International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

Vibration Analysis of CNC Machine Spindle using LabVIEW

[1]G.V.V.S.Reddy Prasad, [2]Dr.Mervin A Herbert, [3]Dr.Shrikantha S Rao
[1] Asst. Professor, Sree Vidyanikethan Engineering college, Tirupati,
[2]Asst. Professor, National Institute of Technology, Karnataka
[3] Professor, National Institute of Technology, Karnataka

Abstract: **-- Vibrations are one of the most important aspects in the dynamic stability considerations, especially in high speed machining. In this case, analysis and monitoring of the vibrations in Computer Numerical Control machine (CNC) spindles are of great concern for fault detection and implementing condition based maintenance. In this context, a study on vibration analysis of the CNC machine spindle is carried out by acquiring and analyzing the vibration signals, thereby the tool wear can be predicted. A single axis piezo-electric accelerometer is used to detect the vibration signals and Laboratory Virtual Instrument Engineering Workbench (LabVIEW), a graphical programming language, is used for acquiring and analyzing the signals. A graphical user interface was developed to represent the condition monitoring in a very effective way. The LabVIEW based condition monitoring system was found to be easier and accurate.**

Keywords**—Computer Numerical Control machine, LabVIEW, Vibration monitoring system.**

I. INTRODUCTION

Vibration is the harmonic, periodic, and random motion of a rotating machine. Misalignment and looseness commonly generate vibrations in operating machines, and even a small amount of imbalance can cause severe damage to the machinery. Hence it is absolutely essential to ensure reliability and accuracy of rotating machinery which can be achieved by monitoring and analyzing. Vibration monitoring of machine tools also helps in monitoring the tool life, tool integrity, part quality and preventing unexpected tool failure causing unscheduled downtime.

The objective of the present work is to analyze the vibrations in CNC spindle using LabVIEW software.

II. LABVIEW

The present work requires vibration analysis to be carried out in LabVIEW software. Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a platform and development environment for a visual programming language from National Instruments. It is gaining its popularity especially for data acquisition and measurement. One area of application of LabVIEW is in the monitoring and analysis of vibration signals. It usually follow a three-step process: data acquisition, data analysis and data visualization/presentation.

LabVIEW is designed to facilitate data collection and analysis, as well as offers numerous display options. With data collection, analysis and display combined in a flexible programming environment, the desktop computer functions as a dedicated measurement device.

Graphical User Interface (GUI) is a software that works at the point of contact (interface) between a computer and its user, and which employs graphic elements (dialog boxes, icons, menus, scroll bars) instead of text characters to let the user give commands to the computer or to manipulate what is on the screen. LabVIEW makes it easy to design graphical user interfaces (GUIs) for our measurement applications. One can interact with data using hundreds of drag-and-drop controls, graphs, and 3D visualization tools and also customize the size, position, and color of built-in controls or create our own in seconds.

III. METHODOLOGY

To monitor vibrations, a sensor that separates the frequency and quantifies the amplitude, is used. Because vibration frequency and amplitude cannot be measured by sight or touch, an instrument is needed which helps to convert the vibrations into a usable quantity that can be processed and displayed along a frequency axis. An accelerometer is the device that measures vibration or acceleration of a structure. Piezoelectric accelerometers use materials such as crystals, which generate electric potential from an applied stress. As stress is applied, such as

IFERP
connecting engineers... developing research
ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

acceleration, an electrical charge is created.

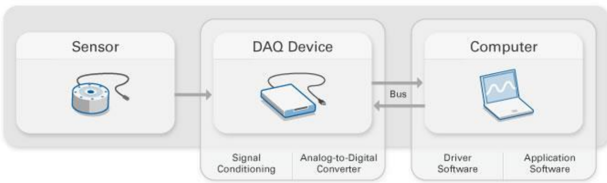

Fig 1. Overview of the Process flow

Dynamic data acquisition has always been at the heart of every sound and vibration application. The signals from accelerometer are captured by a device known as Data Acquisition system. The fundamental task of a Data Acquisition system is to measure or generate real-world physical signals i.e., a DAQ hardware acts as the interface between a computer and signals from the outside world. Data acquisition involves gathering signals from measurement sources and digitizing the signal for storage, analysis and presentation on a personal computer (PC). However, it is not enough to simply acquire the data – one should also be able to analyze, process, and interpret the raw data into meaningful content. Also, the signals from accelerometer are analog and of very small magnitude. They require little signal conditioning like amplification, current excitation, AC coupling, grounding, and filtering. Hence we need an application software to perform these functions.

Lot of research in the analysis area suggests the usage of LabVIEW software as one of the best analysis tool. A LabVIEW program has been developed to read the data from DAQ and develop the steps for signal processing. Then condition monitoring by comparing the acquired signals with reference signals and identifying faults in the system. GUI is also developed for making it easy to display the condition of the spindle. It also gives a warning message if vibrations exceeds its range.

IV. EXPERIMENTAL SETUP

The set up consists of a vertical CNC milling machine, an accelerometer to sense the vibrations, a DAQ system to acquire data and a PC to store and analyse data through LabVIEW.

Fig 2. Experimental setup

Details of the Apparatus

A. CNC machine

The CNC milling machine considered was manufactured by Ace Manufacturing Systems (AMS). It is named as Spark version by AMS. It has a longitudinal table traverse (X-axis) of 300 mm and cross level traverse (Y-axis) of 250 mm. Spindle speed ranges from 60-6000 rpm.

B. Accelerometer

The accelerometer used is a single axis YMC 121A100 IEPE accelerometer. It has a sensitivity of 97.71mV/g. The specifications are:

- Measuring range: ± 50g
- Excitation current: 2 to 10 mA
- Frequency range: 0.5 to 8000 Hz
- Sensitivity: 97.71 mV/g

Fig 3. Sensor fixed to the spindle

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

C. DAQ system

The DAQ considered is NI 9234. It is a 4-channel C Series dynamic signal acquisition module for making high-accuracy audio frequency measurements from integrated electronic piezoelectric (IEPE) and non-IEPE sensors with NI CompactDAQ or CompactRIO systems. The NI 9234 delivers 102 dB of dynamic range and incorporates software-selectable AC/DC coupling and IEPE signal conditioning for accelerometers and microphones. The four input channels simultaneously digitize signals at rates up to 51.2 kHz per channel with built-in anti-aliasing filters that automatically adjust to your sampling rate.

Fig 4. Front Panel of the LabVIEW program

D. Cutting tool:

The main tool for consideration is 50 mm dia face mill. The ISCAR made tool belong to the family F90 SD-12. The designation of the tool is given by F90SD D 50-22-12. The tool inserts are Heliquad inserts with four helical cutting edges, for general use 90° shoulder milling. The designation of the insert is SDMT 1205PDN-RM-IC910.

E. Work Piece

The work piece used is of cast iron material. The dimensions are 60 x 40 x 35 mm.

V. PROCEDURE

The accelerometer is mounted on the spindle. It is connected to DAQ system through BNC cable. DAQ is connected to the PC and a LabVIEW program is coded to read the data from sensor. Machining operation is performed using a face mill tool. Initially machining is performed using new inserts and the signals are taken. Then the new inserts are replaced with worn out inserts and the signals are taken. The time domain signal from the sensor output is captured through the DAQ and the data is saved as LVM files using LabVIEW.

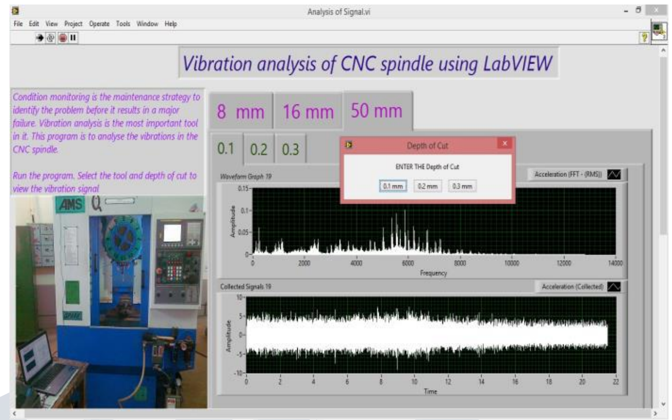

Fig 5. Front Panel of the LabVIEW program

A LabVIEW code is developed to read the data from LVM file. Then the data is analyzed using another LabVIEW program. The operator gets the information through GUI.

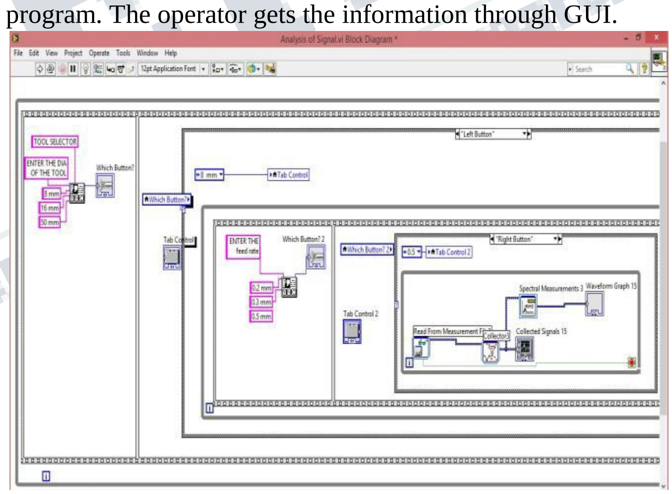

Fig 6. LabVIEW program for Analyzing the signals

Once the data is saved, the spindle vibrations are monitored by comparing the run time values with the saved values. The amplitude of vibrations will be more in a worn out material. Using LabVIEW code, Compare the peak values with that of previous values and based on the difference, the user is notified about the health level of the selected tool. Observe the difference between RMS values also.

IFERP
connecting engineers... developing research

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

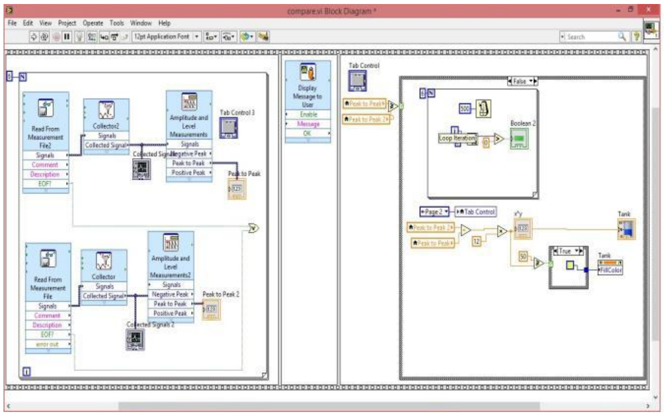

Fig 7. LabVIEW program for comparing signals **4**

If the peak value of the monitoring tool crosses the peak value of the worn out tool, the PC gives alarm to the user to check the tool condition.

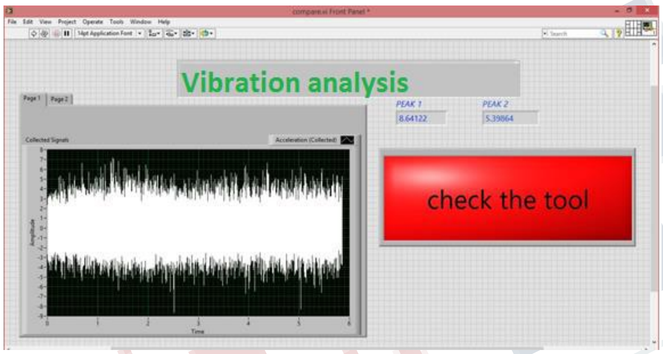

Fig 8. GUI giving warning message

VI. RESULTS AND DISCUSSIONS

Graphs showing the variation of peak values with varying depth of cuts for different tools are presented in the following sections. Vibration signals of the different components were taken. The signals from the spindle when it is running at 1500 rpm (without machining), when it is at idle condition (at zero rpm), and finally when the machine is switched off were recorded. The data from the air compressor was also recorded. The signals from the machine when it is externally excited was considered to observe the natural frequency of the machine.

The natural frequency of the tool was observed to be 6238 Hz. The maximum peak values and RMS values observed for the face mill of 50 mm diameter are given in Table 1.

Face mill 50 mm dia	Maximum Peak Value(units of g)		RMS value (units of g)	
Depth of cut (mm)	New tool	Worn out tool	New tool	Worn out tool
0.1	5.83354	9.0392	0.8832	1.0374
0.2	6.27144	11.9007	0.9342	1.1127
0.3	6.30267	15.3472	0.9979	1.1763

Table 1. Peak and RMS values at various depth of cuts

The graph in Fig 9 shows the variation of peak amplitude with varying depth of cuts for new tool and worn out tool.

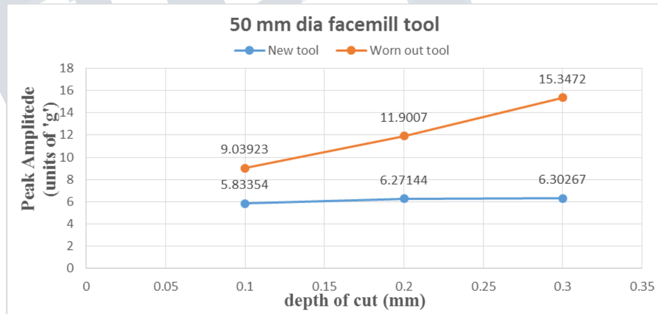

Fig 9. Peak amplitude vs depth of cut for 50 mm dia tool

A peak at 25 Hz was observed in every curve which is because of the spindle speed running at 1500 rpm. It is equal to 25 rps and hence the peak at 25 Hz.

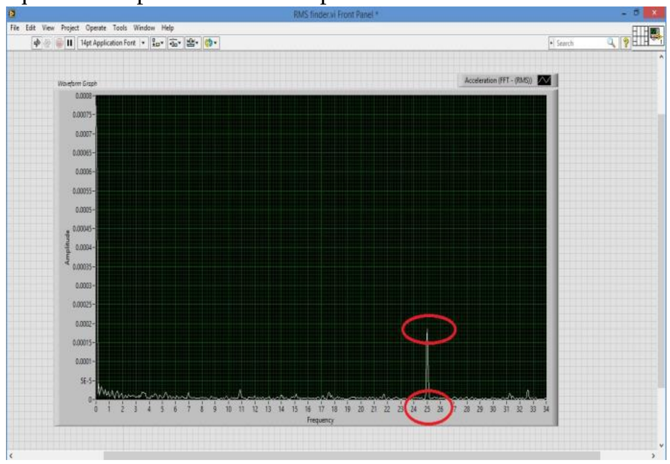

Fig 10. Peak observed at 25 Hz

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 4, Issue 3, March 2017

A peak was observed at 48 Hz in all the signals. This is because of the air compressor which is running at 2880 rpm (48 rps).

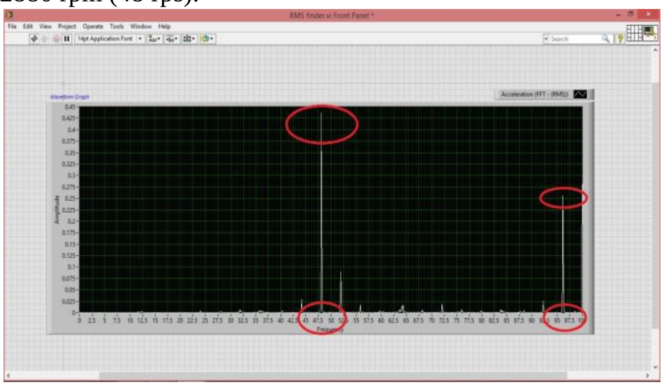

Fig 11. Peak at 48 hz

From the vibration signals data taken at free run, the observed peaks at 4000 Hz and 8000 Hz, as shown in Fig 12 indicates the natural frequencies of some of the machine parts.

Fig 12. Peaks at 4000 hz and 8000 hz

VII. CONCLUSION

The vibration analysis using LabVIEW software and thereby monitor the health of the cutting tools It is concluded that, analysing the vibrations of the system can describe the condition of the system more effectively. One can also get the information on the effect of other machinery on our machine. In future, by implementing online monitoring, the tool condition can be known from time to time and hence tool change can be done only when it is necessary. By adopting this condition monitoring, the life of the cutting tools can be increased which also helps to reduce the cost of production.

REFERENCES

[1] Asan Gani and M.J.E.Salami (2002) "A LabVIEW based Data Acquisition System for Vibration Monitoring and analysis." Student Conference on Research and Development Proceedings, Shah Alam, Malaysia

[2] Choudhury S.K., Goudimenko N.N. and Kudinov V.A. "On-Line control of machine tool vibration in turning." International Journal of Machine Tools & Manufacturing, 1996; 37 (6): 801-811.

[3] Dimla D.E. "Sensors signals for tool-wear monitoring in metal cutting operations - A Review of methods". International Journal of Machine tools and Manufacture, 2000; 40: 1073–1098.

[4] Feng Yong Nan "Using LabVIEW and DAQ to Design a PC-Controlled CNC Mill", a case study by NI. http://sine.ni.com/cs/app/doc/p/id/cs-14034.

[5] Grzelak, Andrew (2012), "Improving Manufacturing Processes Through Energy Monitoring". College of Technology Masters Theses - Paper 61.

[6] Kurada S. and Bradley C. "A review of machine vision sensors for tool condition monitoring." Computers in Industry, 1997; 34: 55–72.

[7] Li Bin, Zhou Yun-fei, Tang Xiao-qi (2004) "A research on open CNC system based on architecture/component software reuse technology" Computers in Industry 55 (2004)

[8] Li X. "Real-time tool wear condition monitoring in turning", Int. J. of Production Research, Taylor & Francis Ltd., 2001, 39, 5, 981-992.

