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Conditioning Monitoring and Fault Diagnosis System of Fan

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Abstract: In our day to day life we use electrical machines such as fans, coolers etc. these electrical machines have induction motor in it. So these appliances face various stresses during operating conditions which may lead faults or failures of the system. Electrical machines are susceptible to variety of faults like mechanical faults, electrical faults, and insulation system faults. Electrical stresses are usually associated with the power supply and Mechanical stresses are caused by overloads and abrupt load changes, which can lead to bearing faults and rotor bar breakage, rotor end ring cracking, misalignment, and bearing gearbox failures etc. A motor failure that is not identified in an initial stage may become catastrophic and the appliance may suffer severe damage. Hence condition monitoring becomes necessary in order to avoid such severe faults. To detect the fault, different motor variables like speed, sound, temperature, current, voltage and vibrations can be used. So that a preventive action can be taken before the occurrence of faults in the fan. In this project, we are using two different fans. First we record the real time sound signals of both the fans in healthy conditions and then we will create Unbalanced wings fault in fan 01 & bearing fault in fan 02, then real time sound signals of both the fans in Unhealthy conditions are recorded. These recorded signals are now analyzed successfully in MATLAB Program. The graphs clearly make the difference in healthy and faulty fan. Now, this information is used to train a neural network so that it is able to detect the fault from the sound of fan.

Keywords: wavelet analysis, sound signature, motor faults, fan faults, condition monitoring.

Introduction

Induction motors are electro-mechanical devices used in most industrial applications for the conversion of power from electrical to mechanical form. These motors are robust machines and used not only for general purposes, but also in very hazardous locations and extreme environments, because induction motors are highly reliable, require low maintenance, have relatively high efficiency, low cost, reasonably small size, ruggedness, and operation with an easily available power supply.

Induction motors are susceptible to many types of fault in industrial applications. Machine fault problems are broad sources of high maintenance cost and unwanted downtime across the industries the prime objective of maintenance department is to keep machinery and plant equipments in good operating condition that prevents failure and production loss [1] .Hence condition monitoring becomes necessary in order to avoid catastrophic faults. There are many condition monitoring methods including thermal imaging analysis, vibration analysis, acoustic emission monitoring but all these monitoring methods require expensive sensors or specialized tools whereas current monitoring out of all does not require additional sensors. Current monitoring are usually applied to detect various types of induction motor faults such as rotor faults, air gap eccentricity fault, bearing faults short winding faults ,load fault etc.[2-3]

Efficient maintenance is a maintenance which is done at the right time and right place. Maintenance can be defined as the activities carried out to prevent a machine or equipment from fault or to restore a machine or equipment to working condition, if fault is there. Preventive maintenance can be improved using condition based monitoring and taking right step at the right time.. Dileo et al. [4] present a review on the classical approaches to maintenance and then compare them with condition-based maintenance (CBM).

Whenever there is a fault in machine, some of the parameters of machine changes. These changes in the machine parameters are dependent upon the degree of faults and the interdependent with other machine parameters. Generally one or more parameter is subjected to change under abnormal condition. Condition monitoring of machine should be carried out when machine is under operation, which known as on-line monitoring. In on-line monitoring some of the critical parameters possible to monitor are speed, vibration, temperature and sound. These parameters should be continuously monitored for early detection of faults. Offline monitoring is also done when the machine is down because of some fault.

In mostly all of industrial ventilation applications fan are used and failure of these fans often forces a process to be shut down. For a healthy and productive work environment it is necessary that Fans of the industries should work in a proper condition. Because of Fan failure productivity and product quality declines [5]. This paper proposes a condition monitoring and fault diagnosis system for fan using wavelet analysis and neural networks.

Proposed Fault diagnosis system for fan

Mechanical faults such as rotor faults, bearing faults, unbalances wings are easily find out by using sound signature analysis .In this paper problem of fault identification in fan system is considered. There are many faults; electrical faults, mechanical faults and insulation faults. The work in this paper mainly concentrates on mechanical faults i.e. bearing faults and unbalanced wings fault. A fault diagnosis system has been developed and implemented in real time for sound signal. The block diagram used for the fan fault diagnosis system is shown in Figure 1. The system consists of following steps: fan system, Acquisition, pre-process, wavelet analysis and others. Wavelet analysis decomposes real time healthy and faulty fan signals. We used db3 decomposition at level 5 in wavelet analysis.

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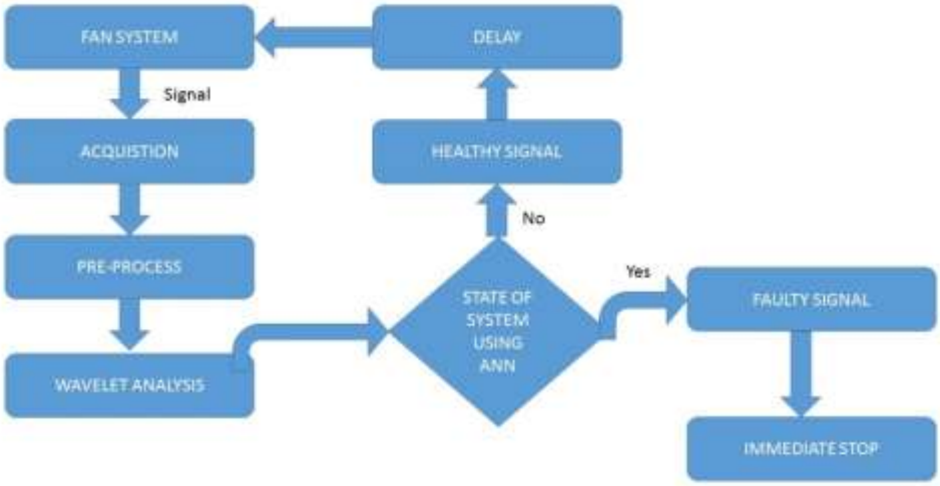

Figure 1. Block representation of proposed condition monitoring system

A. FAN SYSTEM

Two Fans of electronics engineering lab are taken under observation as system. Specification of fans given in Table-1.Fans has various parts such as stator, rotor, blades, bearing, capacitor etc. In first fan 01 we have created unbalanced wings faults and In another fan 02 we have created bearing fault.

Table -1 Specification of Fans

	Fan 01	Fan 02
Manufacturer	Crompton greeves	Orient PSPO
Power	85 W	80W
Voltage	220V-240V	220V-240V
frequency	50 Hz	50 Hz

B. SIGNAL

The signal to be observed may be any signal like sound signal, current signal, temperature etc. But here we have taken only real time sound signals of healthy and faulty fan. The sound signal is captured by using mobile phone recorder for healthy and faulty fan system

C. ACQUISITION SYSTEM

The signal is observed with the help of microphone. the sound signal are converted into electrical signal with the help of microphone. Acquired Electrical signal is analog in nature and it can’t be read by computer, so an analog to digital converter is used to convert analog signal into digital signal. This digital signal is send to computer for decomposition. Where it can be easily processed and analyzed. The Figure 2 shows the acquisition process.

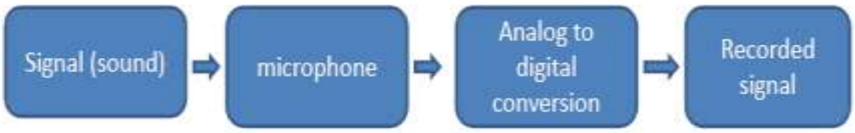

Figure 2. Block representation of acquisition system

D. PRE-PROCESS SYSTEM

These processes can be applied to the real time signal. This system consists of filters and amplifiers If the observed signal is noisy we have to use filters for removing the noise from the signal. If the observed signal is weak we have to use amplifiers for amplifying the weak signal

E. WAVELET ANALYSIS

The processed signal is now analyzed with the help of wavelet 3-step decomposition of the signal at level 5. We have the five-level approximation and five levels of details in MATLAB 7.0.1. Wavelet decomposes this real time signal into one approximation and some detailed signal depend the level of decomposition as shown in Figure 3.

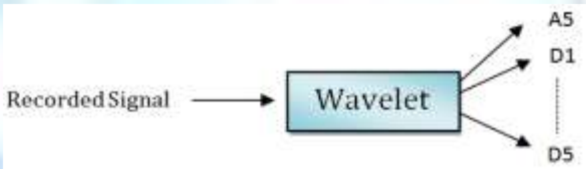

Figure 3. Decomposition of recorded signal using wavelet

F. SYSTEM STATE

All decomposed components of faulty signals are compared with healthy signal. If there is an error the system will display the faulty state of fan system and will stop. If this is healthy then the loop will continuously check the fan system after a periodic delay as shown in Figure 4.

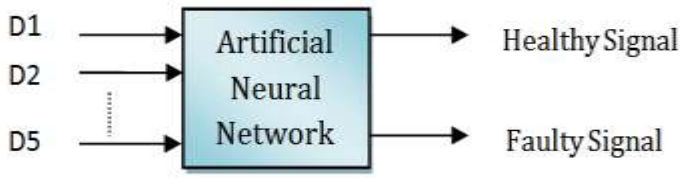

Figure 4. Neural network system for fault diagnosis

Experimental Setup for Sound Signature ANALYSIS

The experimentation has been done in Electronics Engineering Lab at Raja Balwant Singh technical campus Agra, India. The laboratory model consisting of two fans (healthy fan and faulty fan), A computer preloaded with MATLAB software and a mobile phone with recorder facility. Fan is made up of Crompton Greeves Company; its specifications are 120mm long blades, 240V, 50 Hz, 85 W, 300 rpm. The other fan is made up of orient pspo company; its specifications are 120 mm long blades, 240V, 50 Hz, 80 W, 300 rpm. The real time data is acquired with the help of recorder from both the fan one by one and sends them to computer. MATLAB imports these signals and decompose them using wavelet. The estimated parameters compared with the healthy fan under normal operating conditions.

Figure 5. Block representation of experimental setup

Experimental Results for sound signature analysis

The sound signals of two different fans were recorded in healthy conditions and then unbalanced wings fault created in fan 01 and bearing fault is created in Fan 02 and again sounds of both the fans were recorded and preprocessed. After preprocessing both signals are analyzed in MATLAB. The below figures showing the original healthy and faulty signals which clearly indicates the presence of faults. To get the specific signature we decomposed the originals into approximation and detailed components which shows the better difference in the healthy and faulty signals.

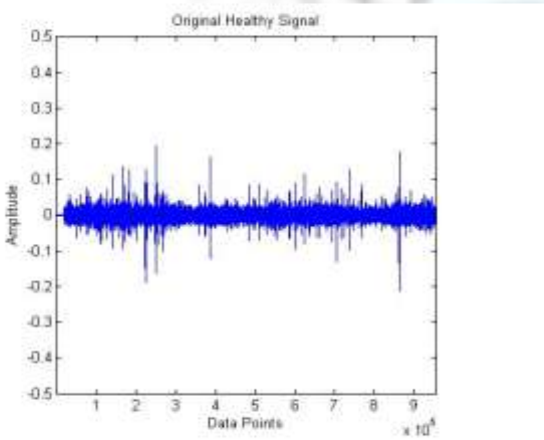

Fig6a: Original Healthy signal of fan 01

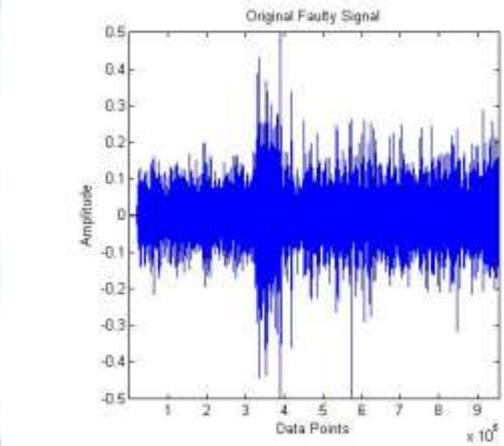

Fig6b: original faulty signal of fan 01

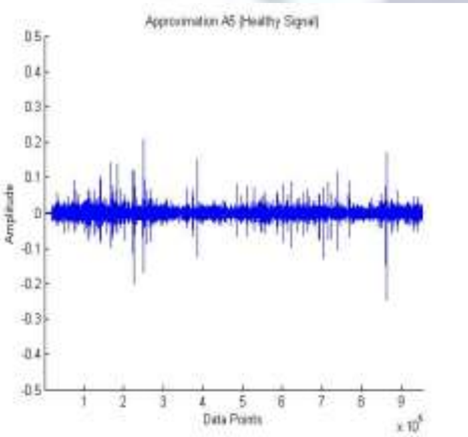

Fig7a: Approximation A5 of Healthy signal of fan 01

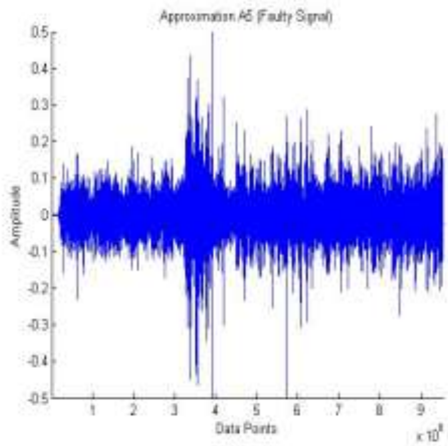

Fig7b: Approximation A5 of faulty signal of fan 01

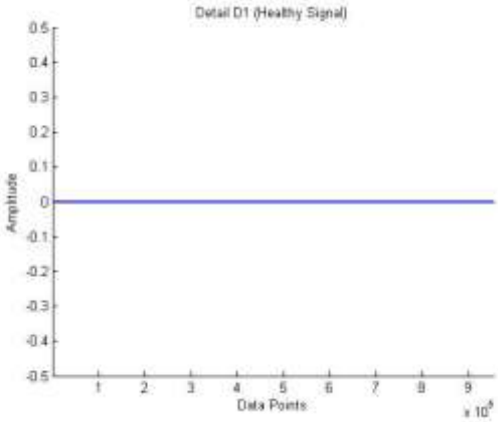

Fig8a: Detail D1healthy signal of fan 01

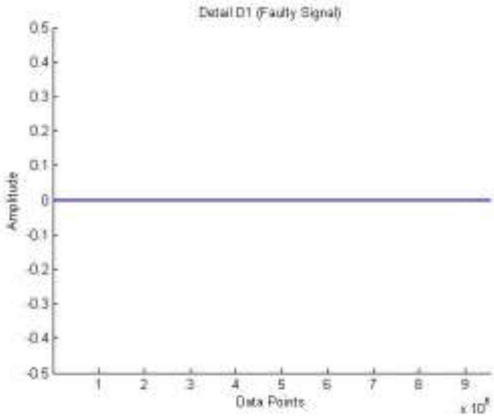

Fig 8b:Detail D1faulty signal of fan 01

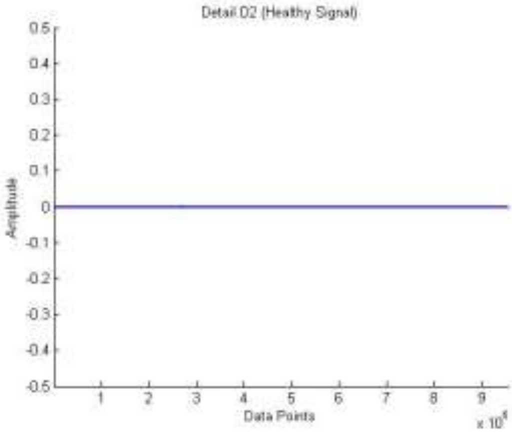

Fig9a: Detail D2healthy signal of fan 01

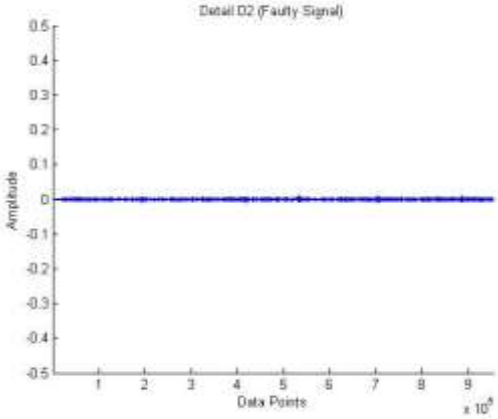

Fig9b: Detail D2faulty signal of fan 01

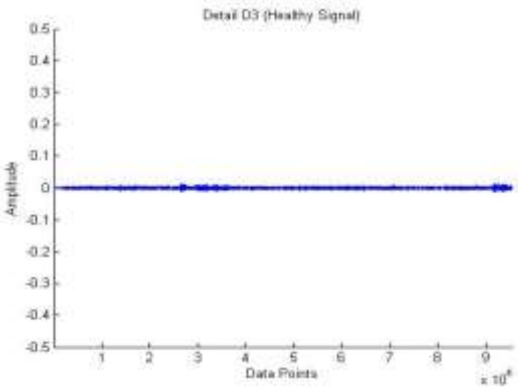

Fig10a: Detail D3 of healthy signal of fan 01

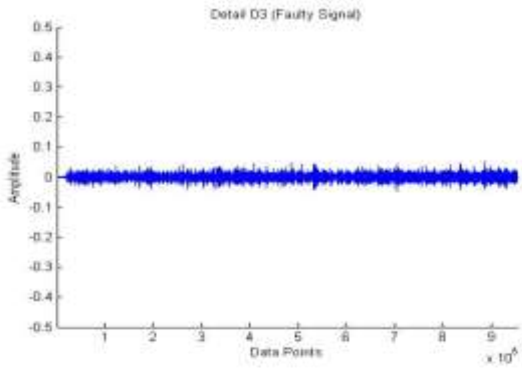

Fig10b: Detail D3 faulty signal of fan 01

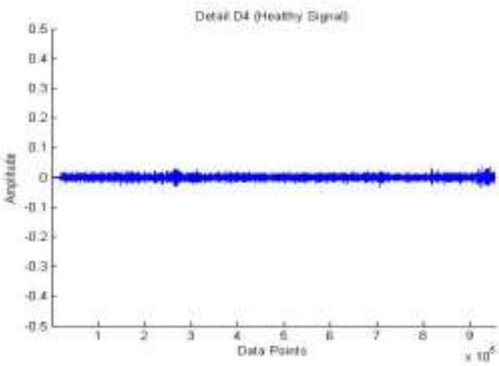

Fig11a:Detail D4 healthy signal of fan 01

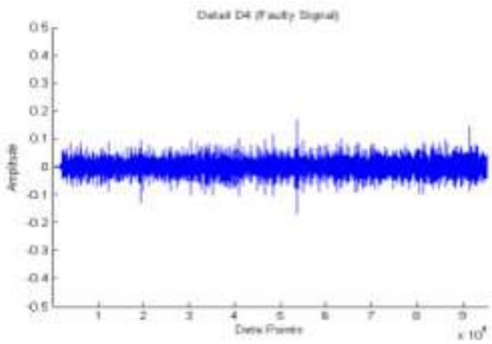

Fig11b: Detail D4 faulty signal of fan 01

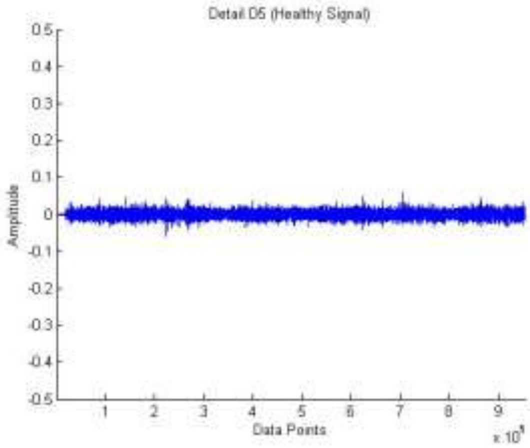

Fig12a: Detail D5 healthy signal of fan 01

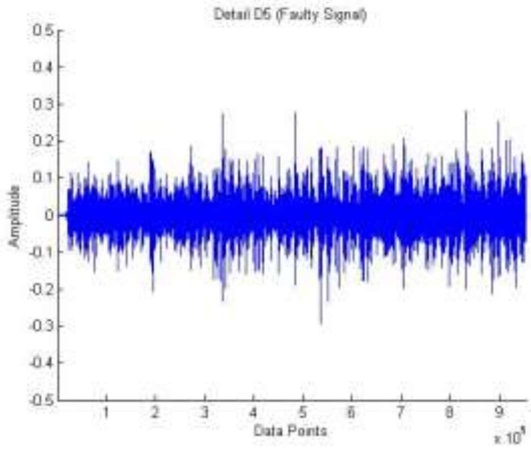

Fig12b:Detail D5 faulty signal of fan 01

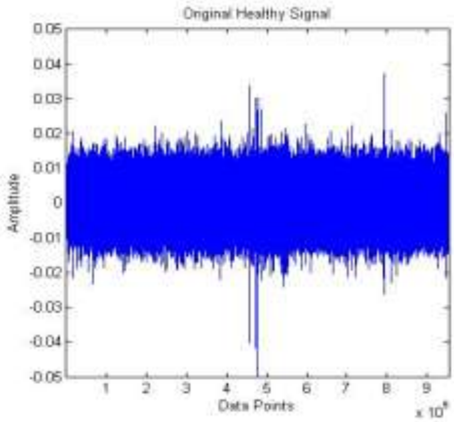

Fig13a: original healthy signal of fan 02

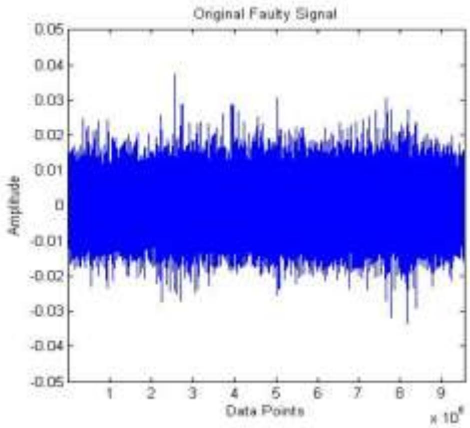

Fig13b: original Faulty signal of fan 02

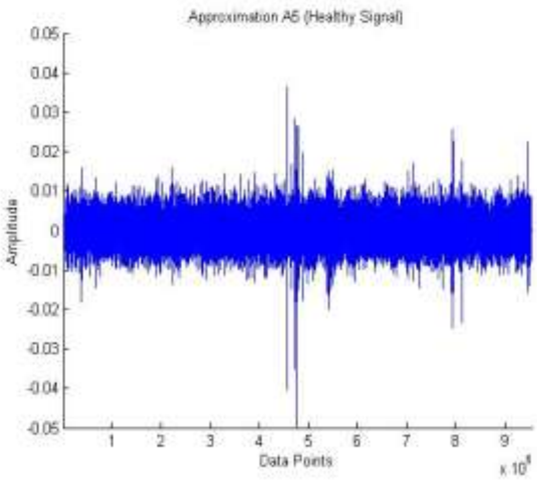

Fig14a: Approximation A5 of Healthy signal of fan 02

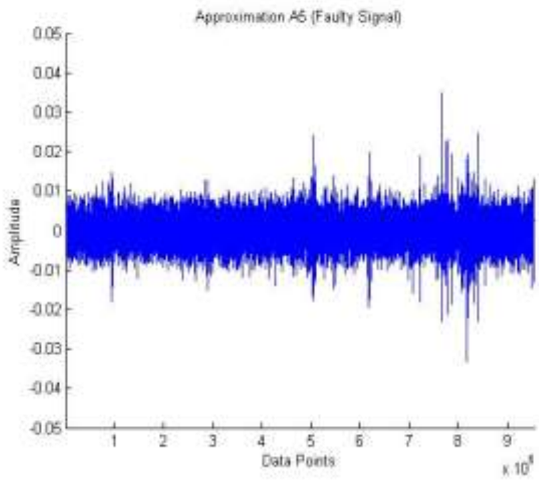

Fig14b: Approximation A5 of faulty signal of fan 02

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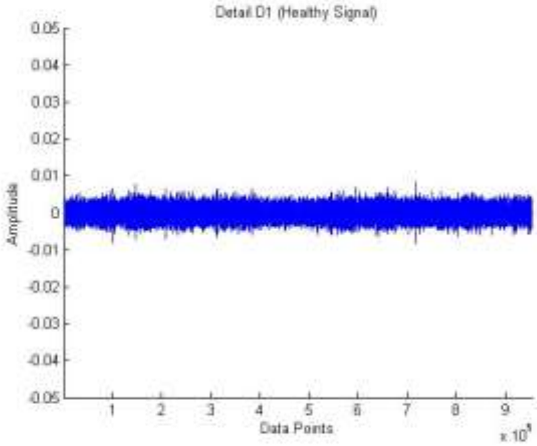

Fig15a: Detail D1healthy signal of fan 02

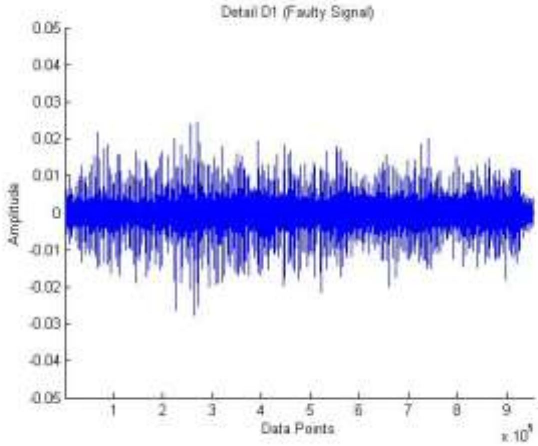

Fig 15b: Detail D1faulty signal of fan 02

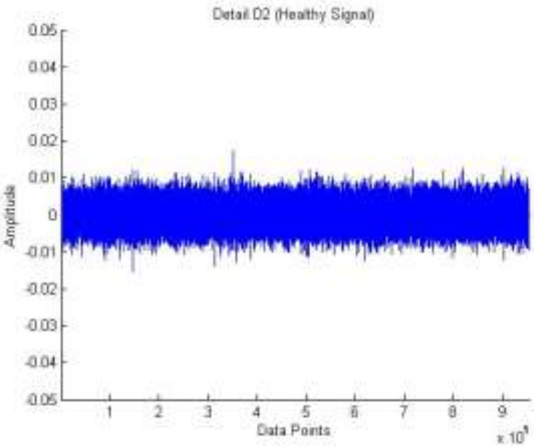

Fig16a: Detail D2healthy signal of fan 02

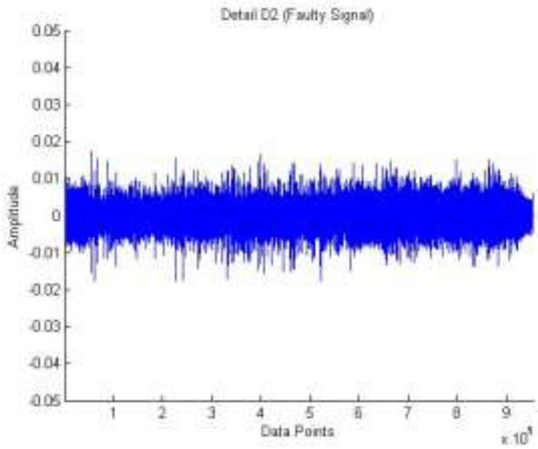

Fig16b: Detail D2faulty signal of fan 02

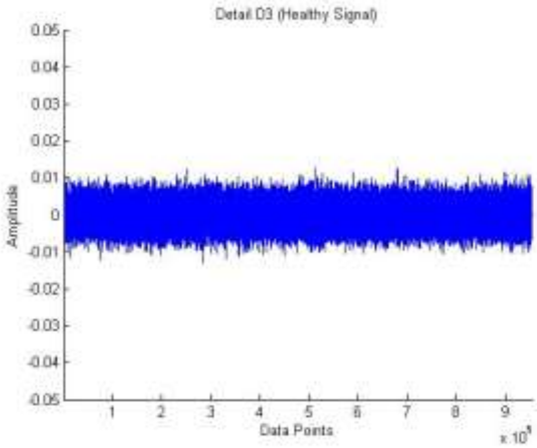

Fig17a: Detail D3 of healthy signal of fan 02

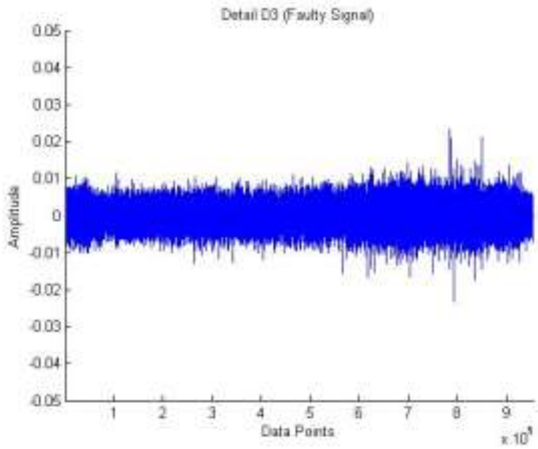

Fig17b: Detail D3 of healthy signal of fan 02

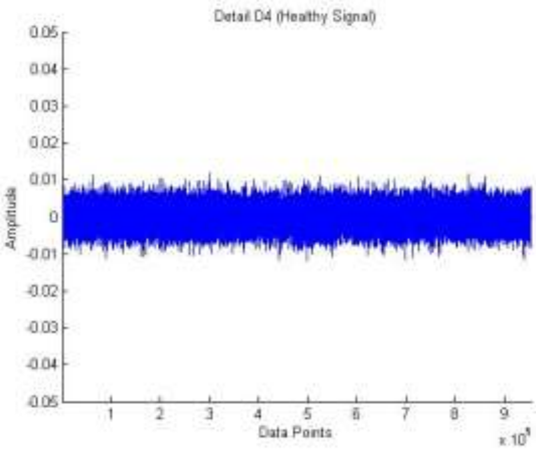

Fig18a: Detail D4 healthy signal of fan 02

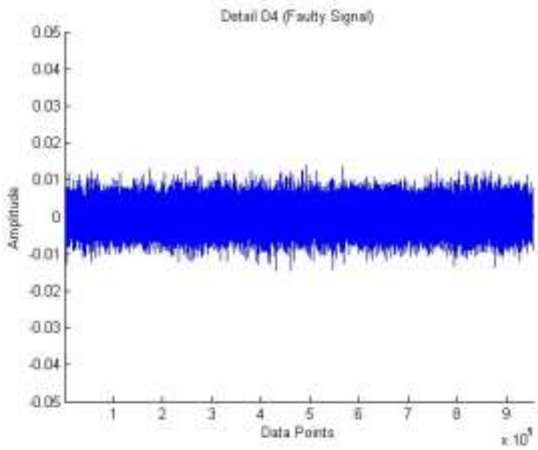

Fig18b: Detail D4 faulty signal of fan 02

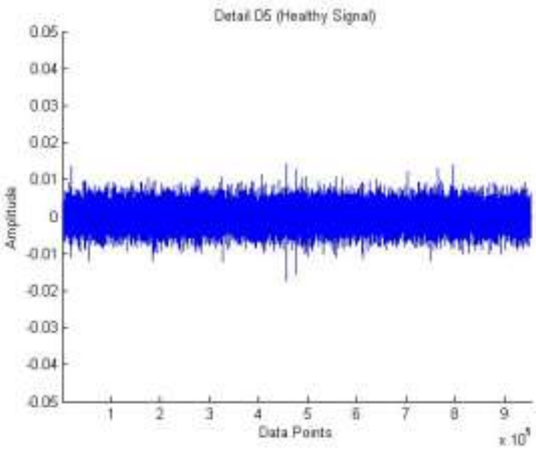

Fig 22a: Detail D5 healthy signal of fan 02

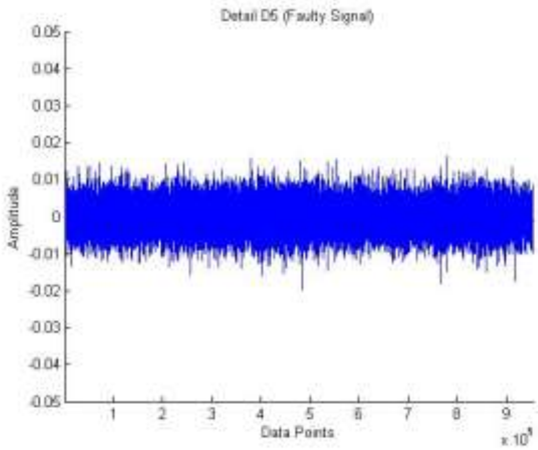

Fig 22b: Detail D5 faulty signal of fan 02

From the above graphs, it clearly makes the difference between healthy and faulty fan signal. In fig. 6a and 6b , the original signals and faulty signals of fan 01 are compared and very clear difference can be observed. similarly approximation 5 , detail D1, detail D2, detail D3, detail D4, detail D5 of healthy and faulty fan 01 are compared as shown in above figures 7a and 7b, 8a and 8b, 9a and 9b, 10a and 10b, 11a and 11b & 12a and 12b respectively.

In the same way, another fan 02 is taken in which bearing fault is created by replacing its bearing having broken rough bearing balls and again the sound signal of fan is recorded with a faulty bearing. In Graph. 13a and 13b, the original signals and faulty signals of fan 02 are compared and very clear difference can be observed. similarly approximation A5, detail D1, detail D2, detail D3, detail D4, detail D5 of healthy and faulty fan 02 are compared as shown in above figures 14a and 14b, 15a 15b, 16a and 16b, 17a and 17b, 18a and 18b & 19a and 19b respectively, From the above graphs, it clearly makes the difference between healthy and faulty fan signal of fan 02 also From the above decomposition of healthy fan and faulty fan identification and diagnosis can be successfully done.

CONCLUSION AND DISCUSSION

The work done in this project is to detect faults in the fan system using real time sound signal. The wavelet components are clearly showing the difference between healthy and faulty fan system for bearing faults. In the wide area of soft computing we focused on neural network which is trained to predict the faults based on wavelet decomposed signals.

In future some other combinations of the following techniques can be use for better results such as:

- Fuzzy Logic
- Genetic Algorithm
- Real-Valued Genetic Algorithm
- Compact Genetic Algorithm
- Compact Real-valued Genetic Algorithm
- Quantum Genetic Algorithm
- Differential Evolution, etc.

❖ Some more variable may be taken from the systems:

- Vibrations of motor
- Temperature of motor
- Current of motor
- Voltage of motor
- Rpm of motor etc

References

[1]. J. T. Renwick and P. E. Babson, "Vibration analysis-a proven techniques as a productions maintenance tool," IEEE Transactions on Industry Applications, vol. 21, no. 2, pp. 324–332, 1985.
[2]. Peter vas,''Parameter estimation, condition monitoring and diagnosis of electrical machines,''Clarendon press oxford.,1993.
[3]. P.J Tavner and J.Penman,'' Condition monitoring of electrical machines,''Hertfordshire, England: Research studies pressltd, ISBN:0863800610,1987.
[4]. M. Dileo, C.Manker, Cadick, and P. E. Jhon, "Condition based maintenance,Cadick Corporation October 1999.,
[5]. D. K. Chaturvedi and Himanshu Vijay, "Parameters Estimation of an Electric Fan Using ANN", Journal of Intelligent Learning Systems and Applications, 2010, 2: 33-38.
[6]. D. K. Chaturvedi and P. S. Satsangi. "Predicting the performance Characteristics of Synchronous Generators: An Alternative Approach " J. of The Institution of Engineers (India), El 74 (1993): 109-113.
[7]. S. Rajakarunakaran, P. Venkumar, K. Devaraj, and K. S. P. Rao, "Artificial Neural Network Approach for Fault Detection in Rotary System," Appl. Soft comput., vol. 8, no. 1, pp. 740–748, 2008.
[8]. J. Lin, M. J. Zuo, and K. R. Fyfe, "Mechanical fault detection based on the wavelet de-noising technique," Journal of Vibration and Acoustics, vol. 126, no. 1, pp. 9–16, 2004.
[9]. V. Uraikul, C. W. Chan, and P. Tontiwachwuthikul, "Artificial Intelligence for Monitoring and Supervisory Control of Process Systems," Eng. Appl. Artif. Intelligent, vol. 20, issue 2, pp.115–131, 2007.
[10]. J. T. Renwick and P. E. Babson, "Vibration analysis-a proven techniques as a productions maintenance tool," IEEE Transactions on Industry Applications, vol. 21, no. 2, pp. 324–332, 1985.
[11]. M. Dileo, C.Manker, Cadick, and P. E. Jhon, "Condition based maintenance," Cadick Corporation, October 1999.
[12]. H. C. Choe, Y. Wan, and A. K. Chan, "Neural pattern identification of railroad wheel-beating faults from audible acoustic signals: comparison of cost,"CWT and DWT features, Department of Electrical Engineering, Taxes A&M University.
[13]. S. Kumar, Neural networks: A Classroom Approach, Tata McGraw-Hill, 2004.
[14]. Zhongming Ye, Bin Wu, Alireza Sadeghian, "Current Signature Analysis of Induction Motor Mechanical Faults by Wavelet Packet Decomposition"
[15]. S. Edwards, A. W. Lees, and M. I. Friswell, "Fault diagnosis of rotating machinery," The Shock and Vibration Digest, vol. 30,no. 1, pp. 4–13, 1998
[16]. H. P. Bloch and F. K. Geitner, "Machinery Failure Analysis and Troubleshooting", chapter 5, Gulf Publishing Company, Houston, Tex, USA, 1983.
[17]. M. Amarnath, R. Shrinidhi, A. Ramachandra, and S. B. Kandagal "Prediction of defects in antifriction bearings using vibration signal analysis," Journal of the Institution of Engineers India Part MC Mechanical Engineering Division, vol. 85, no. 2, pp. 88–92, 2004.
[18]. L. Mann, A. Saxena, and G. M. Knapp, "Statistical-based or condition-based preventive maintenance?" Journal of Quality in Maintenance Engineering, vol. 1, no. 1, pp. 1355–2511, 1995.
[19]. S. Nandi and H. A. Toliyat, "Condition monitoring and fault diagnosis of electrical machines-a review," in Proceedings of the 34th IEEE IAS Annual Meeting on Industry Applications Conference, vol. 1, pp. 197–204, Phoenix, Ariz, USA, October 1999.
[20]. Marcus, "Condition based maintenance on Rail vehicle—possibilities for an innovation, Design and Product development", Nalandalen University, Eskilsting Sweden, 2002.
[21]. A. Korde, "On line condition monitoring of motors using electrical signature analysis," in Proceedings of the 4th International Conference on Engineering and Automation, Orlando, Florida, USA, July-August 2000.