University of Huddersfield Repository

Elbarghathi, Fathalla, Ball, Andrew and Gu, Fengshou

Two stage helical gearbox fault detection and diagnosis based on continuous wavelet transformation of time synchronous averaged vibration signals

Original Citation


This version is available at http://eprints.hud.ac.uk/13477/

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.

http://eprints.hud.ac.uk/
Two Stage Helical Gearbox Fault Detection and Diagnosis based on Continuous Wavelet Transformation of Time Synchronous Averaged Vibration Signals

THEORETICAL BACKGROUND

Continuous Wavelet Transform:
Continuous Wavelet transform is to perform the Following equation:

\[ CWT \{ x(t); a, b \} = \int x(t) \psi^*_a,b (t) dt \]

Where: \( x(t) \) is the vibration signal, \( a \) is scale (dilation) factor, \( b \) is time location (translation) factor and \( \psi^*_a,b (t) \) represents the complex conjugate of wavelet function.

Time Synchronous Averaging:
Assuming a signal \( x(t) \) consists of a periodic signal \( x_r(t) \) and a noisy component \( n(t) \), the period of \( x_r(t) \) is \( T_o \), whose corresponding frequency is \( f_o \). The synchronous average of the signal \( x(t) \) by using TSA can be expressed as:

\[ y(t) = \frac{1}{M} \sum_{i=0}^{M-1} x(t + iT_o) \]

Where \( M \) is the number of average segments and \( y(t) \) is the average signal.

RESULTS

- CWT has been shown to be an effective tool for rotating machinery fault detection and diagnosis.
- TSA allows the noisy components to be removed significantly and hence highlights the fault related impulse components which paves the basis for accurate feature extraction.
- Three types of wavelets: db1, sym2 and coif3 were explored to find the optimal wavelet for separating the small fault.
- The results have shown that wavelet db1 produces the best fault separation whereas the coif3 wavelet fails to do the separation.

FUTURE WORK

- Drive a mathematical model for vibration signal characterisation under healthy and faulty gear condition
- Validate the modelling results and hence the developed algorithms based upon the experiments data.

ABSTRACT

- To find reliable symptoms of a fault in a multistage gearbox.
- Explores the use of time synchronous average (TSA) to suppress the noise and Continuous Wavelet Transformation (CWT).
- The results obtained in diagnosis an incipient gear breakage show that fault diagnosis results can be improved by using an appropriate wavelet.

TEST FACILITIES AND GEAR FAULTS

- DC-Generator (Mechanical Load)
- Two stage helical gearbox
- 3-Phase 1kW induction motor

Figure 1 Experimental test rig of gearbox

Figure 2 Schematic diagram of test rig

Figure 3 Gear faults: (a) 20% tooth damage (b) 100% tooth damage

Figure 4 Gear healthy case plot of continuous coefficient map of the test signal

Figure 5 Gear with one complete tooth removed case plot of continuous coefficient map of the test signal

CONCLUSION

- CWT has been shown to be an effective tool for rotating machinery fault detection and diagnosis.
- TSA allows the noisy components to be removed significantly and hence highlights the fault related impulse components which paves the basis for accurate feature extraction.
- Three types of wavelets: db1, sym2 and coif3 were explored to find the optimal wavelet for separating the small fault.
- The results have shown that wavelet db1 produces the best fault separation whereas the coif3 wavelet fails to do the separation.