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Condition Monitoring of Hydrolic Pump by Wavelet Transform and Artificial Neural Network

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ABSTRACT: Continuous increasing of costs and increasing development of technology has made it necessary to delete some parts of costs that have no role in promoting quality and from the point of performance they are unnecessary. According to what mentioned, the present research has been done to design, development and evaluate fault diagnosis system of hydraulic pump through vibration analyzing and nervous net. The results of this research show that using statistical parameters of vibration spectrum is a simple method for getting characteristics of the spectrum, using data analysis method for selecting major characteristics will reduce the number of parameters and will increase net speed, changing wavelet transform will be successful process for unstable signals getting from hydraulic pump in different states, general accuracy of the net for recognizing defect in all states is higher than 95% and it shows that efficiency of the net for recognizing defect is good and acceptable.

***Keywords*:** Fault Diagnosis, Hydrolic Pump, Wavelet Transform, Artificial Neural Network.

INTRODUCTION

Continuous increasing of current costs and increasing development of technology has made it necessary to delete some parts of costs that have no rule in promoting quality and from the point of performing they are unnecessary (1, 2, and 3). Developing and improving keeping methods are inevitable. Because mechanical instruments have improved technically and machines are powerful and expensive so applying an effective prevention program will have will have the result of reducing direct and indirect costs (4 to 8). Paying attention to fast progress of technology during recent years it is felt that there is need to use different methods for increasing production quality. So industries have paid attention to using non- destructives test as a new method that can prevent from damaging the system through recognizing and predicting defects on time. Hydraulic pump is one of the most important parts of machinery that can stop the system if it faces with any problem and can have time wastes (9 to 14). Paying attention to the above mentioned cases, the present research has been done to design, development and evaluate defect finding system of hydraulic pump through vibration analyzing and nervous net. The results of this research can be used in repair shops and assembling lines. So the method used in this research can be used for other similar researches.

MATERIALS AND METHODS

For getting data at first suitable system of getting data was designed and made according to similar researches (14 to 18). Figures 1 and 2 show this system, As the figures show the system consists of electromotor, hydraulic pump, coupling, shock absorber and rubber bases. Figure 3 shows internal component of hydraulic pump

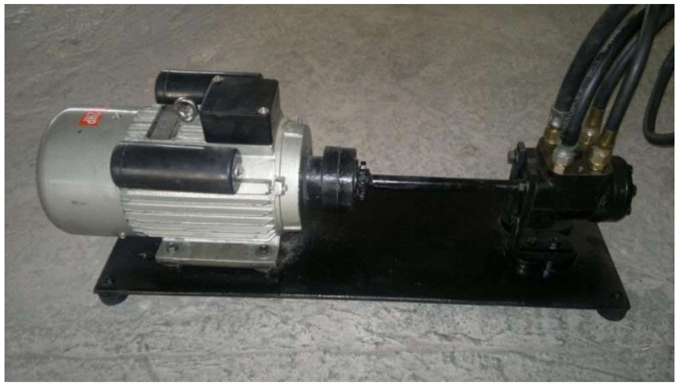

Figure 1. data acquisition set up

Figure 2. Couplings, electrical motor, bumpers and rubber base used to make the system operational

Figure 3. internal component of hydraulic pump

Friction of external side of gears of internal rotor friction of external side of external rotor friction of internal side of pump earing are some defects of pumps that are recognize able through processing vibration situation methods. Defected parts were selected from old pumps. For getting vibration data a piezoelectric accelerometer global test model was used (Figure 4 and table 1). Vibrations of accelerometer are supported by an amplifier and then they are transferred from an analog transformer to a digital transformer and then finally they are transferred to the computer. (Figure 5 and table 2).

Figure 4. used accelerometer for doing research

Table 1. Characteristics of Global Test AP 98-100 sensor

Parameter	Unit	AP98-100 (-01, -02)
Axial sensitivity (± 10 %)	mV/g[*1]	100
Relative transverse sensitivity	%	< 5
Amplitude range	g[*1]	± 50
Max. shock limit (peak value)	g[*1]	± 1 000
Operating temperature range	°C	- 40…+ 125
Frequency range (ripple ± 1 dB)	Hz	0,5…12 000
Self-resonant frequency in attached condition	kHz	> 40
Noise level, RMS (1 Hz ÷ 10 kHz)	g[*1]	< 0,000 2
Output resistance	Ω	< 500
Supply voltage	V	+ (18…30)
Supply current	mA	2…20
Constant output voltage level	V	10…13
Housing material	-	stainless steel
Weight (without cable)	gram	40
Supplied accessories	-	cable AK15[*2], stud AH0105

Figure 5. View of the amplifier and ADC used in research

Table 2. View of the certificate or card Deck (Advantech USB-4704 data acquisition)

<table>
<tr><td>Channels</td><td colspan="11">8-ch Single-ended/ 4-ch differential</td></tr>
<tr><td>Resolution</td><td colspan="11">14 bits</td></tr>
<tr><td>FIFO Size</td><td colspan="11">512 bytes</td></tr>
<tr><td>Sampling Rate</td><td colspan="11">48 kS/s*</td></tr>
<tr><td rowspan="4">Input Range and Gain List</td><td colspan="2">Gain</td><td>1</td><td>20</td><td>16</td><td>10</td><td>8</td><td>5</td><td>4</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Gain Code</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td colspan="2">S/E (V)</td><td>±10</td><td>-</td><td></td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Differential (V)</td><td>-</td><td>±1</td><td>±1.25</td><td>±2</td><td>±2.5</td><td>±4</td><td>±5</td><td>±10</td><td>±20</td></tr>
<tr><td rowspan="3">Drift</td><td colspan="2">Gain</td><td colspan="9">G = 1 to 20 V/V</td></tr>
<tr><td colspan="2">Zero (uV/°C)</td><td colspan="9">9</td></tr>
<tr><td colspan="2">Gain (ppm/°C)</td><td colspan="9">30</td></tr>
<tr><td rowspan="2">Small Signal Bandwidth for PGA</td><td colspan="2">Gain</td><td colspan="9">G = 1 to 20 V/V</td></tr>
<tr><td colspan="2">Bandwidth (MHz)</td><td colspan="9">0.01</td></tr>
<tr><td>Input Protection</td><td colspan="11">30V max.</td></tr>
<tr><td>Input Impedance</td><td colspan="11">127 k</td></tr>
<tr><td>Input Common Mode Voltage</td><td colspan="11">100mV</td></tr>
<tr><td rowspan="4">Accuracy</td><td rowspan="4">DC</td><td>Gain</td><td colspan="9">G = 1 to 20 V/V</td></tr>
<tr><td>INLE (LSB)</td><td colspan="9">±3</td></tr>
<tr><td>DNLE (LSB)</td><td colspan="9">±1.5</td></tr>
<tr><td>Gain Error (%FSR)</td><td colspan="9">0.15</td></tr>
</table>

Getting data was done during different positions of pumps. They are shown in table 3. In each situation about 100 spectrum of data were collected, 70 ones for education and 30 ones for testing and classifying. Each spectrum had 1683 data that were gathered during 0.2 of seconds.

Table 3. Description Pump failures

Pump status
Healthy
Internal rotor wear
External rotor wear
Pump bearing failure

After transferring data to commuter they were processed. Vibration spectrum gathered in time domain were transferred to time- frequency domain for getting their information, this was done by a wavelet transform. These are called primary processing of data. Wavelet transform adapter is a new tools for analyzing wave and can present information about time and wave frequency simultaneously.

In this process selecting main wavelet transform is very important. Main wavelet transform is divided into different classes that some of them are used. Table 4 shows these classes.

Table 4. Families of wavelets in the wavelet transform

Name	Symbol	How to define
Haar	Haar	Haar
Daubechies	Db	DbN , N=1,2,…,n
Symlet	Sym	SymN , N=1,2,…,n
Coiflet	Coif	CoifN , N=1,2,…,n
Biorthogonal	Bior	Bior $N_r.N_d$,$N_r.N_d$=1,2,…,N

RESULTS AND DISCUSSION

Results

Artificial nervous net used in this research is a special one. Lunberg- Mar quat algorithm was used for educating net. This net consisted of an internal layer a hidden layer and an external layer (figure 5).

Logarithm- zigmoid activation function was used for hidden layer and liner function was used for external layer. In internal layer in different states there were different neurons. About 10 neurons were considered for medium layer.

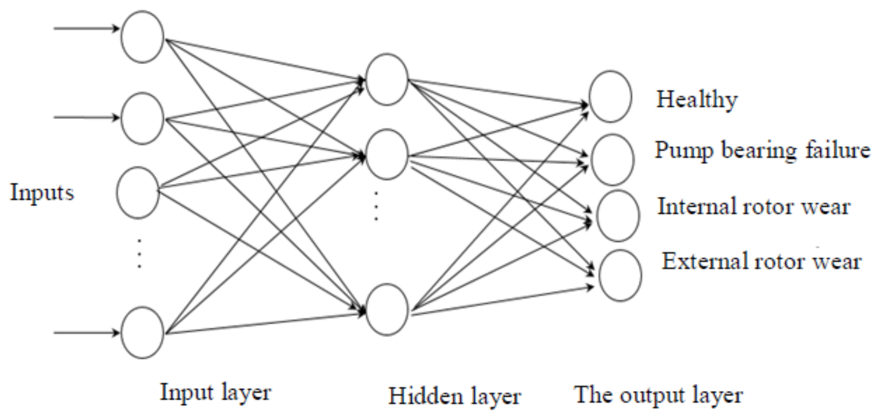

Figure 5. network used for classifying different defects of hydraulic pump

In table 5 different methods of classifying by main wavelet transform has been showed, the results show that decomposition of Wavelet transform by main wavelet transforms such as Daubechie and Biorthogonal is more careful than other methods. As a whole according to the results presented in table 5, kind of Wavelet transform doesn't have any affect on classifying and the only classifying and the only classifying mistake is due to external rotor that presents it vibrations of the two defects are similar to each other and their only difference is their vibration range.

Table 5. Compare various pump defect classification by different wavelet

Type wavelet	Education Data	Assessment data	Test data
Haar	100	100	100
Daubechies	100	100	98.30
Symlet	100	100	100
Coiflet	98.20	100	96.70
Biorthogonal	100	98.30	100

Results of classifying nervous net while using main wavelet transform show that by combining different methods, it will be possible to recognize the defect of hydraulic pump. Using the results of this research it will be possible to recognize the defect vary soon. Vibration signs of the pump show that there is some thing wrong with it and it will be possible to remove it.

CONCLUSION

In the present research vibration situation of hydraulic pump was studied and the defects were classified using nervous net. The results of this research can be summarized as following :

1. Using statistical parameters of vibration spectrum is a simple method for getting characteristics of the spectrum.
2. Using data analysis method for selecting major characteristics will reduce the number of nervous nets and will increase net speed.
3. Changing Wavelet transform will successful processing of unstable signals getting from hydraulic pump in different states could provide the field for the next stages of getting characteristic and classifying.
4. According of nervous net while using mother wavelet transform is higher than other ones.
5. The main error while classifying defects by the net is due to nit recognizing the defect in internal and external rotor.
6. General accuracy of the net for recognizing defect in all states is higher than 95% and it shows that efficiency of the net for recognizing defect in all systems is similar to each other.

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