The combined use of vibration, acoustic emission and oil debris on-line monitoring towards a more effective condition monitoring of rotating machinery

T.H. Loutas, D. Roulias, E. Pauly, V. Kostopoulos

Abstract

The monitoring of progressive wear in gears using various non-destructive technologies as well as the use of advanced signal processing techniques upon the acquired recordings to the direction of more effective diagnostic schemes, is the scope of the present work. For this reason multi-hour tests were performed in healthy gears in a single-stage lab scale gearbox until they were seriously damaged. Three on-line monitoring techniques are implemented in the tests. Vibration and acoustic emission recordings in combination with data coming from oil debris monitoring (ODM) of the lubricating oil are utilized in order to assess the condition of the gears. A plethora of parameters/features were extracted from the acquired waveforms via conventional (in time and frequency domain) and non-conventional (wavelet-based) signal processing techniques. Data fusion was accomplished in the level of integration of the most representative among the extracted features from all three measurement technologies in a single data matrix. Principal component analysis (PCA) was utilized to reduce the dimensionality of the data matrix whereas independent component analysis (ICA) was further applied to identify the independent components among the data and correlate them to different damage modes of the gearbox. Finally heuristic rules based on characteristic values of the resulted independent components were set, realizing thus a health monitoring scheme for gearboxes.

The integration of vibration, AE and ODM data increases the diagnostic capacity and reliability of the condition monitoring scheme concluding to very interesting results. The present work summarizes the joint efforts of two research groups towards a more reliable condition monitoring of rotating machinery and gearboxes specifically.

1. Introduction

In gearboxes and power drive trains in general, gear damage detection is very critical and its early diagnosis can lead to increased safety in aviation and in various industrial applications. Thus the interest for their periodic non-destructive inspection and/or on-line health monitoring is growing and effective diagnostic techniques and methodologies are the objective of extensive research efforts over the last 50 years. To this direction, vibration monitoring has been widely used in various industrial applications. In research level, much attention has been drawn towards the gear diagnostics field.

Few research teams have published experimental data coming from long-term testing to study the effect of natural gear pitting mostly upon vibration recordings. Dempsey et al. at GRC/NASA [1–5] have conducted some excellent experimental