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Review

A review on machinery diagnostics and prognostics implementing condition-based maintenance

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Abstract

Condition-based maintenance (CBM) is a maintenance program that recommends maintenance decisions based on the information collected through condition monitoring. It consists of three main steps: data acquisition, data processing and maintenance decision-making. Diagnostics and prognostics are two important aspects of a CBM program. Research in the CBM area grows rapidly. Hundreds of papers in this area, including theory and practical applications, appear every year in academic journals, conference proceedings and technical reports. This paper attempts to summarise and review the recent research and developments in diagnostics and prognostics of mechanical systems implementing CBM with emphasis on models, algorithms and technologies for data processing and maintenance decision-making. Realising the increasing trend of using multiple sensors in condition monitoring, the authors also discuss different techniques for multiple sensor data fusion. The paper concludes with a brief discussion on current practices and possible future trends of CBM.

Keywords: Diagnostics; Prognostics; Condition monitoring; Condition-based maintenance; Signal processing; Sensor data fusion

Contents

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1. Introduction

Reliability has always been an important aspect in the assessment of industrial products and/or equipments. Good product design is of course essential for products with high reliability. However, no matter how good the product design is, products deteriorate over time since they are operating under certain stress or load in the real environment, often involving randomness. Maintenance has, thus, been introduced as an efficient way to assure a satisfactory level of reliability during the useful life of a physical asset.

The earliest maintenance technique is basically breakdown maintenance (also called unplanned maintenance, or run-to-failure maintenance), which takes place only at breakdowns. A later maintenance technique is time-based preventive maintenance (also called planned maintenance), which sets a periodic interval to perform preventive maintenance regardless of the health status of a physical asset. With the rapid development of modern technology, products have become more and more complex while better quality and higher reliability are required. This makes the cost of preventive maintenance higher and higher. Eventually, preventive maintenance has become a major expense of many industrial companies. Therefore, more efficient maintenance approaches such as condition-based maintenance (CBM) are being implemented to handle the situation. Martin [1] briefly summarised the history of maintenance technique development for machine tools. Indeed, the history applies to other types of machines and systems as well.

CBM is a maintenance program that recommends maintenance actions based on the information collected through condition monitoring. CBM attempts to avoid unnecessary maintenance tasks by taking maintenance actions only when there is evidence of abnormal behaviours of a physical asset. A CBM program, if properly established and effectively implemented, can significantly reduce maintenance cost by reducing the number of unnecessary scheduled preventive maintenance operations.

A CBM program consists of three key steps [2] (see Fig. 1):

1. Data acquisition step (information collecting), to obtain data relevant to system health.
2. Data processing step (information handling), to handle and analyse the data or signals collected in step 1 for better understanding and interpretation of the data.
3. Maintenance decision-making step (decision-making), to recommend efficient maintenance policies.

Diagnostics and prognostics are two important aspects in a CBM program. Diagnostics deals with fault detection, isolation and identification when it occurs. Fault detection is a task to indicate whether something is going wrong in the monitored system; fault isolation is a task to locate the component that is faulty; and fault identification is a task to determine the nature of the fault when it is detected. Prognostics deals with fault

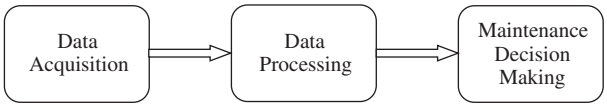

Fig. 1. Three steps in a CBM program.