Predictive Maintenance System

Ms. Bhakti Bharat Satam[1], Ms. Bhakti Dattatray Sawant[2], Ms. Sakshi Bharat Sawant[3], Ms. Parnavee Pravin Shirke[4], Ms. Nandini Sanjeevkumar Singh[5], Ms. S.S. Kadam[6]

[1,2,3,4,5]Student, Yashwantrao Bhonsale Institute of Technology, Sawantwadi,
[6]Faculty, Yashwantrao Bhonsale Institute of Technology, Sawantwadi,
[1]satambhakti1217@gmail.com ,[2] sawantsakshi2809@gmail.com , [3]nandini.sk.singh@gmail.com

Abstract:

Maintenance of industrial systems is essential to ensure safe operation, reliability, and long equipment life. Traditional maintenance techniques such as reactive and preventive maintenance are inefficient for systems that require continuous monitoring and early fault detection [1][5]. Reactive maintenance leads to unexpected failures and increased downtime, while preventive maintenance often results in unnecessary servicing.

This project presents a Predictive Maintenance System that continuously monitors critical parameters such as RPM, temperature, sound, voltage, and current to assess system health in real time [2][6]. A demo windmill model is used to demonstrate the working principle of the system. Sensor data is analyzed using predefined threshold values to identify abnormal operating conditions and predict possible faults before actual failure occurs.

The system provides real-time data display, fault alerts, and maintenance suggestions through an LCD and a dashboard interface. By enabling early fault detection and guided maintenance actions, the proposed system reduces downtime, lowers maintenance costs, and improves overall system reliability, making it an effective and intelligent maintenance solution.

Keywords— machines, IoT, machine health monitoring, ESP32, real-time monitoring, industrial automation.

I. INTRODUCTION

In modern industrial and mechanical systems, proper maintenance plays a crucial role in ensuring continuous operation, safety, and efficiency. Equipment failures not only cause production loss but also lead to increased maintenance costs and reduced system reliability. Therefore, industries are shifting from traditional maintenance techniques to more intelligent and data-driven maintenance approaches.

Conventional maintenance methods such as reactive and preventive maintenance are still widely used [5]. Reactive maintenance is performed only after a system failure occurs, which results in unexpected breakdowns, higher repair costs, and extended downtime [1]. Preventive maintenance follows a scheduled approach where components are serviced or replaced at fixed time intervals, irrespective of their actual operating condition. Although preventive maintenance reduces sudden failures, it often leads to unnecessary maintenance and inefficient resource utilization.

With the advancement of sensors, embedded systems, and data processing technologies, predictive maintenance has emerged as a modern and effective maintenance strategy [6]. Predictive maintenance continuously monitors key system parameters and analyzes real-time data to detect early signs of failure [3][7]. This approach allows maintenance activities to be performed only when required, based on the actual condition of the system.

This project focuses on the development of a Predictive Maintenance System using real-time monitoring and fault prediction techniques. A demo windmill model is used to represent a real-world system and demonstrate the effectiveness of predictive maintenance. By continuously monitoring parameters such as RPM, temperature, sound, voltage, and current, the system predicts potential faults and provides maintenance recommendations before a failure occurs. The proposed system aims to improve system reliability, reduce downtime, and optimize maintenance operations.

II. LITERATURE REVIEW

Maintenance plays a vital role in ensuring the reliability, safety, and efficiency of industrial systems. Traditionally, maintenance strategies such as reactive and preventive maintenance have been widely used across industries. Reactive maintenance involves repairing equipment only after a failure occurs, which often results in unexpected breakdowns, production loss, increased downtime, and higher repair costs. Several studies highlight that reactive maintenance is unsuitable for critical systems that require uninterrupted operation [1][5].

Preventive maintenance, on the other hand, schedules maintenance activities at fixed time intervals regardless of the actual condition of the equipment. Although it reduces sudden failures compared to reactive maintenance, it often leads to unnecessary servicing or replacement of components that are still in good condition. Research indicates that preventive maintenance does not effectively utilize real-time system data and fails to detect early-stage faults [3].

With advancements in sensors, embedded systems, and data analysis techniques, predictive maintenance has emerged as a more efficient maintenance strategy. Predictive maintenance focuses on continuous monitoring of system parameters such as temperature, vibration, speed, sound, voltage, and current to assess equipment health [2][4]. Various researchers have demonstrated that analyzing real-time sensor data helps in identifying abnormal patterns and predicting failures before they occur.

Recent studies show that predictive maintenance systems improve equipment life, reduce downtime, and lower maintenance costs by enabling condition-based maintenance decisions [6][7]. The integration of microcontrollers, sensor networks, and dashboard interfaces further enhances real-time monitoring and fault diagnosis. However, many existing systems are complex and expensive for small-scale applications.

Based on the literature, there is a need for a simple, cost-effective predictive maintenance system that can demonstrate real-time monitoring, early fault prediction, and maintenance guidance. The proposed project addresses this gap by developing a predictive maintenance model using a demo windmill system to showcase the effectiveness of predictive maintenance techniques.

III. OBJECTIVE

The main objective of this project is to design and develop a Predictive Maintenance System that can monitor system health in real time and predict potential faults before actual failure occurs.

The specific objectives of the project are as follows:
To study existing maintenance techniques and identify their limitations.
To design a predictive maintenance model using real-time sensor data.
To continuously monitor critical parameters such as RPM, temperature, sound, voltage, and current.
To analyze sensor data and compare it with predefined threshold values for fault prediction.
To detect abnormal operating conditions at an early stage and predict possible faults.

To provide corrective action suggestions to prevent system breakdowns.
To display real-time data, fault alerts, and system status on an LCD and dashboard interface.
To reduce system downtime, maintenance cost, and improve overall system reliability.
The objectives of this project align with predictive maintenance principles discussed in existing IoT-based maintenance systems [1][6].

IV. METHODOLOGY

The proposed Predictive Maintenance System is designed to monitor the operational condition of a system continuously and predict possible faults before an actual failure occurs **[1][6]**. The methodology follows a systematic approach involving data acquisition, real-time analysis, fault prediction, and maintenance guidance.

Initially, a demo windmill model is used to demonstrate the working principle of the system. Various sensors are interfaced with the system to measure critical parameters such as RPM, temperature, sound, voltage, and current [2][7]. These sensors continuously collect real-time data representing the health and performance of the system during operation.

The collected sensor data is transmitted to a microcontroller, where it is processed and analyzed. Predefined threshold values are set for each parameter based on normal operating conditions. The real-time sensor values are continuously compared with these threshold limits to determine whether the system is operating under normal or abnormal conditions.

If all parameters remain within the safe range, the system continues normal operation and displays real-time readings on an LCD for user observation. When any parameter exceeds its predefined threshold, the system identifies abnormal behavior and predicts a potential fault condition [6][7]. Based on the affected parameter, the system also indicates the corrective action required to prevent system failure.

The processed data and fault status are displayed on an LCD and sent to a dashboard interface. The dashboard provides system health status, fault alerts, and maintenance suggestions, allowing users to monitor the system remotely and take timely maintenance actions.

Through continuous monitoring, early fault prediction, and guided maintenance recommendations, the proposed methodology reduces unexpected breakdowns, minimizes downtime, lowers maintenance costs, and enhances overall system.

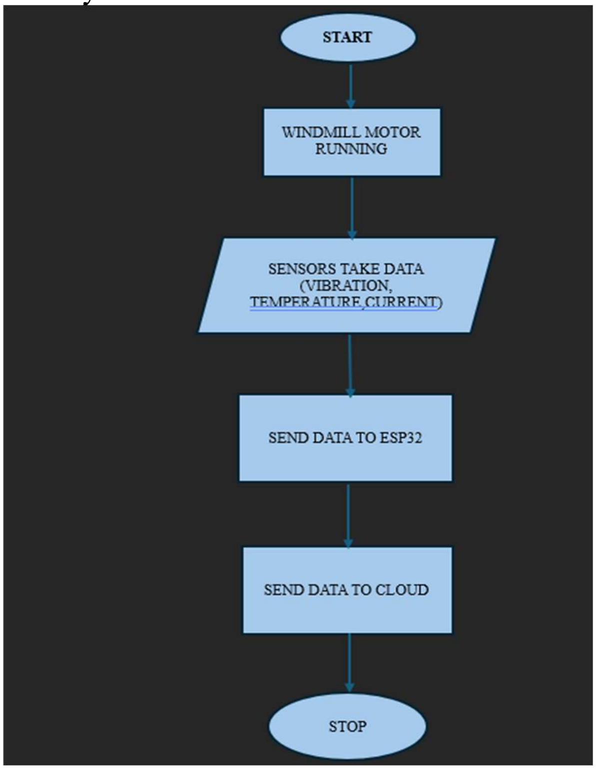

Fig 1: Flowchart For Data Collection

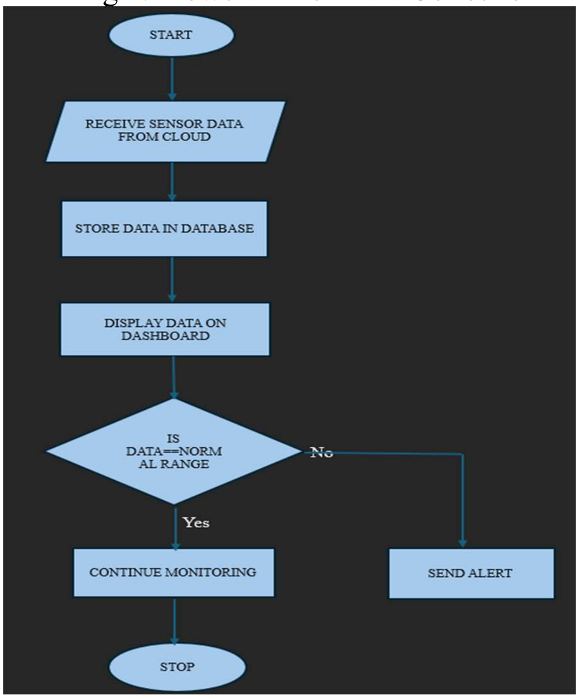

Fig 2: Flowchart For Processing and Monitoring

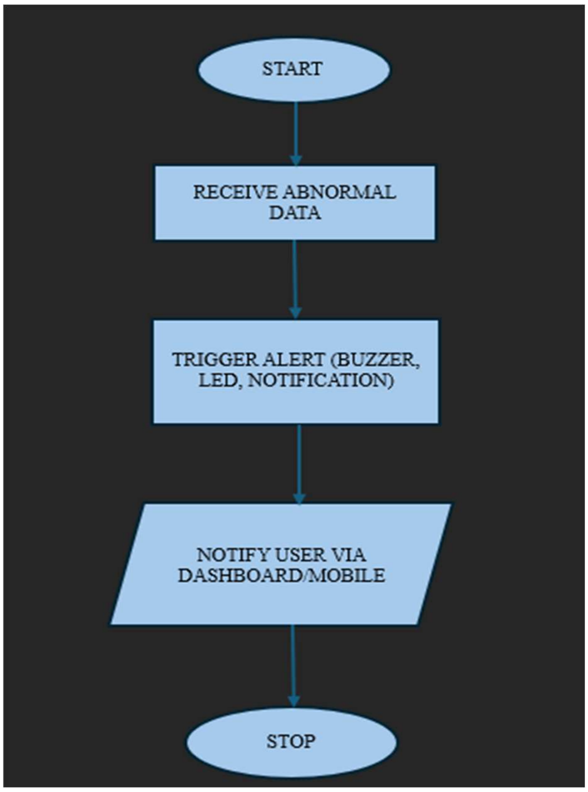

Fig 3: Flowchart For Fault Detection and Error

V. DISCUSSION

Maintenance of systems is crucial to ensure reliable operation, safety, and longer equipment life. Traditional maintenance methods are still widely used, but they are not suitable for systems that require continuous monitoring and early fault detection. This section discusses the limitations of existing maintenance techniques and the advantages of the proposed predictive maintenance system developed in this project.

Existing System

In the existing maintenance approach, systems mainly follow reactive or preventive maintenance methods. Reactive maintenance involves taking corrective action only after a failure occurs, which leads to unexpected breakdowns, increased downtime, and higher maintenance costs [1][5].

Preventive maintenance is performed at fixed intervals without considering the real-time operating condition of the system. Although this approach reduces sudden failures, it often results in unnecessary maintenance or replacement of components that are still functional. Moreover, the existing system does not continuously monitor critical operating parameters such as mechanical, electrical, or environmental conditions. Due to the absence of real-time analysis and fault prediction, early signs of failure often remain undetected.

Proposed System

The proposed system implements a predictive maintenance approach using real-time sensor data and monitoring interfaces. A demo windmill model is used only to demonstrate the working principle of the system. Multiple parameters such as RPM, temperature, sound, voltage, and current are continuously monitored to evaluate the system's health condition [2][4].

The real-time sensor readings are displayed on an LCD for local monitoring. In addition, a dashboard interface provides detailed system status, fault alerts, and maintenance-related information. When abnormal behavior is detected, the system predicts a possible fault before actual failure occurs. Along with fault indication, the system also provides guidance on which component needs to be checked or corrected to prevent the fault.

By predicting faults in advance and suggesting appropriate maintenance actions, the proposed system reduces downtime, avoids major failures, and improves overall system reliability.

The combination of real-time monitoring, LCD display, and dashboard-based alerts makes the system efficient, user-friendly, and suitable for practical applications.

Comparison Summary

- Compared to the existing maintenance methods, the proposed predictive maintenance system:
- Continuously monitors multiple operating parameters.
- Predicts faults at an early stage.
- Displays real-time readings on an LCD.
- Provides fault alerts and corrective suggestions through a dashboard.
- Reduces maintenance cost and system downtime.
- Thus, the proposed system offers an effective and intelligent solution for predictive maintenance compared to conventional maintenance approaches.

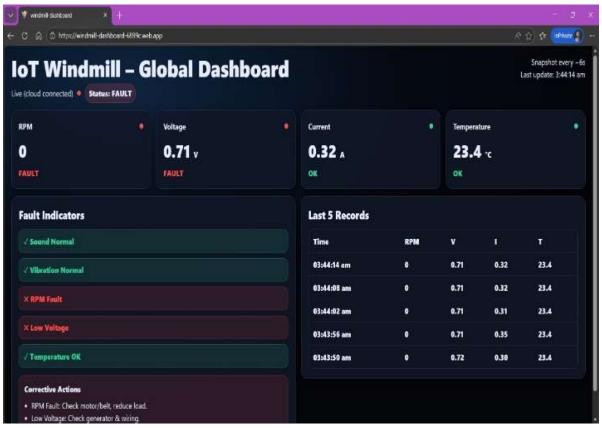

Fig 4: Dashboard Image


Fig 5: Windmill Model Image

VI. CONCLUSION

This project successfully demonstrates the implementation of a predictive maintenance system that overcomes the limitations of traditional reactive and preventive maintenance approaches [1][5]. By continuously monitoring critical parameters such as RPM, temperature, sound, voltage, and current, the system enables early detection of abnormal conditions before actual equipment failure occurs.
The use of real-time sensor data, along with LCD-based local monitoring and a dashboard interface for detailed system analysis, ensures better visibility of the system's health. Unlike conventional methods that rely on fixed schedules or post-failure actions, the proposed system intelligently predicts faults and provides corrective suggestions, allowing timely maintenance and informed decision-making.
As a result, the predictive maintenance system significantly reduces unexpected breakdowns, minimizes system downtime, lowers maintenance costs, and enhances overall reliability and operational efficiency. The demo windmill model effectively validates the working principle of the system, proving its suitability for real-world industrial applications [3][6].
In conclusion, the proposed predictive maintenance system offers a smart, efficient, and user-friendly solution for modern maintenance requirements and serves as a strong foundation for future expansion into large-scale and fully automated industrial monitoring systems.

REFERENCES:

[1] S. A. Khandekar et al., IoT Based Predictive Maintenance of Motors, IJERT, 2021.

[2] A. Sharma et al., Condition Monitoring in Wind Turbines, IEEE, 2020.

[3] K. R. Patel et al., IoT-Enabled Industrial Maintenance, IRJET, 2019.

[4] N. P. Jadhav et al., Low-Cost Vibration Monitoring System, IJRASET, 2022.

[5] R. K. Mobley, An Introduction to Predictive Maintenance, Elsevier Butterworth-Heinemann, 2002.

[6] J. Lee et al., Predictive Maintenance of Industrial Systems Using IoT and Big Data, IEEE Access, 2018.

[7] P. K. Singh et al., Real-Time Monitoring and Fault Detection Using IoT, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 2020.