Vibration & acoustic emission monitoring of cavitation, contamination & starvation in journal bearings

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Abstract

Bearing is an indispensable component of most rotating machinery. Journal bearing with its compact built, large load carrying capacity, high operational speed range, low maintainability, and longer life has a wide range of applications ranging from industrial turbo-machinery to aerospace industries. However, despite its versatility, the journal bearing is a critical element of rotating machinery and the chances of its premature failure during its expected service life are very high. Majority of the premature failures in journal bearings are associated with lubrication such as oil starvation, oil contamination, cavitation, etc. Vibration and acoustic emission (AE) are proven techniques in fault diagnosis of ball bearings and gears. But their applications to journal bearing have not been fully explored. And despite large research work being done on its design aspects, there is a dearth of studies on condition monitoring and fault diagnosis of journal bearing through vibration and acoustic emission. This thesis entitled 'Vibration & Acoustic Emission Monitoring of Cavitation, Contamination & Starvation in Journal Bearings' consists of four major works. These major works form four main chapters of the thesis, excluding the chapters on introduction, literature review and conclusions. The major works are the study of cavitation, particle contamination, oil starvation and fault diagnosis using machine learning.

The first major work deals with the study of vapour cavitation in a journal bearing. The vapour cavitation has been studied through a cavitation rig that consists of a transparent acrylic bearing that allows observation of bubbles evolving during cavitation besides measurement of vibration and acoustic emission. The evolution of bubbles during cavitation at different speeds has been photographed. The occurrence of vapour cavitation in journal bearing is accompanied by a decrease in 1 X vibration and rise in ≈0.5 X vibration. The AE activities occurring during vapour cavitation have frequencies as high as 570 kHz.

The second work deals with the study of particle contamination in a journal bearing. Silica sand particles of different sizes mixed in oil in different concentrations have been used to study how the intervention of particles in bearing lubrication affect the vibration and acoustic emission characteristics of bearing. The interaction of the particles with the bearing excites the natural frequency of bearing and causes an increase in the level of vibration and acoustic emission release. The frequency of AE activities occurring during particle interaction is 214─254 kHz.

The third major work deals with oil starvation in journal bearing whereby, the vibration and acoustic emission signals have been measured as the bearing undergoes different levels of starvation. The decrease in film thickness with increasing level of starvation has been measured in terms of contact resistance through indigenously designed electrical resistance measurement setup. There is a proportionate increase in vibration and acoustic emission as the severity of starvation increases. The AE activities occurring during starvation has frequencies in the range 224─283 kHz.

And lastly, the fourth major work deals with the diagnosis of journal bearing faults using machine learning. Fault diagnosis using machine learning is the application of

machine learning to characterize the faults-namely cavitation, oil contamination and starvation from the normal bearing operations. The characterization model is developed through supervised learning methods. The model is incorporated in an application which takes new data as input and characterizes the type of fault using the fault diagnosis algorithm.