PAPER REF: 4240

GEARBOX FAULT DETECTION USING A NEW DENOISING METHOD BASED ON ENSEMBLE EMPIRICAL MODE DECOMPOSITION AND FFT

Hafida Mahgoun(*), Rais Elhadi Bekka, Ahmed Felkaoui
Laboratory of applied precision mechanics (LMPA), Institute of optics and precision mechanics.
University Ferhat Abbas, 19000 Sétif, Algeria
(*)*Email:* mahafida006@yahoo.fr

ABSTRACT

The vibration signal of a gearbox carries important information which can be used in early damage detection and fault diagnosis, however this signal is usually noisy and the information about the fault in the early stage of its development can be lost. Ensemble Empirical Mode Decomposition (EEMD) is a new method and a powerful tool in signal processing. In this paper, a de-noising technique based on ensemble empirical mode decomposition and fast Fourier transform (FFT) is used to post processing the noisy vibration signal taken from a test bench. Firstly, the signal is decomposed into a number of IMFs using the EEMD decomposition. Secondly, the denoising method based on the thersholding of Donoho and FFT is applied to IMFs to remove the noise. To detect the damage at an early stage a statistical method based on Kurtosis is used. The different stages of the technique, which is named (DEEMDFFT), are introduced in detail. The results given by this technique are compared to those given by wavelet transform (WT) by using simulated and experimental signals.

Keywords: time-scale, time-frequency, denoising, gearbox, fault detection.

INTRODUCTION

Vibration signals are widely used in rotating machines faults diagnosis and precisely in gearboxes fault detection. These signals carry important information which is very useful in early detection of defect. Many techniques have been proposed for processing vibration signals. The time-frequency analysis methods can provide both time and frequency information of signal. Particularly the Short Time Fourier Transform (STFT), Wigner-Ville distribution (WVD) and Wavelet Transform (WT) are widely used in gearbox diagnosis. However, these techniques present some limits and drawbacks. The STFT is appropriate to analyzing the signals with slowly varying and it is inefficient for the analysis of non-stationary signals such the gearbox vibration signals. The WVD method suffers from the cross terms as by indicated the existence of negative energy for some frequency ranges and from the aliasing problem. The use of pseudo WVD eliminates negative power and therefore also the aliasing problem. However, the results obtained with pseudo WVD can be difficult to interpret.

In this work, we present a new method to denoise the vibration signals by the EEMD in purpose to analyze the gearbox data. Firstly, the gearbox signal is decomposed into a collection of IMFs by the EEMD, next, the coefficient of correlation (coefcor) between the signal and each IMF is calculated, the IMF which the coefcor is less than 0.1 was eliminated

because it considered as a noise, after that, a de-noising method based on thersholding and FFT are applied to de-noise the noisy IMFs. Finally, the signal is reconstructed using the denoised IMFs. The main advantages of this procedure are that no artificial information is introduced into the de-noised signal and the IMFs are independently threshold. The results obtained by this method are compared to those obtained by using wavelets. In this paper we have also used Kurtosis as indicator to extract periodic impulses due to defects. Simulation signal was initially used to evaluate the performance of this new de-noising method. Experimental results show that the noise contaminating the gearbox signal was considerably removed and the defect has been detected at very early stage compared to the results given in the literature.

RESULTS AND CONCLUSIONS

Fig.1 shows clearly that the Kurtosis values of raw signals increase rapidly after day 11, which indicates development of the fault, but before that the variation of the Kurtosis values are arbitraries Fig.2. However, the Kurtosis values of the de-noised signals starts increasing in a uniform way from the seventh day which indicates that the fault appears on gear from the seventh day.

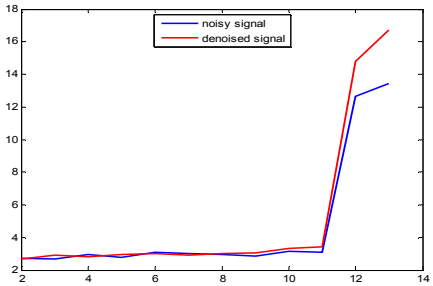

Fig. 1 - Kurtosis value of the acceleration signal from day 2 to day 11 before and after de-noising

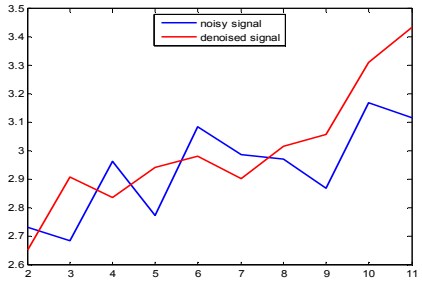

Fig. 2 - Kurtosis value of the acceleration signal from day 2 to day 11 before and after de-noising (Zoomed)

The results presented in this study demonstrate that the combination method of EEMD and denoising based on FFT can be used to identify early damage in gear boxes. We note that the proper choice of the thersholding parameters in the post processing stage is important. Numerical results prove that the de-noising method (DEEMDFFT) can increase the precision of results given by the two methods EEMD and denoising based on FFT. This method is very simple, does not require any choice of wavelet or the scale and it is capable of reducing noise and preserving signal information.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge LASPI (Laboratoire d'Analyse des Signaux et des Processus Industriels, Roanne, France) for signals.

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