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Vibration analysis of rotating machinery using time–frequency analysis and wavelet techniques

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ABSTRACT

Time–frequency analysis, including the wavelet transform, is one of the new and powerful tools in the important field of structural health monitoring, using vibration analysis. Commonly-used signal analysis techniques, based on spectral approaches such as the fast Fourier transform, are powerful in diagnosing a variety of vibration-related problems in rotating machinery. Although these techniques provide powerful diagnostic tools in stationary conditions, they fail to do so in several practical cases involving non-stationary data, which could result either from fast operational conditions, such as the fast start-up of an electrical motor, or from the presence of a fault causing a discontinuity in the vibration signal being monitored. Although the short-time Fourier transform compensates well for the loss of time information incurred by the fast Fourier transform, it fails to successfully resolve fast-changing signals (such as transient signals) resulting from non-stationary environments. To mitigate this situation, wavelet transform tools are considered in this paper as they are superior to both the fast and short-time Fourier transforms in effectively analyzing non-stationary signals. These wavelet tools are applied here, with a suitable choice of a mother wavelet function, to a vibration monitoring system to accurately detect and localize faults occurring in this system. Two cases producing non-stationary signals are considered: stator-to-blade rubbing, and fast start-up and coast-down of a rotor. Two powerful wavelet techniques, namely the continuous wavelet and wavelet packet transforms, are used for the analysis of the monitored vibration signals. In addition, a novel algorithm is proposed and implemented here, which combines these two techniques and the idea of windowing a signal into a number of shaft revolutions to localize faults.

1. Introduction

Rotating machines cover a wide range of critical facilities and provide the backbone of numerous industries, from gas turbines used in the production of electricity to turbo-machinery utilized to generate power in the aerospace industry. It is vital that these machines run safely over time and under different operational conditions, to ensure continuous productivity and prevent any catastrophic failure, which would lead to extremely expensive repairs and may also endanger lives of the operating personnel.

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