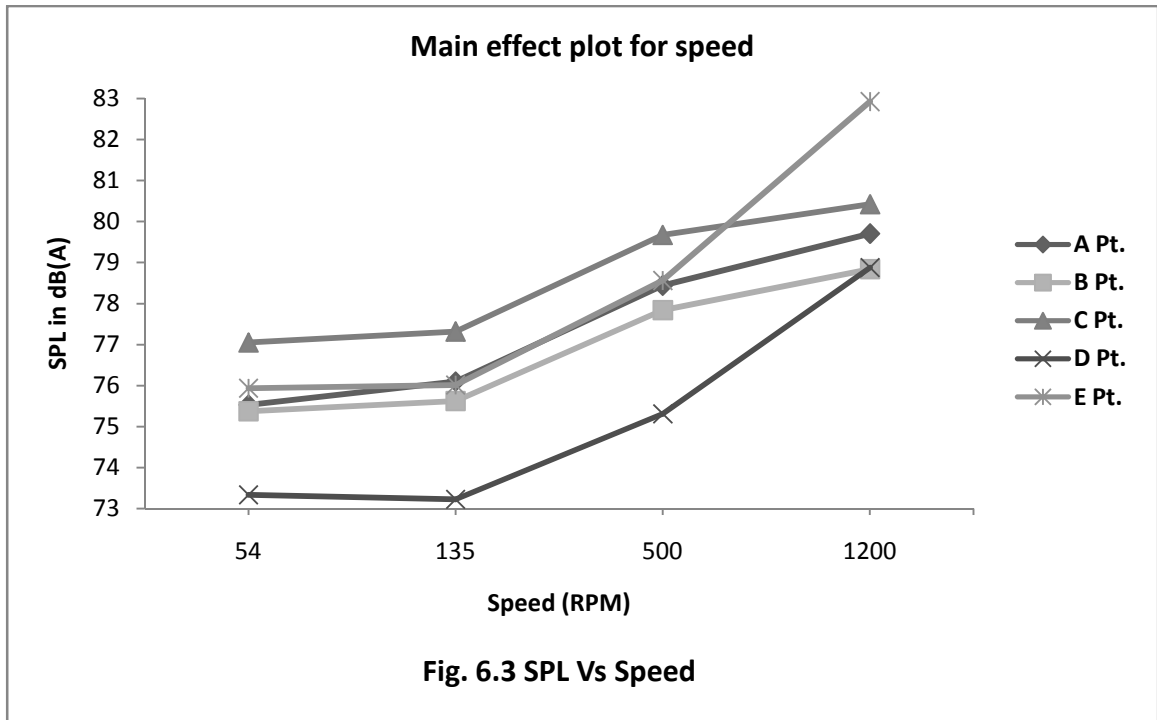
6.2 Analysis for sound pressure level at different points near lathe machine in the turning operation

Before the analysis for sound pressure level at different points, also interested to know about the contribution of each individual parameter effect in the variation of sound pressure level on the basis of Taguchi method. This method shows the main effect plots.

Main effect plot: These plots shows the variation of each individual parameter where the multiple parameters are involved in the process or experiment. The measured data for main effect plots are given in Appendix-E

Taguchi analysis for Aluminium:





At point A

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point B

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Not Significant

At point C

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Not Significant

At point D

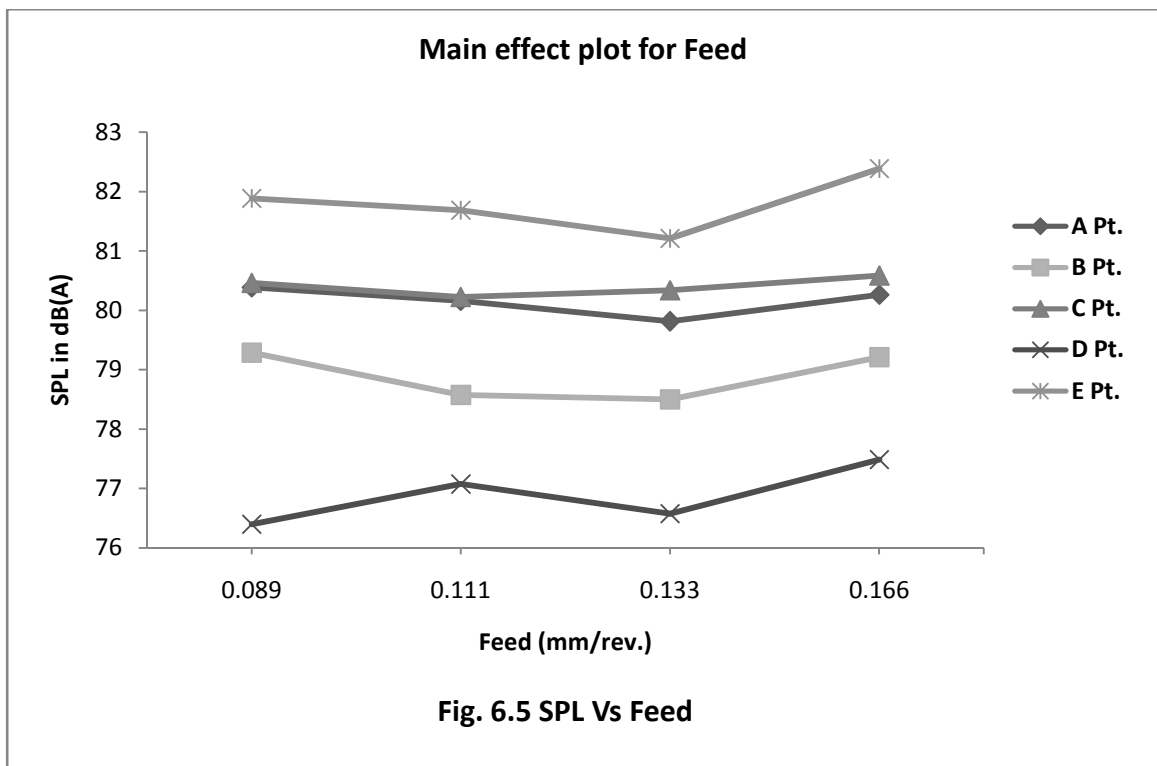
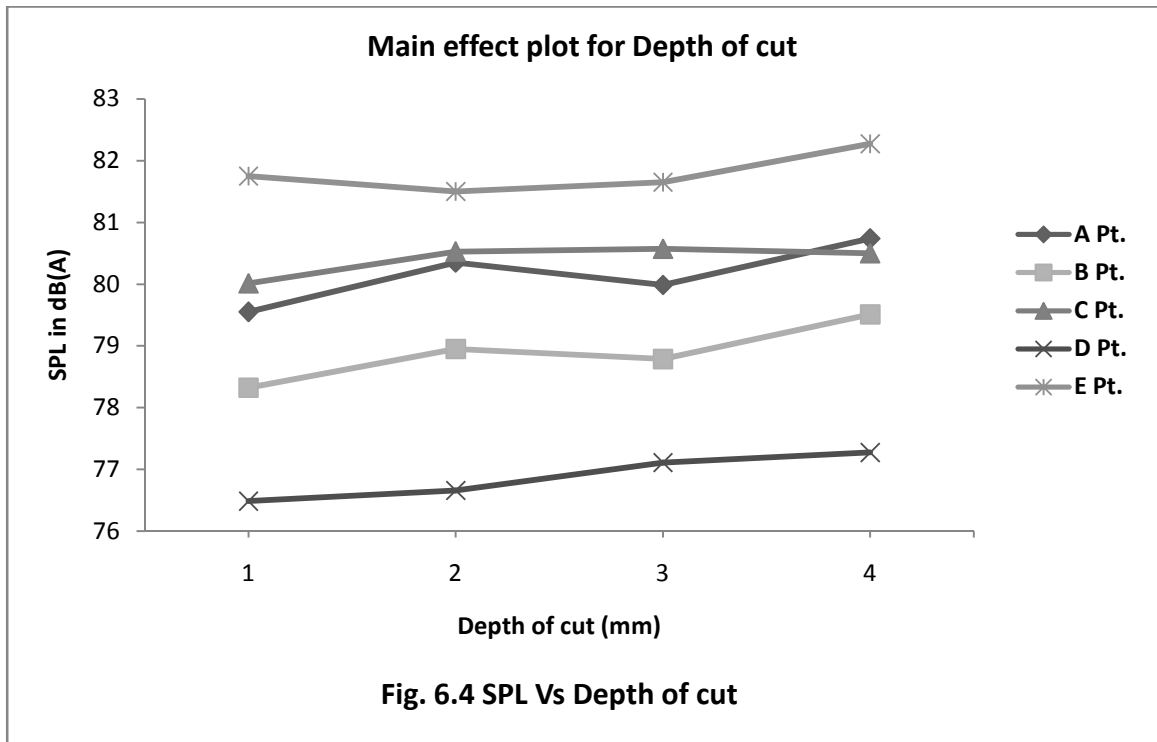
Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

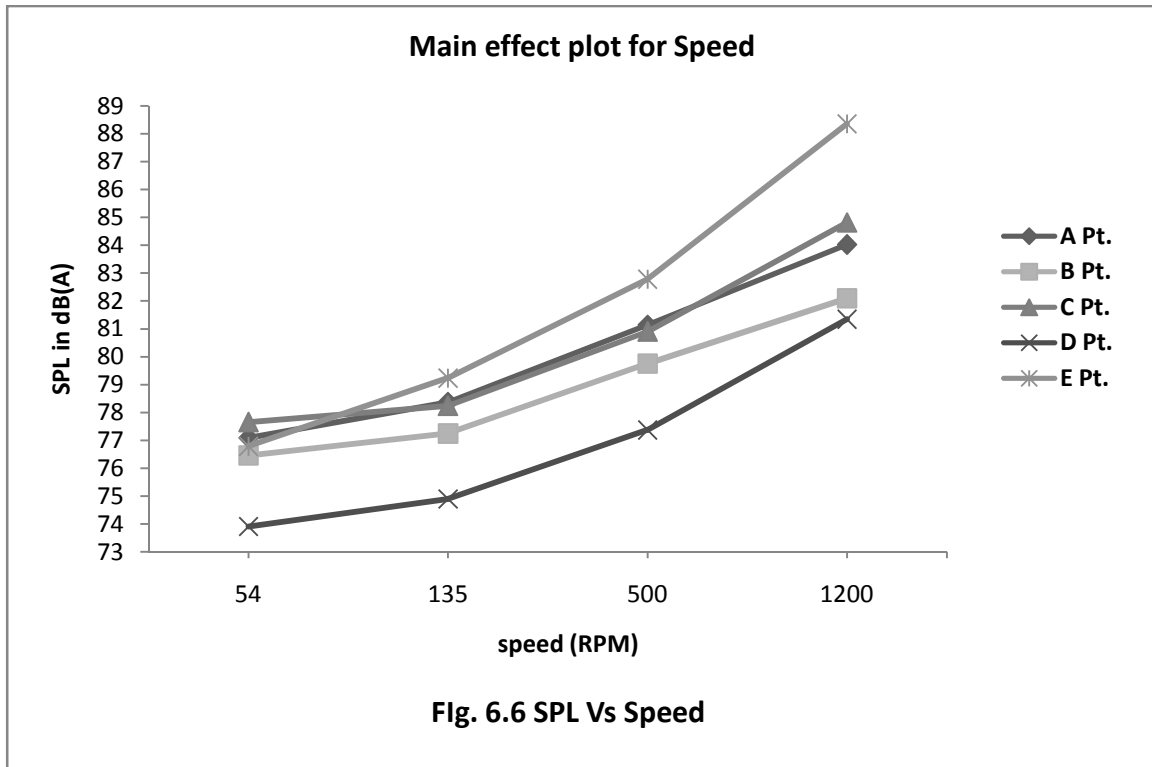
At point E

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

Table 6.11 Significant status

Taguchi analysis for Brass:





At point A

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point B

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point C

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point D

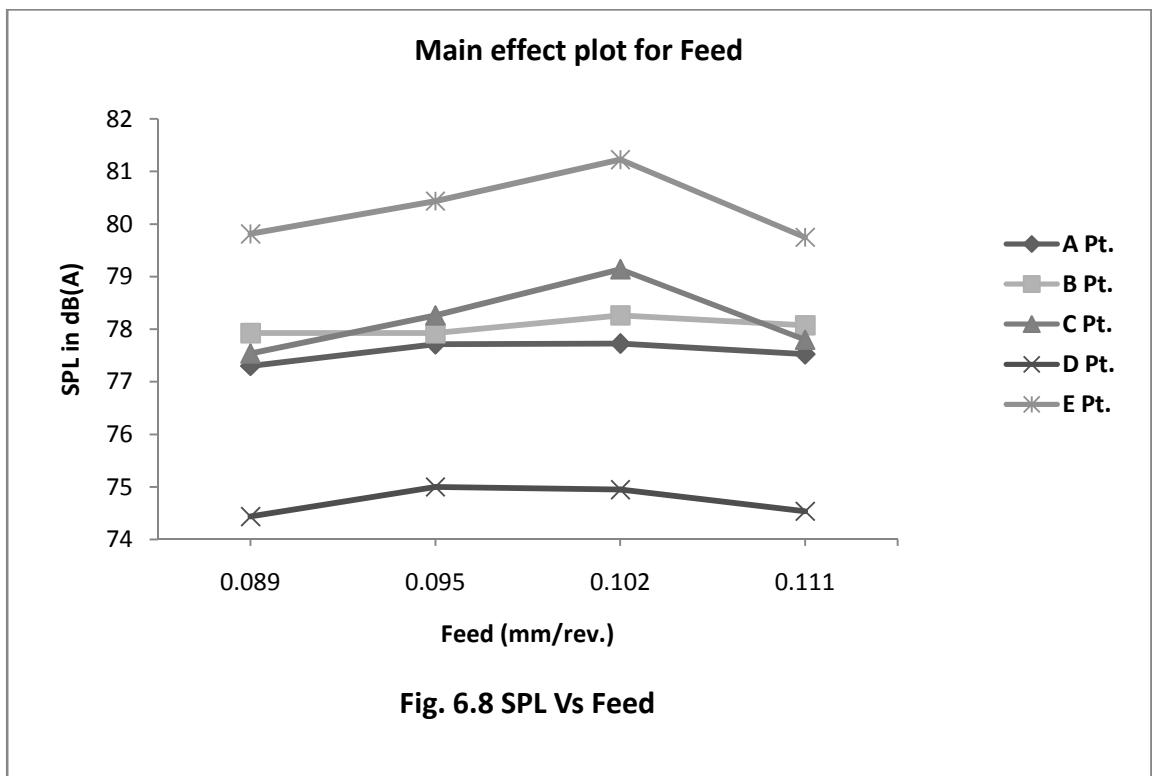
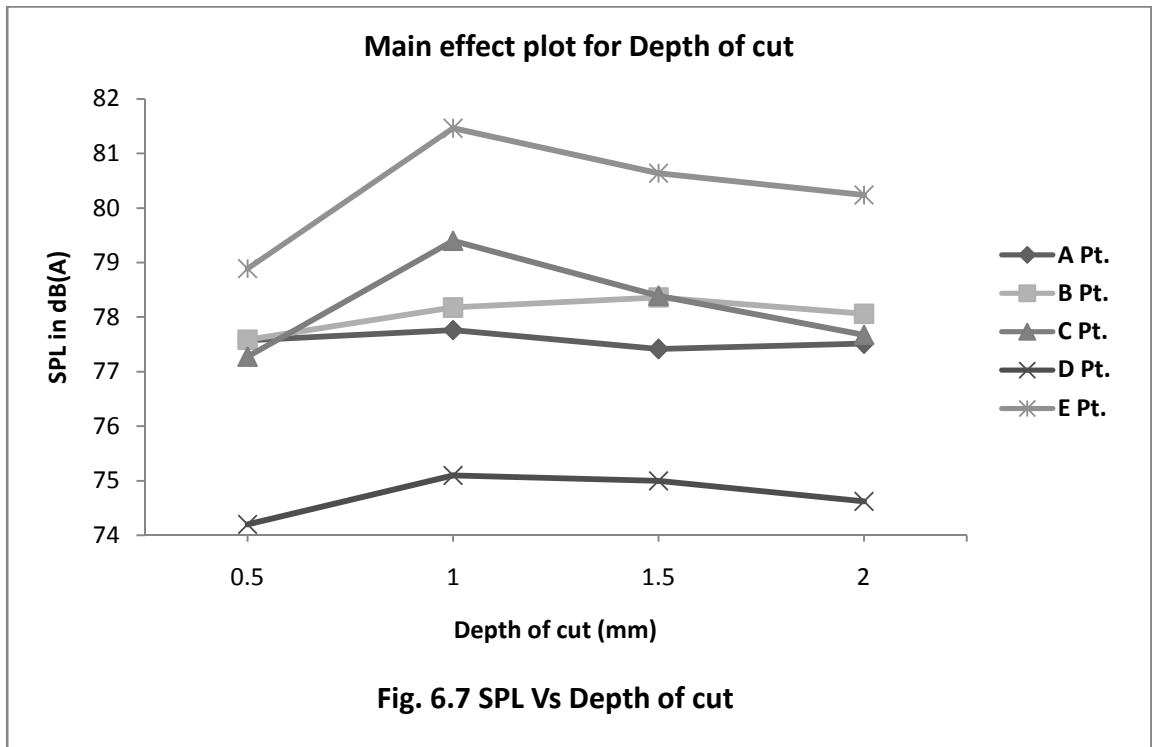
Parameter	Significant status
Depth of cut	Not significant
Feed	Significant
Speed	Significant

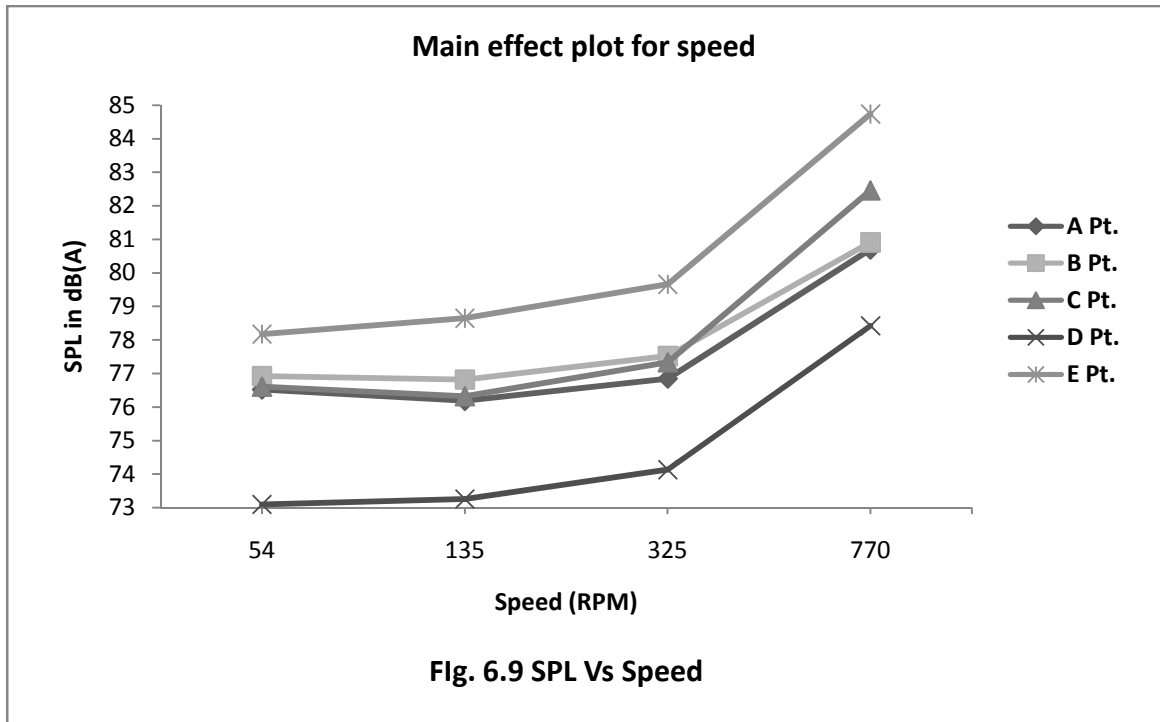
At point E

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

Table 6.12 Significant status

Taguchi analysis for Mild steel:





At point A

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point B

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point C

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point D

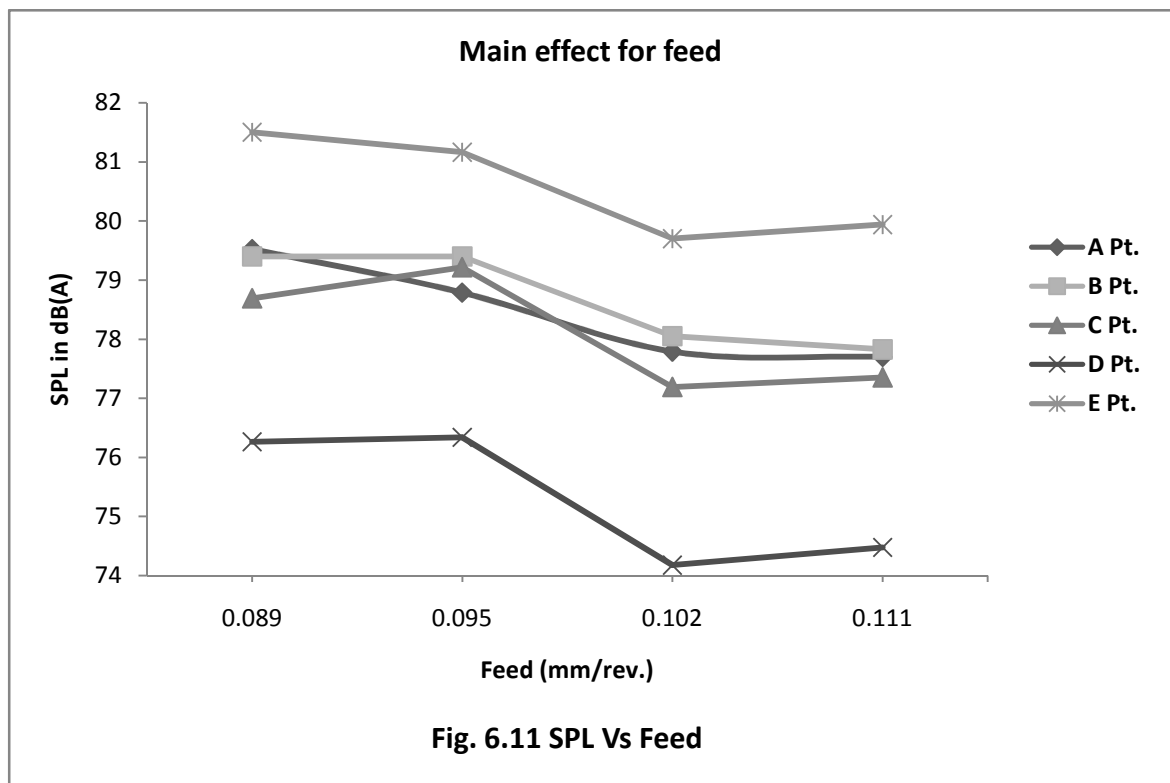
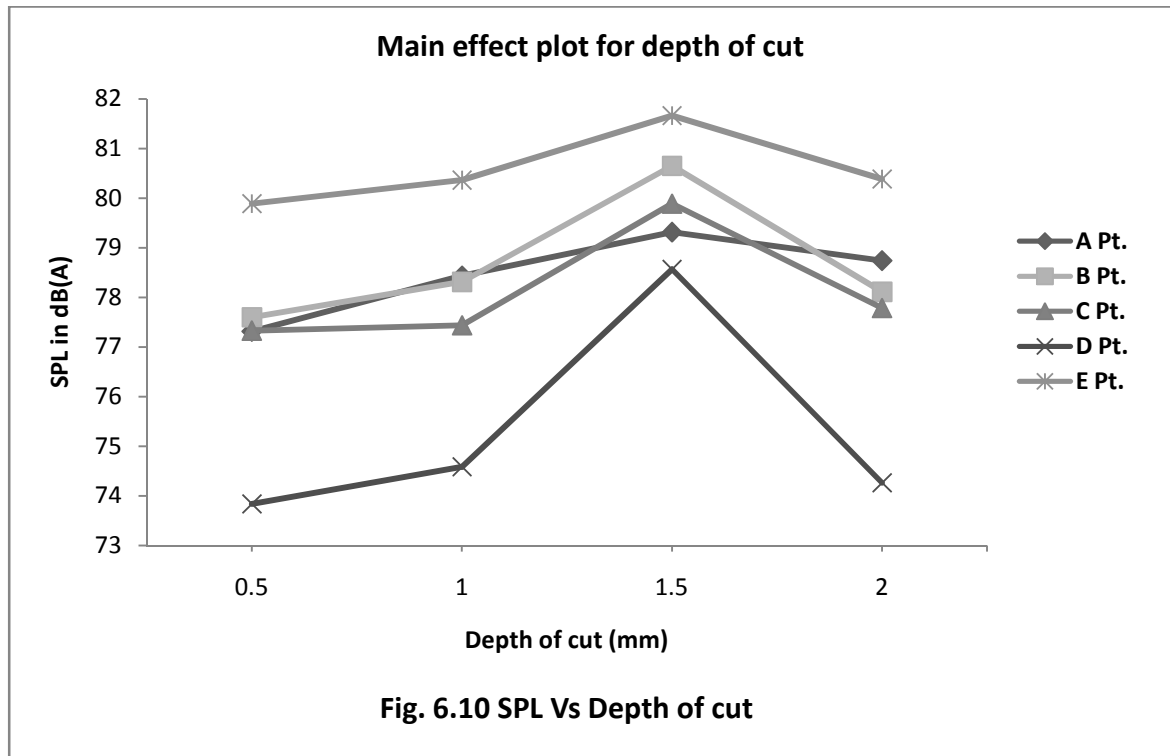
Parameter	Significant status
Depth of cut	Not significant
Feed	Not Significant
Speed	Significant

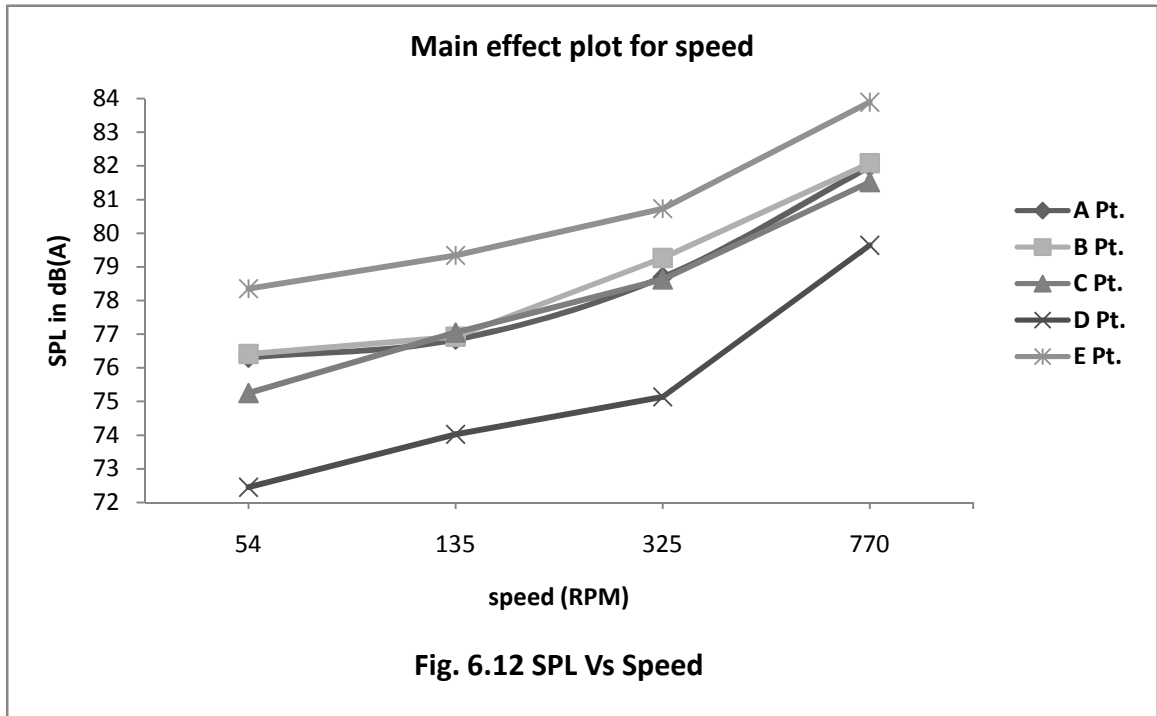
At point E

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

Table 6.13 Significant status

Taguchi analysis for Stainless steel:





At point A

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point B

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point C

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

At point D

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Not significant

At point E

Parameter	Significant status
Depth of cut	Not significant
Feed	Not significant
Speed	Significant

Table 6.14 Significant status

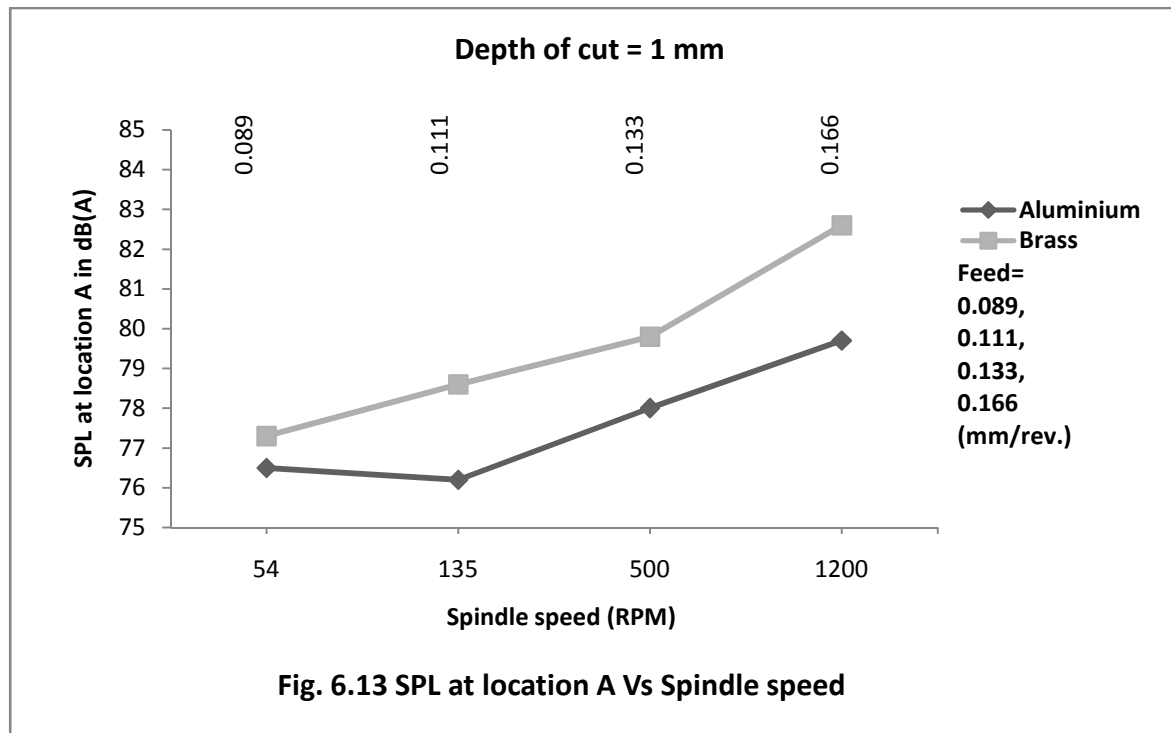
On the basis of above main effect plots, summarize the significant status for each parameter for different locations. The value deciding the significance is 9.78 at the 99% confidence level. It means that the value of F-test should be greater than 9.78 for the significance of particular factor. The measured data for the significant status is given from Appendix-E.

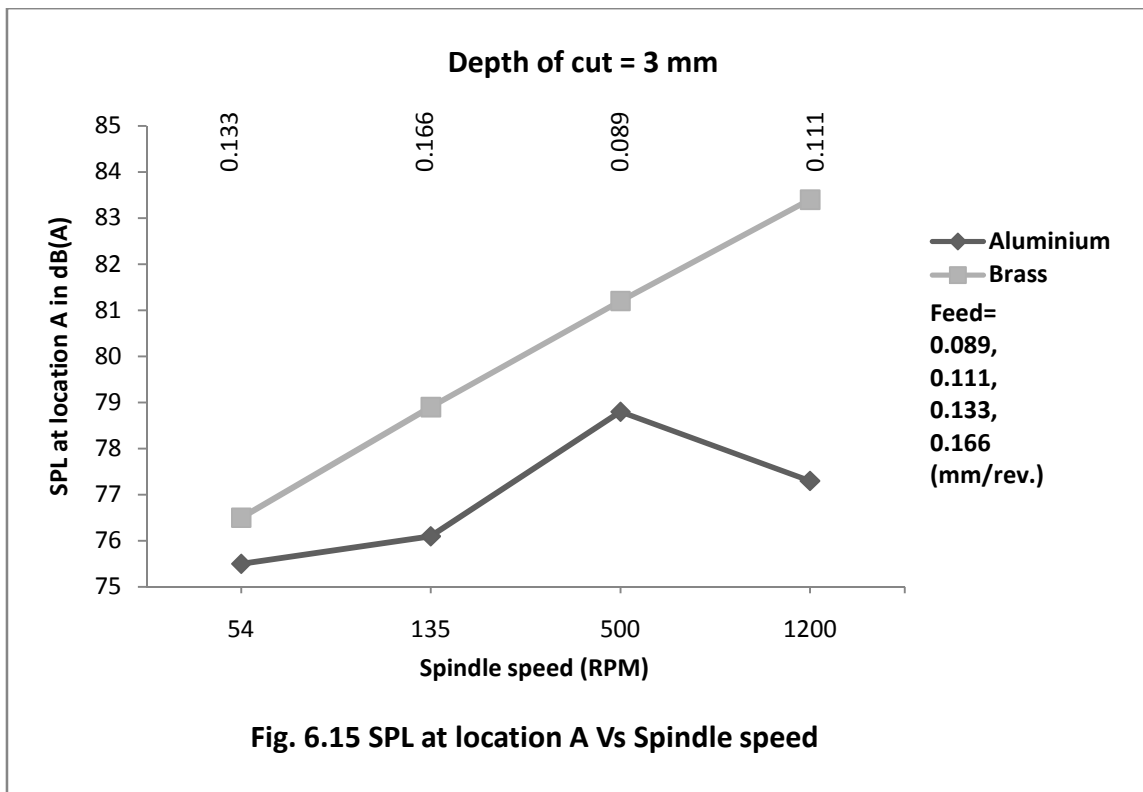
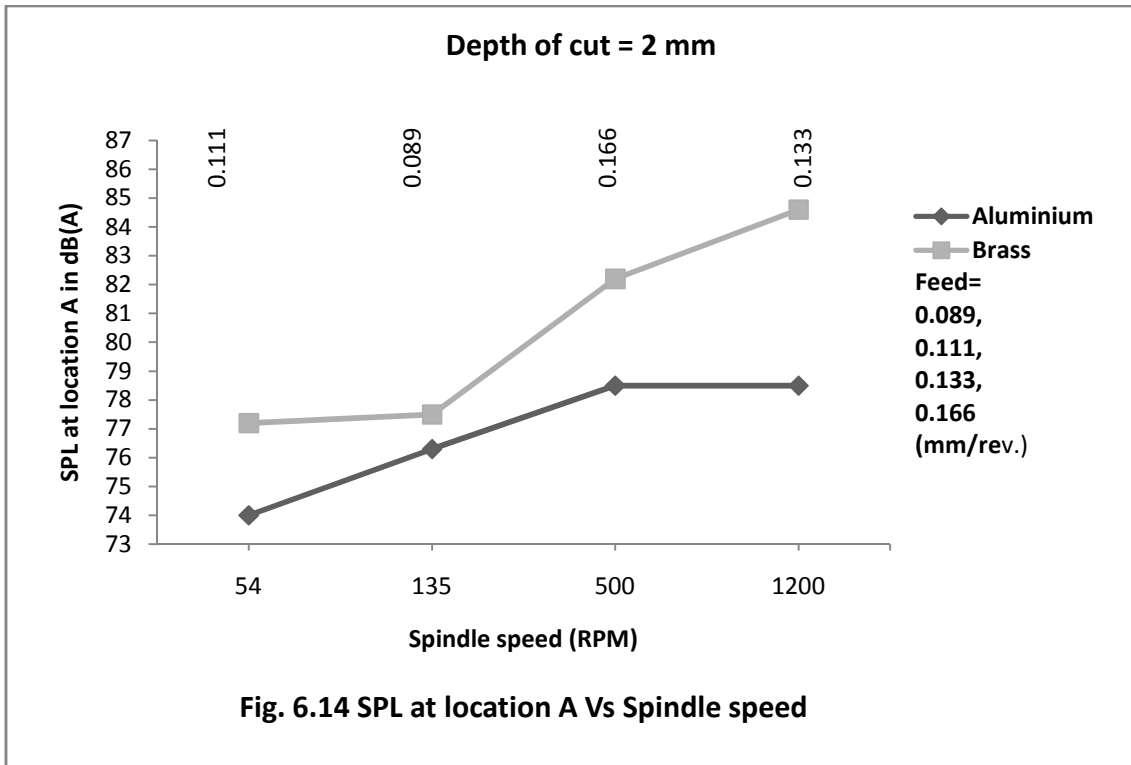
6.2.1 Sound pressure level in the case of Aluminium & Brass

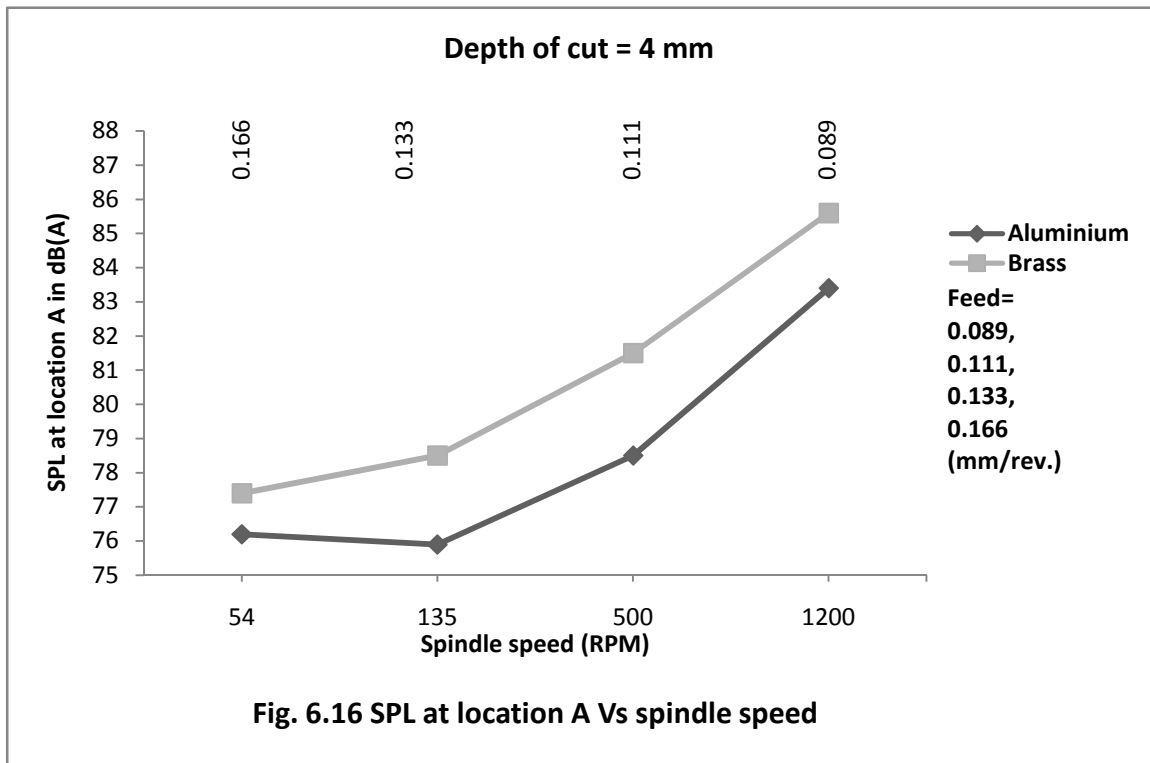
Analysis for sound pressure level was carried out at five different locations (A, B, C, D and E) under three different parameters i.e. depth of cut, feed and speed. The depth of cut varies from 1 to 4 mm, feed varies from 0.089 to 0.166 mm/rev. and speed varies from 54 to 1200 RPM. Analysis shows the variation between sound pressure level and speed at all locations with varying depth of cut and feed parameters. The measured data is given from Table-1 to Table-4 in Appendix-B.

Sound pressure level at location A:

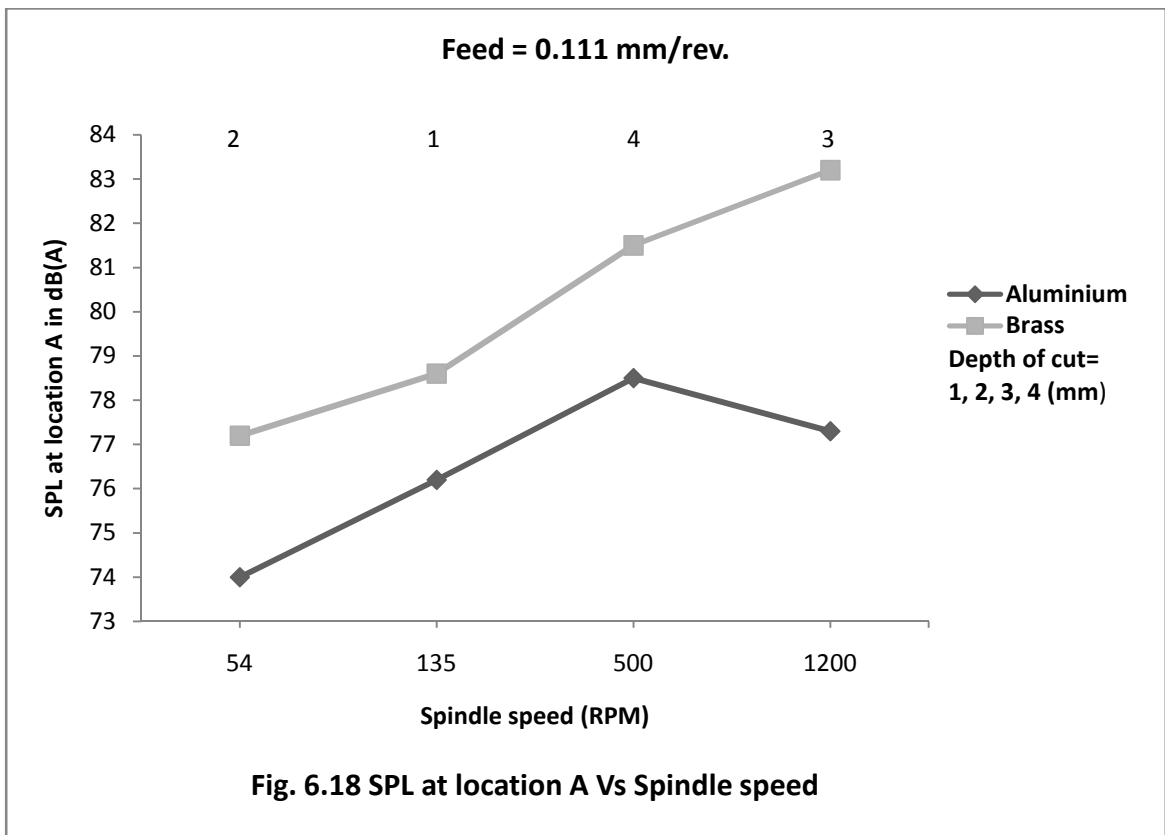
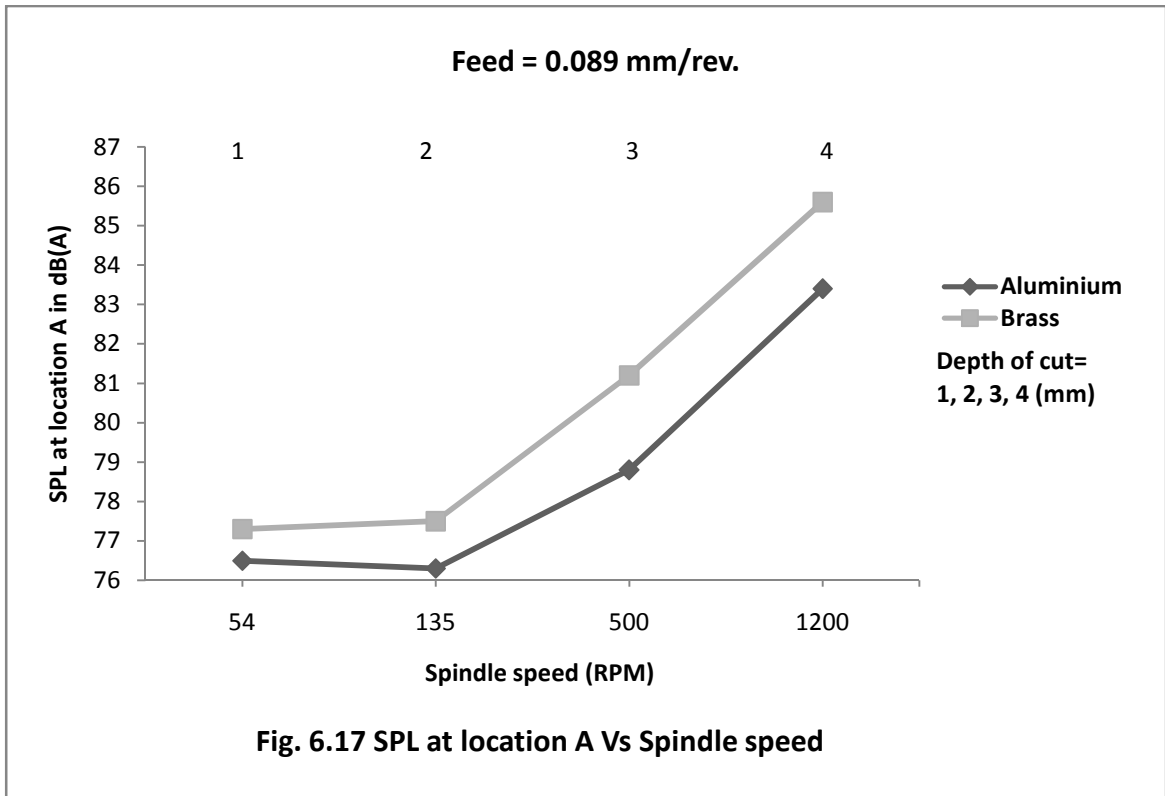
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Aluminium and Brass at location A are shown in fig. 6.13 to 6.16.

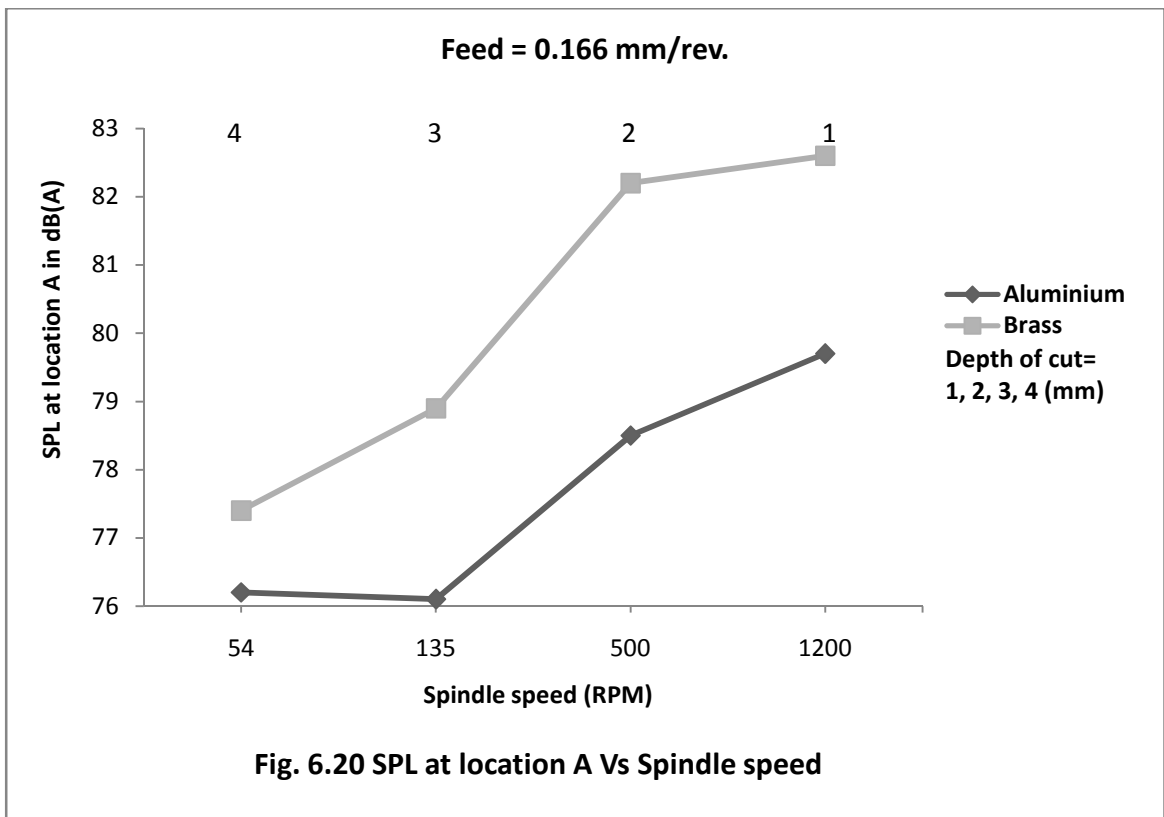
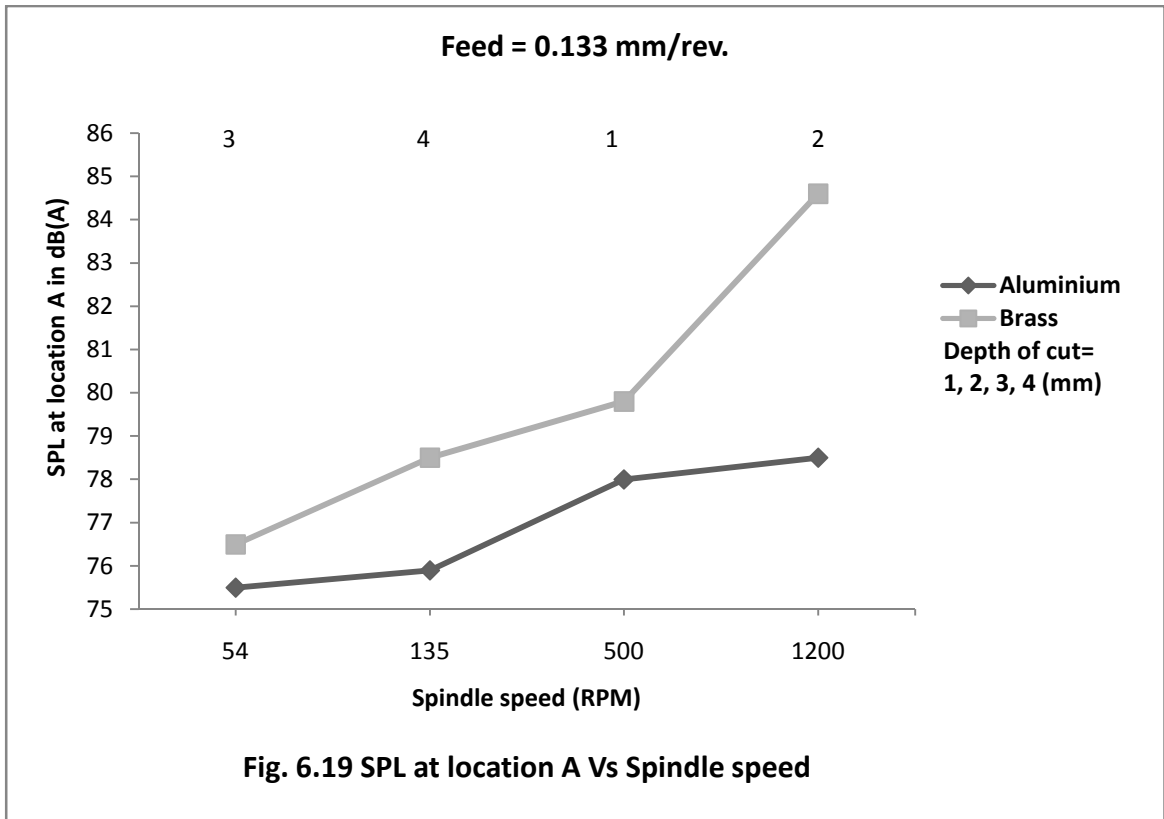






- 1) It is observed that the value of sound pressure level is increased with increasing speed at 1 mm, 2 mm and 4 mm depth of cut for both the materials.
 - 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
 - 3) At 3 mm depth of cut, value of sound pressure level is increased with increasing speed for Brass. For Aluminium it is also increases up to the certain combination of speed 500 RPM and feed 0.089 mm/rev. But at the combination of feed 0.111 mm/rev. and speed 1200 RPM it is decreased.
 - 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 2 mm and 3 mm depth of cut for the combination of speed 1200 RPM & 0.133 mm/rev. and 1200 RPM & feed 0.111 mm/rev. respectively. The difference is 6.1 dB(A).
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Aluminium and Brass at location A are shown in fig. 6.17 to 6.20.

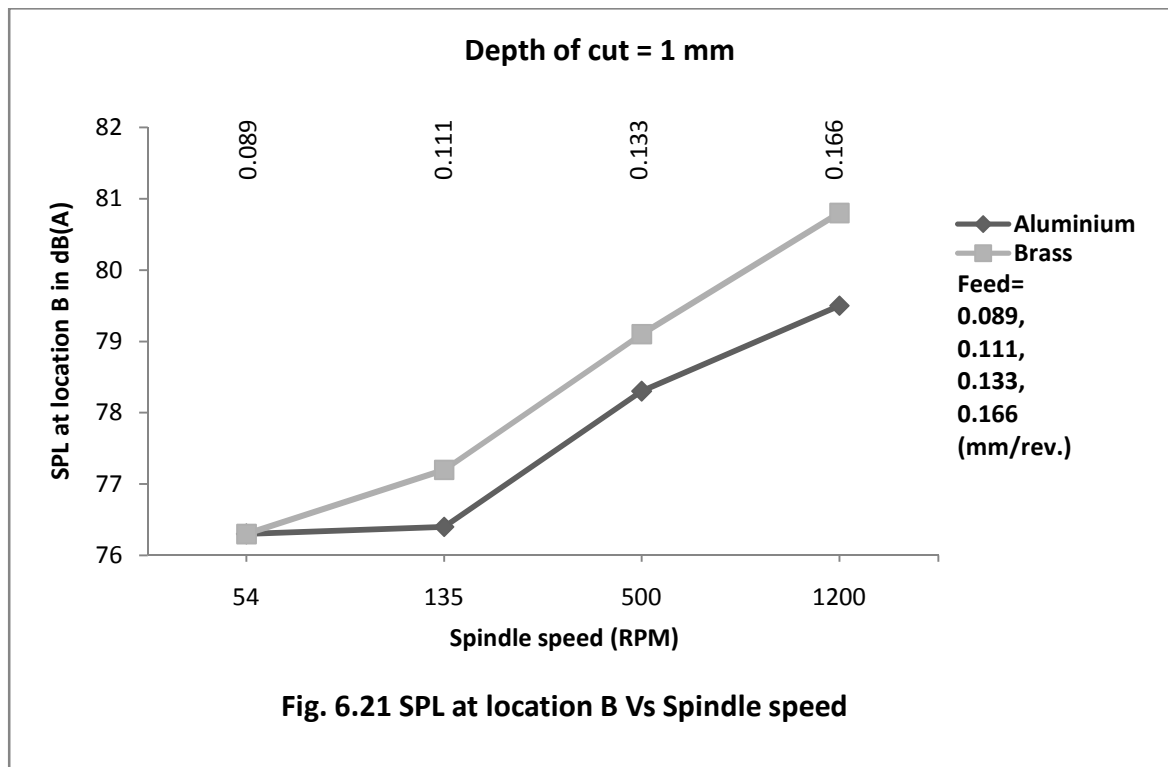


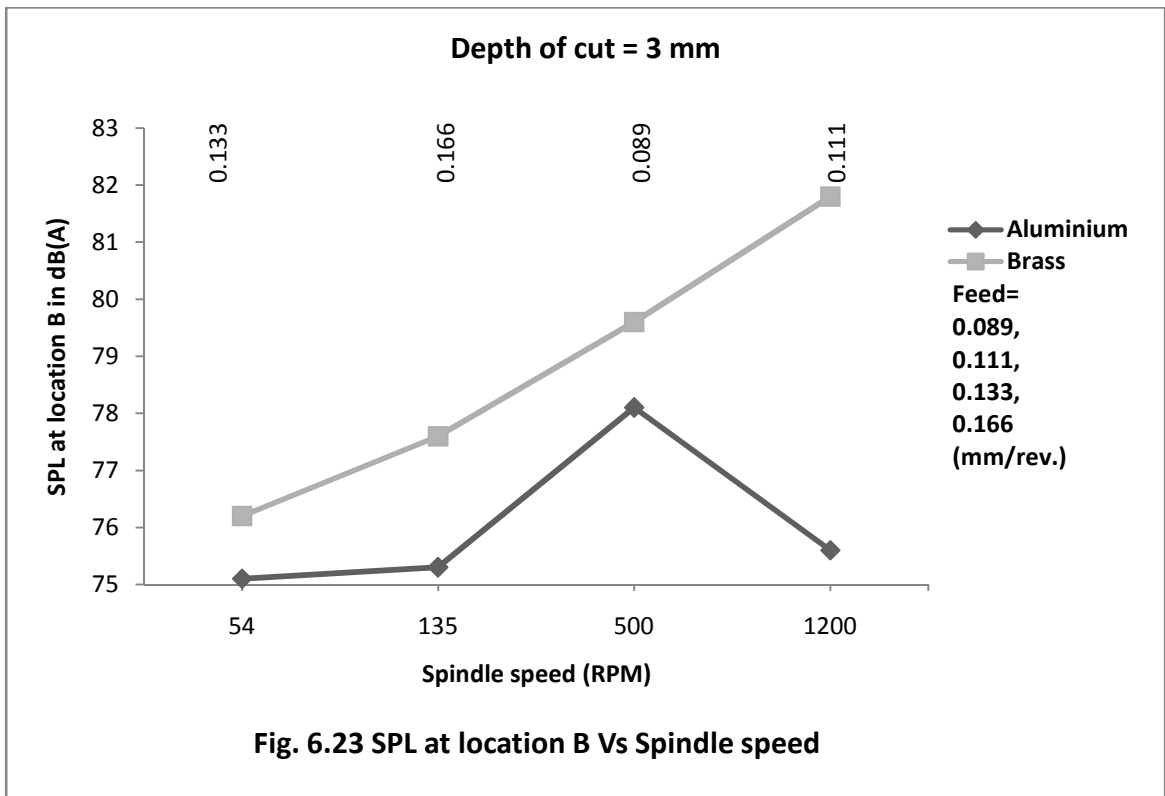
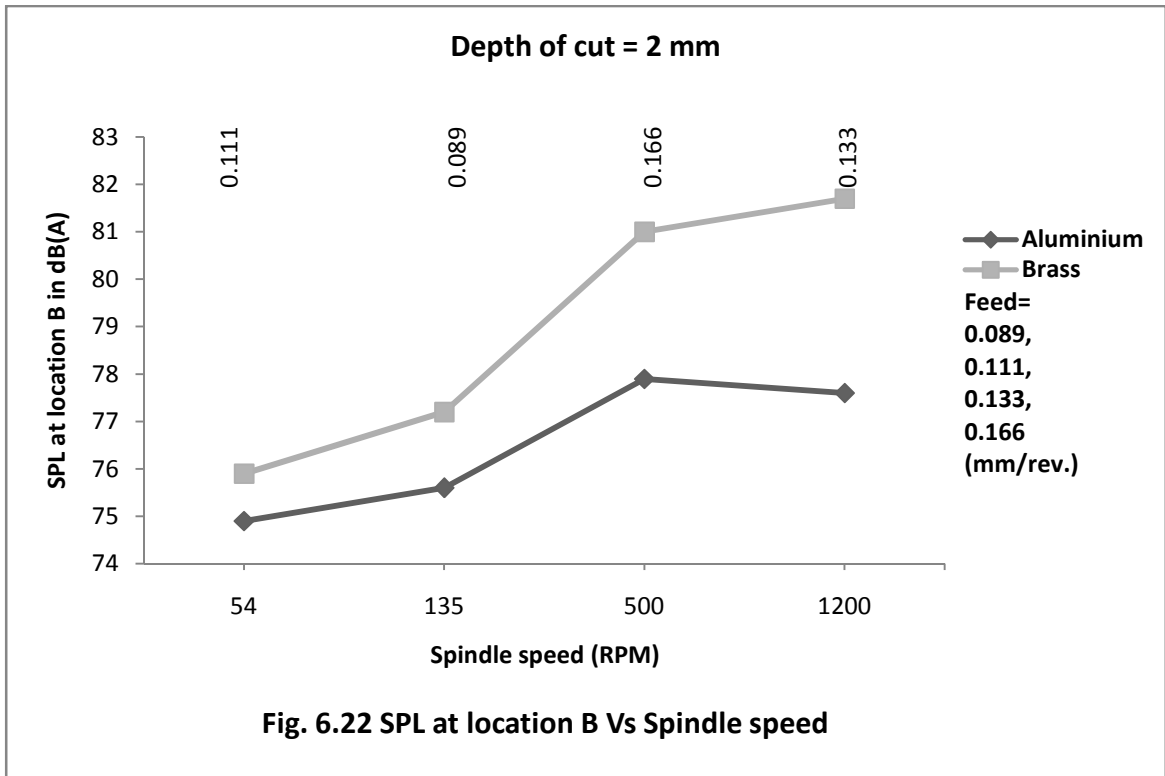


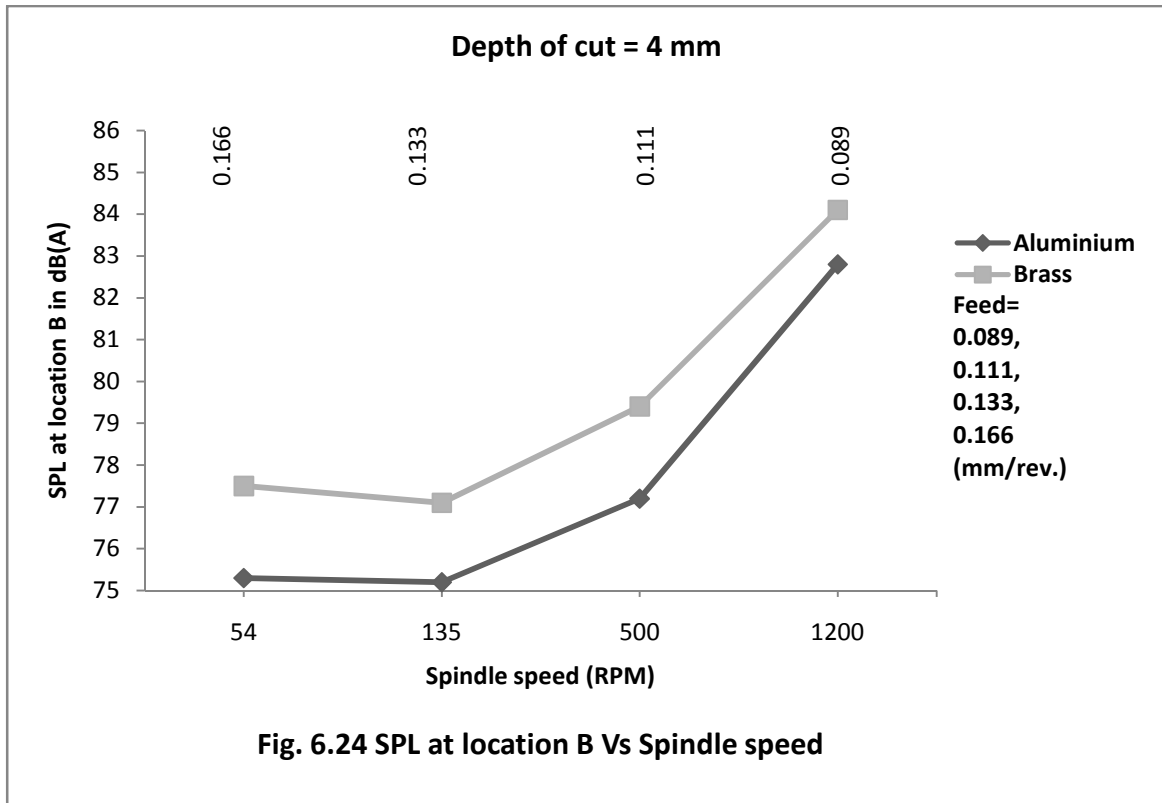
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.089 mm/rev., 0.133 mm/rev and 0.166 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) At feed 0.111 mm/rev., value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is also increases up to the certain combination of speed 500 RPM and 4mm depth of cut. But at the combination of 3 mm depth of cut and speed 1200 RPM it is decreased.
- 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 0.133 mm/rev. for the combination of speed 1200 RPM & 2 mm depth of cut the difference is 6.1 dB(A).

Sound pressure level at location B:

- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Aluminium and Brass at location B are shown in fig. 6.21 to 6.24.

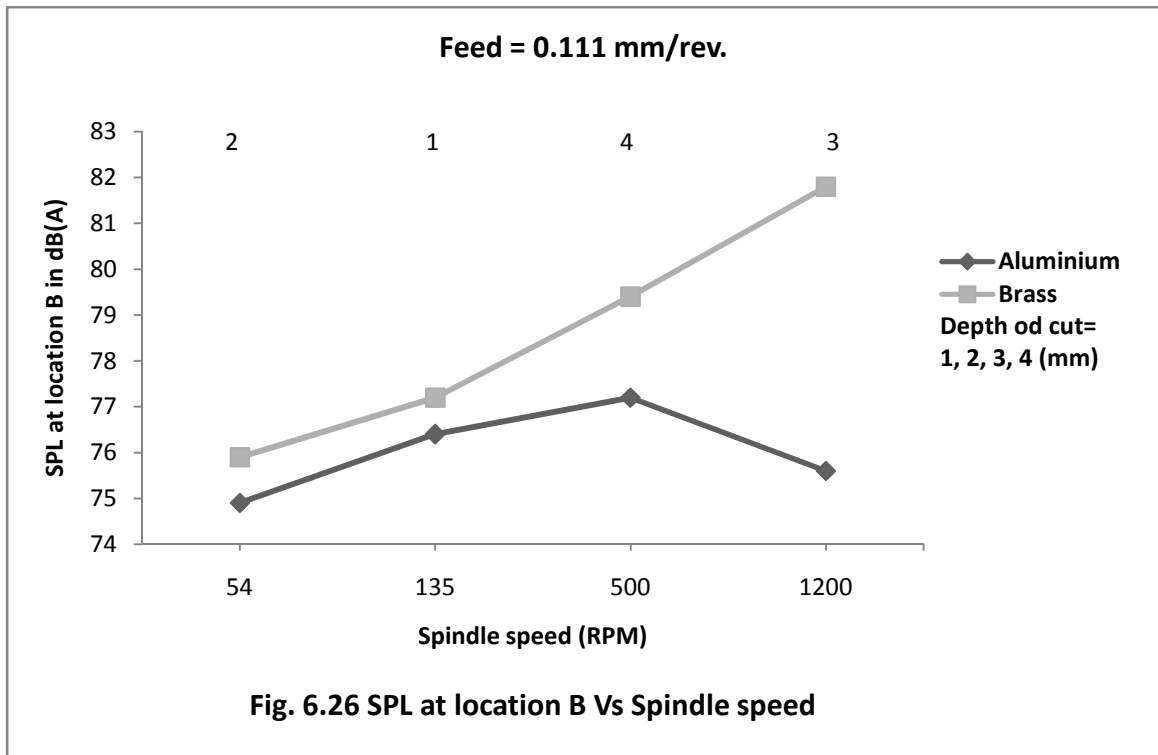
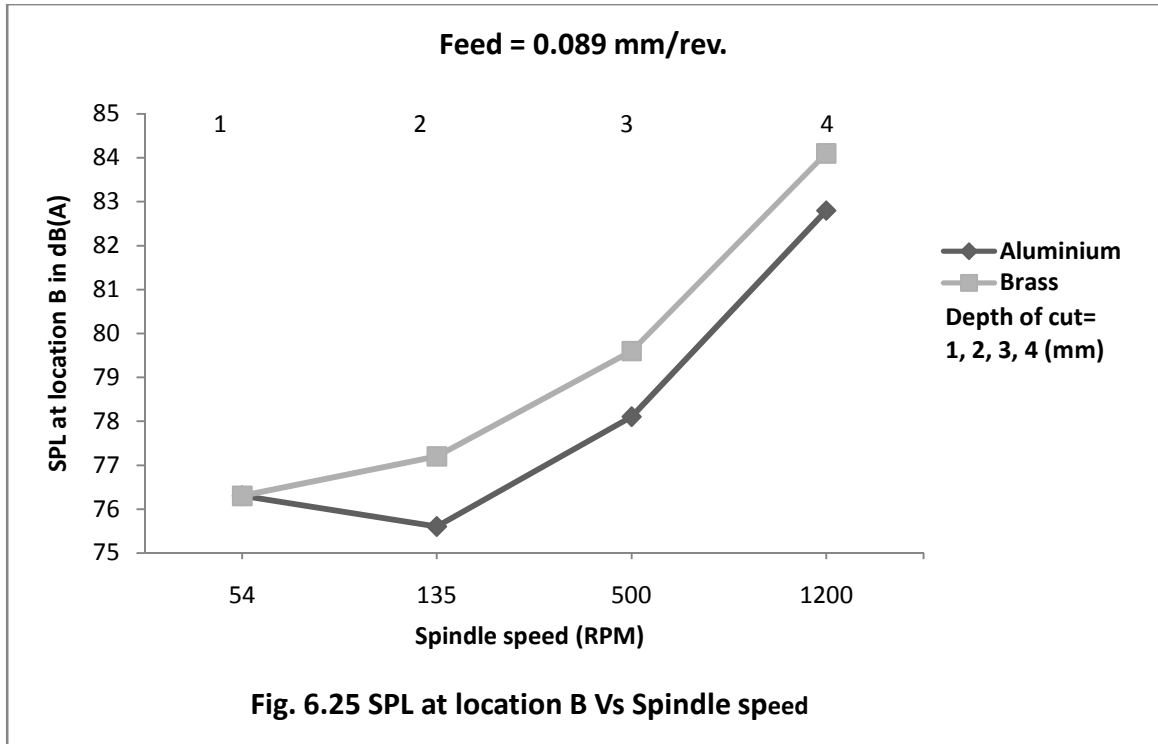


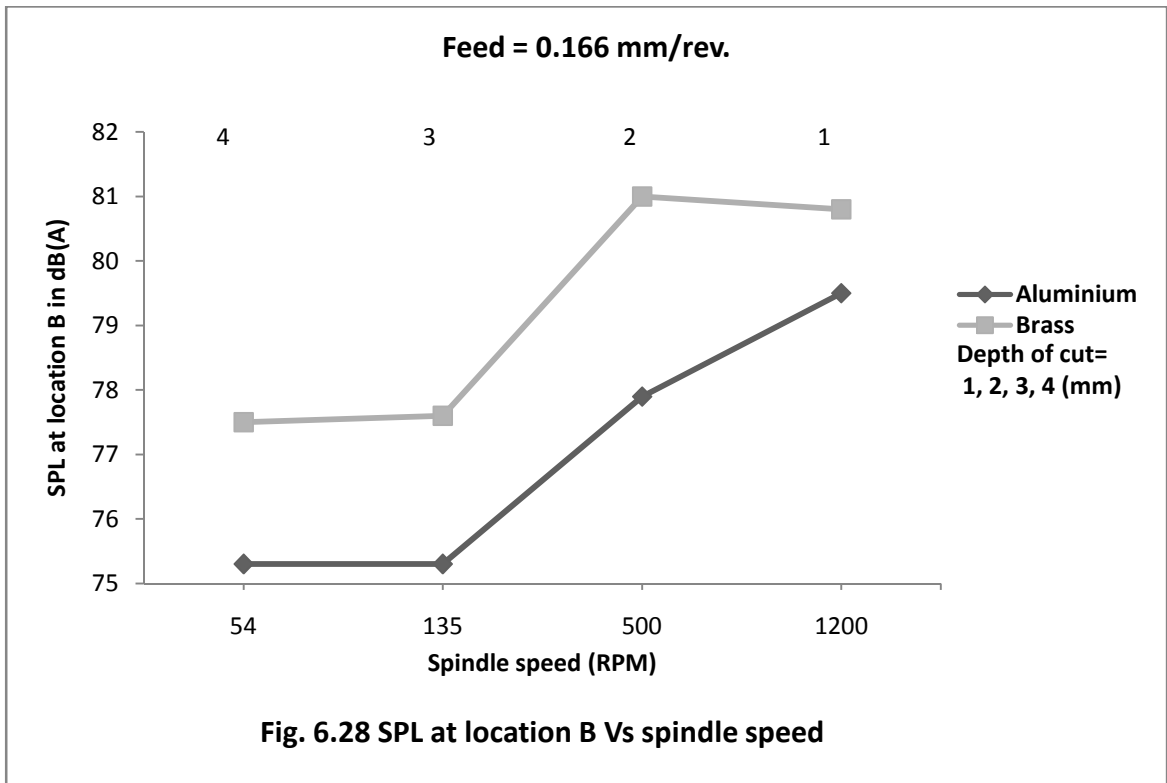
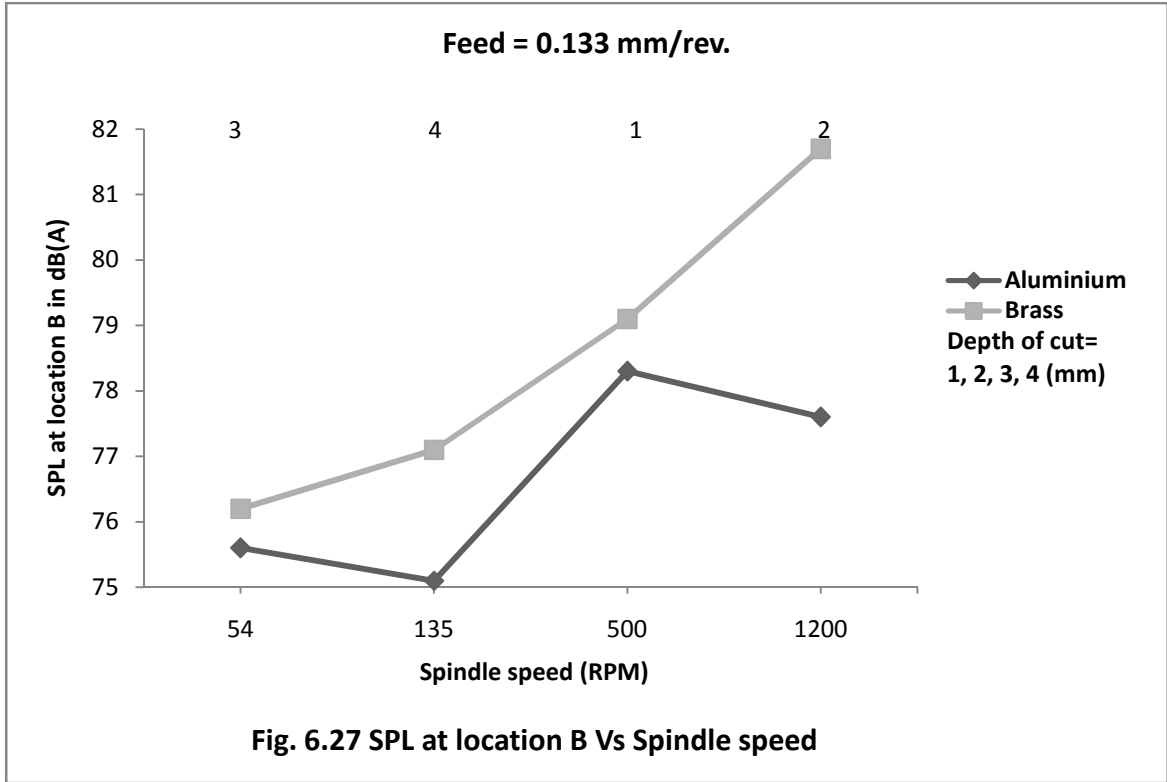




- 1) It is observed that the value of sound pressure level is increased with increasing speed at 1 mm and 4 mm depth of cut for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) At 2 mm and 3 mm depth of cut, value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is also increases up to the certain combination of feed 0.166 mm/rev. and speed 500 RPM and feed 0.089 mm/rev. and speed 500 RPM at 2 mm and 3 mm depth of cut respectively. But at the combination of feed 0.133 mm/rev. & speed 1200 RPM at 2 mm depth of cut and feed 0.111 mm/rev. & speed 1200 RPM at 3 mm depth of cut it is decreased.
- 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 3 mm depth of cut for the combination of speed 1200 RPM & feed 0.111 mm/rev. The difference is 6.1 dB(A).

1) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Aluminium and Brass at location B are shown in fig. 6.25 to 6.28

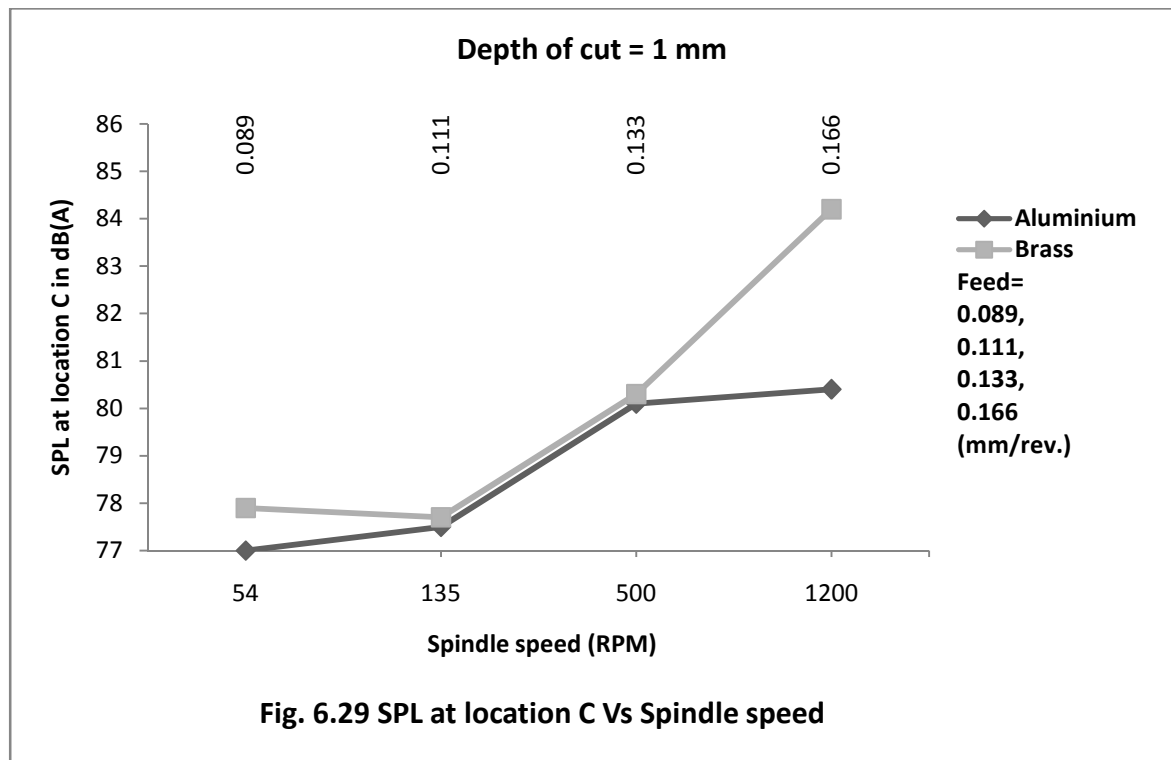


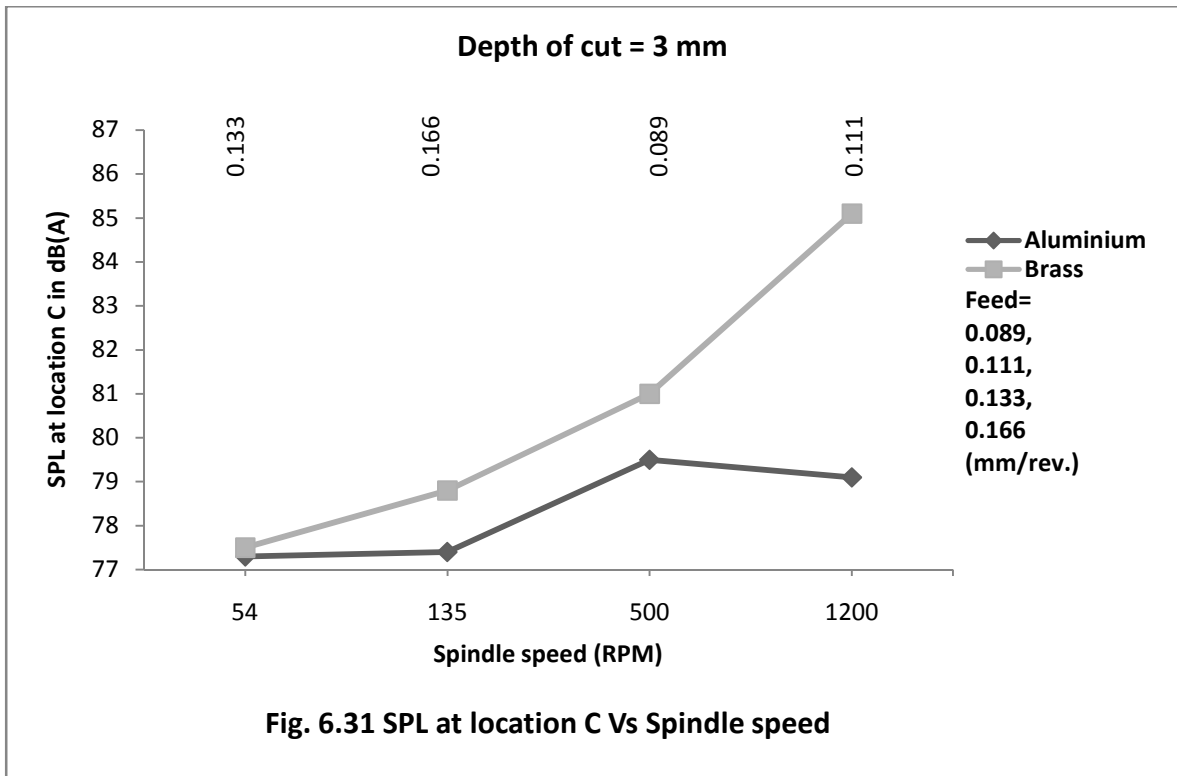
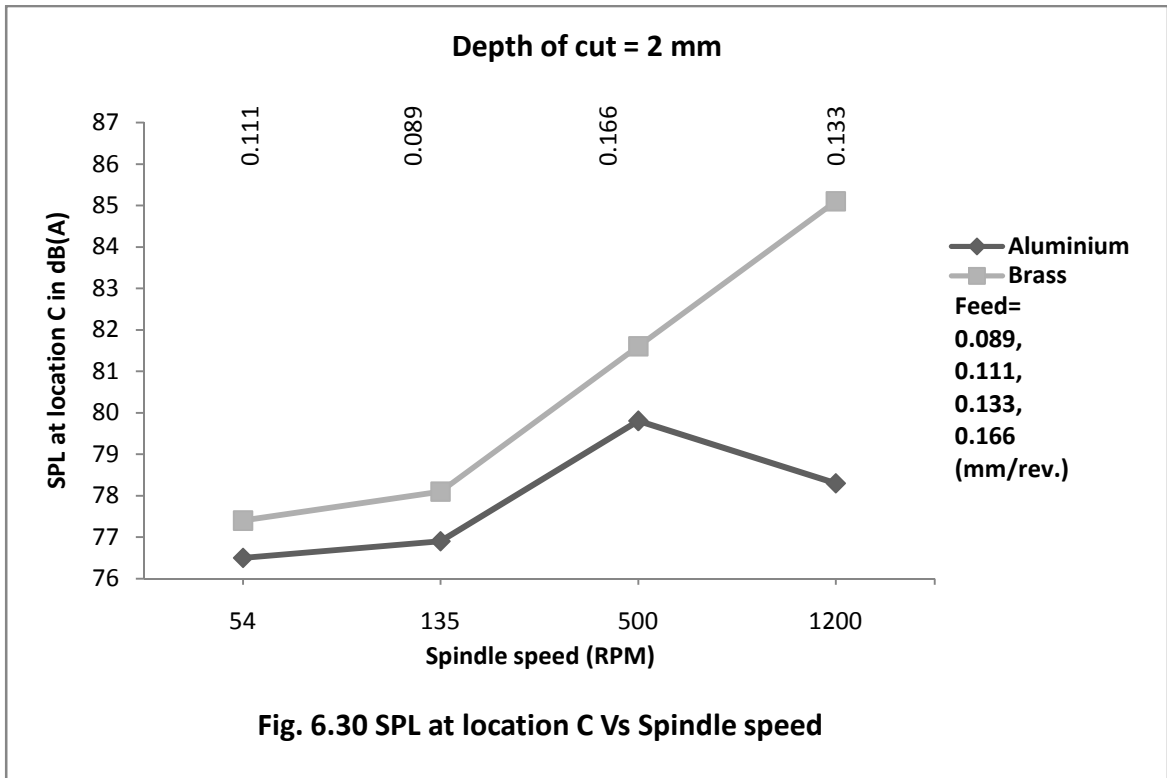


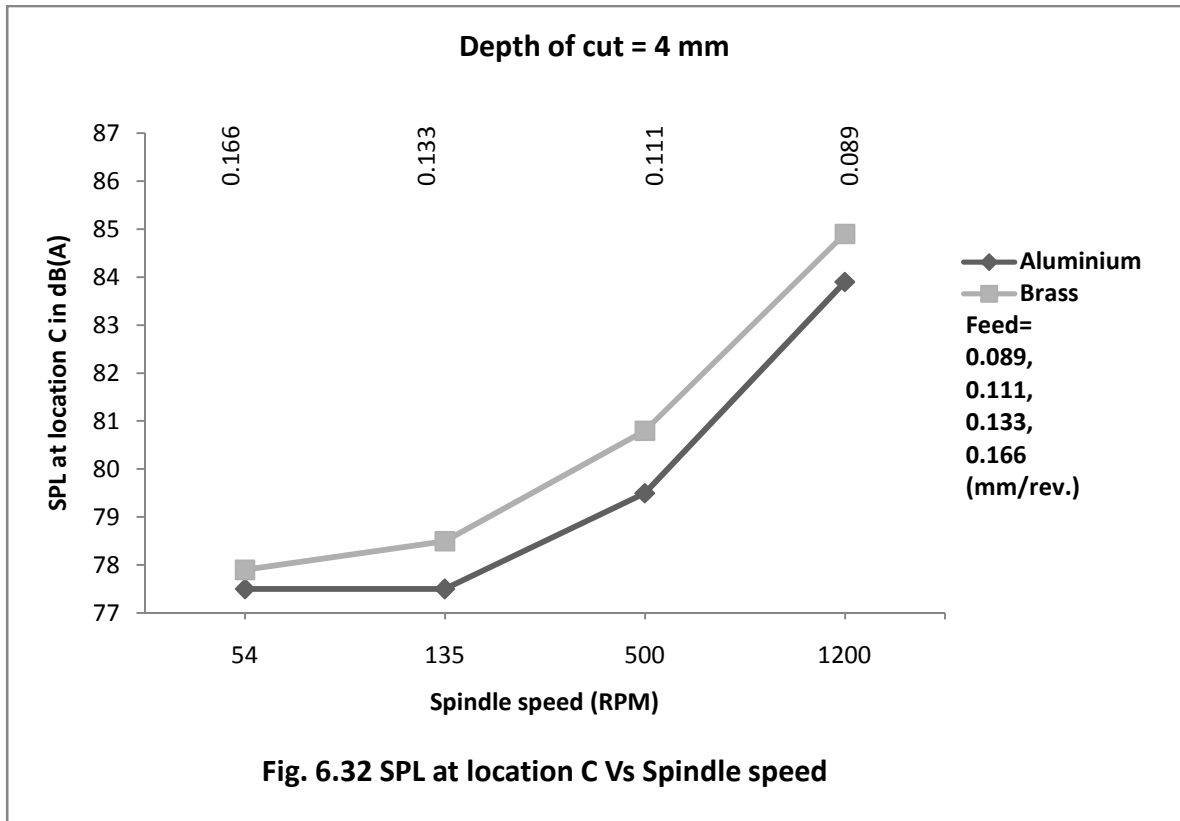
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.089 mm/rev. and 0.166 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) At feed 0.111 mm/rev. and 0.133 mm/rev., value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is also increases up to the certain combination of speed 500 RPM and 4 mm depth of cut. But at the combination of 3 mm depth of cut & speed 1200 RPM at 0.111 mm/rev. and 2 mm depth of cut & speed 1200 RPM at feed 0.133 mm/rev. it is decreased.
- 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 0.111 mm/rev. at the combination of speed 1200 RPM & 3 mm depth of cut. The difference is 6.2 dB(A).

Sound pressure level at location C:

- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Aluminium and Brass at location C are shown in fig. 6.29 to 6.32.

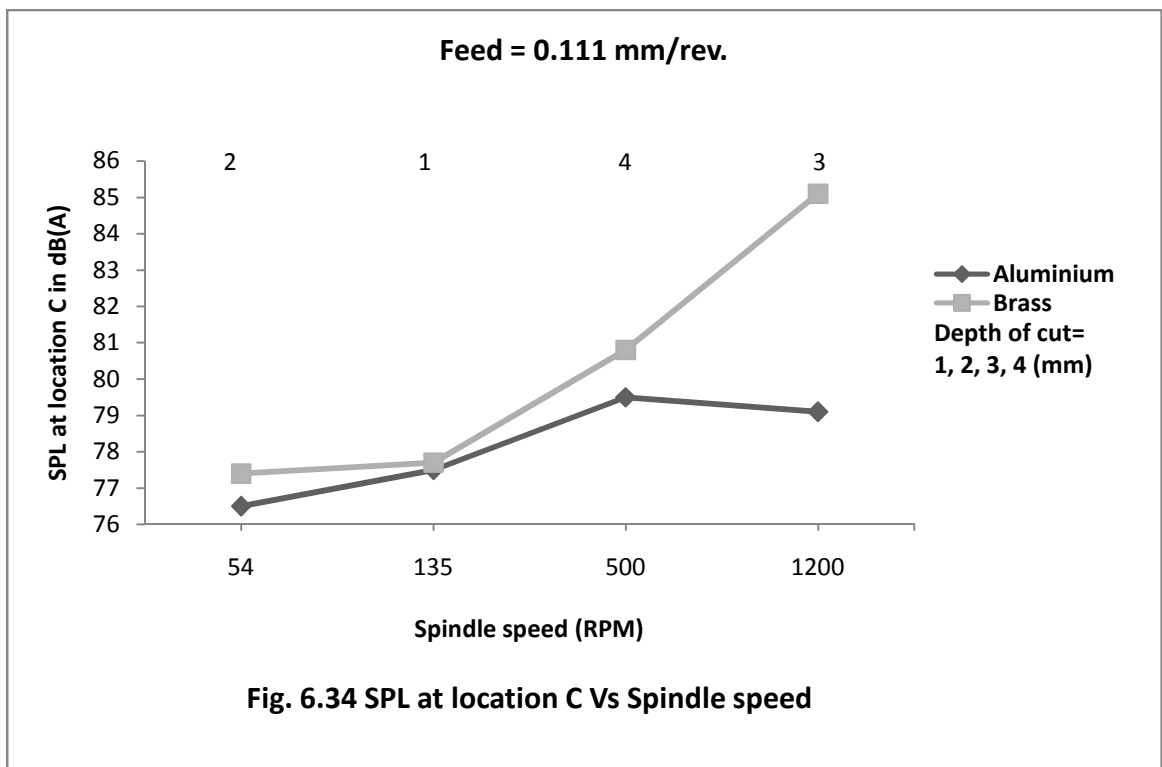
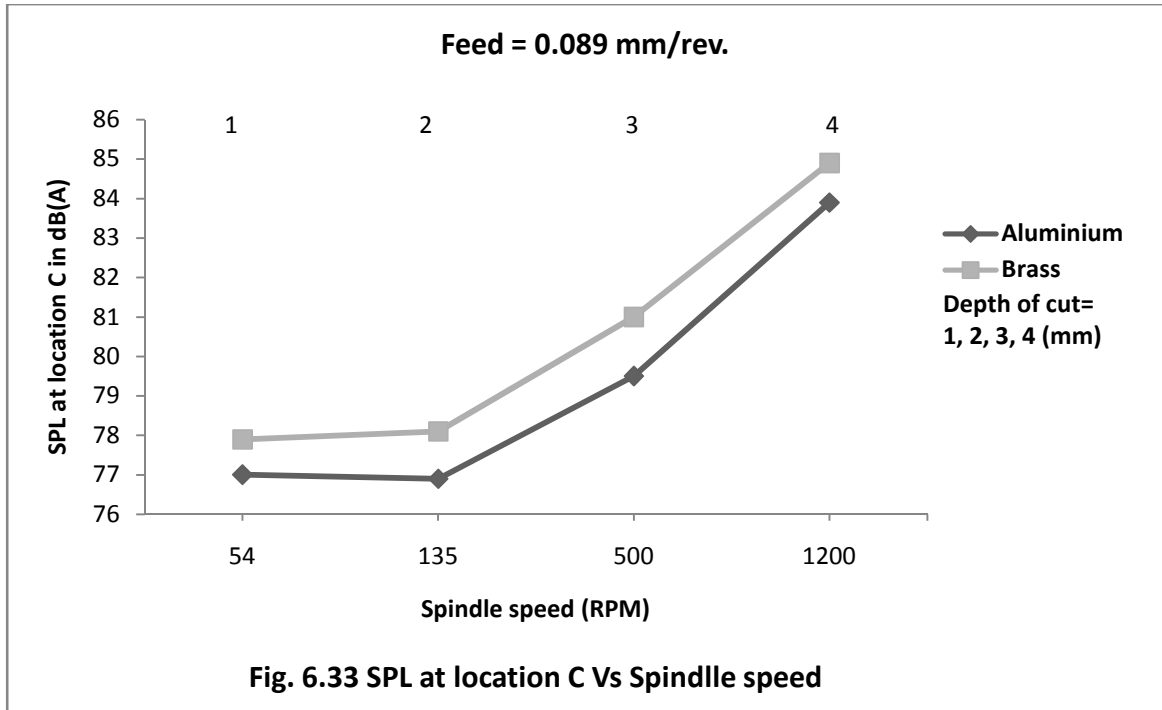


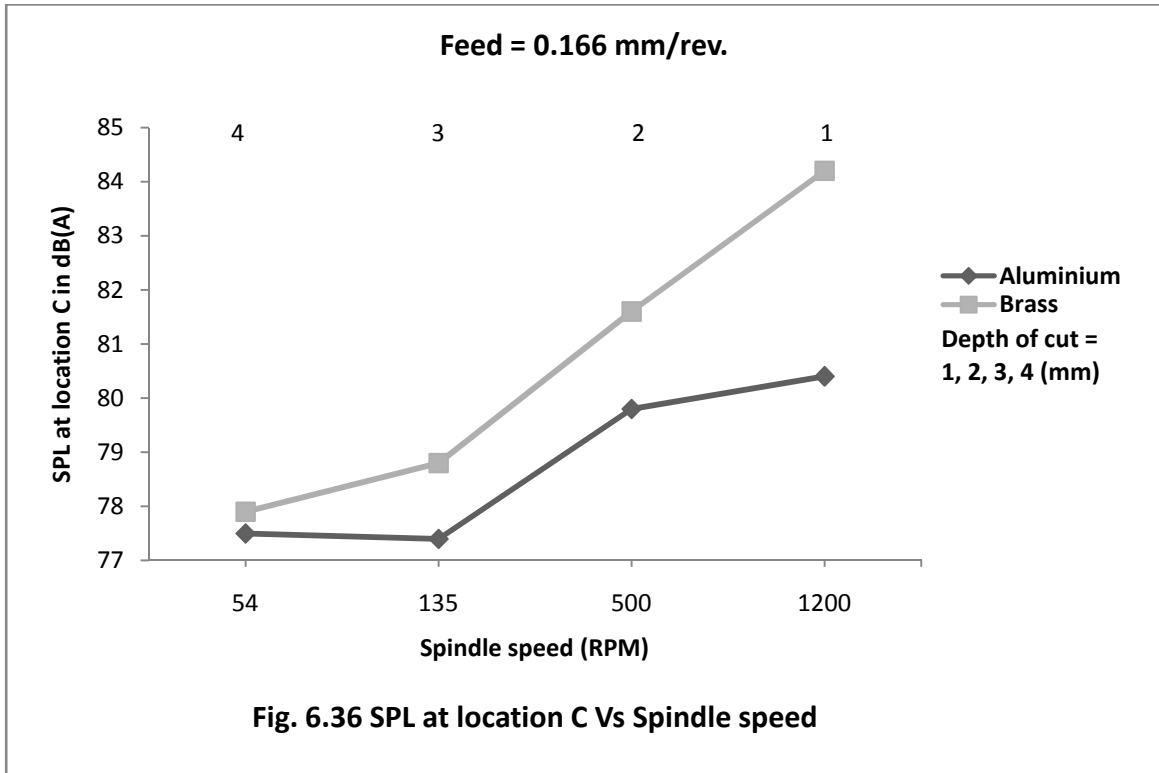
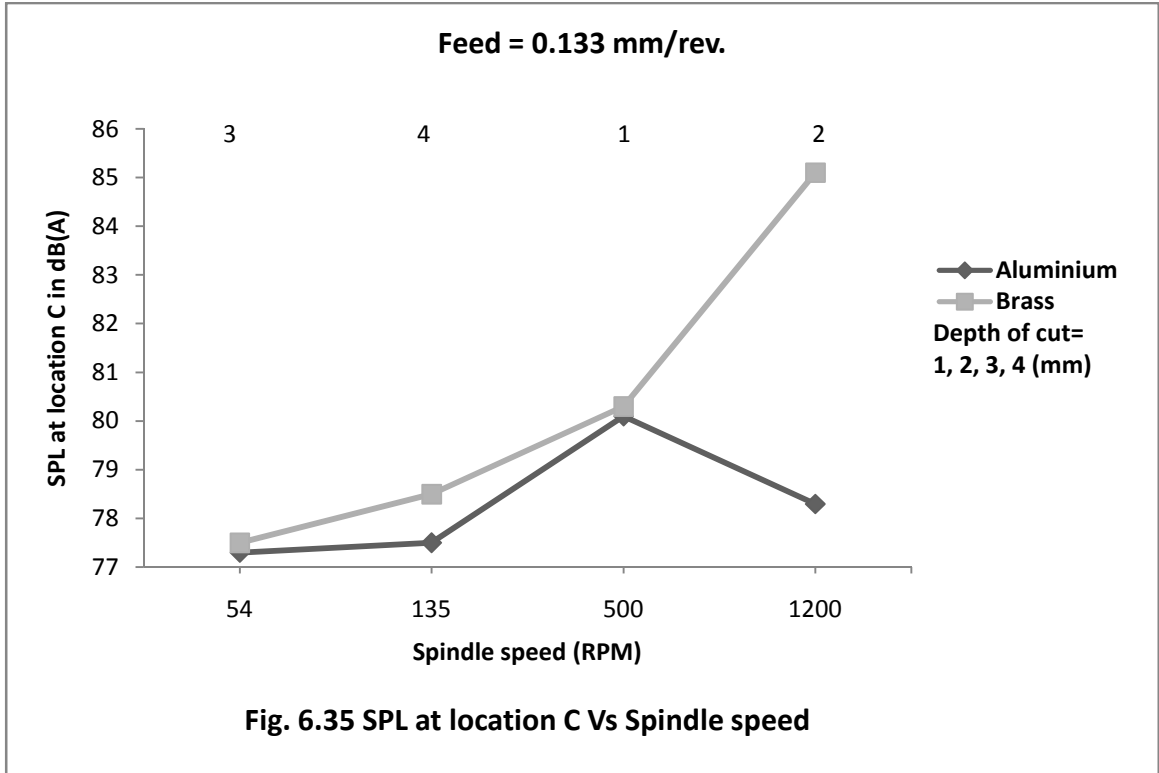




- 1) It is observed that the value of sound pressure level is increased with increasing speed at 1 mm and 4 mm depth of cut for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) At 2 mm and 3 mm depth of cut, value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is also increases up to the certain combination of speed 500 RPM and feed 0.166 mm/rev. and speed 500 RPM and feed 0.089 mm/rev. But at the combination of feed 0.133 mm/rev. & speed 1200 RPM and feed 0.111 mm/rev. & speed 1200 RPM it is decreased.
- 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 2 mm depth of cut for the combination of speed 1200 RPM & feed 0.133. The difference is 6.8 dB(A).

1) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Aluminium and Brass at location C are shown in fig. 6.33 to 6.36.

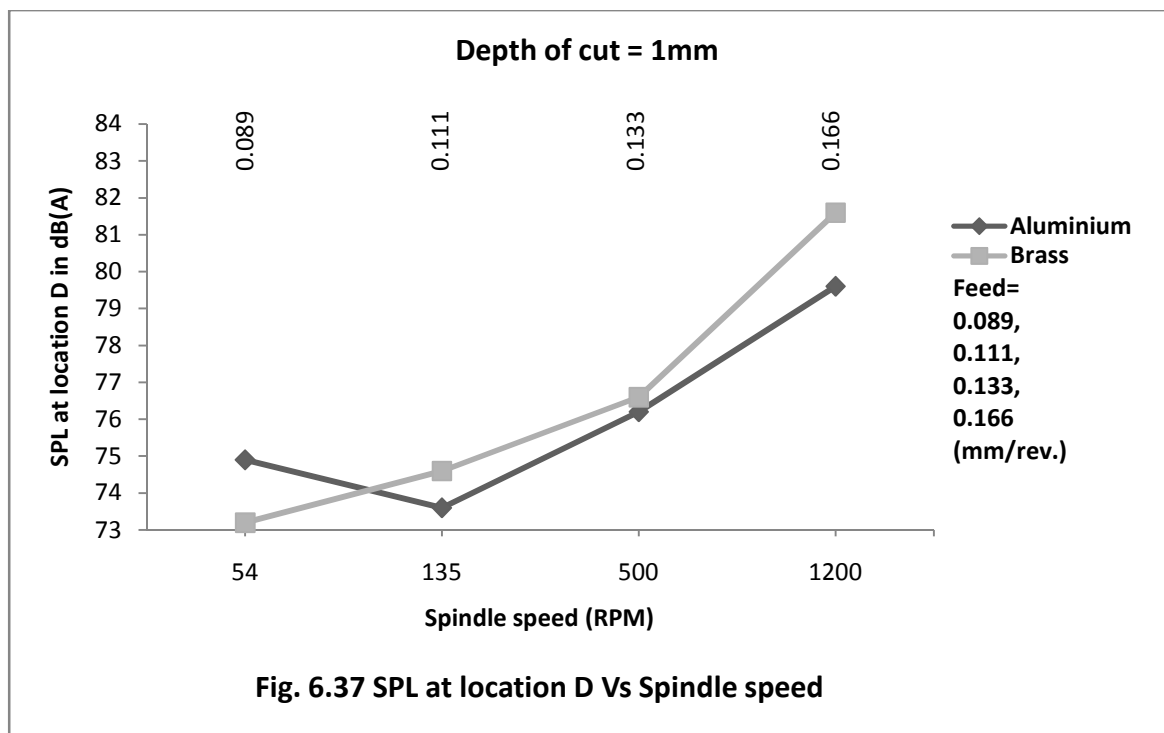


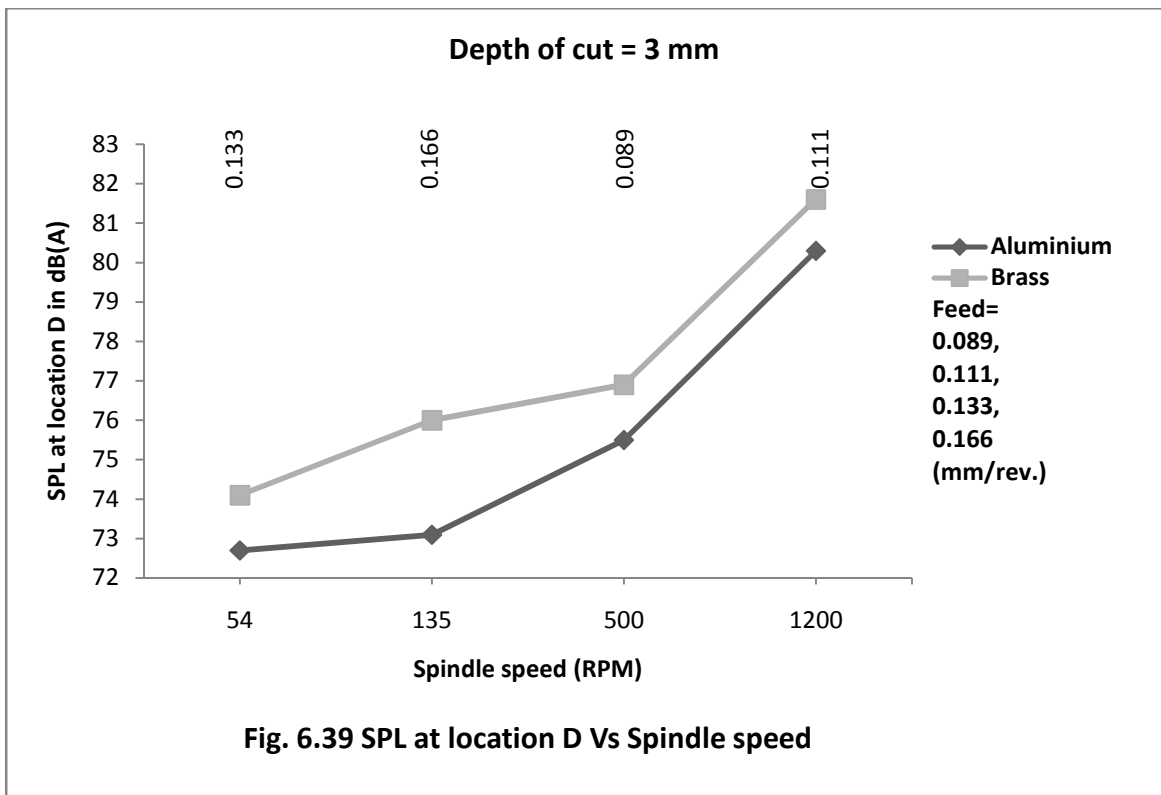
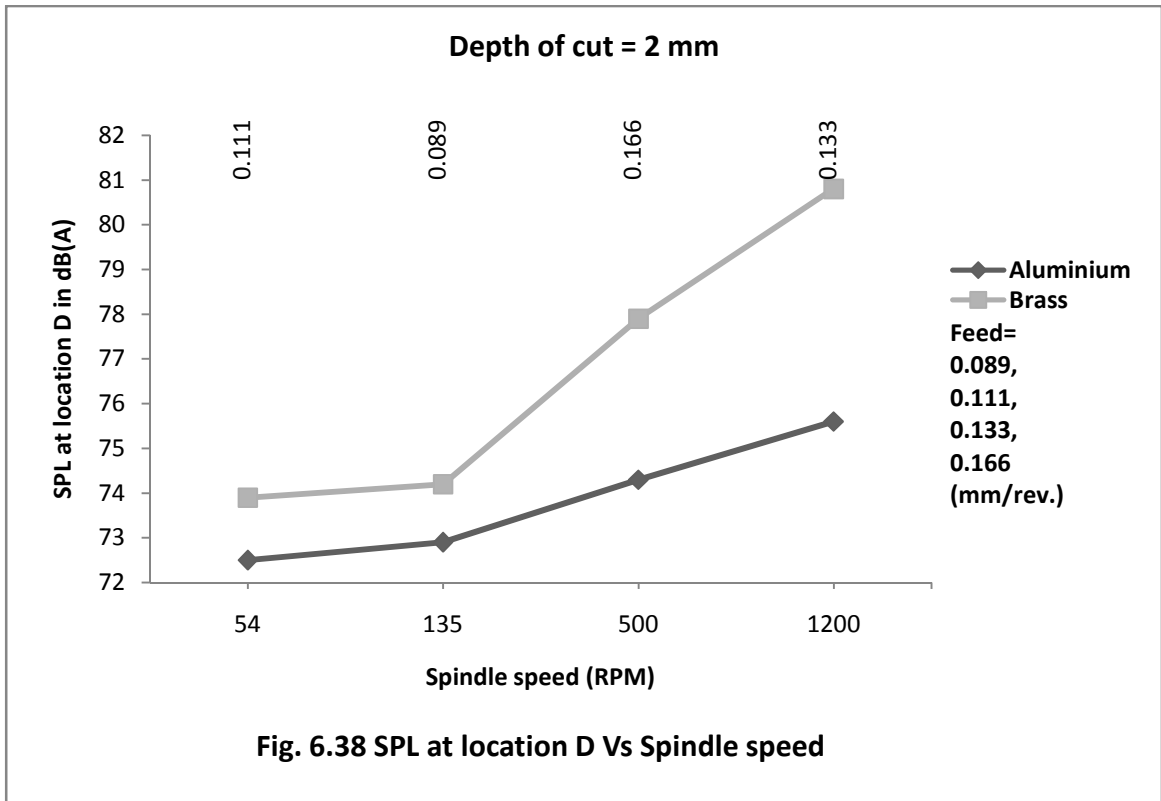


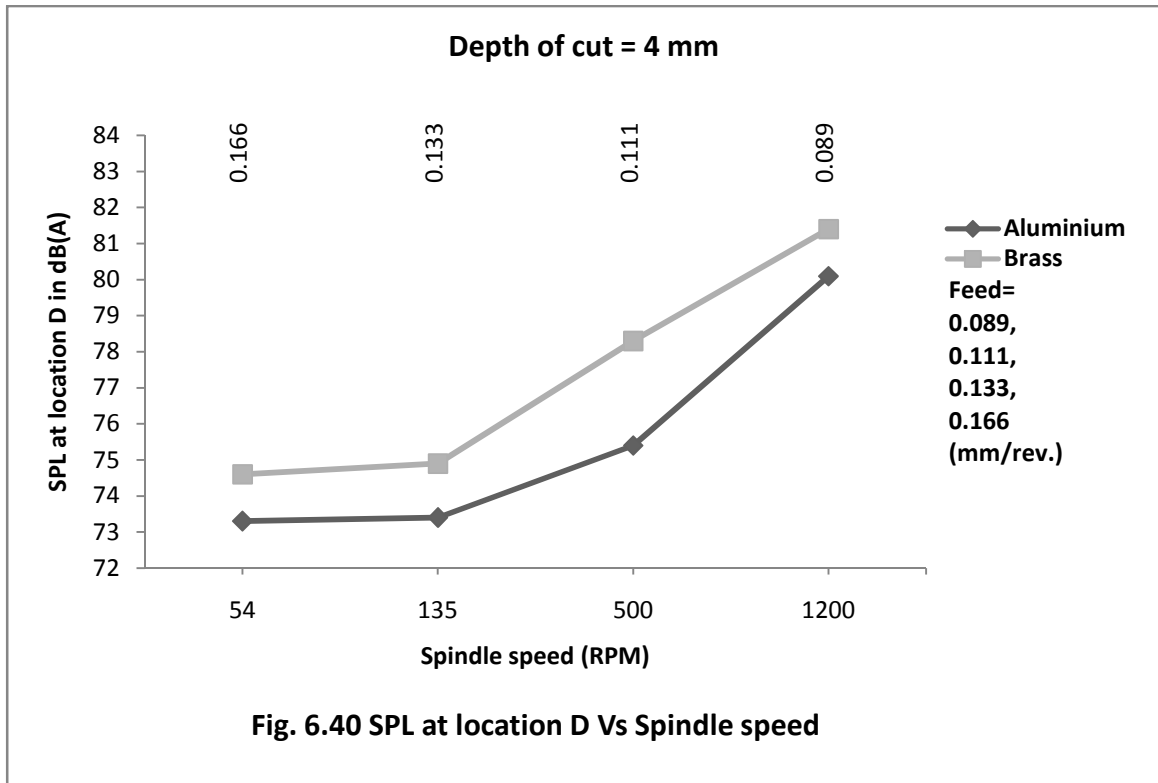
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.089 mm/rev. and 0.166 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) At feed 0.111 mm/rev. and 0.133 mm/rev., value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is also increases up to the certain combination of speed 500 RPM and 4 mm depth of cut and speed 500 RPM and 1 mm depth of cut. But at the combination of 3 mm depth of cut & speed 1200 RPM at 0.111 mm/rev. and 2 mm depth of cut & speed 1200 RPM at feed 0.133 mm/rev. it is decreased.
- 4) The major difference showed between the sound pressure levels of Aluminium and Brass at 0.133 mm/rev. at the combination of speed 1200 RPM & 2 mm depth of cut. The difference is 6.8 dB(A).

Sound pressure level at location D:

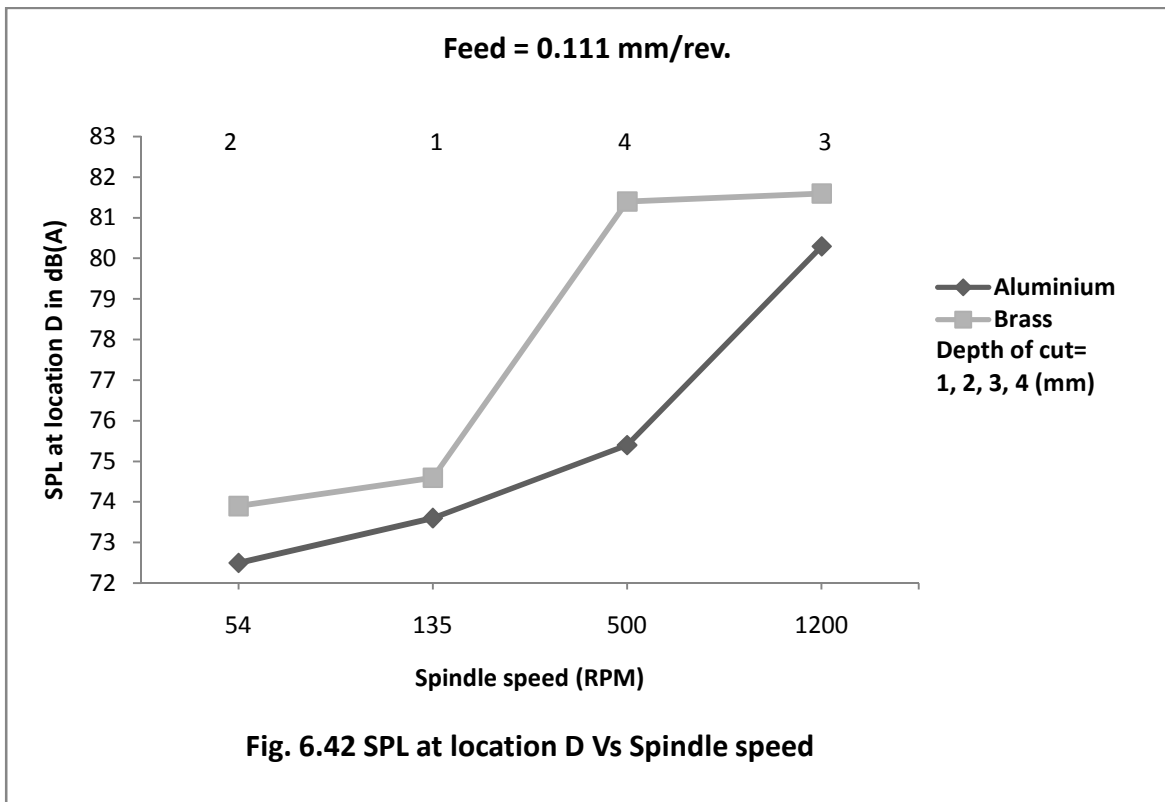
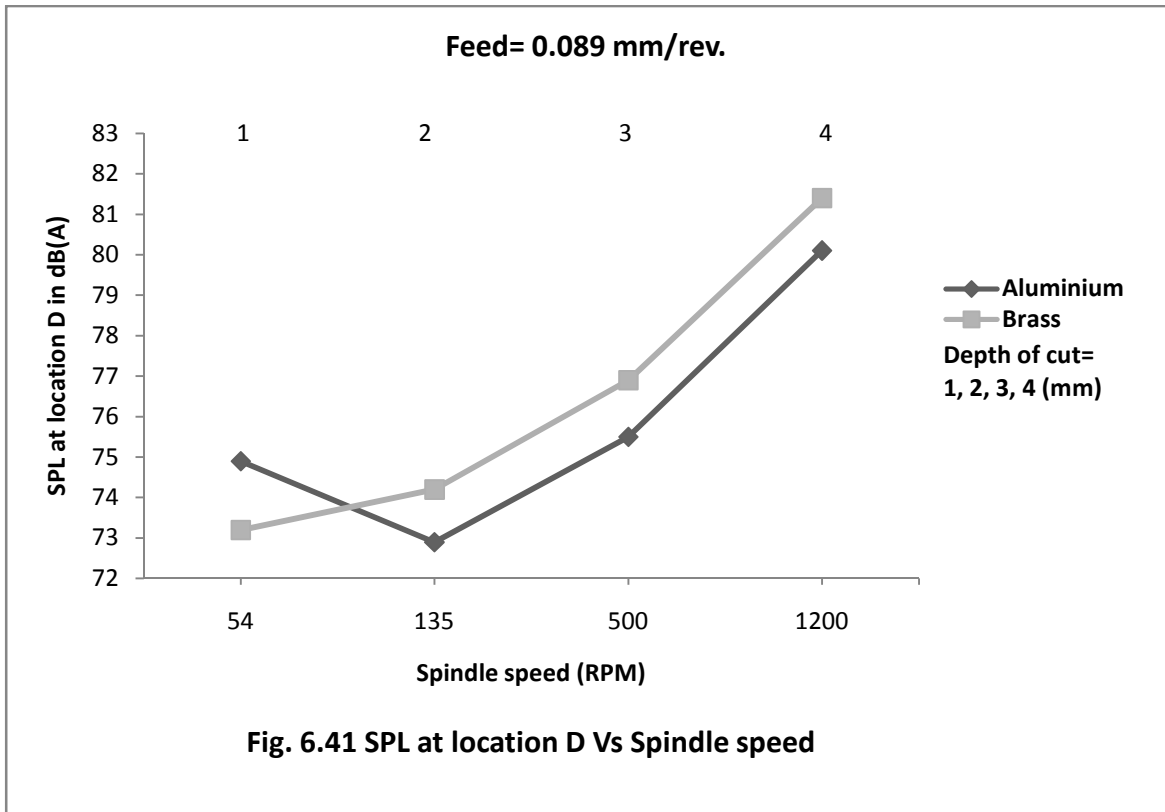
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Aluminium and Brass at location D are shown in fig. 6.37 to 6.40.

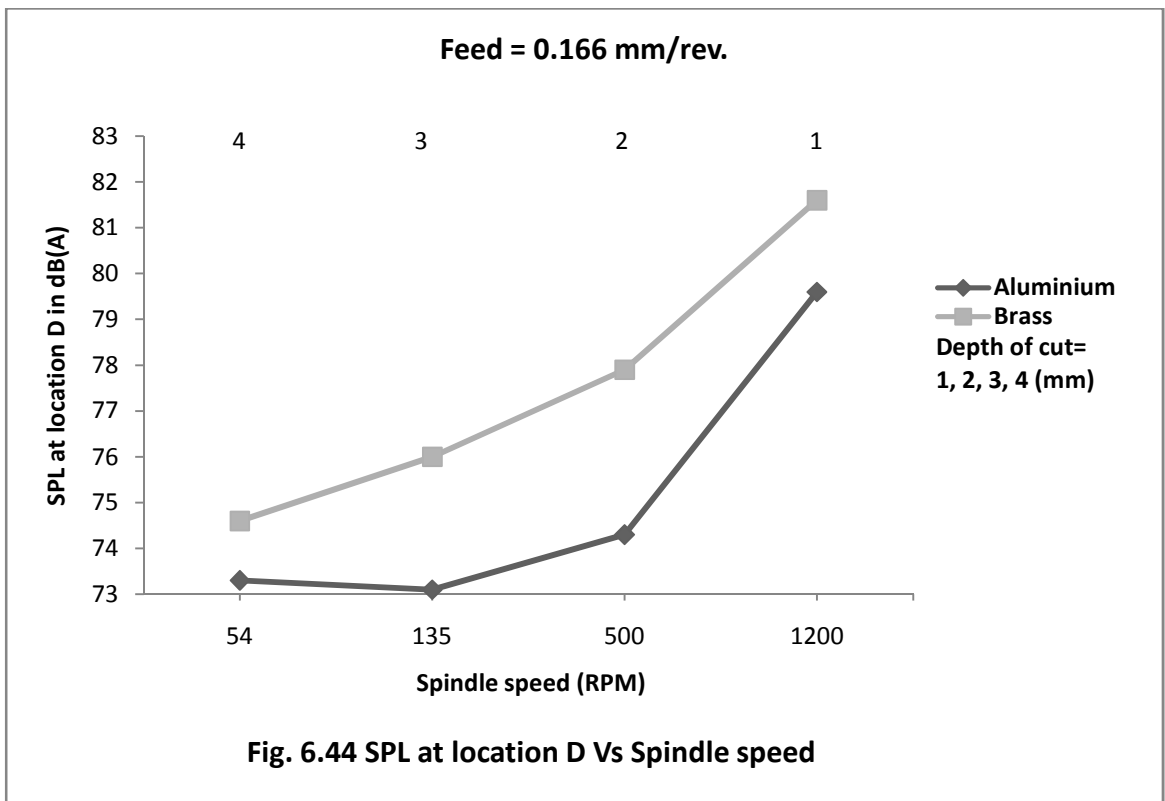
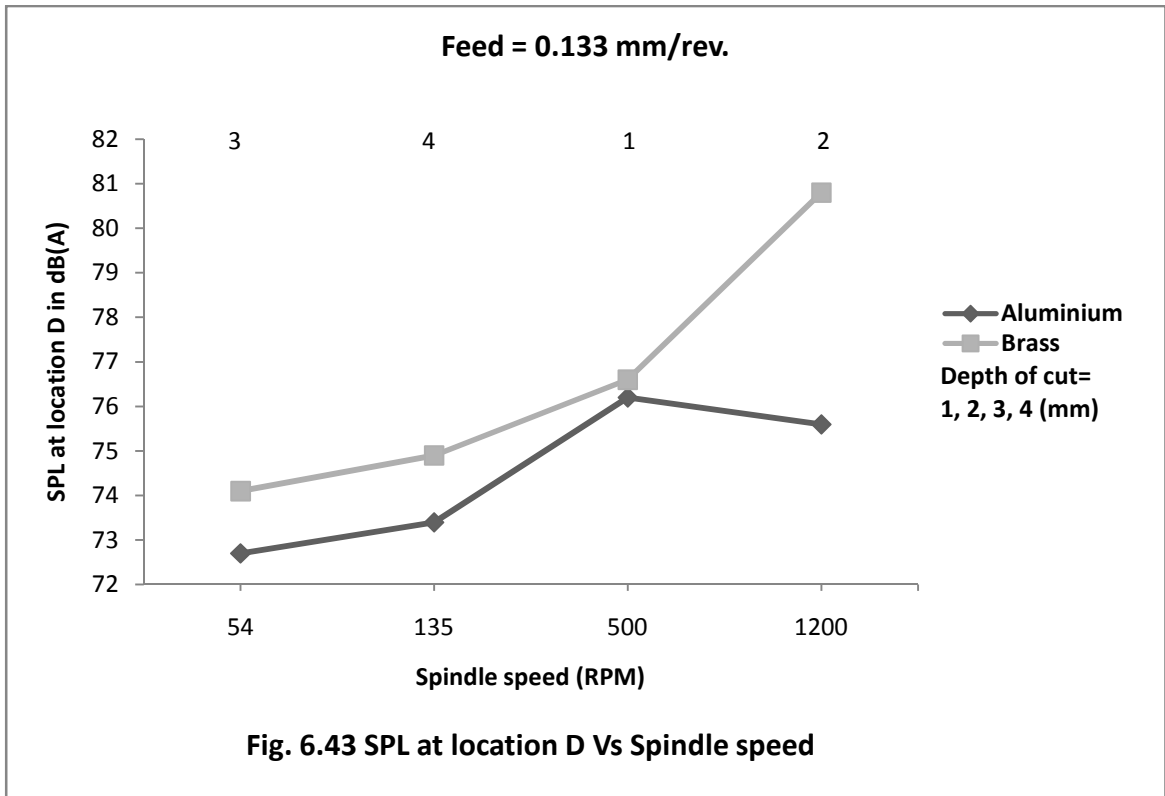






- 1) It is observed that the value of sound pressure level is increased with increasing speed at 2 mm, 3 mm and 4 mm depth of cut for both the materials.
 - 2) At the 1 mm depth of cut, value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is decreased at the combination of feed 0.111 mm/rev. and speed 135 RPM and then increases for the other combinations.
 - 3) At 1 mm depth of cut, the sound pressure level of Aluminium is higher at the combination of feed 0.089 mm/rev. speed 54 RPM than Brass.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Aluminium and Brass at location D are shown in fig. 6.41 to 6.44.

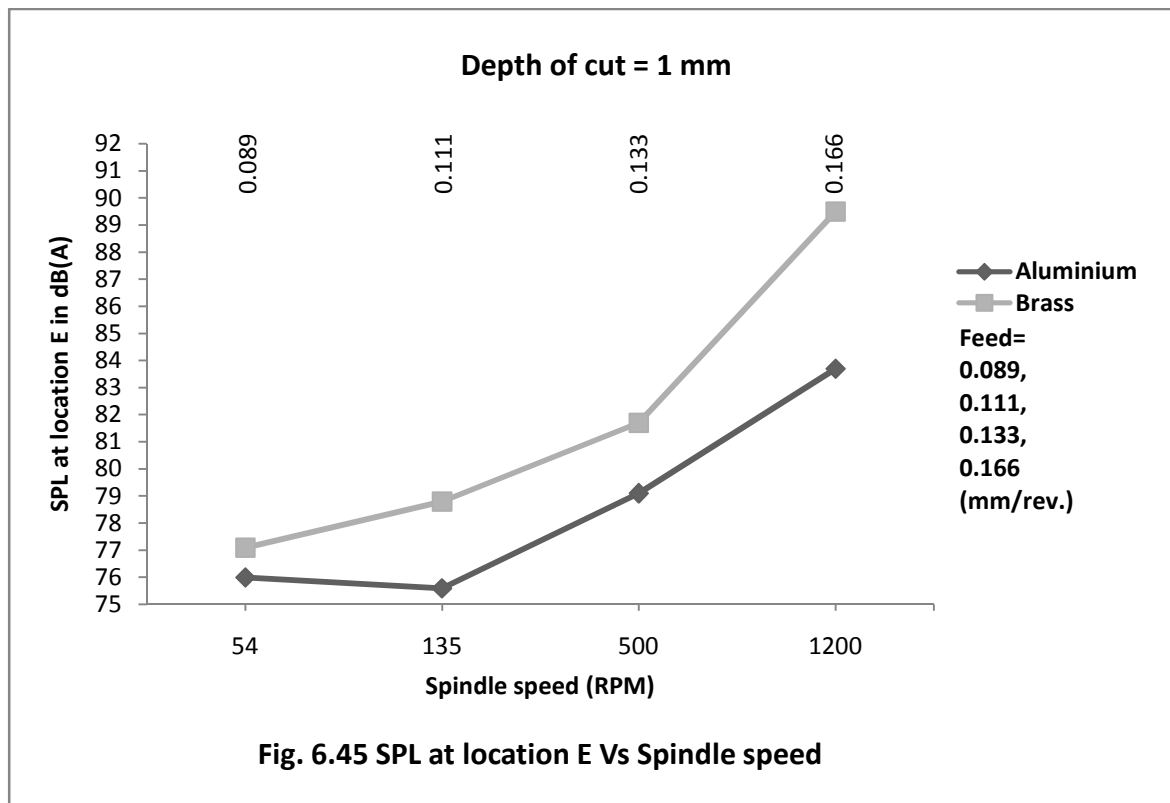


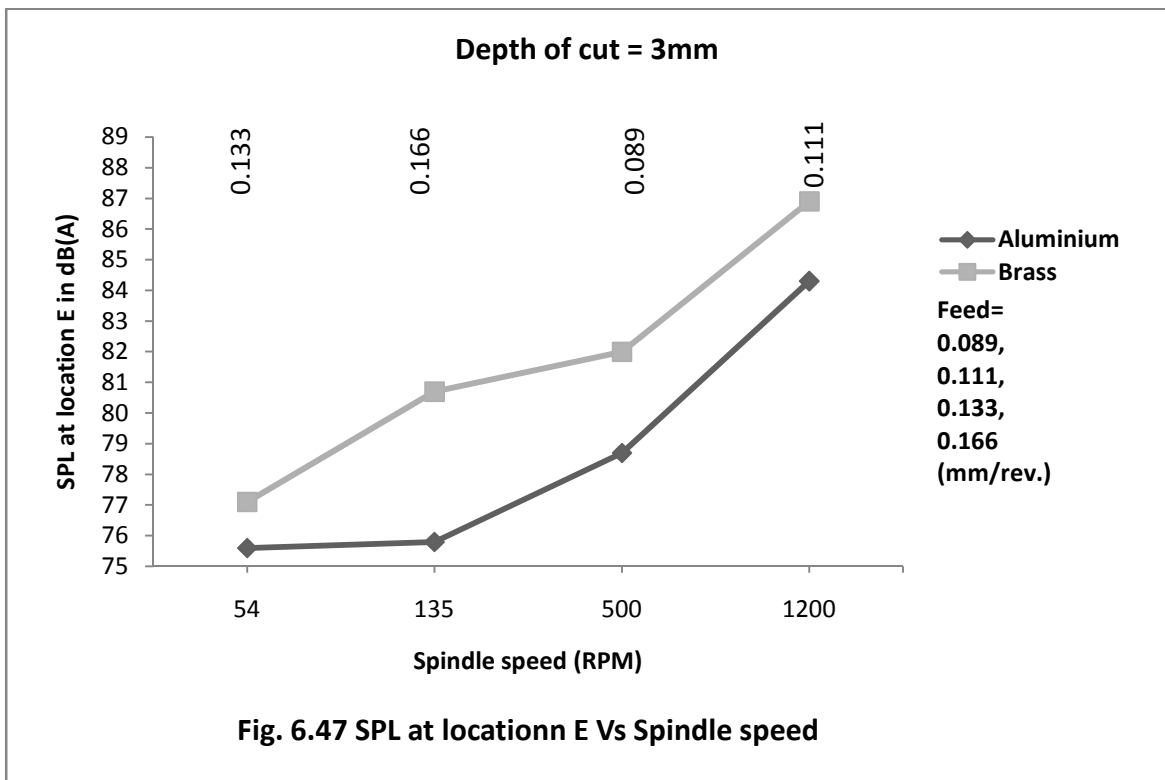
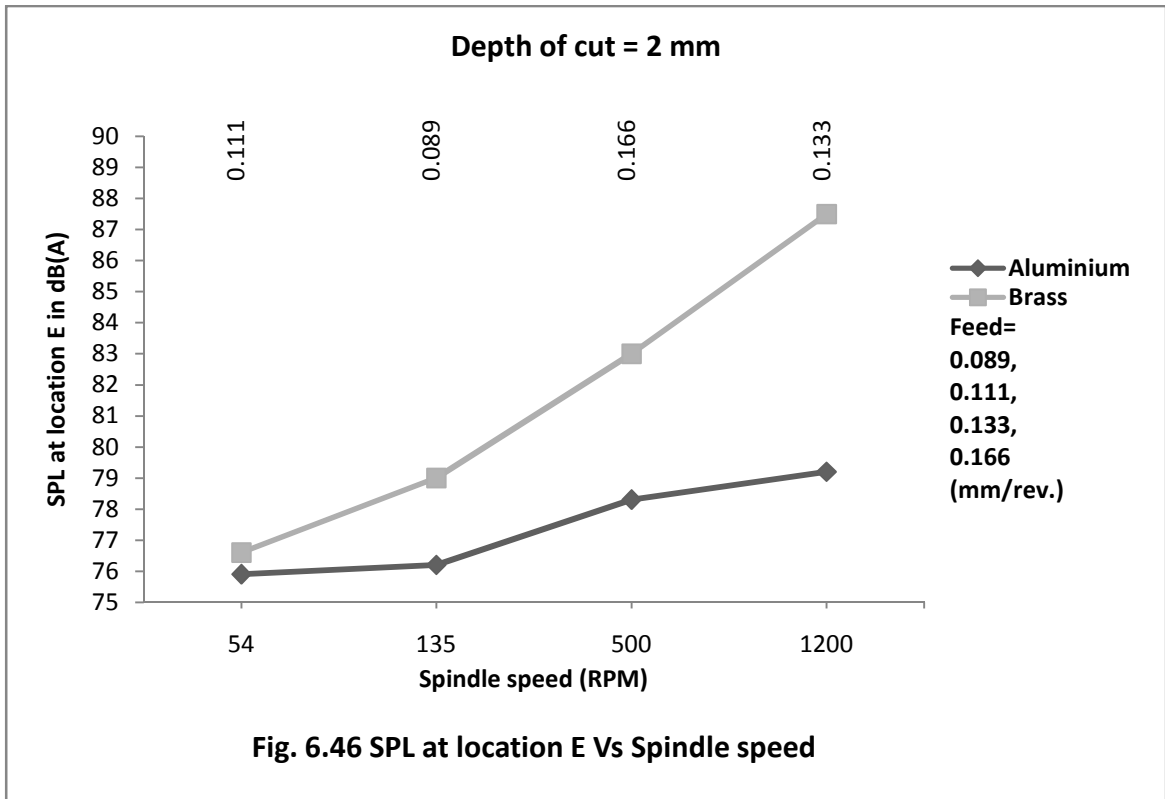


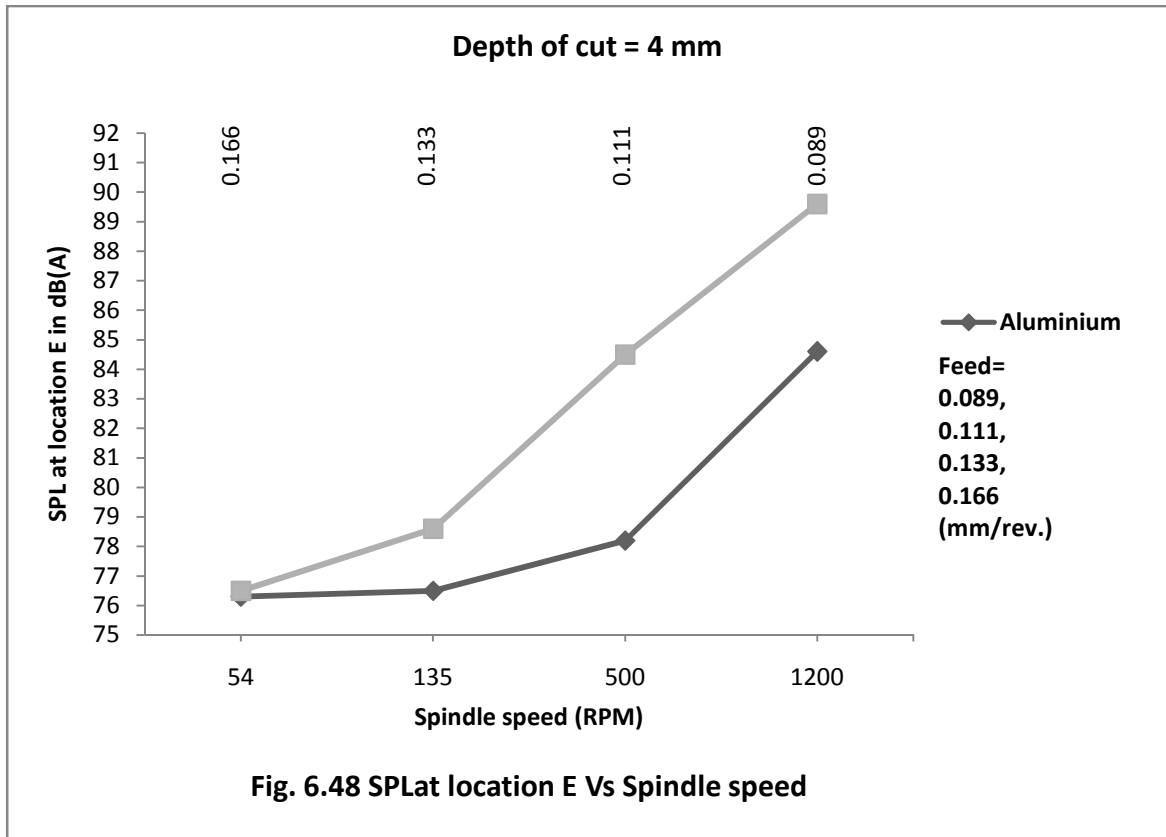
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.111 mm/rev. and 0.166 mm/rev. for both the materials.
- 2) At feed 0.089 mm/rev., value of sound pressure level is increased with increasing speed for Brass. For the Aluminium it is decreased at the combination of feed 2 mm depth of cut and speed 135 RPM and then increases for the other combinations.
- 3) At 0.089 mm/rev., the sound pressure level of Aluminium is higher at the combination of 1 mm depth of cut and speed 54 RPM than Brass.

Sound pressure level at location E:

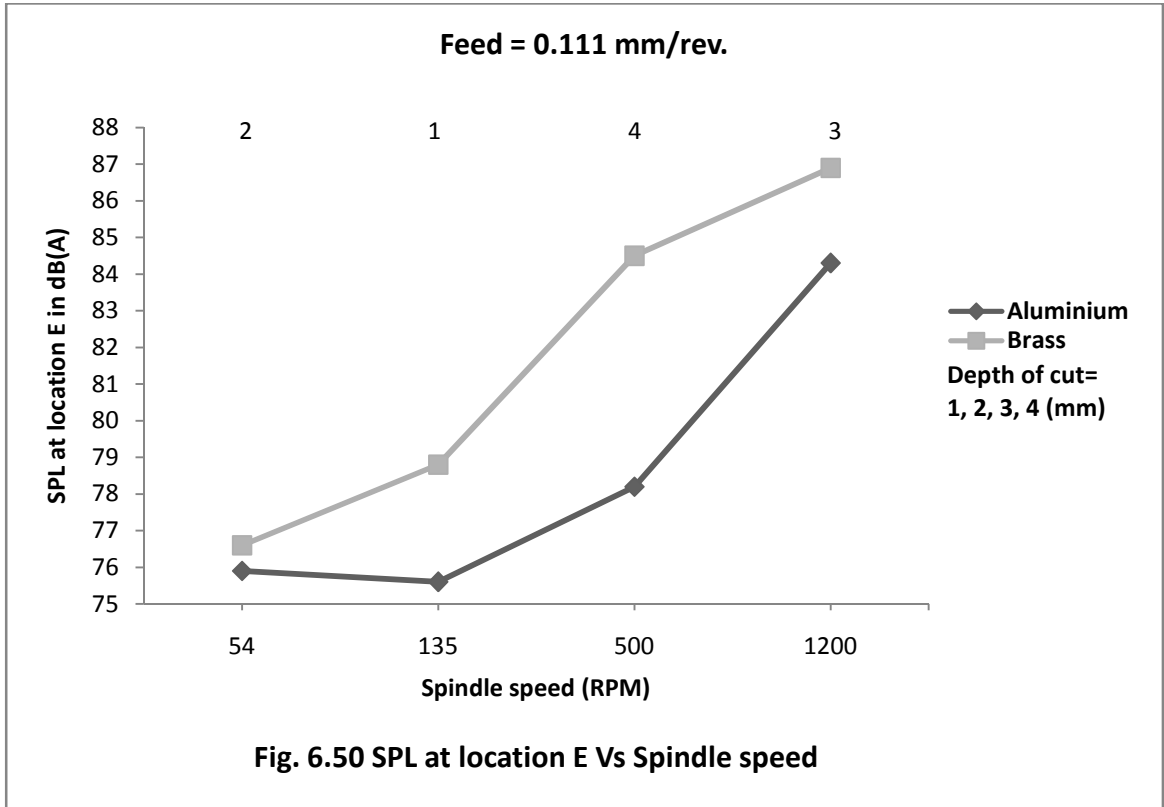
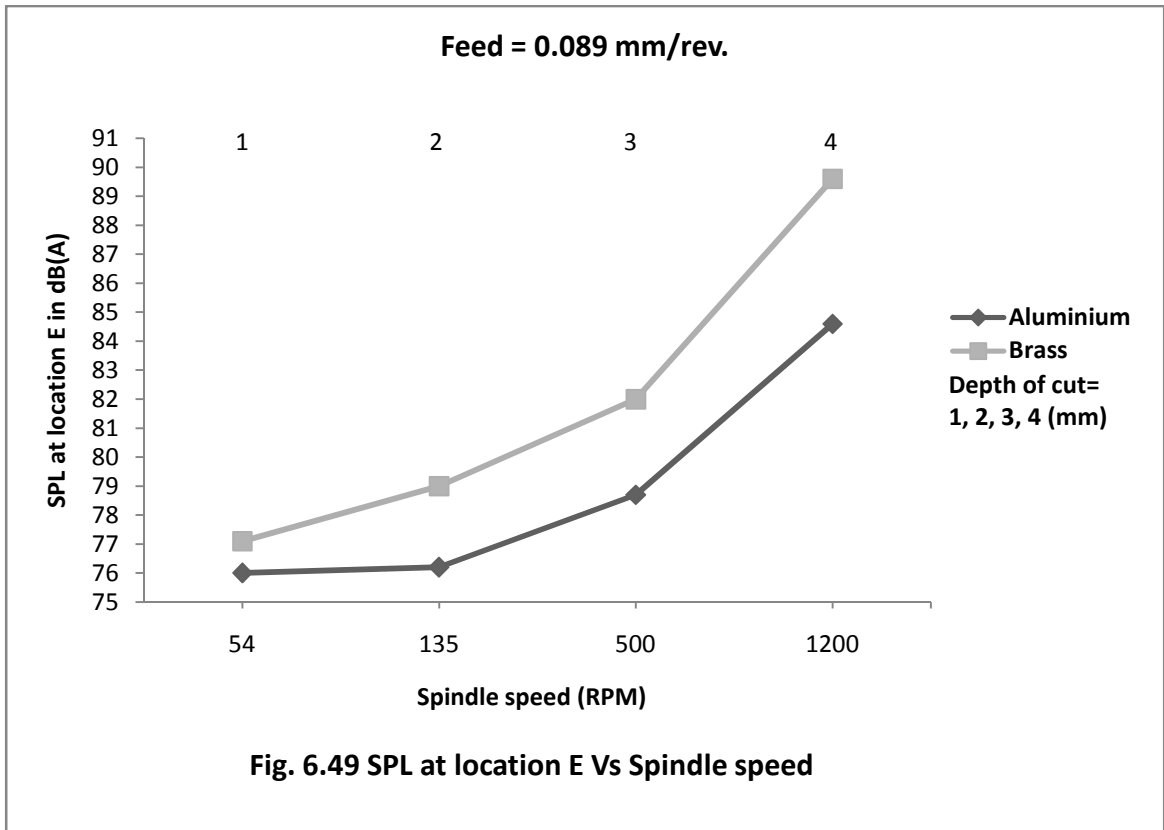
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Aluminium and Brass at location E are shown in fig. 6.45 to 6.48.

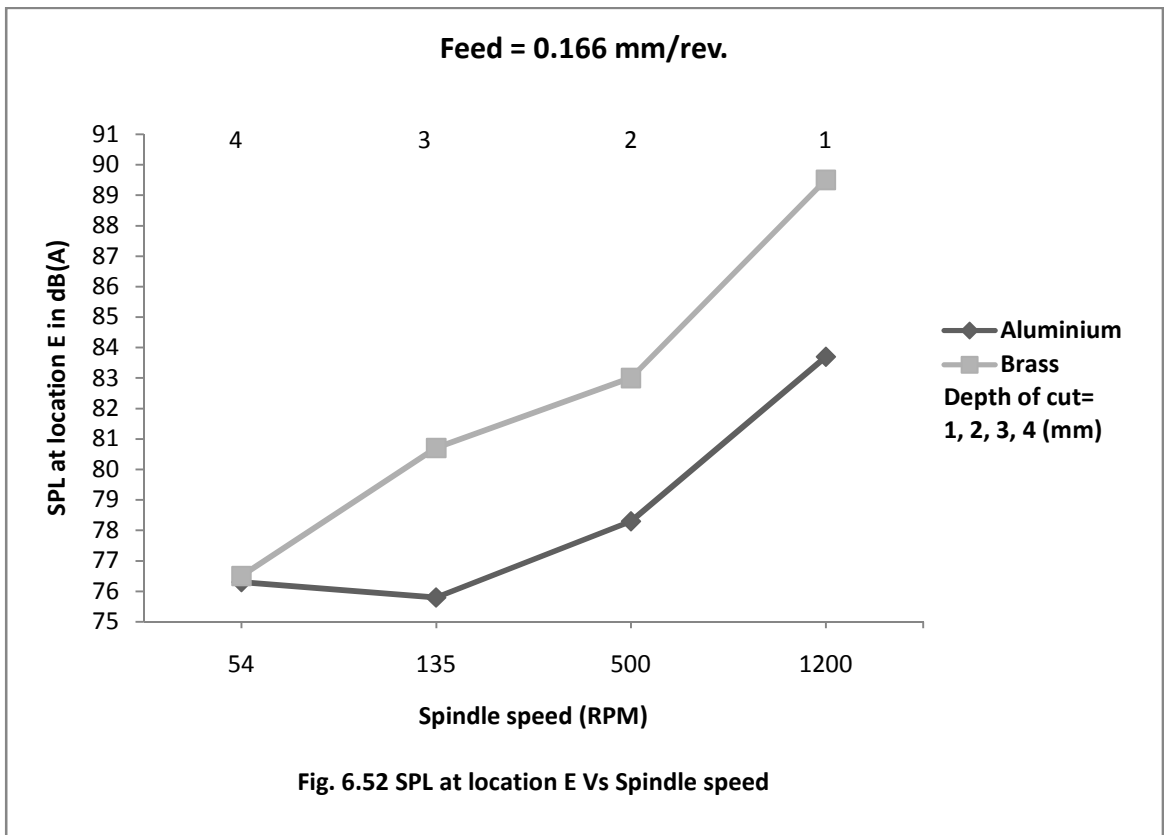
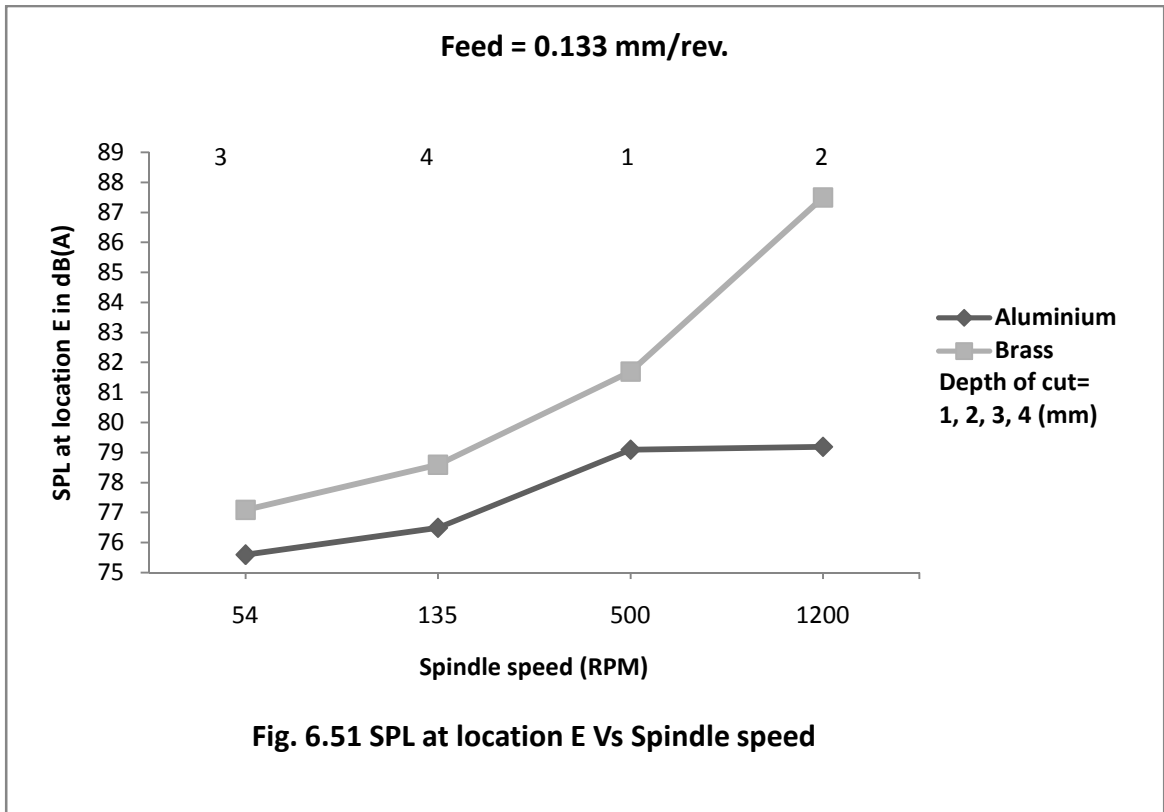






- 1) It is observed that the value of sound pressure level is increased with increasing speed at all the combinations of depth of cut, feed and speed for both the materials.
 - 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
 - 3) The major difference showed between the sound pressure levels of Aluminium and Brass at 2 mm depth of cut for the combination of speed 1200 RPM & feed 0.133 mm/rev. The difference is 8.3 dB(A).
- 1) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Aluminium and Brass at location E are shown in fig. 6.49 to 6.52.





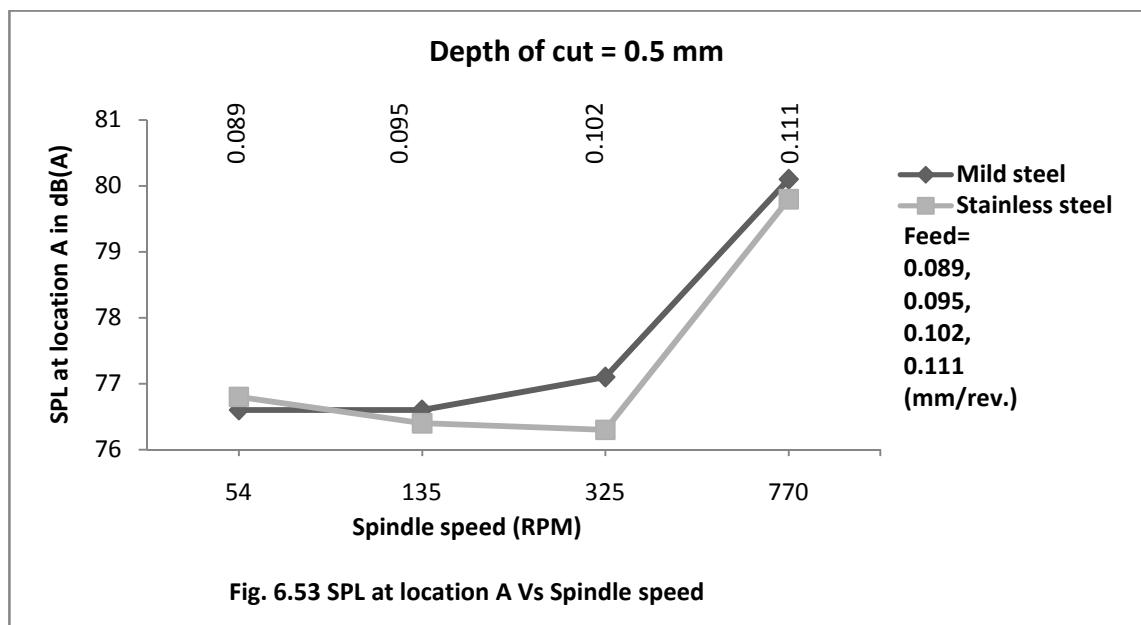
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.111 mm/rev. and 0.166 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Aluminium as compared to Brass for any combination of speed, feed and depth of cut.
- 3) The major difference showed between the sound pressure levels of Aluminium and Brass at 0.133 mm/rev. for the combination of speed 1200 RPM and 2 mm depth of cut. The difference is 8.3 dB(A).

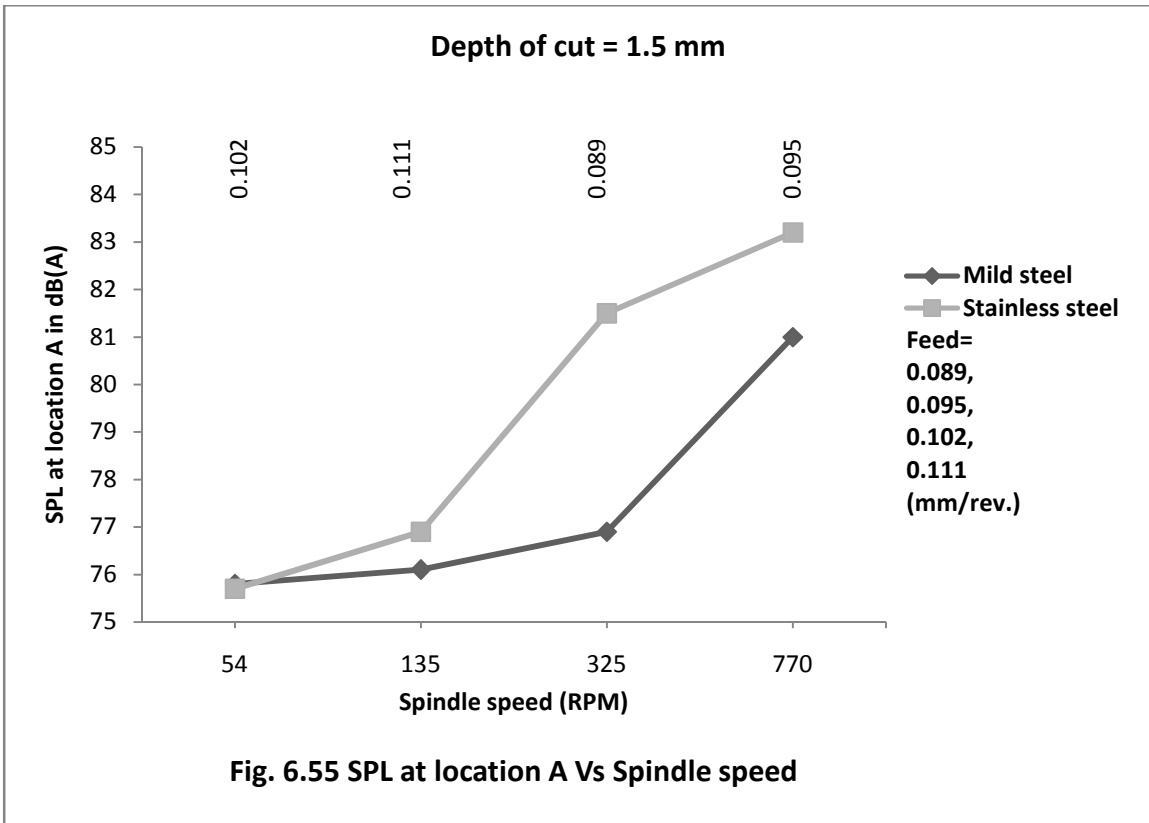
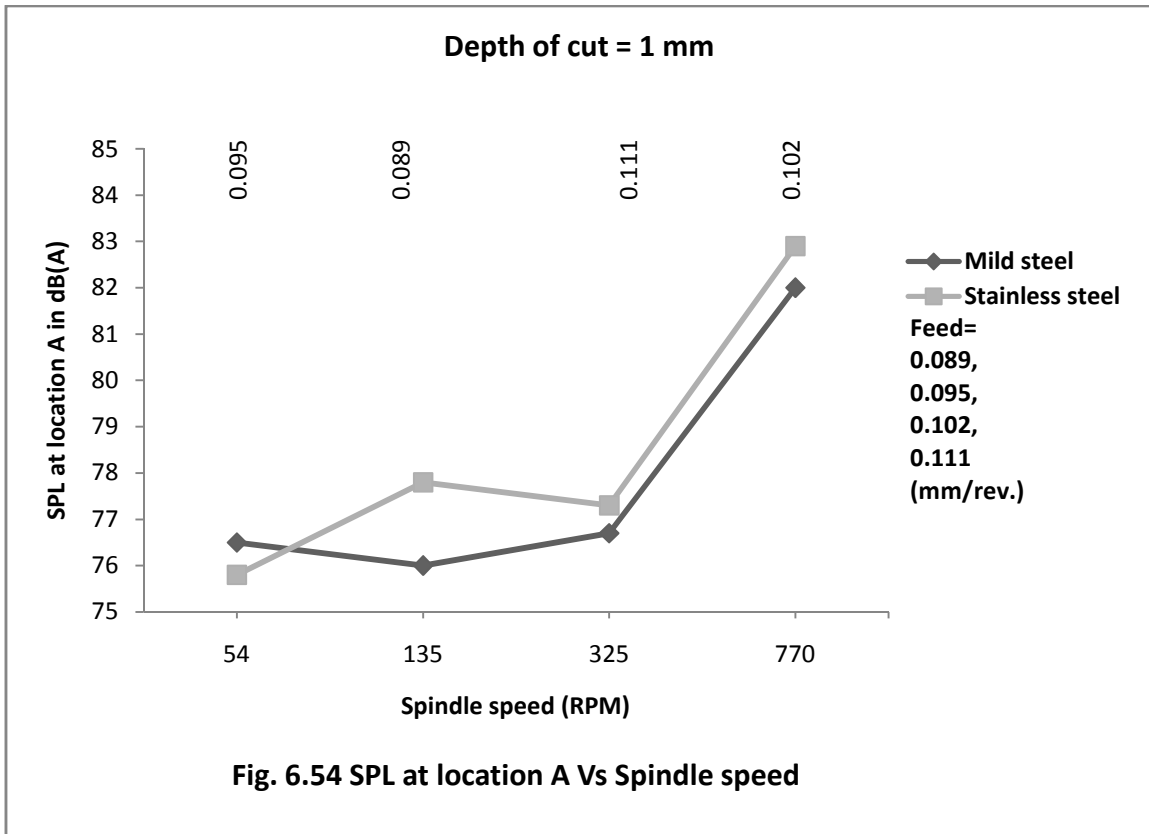
6.2.2 Sound pressure level in the case of Mild steel & Stainless steel

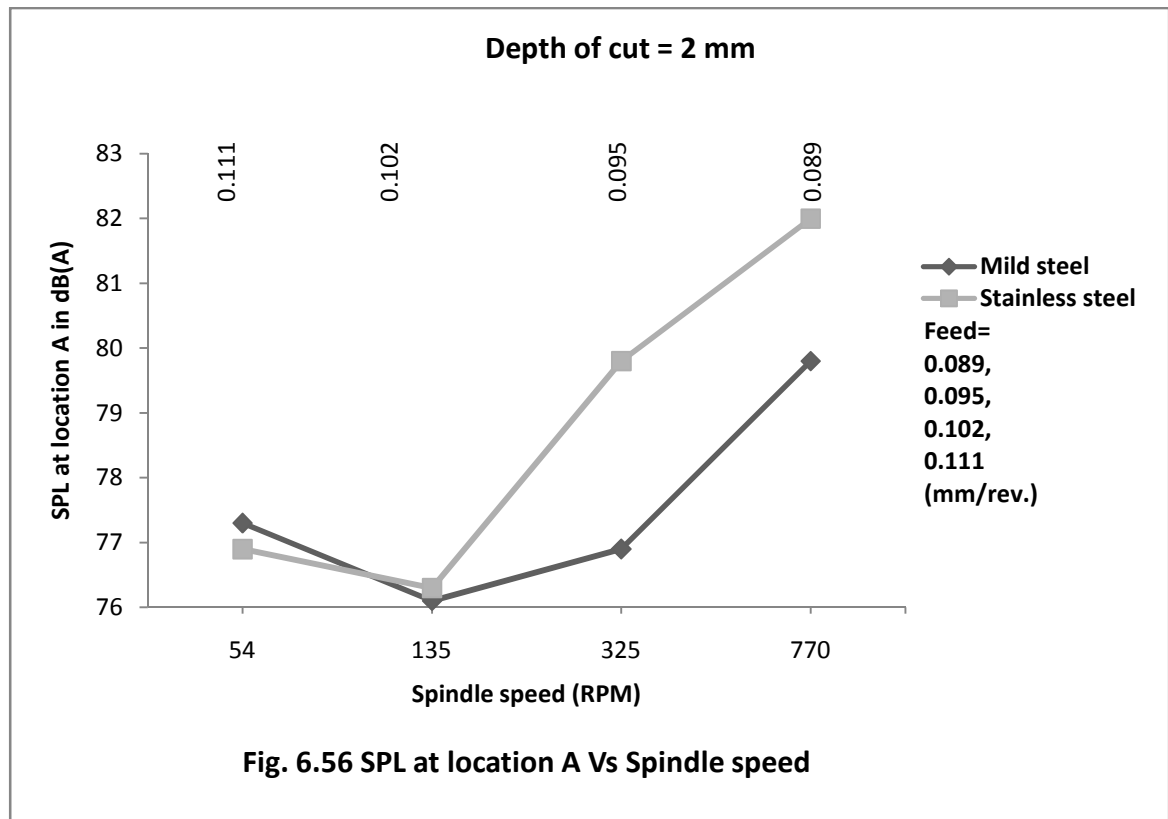
Analysis for sound pressure level was carried out at five different locations (A, B, C, D and E) under three different parameters i.e. depth of cut, feed and speed. The depth of cut varies from 0.5 mm to 2 mm, feed varies from 0.089 to 0.111 mm/rev. and speed varies from 54 to 770 RPM. Analysis shows the variation between sound pressure level and speed at all locations with varying depth of cut and feed parameters. The measured data is given from Table-1 to Table-4 in Appendix-B.

Sound pressure level at location A:

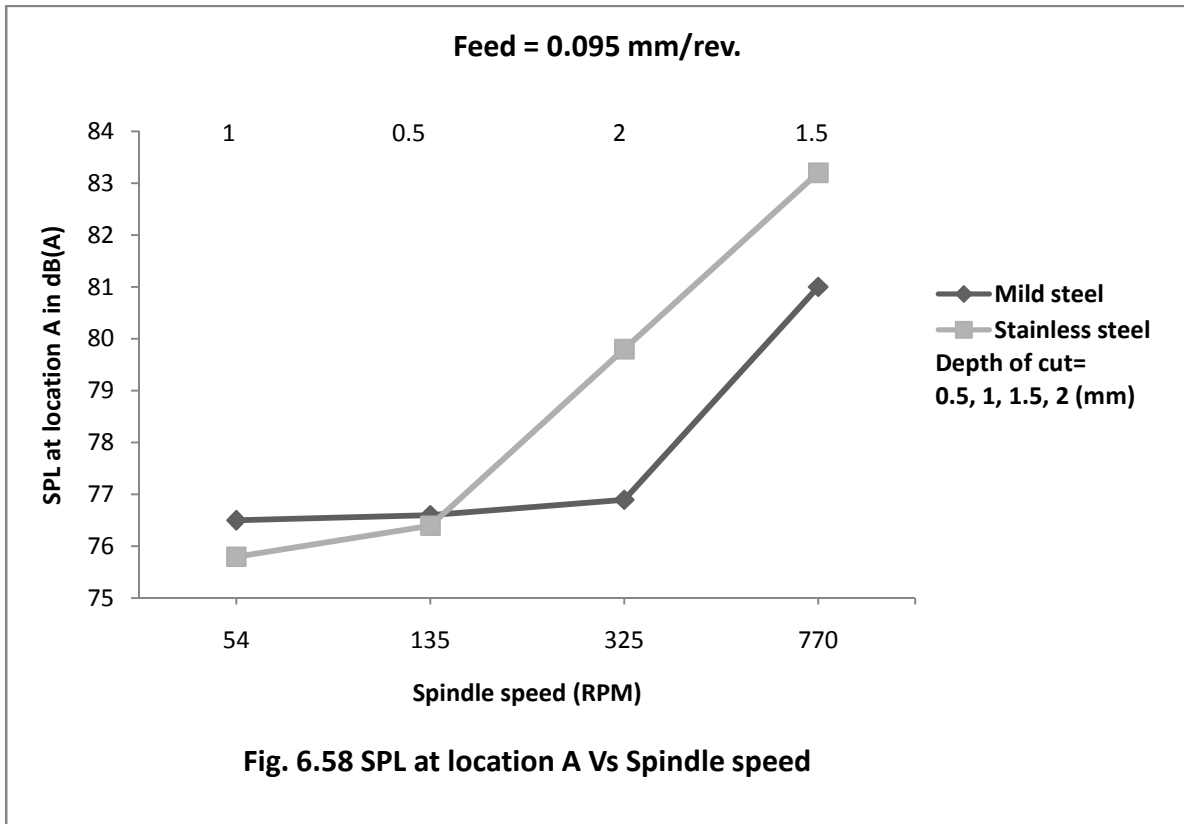
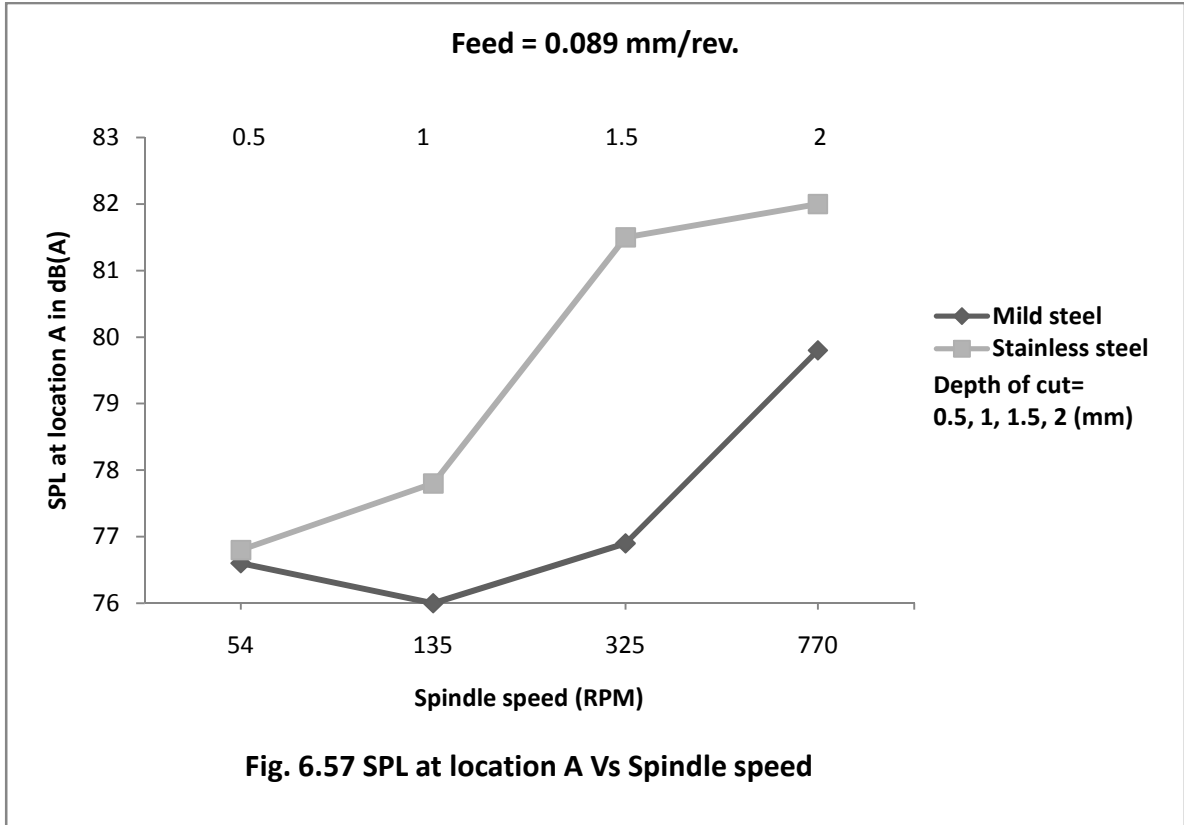
1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location A are shown in fig. 6.53 to 6.56.

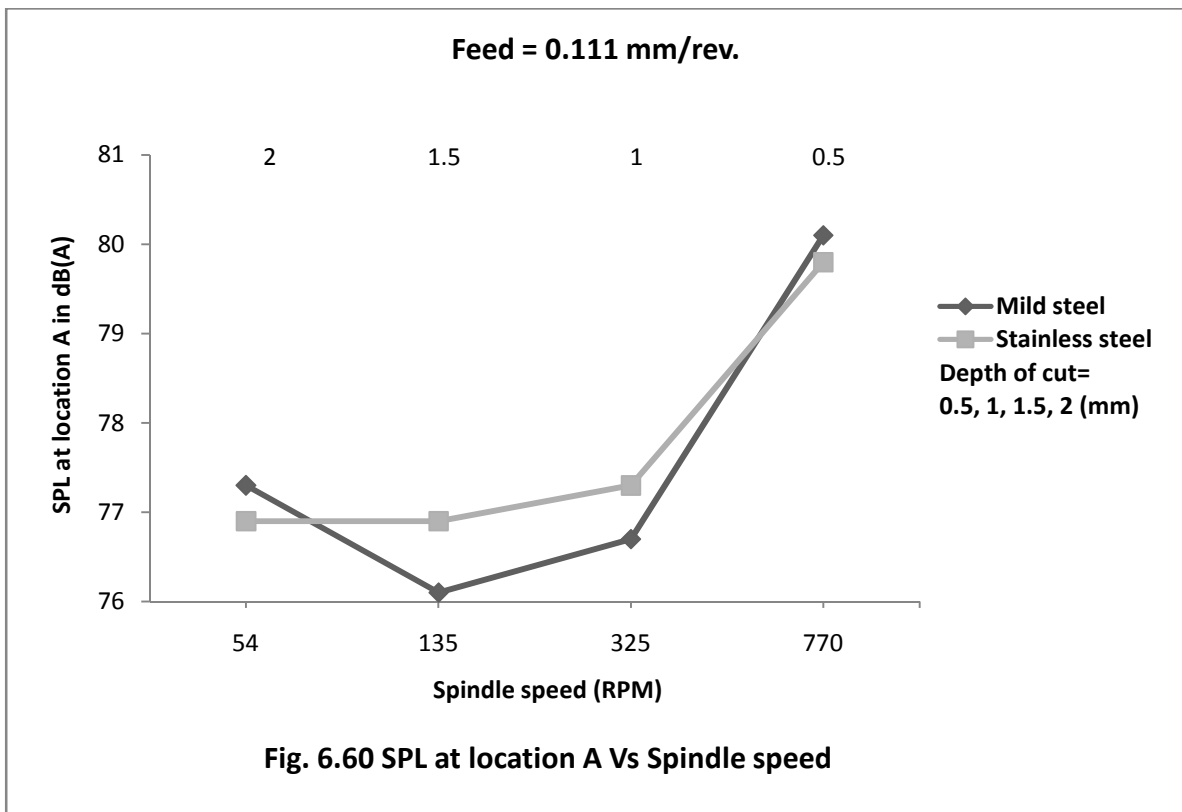
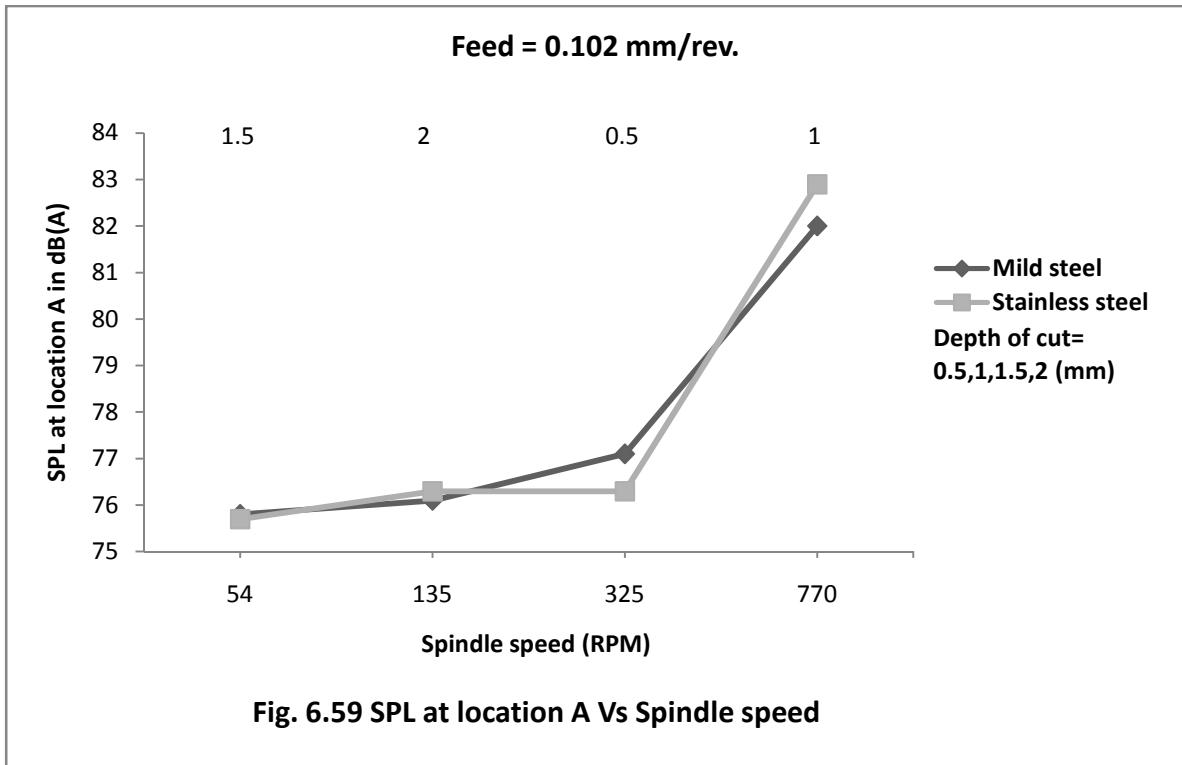






- 1) It is observed that the value of sound pressure level is increased with increasing speed at the 1 mm and 1.5 mm of depth of cut for both the materials.
 - 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
 - 3) At 2 mm depth of cut, value of sound pressure level is decreased for the combination 0.102 mm/rev. and 135 RPM and then increases in other combinations for both the materials. At 0.5 mm depth of cut, value of sound pressure level increases at all the combinations for mild steel. But at the combination of 0.102 mm/rev. and speed 325 RPM it is decreased for Stainless steel and then increases.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location A are shown in fig. 6.57 to 6.60.

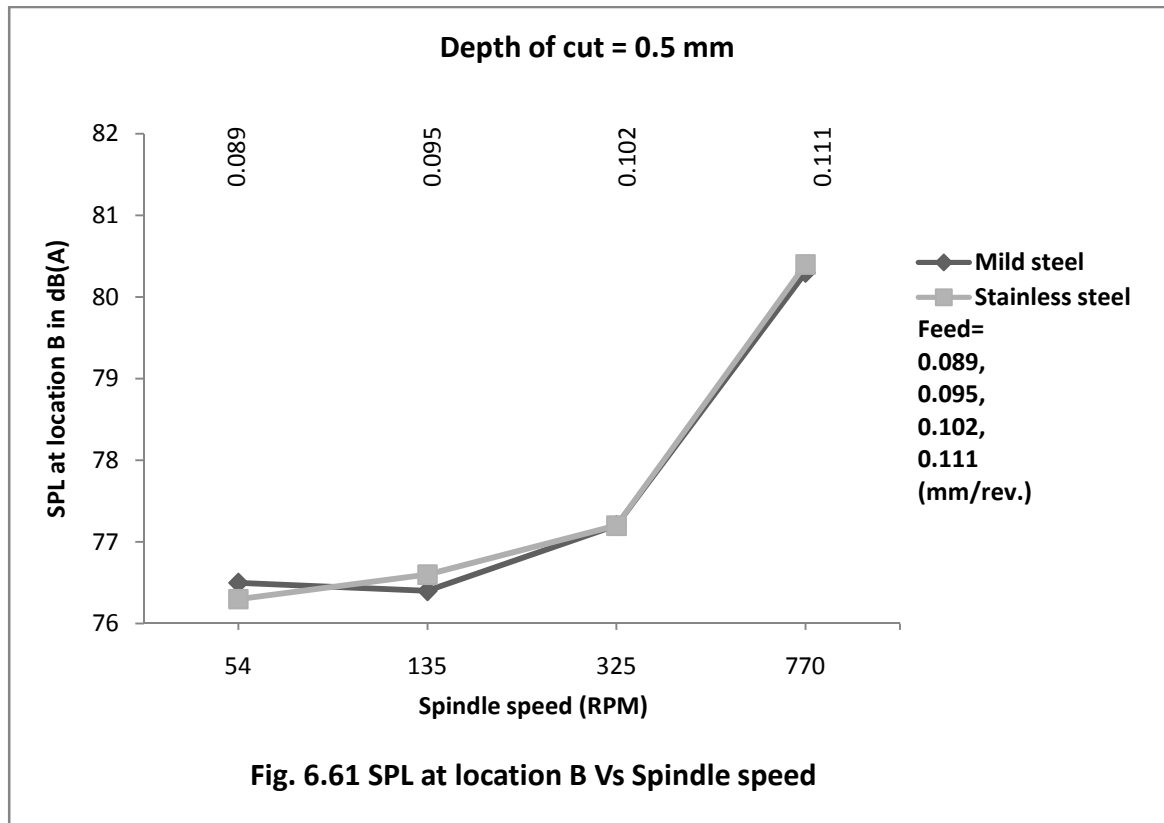


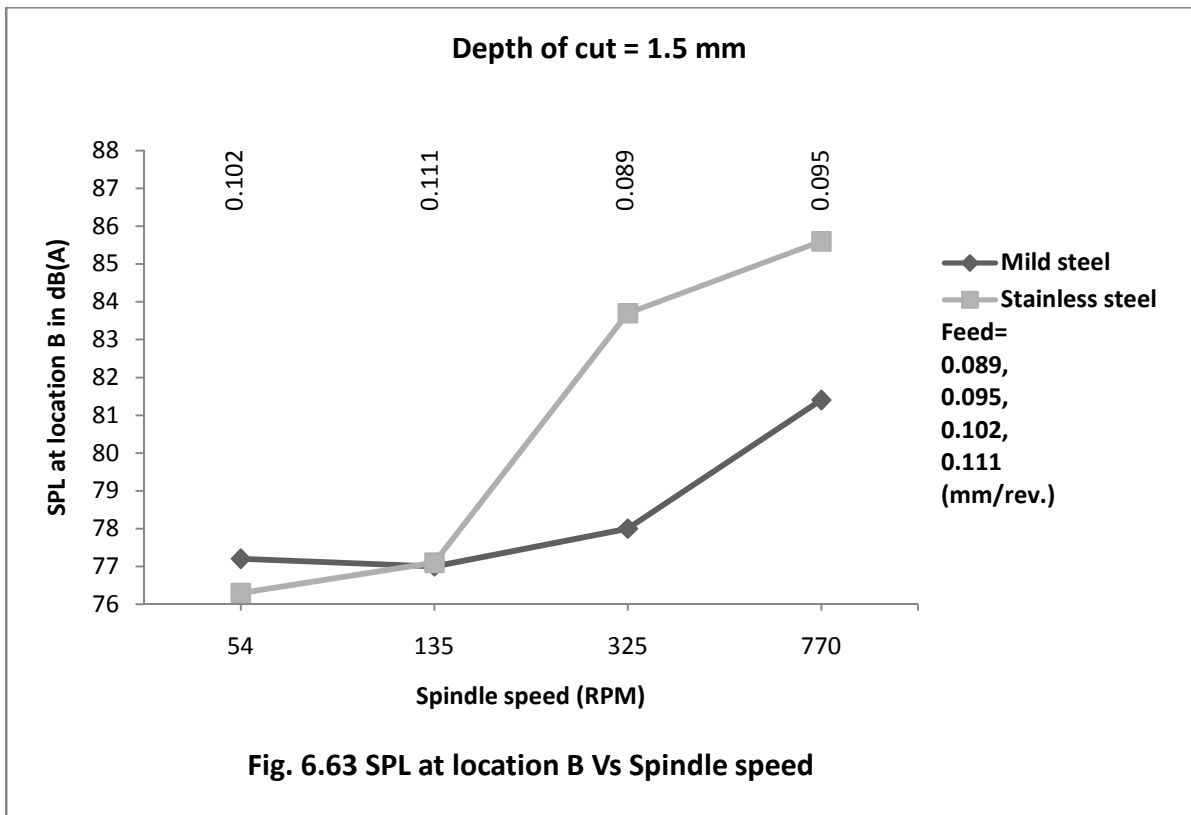
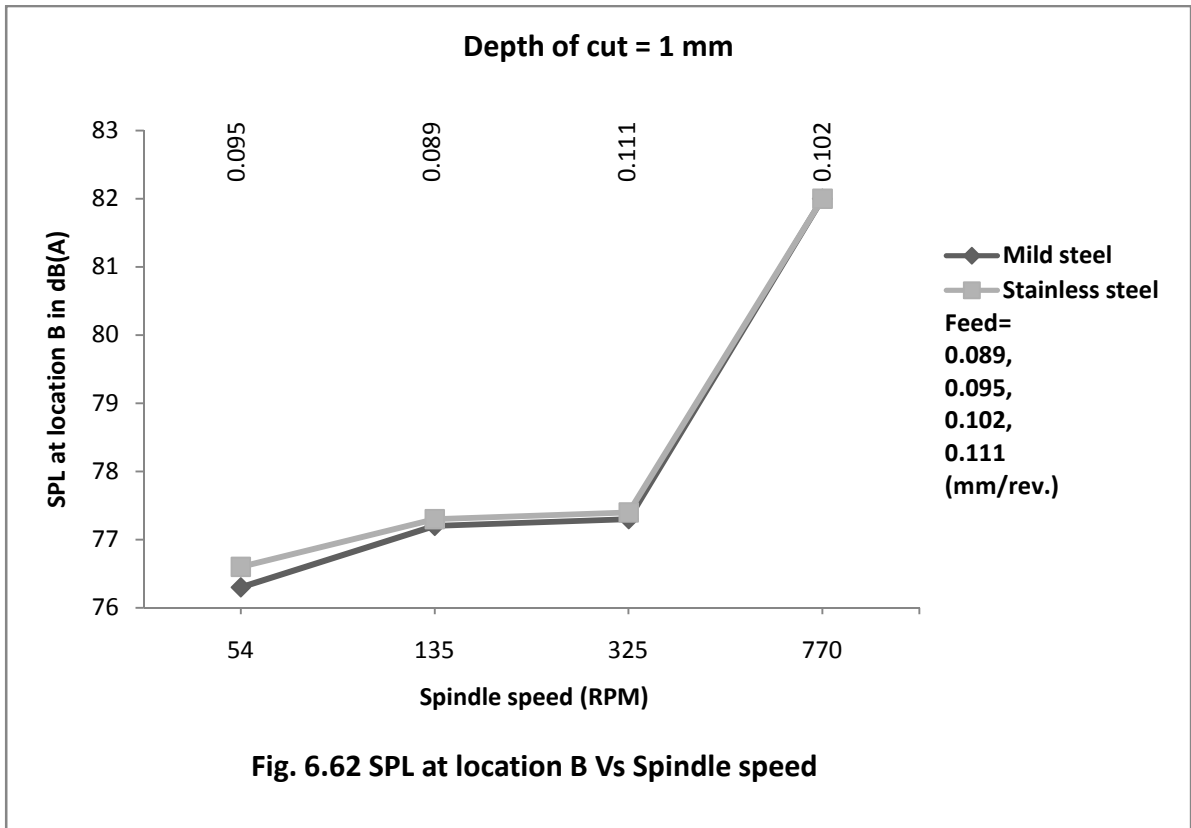


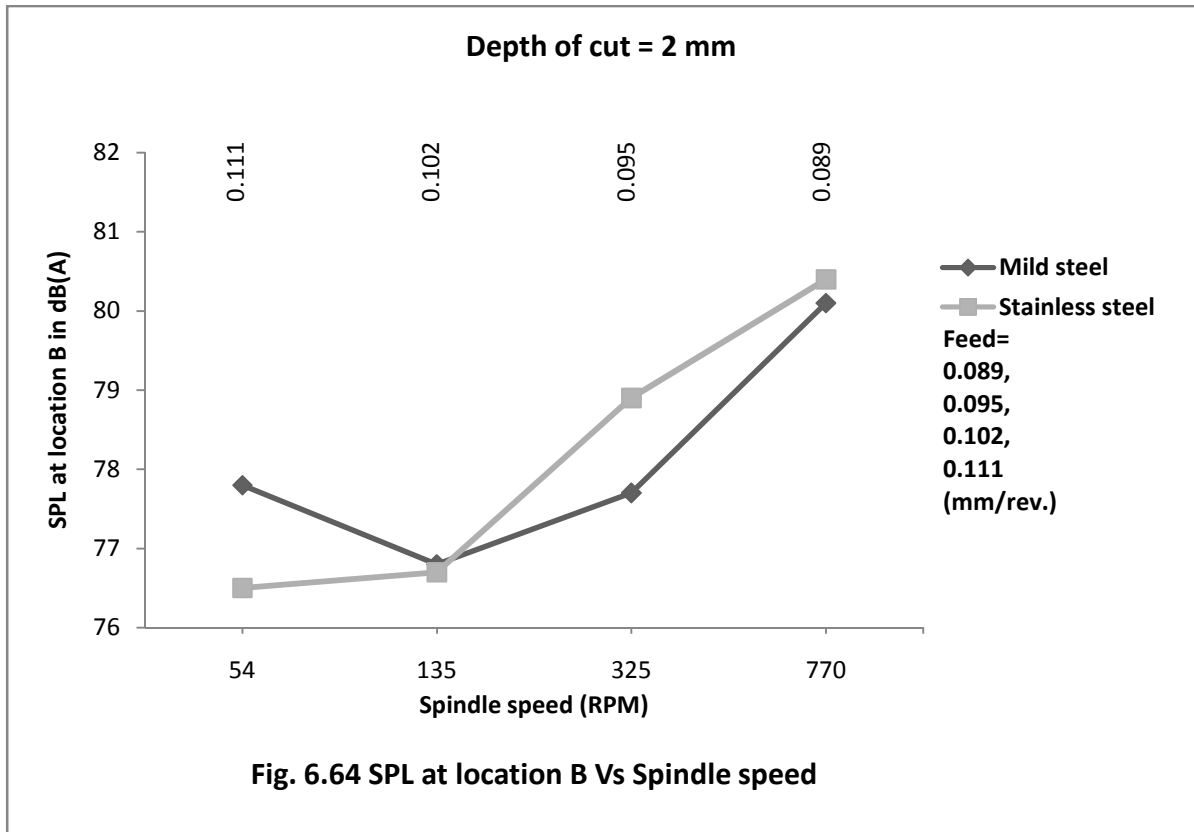
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.095 mm/rev. and 0.102 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
- 3) At feed 0.089 mm/rev. and 0.111 mm/rev., value of sound pressure level is increased with increasing speed for Stainless steel. For the Mild steel it is decreased at the combination of 1 mm depth of cut & speed 135 RPM for feed 0.089 mm/rev. and then increases. It is also decreased at the combination 1.5 mm depth of cut & 135 RPM for feed 0.111 mm/rev.

Sound pressure level at location B:

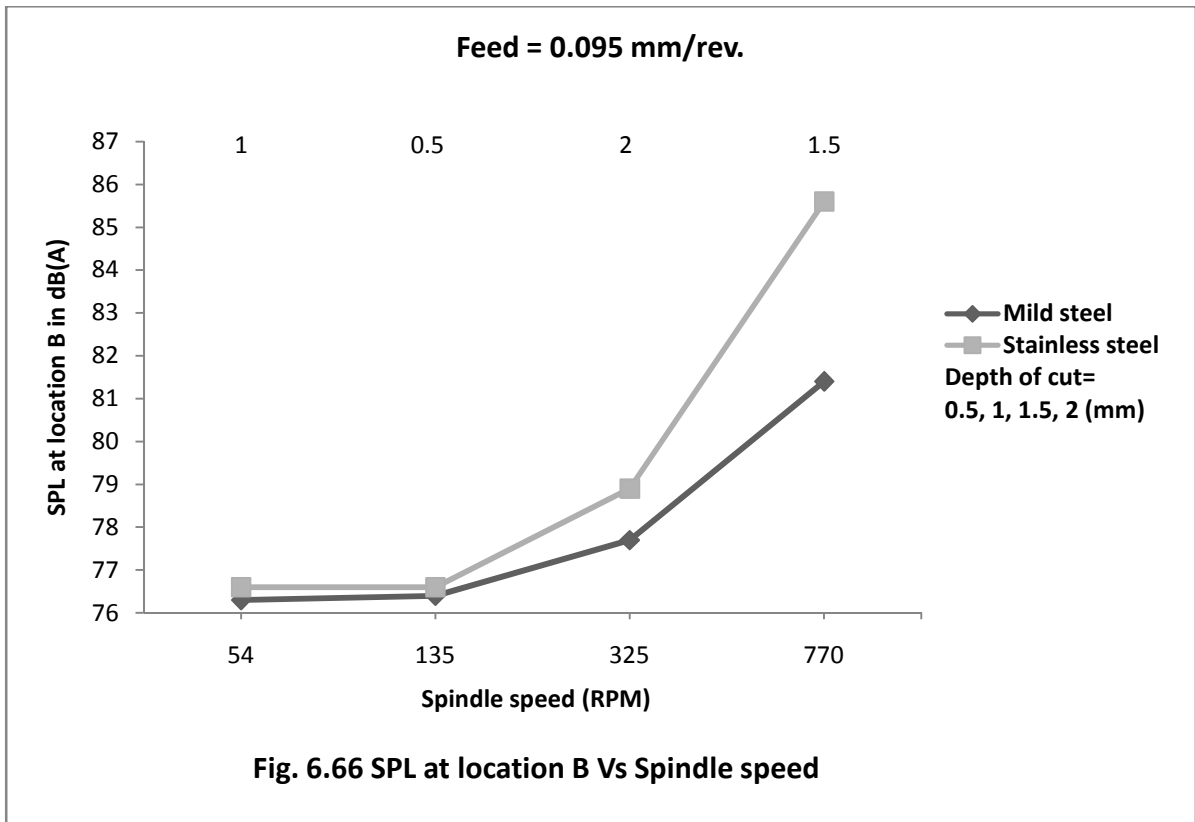
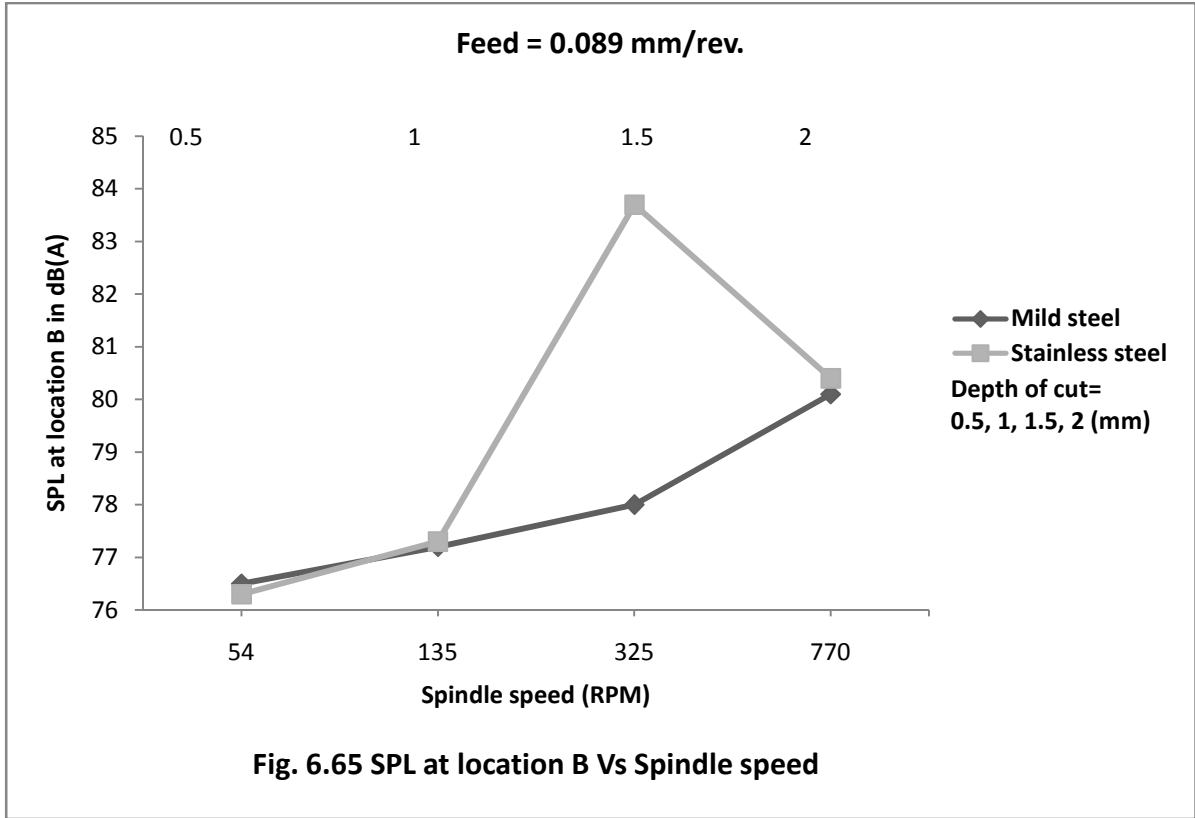
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location B are shown in fig. 6.61 to 6.64.

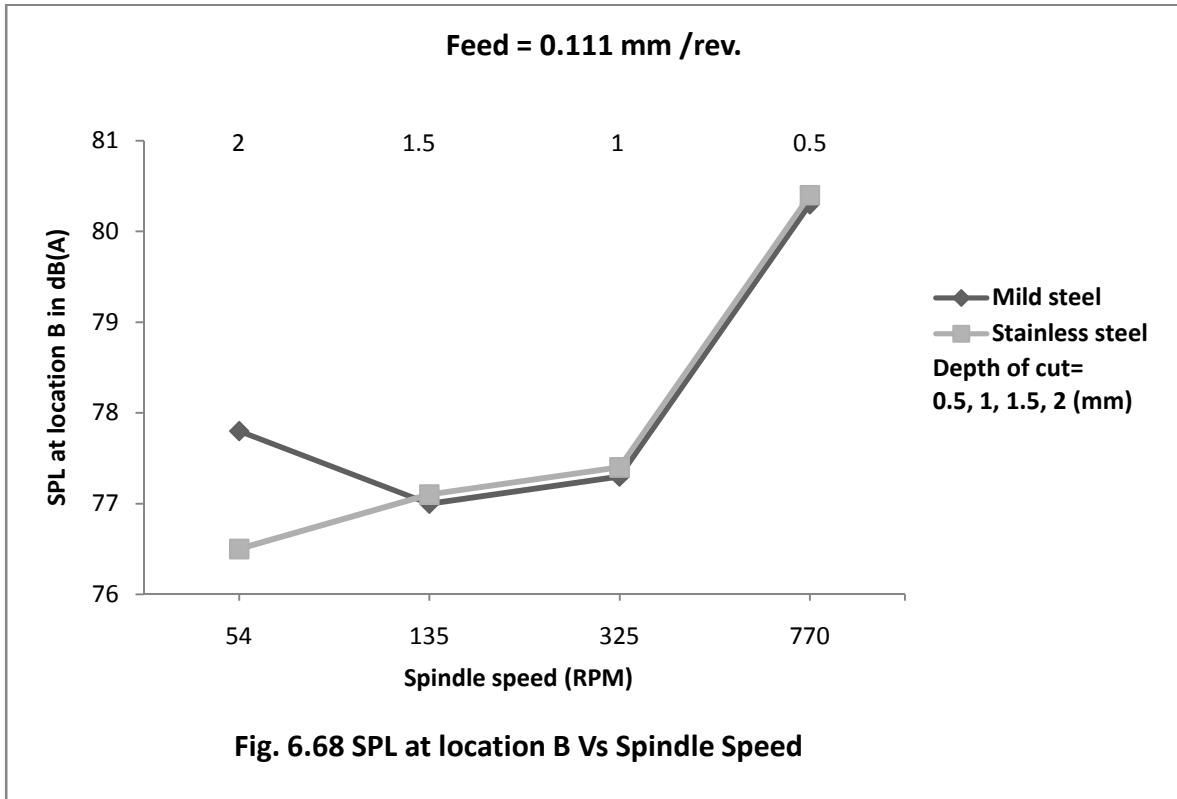
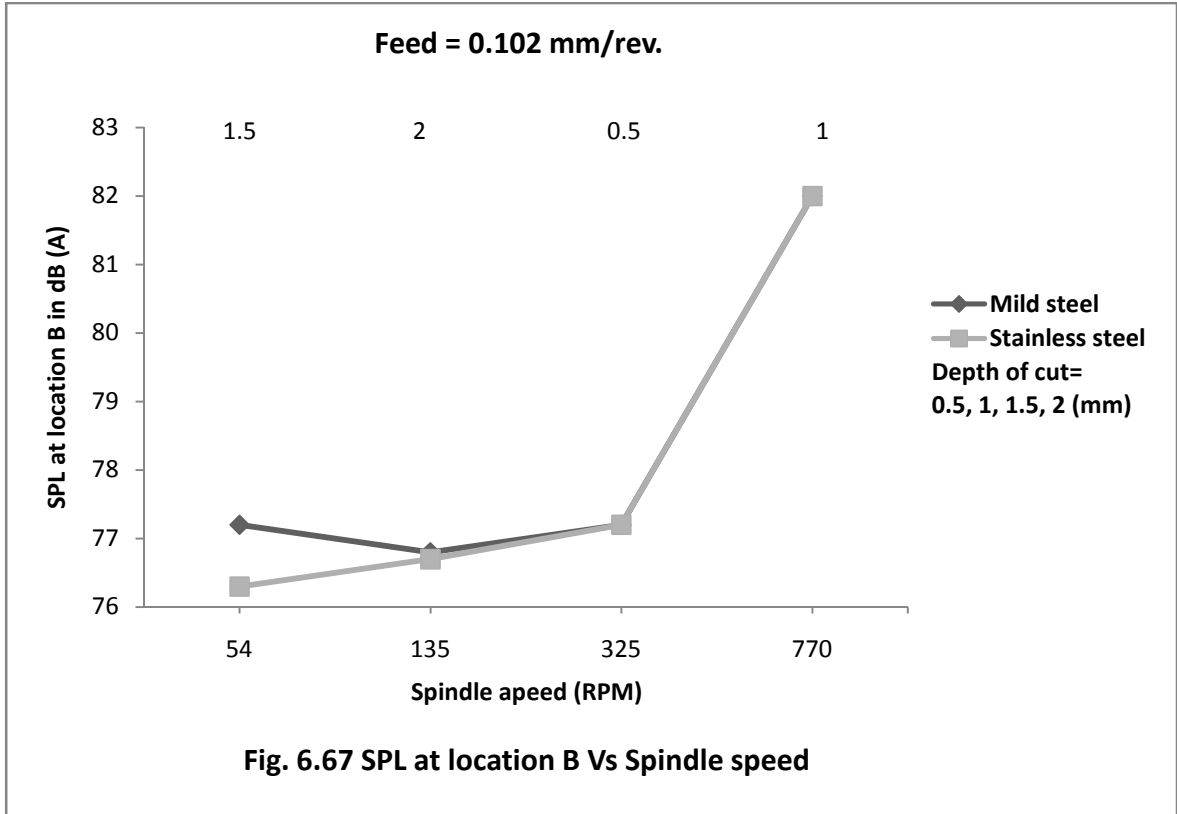






- 1) It is observed that the value of sound pressure level is increased with increasing speed at the 0.5 mm, 1 mm and 1.5 mm depth of cut for both the materials.
 - 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
 - 3) At 2 mm depth of cut, value of sound pressure level is decreased for the combination 0.102 mm/rev. and 135 RPM and then increases in other combinations for both the materials.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location B are shown in fig. 6.65 to 6.68.

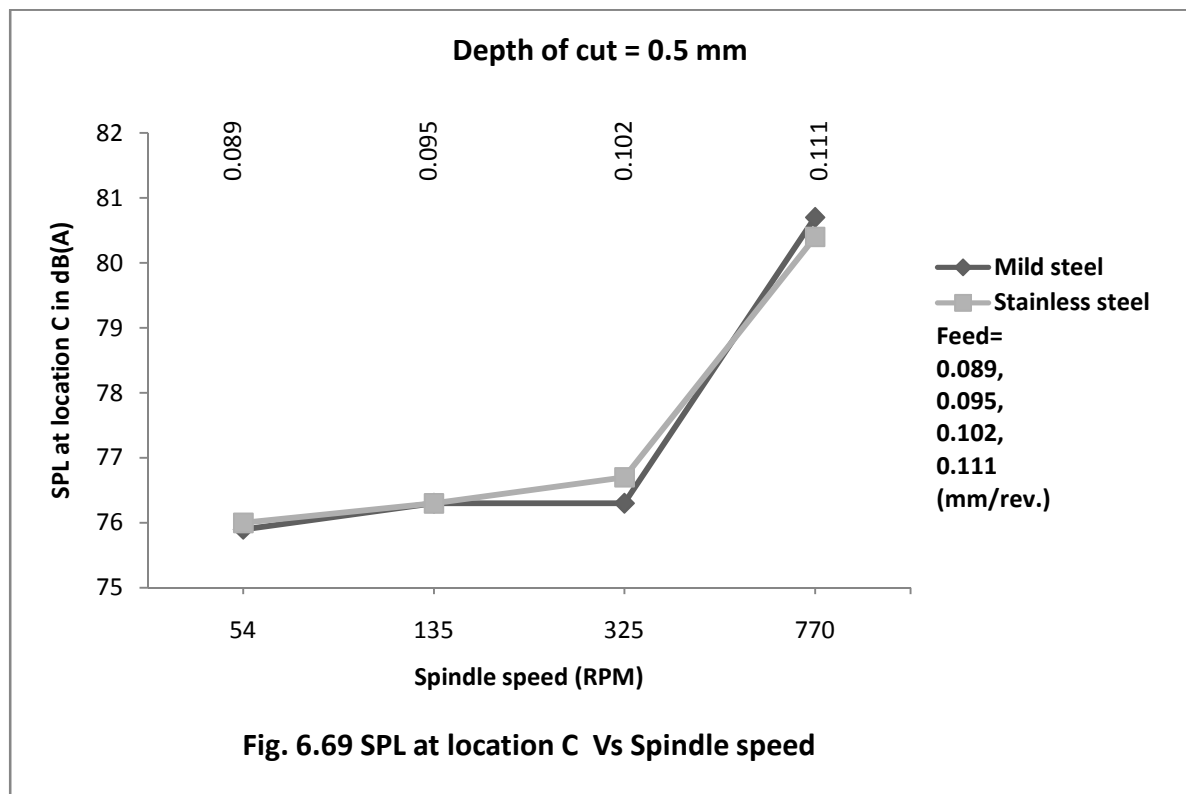


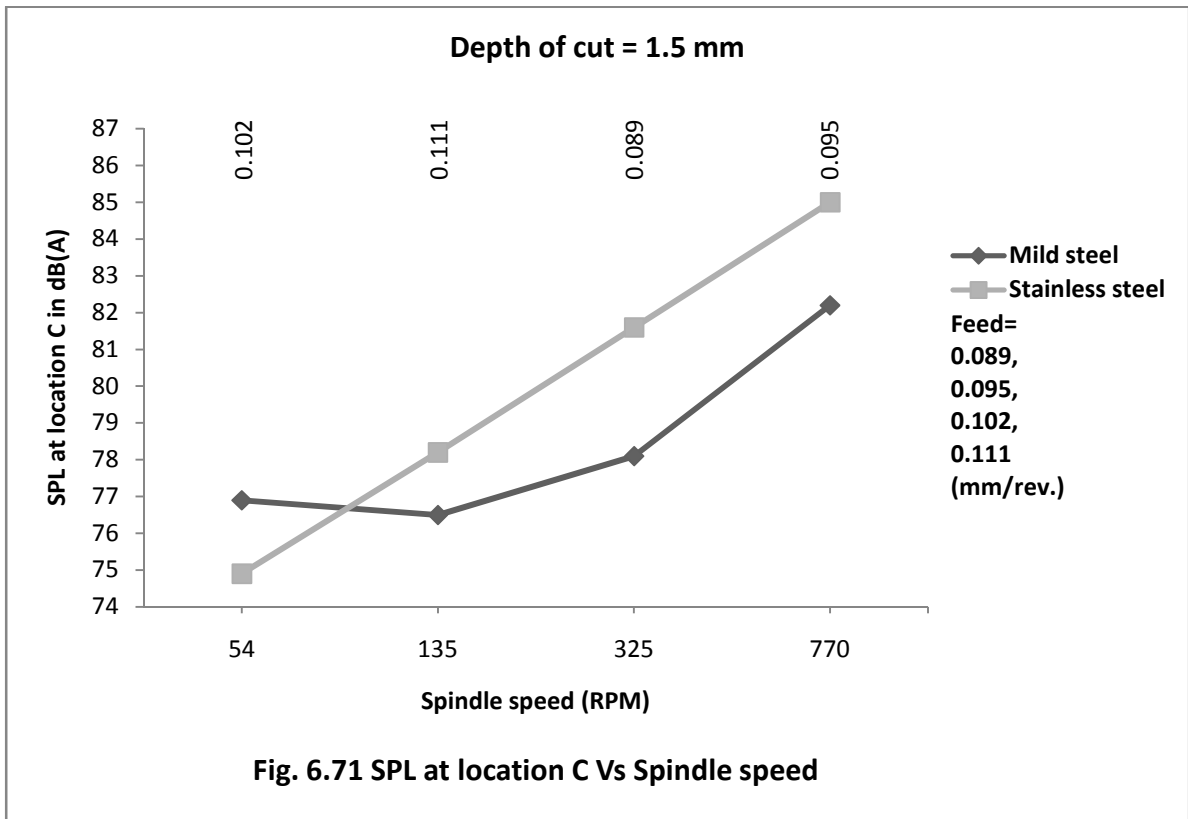
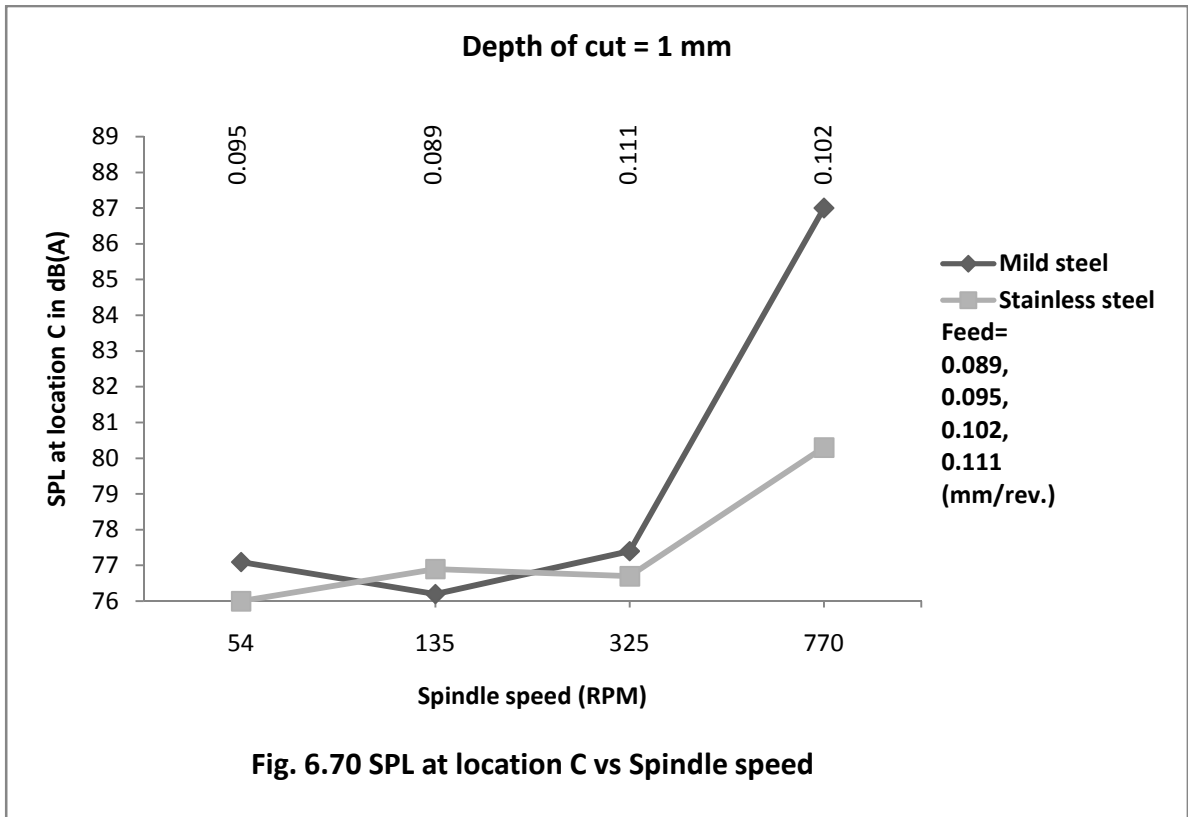


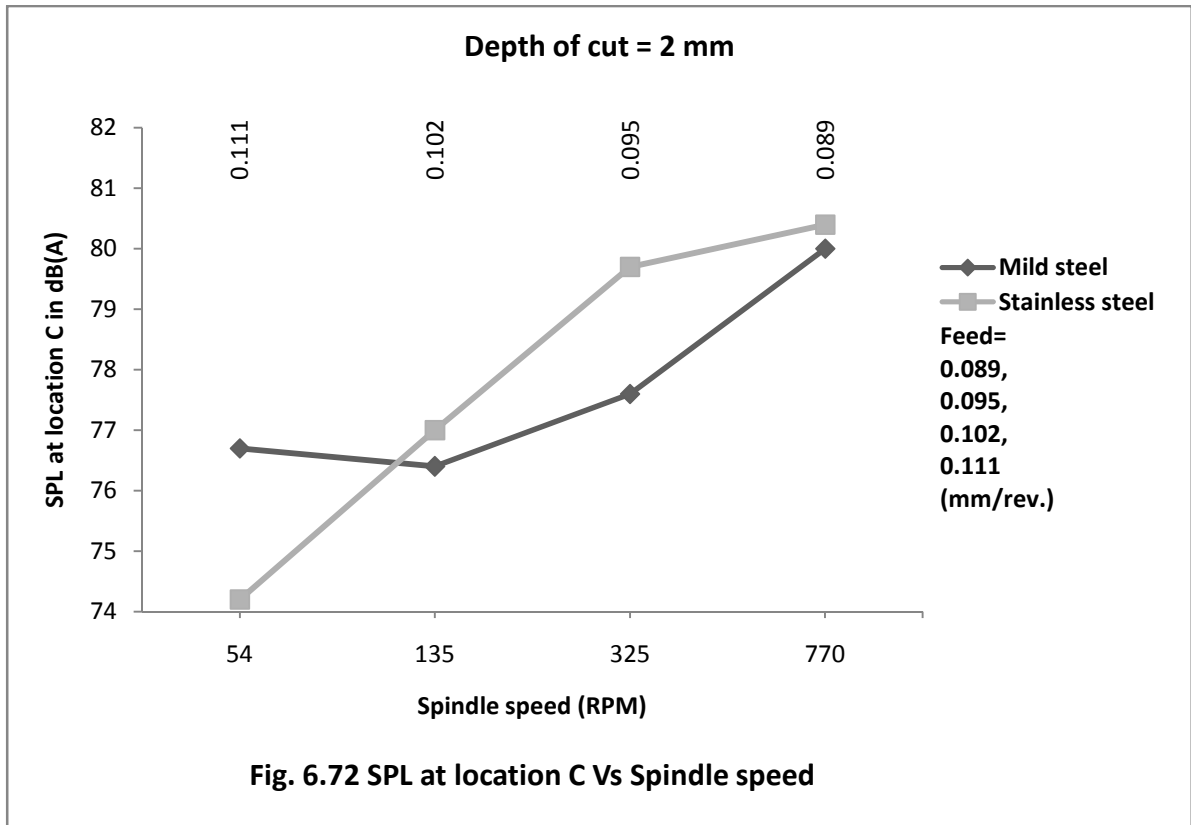
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.095 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
- 3) At feed 0.089 mm/rev., value of sound pressure level is decreased at the combination of 2 mm depth of cut and speed 770 RPM for Stainless steel. For the Mild steel it is decreased at the combination of 2 mm depth of cut & speed 135 RPM and then increases in other combinations for feed 0.102 mm/rev. For the Mild steel it also decreased at the combination of 1.5 mm depth of cut and speed 135 RPM at 0.111 for Mild steel and then increases.

Sound pressure level at location C:

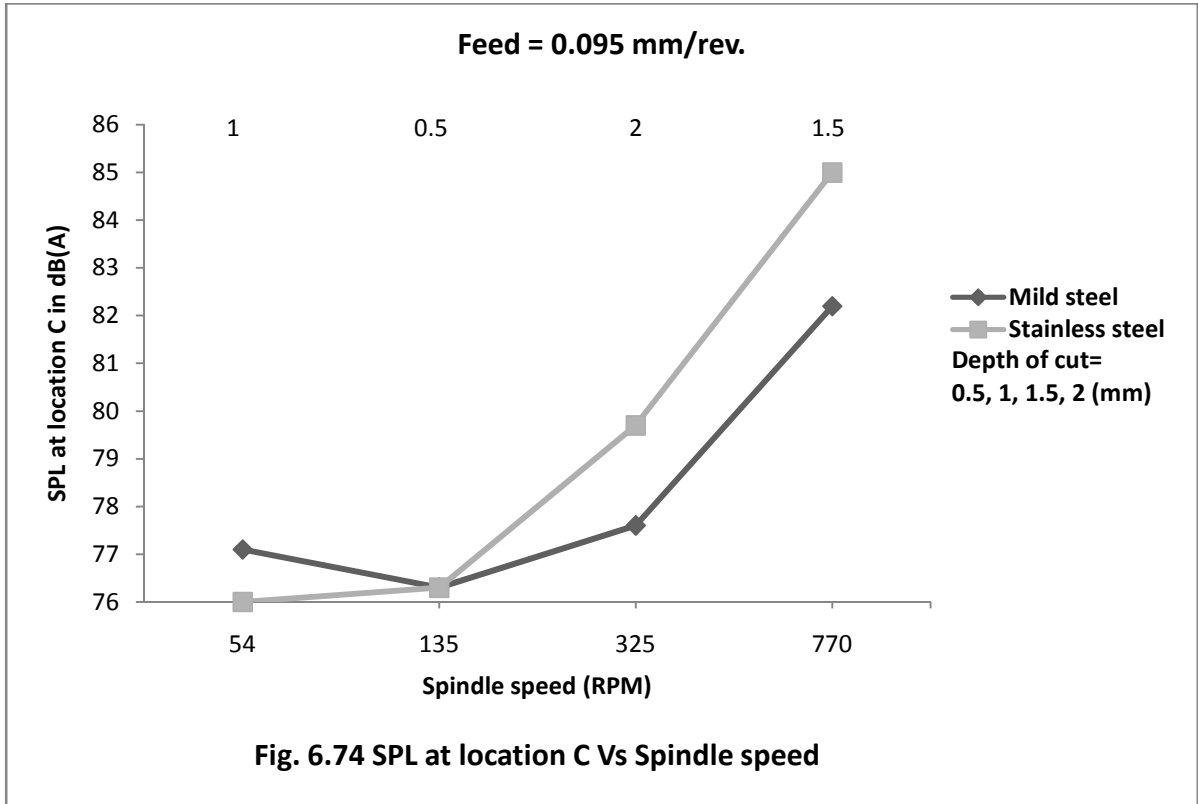
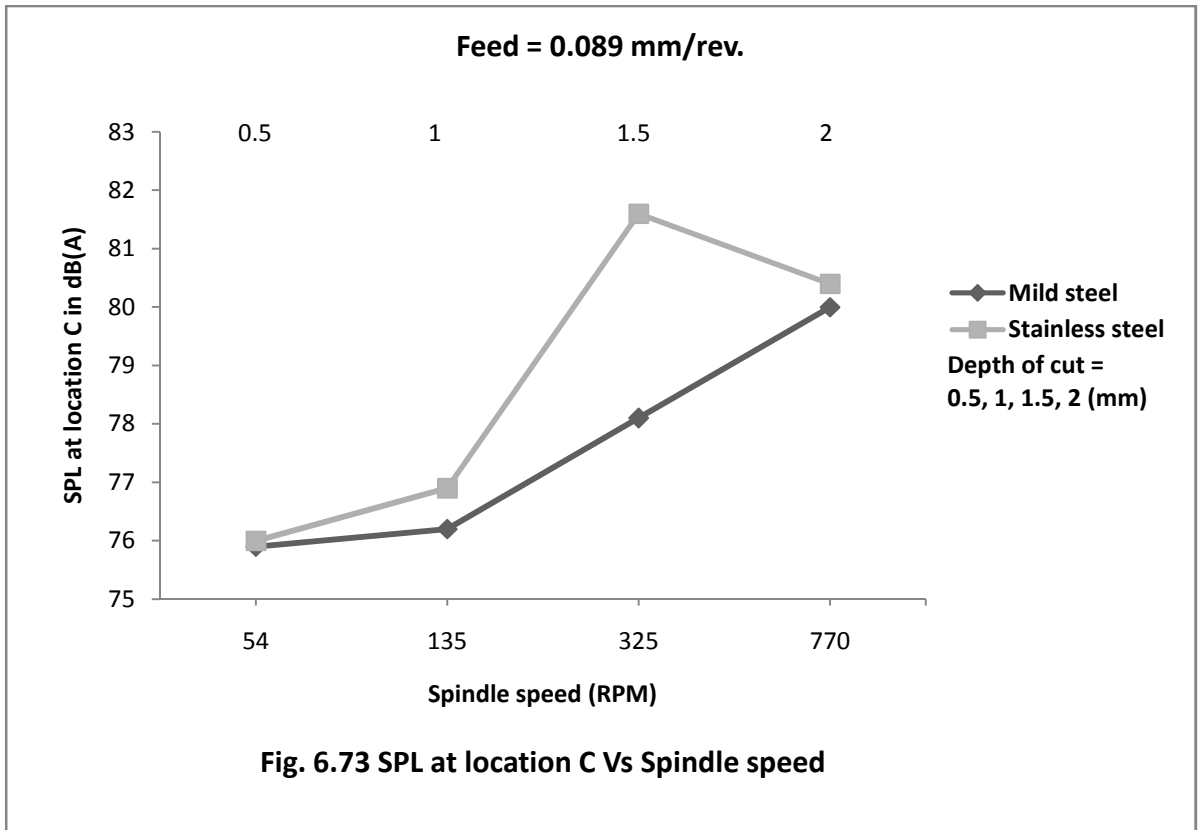
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location C are shown in fig. 6.69 to 6.72.

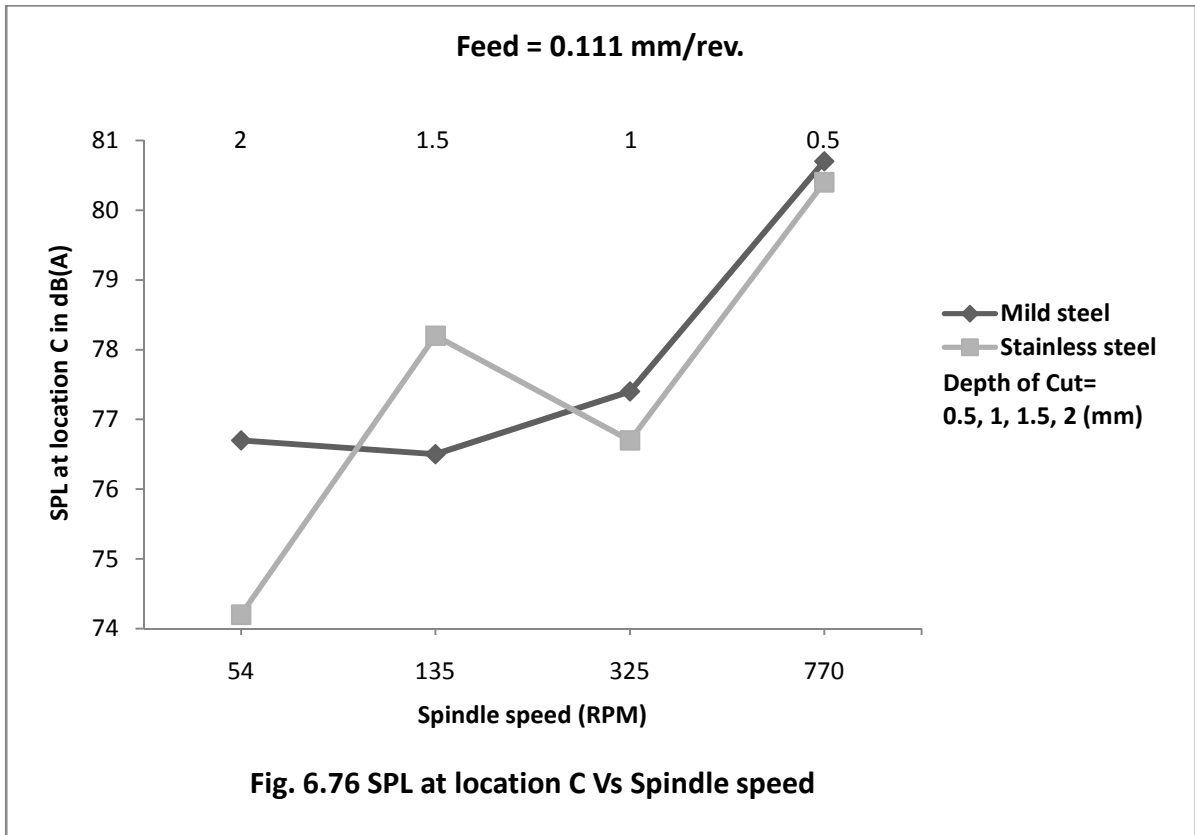
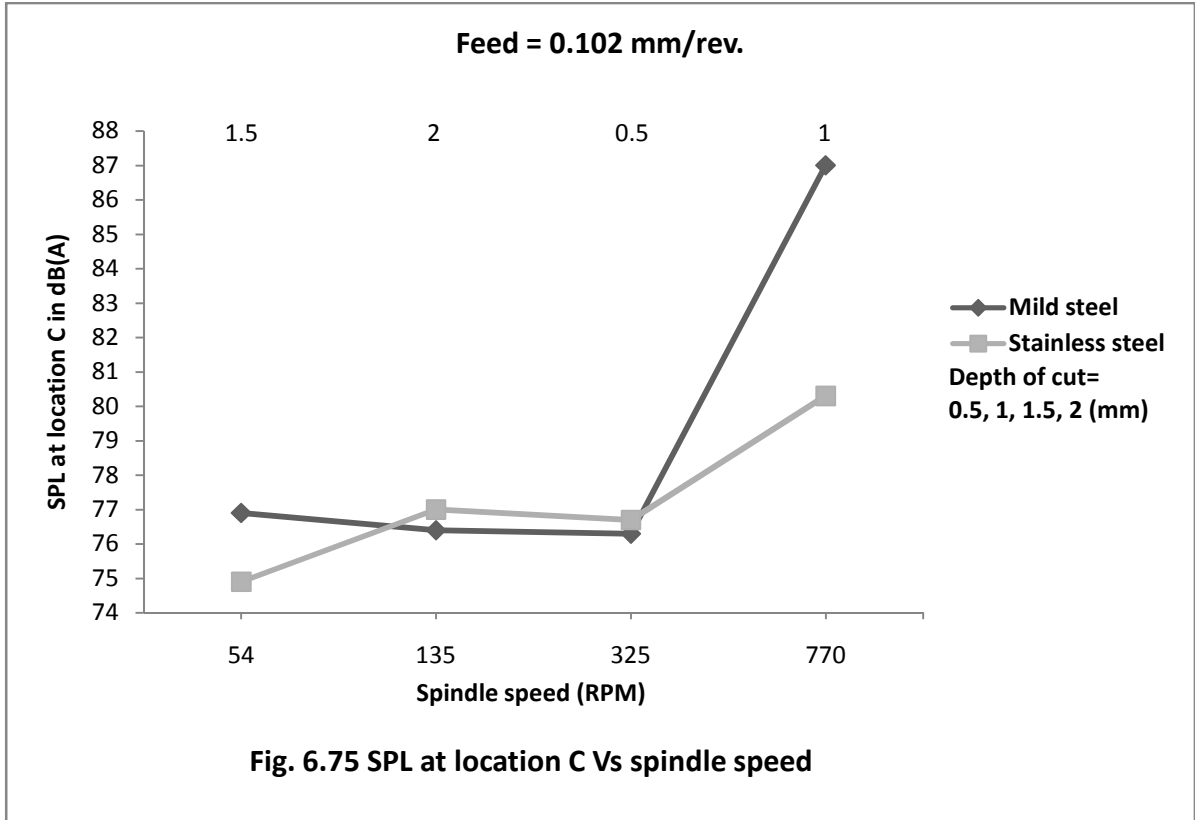






- 1) It is observed that the value of sound pressure level is increased with increasing speed at all the combinations for both the materials.
 - 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut except for the depth of cut 1 mm.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location C are shown in fig. 6.73 to 6.76.

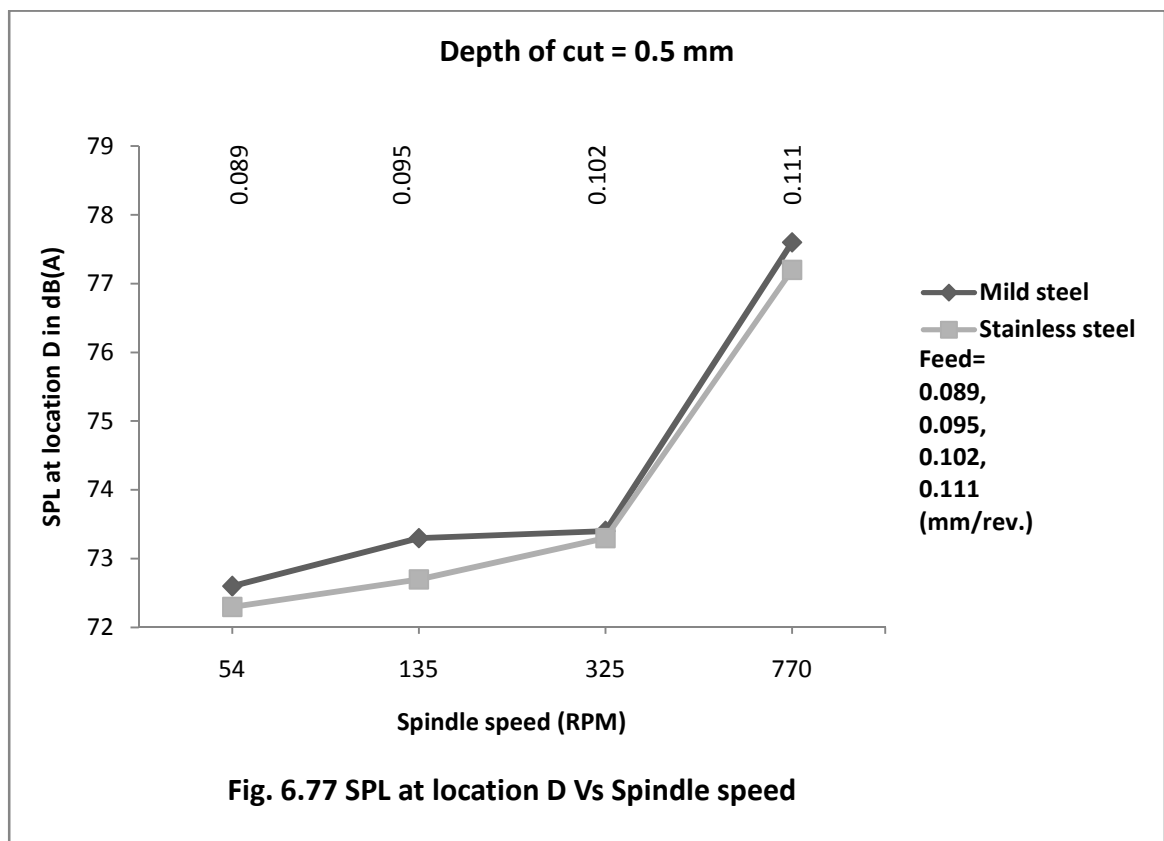


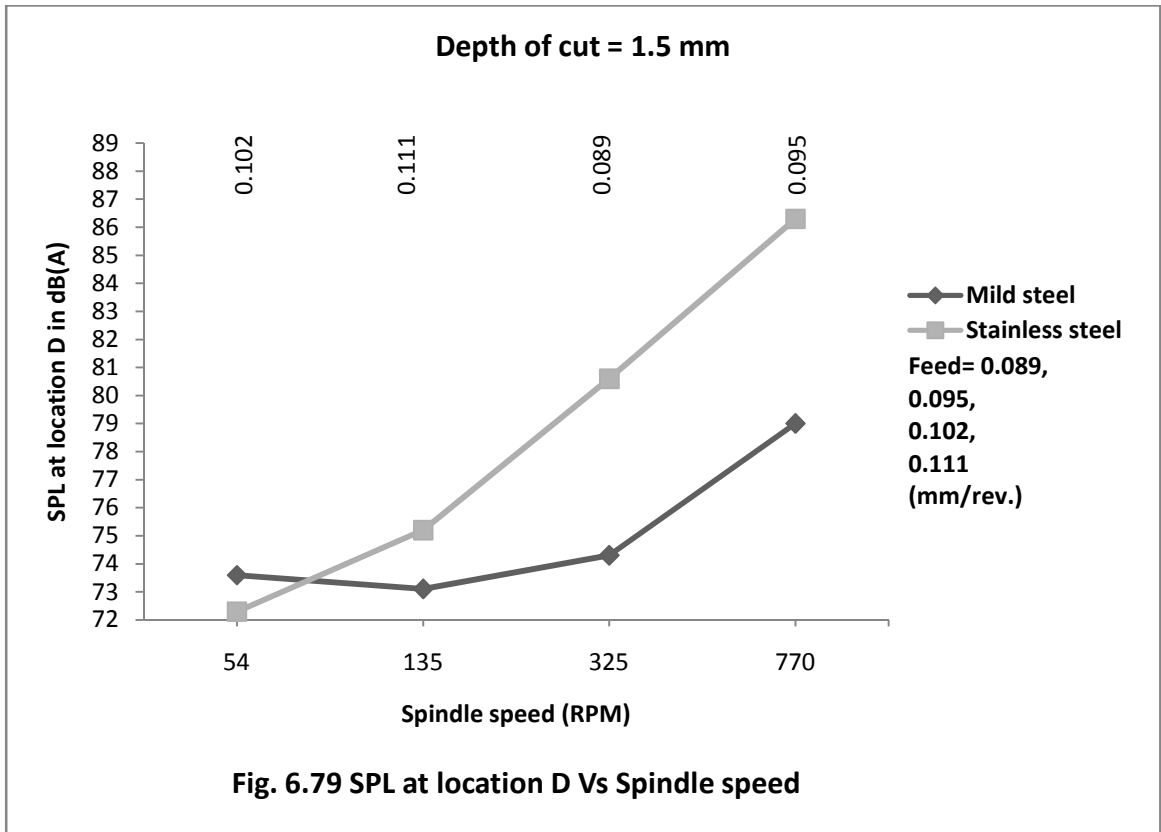
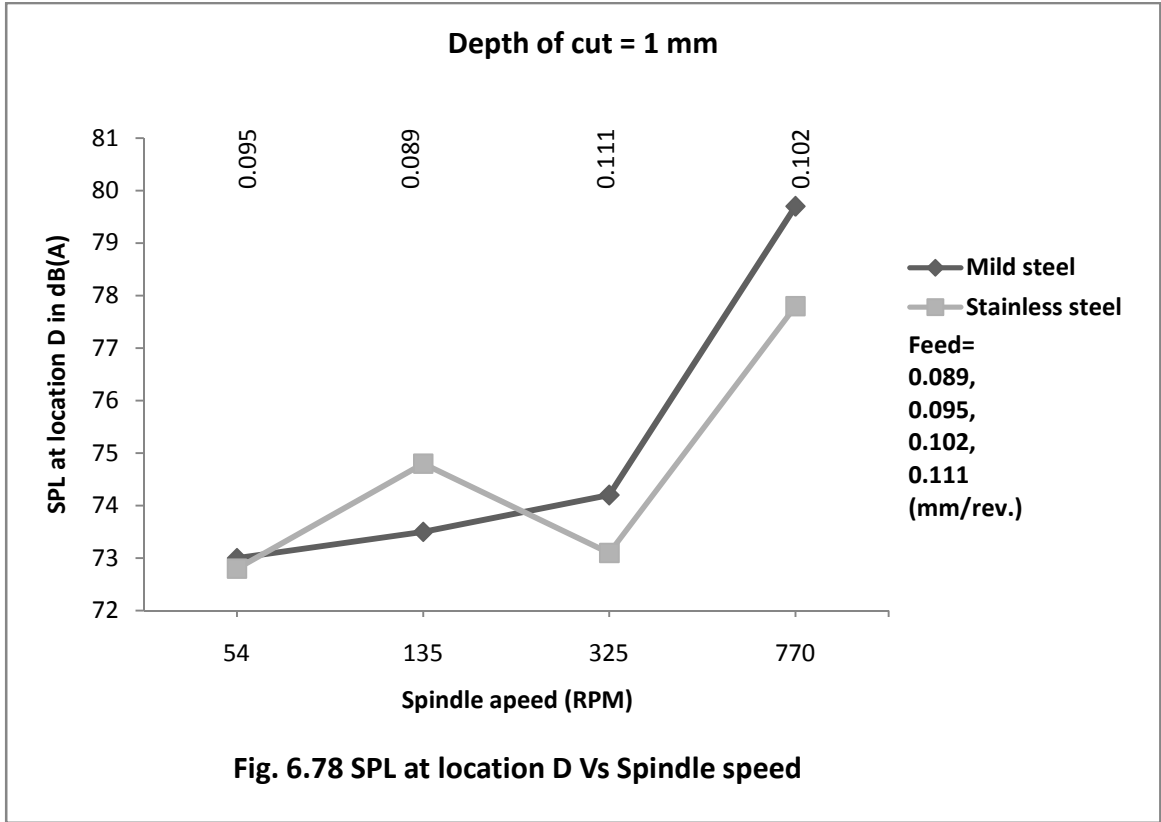


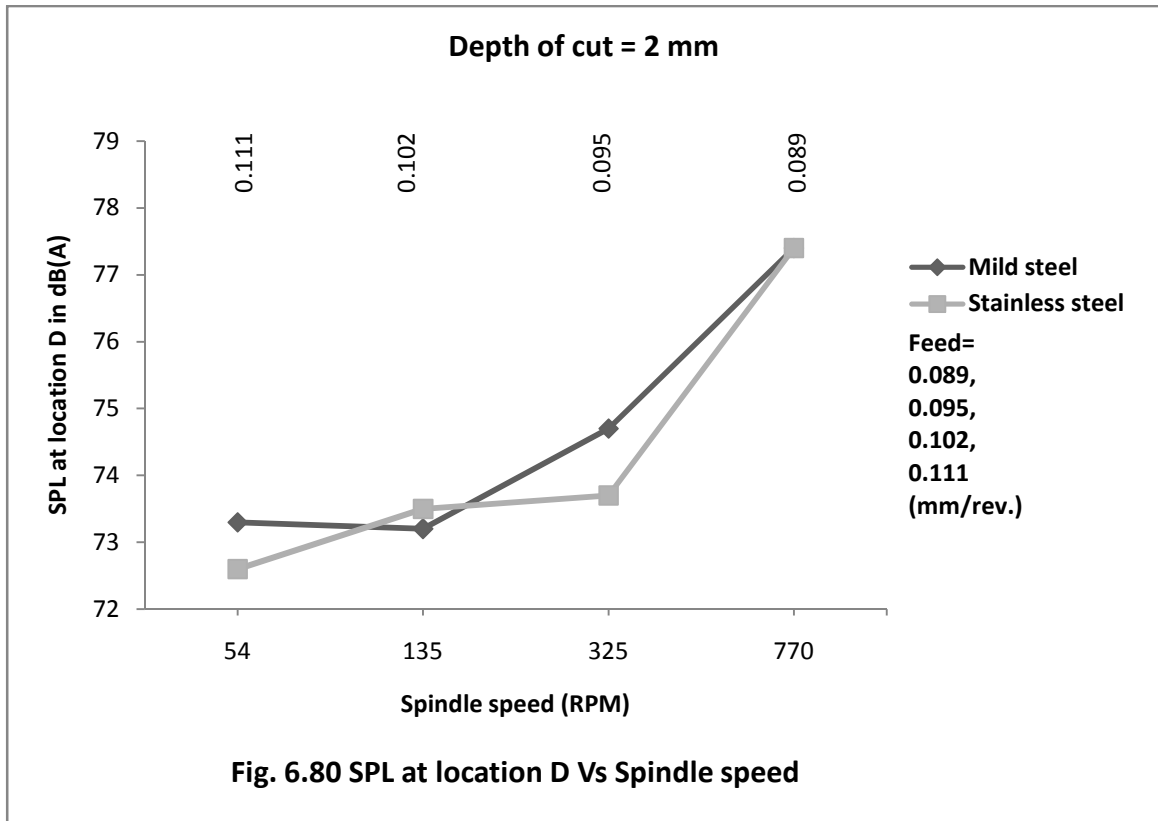
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.095 mm/rev. and 0.102 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
- 3) At feed 0.089 mm/rev., value of sound pressure level is decreased at the combination of 2 mm depth of cut and speed 770 RPM for Stainless steel. It is also decreased at the combination of depth of cut 1.5 mm and speed 135 RPM for feed 0.111 mm/rev.

Sound pressure level at location D:

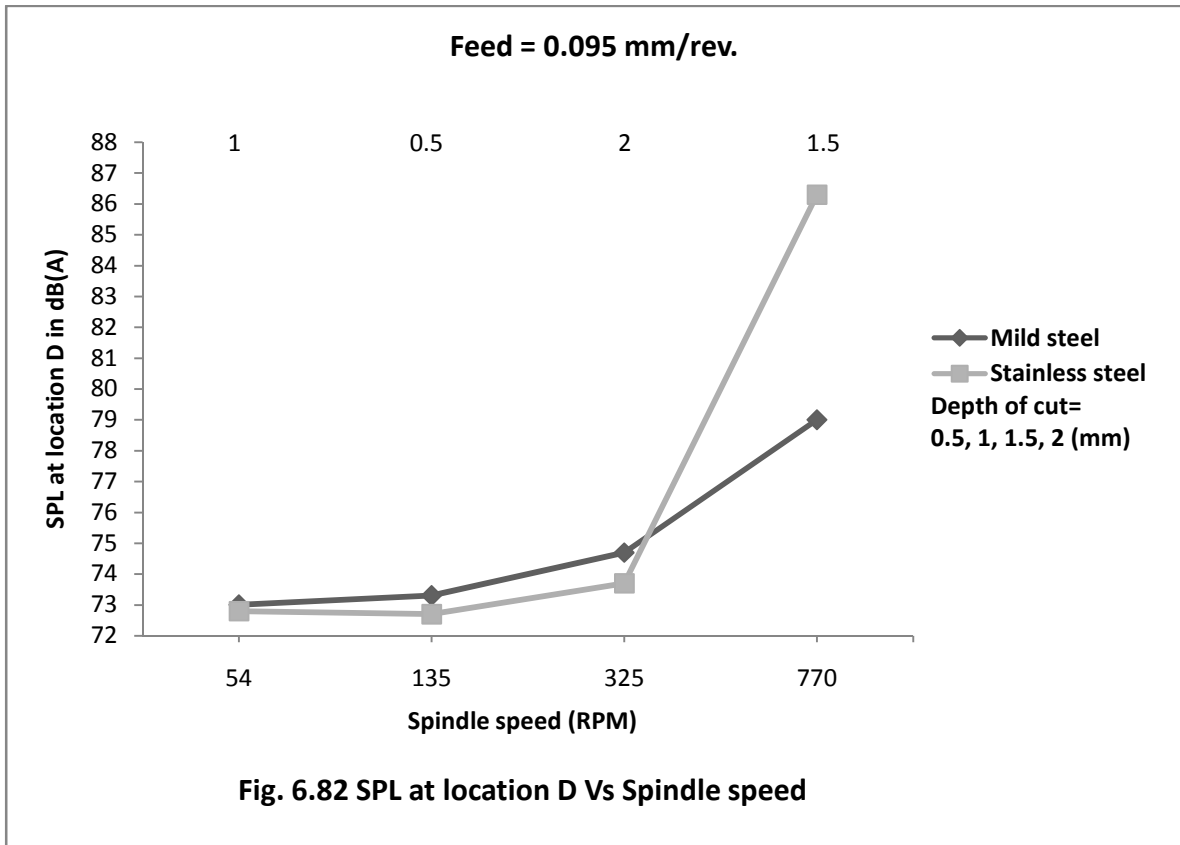
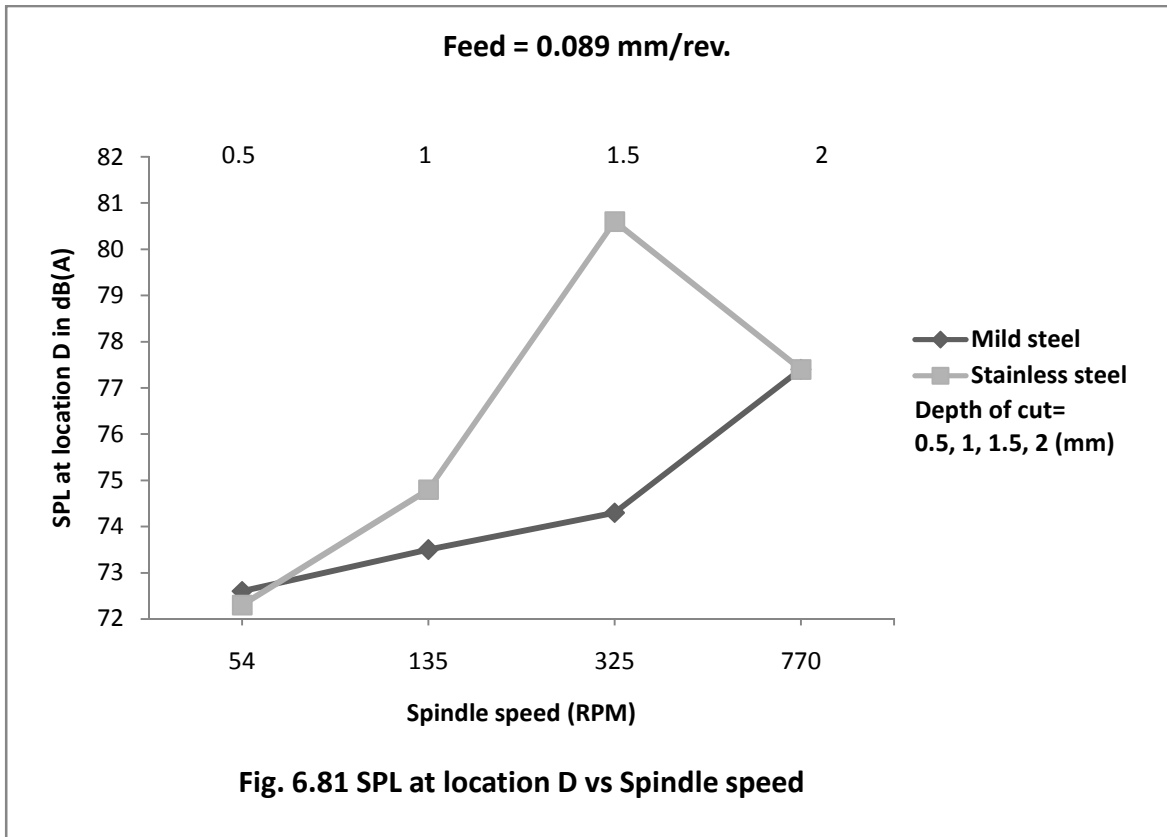
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location D are shown in fig. 6.77 to 6.80.

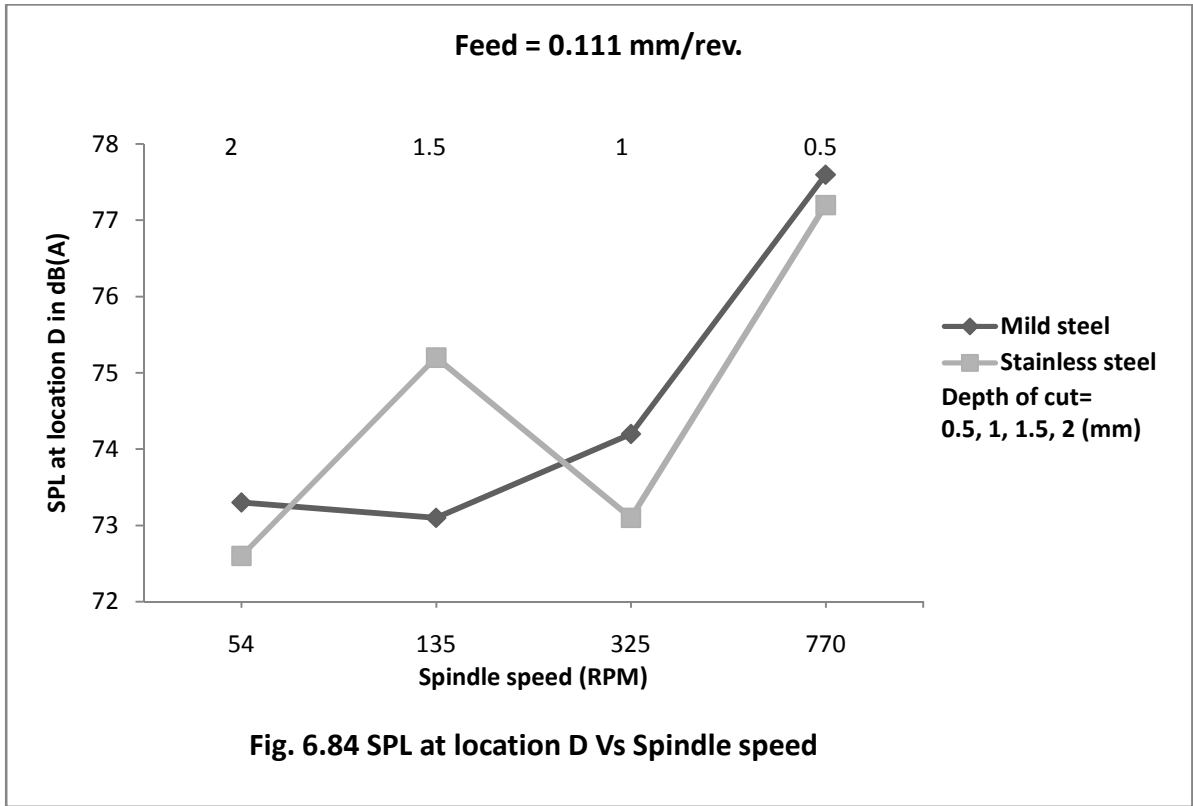
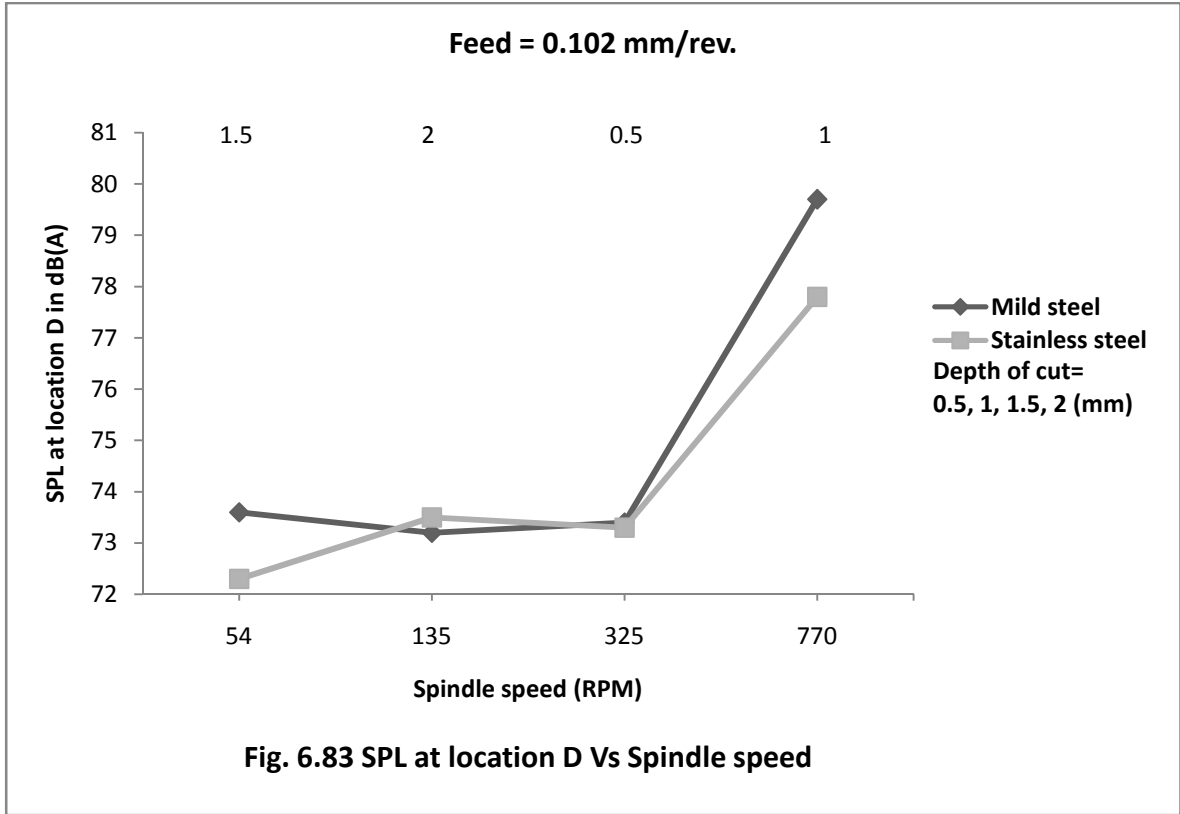






- 1) It is observed that the value of sound pressure level is increased with increasing speed at the 0.5 mm, 1.5 mm and 2 mm of depth of cut for both the materials.
 - 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
 - 3) At 1 mm depth of cut, value of sound pressure level is decreased for the combination 0.111 mm/rev. and 325 RPM and then increases in other combinations for Stainless steel. For the Mild steel it is increased with increasing speed at 1 mm depth of cut.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location D are shown in fig. 6.81 to 6.84.

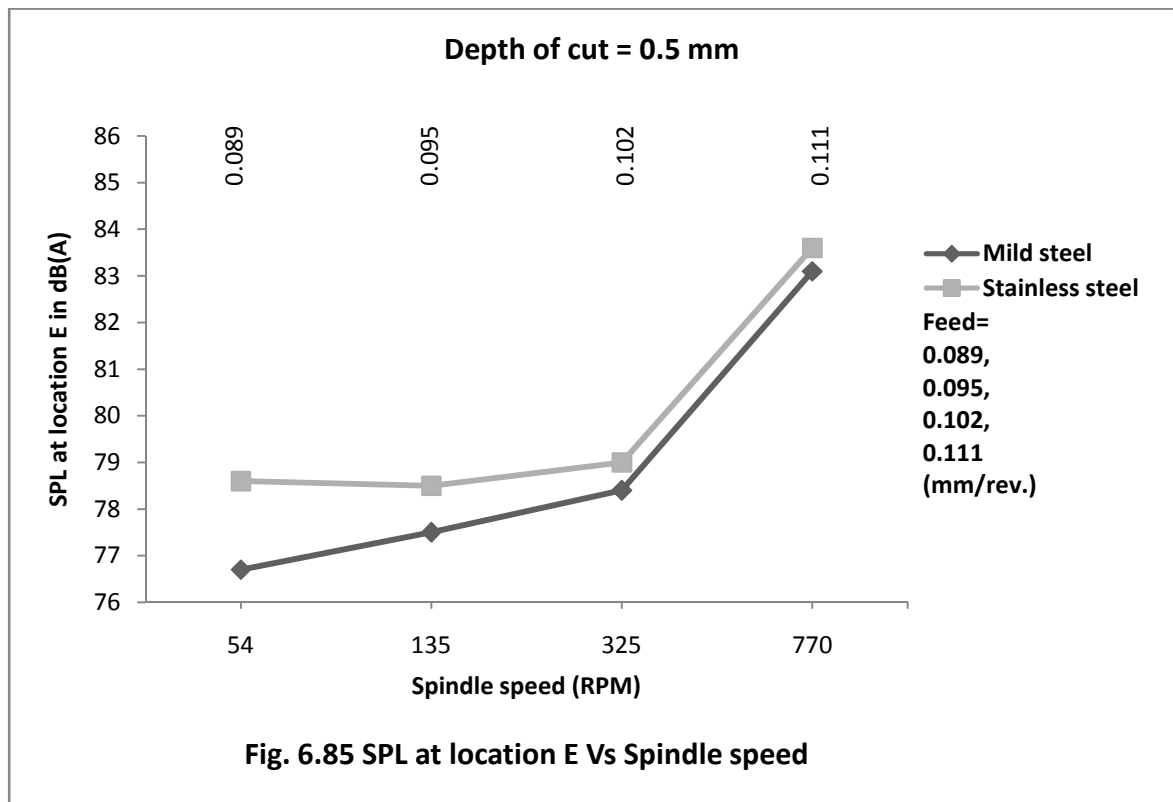


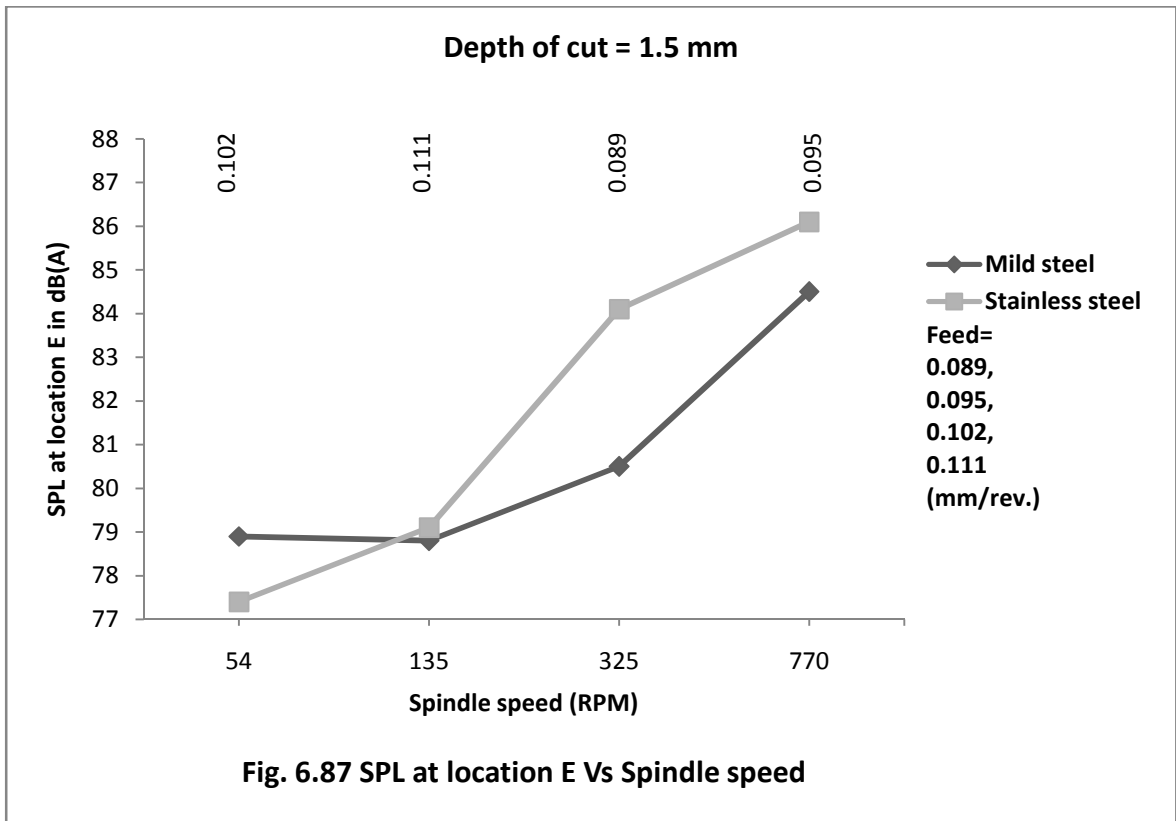
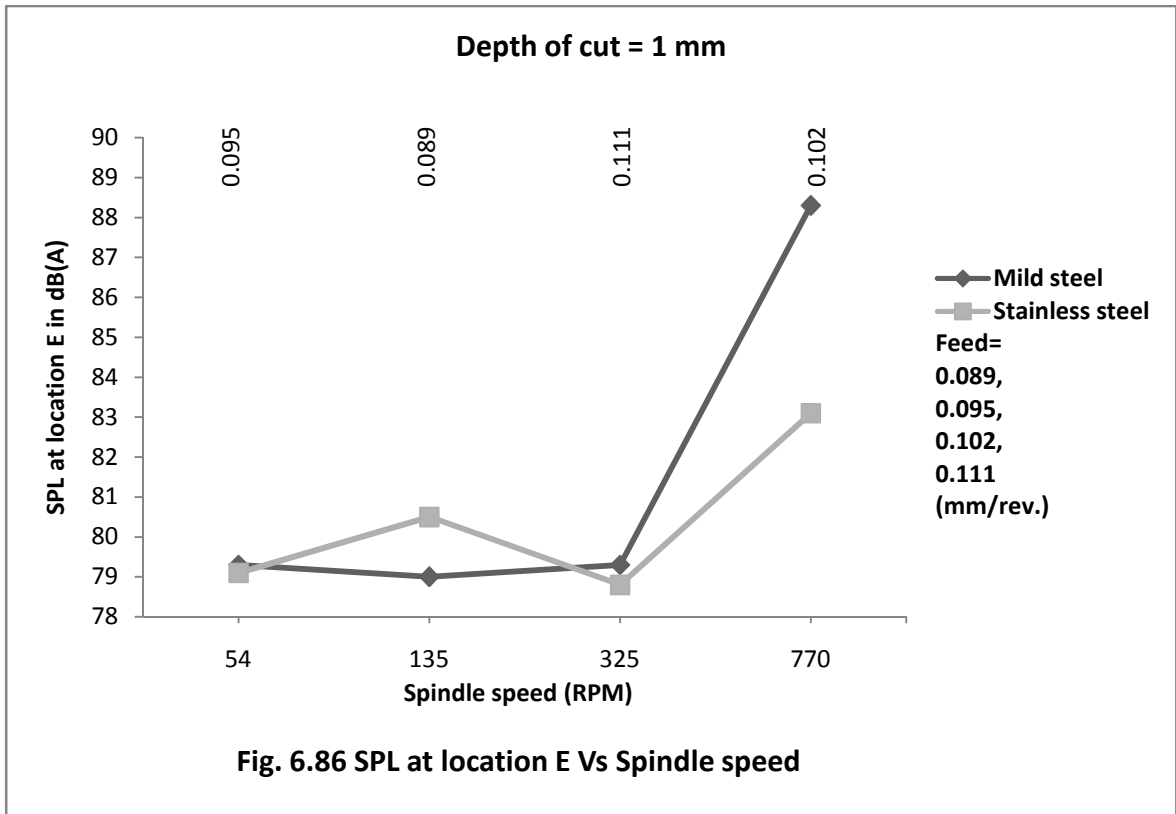


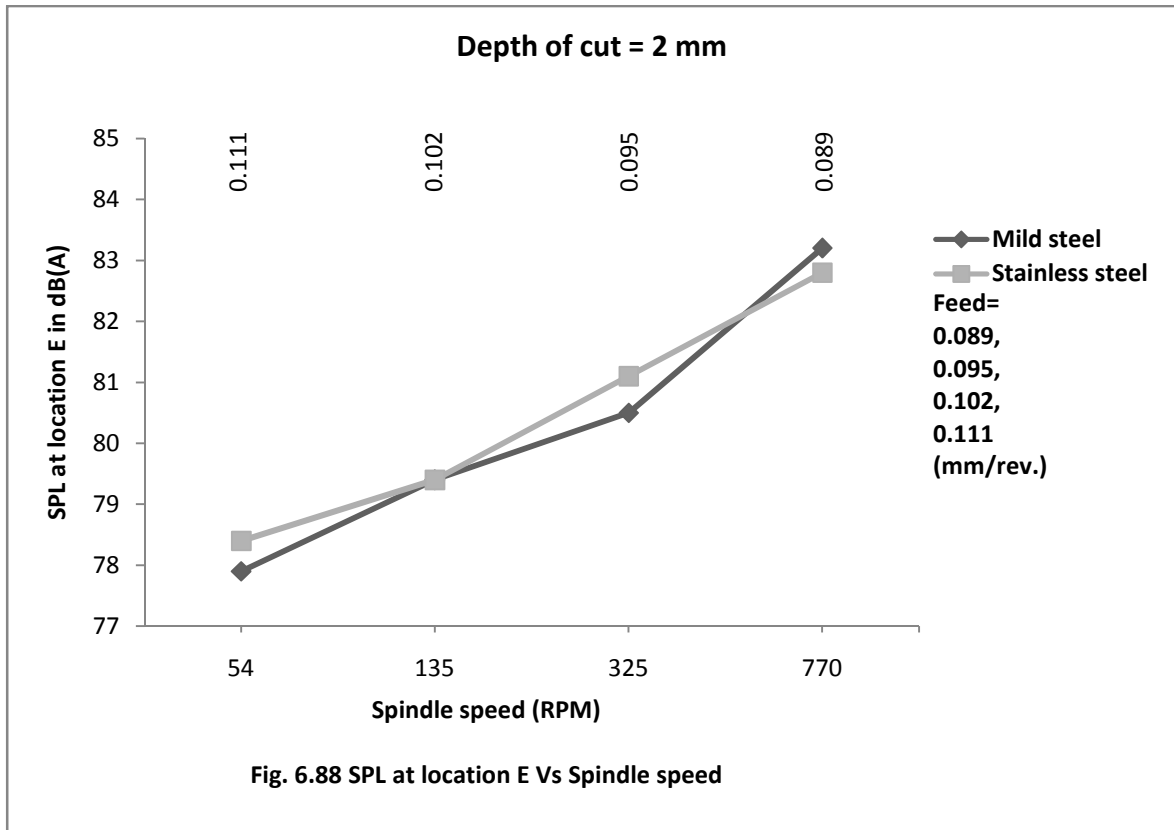
- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.095 mm/rev. and 0.102 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
- 3) At feed 0.089 mm/rev., value of sound pressure level is decreased at the combination of 2 mm and speed 770 RPM for Stainless steel. It is also decreased at the combination of 1 mm depth of cut and 325 RPM for feed 0.111 mm/rev.

Sound pressure level at location E:

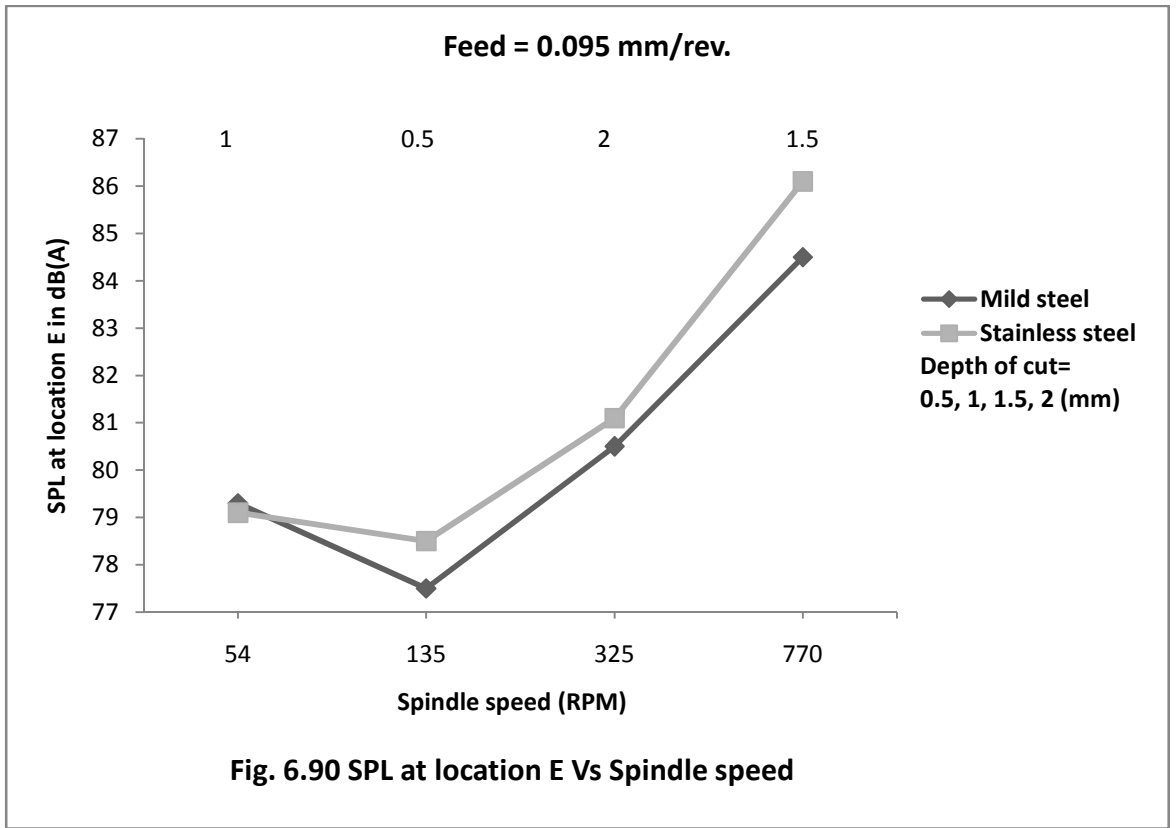
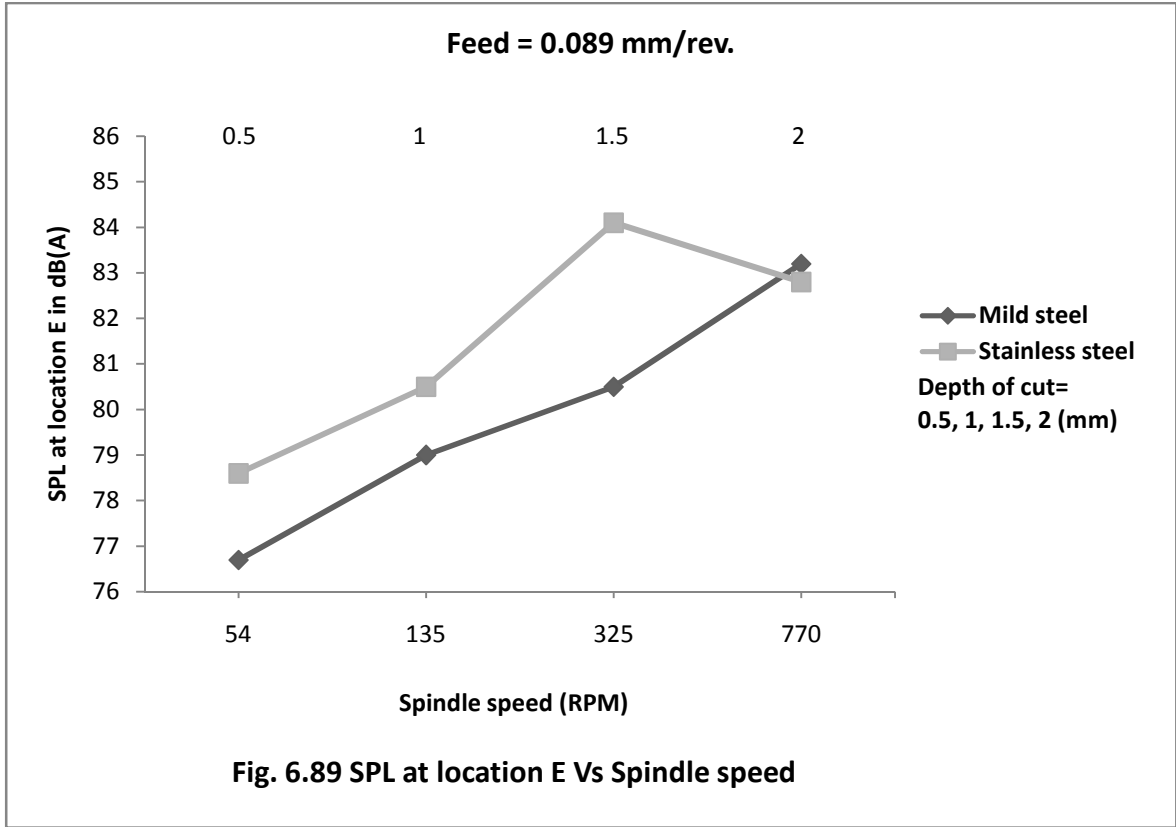
- 1) **Depth of cut:** Sound pressure level is measured by keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location E are shown in fig. 6.85 to 6.88.

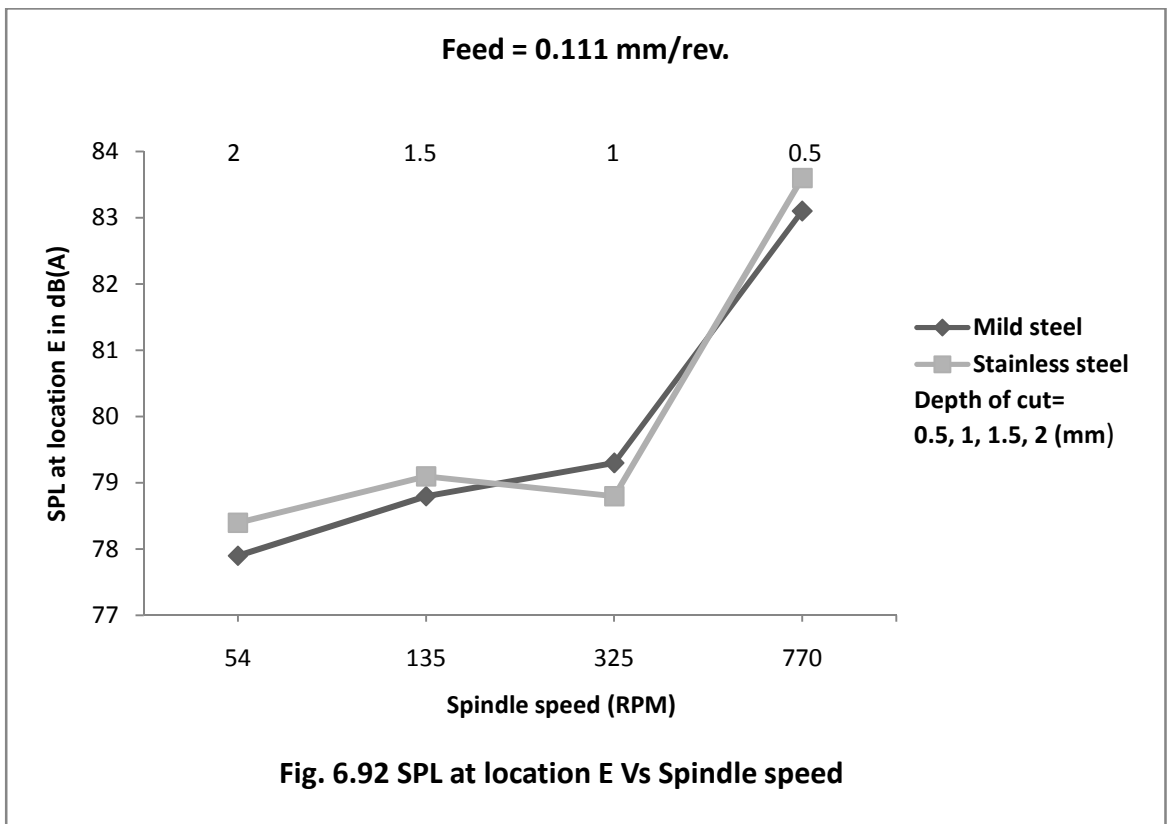
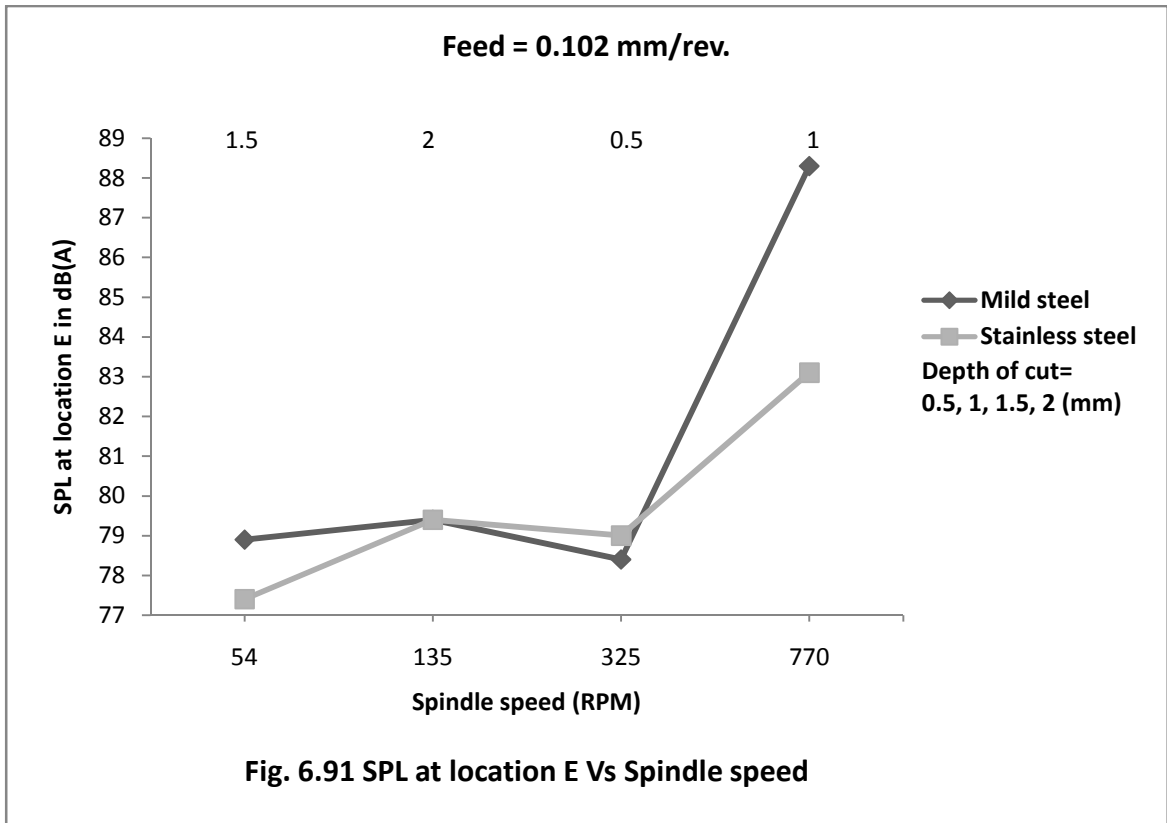






- 1) It is observed that the value of sound pressure level is increased with increasing speed at 0.5 mm, 1.5 mm and 2 mm of depth of cut for both the materials.
 - 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
 - 3) At 1 mm depth of cut, value of sound pressure level is decreased for the combination 0.111 mm/rev. and 135 RPM and then increases in other combinations for Stainless steel. For the Mild steel it is increased with increasing speed at the 1 mm depth of cut.
- 2) **Feed:** Sound pressure level is measured by keeping the feed constant and varies the depth of cut and speed. The comparison between sound pressure levels for Mild steel and Stainless steel at location E are shown in fig. 6.89 to 6.92.



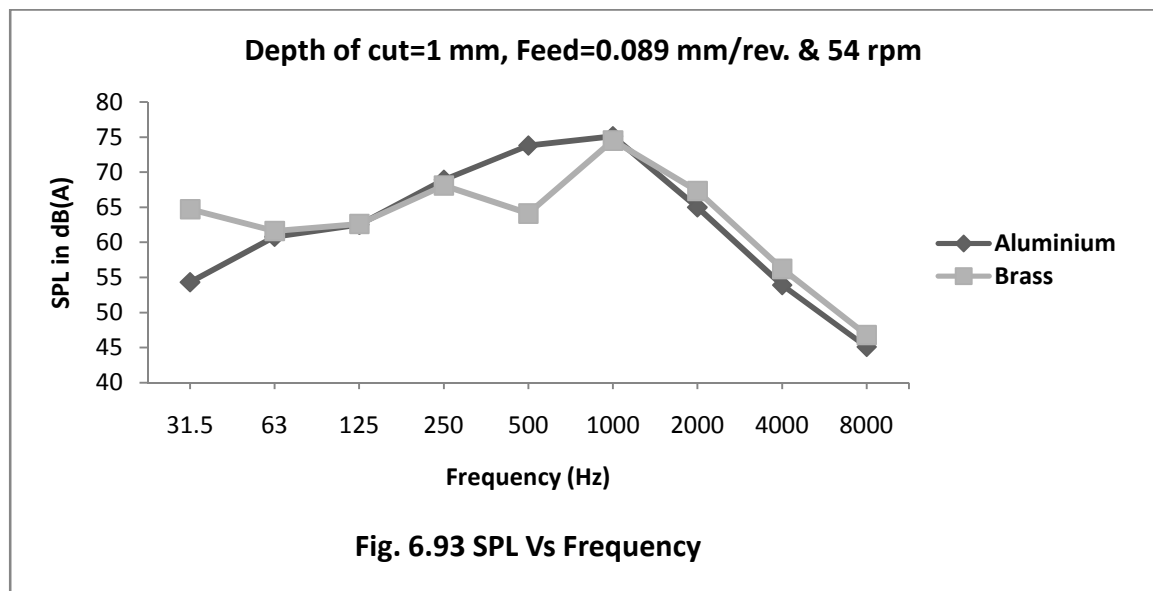


- 1) It is observed that the value of sound pressure level is increased with increasing speed at feed 0.102 mm/rev. and 0.111 mm/rev. for both the materials.
- 2) Value of sound pressure level is less for Mild steel as compared to Stainless steel for any combination of speed, feed and depth of cut.
- 3) At feed 0.089 mm/rev., value of sound pressure level is decreased at the combination of 2 mm depth of cut and speed 770 RPM for Stainless steel. At the feed 0.095 mm/rev. at the combination of 0.5 mm depth of cut and speed 135 RPM for both the materials.

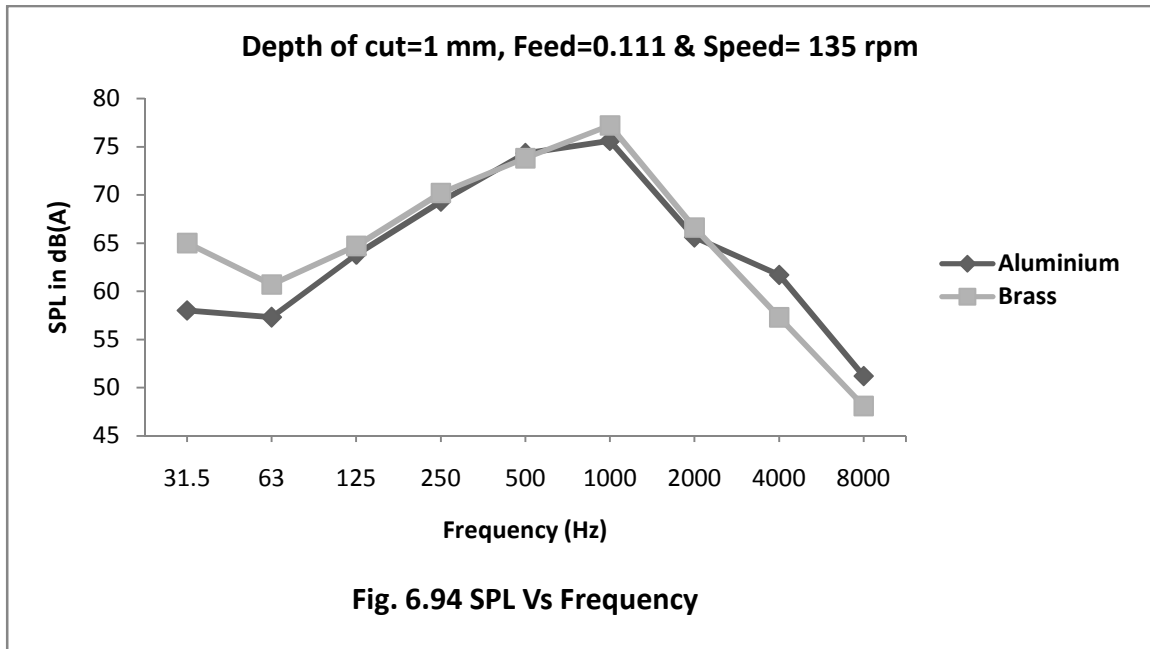
6.3 Analysis for frequency spectrum

6.3.1 Frequency spectrum for Aluminium and Brass

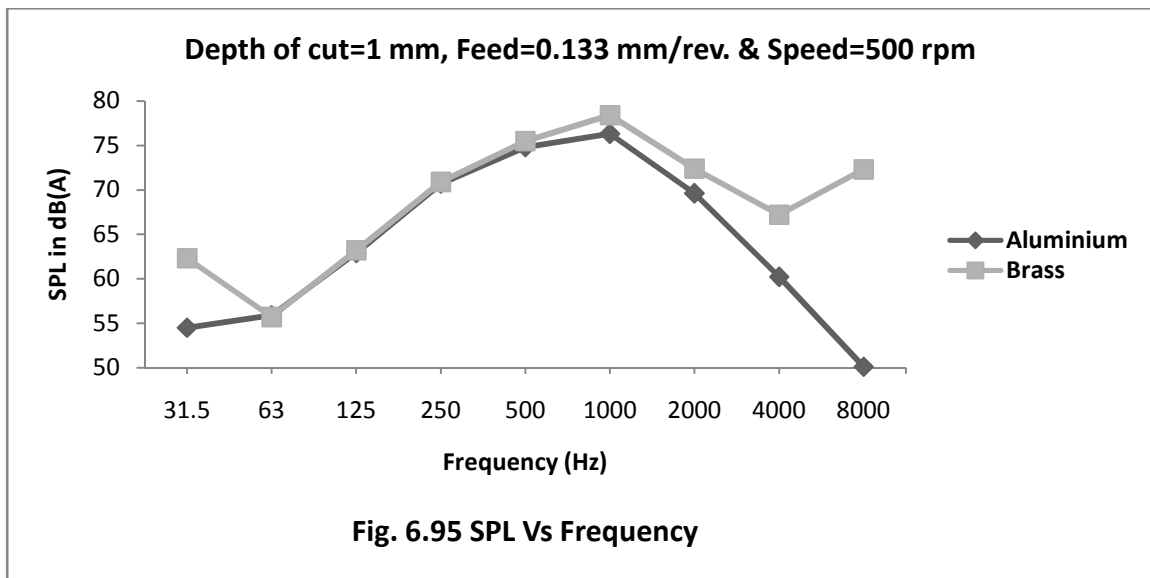
In this analysis, keeping the depth of cut constant and varies the feed and speed. The comparison between sound pressure level and frequency for Aluminium and Brass are shown in fig. 6.93 to 6.108. The analysis of frequency spectrum has been done at 1-1 octave band. The measured data for the frequency spectrum is given from the Table-1 to Table-4 in Appendix-C.



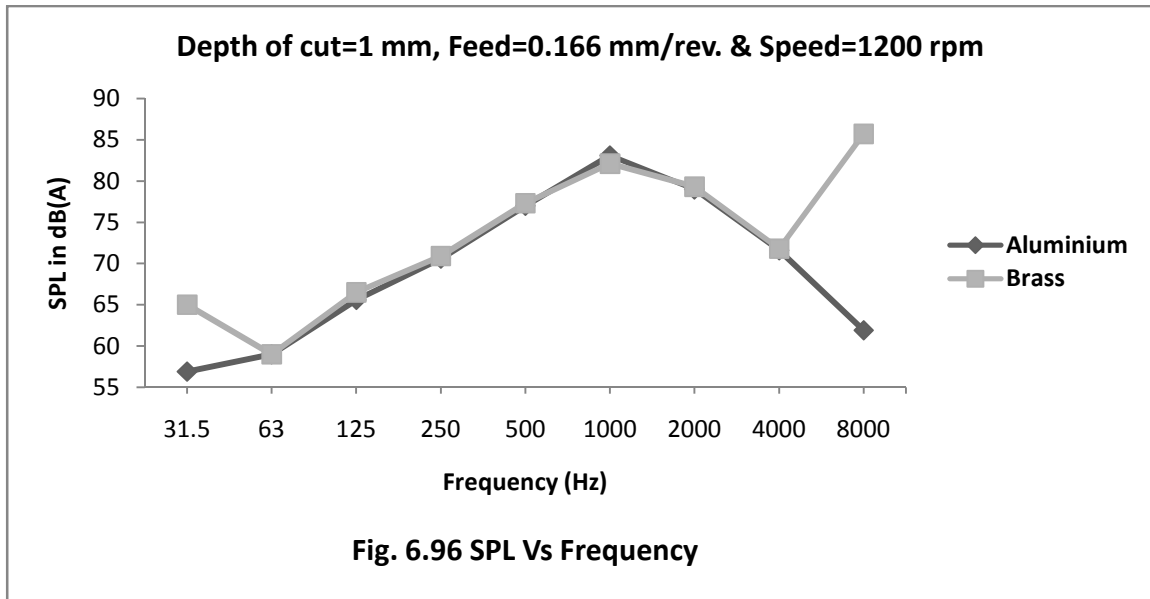
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 75.1 dB(A) and 74.5 dB(A) for Aluminium and Brass respectively.



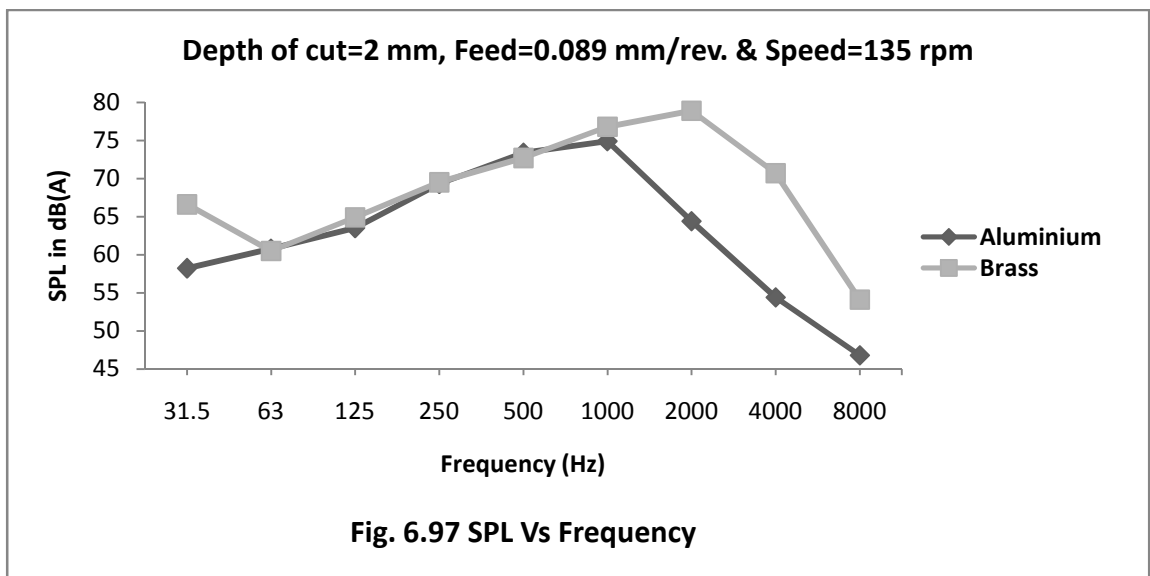
The sound pressure level increased from frequency 31.5 Hz to frequency 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 75.6 dB(A) and 77.2 dB(A) for Aluminium and Brass respectively.



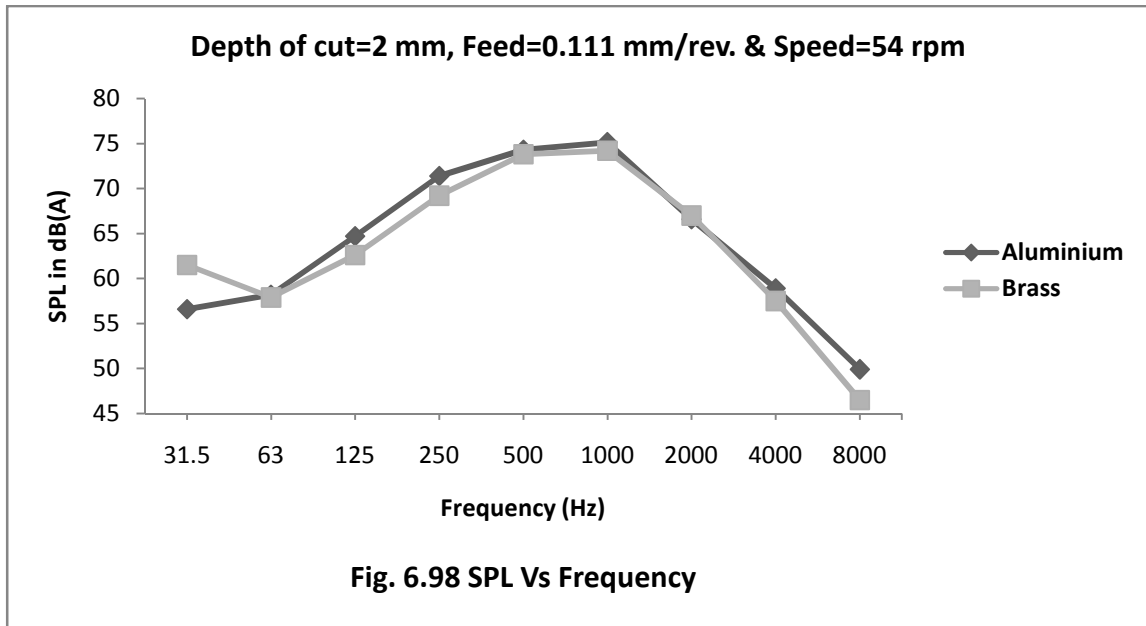
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 76.3 dB(A) and 78.4 dB(A) for Aluminum and Brass respectively.



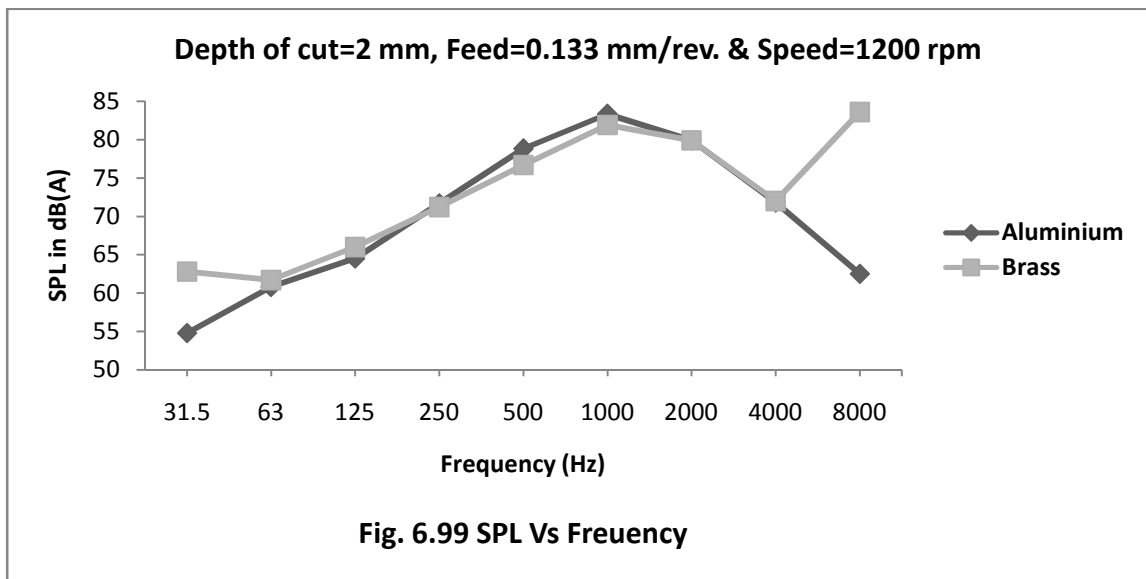
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to the 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 83.1 dB(A) and 82.1 dB(A) for Aluminum and Brass respectively.



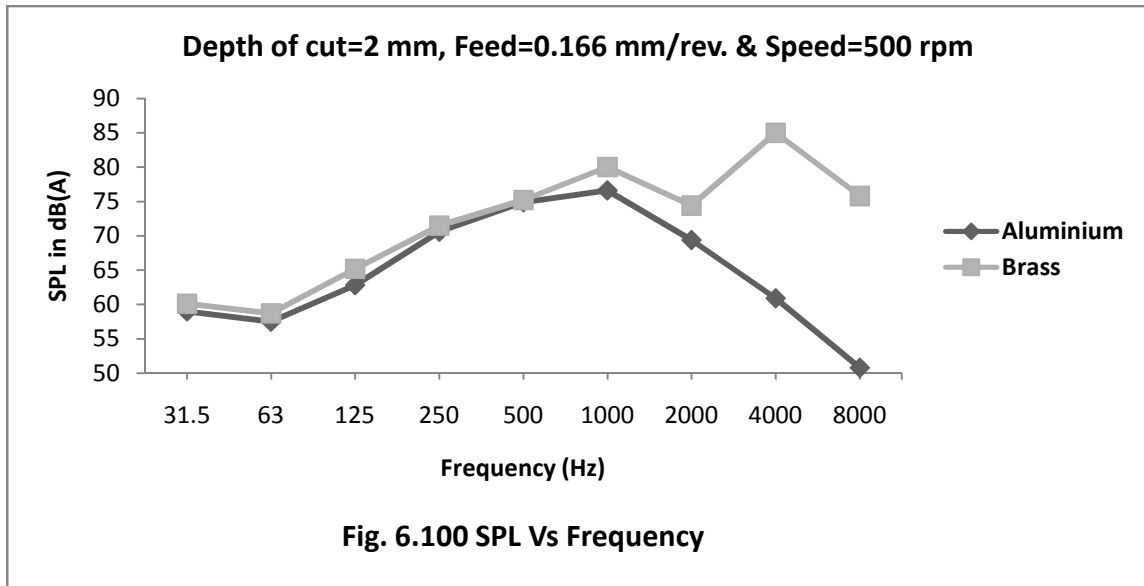
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for Aluminum. It is increased from frequency 31.5 Hz to 2000 Hz and then decreases up to 8000 Hz frequency for Brass. The peak frequency for Aluminum is 1000 Hz. The sound pressure level at 1000 frequency is 74.9 dB(A). For the brass, the peak frequency is 2000 Hz. The sound pressure level at 2000 Hz frequency is 76.8 dB(A).



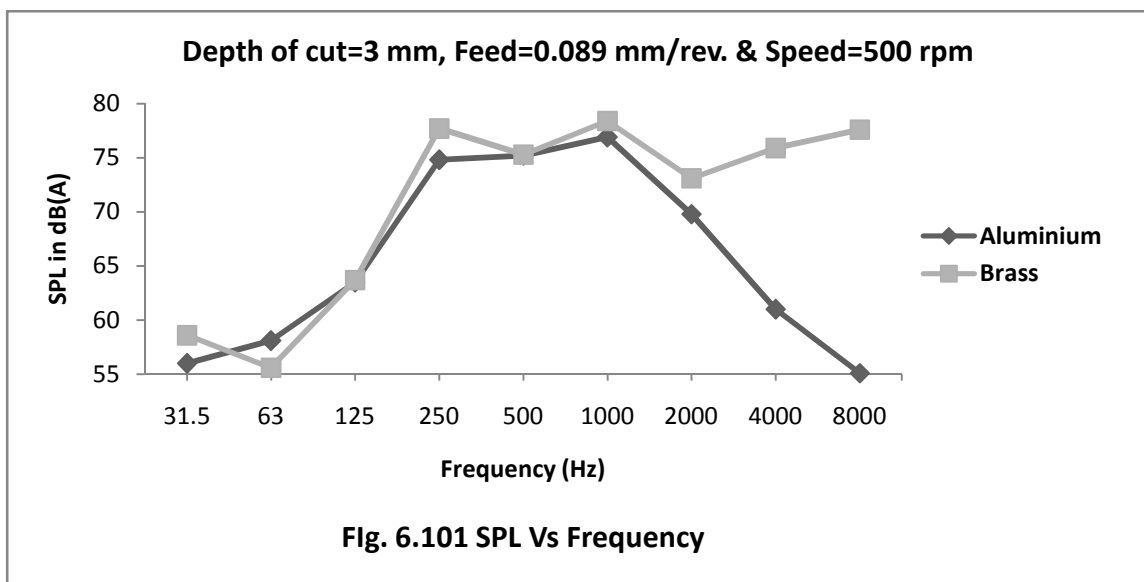
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 75.1 dB(A) and 74.2 dB(A) for Aluminum and Brass respectively.



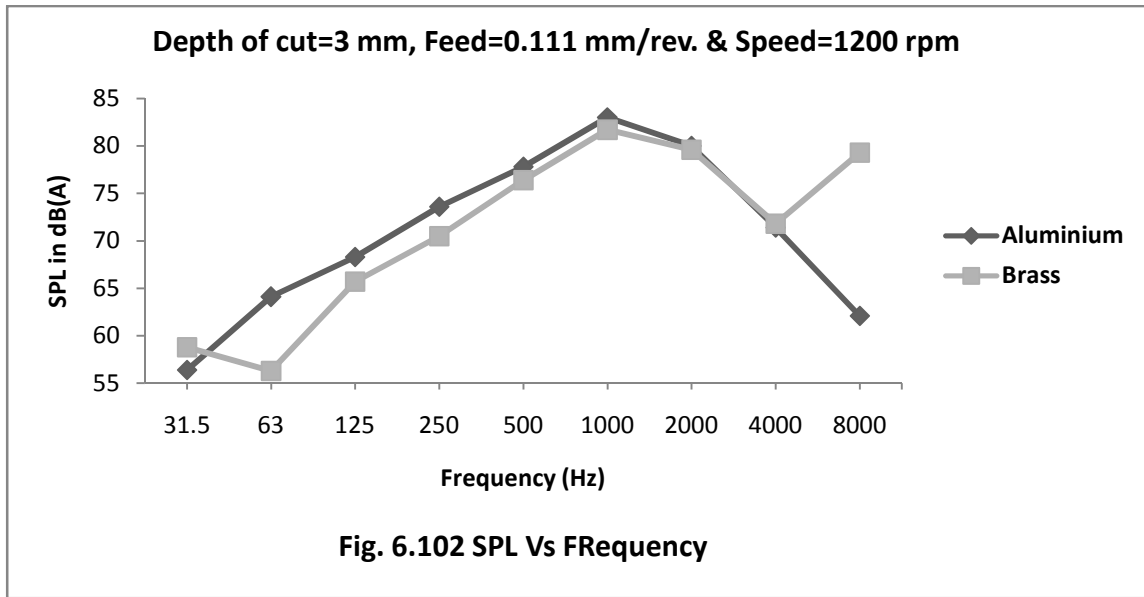
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 83.3 dB(A) and 81.9 dB(A) for Aluminum and Brass respectively.



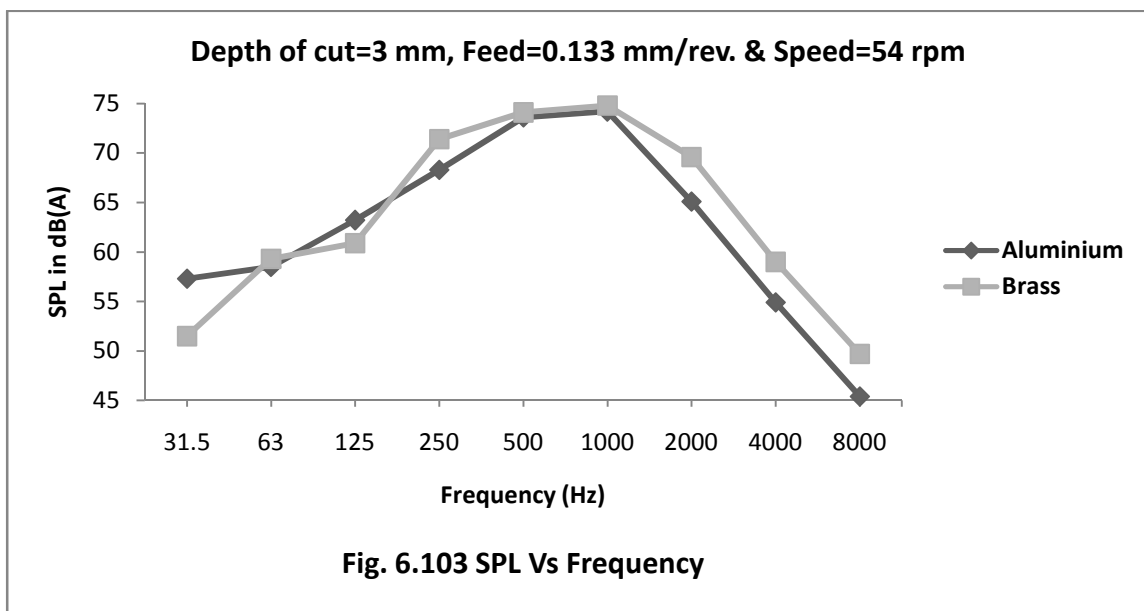
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to the 8000 Hz frequency for Aluminium. It is increased from frequency 31.5 Hz to 4000 Hz and then decreases up to 8000 Hz frequency for Brass. The peak frequency for Aluminium is 1000 Hz. The sound pressure level at 1000 Hz frequency is 76.6 dB(A). For the brass, the peak frequency is 4000 Hz. The sound pressure level at 4000 Hz frequency is 85 dB(A).



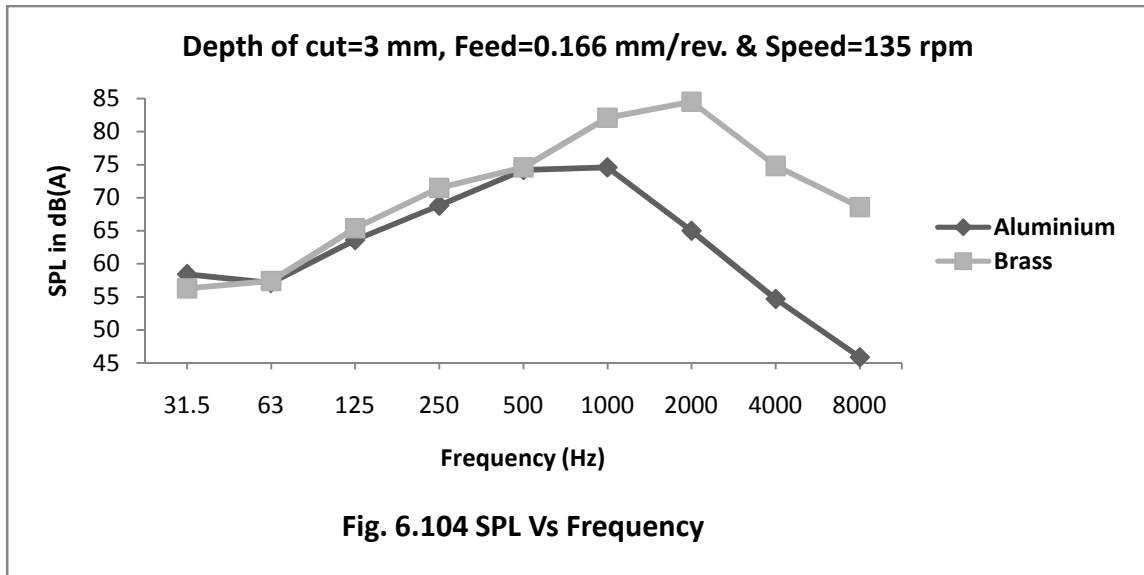
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 76.9 dB(A) and 78.4 dB(A) for Aluminium and Brass respectively.



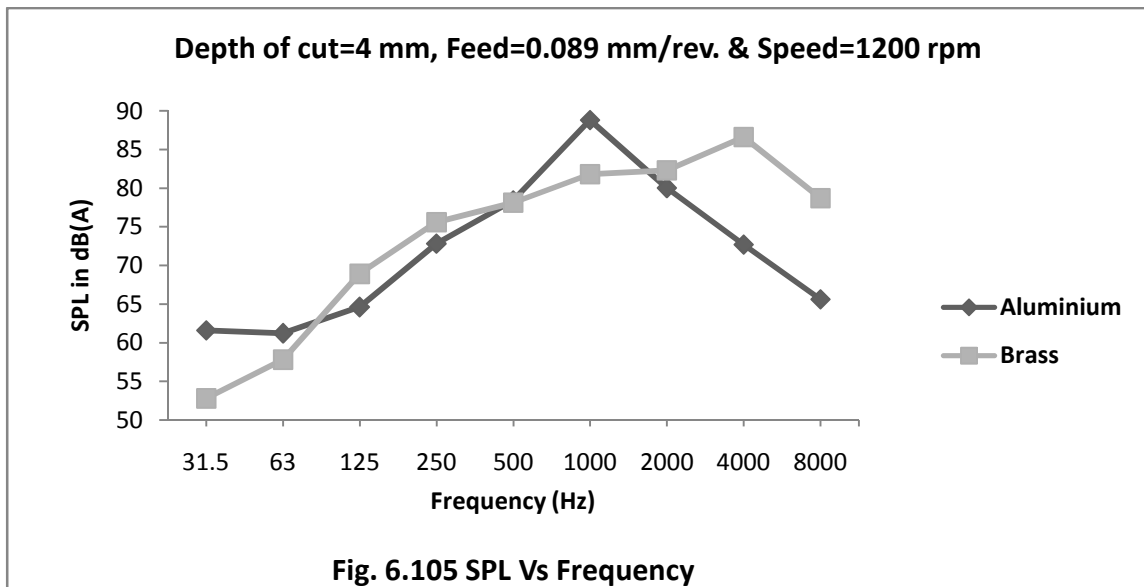
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 83 dB(A) and 81.7 dB(A) for Aluminum and Brass respectively.



The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound ressure level at 1000 Hz frequency is 74.2 dB(A) and 74.8 dB(A) for Aluminum and Brass respectively.

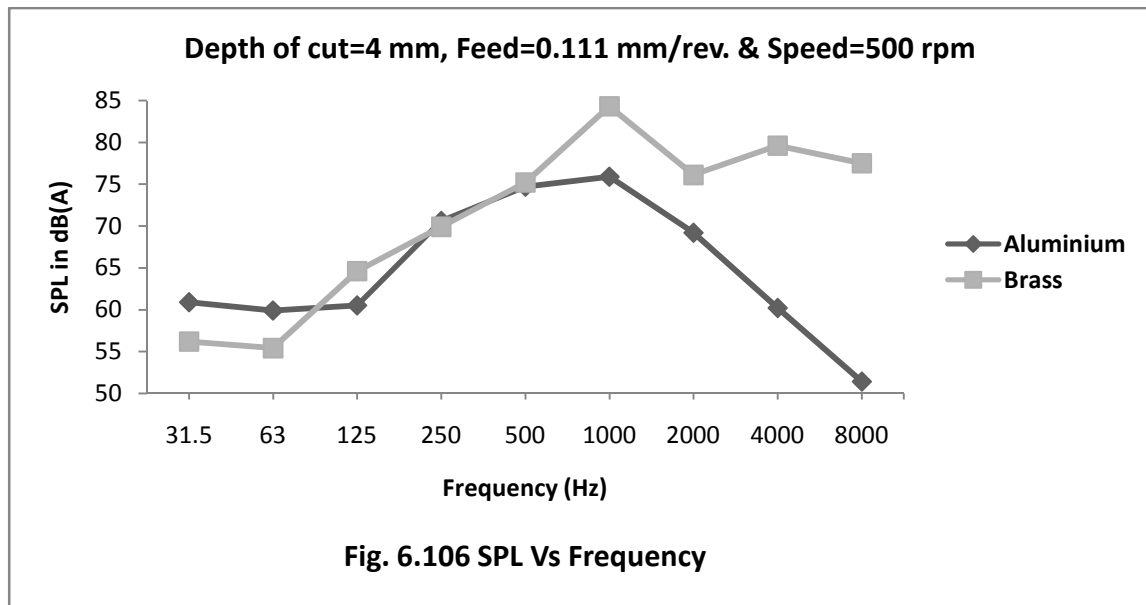


The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for Aluminium. It is increased from frequency 31.5 Hz to 2000 Hz and then decreases up to 8000 Hz frequency for Brass. The peak frequency for Aluminium is 1000 Hz. The sound pressure level at 1000 Hz frequency is 74.6 dB(A). For the brass, the peak frequency is 2000 Hz. The sound pressure level at 2000 Hz frequency is 84.5 dB(A).

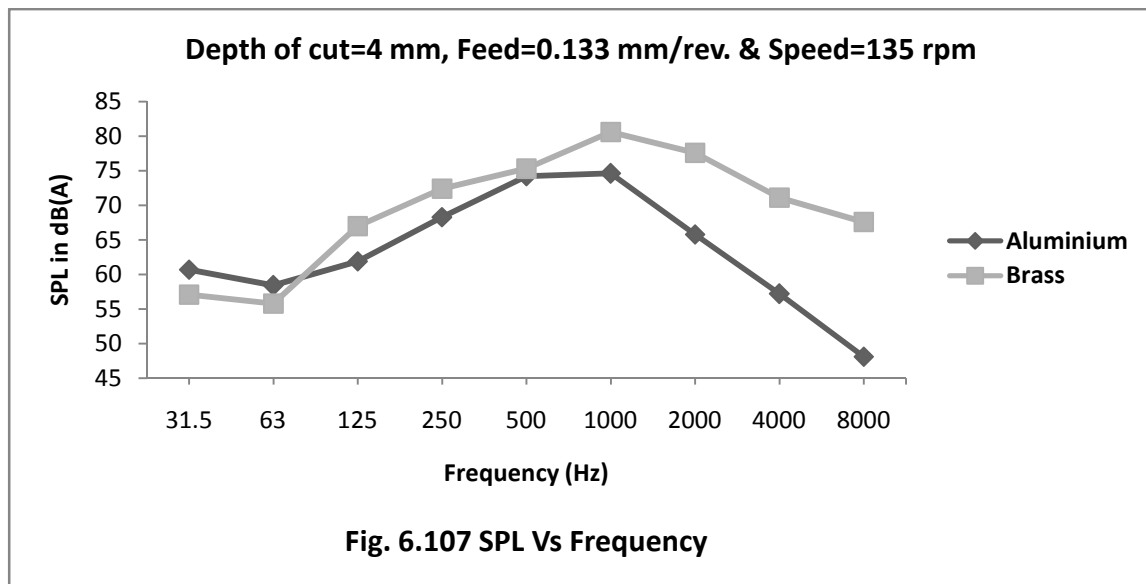


The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for Aluminium. It is increased from frequency 31.5 Hz to 4000 Hz and then decreases up to 8000 Hz frequency for Brass. The peak frequency for Aluminium is 1000 Hz. The sound pressure level at 1000 Hz frequency is 88.8 dB(A).

For the brass, the peak frequency is 2000 Hz. The sound pressure level at 2000 Hz frequency is 86.6 dB(A).

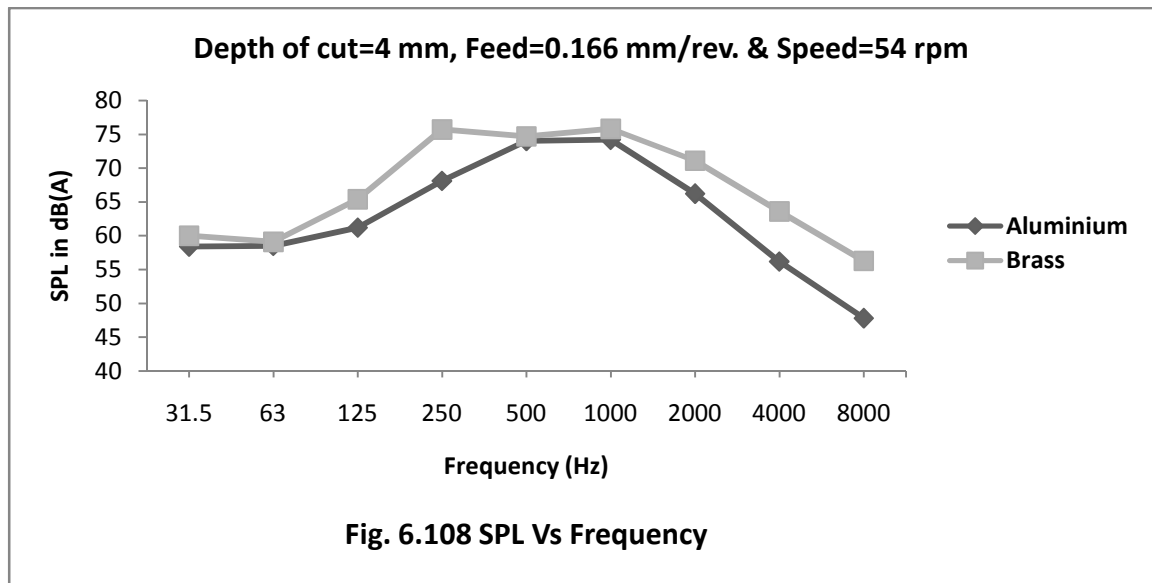


The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 75.9 dB(A) and 84.3 dB(A) for Aluminium and Brass respectively.



The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to frequency 8000 Hz for both the materials. The peak frequency for both

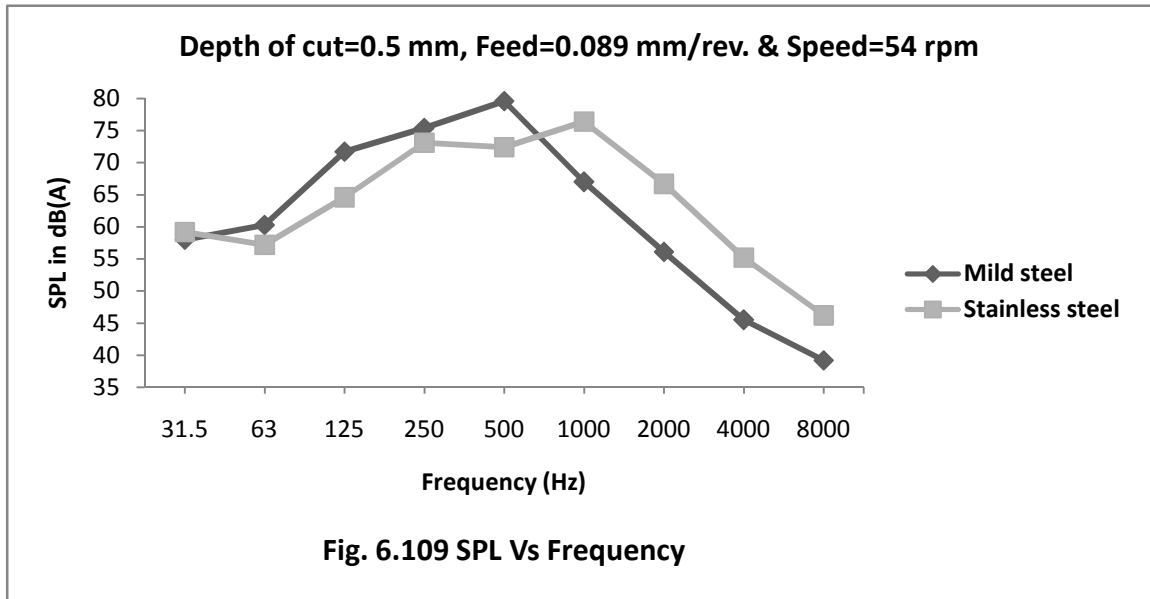
the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 74.6 dB(A) and 80.6 dB(A) for Aluminum and Brass respectively.



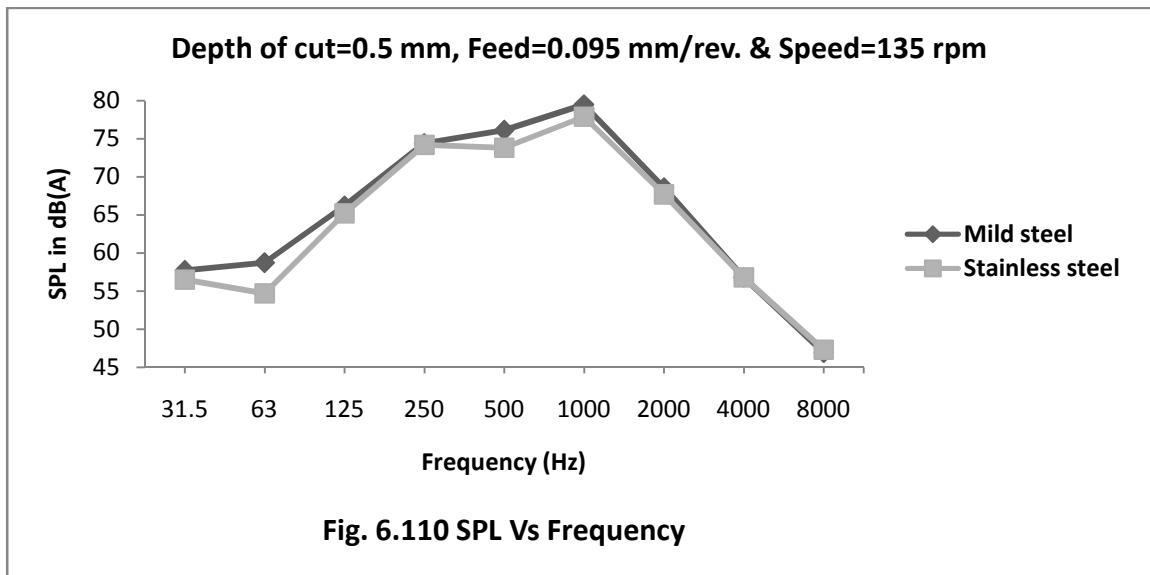
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to the 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 74.2 dB(A) and 75.8 dB(A) for Aluminum and Brass respectively.

6.3.2 Frequency spectrum for Mild steel and Stainless steel

In this analysis, keeping the depth of cut constant and varies feed and speed. The comparison between sound pressure level and frequency for Mild steel and Stainless steel are shown in fig. 6.109 to 6.124. The analysis of frequency spectrum has been done at 1-1 octave band. The measured data for the frequency spectrum is given from the Table-1 to Table-4 in Appendix-C.

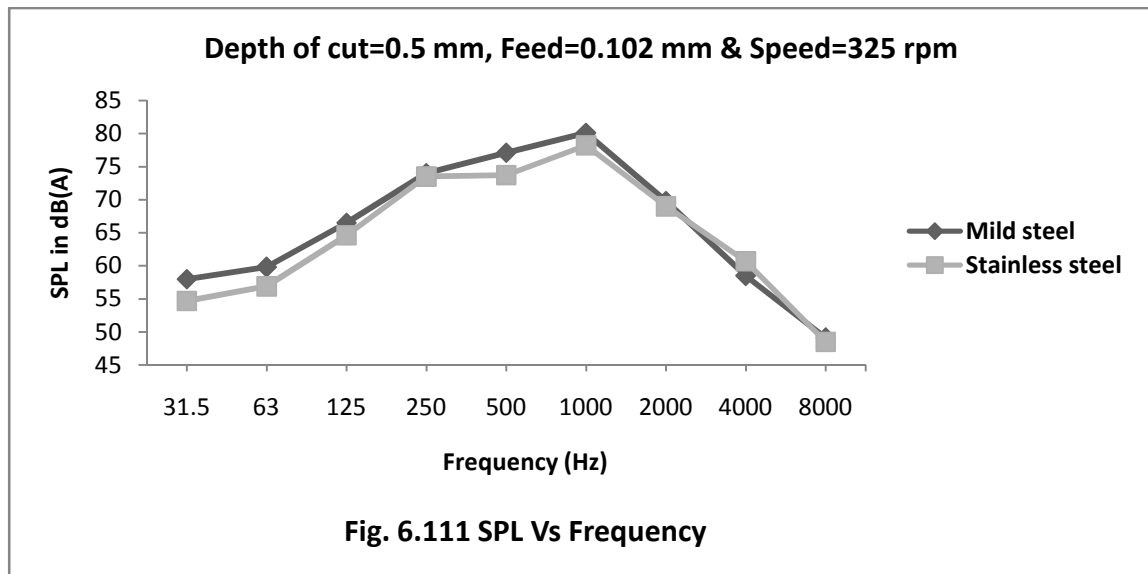


The sound pressure level increased from frequency 31.5 Hz to 500 Hz and then decreases up to 8000 Hz frequency for Mild steel. It is increased from frequency 31.5 Hz to 1000 Hz and then decreases up to frequency 8000 Hz for Stainless steel. The peak frequency for Mild steel is 500 Hz. The sound pressure level at 500 Hz frequency is 79.6 dB(A). For the Stainless steel, the peak frequency is 1000 Hz. The sound pressure level at 1000 Hz frequency is 76.4 dB(A).

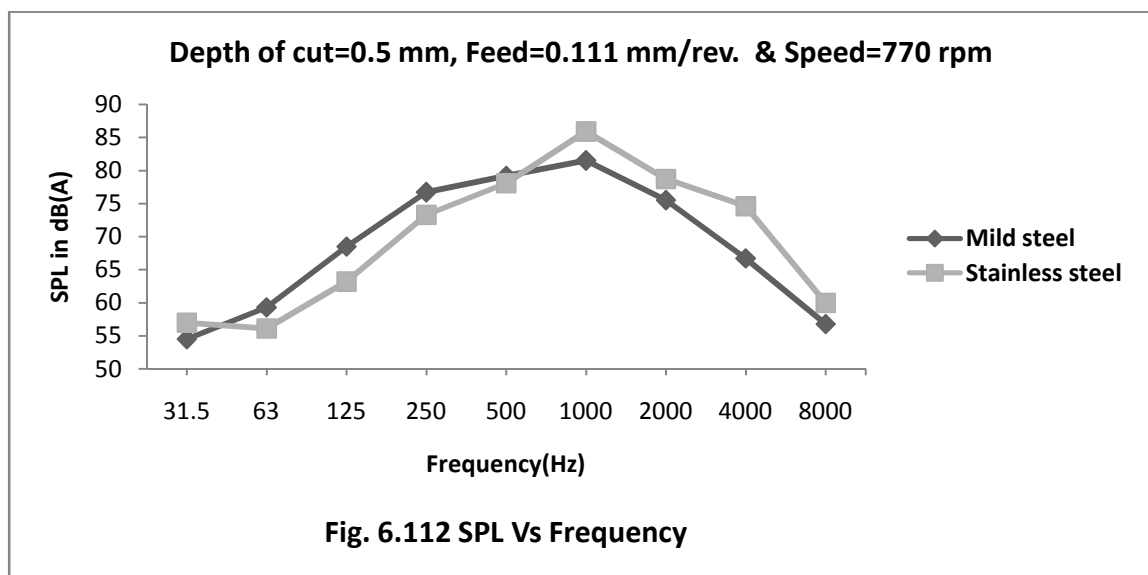


The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to frequency 8000 Hz for both the materials. The peak frequency for both

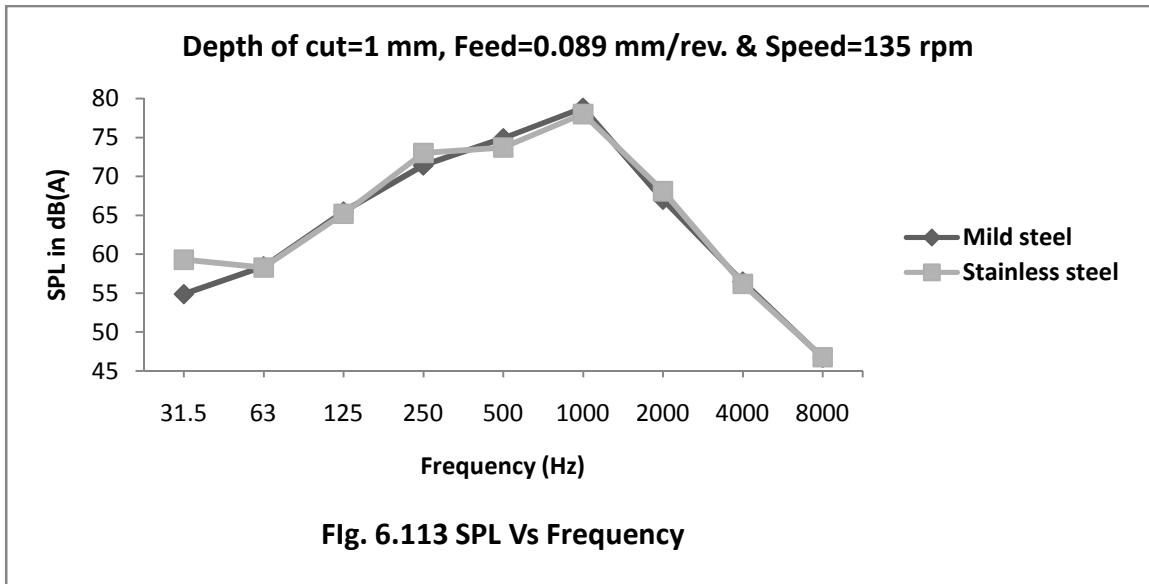
the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 79.5 dB(A) and 77.9 dB(A) for Mild steel and Stainless steel respectively.



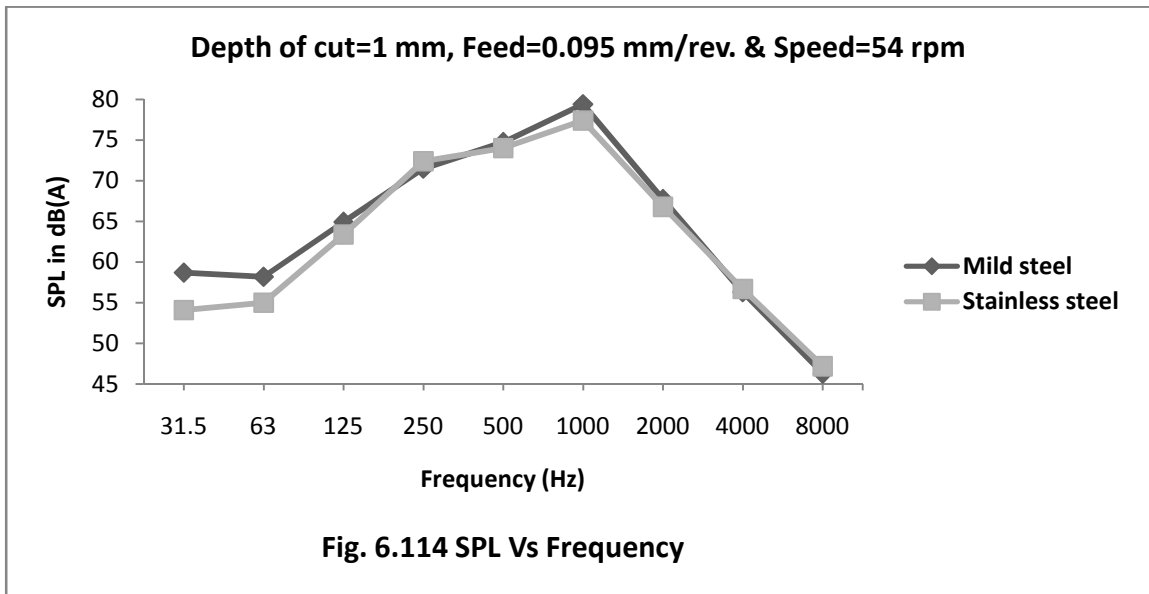
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases to the frequency 8000 Hz for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at this frequency level is 80.1 dB(A) and 78.2 dB(A) for Mild steel and Stainless steel respectively.



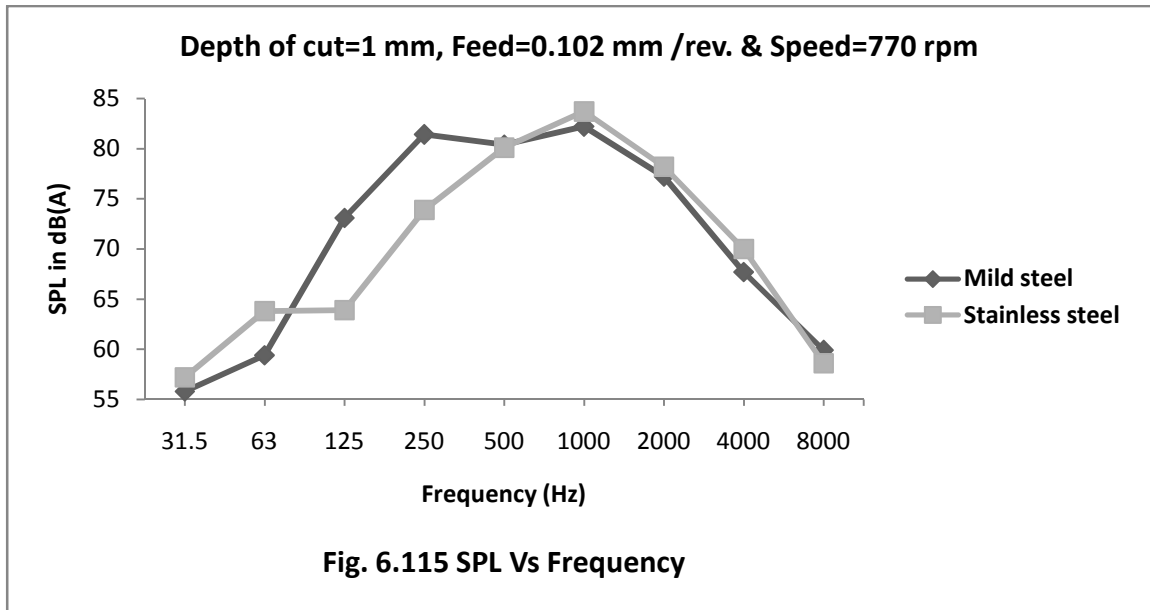
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 81.5 dB(A) and 85.9 dB(A) for Mild steel and Stainless steel respectively.



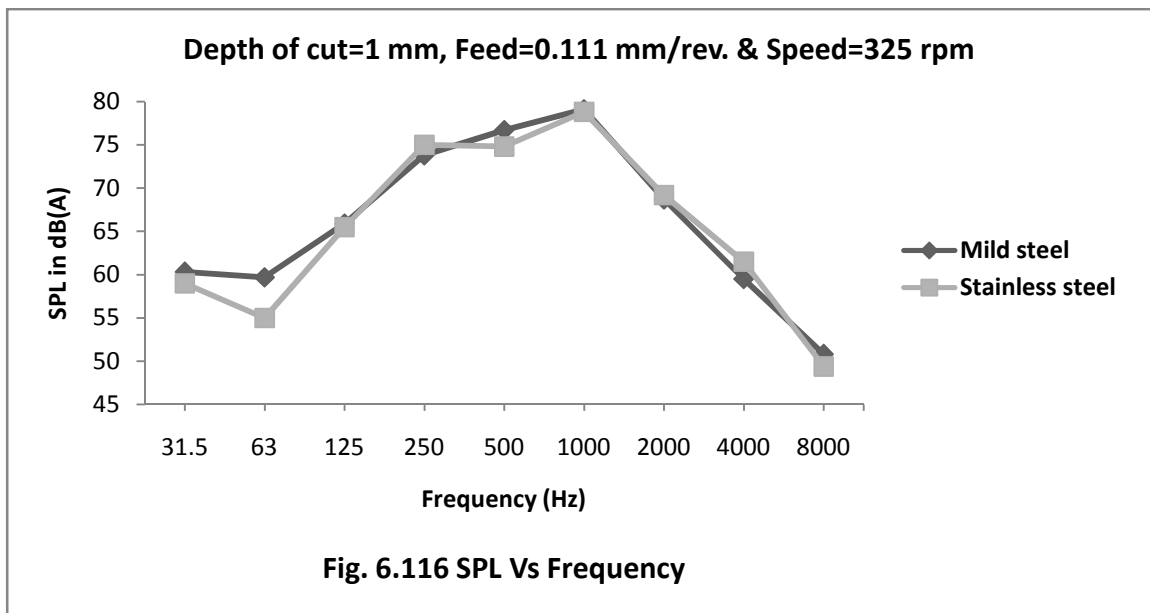
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.8 dB(A) and 78 dB(A) for Mild steel and Stainless steel respectively.



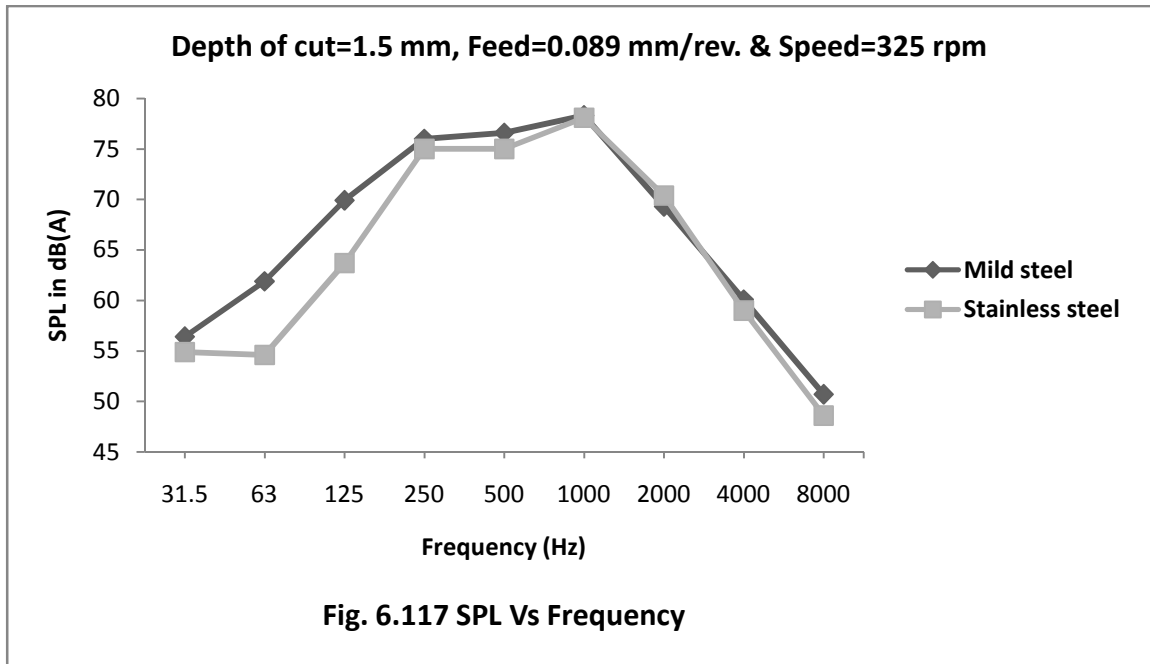
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to the 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 79.4 dB(A) and 77.4 dB(A) for Mild steel and Stainless steel respectively.



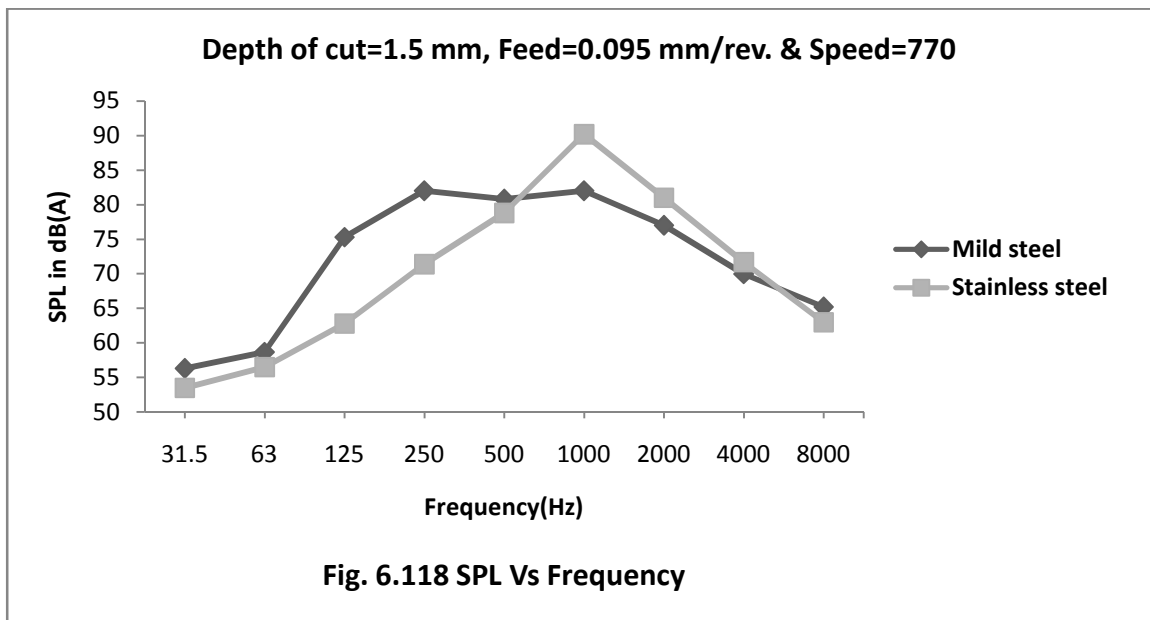
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 82.2 dB(A) and 83.7 dB(A) for Mild steel and Stainless steel respectively.



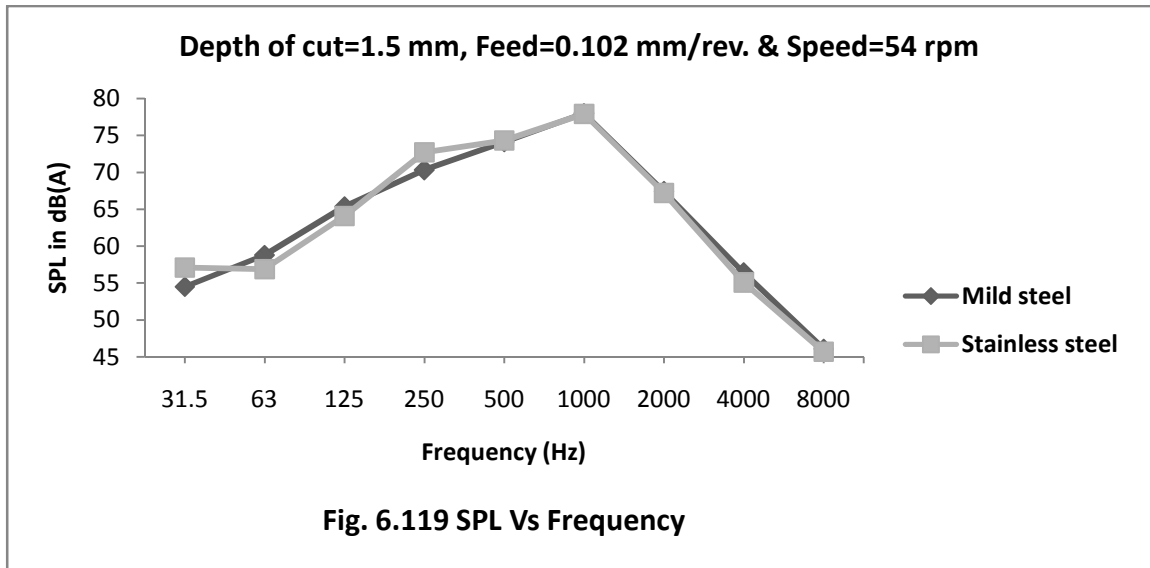
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 79.1 dB(A) and 78.8 dB(A) for Mild steel and Stainless steel respectively.



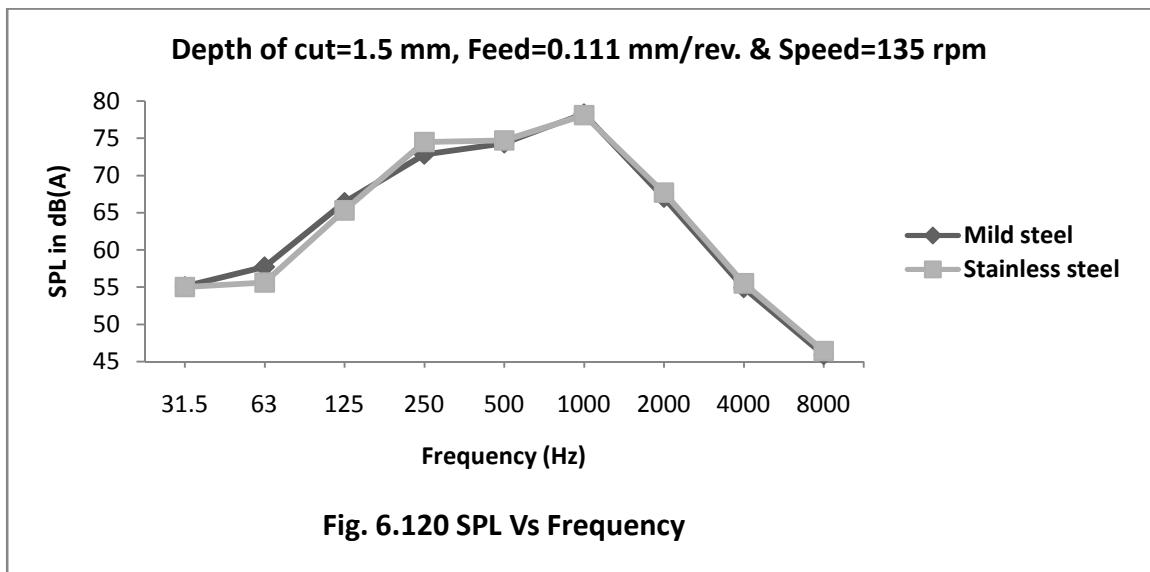
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.3 dB(A) and 78.1 dB(A) for Mild steel and Stainless steel respectively.



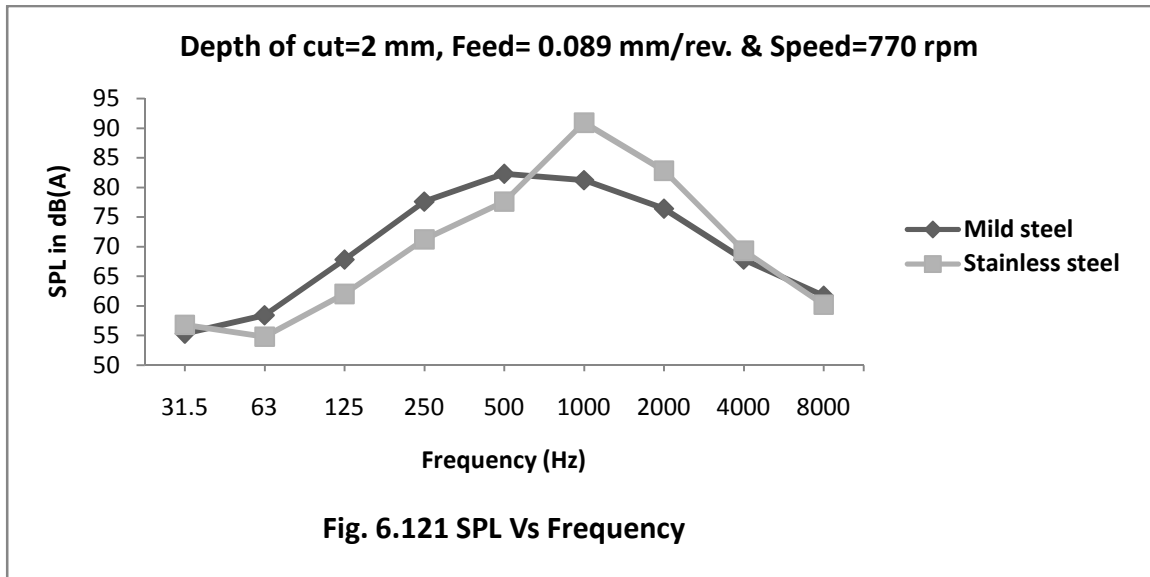
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to frequency 8000 Hz for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 82 dB(A) and 90.2 dB(A) for Mild steel and Stainless steel respectively.



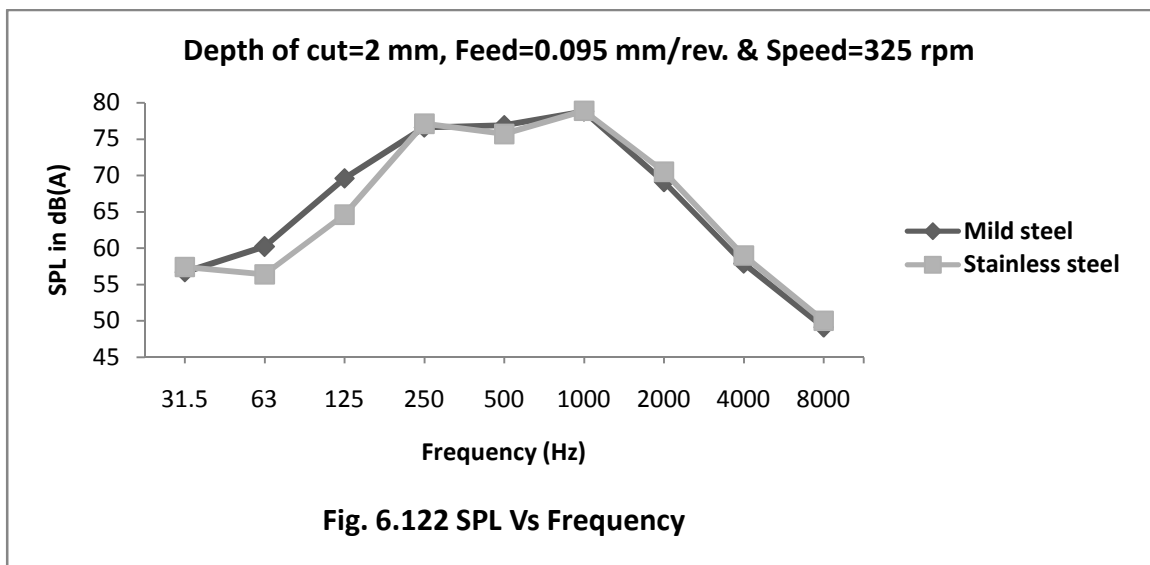
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency level is 78 dB(A) and 77.9 dB(A) for Mild steel and Stainless steel respectively.



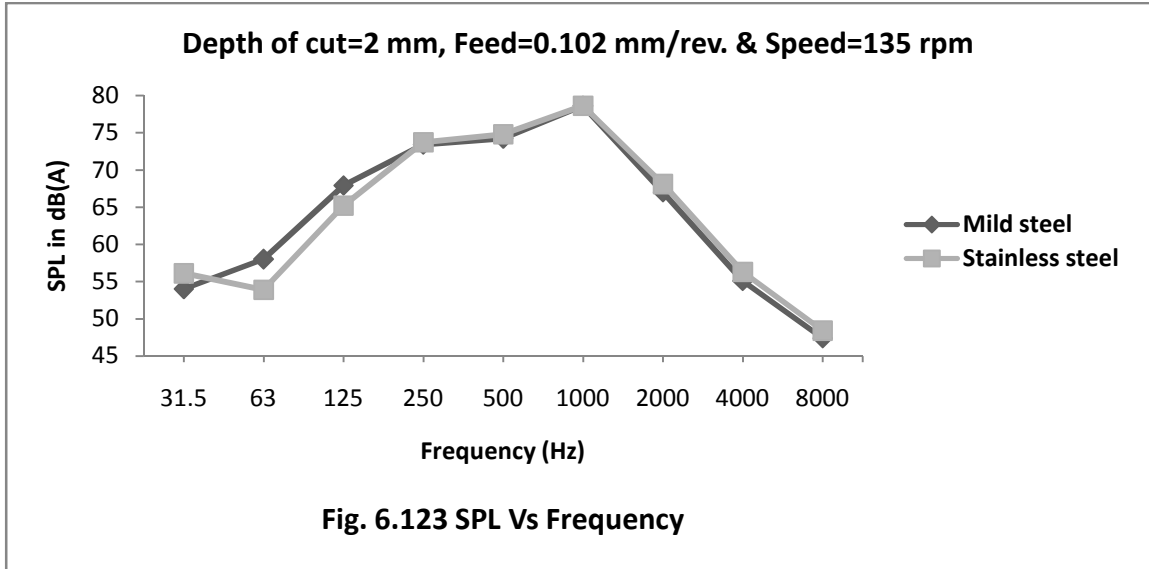
The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.3 dB(A) and 78.1 dB(A) for Mild steel and Stainless steel respectively.



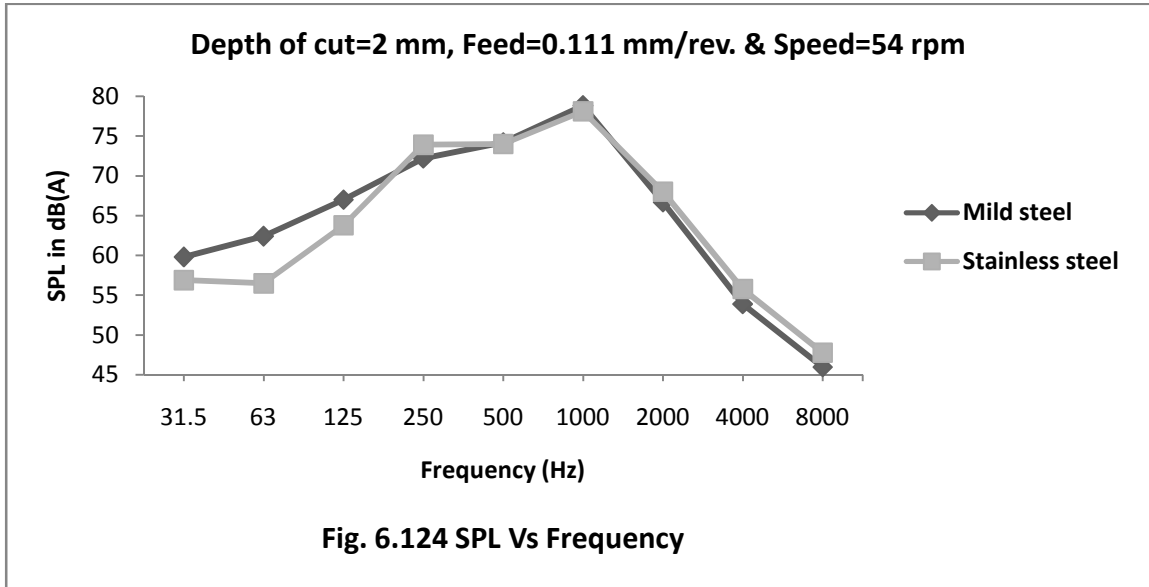
The sound pressure level increased from frequency 31.5 Hz to 500 Hz and then decreases up to 8000 Hz frequency for Mild steel. It is increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for Stainless steel. The peak frequency for Mild steel is 500 Hz. The sound pressure level at 500 Hz frequency is 82.3 dB(A). For the Stainless steel, the peak frequency is 1000 Hz. The sound pressure level at 1000 Hz frequency is 90.9 dB(A).



The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.8 dB(A) and 78.9 dB(A) for Mild steel and Stainless steel respectively.



The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.6 dB(A) and 78.6 dB(A) for Mild steel and Stainless steel respectively.



The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for both the materials. The peak frequency for both the materials is 1000 Hz. The sound pressure level at 1000 Hz frequency is 78.8 dB(A) and 78.1 dB(A) for Mild steel and Stainless steel respectively.

6.4 Results

An analysis of the collected data indicates the following results:

1) Acoustic power:

For Aluminium & Brass:

- At 1 mm depth of cut, the maximum acoustic power is 85.3 dB(A) in the combination of feed 0.133 and speed 500 RPM for Aluminium. At the same depth of cut the maximum acoustic power is 90.2 dB(A) in the combination of feed 0.166 mm/rev. and speed 1200 RPM for Brass.
- At 1 mm depth of cut, the minimum acoustic power is 82.6 dB(A) in the combination of feed 0.111 and speed 135 RPM for Aluminium. At the same depth of cut the minimum acoustic power is 84.4 dB(A) in the combination of feed 0.089 mm/rev. and speed 54 RPM for Brass.
- At 2 mm depth of cut, the combination of feed 0.133 mm/rev. and speed 1200 RPM are same for both the materials in which the maximum acoustic power is 87.1 dB(A) and 91 dB(A) for Aluminium and Brass respectively.
- At 2 mm depth of cut, the combination of feed 0.111 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 82.9 and 83.9 dB(A) for Aluminium and Brass respectively.
- At 3 mm depth of cut, the maximum acoustic power is 88.1 dB(A) in the combination of feed 0.089 and speed 500 RPM for Aluminium. At the same depth of cut the maximum acoustic power is 93.7 dB(A) in the combination of feed 0.111 mm/rev. and speed 1200 RPM for Brass.
- At 3 mm depth of cut, the combination of feed 0.133 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 82.8 and 84.7 dB(A) for Aluminium and Brass respectively.
- At 4 mm depth of cut, the maximum acoustic power is 88 dB(A) in the combination of feed 0.089 mm/rev. and speed 1200 RPM for Aluminium. At the same depth of cut the maximum acoustic power is 91.4 dB(A) in the combination of feed 0.111 mm/rev. and speed 500 RPM for Brass.

- At 4 mm depth of cut, the combination of feed 0.166 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 83.1 and 85.1 dB(A) for Aluminium and Brass respectively.

For Mild steel and Stainless steel

- At 0.5 mm depth of cut, the combination of feed 0.111 mm/rev. and speed 770 RPM are same for both the materials in which the maximum acoustic power is 91.3 dB(A) and 87.7 dB(A) for Mild steel and Stainless steel respectively.
- At 0.5 mm depth of cut, the combination of feed 0.089 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 83.3 dB(A) and 82.6 dB(A) for Mild steel and Stainless steel respectively.
- At 1 mm depth of cut, the combination of feed 0.102 mm/rev. and speed 770 RPM are same for both the materials in which the maximum acoustic power is 91.5 dB(A) and 90.1 dB(A) for Mild steel and Stainless steel respectively.
- At 1 mm depth of cut, the combination of feed 0.095 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 83.1 dB(A) and 83.8 dB(A) for Mild steel and Stainless steel respectively.
- At 1.5 mm depth of cut, the combination of feed 0.095 mm/rev. and speed 770 RPM are same for both the materials in which the maximum acoustic power is 88 dB(A) and 91 dB(A) for Mild steel and Stainless steel respectively.
- At 1.5 mm depth of cut, the combination of feed 0.102 mm/rev. and speed 54 RPM are same for both the materials in which the minimum acoustic power is 83 dB(A) and 85 dB(A) for Mild steel and Stainless steel respectively.
- At 2 mm depth of cut, the maximum acoustic power is 88.7 dB(A) in the combination of feed 0.089 mm/rev. and speed 770 RPM for Mild steel. At the same depth of cut the maximum sound pressure level is 89.5 dB(A) in the combination of feed 0.095 mm/rev. and speed 325 RPM for Stainless steel.
- At 2 mm depth of cut, the minimum acoustic power is 82.9 dB(A) in the combination of feed 0.111 mm/rev. and speed 54 RPM for Mild steel. At the same depth of cut the maximum sound pressure level is 87.1 dB(A) in the combination of feed 0.089 mm/rev. and speed 770 RPM for Stainless steel.

2) Sound pressure level:

- **Sound pressure level at location A:** At 1 mm and 4mm depth of cut the sound pressure level increases in all the combinations for the case of Aluminium and Brass. It is decreased at the combination of 3 mm depth of cut, feed 0.111 mm/rev. only for Aluminium.

For the case of Mild steel and Stainless steel the sound pressure level increased at all the combinations when depth of cut is 1 mm & 1.5 mm. It is decreased at the combinations when depth of cut is 2 mm, feed 0.102 mm/rev. and 135 RPM. It is also decreased at the combination 0.5 mm, feed 0.102 and speed 325 RPM. It is increased at all the combinations of feed 0.095 and 0.102 mm/rev. It is decreased at combinations when feed is 0.089 mm/rev., depth of cut 1 mm and 135 RPM and also decreased at the combination of feed 0.111 mm/rev., depth of cut 1.5 mm and speed 135 RPM for only Mild steel.

- **Sound pressure level at location B:** At 1 mm and 4mm depth of cut the sound pressure level increases in all the combinations for the case of Aluminium and Brass. It is decreased at the combination of 3 mm depth of cut, feed 0.111 and speed 1200 RPM only for Aluminium and also it is decreased at combination of 2 mm depth of cut, feed 0.133 mm/rev. and 1200 RPM.

For the case of Mild steel and Stainless steel the sound pressure level increased at all the combinations when depth of cut is 1 mm & 1.5 mm. It is decreased at the combination of feed 0.102 mm/rev., depth of cut 2 mm and speed 135 RPM only for Mild steel.

- **Sound pressure level at location C:** At 1 mm and 4mm depth of cut the sound pressure level increases in all the combinations for the case of Aluminium and Brass. It is decreased at the combination of 3 mm depth of cut, feed 0.111 and speed 1200 RPM only for Aluminium and also it is decreased at combination of 2 mm depth of cut, feed 0.133 mm/rev. and 1200 RPM.

For the case of Mild steel and Stainless Steel, the sound pressure level increased at all the combinations when depth of cut is 0.5 mm and 1mm depth of cut. It is increased at all combinations of feed 0.095 mm/rev. and 0.102 mm/rev. it is

decreased at the combination of feed 0.089 mm/rev., depth of cut 2 mm and 770 RPM only for Stainless steel. It also decreased for Stainless steel at the combination of feed 0.111 mm/rev., depth of cut 1.5 mm and speed 325 RPM.

- **Sound pressure level at location D:** At 1 mm and 4mm depth of cut the sound pressure level increases in all the combinations for the case of Aluminium and Brass. It is decreased at the combination of 3 mm depth of cut, feed 0.111 and speed 1200 RPM only for Aluminium and also it is decreased at combination of 2 mm depth of cut, feed 0.133 mm/rev. and 1200 RPM.

For the case of Mild steel and Stainless steel the sound pressure level increased at all the combinations when depth of cut is 1 mm & 1.5 mm. It is decreased at the combination of feed 0.102 mm/rev., depth of cut 2 mm and speed 135 RPM only for Mild steel.

- **Sound pressure level at location E:** At 1 mm and 4mm depth of cut the sound pressure level increases in all the combinations for the case of Aluminium and Brass. It is decreased at the combination of 3 mm depth of cut, feed 0.111 mm/rev. only for Aluminium.

For the case of Mild steel and Stainless steel the sound pressure level increased at all the combinations when depth of cut is 1 mm & 1.5 mm. It is decreased at the combinations when depth of cut is 2 mm, feed 0.102 mm/rev. and 135 RPM. It is also decreased at the combination 0.5 mm, feed 0.102 and speed 325 RPM. It is increased at all the combinations of feed 0.095 and 0.102 mm/rev. It is decreased at combinations when feed is 0.089 mm/rev., depth of cut 1 mm and 135 RPM and also decreased at the combination of feed 0.111 mm/rev., depth of cut 1.5 mm and speed 135 RPM for only Mild steel.

- 3) **Frequency spectrum:** The frequency spectrum analysis has been carried out at the location where the sound pressure level is maximum. The sound pressure level is maximum at the location E as shown in figure 5.3.
 - The peak frequency for all the materials is 1000 Hz.
 - The sound pressure level at 1000 Hz frequency is 88.8 dB(A) and 84.3 dB(A) for Aluminium and Brass.

- The sound pressure level at 1000 Hz is 82.2 dB(A) and 90.9 dB(A) for Mild Steel and Stainless steel.
- The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for all the materials.

CHAPTER 7

CONCLUSION AND SCOPE FOR FUTURE WORK

7.1 Conclusion

The object of the present work was to study the effect of different operating parameters i.e. depth of cut, feed and speed on the sound pressure level around a lathe machine during turning operation. It concludes the following points:

1) Acoustic power:

For Aluminium and Brass:

- The maximum acoustic power is 88.1 dB(A) at the combination of 3 mm depth of cut, feed 0.089 mm/rev. and speed 500 RPM for Aluminium. For Brass, the maximum acoustic power is 93.7 dB(A) at the combination of 3 mm depth of cut, feed 0.111 mm/rev. and speed 1200 RPM.
- The minimum acoustic power is 82.6 dB(A) at the combination of 1 mm depth of cut, feed 0.111 mm/rev. and speed 135 RPM for Aluminium. For Brass, the minimum acoustic power is 83.9 dB(A) at the combination of 2 mm depth of cut, feed 0.111 mm/rev. and speed 54 RPM.

For Mild steel and Stainless steel:

- The maximum acoustic power is 91.5 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel. For Stainless steel, the maximum acoustic power is 91 dB(A) at the combination of 1.5 mm depth of cut, feed 0.095 mm/rev. and speed 770 RPM.
- The minimum acoustic power is 82.9 dB(A) at the combination of 2 mm depth of cut, feed 0.111 mm/rev. and speed 54 RPM for Mild steel. For Stainless steel, the minimum acoustic power is 82.6 dB(A) at the combination of 0.5 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM.

2) Sound pressure level:

For Aluminium and Brass:

At location A:

- At the combination of 4 mm depth of cut, feed 0.089 mm/rev. and speed 1200 RPM, the maximum sound pressure level is 83.4 dB(A) and 85.6 dB(A) for Aluminium and Brass respectively.
- At the combination of 3 mm depth of cut, feed 0.133 mm/rev. and speed 54 RPM, the minimum sound pressure level is 75.5 dB(A) and 76.5 dB(A) for Aluminium and Brass respectively.

At location B:

- At the combination of 4 mm depth of cut, feed 0.089 mm/rev. and speed 1200 RPM, the maximum sound pressure level is 82.8 dB(A) and 84.1 dB(A) for Aluminium and Brass respectively.
- At the combination of 2 mm depth of cut, feed 0.111 mm/rev. and speed 54 RPM, the minimum sound pressure level is 74.9 dB(A) and 75.9 dB(A) for Aluminium and Brass respectively.

At location C:

- The maximum sound pressure level is 83.9 dB(A) at the combination of 4 mm depth of cut, feed 0.089 mm/rev. and speed 1200 RPM for Aluminium. For Brass, the maximum sound pressure level is 85.1 dB(A) at the combination of 3 mm depth of cut, feed 0.111 mm/rev. and speed 1200 RPM.
- At the combination of 2 mm depth of cut, feed 0.111 mm/rev. and speed 54 RPM, the minimum sound pressure level is 76.5 dB(A) and 77.4 dB(A) for Aluminium and Brass respectively.

At location D:

- At the combination of 3 mm depth of cut, feed 0.111 mm/rev. and speed 1200 RPM, the maximum sound pressure level is 80.3 dB(A) and 81.6 dB(A) for Aluminium and Brass respectively.
- The minimum sound pressure level is 72.5 dB(A) at the combination of 2 mm depth of cut, feed 0.111 mm/rev. and speed 54 RPM for Aluminium. For Brass, the minimum sound pressure level is 73.2 dB(A) at the combination of 1 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM.

At location E:

- At the combination of 4 mm depth of cut, feed 0.089 mm/rev. and speed 1200 RPM, the maximum sound pressure level is 84.6 dB(A) and 89.6 dB(A) for Aluminium and Brass respectively.
- The minimum sound pressure level is 75.6 dB(A) at the combination of 1 mm depth of cut, feed 0.111 mm/rev. and speed 135 RPM for Aluminium. For Brass, the minimum sound pressure level is 76.5 dB(A) at the combination of 4 mm depth of cut, feed 0.166 mm/rev. and speed 54 RPM.
- At 1 mm and 4 mm depth of cut, sound pressure level increases at all the combinations of feed and speed for Aluminium and Brass.

For Mild steel and Stainless steel:**At location A:**

- The maximum sound pressure level is 82 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel .For Stainless steel, the maximum sound pressure level is 83.2 dB(A) at the combination of 1.5 mm depth of cut, feed 0.095 mm/rev. and speed 770 RPM.
- At the combination of 1.5 mm depth of cut, feed 0.102 mm/rev. and speed 54 RPM, the minimum sound pressure level is 75.8 dB(A) and 75.7 dB(A) for Mild steel and Stainless steel respectively.

At location B:

- The maximum sound pressure level is 82 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel. For Stainless steel, the maximum sound pressure level is 85.6 dB(A) at the combination of 1.5 mm depth of cut, feed 0.095 mm/rev. and speed 770 RPM.
- The minimum sound pressure level is 76.3 dB(A) at the combination of 1 mm depth of cut, feed 0.095 mm/rev. and speed 54 RPM for Mild steel. For Stainless steel, the minimum sound pressure level is 76.3 dB(A) at the combination of 0.5 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM.

At location C:

- The maximum sound pressure level is 87 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel. For Stainless steel,

the maximum sound pressure level is 81.6 dB(A) at the combination of 1.5 mm depth of cut, feed 0.089 mm/rev. and speed 325 RPM.

- At the combination of 0.5 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM, the minimum sound pressure level is 75.9 dB(A) and 76 dB(A) for Mild steel and Stainless steel respectively.

At location D:

- The maximum sound pressure level is 79.7 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel. For Stainless steel, the maximum sound pressure level is 86.3 dB(A) at the combination of 1.5 mm depth of cut, feed 0.095 mm/rev. and speed 770 RPM.
- At the combination of 0.5 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM, the minimum sound pressure level is 72.6 dB(A) and 72.3 dB(A) for Mild steel and Stainless steel respectively.

At location E:

- The maximum sound pressure level is 88.3 dB(A) at the combination of 1 mm depth of cut, feed 0.102 mm/rev. and speed 770 RPM for Mild steel. For Stainless steel, the maximum sound pressure level is 86.1 dB(A) at the combination of 1.5 mm depth of cut, feed 0.095 mm/rev. and speed 770 RPM.
- The minimum sound pressure level is 76.7 dB(A) at the combination of 0.5 mm depth of cut, feed 0.089 mm/rev. and speed 54 RPM for Mild steel. For Stainless steel, the minimum sound pressure level is 77.4 dB(A) at the combination of 1.5 mm depth of cut, feed 0.102 mm/rev. and speed 54 RPM.
- At 0.5 mm and 2 mm depth of cut, sound pressure level increases with increasing speed.
- It decreases at 1 mm depth of cut for the combination of feed 0.089 mm/rev. and speed 135 RPM and then increases up to the combination of feed 0.102 mm/rev. and 770 RPM.

3) Frequency Spectrum:

- The frequency spectrum analysis has been carried out at the location where the sound pressure level is maximum. The sound pressure level is maximum at the location E as shown in figure 5.3.
- The peak frequency for all the materials is 1000 Hz.

- The sound pressure level at 1000 Hz frequency is 88.8 dB(A) and 84.3 dB(A) for Aluminium and Brass.
- The sound pressure level at 1000 Hz is 82.2 dB(A) and 90.9 dB(A) for Mild Steel and Stainless steel.
- The sound pressure level increased from frequency 31.5 Hz to 1000 Hz and then decreases up to 8000 Hz frequency for Aluminium, Brass, Mild steel and Stainless steel.

4) Taguchi analysis:

- On the basis of Taguchi analysis, the most significant parameter on noise is speed.

7.2 Scope for future work

The presented work can be extended by working upon different. Some of them are listed below:

- A proper lathe machine can be designed, so that the minimal noise will generate under different operating parameters.
- It is concluded from results that the maximum sound pressure level is at frequency of 1000 Hz. By using an intensity probe, parts will be found where the maximum sound pressure level occurs at particular frequency.
- With the help of this analysis, it can be extended for other materials.
- To reduce more noise, foundation of a lathe will be designed properly.

REFERENCES

1. **R.A. Collacott**, “*The identification of the source of machine noises contained within a multiple-source environment*”, Applied Acoustics, Volume 9, Pages 225-238, Issue 3, July 1976.
2. **E.J. Richards, M.E. Westcott, R.K. Jeyapalan**, “*Reverberation effects of the enclosure*”, Journal of Sound and Vibration, Volume 62, Pages 547-575, Issue 4, 22 February 1978, Institute of Sound and Vibration Research, University of Southampton, Southampton SO9 5NH, England.
3. **Erkki Jantunen**, “*A summary of methods applied to tool condition monitoring in drilling*”, International Journal of Machine Tools and Manufacture, Volume 42, Pages 997-1010, Issue 9, July 1979.
4. **WimDesmet, Paul Sas, ReeneBoonon and Greg Pinte**, Noise and Vibration Research Group –“Reduction of transient noise emission on machine tools”, Katholieke University, Leuven, *Volume 62, Pages 547-575, Issue 4, 22 February 1979.*
5. **Kurasawahideo, Hanedayoshiaki and Miyaoyoshikazu**, “Measurement and Evaluation of Noise for Machine Tool” in Nagano-Kosen Technology Education Center, *Volume 68, Pages 547-5, Issue 4, 22 February 1983.*
6. **Higginson and R.F.**, “*Measurement of sound power using the acoustic intensity method*”, Applied acoustics, Vol. 50(2), pp. 111-123 (1986).
7. **KarthikeyanSampath, Shiv G. Kapoor and Richard E. Devor**, “*Maximum Noise levels in industrial noise Noise*”, Journal of Sound and Vibration, vol. 127 (3), pp 583-587 (1988).
8. **Desmons L. and Kergomard J.**, “*Reducing combustion noise*”, Applied acoustics Vol. 58(2), pp. 89-140, June (1991).
9. **Lars Håkansson, Sven Johansson, Ingvar Claesson**, “*Simple analysis of machine tool noise produced in workshop environment*” Applied acoustics, Vol. 41, pp. 127-155 (1994).

10. **Astrup Torben**, “*Determination of the acoustical source characteristics of an machine tool noise by using several operating conditions*”, Journal of Sound and Vibration, Vol. 179(5), pp. 869-878(1995).
11. **Cutler-Hammer**, “Electrical Noise in Machine Tool Controls”, Applied Acoustics, vol. 21 (2), pp 139-146 (1997).
12. **P.E. Gyax**, “*Accuracy of calculation of industrial noise*”, Applied Acoustics, vol. 25, pp 144-150 (1997).
13. **M.F. White and R.G. White**, “*Noise reduction in machine tools*”, MME-419, April (2002).
14. **Kaminski T. and Wendeker M.**, “*Idle Noise Reduction of Light, Medium and machines*”, THIESEL Conference on Machine tools (2002).
15. **S. Devos, B. Stallaert, G. Pinte, W. Symens, P. Sas, and J. Swevers**, “*A GIS based road industrial Noise prediction model*”, Applied Acoustics, vol. 63, pp 679–691 (2004).
16. **E. Buckwar, R. Kuske, B. L. Esperance, and T. Soo**, “*Machine tool start noise improvement*”, In: SAE 01-2490 (2004).
17. **Matti Rantatalo1, Kouros Tatar and Peter Norman**, “*A simple model to estimate the impact noise induced by machine tool*”, Journal of Sound and vibration, Vol. 255(2), pp. 229-242 (2005).
18. **Jonasson, H.G.**, “*Noise prediction for industry in Thailand*”, Industrial Research Part D vol. 7 pp 441-449 (2007).
19. **Pichai Pamanikabud, Prakob Vivitjinda**, “*Sampling techniques for the estimation of the annual equivalent Noise level under industrial conditions*”, Applied Acoustics, vol. 64, pp 43–53 (2007).
20. **C. H. Oppenheimer and S. Dubowsky**, “*A methodology for predicting impact-induced acoustic noise in machine systems*”, department of mechanical engineering, Massachusetts institute of technology, Cambridge, USA (2008).
21. **J. S. Sexton, R. D. Milne and B. J. Stone J. S.**, “*A stability analysis of single point machining with varying spindle speed*”, Appl. Math. Modeling 1, 310–318 (2008).

BOOKS:

22. **Tempest W**, “Noise handbook”, Academic Press New York, Second edition (1988).
23. **White R.G. and Walker J.G.**, “*Handbook on Noise and Vibration*”, EllisHorwood New York, Third edition, (1991).
24. **Shastri Satish Trivedi and Manjoo Bala**, “*Handbook on Noise pollution: it’s Scientific and legal Perspective*”, Divyajyoti Prakashan Jodhpur, Second edition, (1994).
25. **Cyril M. Harris**, “*Handbook of Acoustical measurements and Noise Control*”, Mc-Graw Hills (1991).
26. **Martín Tanco, Elisabeth Viles and Lourdes Pozueta.**, “*Comparing Different Approaches for Design of Experiments (DoE)*”, Department of Industrial Management Engineering at TECNUN (University of Navarra), Paseo Manuel Lardizabal 13, San Sebastian, 20018, Spain (2009).

TRAINING PROGRAMME:

27. **Nigam S.P.**, “*Introduction to Noise*”, Noise control programme, Thapar University, Patiala, (2008).

APPENDIX

APPENDIX – A

Table 1

Values of Sound pressure level (Lp) in dB(A) and Acoustic power (Lw) in dB(A) (ref. 10-12 W) for Aluminium

Exp. no.	D.O.C	Feed	Speed	Grid points																	Avg. (Lp)	Lw
				(mm)	(mm/rev.)	(rpm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
1	1	0.089	54	71.7	74.2	72.6	74.1	72	71.9	72.5	74.8	76.5	73.6	75.3	73.6	76	73.4	72.6	71.4	77.1	73.7	82.7
2	1	0.111	135	72.2	73.1	72.6	74.2	71.8	72.4	72.4	74.1	76.4	73.6	75.2	73.9	75.3	73.8	73	71.5	76	73.6	82.6
3	1	0.133	500	75.3	76.8	74.9	76.6	74.7	75.2	74.8	76.6	78.7	75.7	77.8	76.6	78.4	76.2	76.6	73.9	78.7	76.3	85.3
4	1	0.166	1200	72.6	71.3	71.9	72.3	72.4	72.7	71.7	75.9	77.6	77.7	78.8	78.4	79.6	76.5	75.6	76.8	80.8	75.4	84.4
5	2	0.089	135	72	75.1	72.5	74.6	72	72	72.7	74.6	77	74	76.3	73.7	76.5	73.2	73.8	71.2	77.2	74	83
6	2	0.111	54	72.3	74.5	72.7	74.7	73	72	73.2	74.1	76.6	73.7	75.3	73.6	76	72.9	72.7	71.8	76.9	73.9	82.9
7	2	0.133	1200	81.3	75.2	74.5	75	76.2	76.8	72.7	75.8	81.2	78.1	78.8	80.4	82.6	79.2	79.3	78.4	82.6	78.1	87.1
8	2	0.166	500	75.2	76.2	75.8	76.9	74.5	74.7	75.4	77	79.8	77	78	76.9	79	76	76	74.7	79.5	76.6	85.6
9	3	0.089	500	75	76.9	76.1	83.9	80.1	78.5	80.9	85	88.8	79.4	78.8	77.8	79.6	76	75.3	74.1	79.2	79.1	88.1
10	3	0.111	1200	76.2	74.2	76.4	78.6	74.7	76.4	74	78.9	83.9	80.6	82	80.6	82.9	81.1	79.7	78.6	84.2	79	88
11	3	0.133	54	72.1	74.5	72.5	74.9	72	71.9	71.4	74.2	77.1	73.5	75.1	73.6	75.5	73.3	73.2	72.7	76.6	73.8	82.8
12	3	0.166	135	72.7	74.6	73	74.8	72.3	72.2	72.2	74.1	77.4	74.3	76.8	73.9	76.3	73.9	72.2	72.8	76.8	74.1	83.1
13	4	0.089	1200	79.5	76.4	72.6	77.1	73.8	73.8	75.8	78.7	82	82.5	82	82.9	84.3	81.1	81.3	74.1	84.7	79	88
14	4	0.111	500	74.9	76.6	75.9	77.3	74.5	74.2	76.7	77.7	79.7	76.5	78	76.5	78.3	76.4	76.1	74.3	79.4	76.6	85.6
15	4	0.133	135	72.7	75.7	74	75.3	72.9	72.2	72.6	74.6	77.2	74.8	74.9	74.6	77.4	74.3	74	72.6	77.2	74.5	83.5
16	4	0.166	54	72.8	74.7	73.1	75.1	72.4	71.6	72.6	74.3	76.5	73.3	76	74.3	76.3	73.9	74.1	72.7	76.5	74.1	83.1

Table 2

Values of Sound pressure level (Lp) in dB(A) and Acoustic power (Lw) in dB(A) (ref. 10-12 W) for Brass

Exp. no.	D.O.C	Feed	Speed	Grid Points																	Avg. (Lp)	Lw
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
1	1	0.089	54	73.3	76.7	75.4	75.3	73.9	74.5	73.5	75.2	81	74.4	76.7	75.8	77.6	74.6	73.6	73.3	77	75.4	84.4
2	1	0.111	135	81.3	82.1	78.8	79.8	77	77.3	76.3	80.8	86.8	76.3	77.6	77.3	79.2	76.4	75	74.5	78	78.5	87.5
3	1	0.133	500	77.4	77.6	76.5	78.4	76	76	75.4	78.2	83.2	76.9	77.5	77.7	79.2	76.9	76.2	74.9	79.6	77.5	86.5
4	1	0.166	1200	81.1	81.1	80.6	82.7	79.7	80.1	79.1	82.4	85.9	82	82.3	81.8	82.2	79.8	78.3	78.4	82.1	81.2	90.2
5	2	0.089	135	74.1	74.8	75	75.9	73.5	74.5	73.7	75.9	79.7	74.6	77.9	73	77.9	74.2	74.8	73.3	77.7	75.3	84.3
6	2	0.111	54	74.5	74.9	73.9	75.2	72.7	73.3	73.5	74.7	78	73.8	77.6	75.4	77.3	73.8	74.6	72.8	77.3	74.9	83.9
7	2	0.133	1200	82.2	81.2	80.7	82.9	79.5	80.1	79.8	83.3	87.6	81.8	83	82.5	84.2	81.2	80.6	79.9	84.3	82	91
8	2	0.166	500	78.5	78.4	78.2	81.6	79.1	79.8	79	80.1	86.5	78.1	79.8	78.7	80.3	77.6	77.7	79.8	81.6	79.7	88.7
9	3	0.089	500	78.9	79.6	78	82.7	77.7	78.3	78.5	81.7	87.2	78.9	81.1	80	80.6	78.1	78.3	78.4	82.1	80	89
10	3	0.111	1200	84.3	83.4	84.3	85.3	81.2	82.6	81.9	86.2	94.6	84.3	85.2	83.8	86.4	84.7	83.1	84.1	84.6	84.7	93.7
11	3	0.133	54	75	75.4	74.2	76.3	74.1	74.2	74.4	75.5	80.2	74.7	77.7	76.7	77.9	74	74.8	73.5	77.5	75.7	84.7
12	3	0.166	135	76.4	77.4	75.5	77.6	73.5	75.2	75	76.8	81.2	75.9	78	75.8	79.6	75.4	75.8	74.8	78.1	76.6	85.6
13	4	0.089	1200	81.7	82.8	81.9	84.2	79.5	80	79.8	84.3	86.2	81.2	82.9	82.9	84.1	80.8	81.4	79.8	85.5	82.3	91.3
14	4	0.111	500	82.5	80.1	80.4	85.7	80.8	80.2	79.3	81.1	90.4	81.5	82.3	81.6	84.9	81.2	82.3	79.8	86.6	82.4	91.4
15	4	0.133	135	79.2	78.6	78.9	80.8	77.7	78.1	77.8	79.8	85.6	79.4	81.8	79.4	81.1	78.8	78.5	76.7	81	79.6	88.6
16	4	0.166	54	74.8	76.5	74.7	76.1	74.1	74.2	74.7	76.1	82.7	75.7	77.9	76.7	78.3	75	75	73.9	76.9	76.1	85.1

Table 3**Values of Sound pressure level (Lp) in dB(A) and Acoustic power (Lw) in dB(A) (ref. 10-12 W) for Mild steel**

Exp. no.	D.O.C	Feed	Speed	Grid Points																	Avg. (Lp)	Lw
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	dB(A)	dB(A)
1	0.5	0.089	54	73.9	75.7	73.7	74.9	72.8	72.6	72.2	73.5	77.3	72.8	77.4	74.8	77.6	73.5	73.2	72.3	75.2	74.3	83.3
2	0.5	0.095	135	73.9	76.2	73.7	74.9	72.4	72.7	72.3	73.4	78.2	72	77.6	75.3	78	73.8	72.9	72.5	75.2	74.4	83.4
3	0.5	0.102	325	75.6	77.2	75.8	78.3	76	75.1	74.6	75.9	80.2	75	78.8	77.6	80.2	75.2	78	74.4	77	76.8	85.8
4	0.5	0.111	770	82.7	81.8	79.2	84.1	83.1	85.8	81.3	82.3	85.9	80.9	83.5	82.5	82.3	80.2	78.8	80.6	83.4	82.3	91.3
5	1	0.089	135	74.7	75	73.8	74.6	75.1	73.1	72.9	73.7	77.8	73.9	77.1	75.1	78	73.1	73.4	73.1	75.6	74.7	83.7
6	1	0.095	54	73.7	74.3	73	74.4	72.6	71.7	72.6	74.5	76.9	72.8	77.9	74.6	77.8	73.3	73.1	72.4	74.8	74.1	83.1
7	1	0.102	770	79.6	82.6	83.5	85.5	82.1	82.8	80.8	82.5	88.1	81.4	84.9	81.2	84	80.5	81.2	79.9	82.6	82.5	91.5
8	1	0.111	325	74.5	75.6	74.7	75.9	74.3	74.9	73.2	74.3	79.3	74.3	79.2	76.9	79.2	74.8	75.2	73.9	76.6	75.7	84.7
9	1.5	0.089	325	73.6	74.9	74.6	75.3	72.6	72.9	73.6	74.9	78.2	74.2	76.9	76.2	77.2	74.5	73.2	72.9	76	74.8	83.8
10	1.5	0.095	770	78.7	79.4	78.6	80.1	77.2	77.5	76.9	78.9	82.2	77.5	81.4	79.5	81.2	78	77.9	77.5	79.7	79	88
11	1.5	0.102	54	73.2	74.4	73.2	74.1	72.6	71.7	72.4	74	77.2	73.3	76.2	74.8	77.5	73.3	72.7	72.1	74.8	74	83
12	1.5	0.111	135	73.4	75	73.5	74.5	72.8	72.1	73.1	73.5	77.1	73.5	76	75.3	77.7	72.8	72.8	72.3	75.2	74.2	83.2
13	2	0.089	770	79.2	79.7	78.3	80	77.5	80	78.3	79	82.7	79.5	84.1	80.5	81.4	79.1	78.2	77.7	79.2	79.7	88.7
14	2	0.095	325	73.7	75.1	74.5	75.5	74.1	73.7	73	75	78.6	73.9	76.9	76	77.7	73.5	73.6	73.4	75.4	74.9	83.9
15	2	0.102	135	73.4	75	73.6	74.8	72.6	72.9	72.9	74	78.1	73.1	76.2	75.5	78	72.6	72.3	72.7	75.2	74.3	83.3
16	2	0.111	54	73.3	74.4	73.3	74.2	72.6	72.1	73	73.8	76.4	73.3	76.3	74.5	76.7	72.5	72.2	72.1	74.8	73.9	82.9

Table 4**Values of Sound pressure level (Lp) in dB(A) and Acoustic power (Lw) in dB(A) (ref. 10-12 W) for Stainless steel**

Exp. no.	D.O.C	Feed	Speed	Grid Points																	Avg. (Lp)	Lw
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	dB(A)	dB(A)
1	0.5	0.089	54	72.8	74.1	73.6	73.6	72.2	71.8	72.2	73.1	76.8	73.1	74.9	75.1	77.2	72.8	72.1	71.2	74.8	73.6	82.6
2	0.5	0.095	135	73.1	76.9	72.4	74.3	72.7	72.2	72.3	73.7	77.1	72.9	76.9	75.5	76.9	73.2	72.7	72.2	74.6	74.1	83.1
3	0.5	0.102	325	73.2	74.4	73.5	74.9	72.4	73	73	75.1	78.3	73.2	76.7	75.7	77.7	72.7	72.9	72.7	75	74.4	83.4
4	0.5	0.111	770	77.8	78.1	77.7	79.3	76.7	77	76.7	78.7	83.9	77.1	80.5	79.5	81.3	77.6	78.3	78.3	79.5	78.7	87.7
5	1	0.089	135	74.5	77.5	76.8	76.4	75.2	74.1	74.9	75.8	80.7	74.6	77.3	77	80.6	77.8	76	74.4	79.4	76.6	85.6
6	1	0.095	54	73.1	74.7	72.6	74.1	72.7	72.6	74.5	76.2	77.8	73.9	77.9	75.9	78.4	73.7	74.1	73.6	76	74.8	83.8
7	1	0.102	770	81.9	81.3	79.9	85	79.1	78.2	79.6	81.3	87.6	78.1	82.9	79.6	81.2	77	79.8	82.5	82.9	81.1	90.1
8	1	0.111	325	75.8	77.3	76.5	77.7	75.3	75.6	76.5	77.9	81.4	75.6	80.2	78.1	80.9	75.8	77.9	76.7	81	77.7	86.7
9	1.5	0.089	325	78.4	78.9	80	80.5	78.5	79.8	79.8	82.3	85.1	79.8	81.8	83.6	86.9	79.7	80.8	79.9	86.3	81.3	90.3
10	1.5	0.095	770	83.2	86.9	84.3	82.8	83	86.2	83.2	85.5	88.2	79.1	79.6	80.1	80.3	77.5	76.3	78.5	80	82	91
11	1.5	0.102	54	74	76.9	75	76.3	74	74.6	75	75.5	80.4	74.7	78.5	76.8	78.1	75.2	74.7	75.3	77	76	85
12	1.5	0.111	135	75.1	77.6	75.9	77.6	74.1	76	74.7	76.1	80.3	75.2	77.7	76.2	80.9	76.9	75.9	75.1	78.8	76.7	85.7
13	2	0.089	770	78.4	79.6	78.5	78	77	76.8	76.4	77	81.3	78.9	79.3	79.7	79.9	77.4	76.2	75.8	77.9	78.1	87.1
14	2	0.095	325	78.4	81	80.7	79.6	79.2	78.5	76.3	82.1	85	79.3	81.5	80.2	84.8	79.8	81.2	76.3	83.9	80.5	89.5
15	2	0.102	135	78.7	80.5	79.1	80.4	77.8	78.5	78.4	80.5	84.6	79	81.8	80.8	81.8	77.7	79	78.9	78.6	79.8	88.8
16	2	0.111	54	77.7	81.6	79.9	80.6	77.4	79.2	79	80.6	85.2	78.7	82.1	81.3	82.7	78.4	79.1	79	80.8	80.2	89.2

APPENDIX – B

Table 1

Values of Sound pressure level (Lp) in dB(A) for Aluminium

For constant depth of cut

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs. 1	Obs. 2	Avg.	Obs. 1	Obs. 2	Avg.	Obs. 1	Obs. 2	Avg.	Obs. 1	Obs. 2	Avg.	Obs. 1	Obs. 2	Avg.
1	1	0.089	54	76.9	76.1	76.5	76.2	76.3	76.3	76.9	77.1	77	75.8	74	74.9	76	76	76
2	1	0.111	135	75.8	76.5	76.2	76.2	76.6	76.4	77	78	77.5	73.8	73.4	73.6	75.3	75.8	75.6
3	1	0.133	500	78.3	77.7	78	78.7	77.9	78.3	80	80.1	80.1	76.2	76.1	76.2	79.2	79	79.1
4	1	0.166	1200	82.4	76.9	79.7	79.6	79.3	79.5	79.7	81.1	80.4	78.5	80.6	79.6	82.3	85.1	83.7
5	2	0.089	135	76.3	76.2	76.3	75.5	75.7	75.6	77	76.8	76.9	72.6	73.1	72.9	76.1	76.3	76.2
6	2	0.111	54	74.2	73.7	74	74.8	74.9	74.9	76.6	76.3	76.5	72.3	72.6	72.5	76.1	75.7	75.9
7	2	0.133	1200	78.8	78.1	78.5	75.3	79.8	77.6	76.3	80.3	78.3	74	77.2	75.6	77.2	81.1	79.2
8	2	0.166	500	78.5	78.4	78.5	78.1	77.6	77.9	80	79.5	79.8	73.2	75.3	74.3	78.3	78.3	78.3
9	3	0.089	500	79.1	78.5	78.8	77.8	78.3	78.1	79.3	79.6	79.5	75.6	75.4	75.5	78.8	78.5	78.7
10	3	0.111	1200	75.1	79.5	77.3	72.9	78.3	75.6	79.1	79.1	79.1	80.6	79.9	80.3	84.2	84.3	84.3
11	3	0.133	54	75.5	75.5	75.5	75.2	75	75.1	77.3	77.2	77.3	72.3	73.1	72.7	75.9	75.3	75.6
12	3	0.166	135	76.2	76	76.1	75.3	75.3	75.3	77.1	77.7	77.4	73.2	72.9	73.1	76	75.6	75.8
13	4	0.089	1200	83.6	83.2	83.4	82.6	82.9	82.8	84	83.8	83.9	80.1	80.1	80.1	84.6	84.6	84.6
14	4	0.111	500	78.6	78.4	78.5	76.6	77.7	77.2	79.5	79.4	79.5	75.3	75.4	75.4	78.3	78.1	78.2
15	4	0.133	135	76.2	75.6	75.9	75.8	74.6	75.2	77.2	77.7	77.5	73.7	73.1	73.4	76	77	76.5
16	4	0.166	54	76	76.3	76.2	75.2	75.4	75.3	77.8	77.2	77.5	73.6	73	73.3	76.2	76.3	76.3

Table 2**Values of Sound pressure level (Lp) in dB(A) for Brass****For constant depth of cut**

Exp. no.	D.O.C	Feed	Speed	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	1	0.089	54	77.3	77.3	77.3	76.2	76.3	76.3	77.9	77.9	77.9	73.1	73.3	73.2	77.8	76.3	77.1
2	1	0.111	135	79.1	78.1	78.6	77.9	76.5	77.2	77.3	78	77.7	74.9	74.3	74.6	78.8	78.8	78.8
3	1	0.133	500	80.1	79.4	79.8	79.3	78.8	79.1	80	80.6	80.3	76.9	76.2	76.6	82	81.4	81.7
4	1	0.166	1200	84.6	80.5	82.6	83.4	78.2	80.8	85.7	82.7	84.2	80.9	82.3	81.6	88.2	90.7	89.5
5	2	0.089	135	77.8	77.2	77.5	78.4	76	77.2	77.8	78.3	78.1	74.2	74.1	74.2	78.2	79.7	79.0
6	2	0.111	54	76.9	77.4	77.2	75.8	76	75.9	77.3	77.5	77.4	74.1	73.6	73.9	76	77.1	76.6
7	2	0.133	1200	86.8	82.3	84.6	83	80.4	81.7	85.3	84.9	85.1	81.3	80.3	80.8	89.4	85.6	87.5
8	2	0.166	500	81.5	82.9	82.2	82.3	79.7	81	81.6	81.5	81.6	77.9	77.8	77.9	82.6	83.4	83
9	3	0.089	500	81.3	81	81.2	80.2	79	79.6	81.6	80.4	81	76.7	77	76.9	82.3	81.6	82.0
10	3	0.111	1200	84.4	82.4	83.4	81.7	81.9	81.8	85	85.2	85.1	81.5	81.7	81.6	85.2	88.6	86.9
11	3	0.133	54	76.3	76.7	76.5	76.1	76.3	76.2	77.1	77.8	77.5	73.8	74.3	74.1	76.2	78	77.1
12	3	0.166	135	78.8	79	78.9	77.1	78	77.6	78.4	79.1	78.8	76	75.9	76.0	78.7	82.6	80.7
13	4	0.089	1200	85	86.2	85.6	83.7	84.5	84.1	84.4	85.4	84.9	80.9	81.9	81.4	90.6	88.6	89.6
14	4	0.111	500	80.5	82.5	81.5	79.5	79.3	79.4	80.8	80.7	80.8	78.2	78.3	78.3	83.3	85.7	84.5
15	4	0.133	135	77.5	79.4	78.5	76.7	77.4	77.1	78.4	78.6	78.5	74.8	75	74.9	77.4	79.7	78.6
16	4	0.166	54	76.7	78.1	77.4	76.8	78.2	77.5	76.6	79.1	77.9	74.1	75	74.6	77.9	75	76.5

Table 3**Values of Sound pressure level (Lp) in dB(A) for Mild steel****For constant depth of cut**

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.5	0.089	54	76.3	76.8	76.6	76.7	76.3	76.5	76.1	75.6	75.9	72.1	73	72.6	76.6	76.7	76.7
2	0.5	0.095	135	76.3	76.9	76.6	76.2	76.6	76.4	76	76.5	76.3	73.1	73.5	73.3	77.5	77.4	77.5
3	0.5	0.102	325	76.6	77.5	77.1	77.4	76.9	77.2	76.1	76.5	76.3	73.4	73.3	73.4	78.5	78.3	78.4
4	0.5	0.111	770	79.7	80.5	80.1	80.4	80.2	80.3	80.5	80.9	80.7	77.7	77.5	77.6	82.8	83.3	83.1
5	1	0.089	135	75.8	76.2	76	77.1	77.2	77.2	76.2	76.2	76.2	73.3	73.7	73.5	79	79	79
6	1	0.095	54	76.5	76.4	76.5	76.6	76	76.3	76.7	77.4	77.1	73.1	72.9	73	79.7	78.9	79.3
7	1	0.102	770	81.6	82.3	82.0	82.3	81.6	82.0	88.2	85.8	87	79	80.4	79.7	88.2	88.3	88.3
8	1	0.111	325	77.1	76.2	76.7	77.2	77.4	77.3	77.2	77.5	77.4	74.3	74.1	74.2	79.2	79.4	79.3
9	1.5	0.089	325	77.1	76.6	76.9	77.9	78.1	78	77.4	78.8	78.1	74.5	74.1	74.3	80.4	80.5	80.5
10	1.5	0.095	770	80.9	81	81.0	81.5	81.2	81.4	82.1	82.2	82.2	79.5	78.5	79	84.2	84.8	84.5
11	1.5	0.102	54	75.8	75.8	75.8	76.9	77.4	77.2	76.7	77	76.9	73.4	73.8	73.6	79	78.7	78.9
12	1.5	0.111	135	75.9	76.2	76.1	77.1	76.8	77.0	76.5	76.4	76.5	73.2	73	73.1	78.7	78.8	78.8
13	2	0.089	770	79.8	79.8	79.8	80	80.1	80.1	79.7	80.3	80	77.3	77.5	77.4	83.4	82.9	83.2
14	2	0.095	325	76.8	76.9	76.9	77.4	77.9	77.7	77.6	77.6	77.6	74.7	74.7	74.7	81.2	79.8	80.5
15	2	0.102	135	75.7	76.5	76.1	76.6	77	76.8	76.6	76.2	76.4	73.4	72.9	73.2	79.8	79	79.4
16	2	0.111	54	77.7	76.9	77.3	77.7	77.8	77.8	76.8	76.6	76.7	73	73.5	73.3	78.1	77.7	77.9

Table 4**Values of Sound pressure level (L_p) in dB(A) for Stainless steel****For constant depth of cut**

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.5	0.089	54	76.2	77.4	76.8	76.5	76	76.3	76.1	75.9	76	72.3	72.2	72.3	78.7	78.5	78.6
2	0.5	0.095	135	76.1	76.7	76.4	76.1	77.1	76.6	76.1	76.4	76.3	72.5	72.9	72.7	78.6	78.3	78.5
3	0.5	0.102	325	76.2	76.3	76.3	77.4	77	77.2	76.5	76.8	76.7	73.6	72.9	73.3	78.9	79	79
4	0.5	0.111	770	79.6	80	79.8	80.3	80.4	80.4	80.4	80.4	80.4	77.2	77.1	77.2	82.5	84.6	83.6
5	1	0.089	135	77.5	78.1	77.8	77.1	77.5	77.3	77.1	76.6	76.9	74.7	74.9	74.8	80.2	80.8	80.5
6	1	0.095	54	75.5	76.1	75.8	76.9	76.3	76.6	76.1	75.8	76	72.9	72.6	72.8	78.9	79.2	79.1
7	1	0.102	770	80.1	85.7	82.9	83.9	80.1	82	80.2	80.4	80.3	77.6	77.9	77.8	82.6	83.6	83.1
8	1	0.111	325	77	77.5	77.3	77.3	77.4	77.4	76.5	76.8	76.7	72.9	73.2	73.1	78.5	79.1	78.8
9	1.5	0.089	325	81.8	81.2	81.5	83.5	83.8	83.7	81	82.1	81.6	81	80.2	80.6	84	84.2	84.1
10	1.5	0.095	770	84.4	82	83.2	89.5	81.6	85.6	83.8	86.2	85	84.7	87.8	86.3	87.6	84.6	86.1
11	1.5	0.102	54	76.3	75.1	75.7	76.4	76.2	76.3	75.3	74.4	74.9	72.6	71.9	72.3	77.1	77.7	77.4
12	1.5	0.111	135	77	76.7	76.9	77.5	76.7	77.1	76.4	79.9	78.2	75.7	74.6	75.2	78.8	79.3	79.1
13	2	0.089	770	79.2	84.8	82	80.1	80.7	80.4	80	80.7	80.4	77.3	77.5	77.4	82.8	82.8	82.8
14	2	0.095	325	81	78.5	79.8	79	78.7	78.9	77.7	81.6	79.7	73.6	73.7	73.7	84.4	77.7	81.1
15	2	0.102	135	76.4	76.2	76.3	77.3	76.1	76.7	76.6	77.3	77.0	73.8	73.1	73.5	79.4	79.3	79.4
16	2	0.111	54	76.7	77.1	76.9	76.1	76.9	76.5	74.1	74.3	74.2	72.2	72.9	72.6	78.8	77.9	78.4

Table 5**Values of Sound pressure level (Lp) in dB(A) for Aluminium****For constant feed**

Exp. no.	Feed (mm/rev.)	D.O.C (mm)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.089	1	54	76.9	76.1	76.5	76.2	76.3	76.3	76.9	77.1	77	75.8	74	74.9	76	76	76
2	0.089	2	135	76.3	76.2	76.3	75.5	75.7	75.6	77	76.8	76.9	72.6	73.1	72.9	76.1	76.3	76.2
3	0.089	3	500	79.1	78.5	78.8	77.8	78.3	78.1	79.3	79.6	79.5	75.6	75.4	75.5	78.8	78.5	78.7
4	0.089	4	1200	83.6	83.2	83.4	82.6	82.9	82.8	84	83.8	83.9	80.1	80.1	80.1	84.6	84.6	84.6
5	0.111	1	135	75.8	76.5	76.2	76.2	76.6	76.4	77	78	77.5	73.8	73.4	73.6	75.3	75.8	75.6
6	0.111	2	54	74.2	73.7	74.0	74.8	74.9	74.9	76.6	76.3	76.5	72.3	72.6	72.5	76.1	75.7	75.9
7	0.111	3	1200	75.1	79.5	77.3	72.9	78.3	75.6	79.1	79.1	79.1	80.6	79.9	80.3	84.2	84.3	84.3
8	0.111	4	500	78.6	78.4	78.5	76.6	77.7	77.2	79.5	79.4	79.5	75.3	75.4	75.4	78.3	78.1	78.2
9	0.133	1	500	78.3	77.7	78	78.7	77.9	78.3	80	80.1	80.1	76.2	76.1	76.2	79.2	79	79.1
10	0.133	2	1200	78.8	78.1	78.5	75.3	79.8	77.6	76.3	80.3	78.3	74	77.2	75.6	77.2	81.1	79.2
11	0.133	3	54	75.5	75.5	75.5	75.2	75	75.1	77.3	77.2	77.3	72.3	73.1	72.7	75.9	75.3	75.6
12	0.133	4	135	76.2	75.6	75.9	75.8	74.6	75.2	77.2	77.7	77.5	73.7	73.1	73.4	76	77	76.5
13	0.166	1	1200	82.4	76.9	79.7	79.6	79.3	79.5	79.7	81.1	80.4	78.5	80.6	79.6	82.3	85.1	83.7
14	0.166	2	500	78.5	78.4	78.5	78.1	77.6	77.9	80	79.5	79.8	73.2	75.3	74.3	78.3	78.3	78.3
15	0.166	3	135	76.2	76	76.1	75.3	75.3	75.3	77.1	77.7	77.4	73.2	72.9	73.1	76	75.6	75.8
16	0.166	4	54	76	76.3	76.2	75.2	75.4	75.3	77.8	77.2	77.5	73.6	73	73.3	76.2	76.3	76.3

Table 6**Values of Sound pressure level (Lp) in dB(A) for Brass****For constant feed**

Exp. no.	Feed (mm/rev.)	D.O.C (mm)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.089	1	54	77.3	77.3	77.3	76.2	76.3	76.3	77.9	77.9	77.9	73.1	73.3	73.2	77.8	76.3	77.1
2	0.089	2	135	77.8	77.2	77.5	78.4	76	77.2	77.8	78.3	78.1	74.2	74.1	74.2	78.2	79.7	79
3	0.089	3	500	81.3	81	81.2	80.2	79	79.6	81.6	80.4	81	76.7	77	76.9	82.3	81.6	82
4	0.089	4	1200	85	86.2	85.6	83.7	84.5	84.1	84.4	85.4	84.9	80.9	81.9	81.4	90.6	88.6	89.6
5	0.111	1	135	79.1	78.1	78.6	77.9	76.5	77.2	77.3	78	77.7	74.9	74.3	74.6	78.8	78.8	78.8
6	0.111	2	54	76.9	77.4	77.2	75.8	76	75.9	77.3	77.5	77.4	74.1	73.6	73.9	76	77.1	76.6
7	0.111	3	1200	84.4	82.4	83.4	81.7	81.9	81.8	85	85.2	85.1	81.5	81.7	81.6	85.2	88.6	86.9
8	0.111	4	500	80.5	82.5	81.5	79.5	79.3	79.4	80.8	80.7	80.8	78.2	78.3	78.3	83.3	85.7	84.5
9	0.133	1	500	80.1	79.4	79.8	79.3	78.8	79.1	80	80.6	80.3	76.9	76.2	76.6	82	81.4	81.7
10	0.133	2	1200	86.8	82.3	84.6	83	80.4	81.7	85.3	84.9	85.1	81.3	80.3	80.8	89.4	85.6	87.5
11	0.133	3	54	76.3	76.7	76.5	76.1	76.3	76.2	77.1	77.8	77.5	73.8	74.3	74.1	76.2	78	77.1
12	0.133	4	135	77.5	79.4	78.5	76.7	77.4	77.1	78.4	78.6	78.5	74.8	75	74.9	77.4	79.7	78.6
13	0.166	1	1200	84.6	80.5	82.6	83.4	78.2	80.8	85.7	82.7	84.2	80.9	82.3	81.6	88.2	90.7	89.5
14	0.166	2	500	81.5	82.9	82.2	82.3	79.7	81	81.6	81.5	81.6	77.9	77.8	77.9	82.6	83.4	83
15	0.166	3	135	78.8	79	78.9	77.1	78	77.6	78.4	79.1	78.8	76	75.9	76	78.7	82.6	80.7
16	0.166	4	54	76.7	78.1	77.4	76.8	78.2	77.5	76.6	79.1	77.9	74.1	75	74.6	77.9	75	76.5

Table 7**Values of Sound pressure level (Lp) in dB(A) for Mild steel****For constant feed**

Exp. no.	Feed (mm/rev.)	D.O.C (mm)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.089	0.5	54	76.3	76.8	76.6	76.7	76.3	76.5	76.1	75.6	75.9	72.1	73	72.6	76.6	76.7	76.7
2	0.089	1	135	75.8	76.2	76	77.1	77.2	77.2	76.2	76.2	76.2	73.3	73.7	73.5	79	79	79
3	0.089	1.5	325	77.1	76.6	76.9	77.9	78.1	78	77.4	78.8	78.1	74.5	74.1	74.3	80.4	80.5	80.5
4	0.089	2	770	79.8	79.8	79.8	80	80.1	80.1	79.7	80.3	80	77.3	77.5	77.4	83.4	82.9	83.2
5	0.095	0.5	135	76.3	76.9	76.6	76.2	76.6	76.4	76	76.5	76.3	73.1	73.5	73.3	77.5	77.4	77.5
6	0.095	1	54	76.5	76.4	76.5	76.6	76	76.3	76.7	77.4	77.1	73.1	72.9	73	79.7	78.9	79.3
7	0.095	1.5	770	80.9	81	81	81.5	81.2	81.4	82.1	82.2	82.2	79.5	78.5	79	84.2	84.8	84.5
8	0.095	2	325	76.8	76.9	76.9	77.4	77.9	77.7	77.6	77.6	77.6	74.7	74.7	74.7	81.2	79.8	80.5
9	0.102	0.5	325	76.6	77.5	77.1	77.4	76.9	77.2	76.1	76.5	76.3	73.4	73.3	73.4	78.5	78.3	78.4
10	0.102	1	770	81.6	82.3	82	82.3	81.6	82	88.2	85.8	87	79	80.4	79.7	88.2	88.3	88.3
11	0.102	1.5	54	75.8	75.8	75.8	76.9	77.4	77.2	76.7	77	76.9	73.4	73.8	73.6	79	78.7	78.9
12	0.102	2	135	75.7	76.5	76.1	76.6	77	76.8	76.6	76.2	76.4	73.4	72.9	73.2	79.8	79	79.4
13	0.111	0.5	770	79.7	80.5	80.1	80.4	80.2	80.3	80.5	80.9	80.7	77.7	77.5	77.6	82.8	83.3	83.1
14	0.111	1	325	77.1	76.2	76.7	77.2	77.4	77.3	77.2	77.5	77.4	74.3	74.1	74.2	79.2	79.4	79.3
15	0.111	1.5	135	75.9	76.2	76.1	77.1	76.8	77	76.5	76.4	76.5	73.2	73	73.1	78.7	78.8	78.8
16	0.111	2	54	77.7	76.9	77.3	77.7	77.8	77.8	76.8	76.6	76.7	73	73.5	73.3	78.1	77.7	77.9

Table 8**Values of Sound pressure level (L_p) in dB(A) for Stainless steel****For constant feed**

Exp. no.	Feed (mm/rev.)	D.O.C (mm)	Speed (rpm)	Locations														
				A point			B Point			C point			D Point			E point		
				Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.	Obs.1	Obs.2	Avg.
1	0.089	0.5	54	76.2	77.4	76.8	76.5	76	76.3	76.1	75.9	76	72.3	72.2	72.3	78.7	78.5	78.6
2	0.089	1	135	77.5	78.1	77.8	77.1	77.5	77.3	77.1	76.6	76.9	74.7	74.9	74.8	80.2	80.8	80.5
3	0.089	1.5	325	81.8	81.2	81.5	83.5	83.8	83.7	81	82.1	81.6	81	80.2	80.6	84	84.2	84.1
4	0.089	2	770	79.2	84.8	82	80.1	80.7	80.4	80	80.7	80.4	77.3	77.5	77.4	82.8	82.8	82.8
5	0.095	0.5	135	76.1	76.7	76.4	76.1	77.1	76.6	76.1	76.4	76.3	72.5	72.9	72.7	78.6	78.3	78.5
6	0.095	1	54	75.5	76.1	75.8	76.9	76.3	76.6	76.1	75.8	76	72.9	72.6	72.8	78.9	79.2	79.1
7	0.095	1.5	770	84.4	82	83.2	89.5	81.6	85.6	83.8	86.2	85	84.7	87.8	86.3	87.6	84.6	86.1
8	0.095	2	325	81	78.5	79.8	79	78.7	78.9	77.7	81.6	79.7	73.6	73.7	73.7	84.4	77.7	81.1
9	0.102	0.5	325	76.2	76.3	76.3	77.4	77	77.2	76.5	76.8	76.7	73.6	72.9	73.3	78.9	79	79
10	0.102	1	770	80.1	85.7	82.9	83.9	80.1	82	80.2	80.4	80.3	77.6	77.9	77.8	82.6	83.6	83.1
11	0.102	1.5	54	76.3	75.1	75.7	76.4	76.2	76.3	75.3	74.4	74.9	72.6	71.9	72.3	77.1	77.7	77.4
12	0.102	2	135	76.4	76.2	76.3	77.3	76.1	76.7	76.6	77.3	77	73.8	73.1	73.5	79.4	79.3	79.4
13	0.111	0.5	770	79.6	80	79.8	80.3	80.4	80.4	80.4	80.4	80.4	77.2	77.1	77.2	82.5	84.6	83.6
14	0.111	1	325	77	77.5	77.3	77.3	77.4	77.4	76.5	76.8	76.7	72.9	73.2	73.1	78.5	79.1	78.8
15	0.111	1.5	135	77	76.7	76.9	77.5	76.7	77.1	76.4	79.9	78.2	75.7	74.6	75.2	78.8	79.3	79.1
16	0.111	2	54	76.7	77.1	76.9	76.1	76.9	76.5	74.1	74.3	74.2	72.2	72.9	72.6	78.8	77.9	78.4

APPENDIX – C

Table 1

Observation for SPL in dB(A) for Aluminium

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Frequency in Hz								
				31.5	63	125	250	500	1000	2000	4000	8000
1	1	0.089	54	54.3	60.8	62.5	68.9	73.8	75.1	65	53.9	45.1
2	1	0.111	135	58	57.3	63.8	69.3	74.3	75.6	65.6	61.7	51.2
3	1	0.133	500	54.5	55.9	62.9	70.7	74.8	76.3	69.6	60.2	50.1
4	1	0.166	1200	56.9	59	65.6	70.6	77	83.1	79	71.6	61.9
5	2	0.089	135	58.2	60.8	63.5	69.3	73.4	74.9	64.4	54.4	46.8
6	2	0.111	54	56.6	58.2	64.7	71.4	74.3	75.1	66.6	58.9	49.9
7	2	0.133	1200	54.8	60.8	64.5	71.7	78.8	83.3	79.9	71.8	62.5
8	2	0.166	500	59	57.5	62.8	70.6	74.9	76.6	69.4	60.9	50.8
9	3	0.089	500	56	58.1	63.5	74.8	75.2	76.9	69.8	61	55.1
10	3	0.111	1200	56.4	64.1	68.3	73.6	77.8	83	80	71.4	62.1
11	3	0.133	54	57.3	58.5	63.2	68.3	73.6	74.2	65.1	54.9	45.4
12	3	0.166	135	58.4	57.1	63.6	68.8	74.2	74.6	65	54.7	45.9
13	4	0.089	1200	61.6	61.2	64.6	72.8	78.4	88.8	80	72.7	65.6
14	4	0.111	500	60.9	59.9	60.5	70.6	74.7	75.9	69.2	60.2	51.4
15	4	0.133	135	60.7	58.4	61.9	68.3	74.2	74.6	65.8	57.2	48.1
16	4	0.166	54	58.4	58.5	61.2	68.1	74	74.2	66.2	56.2	47.8

Table 2**Observation for SPL in dB(A) for Brass**

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Frequency in Hz								
				31.5	63	125	250	500	1000	2000	4000	8000
1	1	0.089	54	64.7	61.6	62.6	68.1	64.1	74.5	67.3	56.2	46.8
2	1	0.111	135	65	60.7	64.7	70.2	73.8	77.2	66.6	57.3	48.1
3	1	0.133	500	62.3	55.7	63.2	70.9	75.5	78.4	72.4	67.2	72.3
4	1	0.166	1200	65	59	66.5	70.9	77.3	82.1	79.3	71.8	85.7
5	2	0.089	135	66.6	60.5	64.9	69.5	72.7	76.8	78.9	70.7	54.1
6	2	0.111	54	61.5	57.9	62.6	69.2	73.8	74.2	67	57.5	46.5
7	2	0.133	1200	62.8	61.7	66	71.2	76.7	81.9	79.9	72	83.6
8	2	0.166	500	60.1	58.7	65.2	71.5	75.2	80	74.4	85	75.8
9	3	0.089	500	58.6	55.6	63.7	77.7	75.3	78.4	73.1	75.9	77.6
10	3	0.111	1200	58.8	56.3	65.7	70.5	76.4	81.7	79.6	71.8	79.3
11	3	0.133	54	51.5	59.3	60.9	71.4	74.1	74.8	69.6	59	49.7
12	3	0.166	135	56.3	57.4	65.4	71.5	74.6	82.1	84.5	74.8	68.6
13	4	0.089	1200	52.8	57.8	68.9	75.6	78.1	81.8	82.3	86.6	78.7
14	4	0.111	500	56.2	55.4	64.6	69.9	75.2	84.3	76.1	79.6	77.5
15	4	0.133	135	57.1	55.8	67	72.4	75.3	80.6	77.6	71.1	67.6
16	4	0.166	54	60	59.1	65.4	75.7	74.7	75.8	71.1	63.6	56.3

Table 3**Observation for SPL in dB(A) for Mild steel**

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Frequency in Hz								
				31.5	63	125	250	500	1000	2000	4000	8000
1	0.5	0.089	54	58	60.3	71.7	75.4	79.6	67	56.1	45.5	39.2
2	0.5	0.095	135	57.7	58.7	66.2	74.4	76.1	79.5	68.6	56.8	46.9
3	0.5	0.102	325	58	59.8	66.5	74	77.1	80.1	69.8	58.5	49.1
4	0.5	0.111	770	54.5	59.3	68.5	76.7	79.2	81.5	75.5	66.7	56.8
5	1	0.089	135	54.9	58.4	65.5	71.4	74.9	78.8	67	56.5	46.7
6	1	0.095	54	58.7	58.2	64.9	71.5	74.7	79.4	67.7	56.3	46.3
7	1	0.102	770	55.8	59.4	73.1	81.4	80.4	82.2	77.2	67.7	59.9
8	1	0.111	325	60.3	59.7	65.9	73.8	76.7	79.1	68.7	59.5	50.8
9	1.5	0.089	325	56.4	61.9	69.9	76	76.6	78.3	69.3	60.1	50.7
10	1.5	0.095	770	56.3	58.7	75.3	82	80.8	82	77	70	65.2
11	1.5	0.102	54	54.5	58.8	65.4	70.3	74.1	78	67.4	56.4	46.1
12	1.5	0.111	135	55.1	57.7	66.4	72.8	74.3	78.3	67	54.9	45.9
13	2	0.089	770	55.3	58.4	67.8	77.6	82.3	81.2	76.4	67.8	61.7
14	2	0.095	325	56.7	60.2	69.6	76.6	76.9	78.8	69.1	57.9	49.1
15	2	0.102	135	54	58	67.9	73.4	74.2	78.6	67	55.1	47.4
16	2	0.111	54	59.8	62.4	67	72.2	74.2	78.8	66.7	53.9	46

Table 4**Observation for SPL in dB(A) for Stainless steel**

Exp. no.	D.O.C (mm)	Feed (mm/rev.)	Speed (rpm)	Frequency in Hz								
				31.5	63	125	250	500	1000	2000	4000	8000
1	0.5	0.089	54	59.2	57.2	64.6	73.1	72.4	76.4	66.7	55.2	46.2
2	0.5	0.095	135	56.5	54.7	65.2	74.2	73.8	77.9	67.7	56.8	47.3
3	0.5	0.102	325	54.7	56.9	64.6	73.5	73.7	78.2	69	60.7	48.5
4	0.5	0.111	770	57	56.1	63.2	73.3	78.1	85.9	78.7	74.6	60
5	1	0.089	135	59.3	58.3	65.2	73	73.7	78	68.1	56.2	46.8
6	1	0.095	54	54.1	55	63.4	72.4	74	77.4	66.8	56.7	47.2
7	1	0.102	770	57.2	63.8	63.9	73.9	80.1	83.7	78.2	70	58.6
8	1	0.111	325	59	55	65.5	75	74.8	78.8	69.2	61.5	49.4
9	1.5	0.089	325	54.9	54.6	63.7	75	75	78.1	70.4	59	48.6
10	1.5	0.095	770	53.5	56.5	62.8	71.4	78.8	90.2	81	71.7	63
11	1.5	0.102	54	57.1	56.9	64.1	72.7	74.3	77.9	67.2	55.1	45.7
12	1.5	0.111	135	55	55.6	65.3	74.5	74.7	78.1	67.7	55.5	46.4
13	2	0.089	770	56.8	54.8	62	71.2	77.6	90.9	82.8	69.3	60.2
14	2	0.095	325	57.4	56.4	64.6	77.1	75.7	78.9	70.5	59	50
15	2	0.102	135	56.1	53.9	65.2	73.7	74.8	78.6	68.1	56.3	48.4
16	2	0.111	54	56.9	56.5	63.8	73.9	74	78.1	68	55.8	47.8

APPENDIX – D

Acoustic power is calculated with the help of sound pressure level. Sound power is calculated from the formula:

$$L_w = L_p + 10 \log_{10} (S/S_0)$$

L = Sound power in dB(A) (ref. 10-12 W)

L = Average sound pressure level in dB(A)

S_0 = Reference area (1 m²)

S = Hypothetical surface area

Length, a = 2.15 m

Breadth, b = 0.6 m

Height, c = 1.22 m

Area, $S = a*b + 2(a*c + b*c)$

$S = 2.15*0.6 + 2(2.15*1.22 + 0.6*1.22)$

$S = 8 \text{ m}^2$

$$L_w = L_p + 10 \log_{10} (S/S_0)$$

The equation is reduced to:

$$L_w = L_p + 10 \log_{10} (8/1)$$

$$L_w = L_p + 10 * 0.90$$

$$L_w = L_p + 9$$

APPENDIX-E

Table 1

**Analysis of variance (ANOVA) and Main effect plot values
For Aluminium**

Analysis of variance

At point A				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	7.3	3	2.4	2.3
Feed	11.5	3	3.8	3.5
Speed	46.3	3	15.4	14
Total	71.5	15	4.8	-
Error	6.5	6	1.1	-

At point B				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	7.8	3	2.6	1.2
Feed	10.2	3	3.4	1.6
Speed	34.3	3	11.4	5.5
Total	64.9	15	4.3	-
Error	12.6	6	2.1	-

At point C				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	6.5	3	2.2	1.4
Feed	3.5	3	1.2	0.7
Speed	34.2	3	11.4	7.2
Total	53.6	15	3.6	-
Error	9.5	6	1.6	-

At point D				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	11.4	3	3.8	4.7
Feed	4.1	3	1.4	1.7
Speed	83.5	3	27.8	34.2
Total	104	15	6.9	-
Error	5	6	0.8	-

At point E				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	5.3	3	1.8	0.9
Feed	3.5	3	1.2	0.6
Speed	129	3	43	21.8
Total	149.7	15	10	-
Error	11.8	6	2	-

Main effect plot values

Locations	Depth of cut			
	1	2	3	4
A Point	77.6	76.8	76.9	78.5
B Point	77.6	76.5	76	77.6
C Point	78.7	77.9	78.3	79.6
D Point	76.1	73.8	75.4	75.5
E Point	78.6	77.4	78.6	78.9

Locations	Feed			
	0.089	0.111	0.133	0.166
A Point	78.7	76.5	77	77.6
B Point	78.2	76	76.5	77
C Point	79.3	78.1	78.3	78.8
D Point	75.8	75.4	74.5	75
E Point	78.9	78.5	77.6	78.5

Locations	Speed			
	54	135	500	1200
A Point	75.5	76.1	78.4	79.7
B Point	75.4	75.6	77.8	78.8
C Point	77.1	77.3	79.7	80.4
D Point	73.3	73.2	75.3	78.9
E Point	75.9	76	78.6	82.9

Table 2
Analysis of variance (ANOVA) and Main effect plot values
For Brass

Analysis of variance

A Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	3.1	3	1	1
Feed	0.7	3	0.2	0.2
Speed	114.4	3	38.1	38.1
Total	124.5	15	8.3	-
Error	6.3	6	1	-

B Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	2.9	3	1	1.2
Feed	2.1	3	0.7	0.8
Speed	78.6	3	26.2	32.5
Total	88.4	15	5.9	-
Error	4.8	6	0.8	-

C Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	0.8	3	0.3	1.5
Feed	0.3	3	0.1	0.5
Speed	128.3	3	42.8	214
Total	130.6	15	8.7	-
Error	1.2	6	0.2	-

D Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	1.6	3	0.5	5
Feed	2.9	3	1	10
Speed	131.8	3	43.9	439
Total	136.9	15	9.1	-
Error	0.5	6	0.1	-

E Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	1.4	3	0.5	0.3
Feed	2.8	3	0.9	0.6
Speed	302.9	3	101	63.1
Total	316.5	15	21.1	-
Error	9.3	6	1.6	-

Main effect plot values

Locations	Depth of cut			
	1	2	3	4
A Point	79.6	80.4	80	80.7
B Point	78.3	79	78.8	79.5
C Point	80	80.5	80.6	80.5
D Point	76.5	76.7	77.1	77.3
E Point	81.8	81.5	81.7	82.3

Locations	Feed			
	0.089	0.111	0.133	0.166
A Point	80.4	80.2	79.8	80.3
B Point	79.3	78.6	78.5	79.2
C Point	80.5	80.2	80.3	80.6
D Point	76.4	77.1	76.6	77.5
E Point	81.9	81.7	81.2	82.4

Locations	Speed			
	54	135	500	1200
A Point	77.1	78.4	81.2	84
B Point	76.5	77.3	79.8	82.1
C Point	77.7	78.2	80.9	84.8
D Point	73.9	74.9	77.4	81.4
E Point	76.8	79.2	82.8	88.4

Table 3**Analysis of variance (ANOVA) and Main effect plot values****For Mild Steel****Analysis of variance**

A Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	0.3	3	0.1	0.1
Feed	0.5	3	0.2	0.3
Speed	53.3	3	17.8	29.6
Total	57.5	15	3.8	-
Error	3.5	6	0.6	-

B Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	1.3	3	0.4	0.9
Feed	0.3	3	0.1	0.2
Speed	44.9	3	15	30
Total	49.4	15	3.3	-
Error	2.8	6	0.5	-

C Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	10.4	3	3.5	1.3
Feed	5.9	3	2	0.7
Speed	99.8	3	33.3	12.4
Total	132.3	15	8.8	-
Error	16.1	6	2.7	-

D Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	2	3	0.7	1.7
Feed	1	3	0.3	0.8
Speed	75.3	3	25.1	62.7
Total	80.6	15	5.4	-
Error	2.4	6	0.4	-

E Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	13.9	3	4.6	3.7
Feed	5.7	3	1.9	1.5
Speed	109.3	3	36.4	28
Total	136.4	15	9.1	-
Error	7.6	6	1.3	-

Main effect plot values

Locations	Depth of cut			
	0.5	1	1.5	2
A Point	77.6	77.8	77.4	77.5
B Point	77.6	78.2	78.4	78.1
C Point	77.3	79.4	78.4	77.7
D Point	74.2	75.1	75	74.6
E Point	78.9	81.5	80.6	80.2

Locations	Feed			
	0.089	0.095	0.102	0.111
A Point	77.3	77.7	77.7	77.5
B Point	77.9	77.9	78.3	78.1
C Point	77.5	78.3	79.1	77.8
D Point	74.4	75.0	75.0	74.5
E Point	79.8	80.4	81.2	79.8

Locations	Speed			
	54	135	325	770
A Point	76.5	76.2	76.9	80.7
B Point	76.9	76.8	77.5	80.9
C Point	76.6	76.3	77.3	82.5
D Point	73.1	73.3	74.1	78.4
E Point	78.2	78.7	79.7	84.7

Table 4
Analysis of variance (ANOVA) and Main effect plot values
For Stainless Steel

Analysis of variance

A Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	8.5	3	2.8	1.8
Feed	9.1	3	3	2
Speed	78.8	3	26.3	17.5
Total	105.6	15	7	-
Error	9.2	6	1.5	-

B Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	22	3	7.3	2.9
Feed	8.7	3	2.9	1.2
Speed	80.3	3	26.8	10.8
Total	125.9	15	8.4	-
Error	14.9	6	2.5	-

C Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	17.3	3	5.8	4
Feed	11.9	3	4	2.8
Speed	84.6	3	28.2	20.1
Total	122.4	15	8.2	-
Error	8.6	6	1.4	-

D Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	57.5	3	19.2	3.9
Feed	15.8	3	5.3	1.1
Speed	114.4	3	38.1	7.8
Total	216.9	15	14.5	-
Error	29.3	6	4.9	-

E Point				
Parameters	Sum of squares	Degree of freedom	Variance	F-Test
Depth of cut	6.9	3	2.3	1.1
Feed	9.5	3	3.2	1.5
Speed	69.9	3	23.3	11.1
Total	98.8	15	6.6	-
Error	12.4	6	2.1	-

Main effect plot values

Locations	Depth of cut			
	0.5	1	1.5	2
A Point	77.3	78.4	79.3	78.7
B Point	77.6	78.3	80.7	78.1
C Point	77.3	77.4	79.9	77.8
D Point	73.8	74.6	78.6	74.3
E Point	79.9	80.4	81.7	80.4

Locations	Feed			
	0.089	0.095	0.102	0.111
A Point	79.5	78.8	77.8	77.7
B Point	79.4	79.4	78.1	77.8
C Point	78.7	79.2	77.2	77.4
D Point	76.3	76.3	74.2	74.5
E Point	81.5	81.2	79.7	79.9

Locations	Speed			
	54	135	325	770
A Point	76.3	76.8	78.7	82
B Point	76.4	76.9	79.3	82.1
C Point	75.3	77.1	78.6	81.5
D Point	72.5	74	75.1	79.6
E Point	78.4	79.3	80.7	83.9