**MACHINE DIAGNOSIS**

Machine fault diagnostic and prognostic techniques have been the considerable subjects of condition-based maintenance system in the recent time due to the potential advantages that could be gained from reducing downtime, decreasing maintenance costs, and increasing machine availability. For the past few years, research on machine fault diagnosis and prognosis has been developing rapidly. These publications covered in the wide range of statistical approaches to model-based approaches. With the aim of synthesizing and providing the information of these researches for researcher’s community, this paper attempts to summarize and classify the recent published techniques in diagnosis and prognosis of rotating machinery. Furthermore, it also discusses the opportunities as well as the challenges for conducting advance research in the field of machine prognosis.

A failure in industrial equipment results in not only the loss of productivity but also timely services to customers, and may even lead to safety and environmental problems. This emphasizes the need of maintenance in manufacturing operations of organizations. Maintenance is of great importance in keeping availability and reliability levels of production facilities, product quality, etc. Unfortunately, compared with production and manufacturing problems which have received great interest from researchers and practitioners, maintenance gained much less attention in the past. This might be one of the reasons that leads to low maintenance efficiency in industry at present.

one-third of all maintenance costs is wasted as the result of unnecessary or improper maintenance activities. Furthermore, maintenance cost is one of the main expenditure items. According to study, maintenance cost can reach 15-40% of production costs, varying depending on the type of industry. For instance, it is estimated to be more than 600,000 million dollars spent on maintenance in a selected group of companies in 1989 ; maintenance cost as a percentage of total value-added costs could be 20-50% for mining, 15-25% for primary metal and 3-15% for processing and manufacturing industries . Additionally, with the augment of mechanization and automation, many modern plants have installed flexible computer-controlled automatic and unmanned equipments, the maintenance cost has been increased substantially. Therefore, maintenance has been historically regarded as a necessary evil by the various management functions.

Complex equipment in the process industry serves as the company's core assets and profit source, and effective management and maintenance of equipment is an important means of protecting corporate assets. In today's information-intensive infiltration, it is imperative to properly implement equipment online monitoring and fault diagnosis. The stress wave monitoring technology can directly reflect the working state, expected fault and life cycle of the mechanical equipment in continuous operation. In addition, process monitoring parameters such as pressure, temperature, and current can also be used for fault diagnosis of mechanical equipment. At present, the industry divides fault diagnosis methods into three categories: Fault diagnosis based on analysis model, empirical knowledge and data driven [1]. Fault diagnosis method based on analysis model is a method that combines a mathematical model and the current operating status of the equipment. The results of this kind of fault diagnosis method are more accurate, but it is very difficult to establish accurate models, or even impossible [2]. Fault diagnosis method based on empirical knowledge is a method that combines the experience of domain experts and the actual operation of the equipment to diagnose. The accuracy of this type of fault diagnosis method depends on the correctness of the knowledge source and the reliability of the reasoning mechanism. Expert system [3, 4] is the typical representative. The data-driven fault diagnosis method is aimed at complex equipment and uses a large amount of historical monitoring data for diagnosis. This type of diagnostic method avoids complicated mathematical models and expert experience, but the completeness and comprehensiveness of monitoring data are the main factors affecting the credibility of diagnostic results

In the process industry, complex equipment is crucial for generating profits, and proper management and maintenance of these assets are essential for protecting a company's investments. Online monitoring and fault diagnosis of equipment have become imperative in today's information-intensive environment. Stress wave monitoring technology can provide direct insights into the working condition, expected faults, and lifecycle of continuously operating mechanical equipment. Additionally, process monitoring parameters such as pressure, temperature, and current can also be used for fault diagnosis. Currently, there are three categories of fault diagnosis methods: analysis model-based, empirical knowledge-based, and data-driven methods. Analysis model-based methods combine mathematical models with equipment's current operating status for accurate results, but establishing accurate models can be challenging. Empirical knowledge-based methods rely on the experience of domain experts and actual equipment operation, with expert systems being a typical example. Data-driven methods use historical monitoring data for diagnosis and avoid complex mathematical models and expert experience, but the completeness and comprehensiveness of monitoring data affect the credibility of diagnostic results.

In recent times, there has been significant interest in condition-based maintenance systems that utilize machine fault diagnostic and prognostic techniques. These techniques have the potential to reduce downtime, lower maintenance costs, and increase machine availability. Research in machine fault diagnosis and prognosis has been rapidly evolving, covering a wide range of statistical and model-based approaches. This paper aims to summarize and classify recent published techniques for diagnosing and prognosing rotating machinery, with the goal of providing information to the research community. Additionally, it discusses the opportunities and challenges in conducting advanced research in the field of machine prognosis.

Industrial equipment failures can cause disruptions in productivity, customer service delays, safety and environmental concerns. This highlights the importance of maintenance in manufacturing operations for organizations. Maintenance plays a crucial role in maintaining the availability and reliability of production facilities, as well as ensuring product quality. However, in the past, maintenance has received less attention compared to production and manufacturing issues, which may have contributed to the current low efficiency in maintenance practices in the industry.

Approximately one-third of maintenance costs are wasted due to unnecessary or improper maintenance activities. Maintenance costs are a significant expense and can range from 15-40% of production costs, depending on the industry. For example, in 1989, over $600 billion was estimated to have been spent on maintenance in a selected group of companies. Maintenance costs as a percentage of total value-added costs can vary, with ranges of 20-50% for mining, 15-25% for primary metal, and 3-15% for processing and manufacturing industries. Moreover, the adoption of mechanization and automation in modern plants, with flexible computer-controlled automatic and unmanned equipment, has substantially increased maintenance costs. As a result, maintenance has often been viewed as a necessary evil by various management functions.

In this project, we propose a multi-channel Internet of Things (IoT)-based industrial wireless sensor system (IWS) for machine condition monitoring and fault diagnosis using accelerometer, gyroscope, vibration sensor, and temperature sensor data for pre- and post-diagnosis and analysis. We investigate ensemble feature extraction and fault diagnosis using a classifier to address the system requirements of IWS. We also explore a two-step classifier fusion approach using Dempster-Shafer theory to improve diagnosis results. We monitor four types of machine faults and evaluate the proposed system. The final fault diagnosis results using the proposed classifier fusion approach show a high level of certainty, indicating the feasibility of the proposed method for identifying fault patterns. This project provides new insights into the design of a high-accuracy IoT-based fault diagnosis algorithm and serves as a valuable reference for other IWS scenarios. Additionally, we plan to plot a graph to visually display the differences in pre- and post-diagnosis using the collected sensor data.