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Enhancement of Gear Fault Detection through MED-based Signal Processing

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1. Introduction

The problem to detect the gear faults with the help of vibrational signal analysis has been under investigation since last a few decades. Recently a lot of techniques have been applied on this particular problem like Autoregressive (AR)[2] Modeling, Minimum Entropy Deconvolution (MED).[1,3] The aim of this paper is to examine the effect of AR and MED filter for enhancement of fault detection and diagnosis on mesh gear signal.[2]

2. ARMED Algorithm

2.1 ARMED

The AR filter produces the residual signal and it removes the deterministic part of the gear mesh signal. The basic of the Minimum Entropy Deconvolution (MED)[1] is to minimize the entropy of the signal . The MED is used for the extraction of gear mesh fault signal buried under the transmission path effect. The MED is effectively increasing the kurtosis[3] to get reflection of fault severity of gear. The filter changes its coefficient with iterative sequence to generate the maximum kurtosis value of the objective function.

2.2 Experimental setup

A number of experiments have been carried out in the laboratory on gear test experimental setup as illustrated in Figure 1. This experiment will substantiate the MED-based gear fault monitoring approach.

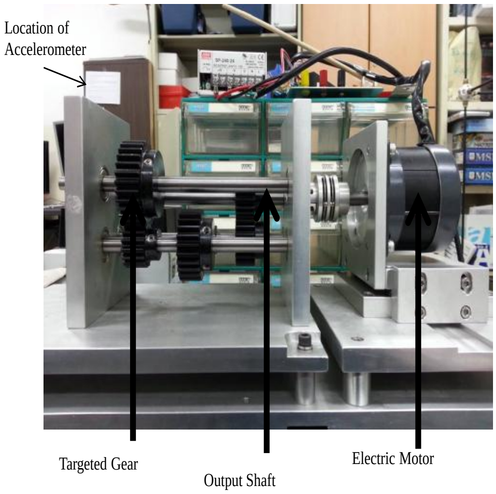

Figure 1 Gear system experimental setup

There are six different sizes of gear in operation to transmit the torque. The targeted gear consists of 30 teeth and conducting gear is having 25 teeth. An artificial damage created by masking one teeth of targeted gear with plastic tape of width 18 mm and its thickness is 0.05 mm and acceleration signal is obtained by using accelerometer mounted on casing near targeted gear. The targeted gears operate on the frequency of 4.5 Hz and its rotational speed is 270 rpm, the data is recorded for 10 seconds. Raw signals is normalized and divided into 15 segments on the basis of the gear time period.

2.3 AR and MED filtered gear signals

The AR(100) model selection was performed by plotting the AR model order of healthy signal and the kurtosis value. The AR process enhances the kurtosis of segment No. 4 (damage case) from 5.93 to 9.03 as shown in Figure 2 and 3. MED techniques with filter length 500 implemented on the residual error signal enhances the kurtosis value and establish great discrimination between healthy and damage cases at remarkable value (kurtosis=112.33) as shown in Figure 2 and 3. The segment No. 4 of healthy case data is used to establish AR model for all segments under investigation. The Figure 2 demonstrate that by using MED filter length more than 400, the kurtosis

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value produced by MED filter in damage case signal is twice in value with respect to healthy case in same parametric conditions.

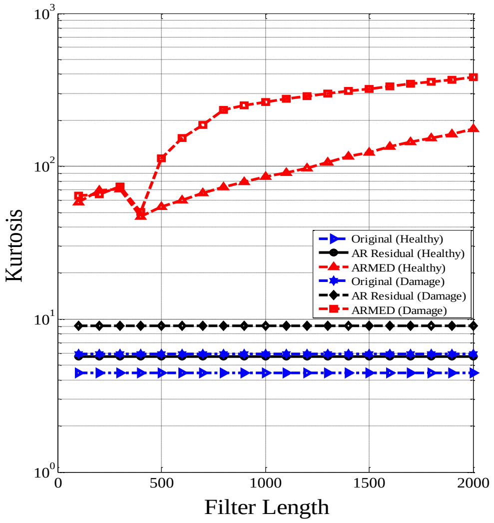

Figure 2 Segment No.4 filter length vs. kurtosis of healthy and damage cases

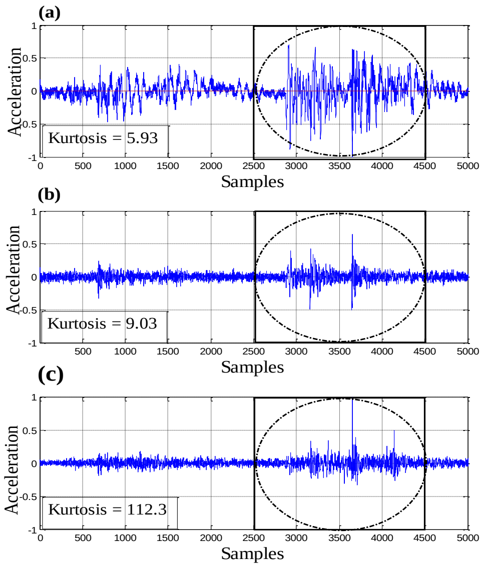

Figure 3 Segment No.4 of damage case as input (a) raw original signal (b) AR(100) residual signal (c) AR(100) + MED(500) output signal

3. Conclusion

The objective of this experiment is to enhance the fault extraction of gear mesh signal by using the AR, MED techniques and examine the relation between MED filter lengths with kurtosis value. The signal is passed through AR(100) and MED(500) filter to explain the effectiveness of ARMED in this paper. Both techniques enhance the kurtosis value on filtration. The MED technique is use to remove transmission effect, enhance the kurtosis value and develop the clarity of damage detection pulse of gear mesh signal. The experiment results of all segments indicate that optimal range of MED filter length lies between 500to1000. It is proven that greater filter length maximize kurtosis value but at a cost of higher computational utility.

Acknowledgments

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References

(1) Ralph A Wiggins, Minimum entropy deconvolution, Geo exploration, Volume 16, Issues 1–2, April 1978: 21-35.

(2) H. Endo, R.B. Randall, Enhancement of autoregressive model based gear tooth fault detection technique by the use of minimum entropy deconvolution filter, Mechanical Systems and Signal Processing, Volume 21. Issue 2, February 2007: 906-919.

(3) Kwak D-H, Lee D-H, Ahn J-H, Koh B-H, Fault detection of roller bearings using signal processing and optimization algorithm, Sensors, 2014; 14(1):283-298.