Characterisation of Major Fault Detection Features and Techniques for the Condition-Based Monitoring of High-speed Centrifugal Blowers

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This paper investigates and characterises the major fault detection signal features and techniques for the diagnostics of rotating element bearings and air leakage faults in high-speed centrifugal blowers. The investigation is based on time domain and frequency domain analysis, as well as on process information, vibration, and acoustic emission fault detection techniques. The results showed that the data analysis method applied in this study is effective, as it yielded a detection accuracy of 100%. A lookup table was compiled to provide an integrated solution for the developer of Condition-Based Monitoring (CBM) applications of centrifugal blowers. The major contribution of this paper is the integration and characterisation of the major fault detection features and techniques.

1. INTRODUCTION

Condition-Based Monitoring (CBM) is a strategy aimed at extending machine life, lowering maintenance cost, and increasing both productivity and profitability.[1] Unlike preventative maintenance, which is based on servicing a machine at scheduled intervals, CBM relies upon actual machine health condition to diagnose faults and to determine when the maintenance is required. The specific advantage of condition monitoring is that potential degradation or failure can be detected. This technique enables the user to take maximum advantage of the useful life of a component, such as a bearing, since the equipment can be left in service if its operational performance meets the desired performance standards.[2]

Centrifugal compressors are widely used in the industry, and in particular in the oil and gas industries, as they compress the propane and mixed refrigerants in the liquefaction process. A 15 HP industrial centrifugal blower was employed for the emulation of high-speed centrifugal blowers. Due to the similarity between centrifugal blowers and centrifugal compressors,[3] this work can be extended to centrifugal compressors and centrifugal equipment.

The global structure of the generally used monitoring system can be divided into three main sections: The first phase is data collection, with data reports gathered in a digital form. The second phase is acquisition, which entails calculation of the statistical values and functions in time and frequency domain with integrated data reduction by fault and operational pattern. The more difficult third phase of automatic fault diagnostics is still under development and permanently adapted to the necessities of industrial applications, mainly dependent on the acting personnel at the monitoring system.[4]

Machine condition, machine faults, and on-going damage can be identified in operating machines by fault symptoms and signatures. Mechanical vibration, acoustic emission (AE), and process information are the three major fault detection techniques in addition to monitoring changes in process operating parameters, such as pressure, temperatures, and efficiency. Thus, this study will provide a characteristics investigation based on these major techniques, which should be included in any full capabilities condition-based maintenance system. Integrating these techniques can yield early detection and trending of numerous equipment faults. Moreover, it could have a potential to reduce false alarms due to noise and fault interference issues.

Vibrations of machines are the results of the dynamic forces due to moving parts and structures (for example, foundations), which are interlinked to the machine and its mechanical properties. All machine components generate specific vibration signatures which are then transmitted to the machine's structure. Vibration analysis detects repetitive motions of a surface on rotating or oscillating machines. The repetitive motions may be caused by unbalance, misalignment, resonance, electrical effects, rolling element bearing faults, or many other problems. The various vibration frequencies in a rotating ma-