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"Discret Wavelet Transform (DWT) for Detection of a Rolling Element Bearing Based on Kurtosis-Energy Selection"

under the following authorship order : **Saida DAHMANE, Fouad BERRABAH, Bilal Djamal Eddine CHERIF, Mohamed Razi MORAKCHI**

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Discret Wavelet Transform (DWT) for Detection of a Rolling Element Bearing Based on Kurtosis-Energy Selection.

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Abstract

Recently, fault detection in asynchronous motors has paid attention of many researchers. The monitoring of these machines is performed through of the use of several physical quantities, among them vibration analysis has a crucial importance for early detection of rolling bearing faults in induction motor (IM), which they represent about 41% of IM's ensemble defects. Commonly, the induction motor operates under non-stationary operating conditions (varying speed, fluctuating load …), and that leads to the birth of non-stationary vibration signals. The vibration signals produced from the bearing cannot generate any information about the state of the machine. Therefore, a proper analysis of these signals by means of different signal processing tools allows us to determine if the entire rotating machinery is in a normal or abnormal state. In the field of bearing fault detection, signal processing though of fault diagnosis methods has taken preponderant place. Among these methods, Fast Fourier Transform is most frequently used enabling the signal decomposition without losing any information, but it is limited to non-stationary signals such as it cannot provide the temporal location of the appearance of another shock after the born of a first one. To overcome this limitation the Discret Wavelet Transform is used providing both of time and frequency location. In this paper, we propose a diagnosis method for the identification of bearing faults, which serves to combine the DWT (Discret Wavelet Transform) and the envelope analysis. The DWT decomposes the signals of the outer race defect and the inner race defect of the bearing to obtain details. These details will be then subjected to a statistical analysis based on the kurtosis and energy coefficient (EC) in order to select the optimum wavelet details including significant harmonics corresponding to the fault cases. The envelope analysis is then applied to the selected details for extracting the frequencies' characteristics of bearing faults. The calculated theoretical faults following the equations (1)-(3) mentioned in **[1]** are the rotation frequency f_r =28.83 Hz; the inner race frequency $f_{ir} = 156.34$ Hz; the outer race frequency f_{or} =103.12 Hz, this all from exploiting the data of vibration signals that are measured at a sampling frequency of 12000 Hz and a motor speed of 1730 RPM, available in CWRU **[2]**. The selection of the details obtained from the signals corresponding to the outer race and the inner race defects must respond to the greatest value of both the kurtosis and the energy value. As shown in table I, detail 1 matches to the greatest value of the kurtosis and the EC. For the healthy bearing case, the chosen detail has the smallest values that confirms its undamaged case. Taken into account that a value of kurtosis lower than 3 belongs to a good state of the bearing. The results obtained by this combined method are compared with those obtained theoretically that demonstrates well its effectiveness.

Key words: induction motor; bearing; vibration; DWT; inner race; outer race; kurtosis.

Biography of presenting author

DAHMANE Saida studied industrial engineering and maintenance at National School of Technology- Algeirs and obtained Master degree in the same field in 2020. I am currently a Phd student registered my 1st year on (2020-2021) in the University of M'sila in the electromechanical field, and supervised by Mr. Fouad BERRABAH from the University of M'sila. Then specialized in the mechanical fault diagnosis field where acquiring knowledge and skills for having a fulfilled cursus.

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Fig. 1 (a-c) shows, respectively, the raw vibration signals of the healthy bearing and the defective bearings in the inner race and outer race faults, respectively.

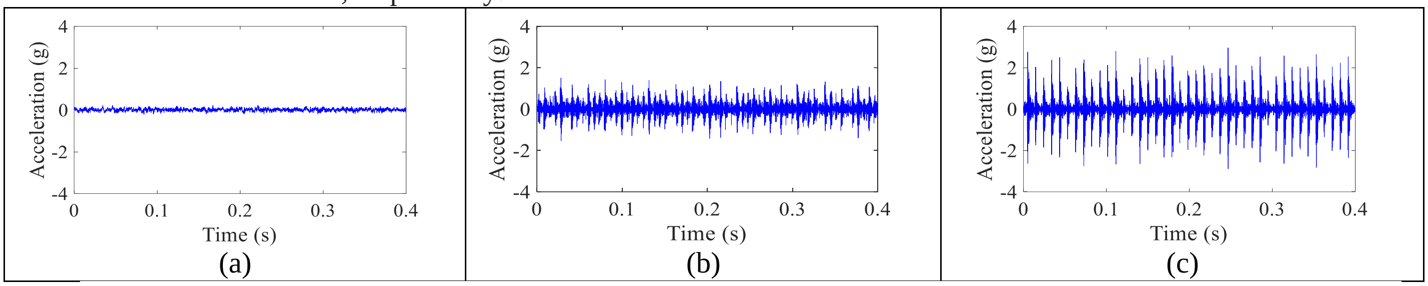

Fig.1. Raw vibration signals of bearing in (a): The healthy case. (b): The inner race fault case. (c): The outer race fault case.

The calculated factors (kurtosis, energy coefficient (EC)) of each detail obtained by the DWT are listed in the table

Tab.I. The calculated factor values (Kurtosis, energy (EC) of the obtained details.

		details						
Case	Factor	d1	d2	d3	d4	d5	d6	d7
Healthy bearing	kurtosis	2.3660	2.5528	3.0581	3.0556	3.0087	2.8529	2.4223
	Energy	-14.6231	-8.5217	-6.3317	-7.2131	-9.6173	-7.2099	-8.1937
Inner race fault	kurtosis	5.7610	5.1599	3.3766	2.9812	3.5388	3.2898	3.1266
	Energy	-3.6923	-9.9157	-7.8862	-8.6284	-6.7502	-5.2175	-9.0889
Outer race fault	Kurtosis	8.1151	7.8510	4.1884	5.2689	4.7783	3.4539	3.5373
	Energy	-2.9100	-10.0199	-7.7275	-8.2898	-7.1375	-8.3837	-6.5563

The detail 1 is illustrated in fig. 2 and its envelope spectrum is depicted in fig.3.

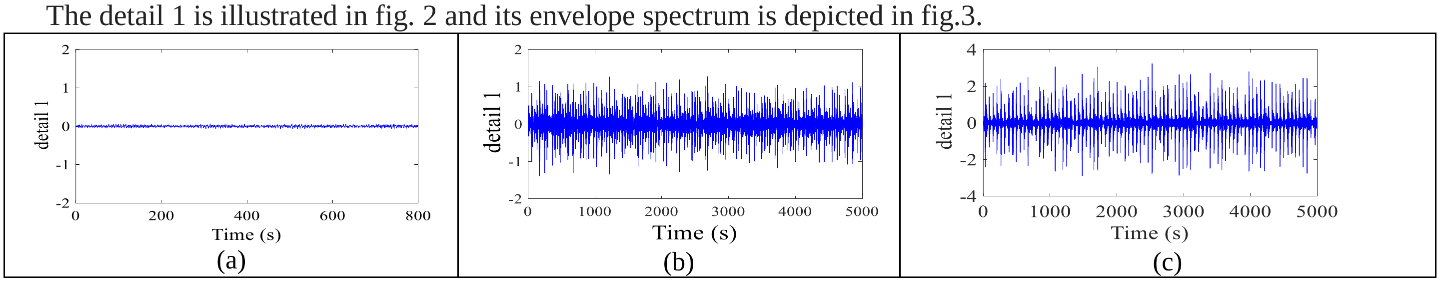

Fig.2. The detail 1 obtained by DWT for (a): healthy bearing. (b): outer race fault. (c): inner race fault.

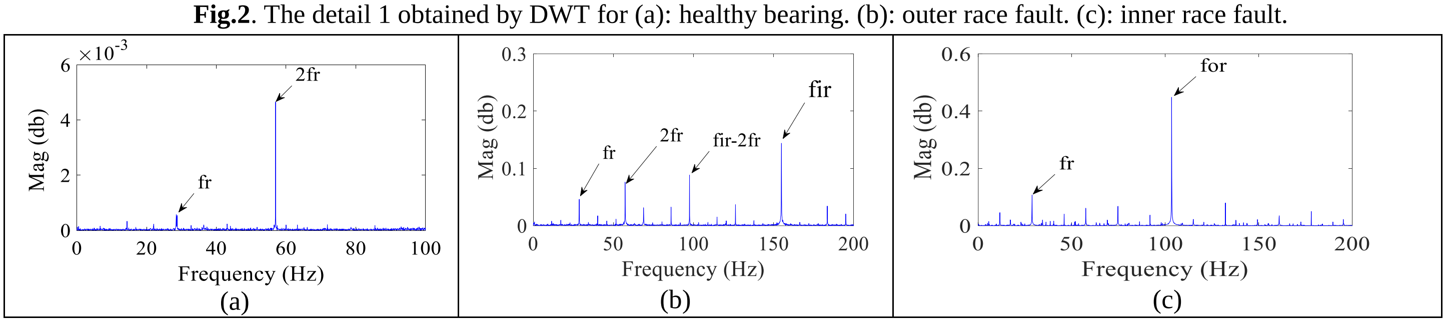

Fig.3. Envelope analysis spectrum of (a): healthy bearing. (b): outer race fault. (c): inner race fault.

Conclusion

The current research presents the utilization of bearing fault identification combined technique based on vibration signals. The proposed method is up of a signal decomposition technique, the DWT. Then the selection of details is applied based on energy and kurtosis factors and thereafter, the envelope analysis is used to check the presence of the fault frequencies comparing them with those calculated theoretically. The results obtained confirm well the efficacy of the proposed method and they are all validated by experiments carried out in the CWRU **[2]**.

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