MONITORING AND ANALYSIS OF VIBRATION SIGNAL BASED ON VIRTUAL INSTRUMENTATION

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Abstract

Machine plays a vital role in the plant. Maintenance is a very important factor for a machine, which is required regularly. Vibration monitoring and analysis is a predictive maintenance technique by which the faults can be detected in the machines. In this work, data acquisition system (hardwaremodule9234), signal analysis and lab VIEW are used to detect various faults which occur in the machine. As a result, the necessary control action can be taken on the machine in advance. For processing and analysis of vibration signal, time domain and frequency domain analysis of vibration signal is implemented. Spectrum analysis has provided more accurate information about the vibration signal type, signal fault region and fault extent as compared to time domain analysis.

Keywords

Virtual instrumentation, Data acquisition, Vibration signal analysis, Power spectrum and LabVIEW.

1. 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.

The nature of signal to be measured and dictated the degree of sophistication required in the acquisition system. Numerous ways are available to transfer the data into a computer .Data Acquisition Card (DAQ) card is one of the module that interfaces the physical performance in the real world to the digital computation of artificial world. It is easy to use, multifunctional and less costly than other data transfer device.

Computers have played a vital role in process monitoring and control. Over the time, their scope has phenomenally increased .Earlier GPIB was the most popular interfacing for test and measurement instruments as prior to virtual instrumentation (VI). VI has emerged into a multifaceted technique that encompassed the entire area of computer based instrumentation. To a large extent, hardware is also reduced. For these advantages, VI has made as the dominant tool for the expansion and contrivance of instrumentation applications and systems. Lab VIEW (laboratory virtual instrument engineering workbench) may be interfaced with various instruments as the driver software which is easily available. Many applications like controlling and monitoring are done by lab VIEW software [1].

This paper is organized as follows: the various maintenance techniques are described in Section 2.Component of the proposed system is described in Section 3.The algorithm for vibration signal monitoring system is presented in Section 4. The simulation result along with discussion is described in Section 5. This paper is concluded in Section 6.

2. Various Maintenance Techniques

Maintenance is required in regular interval of time. There are various types of maintenance techniques of a machine through which the fault can be detected. In break down maintenance, regular servicing of machine is not done until the machine breaks down. In preventive maintenance, machine requires regular maintenance after stipulated time period whether the machine runs or not. At that particular period, the work of machine has been stopped. It is costly

method of maintenance because production has been stopped at that period. In predictive maintenance, the performance & relative data of machinery have been collected. This helps for planning the maintenance of machinery in advance that results less maintenance cost. Due to smooth efficiency and productivity, the operating cost can be reduced. It is called on line condition monitoring of the system. Predictive maintenance technique includes vibration monitoring system [2].

Vibration occurs when a machine runs. It is an important technique in which internal faults of the machine can be easily detected. There are various causes for which vibration occurs. These are repeating force, looseness, resonance etc. By vibration monitoring, the preventive action can be taken on the machine. Control action can be done on the machine in advance. Vibration signal processing and monitoring are performed by two process. One is time domain signal processing. This signal analysis gives the real time signal and extracts the signal characteristics like value of amplitude, time & phase characteristics. Another one is frequency domain analysis. The various information like amplitude, phase, power spectrum, Fast Fourier transform (FFT), a windowing action, filtering are obtained by this signal analysis [3]. This analysis gives more information about the signal & signal system through which it is generated. It is good as compared to time domain analysis.

3. Components of Vibration Monitoring System

Vibration monitoring and Analysis system consists of following components: sensor system, vibration signal acquisition, vibration signal analysis, vibration signal processing, vibration signal display and recording [4].The structure of the vibration monitor system is shown in Fig.1.
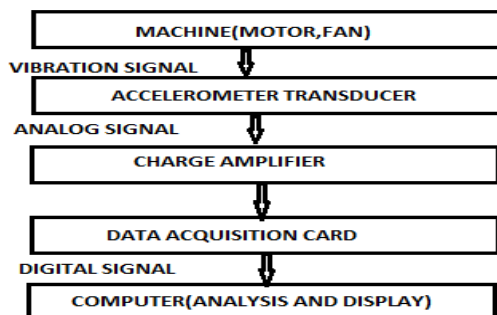

Figure 1: Component of vibration monitoring system

In vibration monitoring system, different components like accelerometer transducer, amplifier, data acquisition card, and computer are required. For controlling of machine, motor control unit is required.

Machine condition monitoring and analysis is an important role in the plant. Because any damage in machine causes a great loss. In vibration analysis, vibration transducer is mounted with machine. Accelerometer transducer is used as a vibration transducer. When vibration occurs in machine three parameters are changed. These are displacement, velocity and acceleration of machine. Accelerometer transducer is directly proportional to the velocity, displacement, acceleration and frequency of signal. By above factors, the machinery condition can be accurately diagnosed. Charge amplifier gives the moderate voltage output that satisfies to data acquisition card. The hardware module 9234 is used as a data acquisition card. Data acquisition card must have high acquisition rate, because if the vibration of the machine increases, consequently velocity of the machine also increases. The acquisition rate must also be increased to prevent aliasing effect of the wave form and to calculate the component frequency of the displacement.

4. Algorithm

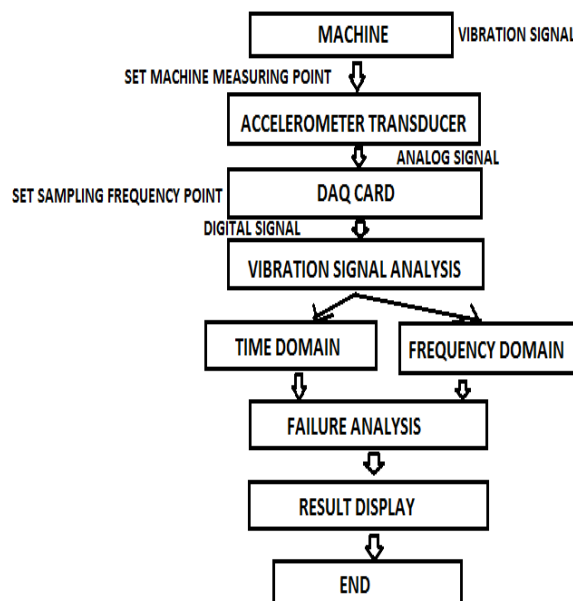Flow chart for vibration signal monitoring system is presented in Fig.2.

Figure 2: Flow chart for vibration signal analysis

The algorithm for vibration signal monitoring and analysis is discussed in following steps:-

(i).   First a machine measuring point is selected in terms of acceleration, velocity and displacement in normal running condition of machine.

(ii).   Comparison of above three parameters with machine measuring point is done after vibration is created in the machine.

(iii). High sampling frequency or high acquisition rate is set.

(iv).   The vibration signal processing and analysis is done in time domain and frequency domain for finding the fault of vibration signal.

(v).   Time domain analysis is done by first and second integration of acceleration of vibration signal.

(vi).   The spectrum analysis is performed by fast Fourier transform (FFT), windowing, digital filter.

(vii). Failure analysis is done by comparing above two signal processing method.

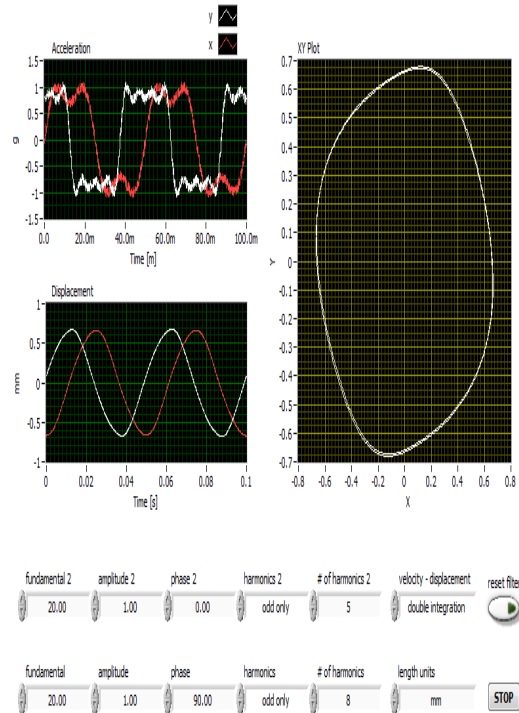(viii). Fault regions are obtained and result is displayed. So that the control action can be taken.

5. Simulation Result and Discussion

Using the first and second integration of acceleration for vibration signal, the analysis of vibration signal is performed. The block diagram of double integration of acceleration is shown in fig.3.The front panel of double integration of acceleration is shown in fig.4.

Figure4: Front panel of double integration acceleration.

By simulating the block diagram which is shown in Fig.5, the fault reason and fault extent is determined.
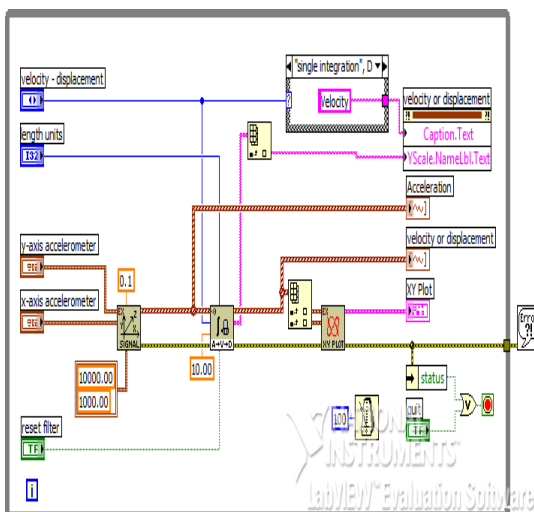

Figure 3: Block diagram of double integration of acceleration
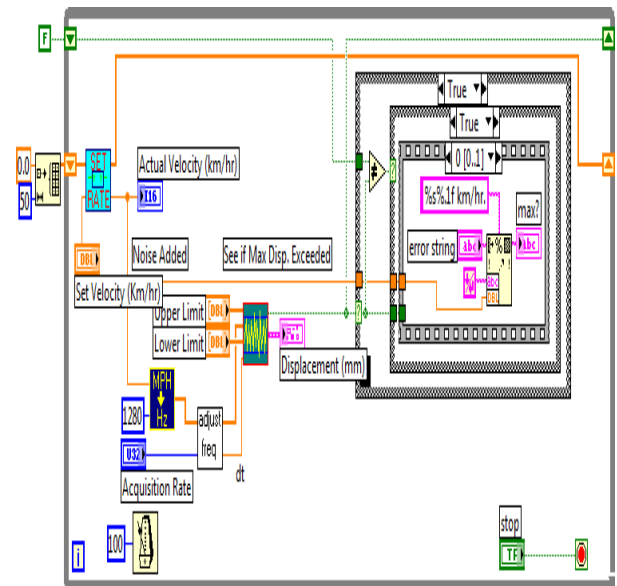

Figure 5: The block diagram   of vibration signal processing in time domain

In this block diagram, time domain analysis of vibration signal is performed. Here, the set velocity and actual velocity are set. Here, the upper and lower limit of the displacement are set as machine measuring point at normal condition.. If the maximum displacement exceeded the lower limit and higher limit, then a red indication has appeared. So that control action can be done but it is difficult to find .The output displacement of the vibration signal is displayed in the graph in time domain. It is shown in Fig 6. From this graph it is difficult to find the exact fault of the vibration signal. It is also difficult to find the fault region.
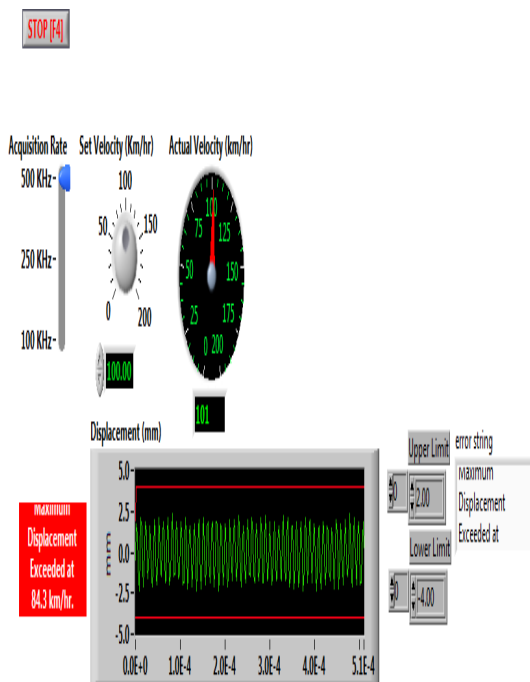

Figure 6: front Panel of time domain analysis

This above front panel shows that maximum displacement exceeds the limit. A red indication has appeared and the exact velocity is obtained at which the maximum displacement exceeds the upper limit. But it is difficult to find the exact region of fault by analyzing the front panel which is shown in fig.6.

For avoiding the difficulties in time domain analysis, frequency domain analysis is performed. Velocity which is in time domain is converted to frequency domain using FFT algorithm, which is shown in Fig.7.the frequency domain of vibration signal is presented in power spectrum in Fig.8.
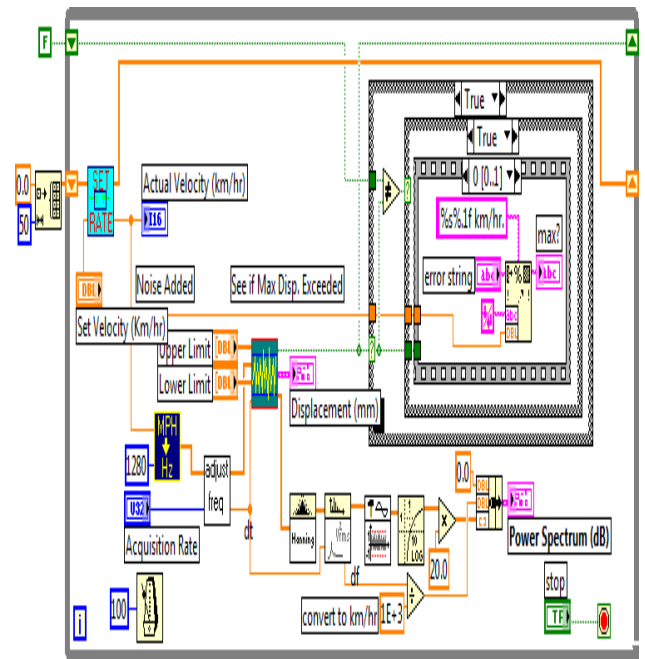

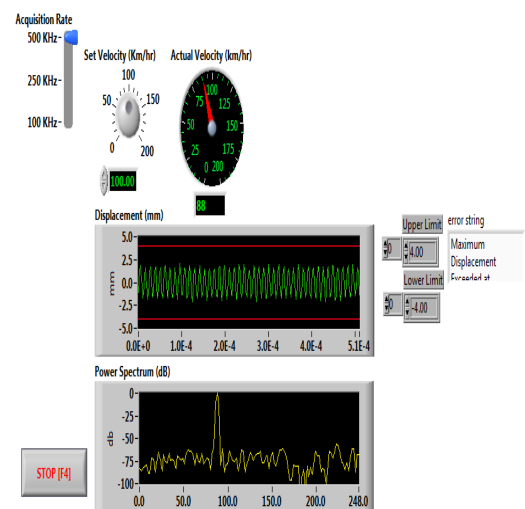**Figure 7: Block diagram of spectrum analysis**

Figure 8. Front panel of power spectrum analysis

The comparison of vibration signal in time domain and frequency domain is presented in fig8. The data acquisition rate has been increased to prevent aliasing of the waveform and to get accurately frequency component of the displacement. The vibration signal is not a sine wave in the power spectrum .Power spectrum has a spike graph. From this the exact frequency component of fault location

is obtained. It is easy to find the component of a machine in which fault has occurred. So that replacement of component is done immediately. It is much better analysis compared to time domain analysis.

6. Conclusion

This paper presents analysis and monitoring of vibration signal in terms of time domain and frequency domain. In time domain analysis, it is difficult to find the fault region and fault type. The fault of vibration signal is not clearly obtained from displacement graph which is in time domain. So, frequency domain or power spectrum analysis of vibration signal is performed and the fault type and fault region are easily detected by this analysis. By comparing the two analysis, it is obtained more information about the type of vibration signal, type of signal fault, fault region from the spectrum analysis. It helps in taking preventive control action immediately.

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