© 2014 IJEDR | Volume 2, Issue 2 | ISSN: 2321-9939

Monitoring and Analysis of Vibration Signal in Machine Tool Structures

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Abstract— Vibration monitoring is becoming an established technique for managing the maintenance of machinery. Machine condition monitoring is the process of monitoring the condition of a machine with the intent to predict mechanical wear and failure. Vibration, noise, and temperature measurements are often used as key indicators of the state of the machine. This paper deals with monitoring the vibrations on the machine with the help of ADXL345 Accelerometer and performing the turning operation on brass and mild steel at various parameters and analyzing the time response and frequency response graph. For processing and analysis of vibration signal, time domain and frequency domain analysis of vibration signal is implemented. Machine condition monitoring is important because it provides information about the health of a machine. We can use this information to detect warning signs early and help your organization stop unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs.

Keywords— Aurdino UNO, ADXL345 Accelerometer, Matlab, Testing materials

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I. INTRODUCTION

Vibration occurs in machine in different plant. Vibration can be a good indicator of machine monitoring system. From the graph of vibration signal, the internal faults in machine can be detected easily. As a result, preventive action can be taken.

Machine condition monitoring is the process of monitoring the condition of a machine with the intent to predict mechanical wear and failure. Vibration, noise, and temperature measurements are often used as key indicators of the state of the machine. Trends in the data provide health information about the machine and help detect machine faults early, which prevent unexpected failure and costly repair. Machine condition monitoring is important because it provides information about the health of a machine. We can use this information to detect warning signs early and help your organization stop unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs.

In this paper we have utilized a Fast Fourier Transform (FFT) which is a special case of the generalized Discrete Fourier Transform and converts the vibration signal from its time domain representation to its equivalent frequency domain representation. However, frequency analysis (sometimes called Spectral Analysis or Vibration Signature Analysis) is only one aspect of interpreting the information contained in a vibration signal. Frequency analysis tends to be most useful on machines that employ rolling element bearings and whose main failure modes tend to be the degradation of those bearings, which typically exhibit an increase in characteristic frequencies associated with the bearing geometries and constructions. The coding is performed in Matlab from which the graphs are obtained for time response and frequency response.

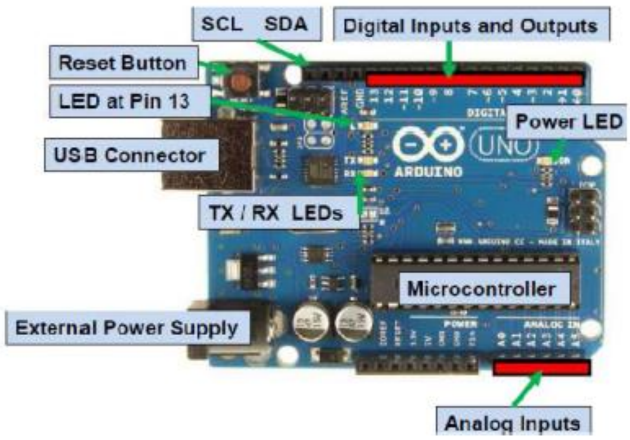


Fig. 1 Aurdino UNO with description

Table 1 Aurdino UNO Specifications

1.	Microcontroller	ATmega328
2.	Operating Voltage	5V
3.	Input Voltage (recommended)	7-12V
4.	Input Voltage (limits)	6-20V

5.	Digital I/O Pins	14 (of which 6 provide PWM output)
6.	Analog Input Pins	6
7.	DC Current per I/O Pin	40mA
8.	DC Current for 3.3V Pin	50mA
9.	32 KB (ATmega328) of which 0.5 KB used by boot loader	32 KB (ATmega328) of which 0.5 KB used by boot loader
10.	SRAM	2 KB (ATmega328)
11.	EEPROM	1 KB (ATmega328)
12.	Clock Speed	16MHz

II.METHODOLOGY

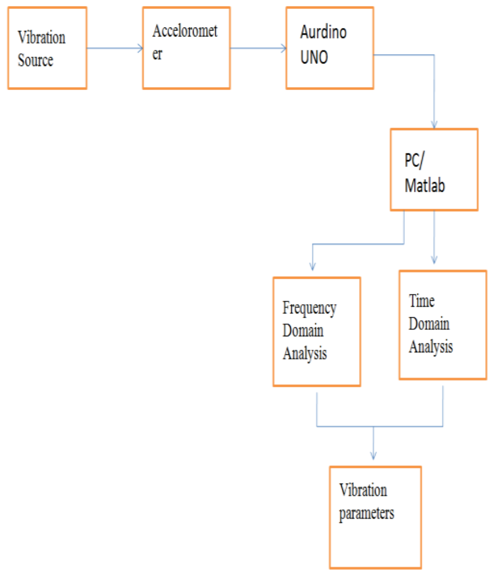


Fig. 2 General Block Diagram

Fig.2 shows the general block diagram. In this method Aurdino UNO is used along with the digital accelerometer which measures the vibrations from the machine and gives the digital output after burning the program for the accelerometer. Thereafter Aurdino is interfaced with Matlab and graphs are obtained from the readings as recorded by the accelerometer. Thereafter time domain and frequency domain analysis is performed in Matlab to analyze the vibrations.

Through fast Fourier transform we can convert the time domain data (as a matrix of voltage output, *V_time*) in the frequency domain. By using MATLAB, following commands can be used:

$$V\_fft = abs\ (fft(V\_time))$$

This command will produce a matrix of voltage values in the frequency domain. The corresponding matrix of frequencies can be obtained from

$$f = (0{:}\ N\text{-}1)/\ (N*T)$$

Where N is the total number of samples in the time domain and T the sampling interval.

III.EXPERIMENTAL SETUP

Table 2 Analysis of brass and mild steel for different parameters

Speed (in rpm)	Feed rate (in mm/rev)	Depth of Cut (in mm)
280	0.05	1
450	0.05	1
710	0.05	1

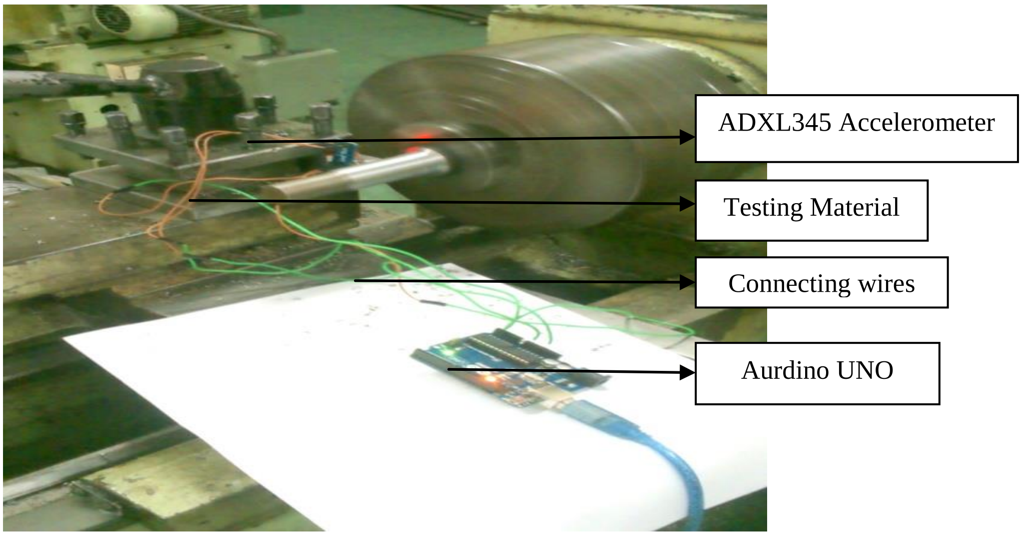


Fig. 3: Sensor mounted on the cutting tool

Copper mild steel block as shown in fig. 3 is fastened at the chuck and the turning operation is performed at various speeds with different feed and depth with the help of high speed steel turning tool and the readings are recorded by the ADXL345 accelerometer and transmitted to the Aurdino through serial port which is then transmitted to the Matlab for the time and frequency response analysis.

In this experiment turning operation is performed for brass and mild steel at different speeds with the same feed and depth for all the speeds.

IV.RESULTS AND DISCUSSION

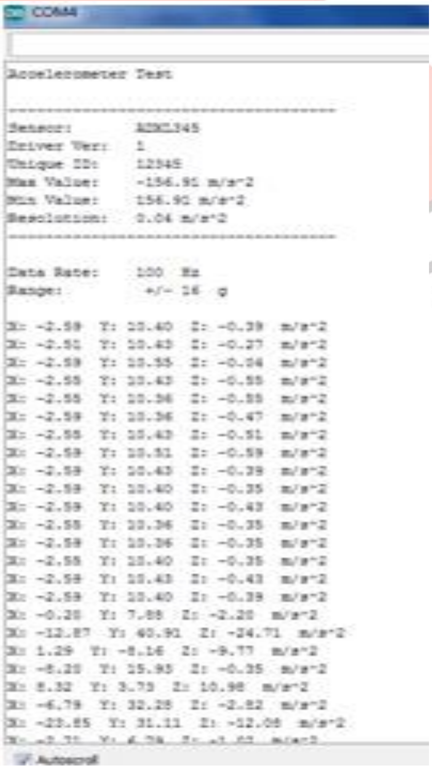
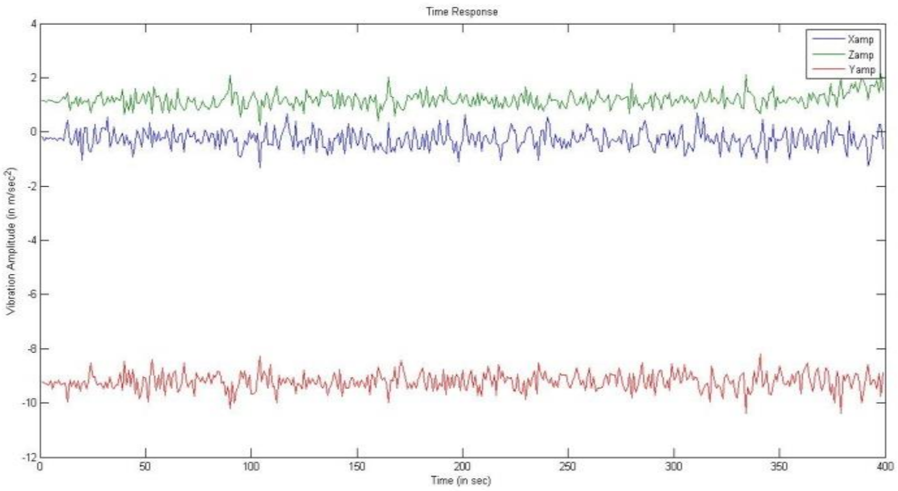
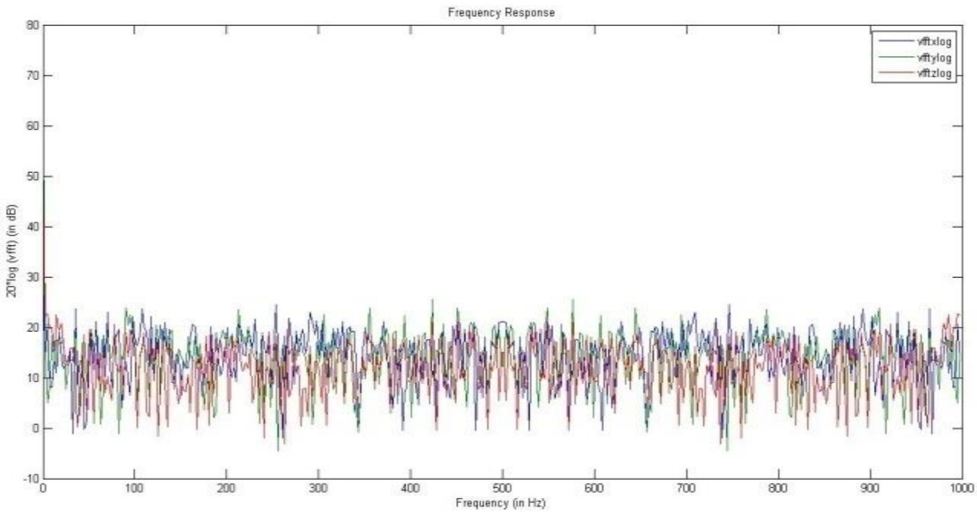


Fig. 4 Display of readings on serial monitor

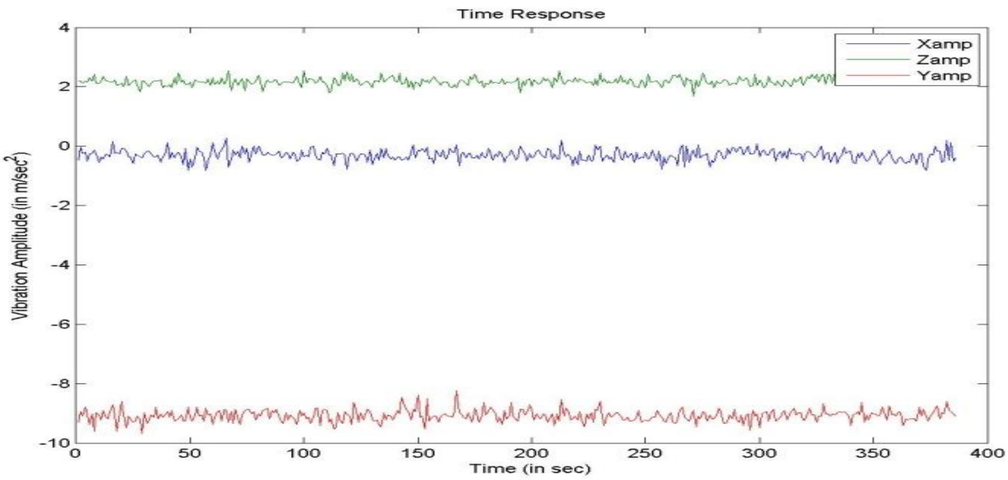
After verifying and compiling the program in Aurdino UNO select the serial monitor from the tools which results in the accelerometer reading in x, y, z direction which will be displayed in the serial monitor.


Time Response
Xamp
Zamp
Yamp
Vibration Amplitude (in m/sec²)
Time (in sec)

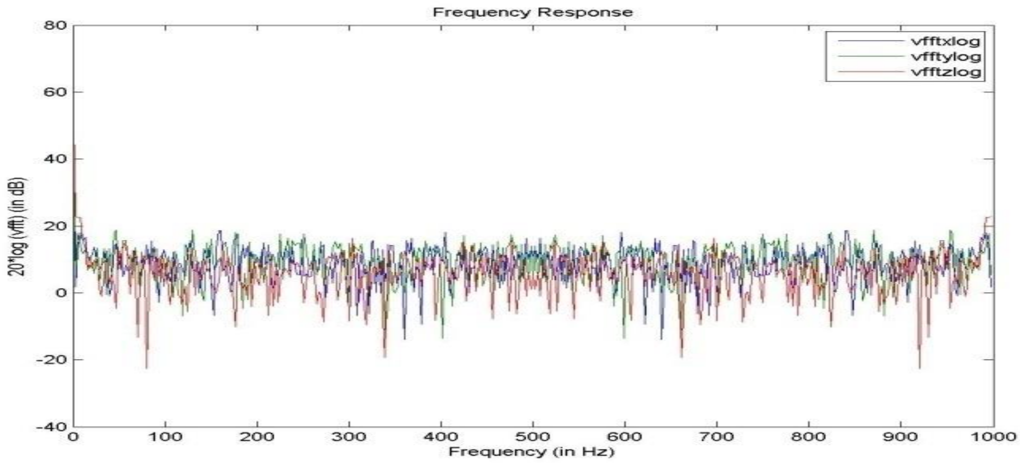
(a)


Frequency Response
vfftxlog
vfftylog
vfftzlog
20*log (vfft) (in dB)
Frequency (in Hz)

(b)


Time Response
Xamp
Zamp
Yamp
Vibration Amplitude (in m/sec²)
Time (in sec)

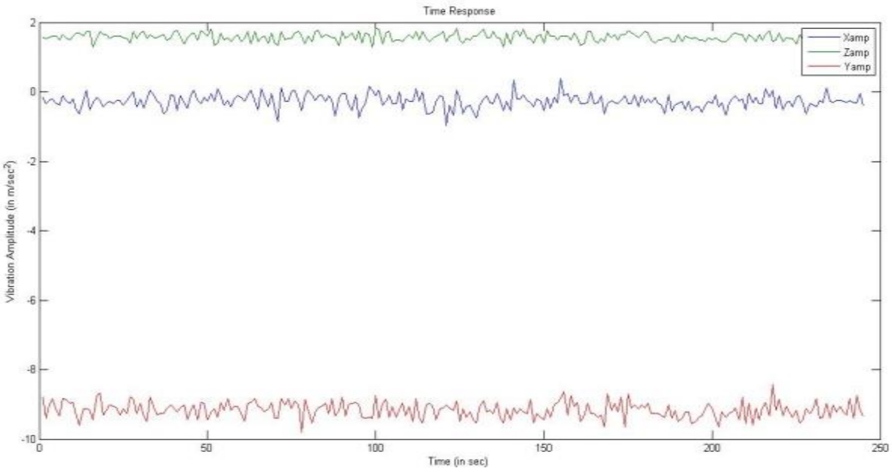
(c)



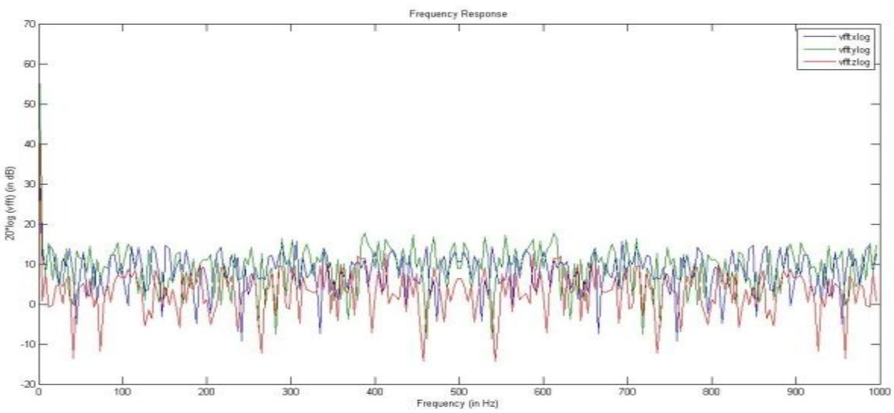
(d)

Fig. 5

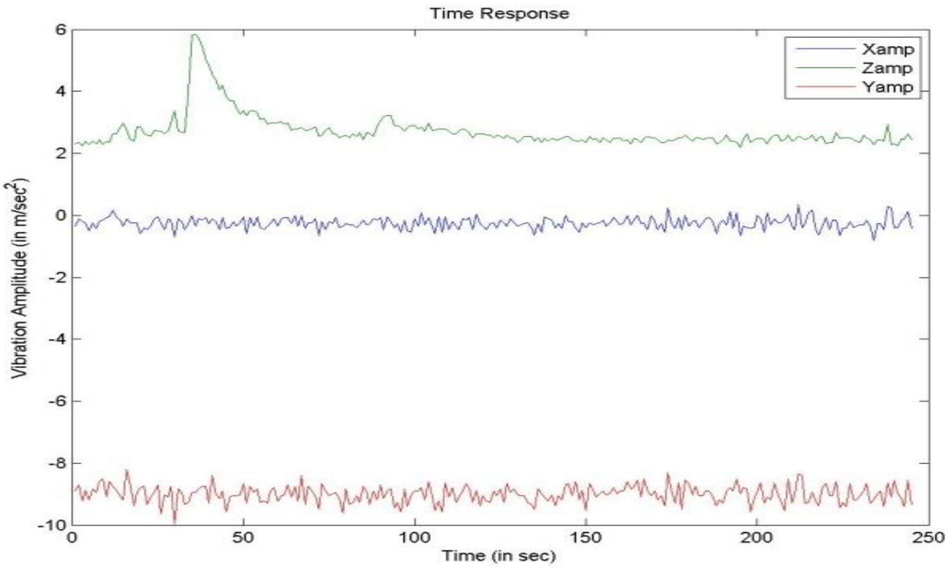
Fig.5 (a) and (c) Time response of brass and mild steel at 280 rpm respectively.
Fig.5 (b) and (d) Frequency response of brass and mild steel at 280 rpm respectively



(a)



(b)



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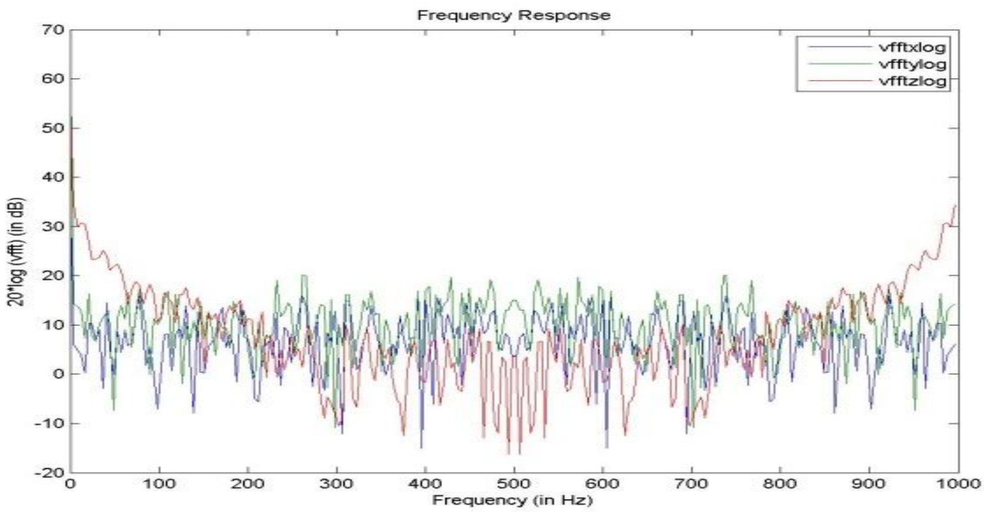
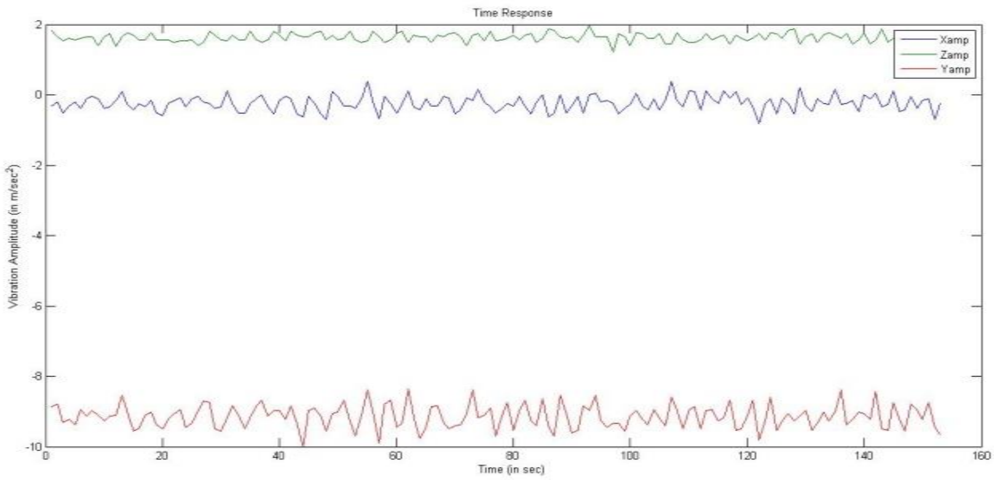


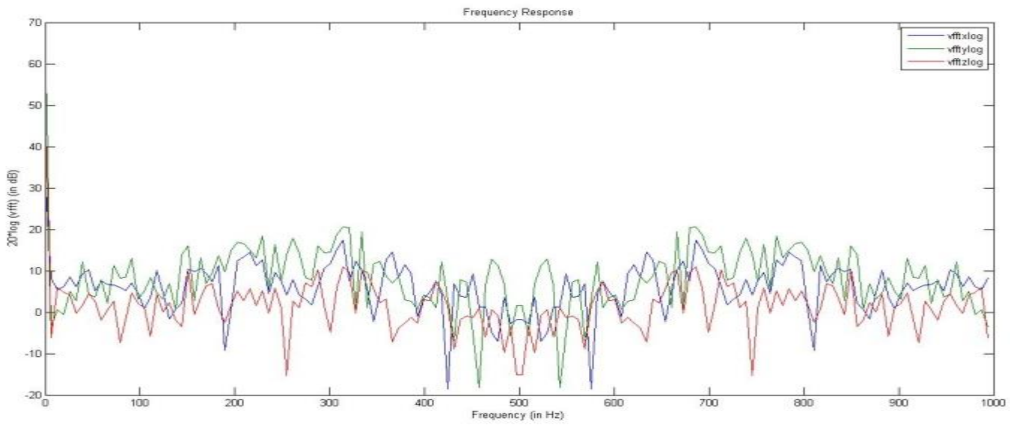
(d)

Fig. 6

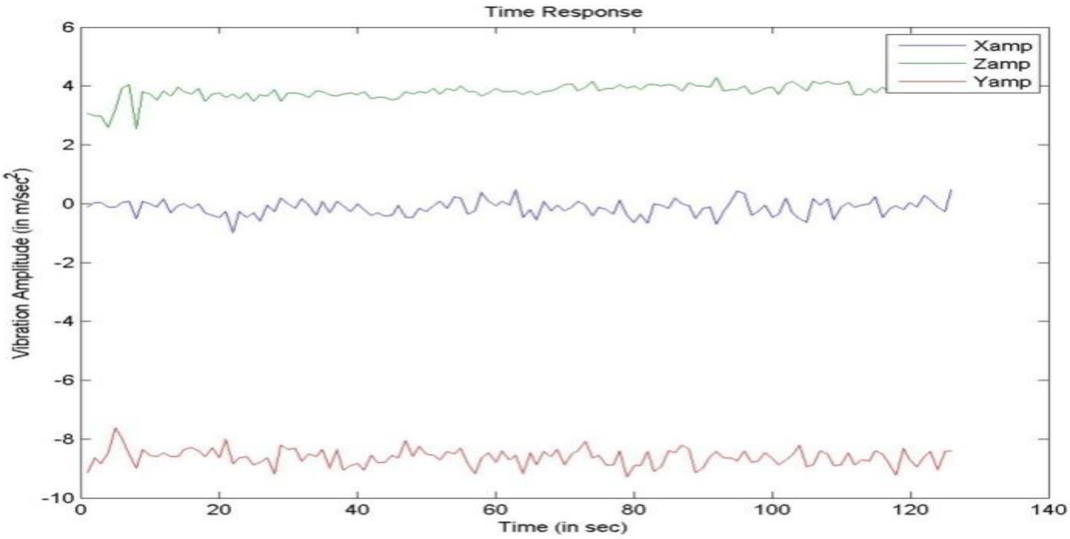
Fig.6 (a) and (c) Time response of brass and mild steel at 450 rpm respectively.
Fig.6 (b) and (d) Frequency response of brass and mild steel at 450 rpm respectively



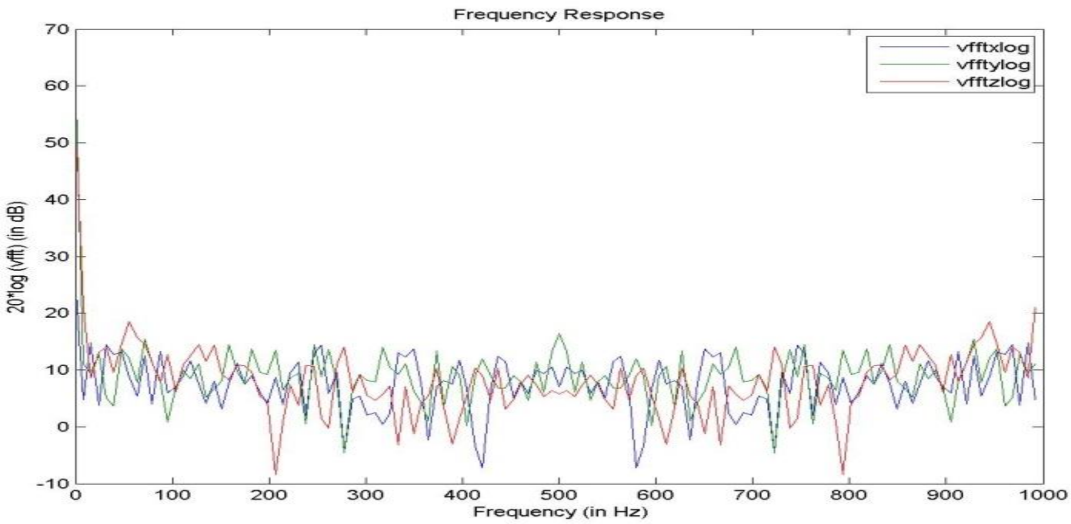
(a)



(b)



(c)



(d)

Fig.7 (a) and (c) Time response of brass and mild steel at 710 rpm respectively. Fig.7 (b) and (d) Frequency response of brass and mild steel at 710 rpm respectively

Graph between time (in sec) on x-axis and vibration amplitude (in m/sec^2) on y-axis is plotted for time response and similarly graph between frequency (in Hz) on x-axis and 20*log (vfft) (in dB) on y-axis is plotted for frequency response. The cutting tool vibration signal for brass and mild steel at cutting speed 280 rpm, feed rate 0.05 mm, and depth of cut 1.0 mm is shown in Fig. 5. It clear from the graph for the time response the intensity of the vibration for the mild steel is slightly greater than the brass while for frequency time response there are lot of peaks for the both the brass and the mild steel. For time response as shown in fig. 6 in mild steel there is a sudden peak in the vibration amplitude as compared to the brass and for the frequency response the initial vibration of mild steel is slightly greater than the brass. As shown in fig. 7 for time response in mild steel the vibration amplitude is almost constant throughout the time period while for the brass it slightly increases and then becomes constant while in frequency response for the brass vibration amplitude is slightly reduced at some frequencies.

V.CONCLUSION

This paper presents analysis and monitoring of vibration signal in terms of time domain and frequency domain. By analyzing the above graphs it may be concluded that the intensity of vibration intensity increases as the cutting speed increases by keeping the feed rate and depth of cut constant for the brass and mild steel and this work can be further extended by changing the parameters for some other materials.

VI.ACKNOWLEDGEMENT

It is with great pleasure and pride that we are presenting this paper before you. At this moment of triumph, it would be unfair to neglect all those who helped us in the successful completion of this project work.

We express our deep sense of gratitude to Associate Professor I.S. Rajay Vedaraj from the department of SMBS (School of Mechanical & Building Sciences), VIT University for giving us support at every stage of this project work. We are indebted to his esteemed guidance, constant encouragement and fruitful suggestions from the beginning to the end of this project. His trust and support inspired us in the most important moments of making right decisions.

Also we are thankful to Prof. S. Denis Ashok, Program Manager Mechatronics Division, VIT University for providing a solid background for our project and research thereafter.

REFERENCES

[1] Suratsavadee Korkua, Himanshu Jain, Wei-Jen Lee, Chiman Kwan “Wireless Health Monitoring System for Vibration Detection of Induction Motors” IEEE 2010.
[2] A.S. Weddell, G.V. Merrett, S. Barrow, B.M. Al-Hashimi “Vibration-Powered Sensing System for Engine Condition Monitoring” Electronics and Computer Science, University of Southampton, Southampton, SO17 1BJ, UK.
[3] Ni Dajun, Jing Minqing, Fan Hongwei, Li Meng, Liu Heng, Li Jun “Study on Monitoring and Warning System for High-speed Motorized Spindle Based on Vibration Signals” 2013 Fifth Conference on Measuring Technology and Mechatronics Automation.
[4] Jingqiu Huang, Harutoshi Ogai, Chen Shao, Juanqing Zheng, Izumi Maruyama, Shinji Nagata, Hiroshi Inujima “On Vibration Signal Analysis in Bridge Health Monitoring System by Using Independent Component Analysis” SICE Annual Conference 2010 August 18-21, 2010, The Grand Hotel, Taipei, Taiwan.
[5] Yang Wang, Fu-Xiong Sun, Tun-Shu Huang “Development of On-line Vibration Condition Monitoring System of Hydro Generators” Third International Conference on Machine Learning and Cybernetics, Shanghai, 26-29 August 2004.
[6] He Guanglin, Xu Hongyu “Design and simulation of the vibration monitoring system Based on wireless sensor network” 2012 International Conference on Information Management, Innovation Management and Industrial Engineering.
[7] C.B. Xu, F. H. Wang, Z. J. Jin “Design and Implementation of Vibration On-line Monitoring System of Power Transformer”Department of Electrical Engineering Shanghai Jiao tong University Shanghai, China IEEE 2013.
[8] He Ting-ting, Wang Jing-di, Guo Jie, Huang Hai, Chen Xiang-xian, Pan Jie “A Vibration Based Condition Monitoring System for Power Transformers” Department of Instrumentation Science and Engineering, Zhejiang University,Hangzhou,310027,China IEEE 2009.
[9] Friedel Gerfers, Michael Kohlstadt, Li-Peng Wang, Thomas Northemann, Markus Kuderer, Alexander Buhmann, Yiannos Manoli “An Ultra Low-Noise Vibration Monitoring System” Department of Microsystems Engineering Albert-Ludwigs University 79110 Freiburg, Germany.
[10] K. N. Ede1, E. A. Ogbonnaya, M. T. Lilly, S. O. T. Ogaji and S. D. Probert “ Vibration Monitoring of Rotating Systems” School of Engineering, Cranfield University, Bedfordshire, United Kingdom.
[11] Suresh Bhalla “Vibration Characteristic of Aluminium Cantilever Beam Using Piezoelectric Sensors” Department of Civil Engineering IIT Delhi.
[12] Lorand Szabo, Károly Agoston Biro, Denes Fodor and Erno Kovacs “Improved Condition Monitoring System for Induction Machines Using a Model-Based Fault Detection Approach” Department of Electrical Machines, Technical University of Cluj.
[13] Sunita Mohanta, Umesh Chandra Pati “Monitoring and Analysis of Vibration Signal Based on Virtual Instrumentation” International Journal of Advanced computer Research.
[14] Priyam A. Parikh, Hitesh B. Shah, Saurin Sheth “Development of a multi-channel wireless data acquisition system for swarm robots” International Journal of Engineering Development and Research 2014.
[15] A PDF on ADXL345 Digital Accelerometer.
[16] A PDF on Aurdino Microcontroller Guide.
[17] A PDF on Tool Condition Monitoring in Machining - Neural Networks.
[18] Website: http://arduino.cc/
[19] Website: http://www.instructables.com/
[20] Website:http://www.analog.com/en/mems-sensors/mems-inertial-sensors/adxl345/products/product.html