Design of Spindle Vibration Testing System Based on Lab VIEW

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Abstract: A spindle vibration testing system is developed with necessary sensor, signal conditioner and data acquisition card based on LabVIEW software in this paper. The spindle vibration testing and analysis system is formed based on virtual instrument graphical programming language LabVIEW. The hardwares are reduced in testing process. At the same time, acquisition, processing and analysis for vibration signal are realized, and the costs of hardware are greatly reduced. The testing work is made more convenient and quick by this system, and test is made more intuitive by its real-time display function. The system is mainly used in spindle vibration detection on cotton, wool and hold. Meanwhile, it is also instructive to other low-frequency signal analysis. This system has low energy, cost-effective, simple and friendly interface, stable and reliable performance relative to traditional instruments.

Keywords: LabVIEW; spindle; data acquisition; vibration signal analysis

Spindle is the main component of twisting and winding. The production and quality of yarn are directly affected by spindle's operation situation. So spindle plays an important role in the development of textile industry. Currently the vibration test for spindle is mainly based on the combination of traditional instruments. It has Large size and energy system, poor working conditions and low work efficiency. The accuracy and reliability of the test results are not high. A data acquisition and analysis system for spindle vibration signal is formed by using LabVIEW software and data acquisition card in this paper. Test hardwares are reduced by using the method that software is the instrument. Collected signals are displayed in the form of waveform and text when the system is in the collection of the vibration signal. An analysis and processing for the vibration signals is done in the time domain, frequency domain, and amplitude domain. Data storage and playback are completed in the file management module. This system is easy to operate, friendly interface, and can be widely used in all kinds of vibration test.

1. Composition of the spindle vibration testing system

Spindle vibration testing system mainly consists of two parts. One part is the sensor measuring system which includes vibration sensor, Signal Conditioner and related measurement part. Its role is to gather the spindle signals,and make the signals become standard voltage or current signal. The other part is displaying, processing and analysis system for the measurement data. Its role is to receive signals and display the specific vibration, while all further analysis and processing[1].

2. Hardware structure of the test system

This testing system picks vibration signals through the sensors and converts it into electrical signals. The signal is passed to the computer by the DAQ board after signal conditioning of the signal filtering and amplification, and then is processed by the computer software. Figure 1 is the schematic diagram of hardware.

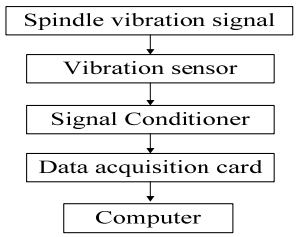

Figure 1. Hardware of the test system

2.1. Configuration of the sensor

The sensor of vibration signal measurement mainly contains speedometer and speed sensor. This system uses non-contact assolenoid style. It adopts high-performance components which call SMR as sensitive components, and uses them to measure dynamic vibration and acceleration. It contains magnet head, and is installed 1mm above the body surface. It is used to measure vibration signal which is in parallel with the axial direction.

It outputs alternating voltage signal when measuring the spindle vibration. It outputs signal of approximate 4V dc voltage when there is no vibration (Operating voltage

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DC12V). When there is vibration, the output is the AC signal which is superimposed on the DC voltage. As shown in Figure 2.

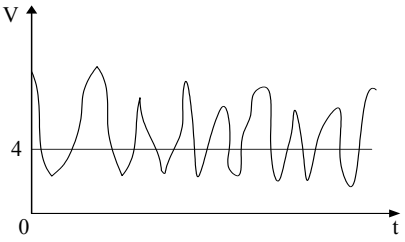

Figure 2. Sensor output waveform

2.2. Configuration of Data Acquisition Card

Data Acquisition Card whose precision and speed affect the overall performance of the testing system is the important component of virtual instrument system. This system is used in Advantech's USB-4711A Data Acquisition Card. It obtains the necessary power through the USB port without external power supply. USB-4711A is a 12-bit multifunction module with 150kS/s maximum sampling rate. It provides 16 single-ended/8 differential AI channels along with 2 AO channels. It also offers 8 TTL DI/O channels for on-off control applications. Besides, one 16-bit counter channel is available onboard. These are enough to meet the testing requirements[2]. Spindle vibration signal which is collected from experiment is low-voltage analog signal, and the signal is generally less than 10V. This Data Acquicition Card whose signal input range is ± 10V can meet the requirements. Signal which has been conditioned is connected to the removable screw eyelet terminals by using single-grounded approach. Data Acquisition Card is accessed to USB port.

3. Software design of the test system

Advantech's USB-4711A Data Acquisition Card is used in the test system. User Libraries-Advantech DA&C will be automatically generated in LabVIEW after acquisition card hardware drivers is installed. Software part of the system includes data acquisition, data processing, display and storage. The block diagram of test system is shown in Figure 3.

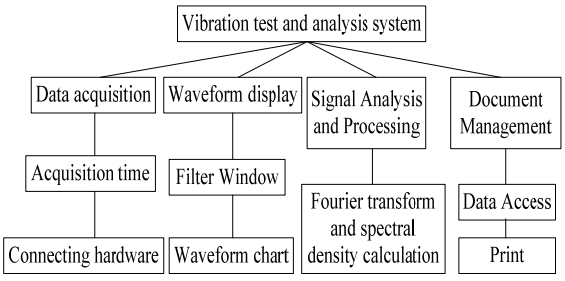

Figure 3. Block diagram of the test system

System's program is designed in the way of the main menu, primarily for the purpose of the system's expansion[3]. When new features are added to the system, only the content is added in the main menu without the need to make changes to the entire program. This makes the expansion of the system very convenient, and fully embodies the advantages that software is instrument. The basic idea of structured and modular programming is used in the programming process. The Program includes four modules, data acquisition module, signal analysis module, document management module and display module.

3.1. The data acquisition module

Data acquisition is a process which the various parameters (which can be physical, it can be chemical, biomass, etc.) of the measured object (external world, on-site) are finally sent to the computer for data processing or storage records. Appropriate conversion is made through a variety of sensing devices before the signal conditioning, sampling, quantization, coding, transmission and other steps. Complete sets of equipment for data collection is known as Data Acquisition System. It is not only the contact bridge of virtual instrument and external world, but also an important way to get information[4].

Data acquisition module is the main control of the various acquisition parameters, for example the choice of Data Acquisition Card, the selection of data acquisition channel, the calibration of the sensor signal, the filtering of sampling signal, data storage, etc. As is shown in Figure 4, sub-functions of Advantech Data Acquisition is mainly called. The analog signal can be real-time collected with this module.

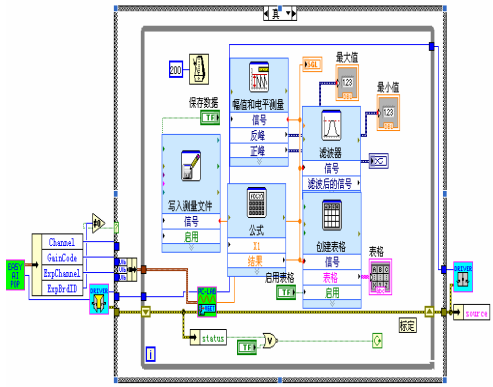

Figure 4. Program modules of the data acquisition

3.2. Signal Analysis Module

Analysis of the signal can be divided into time domain analysis and frequency domain analysis, which are the two different angles and sides of signal analysis. They can reflect some characteristics of the signal, and the two analysis methods are usually necessary in practice[5]. Time domain analysis is the research that the output signal of the system changes over time in the time

domain. Due to time-domain analysis is directly analysis method of the system in time domain, so the time-domain analysis has the advantages of intuitive and accurate. Spindle vibration signal in time domain is shown in Figure 5.

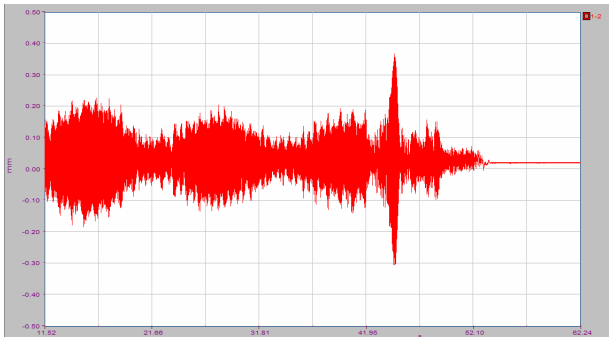

Figure 5. Spindle vibration signal in time domain

Frequency domain analysis is that the time course of the test signal is changed by Fourier transform to the frequency domain for analysis and processing. It is the most important method of signal analysis. Spindle vibration signal in frequency domain is shown in Figure 6.

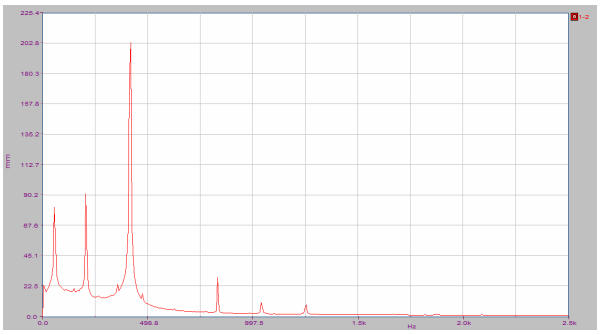

Figure 6. Spindle vibration signal in frequency domain

4. Analysis of test results

When the Program is running, the type of Data Acquisition Card is firstly selected before the collection channel.. Data is collected , and at the same time signal filtering is performed after the basic parameters of the sampling frequency is set. The collected signal is shown in the form of waveform, and the maximum and minimum of collected data is real-time displayed. When the Save Data button is pressed, data can be saved in the document of the specified path. The front panel of data acquisition is shown in Figure 7.

It can be seen from Figure 7 that output value of the panel is the voltage signal, and the unit is mV. The front panel shows the voltage measurements, as shown in Table 1.

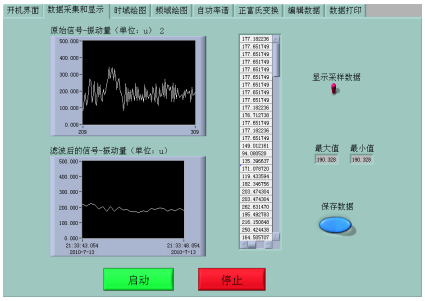

Figure 7. Vibration signal acquisition of the spindle

Table 1. Table of voltage measurements

Cycle	Vibration(mV)		
	Max	***Min***	***Vpp***
1	0.845	-0.668	1.514
2	0.777	-0.937	1.714
3	0.904	-0.859	1.763
4	0.567	-0.800	1.367
Average	0.773	-0.816	1.589

The displacement of the spindle vibration can be approximately calculated through sensor calibration, so spindle vibration measurement is achieved. After calibration, the measurements of spindle vibration are shown in Table 2.

Table 2. Table of vibration measurements

Cycle	Vibration(mm)		
	Max	***Min***	***Vpp***
1	0.02501	0.01907	0.00594
2	0.02493	0.01877	0.00616
3	0.02404	0.01841	0.00563
4	0.02523	0.01895	0.00628
Average	0.02480	0.01880	0.00600

It can be seen from the data in Table 2 that the maximum and minimum reflect the offset distance between spindle top swing and sensor contactor. Peak-to-peak value reflects the vibration of spindle top swing. As the spindle is rotating part, so its vibration will shows a certain periodicity. Vibration datas of four cycles which are processed in average are chosen in Table 2. The test results are more accurate.

5. Conclusions

Data acquisition and signal analysis system of spindle vibration is constructed in this paper by using virtual instrument development platform of LabVIEW. This system has the following characteristics.

⑴Graphical programming software LabVIEW which is extremely popular in the current measurement field is used as development platform, so programming efficiency and software quality are improved.

⑵Different types of data can be read. Signal is analyzed and processed in time domain and frequency domain, and features of signal are correctly extracted. Appropriate real-time display is in the system.

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(3)A friendly interactive interface is in the system. The test system not only can be used in spindle-line testing of wool, cotton, linen, but also can be used for other rotating machinery.

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