Real-time Fault Diagnostic in Rotating Shaft using IoT-based Architecture and Fuzzy Logic Analysis

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***Abstract*— The rotating shaft, commonly known as an axle, plays a crucial role in enabling rotational motion and power transmission within industrial rotating machines. However, assessing the condition of a rotating shaft presents a significant challenge due to its concealed nature. Traditionally, manual inspections by technicians have been relied upon to detect potential damage, resulting in time-consuming processes and potential delays in fault diagnostic. To address this issue, this paper proposes an IoT-based architecture integrated with fuzzy logic to enable real-time fault diagnostic in rotating shaft. By employing fuzzy logic classification based on vibration frequency and noise analysis, the system accurately determines the condition of the rotating shaft. Experimental results confirm the successful implementation of the proposed system, providing valuable insights into the current condition of the rotating shaft. This real-time approach enables proactive maintenance strategies and mitigates the risk of unexpected industrial machine failures.**

Keywords—fuzzy logic, internet of things, rotating shaft, fault diagnosis, condition monitoring

I. INTRODUCTION

The rotating shaft, often referred to as an axle, represents a pivotal mechanical element responsible for rotational motion around an axis while facilitating the transmission of power or motion. Typically fashioned as a cylindrical structure crafted from durable materials, such as metal, this component finds ubiquitous application in a diverse array of mechanical systems, devices, and industrial machinery [1]. Consequently, it is commonplace to encounter rotating shaft within large-scale factories housing substantial machinery. Moreover, these shaft frequently establish connections with other shaft or various industrial machine components, further augmenting their functional capabilities.

One of the inherent challenges associated with utilizing a rotating shaft lies in the difficulty of determining its condition on a industrial machine, specifically whether it is in optimal working order. Typically, the detection of damage occurring on a industrial machine's rotating shaft heavily relies on manual inspection carried out by designated technicians. Consequently, assessing the condition of the rotating shaft can be a time-consuming process, leading to potential delays in diagnostic [2], [3]. Furthermore, the timely and early-stage detection of faults also proves to be a significant issue. This predicament arises due to the absence of indicators that provide real-time insights into the current condition of the rotating shaft. Consequently, damages can only be discerned by technicians during subsequent inspection routines. Moreover, the occurrence of unexpected industrial machine failures can result in production downtime and an increase in customer complaints for the company or organization [4].

The difficulty associated with determining the condition of rotating shaft on industrial machines can be effectively resolved through the implementation of fuzzy logic [5]. Fuzzy logic, a mathematical framework adept at handling imprecise and uncertain information, presents a robust solution for assessing the condition of rotating shaft. In contrast to traditional binary logic, which operates in a true or false manner, fuzzy logic introduces degrees of truth where variables can possess values between 0 and 1. This characteristic allows for a more nuanced representation of the extent to which variables are true or false. By employing fuzzy logic, the IoT-based system can accurately evaluate the condition of rotating shaft, taking into account the various degrees of truth associated with different parameters. This capability enables a more comprehensive and accurate assessment, enhancing the system's effectiveness in monitoring and detecting faults in real-time.

This paper presents a real-time IoT-based architecture augmented with fuzzy logic implementation to facilitate the diagnostic of faults in rotating shaft in real time. The proposed architecture encompasses the deployment of a real-time monitoring dashboard and a sensing system specifically designed to detect faults in rotating shaft, employing fuzzy logic algorithms. The core objective of the architecture is to classify the condition of rotating shaft into three categories: normal functioning, moderate functioning, and severe malfunctioning. This classification is determined based on the degree of noise and vibration exhibited by the rotating shaft. By leveraging fuzzy logic's ability to handle imprecise and uncertain data, the proposed architecture enables a precise and nuanced assessment of the rotating shaft's condition, enabling proactive maintenance and minimizing potential disruptions caused by unforeseen faults.

II. LITERATURE REVIEW

To replicate the functionality of rotating shaft in industrial settings and test for defects, the Gearbox Diagnostics Simulator (GDS) is employed [6]. The setup aims to identify any issues or problems present in the industrial machine's rotating components. Comprising a gearbox with a single shaft, bearings, and a computer-controlled mechanical brake, the setup facilitates the collection of vibration data and thermal signatures from the gears through the use of sensors. The Fault Condition Monitoring (FCM) system employs smart vibration analysis methods to diagnose faults in cooling fan shaft [7]. FCM integrates an accelerometer sensor to detect faults using vibration analysis. The collected vibration data undergoes processing and filtering to remove outliers and implemented in real-time to identify faults in test data. Furthermore, an approach for condition monitoring utilizing vibration parameters has been proposed [8]. This approach accurately classifies the condition of rotating shaft as normal,