Study Of Vibration For CNC Machine At Difference Feed

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ABSTRACT :

This paper is to represent the study of vibration and its analysis in relation with faults of turning centre CNC machine by Fast Fourier Transform FFT, standard measurement displacement, velocity and acceleration with frequency and time domain. A parameter set defines a set of measurement parameter values that can be used to take a recording. These are useful when you are taking a large number of recordings, each using the same parameter values. The direction refers to the orientation of the sensor-horizontal, vertical, and axial. The results showed on turret position that the vibration is depending on type of metal, axial direction, Feed .At (0.005 mm/rev) the value of vibration in axial ,horizontal &vertical for (AL) (0.014 , 0.012 , 0.01 rms) respectively ,(Feed 0.01 mm/rev) the value of vibration (0.014 , 0.013 , 0.011 rms) respectively and Feed(0.015 mm/rev) the value of vibration (0.017 , 0.011 , 0.011 rms) respectively . At Feed (0.005 mm/rev) the value of vibration in axial ,horizontal & vertical for (MS) (0.029 , 0.02 , 0.017 rms) respectively , Feed(0.01 mm/rev) the value of vibration (0.037 , 0.031 , 0.037 rms) respectively and feed (0.015 mm/rev) the value of vibration (0.043 , 0.041 , 0.043 rms) respectively .

KEYWORDS : vibration , CNC machine , FFT , Feed , MS , AL, acceleration .

1 INTRODUCTION

Vibration is a repetitive, periodic, or oscillatory response of a mechanical system. The rate of the vibration cycles is termed "frequency." Repetitive motions that are somewhat clean and regular, and that occur at relatively low frequencies, are commonly called oscillations, while any repetitive motion, even at high frequencies, with low amplitudes, and having irregular and random behavior falls into the general class of vibration. [1]

The vibration which occurs in most machines, vehicles, structures, buildings and dynamic systems is undesirable, not only because of the resulting unpleasant motions and the dynamic stresses which may lead to fatigue and failure of the structure or machine, and the energy losses and reduction in performance which accompany vibrations, but also because of the noise produced. Noise is generally considered to be unwanted sound, and since sound is produced by some source of motion or vibration causing pressure changes which propagate through the air or other transmitting medium, vibration control is of fundamental importance to sound attenuation .Singular convolution occur commonly in many science and engineering problems and are a special class of mathematical transformation . Vibration analysis of machines and structures is therefore often a necessary prerequisite for controlling not only vibration but also noise.[2, 3]

To process a signal is to make numerical manipulation for signal samples. The objective of processing a signal can be to detect the trend , to extract a wanted signal from a mixture of various signal components including unwanted noise , to look at the patterns present in a signal for understanding underlying physical processes in the real world . To analyse a digital system is to find out the relationship between input and output, or to design a processor with pre-defined functions ,such as filtering and amplifying under applied certain frequency range requirements .The mathematical analysis based on elastic theory were well conducted . A digital signal or a digital system can be analysed in time domain , frequency domain or complex domain , etc. [4, 5]

The word coordinate a squires a slightly different, additional meaning in structural dynamics. We are used to using coordinates, X,Y and Z , say, when describing the location of a point in structure. These are Cartesian coordinates (named after Rene Descartes), sometimes also known as " rectangular" coordinates. However, the same word " coordinate " can be used to mean the movement of a point on

a structure from some standard configuration . As an example , the positions of the grid points chosen for the analysis of a structure could be specified X,Y and Z coordinates from some fixed point . However, the displacements of those points , when the structure is loaded in some way , are often also referred to as coordinates . [6]

The response of the structure to excitation depends upon method of application and the location of the exciting force or motion , and the dynamic characteristics of the structure. Such as its natural frequencies and inherent damping level.[7]

The physical movement or motion of a rotating machine is normally referred to as vibration . Since the vibration frequency and amplitude cannot be measured by sight or touch , a means must be employed to convert the vibration into a usable product that can be measured and analyzed . Electronics , mechanics , and chemical physics are closely related . Therefore , it would logically follow that the conversion of the mechanical vibration into an electronic signal is the best solution. The means of converting the mechanical vibration into an electronic signal is called a transducer . The transducer output is proportionate to how fast machine is moving (frequency) and how much the machine is moving (amplitude). The frequency describes what is wrong with machine and the amplitude describes relative severity of the problem . [8]

Vibration signals are important for monitoring tool condition in turning process . Accelerometers were mounted in the cutting too, one in the tangential direction of the tool holder and the other one was placed in the axial direction of the tool holder for measuring vibration amplitude in terms of acceleration (g-levels) . A computer code has been developed in lab view for data acquisition , data storage and display. Fast Fourier Transform (FFT) computation algorithm was included in the computer program to extract the vibration amplitude in the time and frequency domain, which will be explained in software development section . [9]

Some experiments are based in cutting forces for instance a cutting force ratio is utilized to predict the in-process surface roughness regardless of the cutting conditions .Using regression analysis regression coefficients are calculated and utilized surface roughness prediction model for turning machine . [10,11]

2 POWER MODEL

The equation for power is :

$$P = F \times V \qquad \text{------------------(1)}$$

Where :

P : is the power in watt.

F : is the main force in N .

V : is the cutting speed in m/min .

The power is dissipated mainly in the shear zone (due to the energy required to shear the material) and the rake face of the tool (due to tool-chip interface friction).The sharpness of the tool tip also influences forces and power .[12]

$$F = k * d * f \qquad \text{---------------- (2)}$$

Where :

F : is the main force in N .

K : is the constant of material .

d : is the depth of cut (mm) .

f : is the feed (mm/rev) .

$$V = \frac{\pi D N}{1000} \qquad \text{-------------------- (3)}$$

Where :

V : is the cutting speed in m/min .

D : is the initial diameter of the W.P 9(mm) .

N : is the rotational speed of the W.P (rpm) .

In operations performed on lathes (turning operation), the primary cutting motion V (rotary) is imparted to the W.P , and the feed motion f (in most cases straight along the axis of the W.P) is imparted to single –point tool . the tool feed rate f is usually very much smaller than the surface speed V of the W.P . [13]

From equation (2&3)

$$P = k \times d \times f \times V \qquad \text{-------------------- (4)}$$

3 EXPERIMENTAL METHOD

In the experimental part, two metals viz., Aluminum (AL) and mild steel (MS) as a cutting metal, the speed of CNC machine is fixed on 1200 rpm, while the depth of cutting D.O.C is 0.5mm. Three Feed have been selected 0.005, 0.01 and 0.015 mm/rev. The vibro meter Vb3000 is selected to measure the vibration and the FFT of it as shown figure 1. However, the spindle head for CNC machine is operated or rotating and the turret starts cutting. The sensor of Vb3000 is put on turret position to measure the vibration

amplitude and frequency for axial, vertical, horizontal for all material and operating conditions.

4 RESULTS AND DISCUSSION

The vibration meter VB 3000 is shown in figure 1. Gives three relations named displacement with frequency and velocity with frequency and as taken here the acceleration with frequency. Figures 2, 3 and 4 show the variation of root mean square(rms) of acceleration (g) with frequency (Hz) at axial, horizontal and vertical direction respectively for (AL) at Feed of 0.005 mm/rev (0.014 , 0.012 , 0.01 rms).Figures 5, 6 and 7 show the variation of root mean square (rms) of acceleration (g) at feed (0.01 mm/rev) (0.014 , 0.013 , 0.011 rms) respectively and Figures 8 , 9 , 10 show the variation of root mean square (rms) of acceleration (g)at feed (0.015 mm/rev) (0.017 , 0.011 , 0.011 rms) respectively . It can be observed that the value of acceleration at axial direction is the highest as compare with horizontal and vertical.

Figure 11, 12 and 13 give the variation of acceleration rms with frequency for MS metal at Feed 0.005 mm/rev at three directions viz., axial, horizontal and vertical (0.029 , 0.02 , 0.017 rms) respectively. Figures 14,15 and 16 show the vibration of root mean square rms of acceleration g at feed (0.01 mm/rev) (0.037 , 0.031 , 0.037 rms) respectively and Figures 17 , 18 and 19 show the variation of root mean square rms of acceleration g at feed (0.015 mm/rev) (0.043 , 0.041 , 0.043 rms) respectively . It can be observed that the value of acceleration at axial direction is the highest as compare with horizontal and vertical. In the comparison between the aluminum and MS metal at same speed ,D.O.C and Feed, the vibration in terms MS of acceleration is greater than the vibration of aluminum.

In these figures it can be noticed that the maximum vibration happened at upper Feed (0.015 mm/rev) for metal (AL) viz., axial, horizontal and vertical (0.017 , 0.011, 0.011 rms) , for metal (MS) viz., axial, horizontal and vertical (0.043 , 0.041, 0.043 rms) and so distinct shooting

of acceleration when the values of maximum root mean square for mode Acceleration is measured in location turret and for AL and MS at axial, horizontal and vertical direction.

In the comparison between Figure 2,5 And Figure 8. it can be noticed that at Feed 0.015 is highest than 0.005 and 0.01 .Figure (3,4,6,7,9 and 10) give the variation of acceleration rms with frequency for AL Metal at Feed 0.015 mm/rev highest than at Feed 0.005 and 0.01 any direction as can seen in Figures.

Figure 20 and 21 the variation of power (kw) with Feed (0.005,0,01 & 0.015 mm/rev) for metal AL & MS we can calculated cutting speed from equation (3)and the power from equation (4) .In these figure it can be noticed that maximum power happened at upper Feed (0.015 mm/rev) & at metal (MS) (15.072) highest than from metal(Al) (6.594) and maximum vibration happened at upper Feed.

Table1. summarized the figures results numerically and presented as below.

Table 2. Calculated cutting speed , Force (F) & power from equation (3,2&4 respectively).

From the figures and table , the following observations can be noticed:

- The percentage value of turret for (AL) , Feed = 0.005mm/rev , increase in axial to horizontal = 15% and axial to vertical=29% .
- For (AL) , Feed = 0.01 mm/rev , increase in axial to horizontal = 8% and axial to vertical = 22% .
- For (AL) , Feed = 0.015 mm/rev , increase in axial to horizontal and vertical = 35%.
- The percentage value of turret for (Ms) , Feed = 0.005mm/rev , increase in axial to horizontal = 31% and axial to vertical =41% .
- For (MS) , Feed = 0.01 mm/rev , increase in axial to horizontal = 16% and axial to vertical it is equal .
- For (MS) , Feed = 0.015 mm/rev , increase in axial to horizontal = 5% and axial to vertical it is equal.

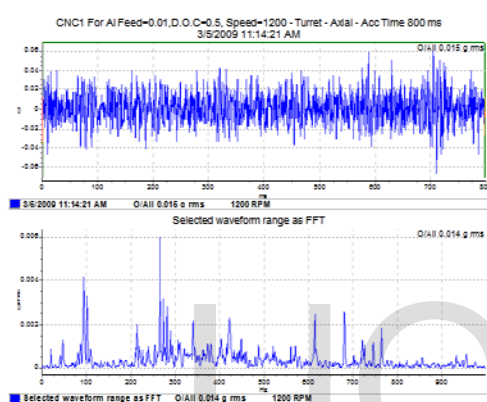## 4.1 Figures and Tables

Figure 1. The vibration meter Vb 3000

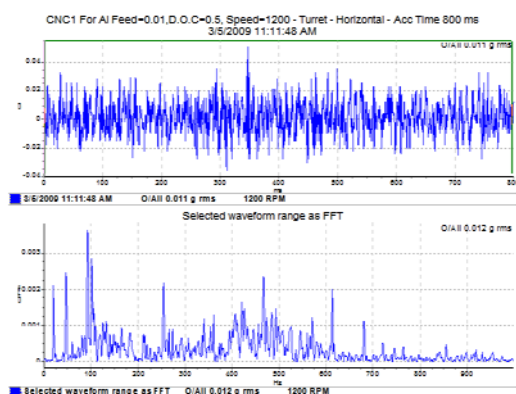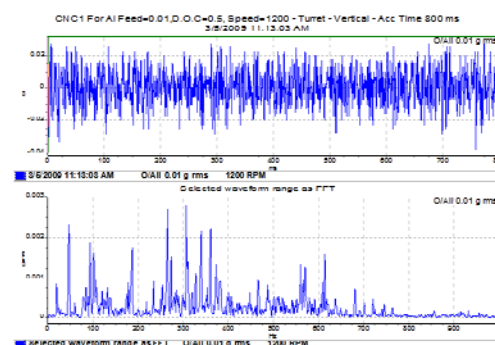Figure 4.Vertical, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.005 mm/rev.

Figure 2.Axial, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.005 mm/rev.
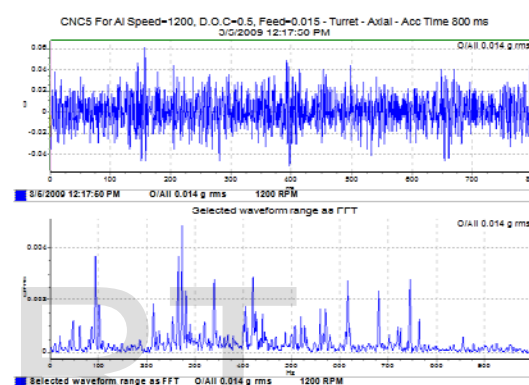

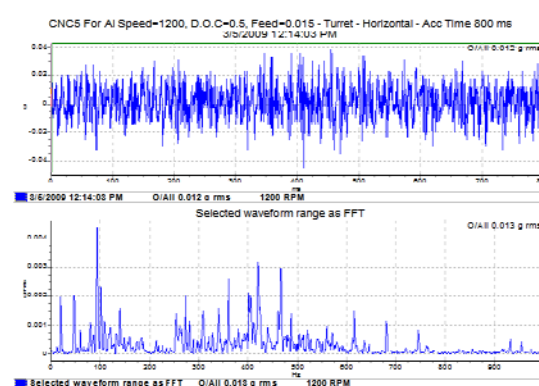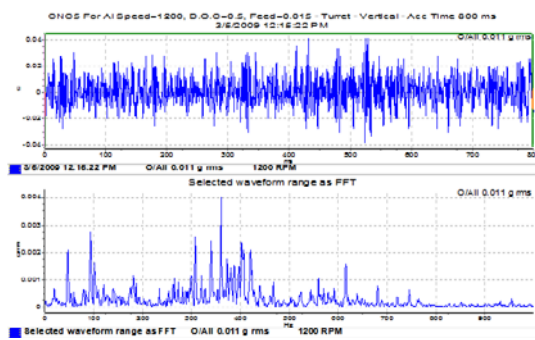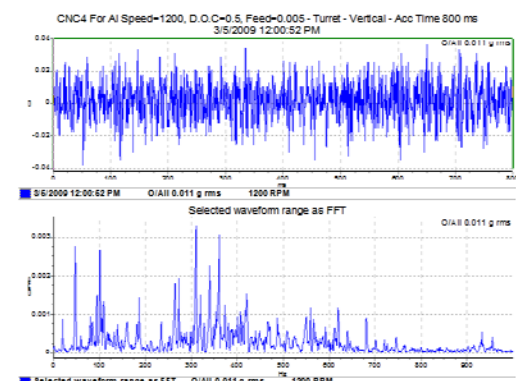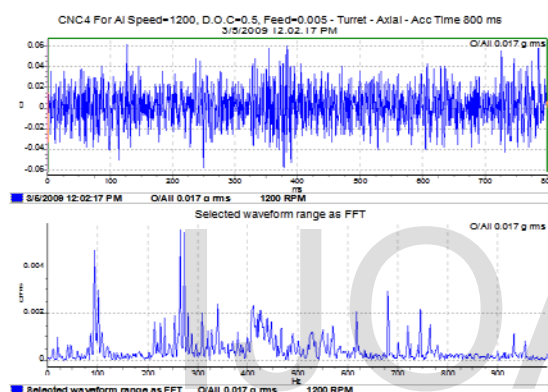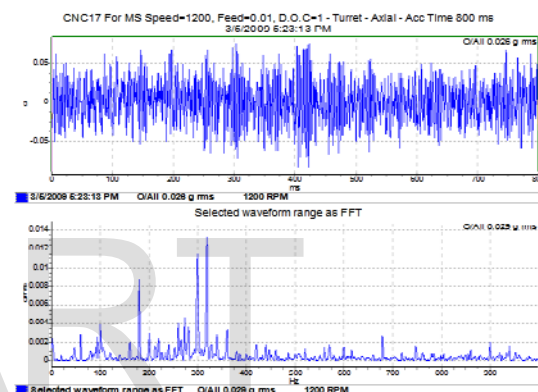Figure5.Axial, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.01 mm/rev.
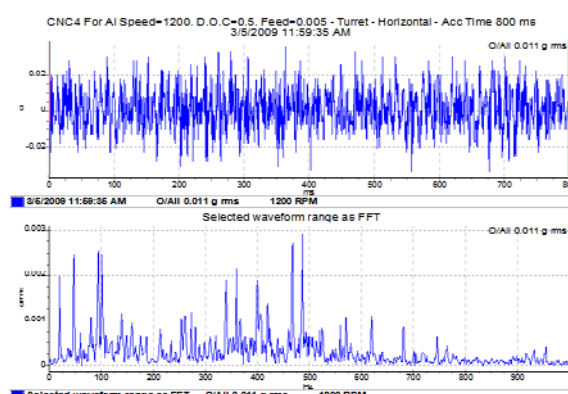

Figure 3.Horizontal, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.005 mm/rev.

Figure 6.Horizontal, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.01 mm/rev.

Figure 7. Vertical, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.01 mm/rev.

Figure 10. Vertical, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.015 mm/rev.

Figure 8. Axial, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.015 mm/rev.

Figure 11. Axial, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.005 mm/rev.

Figure 9. Horizontal, Variation of root mean square of acceleration with frequency for aluminum at feed = 0.015 mm/rev.
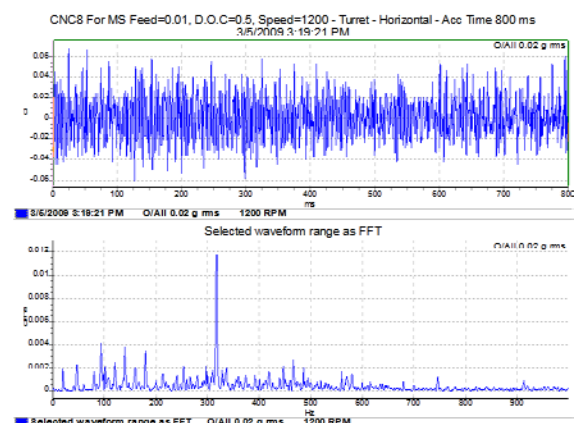

Figure 12. Horizontal, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.005 mm/rev.
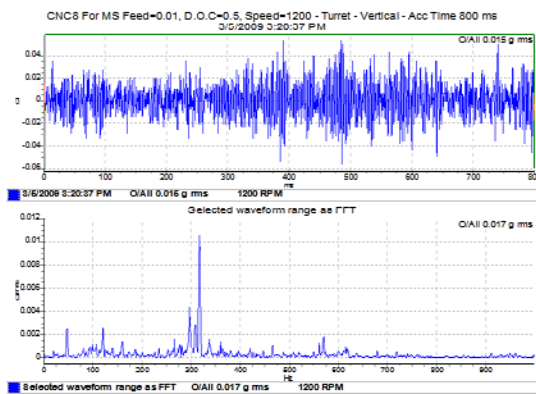
Figure   13.Vertical, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.005 mm/rev.
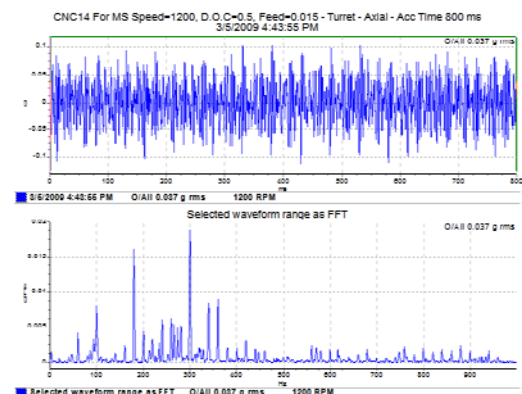

Figure 16.Vertical, Variation of root mean square of acceleration with frequency for mild   steel at feed = 0.01mm/rev.
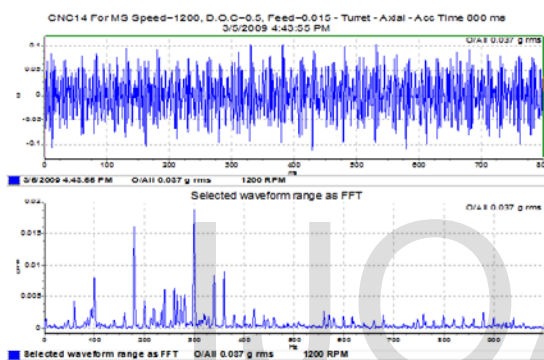

Figure 14.Axial, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.01 mm/rev.
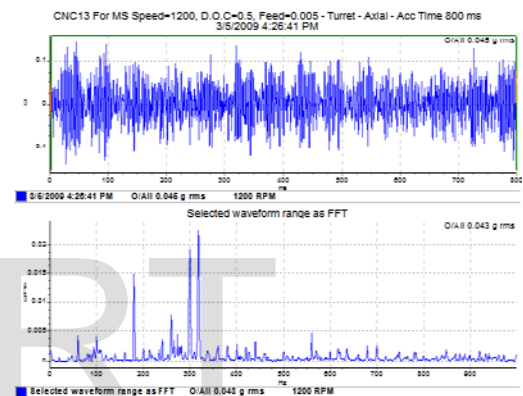

Figure 17.Axial, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.015 mm/rev.
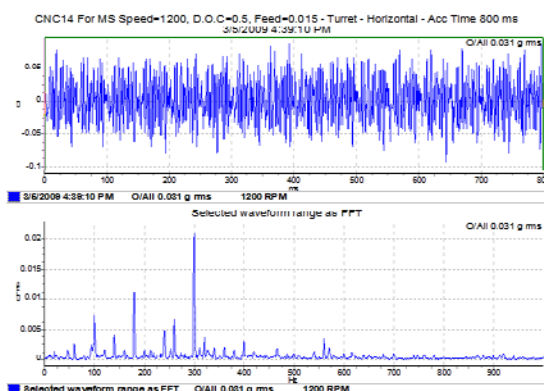

Figure   15.Horizontal, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.01mm/rev.

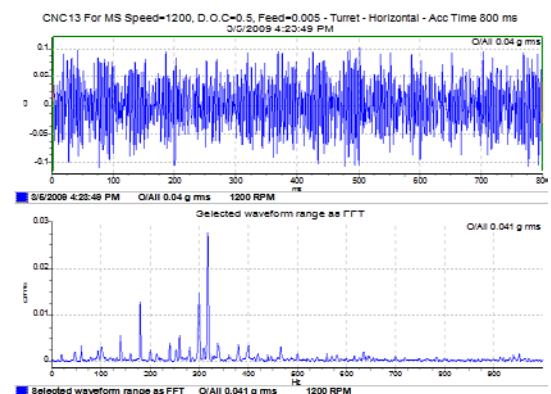Figure 18.Horizontal, Variation of root mean square of acceleration with frequency for mild   steel at feed = 0.015 mm/rev.
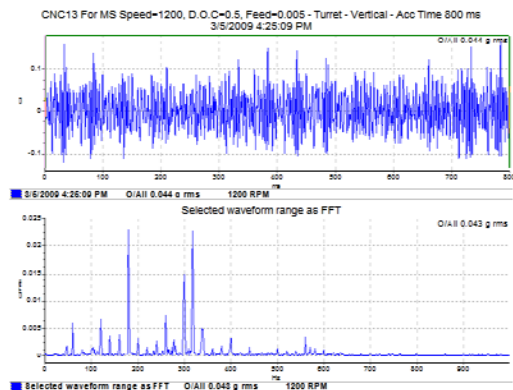
Figure 19.Vertical, Variation of root mean square of acceleration with frequency for mild steel at feed = 0.015 mm/rev.
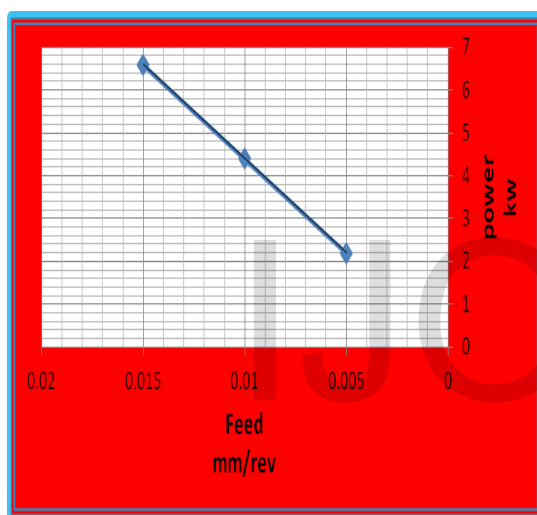

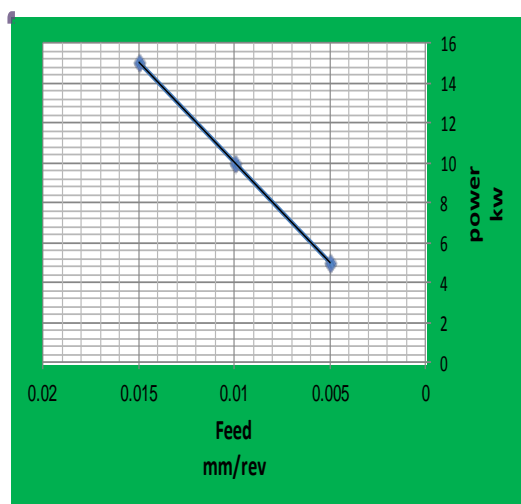Figure (20) relationship between Power and Feed for (AL).

Figure (21) relationship between Power and Feed for(MS).

TABLE 1. THE RESULTS OF TESTS

Metals	Feed (mm/rev)	Axial (rms of g)	Horizontal (rms of g)	Vertical (rms of g)
AL	0.005	0.014	0.012	0.01
	0.01	0.014	0.013	0.011
	0.015	0.017	0.011	0.011
MS	0.005	0.029	0.02	0.017
	0.01	0.037	0.031	0.037
	0.015	0.043	0.041	0.043

Table 2. The Value of power

Metals	Feed (mm/rev)	K constant	D Diameter(mm)	Velocity (m/min)	Power kw
AL	0.005	700	100	376.8	2.198
	0.01	700	100	376.8	4.396
	0.015	700	100	376.8	6.594
MS	0.005	1600	100	376.8	5.024
	0.01	1600	100	376.8	10.048
	0.015	1600	100	376.8	15.072

CONCLUSIONS:

From the above results it can be derived the following conclusions:

1. The vibration in axial direction is the highest in comparison with horizontal and vertical for AL and MS.

2. The type of metal or its hardness effects directly on the vibration quantity .

3. Logically , with increase in Feed the vibration is increased.

4. Logically , with increase in Feed the power is increased .

5. The studies of vibration analysis in CNC machine (turret) suggest tool design when the value of vibration comes to be more than yield limits (0.5 rms g) for this study CNC machine .

6. The type of metal or its hardness effects directly on the vibration than power .

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