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

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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 $x_T(t)$ and a noisy component $n(t)$, the period of $x_T(t)$ 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.

TEST FACILITIES AND GEAR FAULTS

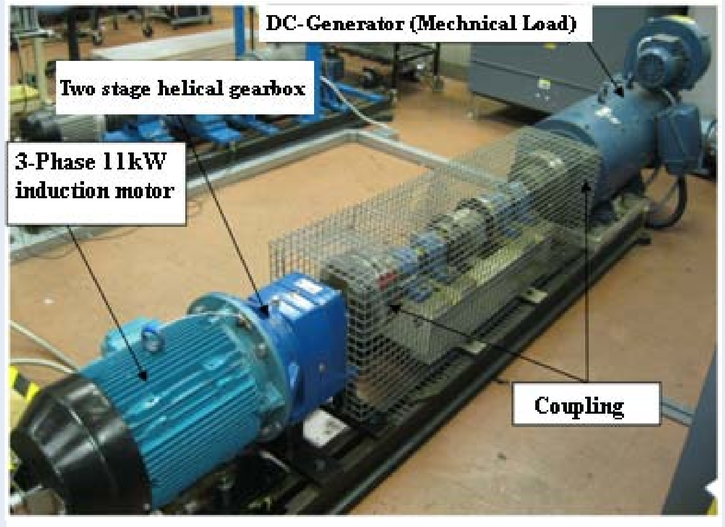

Figure 1 Experimental test rig of gearbox

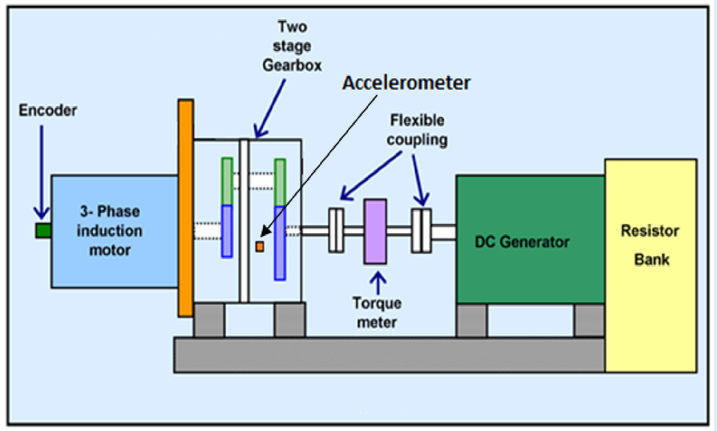

Figure 2 Schematic diagram of test rig

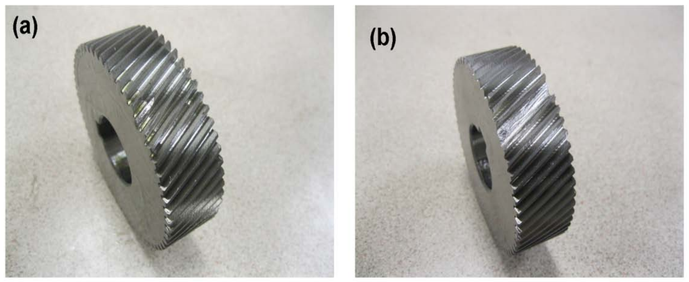

Figure 3 Gear faults: (a) 20% tooth damage (b) 100% tooth damage

RESULTS

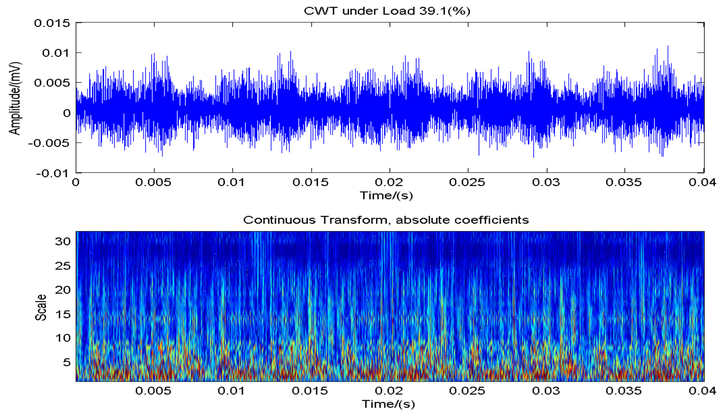

Figure 4 Gear healthy case plot of continuous coefficient map of the test signal

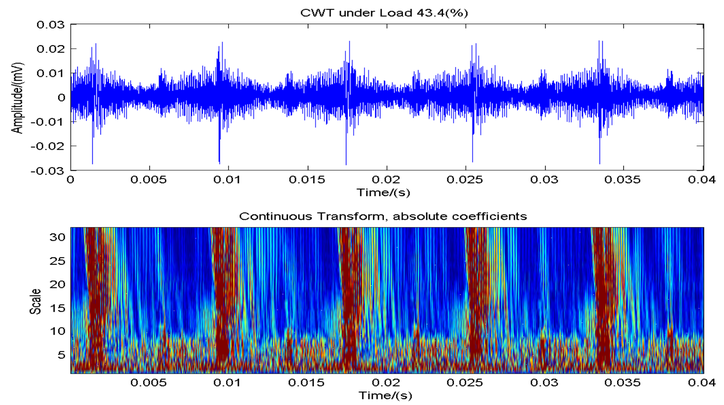

Figure 5 Gear with one complete tooth removed case plot of continuous coefficient map of the test signal

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.

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 .

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