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ORIGINAL PAPER

Evaluation of performance of vibration signatures for condition monitoring of worm gearbox by using ANN

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Abstract
The worm wheel is the critical element and is vulnerable to failure due to fault occurring on it that leads to downtime hampering productivity. The condition monitoring can predict deteriorating health due to the fault. This work presents the experimental investigation of the worm gearbox carried out by the design of experiments (DOE) that utilizes amplitudes of denoised vibration signatures. During the experiments, trials are designed by the response surface method Box-Behnken DOE method. The cases considered for a single fault are (a) healthy gearbox (b) defective bearing inner race (c) defective outer race (d) defective worm wheel followed by cases comprising of a combination of two faults (e) fault on bearing inner and outer race (f) faulty worm wheel and bearing inner race (g) defective worm wheel and bearing outer race (h) fault on all three was acquired. The statistical parameters extracted from the acquired vibration signatures were used as input to train the ANN model and the performance is evaluated. The results show that the worm wheel is predominant for the fault over the other entities. ANN model predicts fault with an accuracy of 92.9%. Research outcomes envisage that the methodology used has good solidity to improve the performance.

Keywords Worm wheel · Fault · Condition monitoring · Vibration signature · DOE · ANN

1 Introduction

Nowadays condition monitoring plays a vital role in all industries such as chemical, power plants, pharmaceutical, and automobile industries. Correct fault identification, analysis, classification, and severity of fault are vital subjects in the predictive maintenance field. Different predictive maintenance methods like thermal analysis, acoustic analysis, motor current signature analysis, and vibration analysis have been used for fault analysis of gearboxes [1–3]. Out of these methods, vibration analysis is a more popular method for fault identification of gearbox. Predictive maintenance or condition-based maintenance of the gearbox increases efficiency, reliability, safety and productivity, lowers the maintenance cost, and sudden stoppage of the machine [4]. Limited research has been carried out on fault diagnosis of combined faults present in gearboxes by using vibration analysis. The gearbox consists of different components viz shafts, gears, bearings, casing, keys, and couplings. Among these components, gear and bearing are critical components and the nature of the vibration signature for fault present in multiple components of a gearbox is different from the vibration signature of fault present in individual components of the gearbox [5]. In condition monitoring of rotating machinery, extracted vibration signatures from the accelerometer sensors are contaminated by background noise, electromagnetic interference, and vibrations originating from other components of the machine. Hence, the initial task of fault analysis is to separate the actual component vibration signal from the contaminated signal. The denoising method plays a vital role to separate gear and bearing vibration signatures from contaminated vibration signatures [6]. Different denoising algorithms were employed such as improved median filter and wavelet packet [7] synchronous cumulative average noise reduction (SCA) and the denoised signals to separate with the improved fast independent component analysis (FastICA) algorithm [8] gaussian mixture model and quantum-inspired

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