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Vibration Signal Analysis of Washing Machine Based on Method of Lissajou's Figure

Chunyou Zhang, Xiaoqiang Wu, Xiaomin Shan

Department of Mechanical Engineering, Inner Mongolia University for the Nationalities, Tongliao, 028000, China

Abstract: With the development of economic and improvement of living standards, washing machine becomes one of the most commonly used appliance in the family. So, the performance and service life is directly related to the quality of people's lives. Thus, this paper uses the form of test to analyze the vibration signal of washing machine. Firstly, the eddy current sensor is installed at the position of near the washing machine, and the program of data acquisition is compiled in the software of Labview to collect the signal on the sensor. Then, the figures are plotted by using the measured data in the software of MATLAB. Finally, the phase difference and frequency of washing machine vibration signal are obtained by compared with Lissajou's figure. It provides the reference for the optimization design and manufacturing of washing machine.

Keywords Eddy Current Sensor, Data Acquisition, Lissajou's Figure

INTRODUCTION

With the development of economic and improvement of living standards, washing machine becomes one of the most commonly used appliance in the family. So, the performance and service life is directly related to the quality of people's lives. It is vital for the performance to study the stationarity of washing machine, and have the great effect on the service life. Then, it is vital for vibration of washing machine to analyze.

The vibration of washing machine is analyzed at the working process of washing machine in this paper. Firstly, the eddy current sensor is installed at the position of near the washing machine, and reacts the vibration of washing machine. Then, the program of data acquisition is compiled in the software of Labview, at the same time, the data are collected by using the equipment of data acquisition. Finally, the figures are plotted by using the data in the software of MATLAB, and the phase difference and frequency of washing machine vibration signal are obtained by compared with Lissajou's figure. It provides the reference for the optimization design and manufacturing of washing machine.

WORKING PRINCIPLE OF EDDY CURRENT SENSOR

As shown in the Fig.1, the eddy current sensor is mainly composed of probe, extension cable and previa device. The probe of eddy current sensor is mainly composed of framework and the coil mounted on the frame. The previa device has mainly the function of signal produce, signal conversion, signal extraction and signal processing [1-3]. According to the principle of electromagnetic field, the coil around will produce the high frequency magnetic field after reaching into high frequency current near by the coil of sensor. When the magnetic field passes the surface of spindle nearly, the eddy current will be produced. This invariably eddy current will generate an eddy current magnetic field around it, and its direction is in the opposite direction of the former coil magnetic field. The two magnetic field superposition will change the impedance of the primary coil. When the parameters permeability, incentive current intensity and frequency of coil impedance are keep unchanged, the impedance is seen as the single-value function of gap from probe to metal surface, and they have the proportional relation. The change of impedance will be transformed the voltage or the current by the conversion circuit. The vibration of axis and displacement of axis are obtained by the change of gap on the display instrument. The working principle of eddy current sensor is shown in the Fig.1.

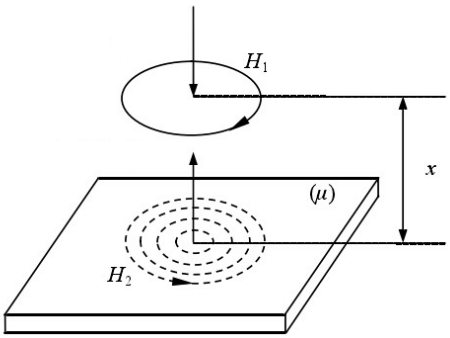

Fig.1 Working principle of eddy current sensor

ACQUISITION OF VIBRATION SIGNAL

Platform of Vibration Signal Acquisition

As shown in the Fig.2, the platform of vibration signal acquisition is built. The platform inculdes the equipment of washing machine, eddy current sensor, acquisition card and computer. According to the following steps to connect:

1) The washing machine is installed on the experiment table, and the stationarity of washing machine need to be guaranteed.

2) The output end of eddy current sensor is connected to the channel 0 of acquisition card NI9233.

3) The USB NI CompactDAQ is connected to the conputer by the data line, fixed in the side of washing machine through the magneticand and keep a certain distance.

4) Washing machine, acquisition card and computer power supply is connected.

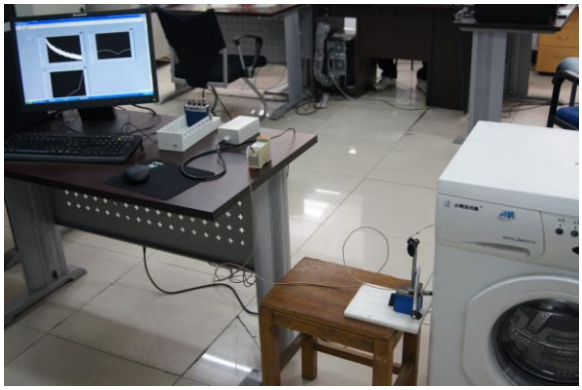

Fig.2 Building hardware equipment

Program of Data Acquisition

After platform of vibration signal acquisition building completed, the program of data acquisition is compiled to reading the vibration signal of acquisition card for realizing the signal acquisition. The program of data acquisition is compiled in the Labview[4-5] in this paper. The main steps are the following:

1) The acquisition module DAQ is inserted, and the channel of accelerated speed is set in the inner parameters. Then, the sensitivity is set according to the specifically sensor, and the frequency of sampling and the number of sampling point are selected according to the specific circumstance.

2) The filter 1 is inserted, and the type of filter is bandstop. The low cutoff frequency is 45 Hz, the higer cutoff frequency is 55 Hz for eliminating the interference of power supply signal.

3) The filter 2 is inserted, and the type of filter is bandpass. The low cutoff frequency is 1 Hz, the higer cutoff frequency is 100 Hz for eliminating the low frequency vibration and high frequency noise.

4) The change curve of signal will be displayed by inserting the graphic meter.

5) The data of signal is deposited in the specified path by inserting the module of writing measurement files.

6) For controlling the acquisition time expediently, the circulation While is added and the button of Stop is added.

Front panel of acquisition program is shown in the Fig.3 and the rear panel of acquisition program is shown in the Fig.4.

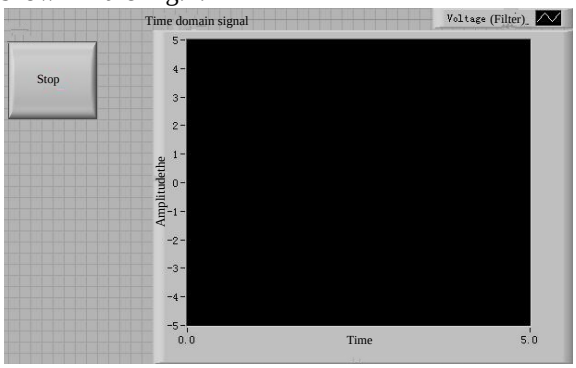

Fig.4 Front panel of acquisition program

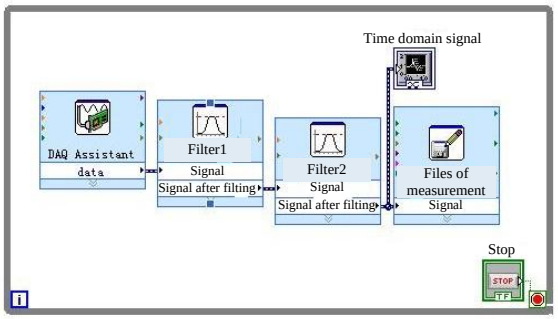

Fig.5 Rear panel of acquisition program

Data Acquisition

According to the above two section, the acquisition hardware is connected and the program of acquisition is compiled completely. The next work is that the datas are acquisited. The process of acquisition is the following.

1 The Labview acquisition program in the computer is opened, and power is supplied to the acquisition card and washing machine.

2 The rotation speed of washing machine, the acquisition frequency and the number of acquisition point of the module of DAQ are set.

3 When the rotation speed of washing machine get stable, the program of acquisition is started to collect data.

4 Selecting the appropriate data to analyze.

ANALYSIS OF VIBRATION SIGNAL

After the equipment of signal acquisition running, a certain period of the collected data is analyzed. The acquisition frequency of data acquisition is 2000, and selecting the data of 1 second to plot the figure of time domain, spectrum, power spectrum and after logarithmic of vibration signal in software MATLAB. The figures are shown in the Fig.5.

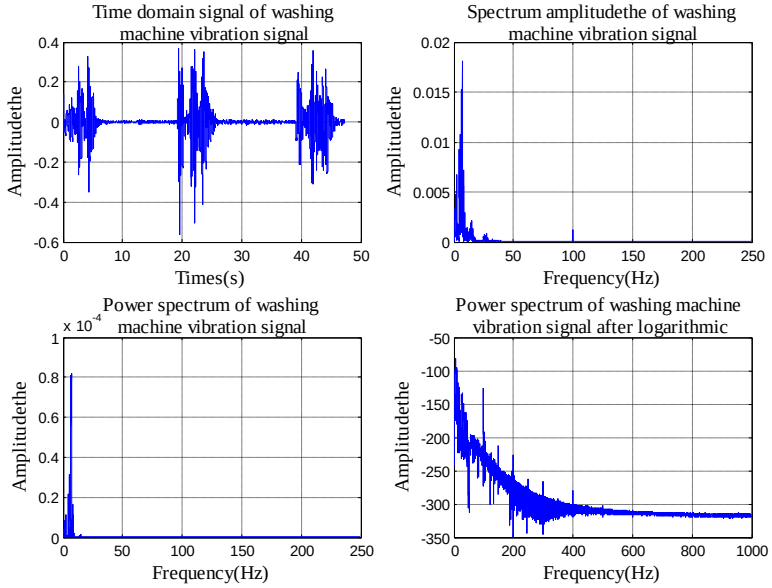

Fig.5 Figure of time domain, spectrum, power spectrum and after logarithmic of vibration signal

From the Fig.5, in this time period, the large amplitudethe of washing machine vibration frequency is about 9 Hz. Therefore, the measured signal is compared with the sine signal of frequency 9 Hz and phase 0 using the Lissajou's figure method. Lissajou's figure is also called waveform synthesis method. The method is to respectively add the signal measured frequency and the standard signal known frequency to the Y axis input terminal and X axis input of the oscilloscope. Then, the waveform synthesis figure will appear on the display of oscilloscope, and this figure is the Lissajou's figure. The rendered waveform Lissajou's figure will also different with the different of two input signals of frequency, phase, amplitude[6]. The typical Lissajou's figures are shown in the Fig.6.

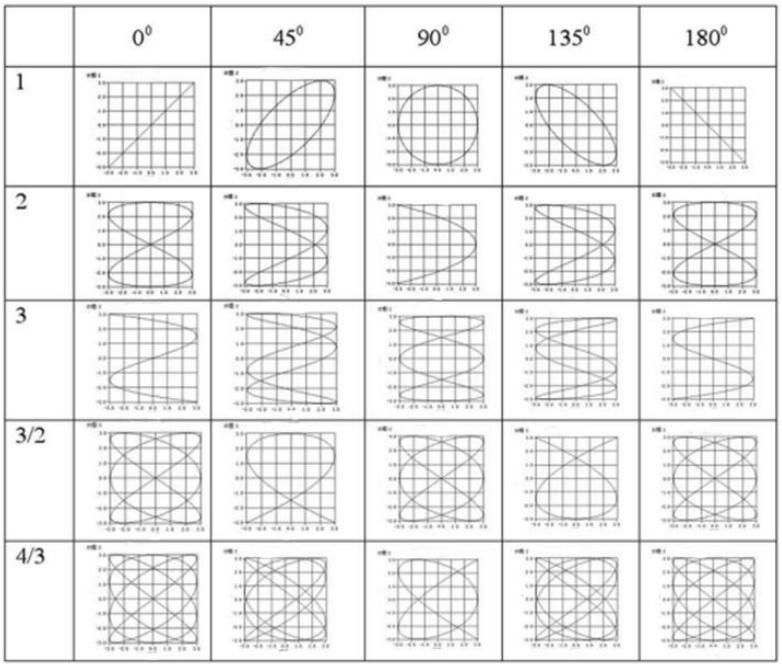

Fig.6 Lissajous's figure of different frequency ratio and phase difference

According to the above plot principle of Lissajou's figure, using the known frequency signal x=sin（2π ×6.9t）to be the input signal of x axis, and the above acquisition signals are the input signals of y axis. So, the Lissajou's figure is plotted in the software MATLAB. The figures are shown in the Fig.7. Because the noise interference of measured signal is strong and frequency values are not the only, so, the figure do not specification. But, the profile of figure is ellipse roughly from the Fig.7. Then, according to the Fig.6, the frequency of vibration signal is about 6.9 Hz, and the phase difference between sinusoidal signal is about 45 degrees.

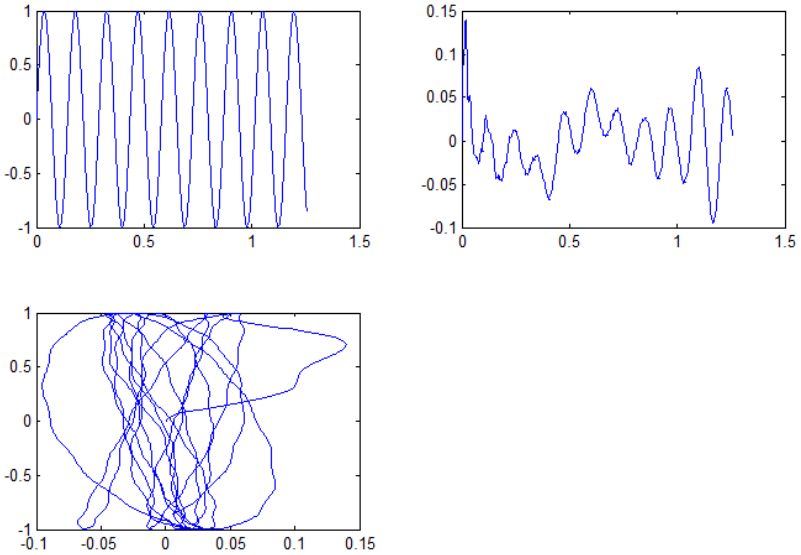

Fig.7 Lissajous's figure of vibration figure

CONCLUSION

Through this article research to know qualitative, The vibration of washing machine mainly occurred in low frequency area, and around 6.9 Hz. The vibration amplitude of washing machine is larger in the process of open and stop, and even big shake. Thus, the vibration of washing machine at the process of open and stop need to be reduced in the process of design and produce of washing machine for enhancing stationarity and extending the service life.

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