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Two Stage Helical Gearbox Fault Detection and Diagnosis based on Continuous Wavelet Transformation of Time Synchronous Averaged Vibration Signals

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 Continue 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.

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 \(x_p(t)\) and a noisy component \(n(t)\), the period of \(x_p(t)\) is \(T_0\), whose corresponding frequency is \(f_0\). The synchronous average of the signal \(x(t)\) by using TSA can be expressed as:

\[
y(t) = \frac{1}{M} \sum_{i=0}^{M-1} x(t + iT_0)
\]

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.

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