Machine Fault Detection by Signal Denoising—with Application to Industrial Gas Turbines

Yu Zhang, Chris Bingham, Zhijing Yang, Bingo Wing-Kuen Ling, Michael Gallimore

PII: S0263-2241(14)00339-X
DOI: http://dx.doi.org/10.1016/j.measurement.2014.08.020
Reference: MEASUR 2947

To appear in: *Measurement*

Received Date: 18 September 2013
Revised Date: 23 May 2014
Accepted Date: 14 August 2014

Please cite this article as: Y. Zhang, C. Bingham, Z. Yang, B.W-K. Ling, M. Gallimore, Machine Fault Detection by Signal Denoising—with Application to Industrial Gas Turbines, *Measurement* (2014), doi: http://dx.doi.org/10.1016/j.measurement.2014.08.020

Machine Fault Detection by Signal Denoising—with Application to Industrial Gas Turbines

Yu Zhang[a], Chris Bingham[a]*, Zhijing Yang[b], Bingo Wing-Kuen Ling[c], Michael Gallimore[a]

[a]*School of Engineering, University of Lincoln, Lincoln, LN6 7TS, U.K.*

[b]*Faculty of Computer, Guangdong University of Technology, Guangzhou, 510006, China*

[c]*Faculty of Information Engineering, Guangdong University of Technology, Guangzhou, 510006, China*

Abstract

The paper proposes a new methodology of machine fault detection for industrial gas turbine (IGT) systems. The integrated use of empirical mode decomposition (EMD), principal component analysis (PCA) and Savitzky–Golay (S-G) adaptive filtering are applied to extract noise from underlying measurements. Through analysis of the resulting noise, along with the use of a developed power index, it is shown that transient measurements associated with system load or demand changes, for instance, can be effectively discriminated from those that are characteristic of emerging faults – the former being a primary contributor to generating 'false alerts' using more traditional techniques that are only robust when used with steady-state measurements. Comparative studies show the benefits of the hybrid technique compared to the more usual use of EMD and PCA alone. Three operational conditions are identifiable from the resulting noise analysis viz. normal behaviour, transient operation, and characteristics of emerging machine faults. The efficacy of the proposed approach is demonstrated using two experimental case studies (bearing wear and burner faults) on sub-15MW IGTs.

Highlights

- EMD, PCA and S-G adaptive filtering used for noise extraction.
- Spectral power index developed for noise analysis.
- Discrimination between normal unit operation, transient characteristics, and emerging machine fault conditions.
- Experimental trials indicating the emergence of bearing wear and burner faults.

Keywords: Machine fault detection; empirical mode decomposition; principal component analysis; Savitzky–Golay adaptive filtering; spectral analysis.

* Corresponding author. Tel.: +44 1522 837912;
E-mail address: *cbingham@lincoln.ac.uk*