Development of Data Acquisition System for Condition Monitoring of CNC machine

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Abstract- The Development of Data Acquisition System for Condition Monitoring of CNC Machine aims to enhance machine performance and prevent downtime through real-time data analysis and predictive maintenance. The system utilizes various sensors such as temperature, vibration, acoustic emission, and RPM sensors to capture critical data from the CNC machine. A key component of the system is the ESP8266 microcontroller, which processes the sensor data in real-time. The data is then transmitted to the Thingspeak cloud for storage and analysis. This enables remote monitoring of the CNC machine's condition, allowing for timely intervention and maintenance.

Furthermore, the system employs Google Apps Script to send alarm signals via email if sensor data exceeds pre-set threshold values. This proactive approach ensures that potential issues are promptly, minimizing the risk of costly breakdowns and optimizing machine uptime. By harnessing sensor data for fault detection and predictive maintenance, the system enables users to anticipate and address potential issues before they escalate. This not only enhances the reliability and efficiency of the CNC machine but also reduces maintenance costs and downtime.

In summary, the Development of Data Acquisition System for Condition Monitoring of CNC Machine offers a comprehensive solution for optimizing machine performance and maintenance processes. By integrating advanced sensors, microcontroller technology, cloud storage, and email alerts, the system empowers users to monitor, analyze, and respond to machine conditions in real-time, ultimately improving productivity and reducing operational risks.

Keyword: Sensors, ESP8266 Microcontroller, Thingspeak Cloud, Google App Script, Google Sheet, CNC Machine

I. INTRODUCTION

Workshops are crucial for the quick creation and innovation of new goods and processes. Recognizing the value of workshops in encouraging creativity and productivity, we embark on the "Development of Data Acquisition System for Condition Monitoring of CNC Machine" project. Our project, which uses smart technology, intends to transform workshops by including cutting-edge gadgets for improved data collecting and analysis.

In this project, we use innovative technology to provide workshops with real-time information about the performance and condition of CNC machines. By building a comprehensive data collecting system, we provide workshops with the tools they need to quickly and efficiently understand vital data. This technological breakthrough acts as a catalyst, providing workshops with the ability to optimize operations and excel in their respective industries.

Our project aims to take workshops to new heights by utilizing cutting-edge technology and innovative solutions, providing them with unique capabilities equivalent to superheroes. We hope that by providing workshops with the ability to quickly collect and evaluate data, we will help them achieve excellence and keep a competitive advancement in today's fast-paced business landscape.

II. LITERATURE SURVEY

The following literature review aims at capturing real time data of various machines using various technologies and methods.

1. Integration of IoT Devices with Lathes for Real-Time Data Capture:

This research by Dr. A.S.R. Murty et al focuses on integrating IoT devices and sensors with lathes to capture real-time data on various factors such as speed, temperature, vibration, and tool wear. They emphasize remote monitoring and analysis through a network that collects, transmits, and processes data. Additionally, the study addresses security concerns to protect industrial data from cyber threats.

2. Predictive Maintenance Techniques in Industrial Operations:

Alberto Jimenez-Cortadi et al research contributes to predictive maintenance techniques, particularly in industrial operations. Their study, centered on machining processes and machine tools, utilizes predictive maintenance to improve efficiency, minimize downtime, and optimize overall performance.

3. Development of Real-Time System for Machine Tools:

Herman Budi Harja et al focus on developing a real-time system for machine tools. They aim to use Data Acquisition (DAQ) to build a dynamic model for these tools, providing insights into operational behavior and indicating maintenance requirements.

4. Application of Sensor Fusion for Monitoring CNC Tool Wear:

Jonathan Downey et al work within the REALISM project investigates sensor fusion in real-time production to monitor CNC tool wear. Their research analyses and interprets data fusion from sensors like Force, Acoustic Emission, and Vibration sensors to provide intelligent insights, building upon previous sensor deployment strategies.

5. Low-Cost Data Acquisition System for Sensing Applications:

Pratiksha Sarma et al present a low-cost data acquisition system for sensing applications. Their system utilizes an Arduino UNO board for data acquisition and interfaces analog sensor data from a signal processing unit to a PC. Python programming is used for data processing and to provide a graphical interface.

6. Calculation Method for Preventive Maintenance Cycle of Machine Tools:

Yuan Guo et al have developed a calculation method for determining the preventive maintenance cycle of machine tools and forecasting task processing completion time. They have also built a prototype system for data acquisition and monitoring of numerical control machine tools.

7. Predictive Maintenance through Vibration Monitoring and Analysis:

Sunita Mohanta et al explore various maintenance techniques, including predictive maintenance through vibration monitoring and analysis. Their study incorporates accelerometer transducers, charge amplifiers, data acquisition cards (DAQ), and computers for monitoring vibration signals.

8. Sound Detection Monitoring Tool for CNC Milling Sounds:

Ully Raihany et al introduce a sound detection monitoring tool for CNC milling sounds, utilizing the K-Means clustering algorithm. This tool aims to analyze and classify sound patterns during CNC milling operations for fault detection and optimization of machining operations.

9. IoT-enabled Condition Monitoring for Predictive Maintenance of CNC Machines:

Norlida Jamila et al study focuses on leveraging IoT technology for condition monitoring and predictive maintenance of CNC machines. By integrating IoT sensors, the research aims to identify potential faults and optimize maintenance schedules in real-time, contributing to enhanced CNC machine performance and reduced downtime.

10. Approach to Rapid Development of Data-Driven Applications for Smart Cities using AppSheet and Apps Script

Vasja Roblek et al discussing an innovative approach to quickly building data-driven applications for smart cities. The paper focuses on leveraging platforms like AppSheet and Apps Script to develop applications that harness data for improving urban infrastructure and services.

III. PROPOSED METHODOLOGY/PROJECT IMPLEMENTATION

In today's manufacturing industry, the efficient operation of CNC machines is critical for productivity and product quality. However, unforeseen breakdowns and maintenance issues can lead to costly downtime and production losses. Traditional maintenance approaches often rely on periodic inspections or reactive repairs, which may not adequately address emerging issues or prevent unexpected failures.

To address these challenges, there is a pressing need for the development of an advanced condition monitoring system for CNC machines that can provide real-time insights into machine health and predict maintenance-related issues before they escalate into costly problems. This system should utilize a combination of sensors, IoT technology, and data analytics to co…

1. Problem Understanding:

The initial phase involves comprehensively understanding the challenges and requirements associated with monitoring and maintaining CNC machines. This includes identifying potential issues such as temperature fluctuations, vibration levels, acoustic emissions, and RPM variations, which can signify machine health concerns. Understanding the significance of real-time data acquisition and its impact on predictive maintenance is crucial in this phase.

2. Study of Existing Systems:

Conducting a thorough study of existing systems and technologies used for condition monitoring of CNC machines provides valuable insights into industry practices, technological advancements, and potential gaps. By analysing existing solutions, we can identify areas for improvement and innovation, ensuring our system addresses contemporary needs effectively.

3. Analysis of Problem:

Once the problem landscape is understood and existing systems are studied, a detailed analysis of the specific challenges and requirements is conducted. This involves breaking down each aspect of CNC machine monitoring, including sensor selection, data processing, storage, visualization, and alert mechanisms. Through this analysis, we gain clarity on the technical specifications and functionalities our system must incorporate.

4. Identification and Development of Solution:

Based on the problem analysis, suitable solutions are identified and conceptualized. This involves selecting appropriate sensors capable of capturing relevant data such as temperature, vibration, acoustic emission, and RPM. The choice of ESP8266 microcontroller for data processing and integration with ThingSpeak cloud platform for data storage is determined. Additionally, the design and development of the alert mechanism using Google Apps Script for email notifications to the workshop Head of Department (HOD) upon threshold exceedance are planned in this phase.

5. Development of System:

With the solution framework in place, the actual development of the DAQ (Data Acquisition) system commences. This includes hardware implementation involving sensor integration with the microcontroller, firmware development for data processing and communication, and software development for cloud integration and alert generation. The system is designed to ensure seamless data capture, processing, transmission, and storage in real-time.

6. Implementation and Trial of System:

Once the system is developed, it undergoes rigorous testing and validation to ensure its functionality, reliability, and performance meet the desired standards. This involves deploying the system in a controlled environment, such as a CNC machine workshop, and monitoring its operation under varying conditions. Through trial runs, any technical issues or operational challenges are

identified and addressed, ensuring the system is ready for real-world deployment.

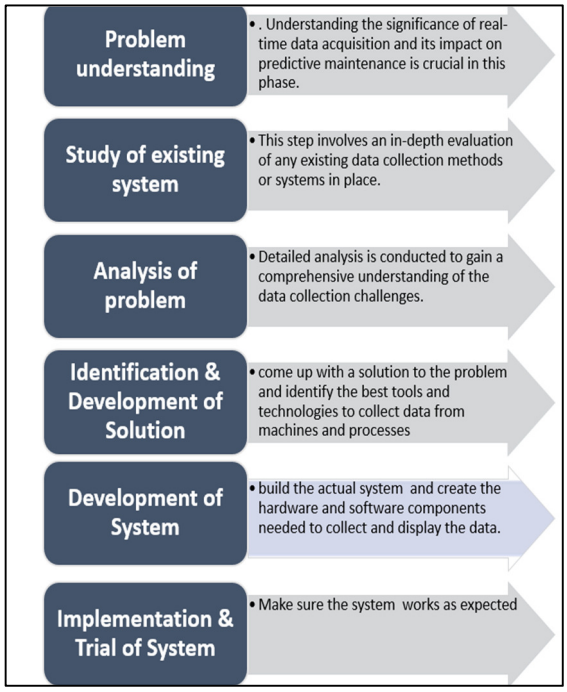

Fig. Methodology

By following this methodology, we can systematically develop and implement a robust DAQ system for condition monitoring of CNC machines, enabling predictive maintenance and real-time monitoring of machine health

IV. RESULT

The trials conducted on the various sensors integrated into our CNC machine monitoring system yielded promising results, confirming the effectiveness of our project in improving operational efficiency and maintenance practices. Throughout the temperature sensor trial, careful monitoring of motor heat variations provided valuable insights into the machine's thermal behaviour. The collected data was seamlessly transmitted to the Thingspeak cloud platform, facilitating centralized analysis. Similarly, the vibration sensor trial demonstrated its capability in detecting irregular machine vibrations, crucial for preventing mechanical issues. The RPM sensor consistently provided accurate rotational speed data under diverse operating conditions, aiding in optimizing machining processes. Additionally, the acoustic sensor trial highlighted its effectiveness in monitoring cutting tool performance by analysing sound data during machining operations. These trials collectively demonstrated the robustness and reliability of our sensor network in real-world industrial settings. The seamless integration of sensor data with cloud-based platforms, including Google Sheets for real-time data visualization, further enhanced our monitoring capabilities. Moreover, proactive email alerts were configured to enable swift intervention in case of threshold breaches. Overall, the successful outcomes of these trials validate the practical utility of our project in enhancing CNC machine monitoring and maintenance practices, making it a valuable asset in industrial environments.

E.g. Vibration sensor

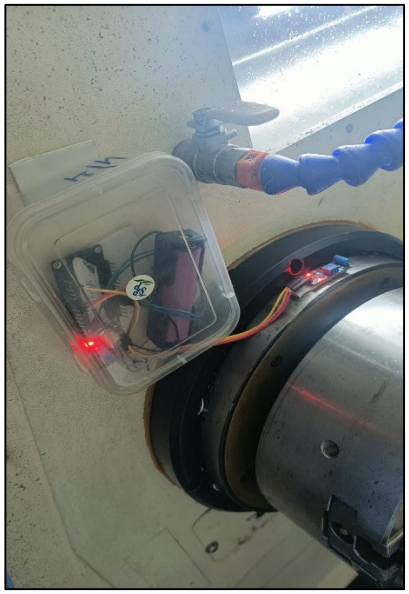

Fig. Vibration sensor mounting

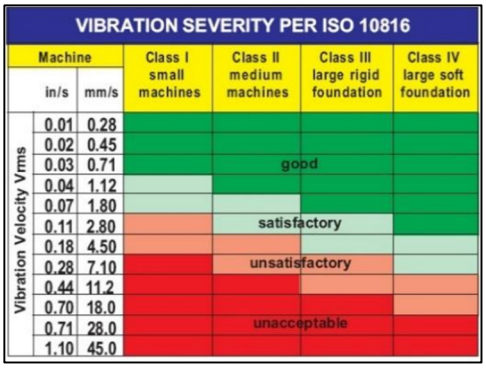

Fig. threshold value chart for vibration

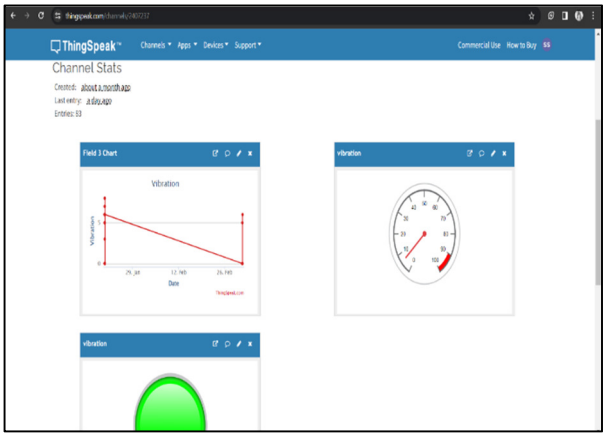

Fig. Thingspeak cloud dashboard of Vibration

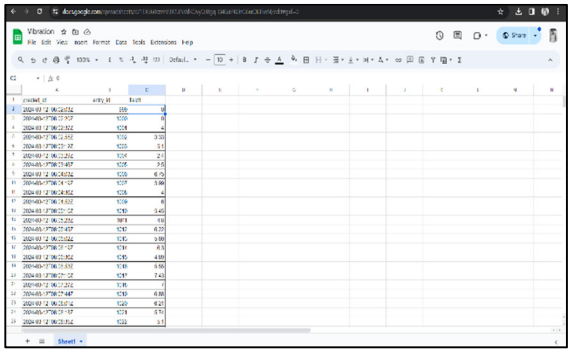

Fig. Google sheet of Vibration data

Fig. Email alert for vibration

CONCLUSION

In conclusion, our DAQ system for CNC machine condition monitoring represents a significant leap in industrial efficiency. Seamlessly integrating sensors, processing, and cloud storage, it enables real-time analysis and proactive maintenance. Our research demonstrates its effectiveness in capturing critical parameters, identifying issues early, and alerting maintenance swiftly. Beyond individual machines, this system has the potential to revolutionize manufacturing by optimizing efficiency and productivity. Our paper highlights its transformative potential, envisioning a future where proactive maintenance and real-time monitoring are standard, ensuring unprecedented reliability and efficiency in industrial settings.

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