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Original Citation

Elbarghathi, Fathalla, Ball, Andrew and Gu, Fengshou (2012) Two stage helical gearbox fault detection and diagnosis based on continuous wavelet transformation of time synchronous averaged vibration signals. In: Proceedings of The Queen's Diamond Jubilee Computing and Engineering Annual Researchers' Conference 2012: CEARC'12. University of Huddersfield, Huddersfield. ISBN 978-1-86218-106-9

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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

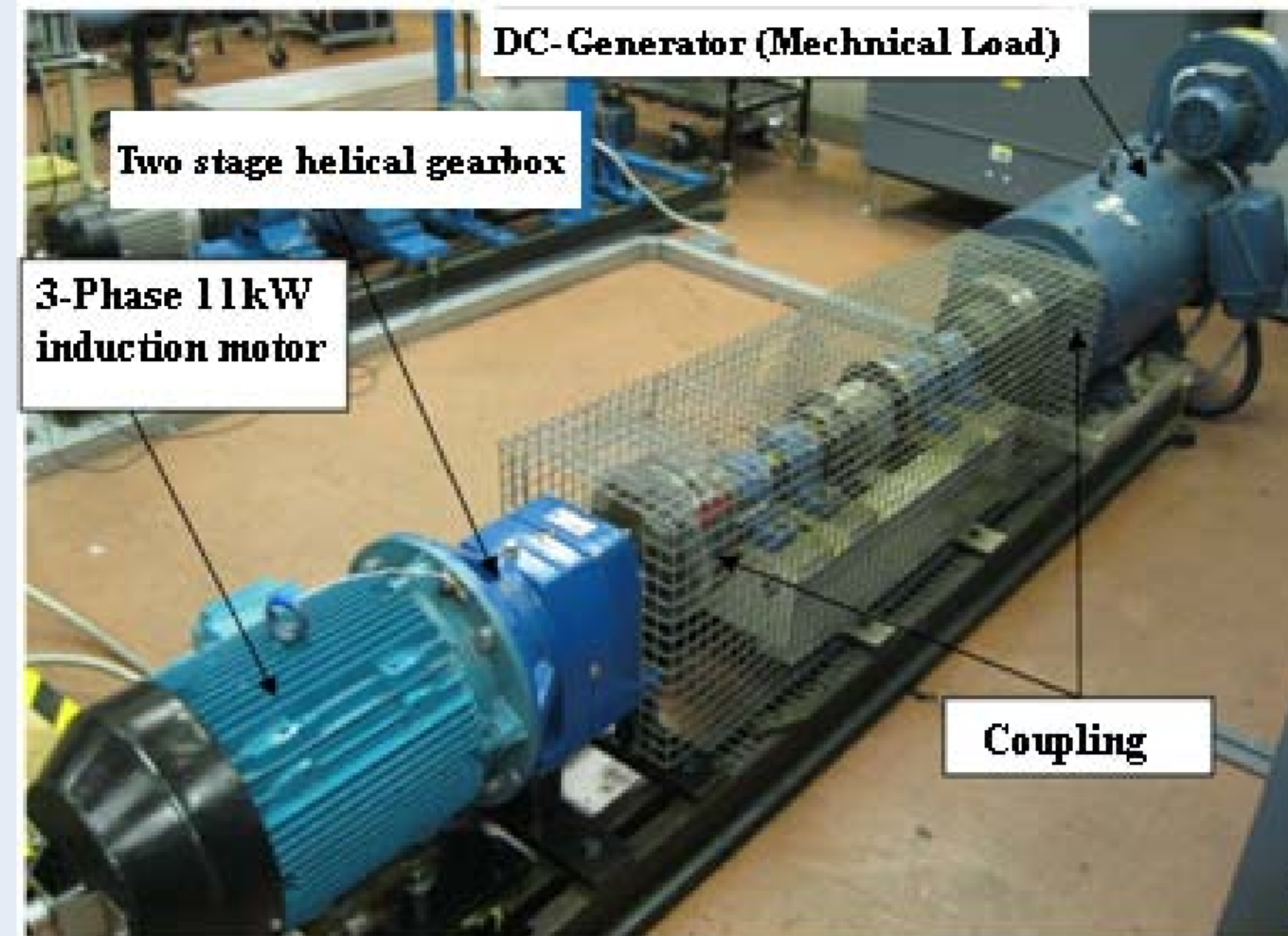


Figure 1 Experimental test rig of gearbox

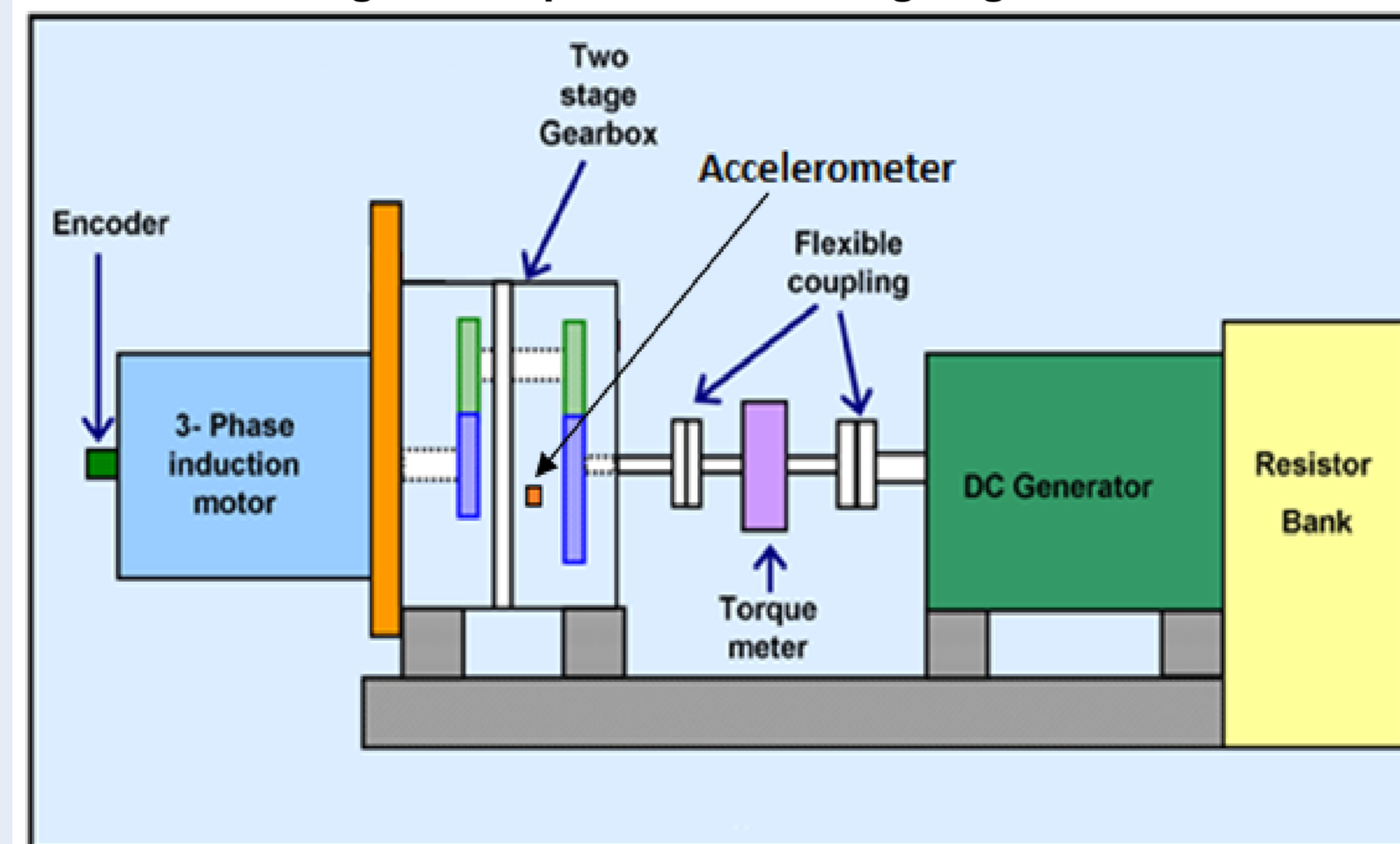


Figure 2 Schematic diagram of test rig

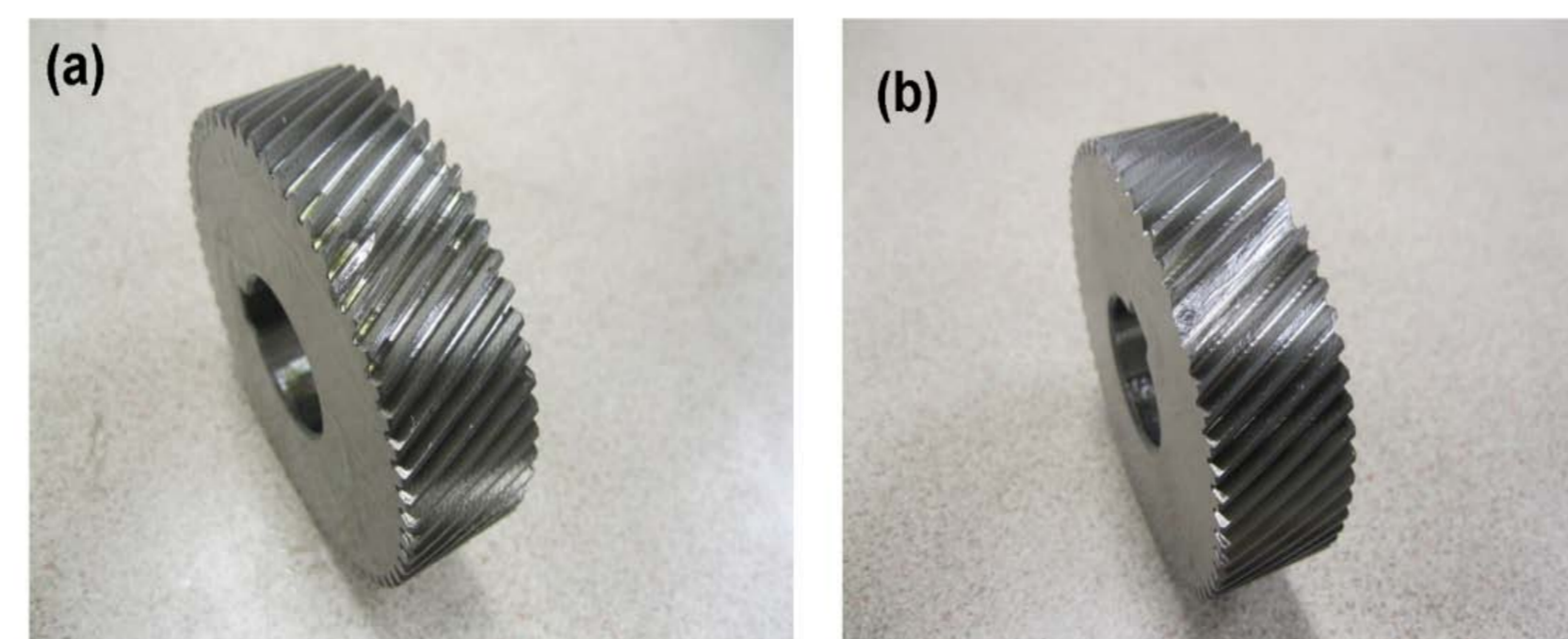


Figure 3 Gear faults: (a) 20% tooth damage (b) 100% tooth damage

RESULTS

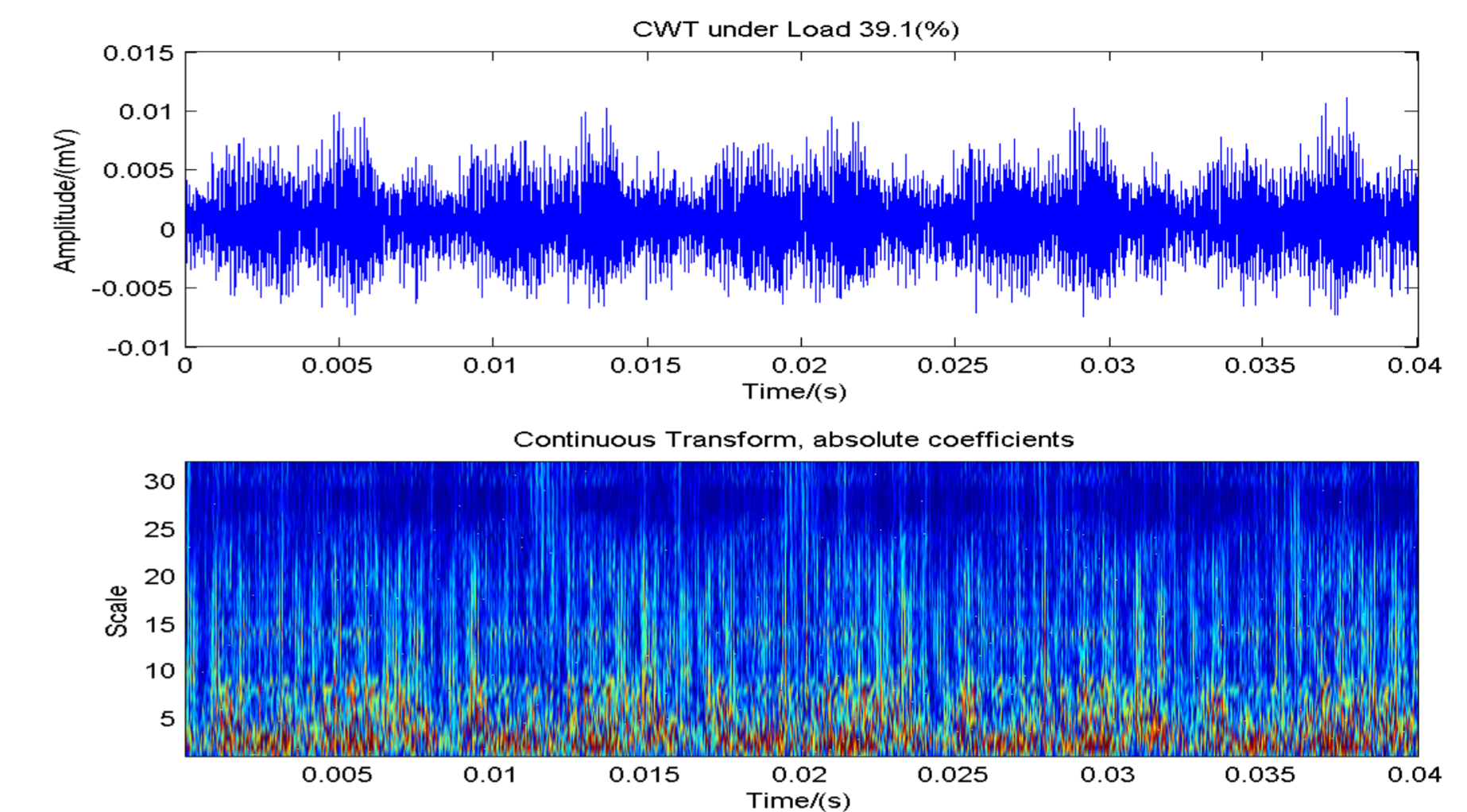


Figure 4 Gear healthy case plot of continuous coefficient map of the test signal

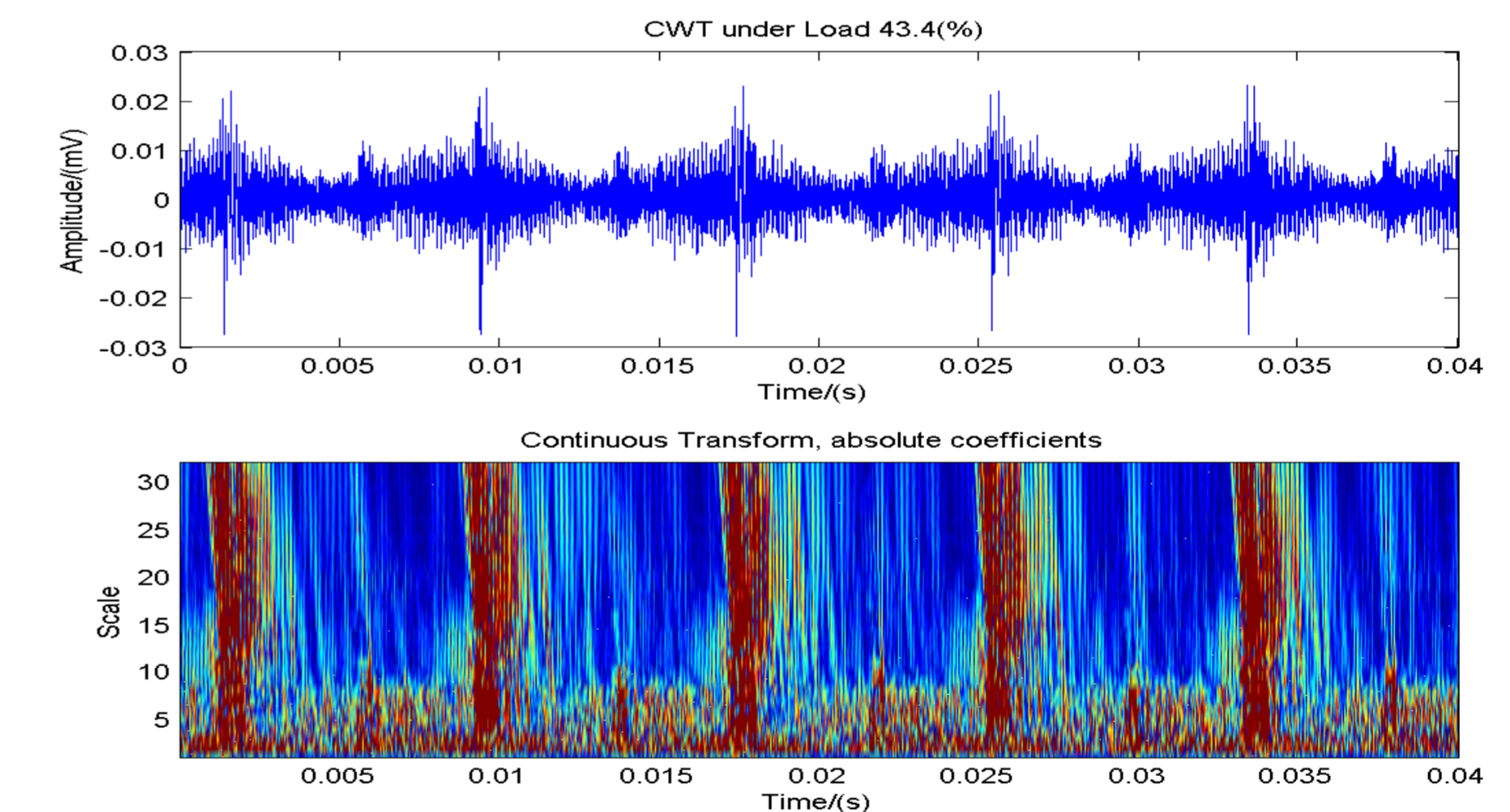


Figure 5 Gear with one complete tooth removed case plot of continuous coefficient map of the test signal

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 .