A Project Report on

IoT Based Condition Monitoring of CNC Machine

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in partial fulfillment for the award of the degree

BACHELOR OF ENGINEERING

in

Electronics and Telecommunication Engineering

Under the Guidance of

Dr. Jayasudha Koti

St. Francis Institute of Technology, Mumbai

University of Mumbai

2022 - 2023

CERTIFICATE

This is to certify that Vedaant Bhangle, Suyog Brid, Vaibhav Shetty, Devayani Vishwakarma are the bonafide students of St. Francis Institute of Technology, Mumbai. They have successfully carried out the project titled "IoT Based Condition Monitoring of CNC Machine" in partial fulfilment of the requirement of B. E. Degree in Electronics and Telecommunication Engineering of Mumbai University during the academic year 2022-2023. The work has not been presented elsewhere for the award of any other degree or diploma prior to this.

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Project Report Approval for B.E.

This project entitled ***'IoT Based Condition Monitoring of CNC Machine'*** by **Vedaant Bhangle, Suyog Brid, Vaibhav Shetty, Devayani Vishwakarma** is approved for the degree of Bachelor of Engineering in Electronics and Telecommunication from University of Mumbai.

Examiners

1. - - - - - - - - - - - - - - - - - -

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Date:

Place:

ACKNOWLEDGEMENT

We are thankful to a number of individuals who have contributed towards our final year project and without their help it would not have been possible. Firstly, we offer our sincere thanks to our project guide, Dr. Jayasudha Koti for her constant and timely help and guidance throughout our preparation.

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Signatures of all the students in the group

(Vedaant Bhangle)

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(Devayani Vishwakarma)

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in this submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Signatures of all the students in the group

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Abstract

In the internet of things (IoT) smart sensors and actuators are used to enhance manufacturing and industrial processes . The biggest benefit of IoT is that it gives manufacturers the ability to automate, to optimize their operating efficiency like a reduced Errors, downtime, cost and predictive maintenance. real-time monitoring and collection of data from all necessary perspectives can be done remotely. Industries manufacturing at large scale often find it difficult to monitor the condition of the machines. Downtime due to machine faults and operator negligence contributes to machine inefficiency. Our work implements a multiple sensor-based condition monitoring system deployed on a CNC machine. The major steps for preventive maintenance are daily inspecting of Hydraulic temperature, and temperature of electrical panel. The IoT system uses sensors measuring temperature of hydraulic and electrical panel of CNC machine. A cloud-based platform is created for displaying of real-time graphs, and Daunt chart for important parameters and overall equipment effectiveness.The data collected from the machine can be used to quickly diagnose the problem and condition monitoring that help to pinpoint the cause of downtime in the process. In addition to controlling the electric panel temperature, this system turns on the electric bulb when the temperature drops below the threshold value.

Keywords: *CNC machine, IOT, Predictive maintenance*

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List of Abbreviations

API	Application Programming Interface
CNC	Computer Numerical Control
ERP	Enterprise Resource Planning
GPIO	General Purpose Input/Output
SMPS	Switched Mode Power Supply

Chapter 1

Introduction

1.1 Motivation

1. **Improving productivity and process efficiency:** One of the main challenges faced by the manufacturing industry is to improve productivity and process efficiency. By monitoring the condition of critical machine tool components and machining processes, manufacturers can increase the availability of the machine tool and achieve a more robust machining process. [1], [2]. This ultimately leads to improved productivity and efficiency.

2. **Reducing machine downtime:** Failures in the machining process and machine tool components can have negative effects on the final produced part and can also result in machine downtime. By implementing a condition monitoring system, manufacturers can detect and address potential issues before they lead to machine downtime, reducing production losses and associated costs.

3. **Extending the lifespan of machine components:** Instabilities in machining processes can shorten the lifespan of the cutting edges, machine tool and electronics components. By monitoring critical parameters such as hydraulic temperature and temperature humidity of electrical panel, manufacturers can take preventative measures to extend the lifespan of these components and reduce maintenance costs.

4. **Remote monitoring and control:** With the help of an IoT based condition monitoring system, manufacturers can remotely monitor and control the condition of their CNC machines from anywhere in the world. This allows for greater flexibility and improves the overall management of manufacturing processes.

The Industrial Internet of Things (IIoT) is a game-changer in the manufacturing industry, offering real-time data and analytics that can help businesses make better decisions, optimize their operations, and improve their bottom line. In this context.Overall, developing an IoT based condition monitoring system for CNC machines can lead to significant improvements in productivity, efficiency, and machine performance, making it a highly valuable project for the manufacturing industry

1.2 Problem Statement

To design and develop a cost-effective and reliable system that can monitor the health status of CNC machines in real-time to prevent unexpected failures and minimize downtime.

1.3 Methodology

1. **Identify critical machine components and parameters:** The first step in developing a condition monitoring system is to identify the critical machine components and parameters that need to be monitored. In this project, the critical components are the hydraulic system and the electrical panel, and the critical parameters are the hydraulic temperature and the temperature and humidity of the electrical panel.

2. **Select appropriate sensors:** Once the critical components and parameters have been identified, appropriate sensors need to be selected to measure these parameters. In this project, a DHT11 temperature sensor and a DS18B20 liquid temperature sensor were selected.

3. **Implement hardware components:** The next step is to implement the hardware components, which includes installing the sensors on the machine and connecting them to a microcontroller or single-board computer such as Arduino or Raspberry Pi. In this project, the sensors were installed on the machine and connected to a Raspberry Pi.

4. **Develop software components:** The software components of the system involve developing the logic to process sensor data and communicate it to a cloud database or mobile application. In this project, Node-red software was used to process sensor data and push it to a MongoDB cloud database. An API was then used to fetch this data in a mobile application, allowing users to monitor real-time data from anywhere in the world.

5. **Implement anomaly detection:** In the future, machine learning techniques can be used to spot abnormalities and problems with machines by analyzing historical sensor data. This can help in predicting potential issues before they lead to machine downtime and associated costs.

6. **Implement control measures:** The final step is to implement control measures, such as an electric bulb to control the electric panel temperature, to reduce the likelihood of component damage or failure.

7. **Test and validate the system:** Once the system is implemented, it needs to be tested and validated to ensure it is working as intended. Any issues or bugs that are identified during testing need to be addressed before the system can be deployed in a production environment.

Overall, the methodology for developing an IoT based condition monitoring system for CNC machines involves identifying critical parameters, selecting appropriate sensors, implementing hardware and software components, implementing anomaly detection and control measures, and testing and validating the system.

1.4 Organization of Project Report

This project report is organized as follows:

Chapter 2 presents the literature survey on the existing techniques

Chapter 3 provides a brief explanation of â€¦.

Chapter 4 is dedicated to the simulation and experimental results.

Chapter 5 presents the conclusions and future scope for this project.

Chapter 2

Literature Review

Condition monitoring has become increasingly important in various industries to detect and diagnose machine failures early, prevent downtime, and improve productivity. In recent years, there has been a growing interest in using the Internet of Things (IoT) technology for condition monitoring, which allows for remote monitoring and control of machines.

2.1 Literature Review on IoT Based Condition Monitoring System of CNC Machine

This chapter contains the literature survey, which is the summary of the work done by some other researchers on the topic of Condition Monitoring .This work was referred by the group members for the better implementation of our project.

- B. Siddhartha et al. [1] developed a multiple sensor-based condition monitoring system for CNC machines. The system uses sensors to measure parameters such as vibration, current, temperature, and coolant levels, and a cloud-based platform to display real-time graphs of the data. The system can quickly diagnose problems and pinpoint the cause of downtime.

- A. Khademi et al. [2] made rotating machinery IoT-enabled by adding hardware and introducing a new generation of accelerometer sensors to measure vibrations. They also developed a web application for data acquisition to evaluate the hardware.

- Sudharani Potturi et al. [3] proposed an IoT-based monitoring and control system for induction motors in various applications such as electric vehicles, industries, and agriculture fields. The system uses sensors to monitor parameters such as temperature, speed, current, and voltage remotely and sends the data to a processing unit for analysis.

- O. P. Choudhary et al. [4] designed an IoT-based condition monitoring system to improve overall machine performance, capacity, sustainability, and user safety. The system can monitor and control multiple devices remotely.

- V. A. Wankhede et al. [5] pointed out that the lack of automation and real-time monitoring makes it difficult for manufacturers to track machine health and manufacturing processes remotely. They proposed using IoT technology for machine health monitoring, but noted several challenges related to IoT in maintenance parameters monitoring.

- Mohan Krishna K et al. [6] developed a CNC machine's condition monitoring system based on Artificial Neural Network (ANN) and real-time machine data. They classified the condition of a CNC machine by deciding whether it was a fresh or worn machine using machine learning techniques.

- K. Hazarika et al. [7] reviewed IoT-based electrical parameters monitoring and controlling technology for avoiding catastrophic failures. They proposed using different sensors and server models for communication, mostly using GSM-GPRS, and sending messages to a dedicated device for further action in case of abnormality.

- D. M. Vijayakumar et al. [8] studied the productivity of CNC machines using IoT platforms for predictive and prescriptive maintenance. They proposed using IoT technology to measure productivity and improve maintenance practices.

Overall, the literature review indicates that IoT technology has great potential for condition monitoring in various industries. The use of sensors, machine learning techniques, and cloud-based platforms can enable remote monitoring and control of machines, prevent downtime, and improve productivity. However, challenges related to maintenance parameters monitoring, data privacy, and cybersecurity must be addressed for successful implementation of IoT-based condition monitoring systems.

Chapter 3

Theoretical Background/Design Methodology

Software and Hardware Support

3.1 React Native

React Native has been successfully adopted by hundreds of businesses worldwide, including Uber, Microsoft, and Facebook, and is used across a whole range of industries. React Native (also known as RN) is a popular JavaScript-based mobile app framework that allows you to build natively-rendered mobile apps for iOS and Android. The framework lets you create an application for various platforms by using the same codebase.

React Native was first released by Facebook as an open-source project in 2015. In just a couple of years, it became one of the top solutions used for mobile development. React Native development is used to power some of the world's leading mobile apps, including Instagram, Facebook, and Skype.

There are several reasons behind React Native's global success. Firstly, by using React Native, companies can create code just once and use it to power both their iOS and Android apps. This translates to huge time and resource savings. Secondly, React Native was built based on React â€“ a JavaScript library, which was already hugely popular when the mobile framework was released. We discuss the differences between React and React Native in detail further in this section. Thirdly, the framework empowered frontend developers, who could previously only work with web-based technologies, to create robust, production-ready apps for mobile platforms.

3.2 Java Script

JavaScript is a text-based programming language that allows you to create interactive elements on your web page. The World Wide Web as we know it looks nothing like the early days of grey boxes and walls of text. Nowadays, we canâ€™t imagine browsing the web without interactive websites, clickable buttons, and online video games. The ways we interact with the internet have radically changed over the years and, for the most part, itâ€™s all down to JavaScript.

JavaScript is one of the most-used programming languages. According to Northeastern University, itâ€™s the second-most popular coding language out there. Clearly, JavaScript is an integral part of our daily online lives. Another powerful use of the JavaScript programming language is creating versatile apps that can fulfill all sorts of needs. In fact, chances are you use one of the many web or mobile applications created with JavaScript every day.

3.3 Mongo DB

MongoDB is an open-source document-oriented database that is designed to store a large scale of data and also allows you to work with that data very efficiently. It is categorized under the NoSQL (Not only SQL) database because the storage and retrieval of data in the MongoDB are not in the form of tables.

MongoDB also has built-in support for horizontal scaling, which means that it can distribute data across multiple servers, thereby improving performance and availability. It also supports sharding, which allows users to partition data across multiple servers to improve query performance.

The MongoDB database is developed and managed by MongoDB.Inc under SSPL(Server Side Public License) and initially released in February 2009. It also provides official driver support for all the popular languages like C, C++, C, and .Net, Go, Java, Node.js, Perl, PHP, Python, Motor, Ruby, Scala, Swift, Mongoid. So, that you can create an application using any of these languages. Nowadays there are so many companies that used MongoDB like Facebook, Nokia, eBay, Adobe, Google, etc. to store their large amount of data.

3.4 Node-Red

Node-RED is a programming tool for wiring together hardware devices, APIs and online services. Primarily, it is a visual tool designed for the Internet of Things, but it can also be used for other applications to very quickly assemble flows of various services.

It is open source and was originally created by the IBM Emerging Technology organisation. It is included in IBMâ€™s Bluemix (a Platform-as-a-Service or PaaS) IoT starter application package. Node-RED can also be deployed separately using the Node.js application. At present, Node-RED is a JS Foundation project.

Node-RED enables users to stitch together Web services and hardware by replacing common low-level coding tasks (like a simple service talking to a serial port), and this can be done with a visual drag-drop interface. Various components in Node-RED are connected together to create a flow. Most of the code needed is created automatically.

3.5 Raspberry pi

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. Itâ€™s capable of doing everything you€™d expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

Whatâ€™s more, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. We want to see the Raspberry Pi being used by kids all over the world to learn to program and understand how computers work.

The Raspberry Pi Foundation is a registered educational charity (registration number 1129409) based in the UK. Our Foundationâ€™s goal is to advance the education of adults and children, particularly in the field of computers, computer science and related subjects.

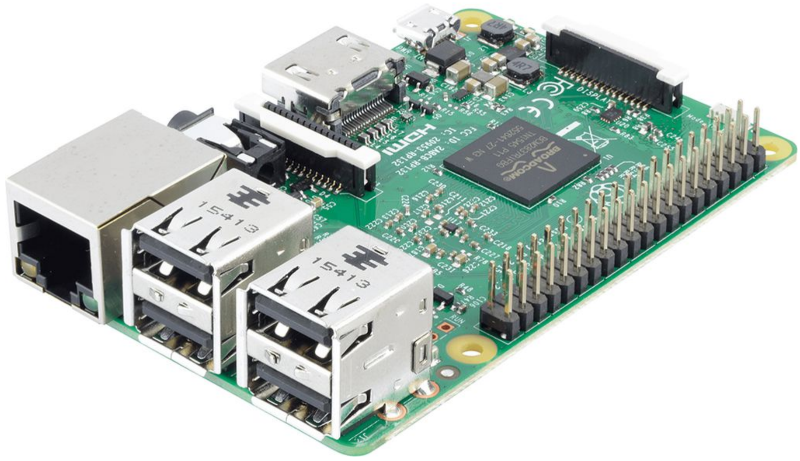


Figure 3.1: Raspberry pi

3.6 DHT11 Sensor

DHT11 is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc to measure humidity and temperature instantaneously. DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor [3].

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers.

The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy [5]. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5mA.

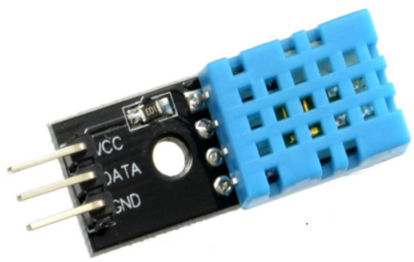


Figure 3.2: Temperature Humidity Sensor

3.7 DS18B20 Sensor

The DS18B20 is one type of temperature sensor and it supplies 9-bit to 12-bit readings of temperature. These values show the temperature of a particular device. The communication of this sensor can be done through a one-wire bus protocol which uses one data line to communicate with an inner microprocessor. Additionally, this sensor gets the power supply directly from the data line so that the need for an external power supply can be eliminated. The applications of the DS18B20 temperature sensor include industrial systems, consumer products, systems which are sensitive thermally, thermostatic controls, and thermometers.

The working principle of this DS18B20 temperature sensor is like a temperature sensor. The resolution of this sensor ranges from 9-bits to 12-bits. But the default resolution which is used to power-up is 12-bit [4]. This sensor gets power within a low-power inactive condition. The temperature measurement, as well as the conversion of A-to-D, can be done with a convert-T command. The resulting temperature information can be stored within the 2-byte register in the sensor, and after that, this sensor returns to its inactive state.

If the sensor is power-driven by an exterior power supply, then the master can provide read time slots next to the Convert T command. The sensor will react by supplying 0 though the temperature change is in the improvement and reacts by supplying 1 though the temperature change is done.

Figure 3.3: Liquid Temperature Sensor

Working Principle

- Sensor installation: The first step in implementing an IoT-based condition monitoring system is to install the sensors DHT11 and DS18B20 on the CNC machine. These sensors can include temperature sensors, humidity sensors, and liquid sensors so on.

- Data collection: Once the sensors are installed, they start collecting data on machine parameters such as temperature and humidity. The data collected from these sensors is transmitted to a central data storage unit, such as a cloud-based database, in real-time.

- Data processing: The collected data stored in key value pair with the help of API we are able to fetch data in our mobile application through which user can monitor real time data any where in the world.

- Anomaly detection: The processed data is analyzed to detect any abnormalities in the machine's behavior. For instance, if the temperature of a particular component exceeds a certain threshold, the system can alert the operator of a potential problem.

- Alert generation: When the system detects an anomaly, it generates alerts in the form of email .This enables the operator to take corrective action before any serious damage occurs.

- Increase temperature value: If the values goes below the range then lamp which is connected to the panel will start on and warm the atmosphere to increase the temperature.

- Predictive maintenance: With the data collected over time, the system can also predict the maintenance needs of the machine, enabling proactive maintenance, which reduces downtime and saves costs.

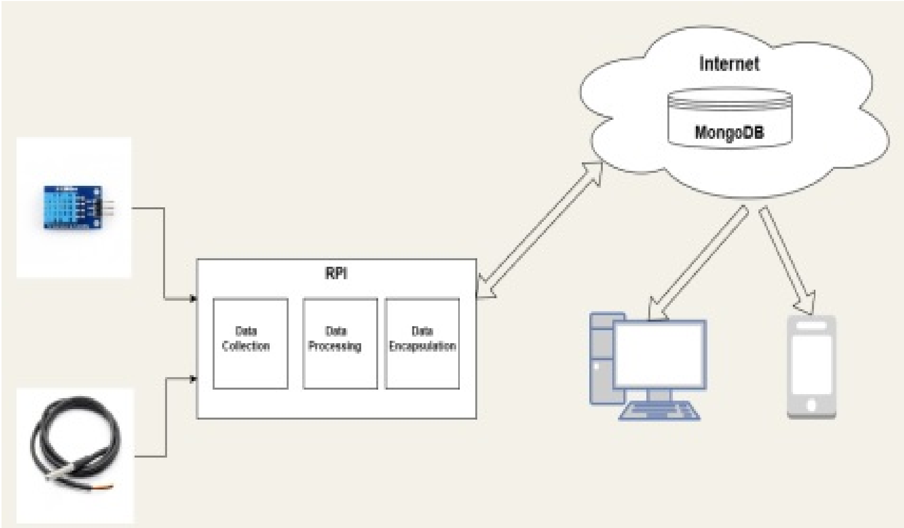


Figure 3.4: Block diagram

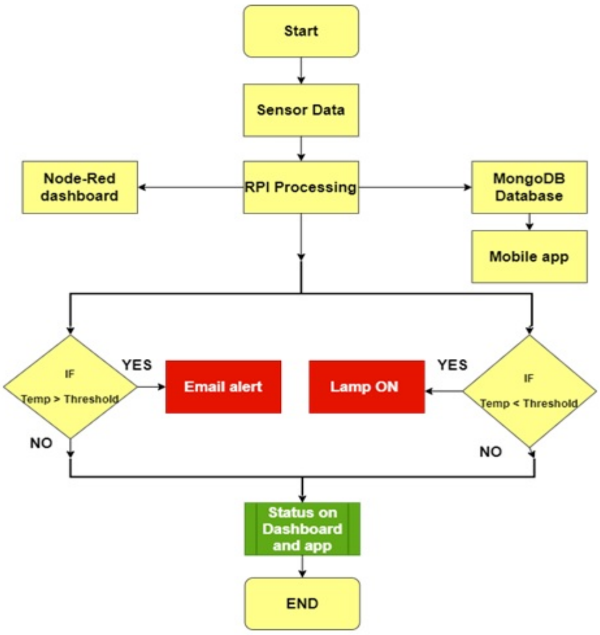


Figure 3.5: Flow Chart

- Start the IoT devices (sensors)
- Collect data from the CNC machine sensors (temperature,humidity.)
- Process the data locally using rpi
- Transmit the processed data to a cloud platform
- Analyze the data on the cloud platform using machine learning algorithms
- Compare the current sensor data with historical data to detect anomalies

- If an anomaly is detected, trigger an alarm or alert the machine operator
- Store the sensor data and anomaly detection results in a database for future reference and analysis.
- If the threshold goes down then the bulb will start on and you can view data through mobile app or remote locally.

Chapter 4

Simulation and Experimental Results

4.1 CNC Machine

Figure 4.1: CNC Machine

A CNC (Computer Numerical Control) machine is a highly advanced and precise manufacturing tool that is controlled by a computer program. It is widely used in industries such as automotive, aerospace, and manufacturing for precision machining and production of complex parts and components.

CNC machines operate using a pre-programmed computer software that controls the movement of the machine's cutting tools to cut and shape the workpiece to a high degree of accuracy and precision. The software translates the design specifications into machine code, which is then executed by the CNC machine to produce the desired part or component.

The use of CNC machines has revolutionized the manufacturing industry, as it enables the production of complex parts with a high degree of accuracy and consistency. CNC machines can perform a wide range of tasks, including drilling, milling, turning, and grinding, among others [6]. Moreover, CNC machines are capable of producing parts with very tight tolerances, which is essential for many industries that require high precision components.

In recent years, the integration of IoT (Internet of Things) technology has enabled the development of IoT-based condition monitoring systems for CNC machines. These systems use sensors and devices to collect real-time data on various parameters such as vibration, temperature, and tool wear. The data is then analyzed using data analytics software to identify potential issues before they become critical, allowing for preventive maintenance and reducing downtime.

4.2 Hardware

Figure 4.2: Hardware implementation

Installing the necessary hardware is an important step in setting up an IoT-based condition monitoring system for CNC machines.To monitor the condition of a CNC machine using IoT, you will need a number of components, including a board (such as an Arduino or Raspberry Pi), sensors (such as temperature, humidity sensors), a power supply, and a network connection (such as Wi-Fi or Ethernet). Select a suitable location to install the hardware components. This location should be close to the CNC machine and easily accessible for maintenance and troubleshooting.

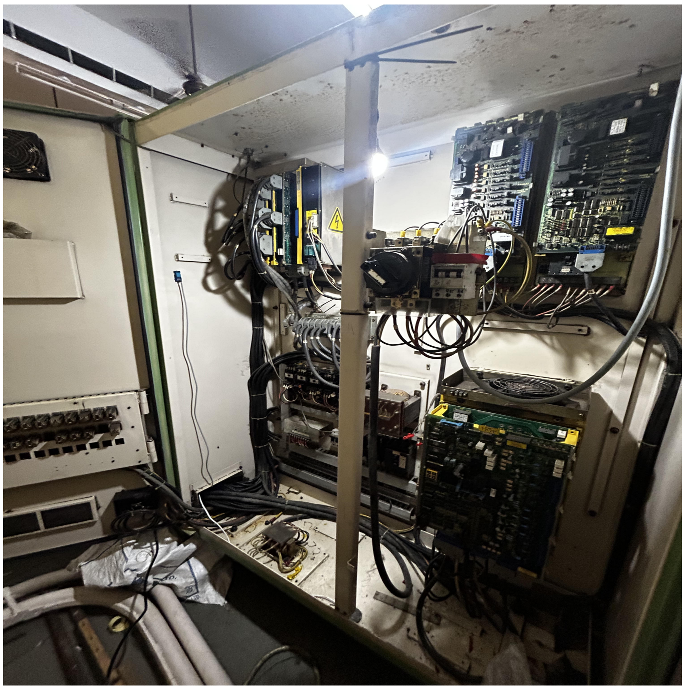


Figure 4.3: Panel Temperature Sensing

Panel temperature sensing is an important aspect of condition monitoring for CNC machines. A temperature sensor can be mounted on the machine's panel and can measure temperatures in the range required for your application.Connect the temperature sensor to the rpi board.To enable IoT functionality, you need to connect the rpi board to the internet. This can be done using a Wi-Fi module

Figure 4.4: Hydraulic Temperature Sensing

Hydraulic temperature sensing is a crucial aspect of condition monitoring in CNC machines, and with the help of IoT, it becomes even more effective. By installing temperature sensors at various points in the hydraulic system of a CNC machine, it becomes possible to monitor the temperature of the hydraulic fluid in real-time. This information can be collected and analyzed using IoT technologies, providing valuable insights into the performance of the CNC machine.

4.3 Node-Red Dashboard

- Figure 4.5 shows Node-Red dashboard of CNC The Node-Red dashboard is an essential component of your IoT-based condition monitoring system for CNC machines. It provides an easy-to-use interface through which you can monitor the temperature and humidity of the electrical panel and the temperature of the hydraulic system in real-time. The dashboard consists of gauges and charts that display the real-time values of these parameters.

- The charts show the time vs. temperature relationship, and you can view the total 1-hour graph to understand the trends and patterns in the parameter values. This information can help you identify any abnormalities or problems with the CNC machine's components and take necessary actions to prevent any failures.

- The dashboard also displays the status of the lamp, which indicates the temperature of the electrical panel. green indicate lamp OFF and red indicate lamp ON . Additionally, you can view past data by downloading the data in the form of a CSV file using the "download CSV" button. This feature is helpful for analyzing historical trends and identifying patterns in the parameter values.

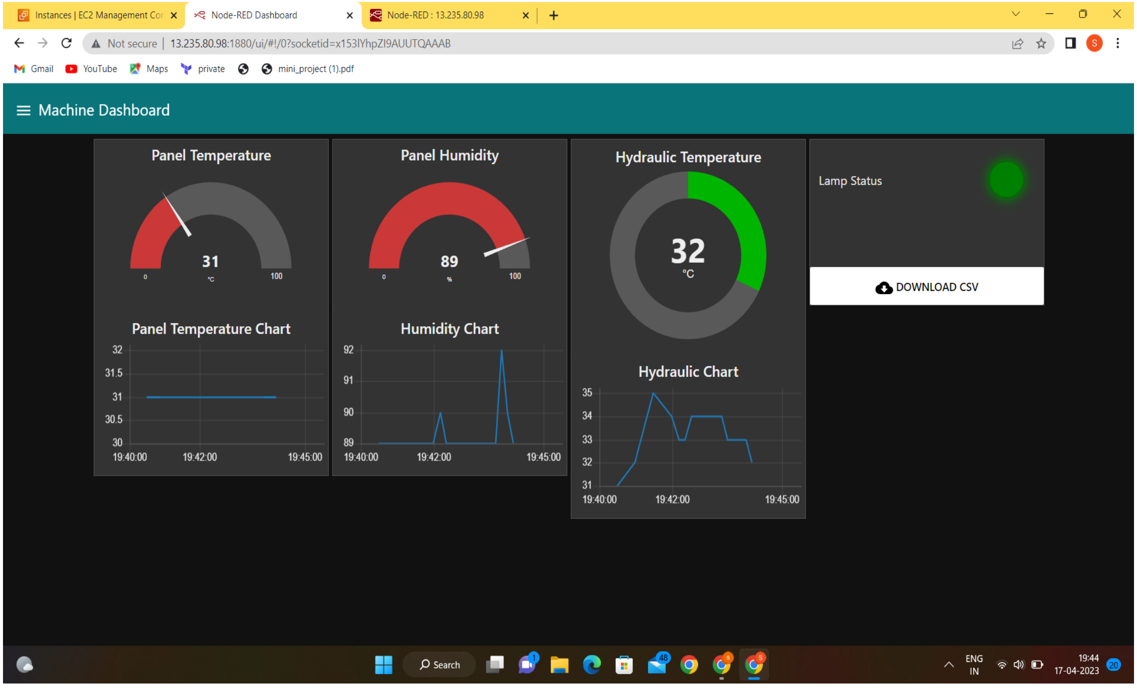


Figure 4.5: Node-Red CNC Dashboard

- Figure 4.6 shows parameter outcome of CNC machine which stored in csv files format where you can observe the temperature for particular time and date and you can observe the previous stored data about 1 month or more.

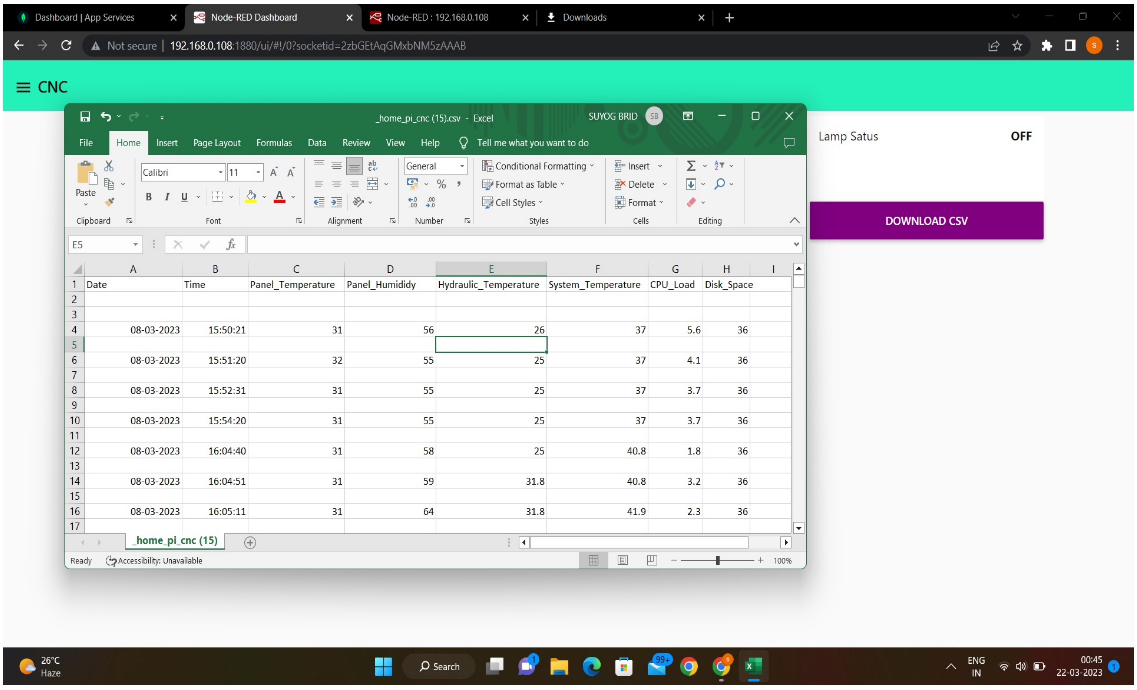


Figure 4.6: CNC Parameter Outcome

- Figure 4.7 shows Node-Red Dashboard of Rpi In another tab of the Node-Red dashboard, you can monitor the parameters of the Raspberry Pi, such as CPU load, CPU temperature, disk space, and whether the Pi is on or off. You can also restart and shutdown the Pi using the dashboard button, which provides a convenient way to manage the Pi's operations.

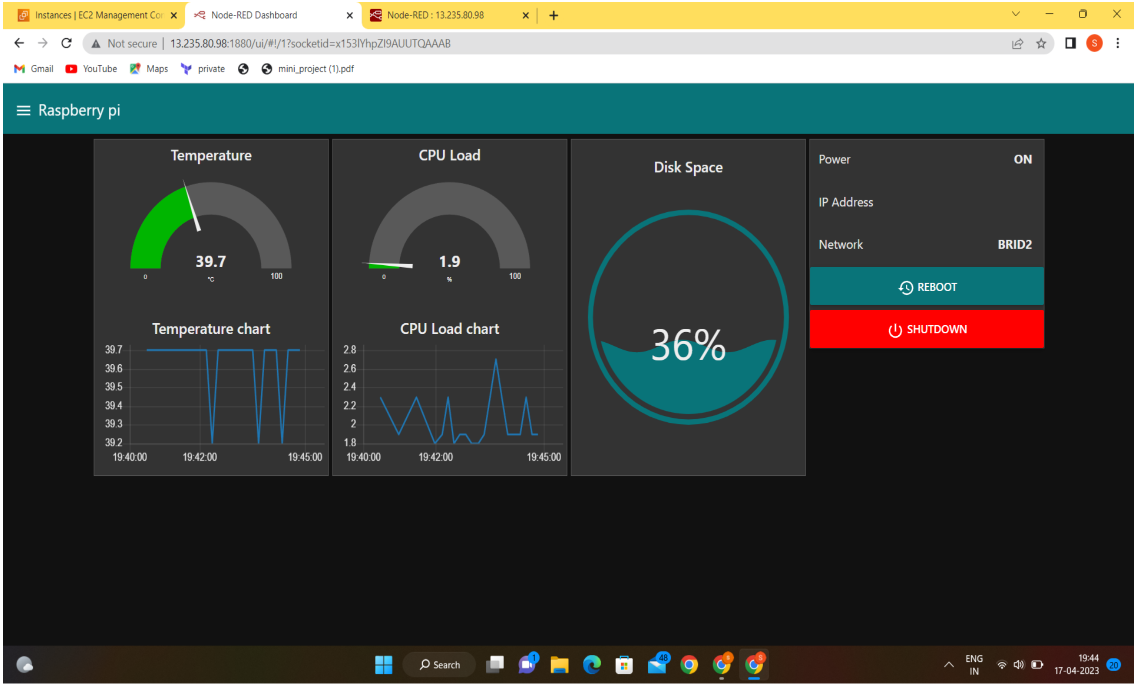


Figure 4.7: Node-Red Rpi Dashboard

- Figure 4.8 shows Node-Red flow The Node-Red dashboard is built using Node-Red software on the Raspberry Pi, which processes the sensor data and uses dashboard nodes to display the information in an easy-to-understand format. The dashboard's user-friendly interface makes it easy for users to monitor and control the CNC machine's components, ensuring maximum efficiency and productivity.

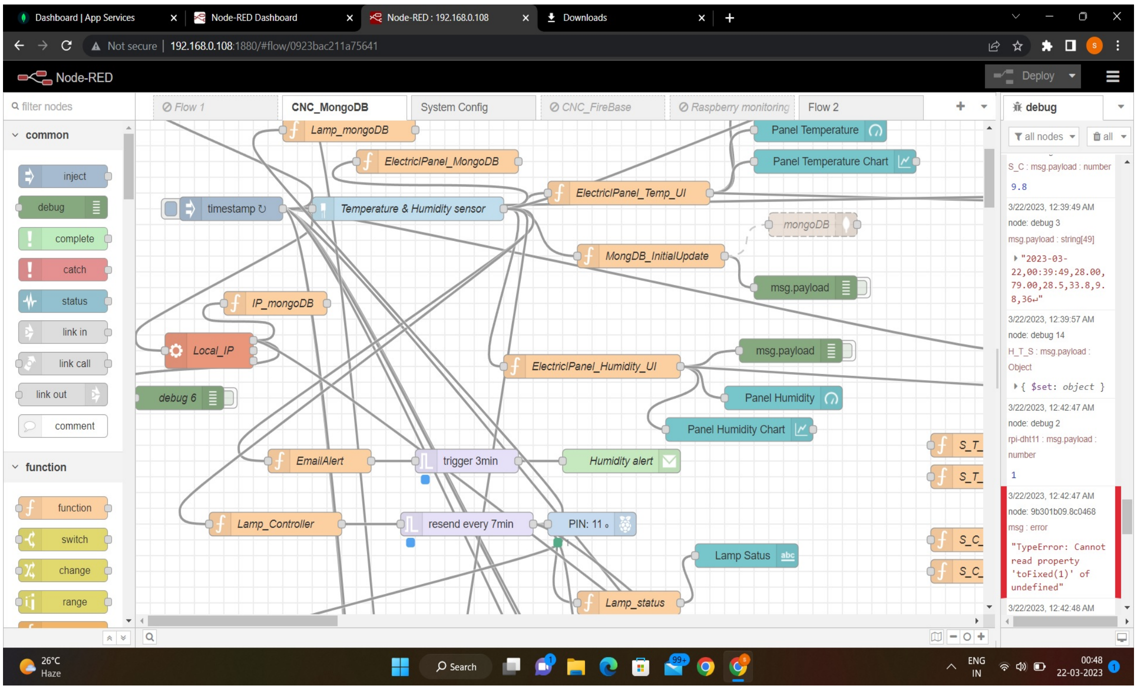


Figure 4.8: Node-Red Flow

4.4 Mongo DB

- Figure 4.9 shows mongoDB database In our project, we have successfully implemented the functionality to push the sensor data to the mongoDB database. This was achieved by using appropriate programming techniques and libraries. The data is stored in the database in the form of key-value pairs, which makes it easy to retrieve and manipulate the data as required.

- Furthermore, we have also implemented the functionality to fetch the stored data using the mongoDB data API. This API provides a convenient way to access the database and retrieve the data in a structured format. This allows us to perform various operations on the data, such as filtering, sorting, and aggregation.

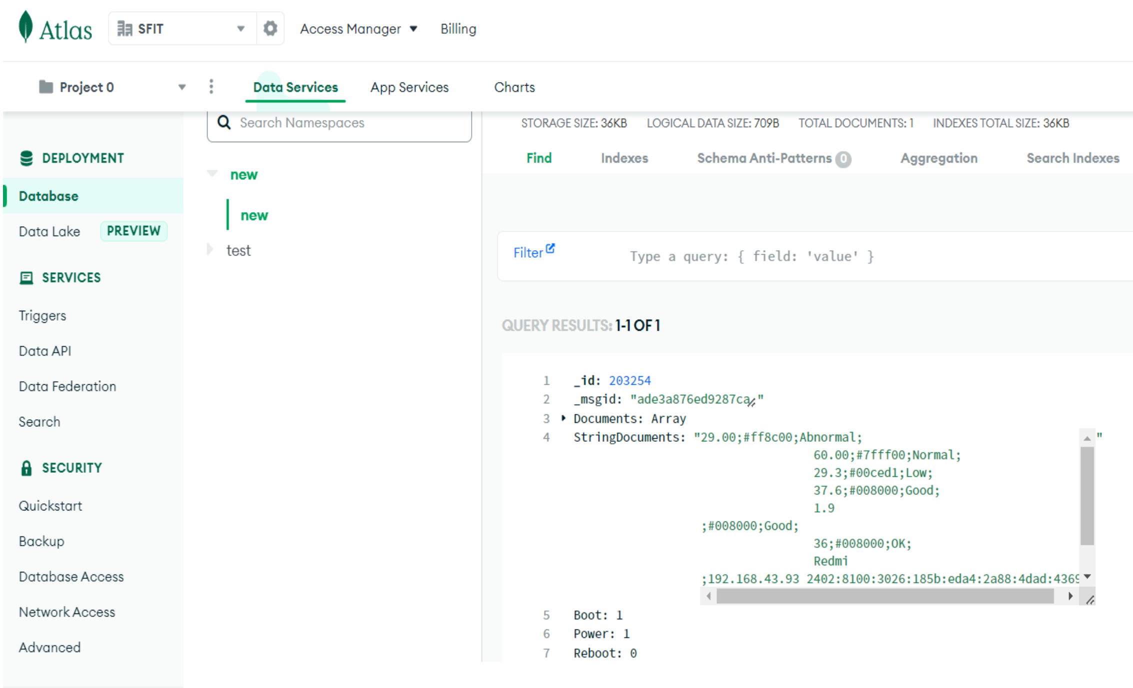


Figure 4.9: Mongo DB Dashboard

4.5 Mobile Application

App Name: CNC Monitor CNC Monitor is a mobile application that allows users to monitor the condition of their CNC machines remotely using IoT sensors and devices. The application provides real-time data and alerts about the performance, health, and maintenance needs of the machines, helping users to optimize their operations, reduce downtime, and improve productivity.

Features:

- User authentication and authorization
- Dashboard to display real-time sensor data and machine status
- Alerts and notifications for abnormal conditions and maintenance needs
- Historical data analysis and visualization for trend analysis and predictive maintenance

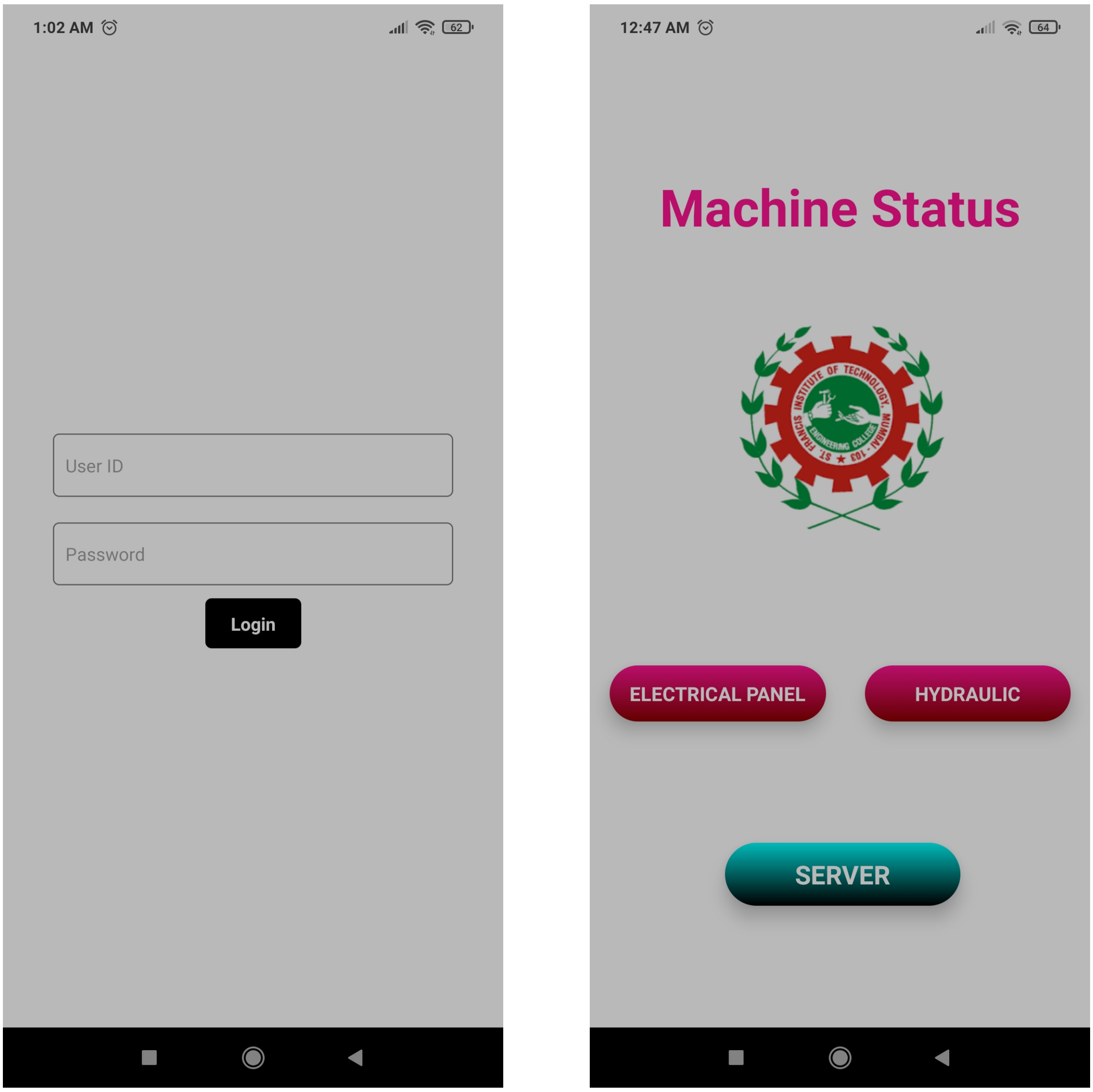
- Machine configuration and settings management
- User profile and preferences management

Technologies:

- Native mobile application development frameworks
- IoT sensor data acquisition and processing
- Data visualization and analysis tools (e.g., charting libraries, machine learning algorithms)
- Cloud-based server infrastructure (e.g., AWS, Azure) for data storage and processing

Screen:

- The login screen, shown in Figure 4.10(a), allows users to access the application by entering their username and password. Once logged in, the home page, shown in Figure 4.10(b), is displayed. This page includes buttons for navigating to other screens, such as the electrical panel, hydraulic, and server screens.
- The electrical panel screen, shown in Figure 4.11, provides real-time monitoring of temperature and humidity levels in the electrical panel. The status field of the temperature and humidity levels indicate whether they are normal, abnormal, or in the danger zone. The gauge color changes accordingly to provide an easy-to-read visual indication of the current status. Additionally, the status of the lamp is also displayed.



(a) Login Screen (b) Home Screen

Figure 4.10: Login and Home Screen

Figure 4.11: Electrical Panel Screen

- The hydraulic screen, shown in Figure 4.12, is similar to the electrical panel screen, but instead monitors the temperature of the hydraulic system. This screen provides real-time monitoring of temperature levels and displays the current status.

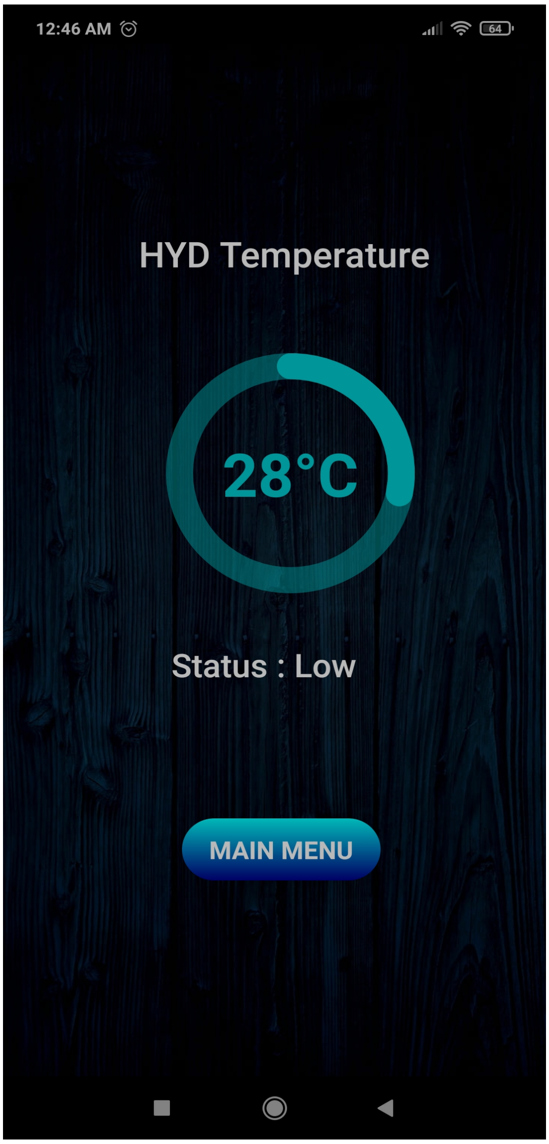


Figure 4.12: Hydraulic Screen

- The server screen, shown in Figure 4.13, allows users to monitor the temperature, CPU load, disk space, and network details of the Raspberry Pi. This information can be useful for troubleshooting or optimizing the performance of the system.

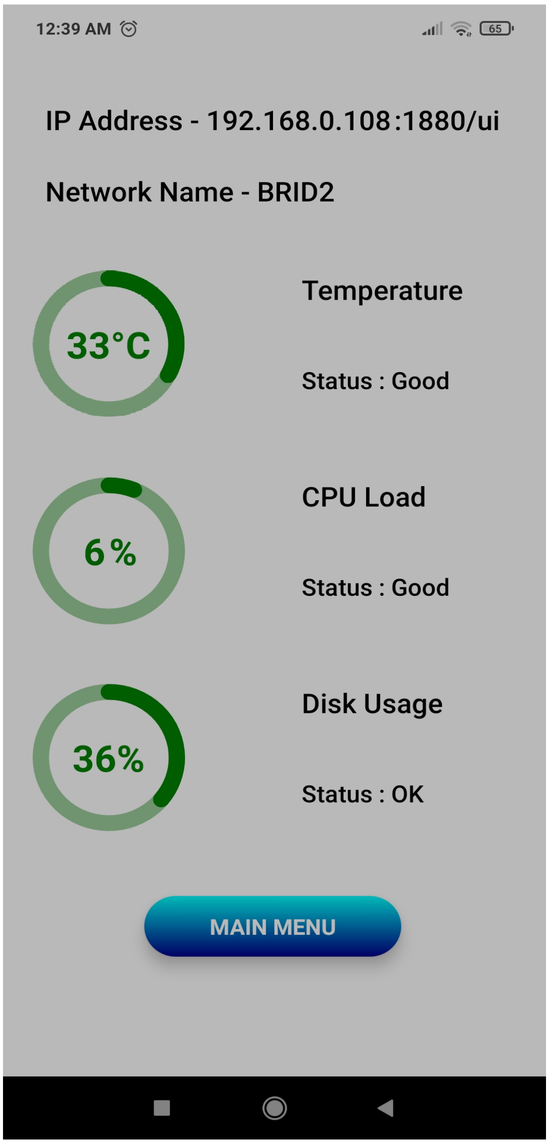


Figure 4.13: Server Screen

- Lastly, Figure 4.14 shows an email alert that is generated by Node-Red when the electrical panel temperature exceeds a pre-defined threshold value. This alert system ensures that users are promptly notified of any critical issues, allowing them to take corrective action before any damage occurs.

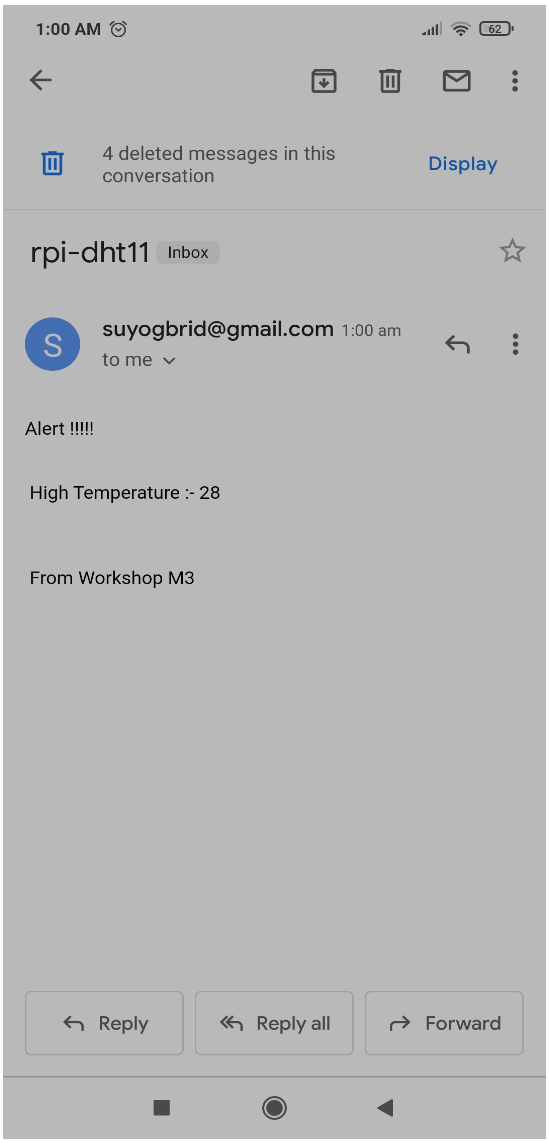


Figure 4.14: Email Alert

Overall, the mobile application provides a user-friendly interface for monitoring various parameters in real-time, making it an essential tool for ensuring optimal performance of the system.

Chapter 5

Conclusion

5.1 Conclusion

- In conclusion, our IoT-based condition monitoring system for CNC machines provides an effective solution to the challenges faced by the manufacturing industry. By monitoring critical components and machining processes, we can increase machine availability and achieve a more robust machining process. The system monitors parameters like temperature and humidity of the electrical panel and hydraulic temperature, displaying them on a mobile app, and alerts the user in case of any abnormalities.

- The implementation of this system is easy, cost-effective, and can be customized to suit different manufacturing processes. In addition, our system can be integrated with other systems to achieve greater efficiency and productivity. We have successfully implemented our system on our college CNC machine and obtained promising results.

- In the future, we plan to extend our system's capabilities by implementing machine learning techniques to spot abnormalities and problems with machines by conserving parameter data. We also plan to explore the integration of our system with other enterprise resource planning systems to provide better insights into production planning and scheduling. Overall, our IoT-based condition monitoring system for CNC machines provides an effective solution to the manufacturing industry's challenges and has significant potential for further development and application.

5.2 Future Scope

1. **Predictive maintenance:** Implementing machine learning algorithms to analyze the data collected from the sensors and predict when maintenance is required before a failure occurs. This can help reduce downtime and improve machine efficiency.

2. **Remote monitoring:** Expanding the system to enable remote monitoring of multiple machines from a central location. This can help companies to monitor their machines across different locations and make decisions based on the data collected.

3. **Integration with ERP systems:** Integrating the condition monitoring system with ERP systems can provide better insights into production planning and scheduling. This integration can help companies to optimize production processes and improve overall efficiency.

4. **Automatic control:** Incorporating automatic control of the machine's parameters based on the data collected from the sensors. This can help in maintaining optimum conditions for the machine and its components, reducing the risk of failure, and extending their lifespan.

5. **Energy management:** Adding energy management capabilities to the system can help reduce energy consumption and operating costs. This can be achieved by monitoring energy usage and optimizing the machine's operating conditions based on energy consumption.

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Chapter 6

Timeline Chart

Table 6.1: Timeline Chart for SEM VII

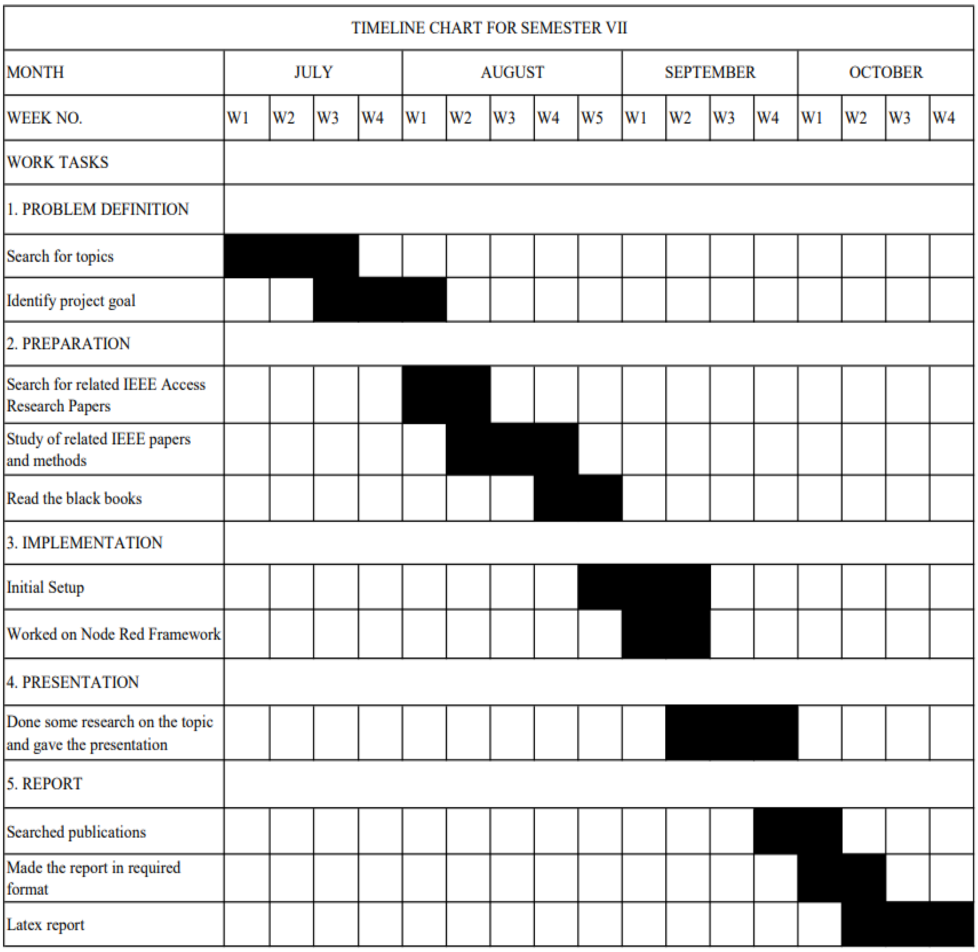

Table 6.2: Timeline Chart for SEM VIII

TIMELINE CHART FOR SEMESTER VIII																
MONTH	JANUARY				FEBRUARY				MARCH				APRIL			
WEEK NO.	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
WORK TASKS																
1, IMPLEMENTATION																
Changes on Node red Dashnoard																
Worked on MongoDB Database																
Data Collection																
Data Analysis																
Worked On Mobile Application																
2. PRESENTATION																
Presented the work to both the mentors																
Change in Mobile Application																
Further verification and Approvement of Applications																
3. POSTER AND REPORT																
Design Poster For Poster Competition																
Presented The Poster and explain objective of Project																
Made the black book report in required format																

Appendix-I:

The following is a list of components required for implementing IoT-based condition monitoring of CNC machines:

- Temperature Sensors: These are used to monitor the temperature of hydraulic fluid in the CNC machine's hydraulic system.
- IoT Gateway: This acts as a bridge between the CNC machine and the cloud-based platform, facilitating data transmission.
- Cloud-Based Platform: This is where the data collected by the temperature sensors is stored and analyzed.
- Analytics Tools: These are used to analyze the data collected from the CNC machine to provide insights into its performance.
- User Interface: This is used to present the data analyzed in a visual format, such as graphs, charts, or dashboards.
- Alert and Notification System: This is used to trigger alerts and notifications in case of any abnormality or potential failure.
- Power Supply: This is required to power the IoT gateway and the temperature sensors.
- Mounting Hardware: This is used to mount the temperature sensors and the IoT gateway onto the CNC machine.
- Cables and Connectors: These are used to connect the temperature sensors and the IoT gateway to the CNC machine and the cloud-based platform.

- Installation and Configuration Tools: These are used to install and configure the components of the IoT-based condition monitoring system.

It is important to note that the specific components required for IoT-based condition monitoring of CNC machines may vary depending on the manufacturer's requirements and the specific application. However, the above list provides a general overview of the key components required for such a system.

Appendix-II: Copies of the Published Papers

Appendix-III: Experimental Data

Experimental data for IoT based condition monitoring of CNC machine can be collected using sensors and monitoring devices. Here is an example dataset that could be collected:
Sensor Name: DHT11 Sensor

- Humidity Value
- Temperature Value

Sensor Name: DS18B20 Sensor

- Humidity value
- Temperature Value

Appendix-IV:

The following is a sample data collection sheet that can be used to record the data collected from the IoT sensors and devices for condition monitoring of a CNC machine:

Table 6.3: Panel Temperature

TimeStamp	Temperature
15:50:21	31
15:51:20	32
16:04:40	31
16:04:51	31

Table 6.4: Hydraulic Temperature

TimeStamp	Temperature
15:50:21	26
15:51:20	25
16:04:40	25
16:04:51	31.8