ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2211

Health Monitoring System for CNC Machine

Dr. S. P. Jolhe[1]; Sanyojika Gawande[2]; Dhanashri Kove[3]; Sana Saiyyad[4]; Devika Rajgadkar[5]
Department of Electrical Engineering, GCOEN
Rashtrasant Tukadoji Maharaj Nagpur University

Abstract:- This paper introduces a novel Health Monitoring System (HMS) tailored for CNC machines, addressing the critical need for maintaining their optimal performance and preventing unexpected breakdowns in modern manufacturing settings. The system integrates various sensors and data acquisition methods to continuously monitor key parameters like temperature, vibration, and tool wear. By employing advanced data analytics and machine learning algorithms, the HMS can swiftly identify anomalies in real-time, facilitating proactive maintenance and minimizing operational downtime. Additionally, the system features a user-friendly interface for visualizing machine health status and creating predictive maintenance schedules. Experimental validation conducted on a CNC machining center validates the efficacy and reliability of the developed HMS in enhancing machine efficiency, prolonging equipment lifespan, and curbing maintenance expenses. In summary, this Health Monitoring System offers a robust solution for ensuring the seamless operation and longevity of CNC machines in modern manufacturing environments.

I. INTRODUCTION

This paper introduces a novel health monitoring system tailored specifically for Computer Numerical Control (CNC) machines, leveraging Global System for Mobile Communications (GSM) technology. CNC machines are integral to modern manufacturing processes, and ensuring their optimal performance and timely maintenance is crucial for uninterrupted production cycles and cost efficiency. The proposed system integrates various sensors to monitor key parameters such as temperature, vibration, and power consumption in real-time. Data collected from these sensors are processed locally using a microcontroller unit, which then communicates with a GSM module for remote transmission of the processed information. This utilization of GSM technology enables the system to transmit data to designated recipients, such as maintenance personnel or operators, facilitating remote monitoring of CNC machine health status.

Additionally, the system incorporates an alert mechanism to promptly notify stakeholders in case of any anomaly or potential issue detected during the monitoring process. These alerts can be delivered via SMS or email, providing timely insights to facilitate proactive maintenance interventions, thereby minimizing downtime and reducing the risk of unexpected failures. The paper discusses in detail the design and implementation of the health monitoring system, including the selection of sensors, hardware components, and communication protocols. Moreover, practical considerations regarding power efficiency, data transmission reliability, and security aspects are addressed to ensure the system's effectiveness and robustness in industrial environments.

When it comes to 3-phase devices like induction motors and transformers, maintaining optimal operational conditions is critical for prolonging their service life. Overloading and ineffective cooling are major causes of failure in such devices, leading to disruptions in power systems. Online monitoring of key operational parameters, such as voltage balance and temperature, can provide valuable insights into the health of these devices, enabling utilities to optimize their usage and prevent sudden failures. By continuously monitoring for faults such as under voltage, over voltage, unbalanced voltage, single phasing, and over temperature, the system ensures timely detection and alerts relevant stakeholders via SMS using a GSM module. Additionally, the system includes provisions for automatic restoration after faults are rectified, minimizing the need for manual intervention. Key components utilized in the project include a PIC microcontroller 18f25k22, potential transformer (PT), regulator, relay, and LCD.

II. METHODOLOGY

This paper presents the design and implementation of a cost-effective Health Monitoring System for CNC Machines using a GSM module, with a focus on usability in isolated locations. Unlike software-driven systems, which often require extensive connections, equipment, and technical expertise, our system prioritizes simplicity of installation and remote notification capabilities. The main feature of this system is its ability to make automatic decisions regarding the health status of the CNC machine. The decision-making process is illustrated in Figure 1, where initialization of sensors, processing controller, and GSM modem precedes data measurement. The microcontroller then compares these values with those stored in EEPROM memory. If any parameter deviates from its saved value, the microcontroller sends a notification to the control center. If all parameters are within safe limits, the system proceeds to the next testing phase. This loop continues until a negative decision is reached. However, if the decision is positive, the microcontroller takes further action and sends the necessary information before resuming the loop. This design ensures efficient monitoring and timely intervention, even in remote or isolated locations.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAR2211

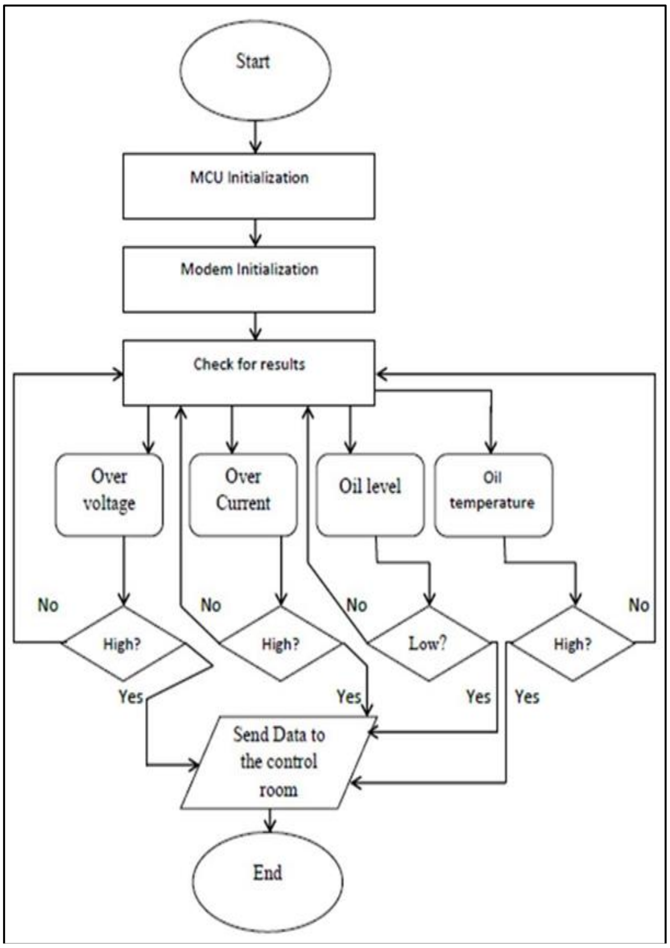

Fig 1 Flow chart of Health Monitoring System for CNC Machine

III. SYSTEM OVERVIEW

The provided block diagram illustrates the Health Monitoring System for CNC Machines, comprising key components such as a microcontroller, measurement devices, sensor units, and interfacing ICs. The system monitors various parameters such as voltage, current, temperature, humidity, and oil level. This data is collected by the microcontroller and can be transmitted to a PC or laptop, which can further relay it to a server situated anywhere globally via internet communication.

In the event of faults such as unbalanced voltage, under/overvoltage, motor overload, stabilizer sparking, or hydraulic overload, the microcontroller's programmed algorithms analyze the fault and send signals to driver relays to disconnect the contactor and isolate the substation, ensuring safety.

The power transformer steps down the voltage from 230V single phase to 12V, which is rectified to provide a 12V supply using a full wave rectifier. This rectified supply is regulated to 5V, necessary for the operation of the microcontroller and sensors. The power transformer and current transducer are powered by the line conductors. An LCD display is utilized to show monitored parameters at the substation.

A driver IC acts as a current booster, amplifying the microcontroller's output to drive the relays effectively. The microcontroller is programmed to monitor specific limits such as oil temperature, oil level, and humidity within the CNC machine. When faults like overvoltage, overcurrent, under/overvoltage, or phase failure occur, the microcontroller triggers the driver IC to trip the relay, thereby isolating the CNC machine and ensuring industrial safety.

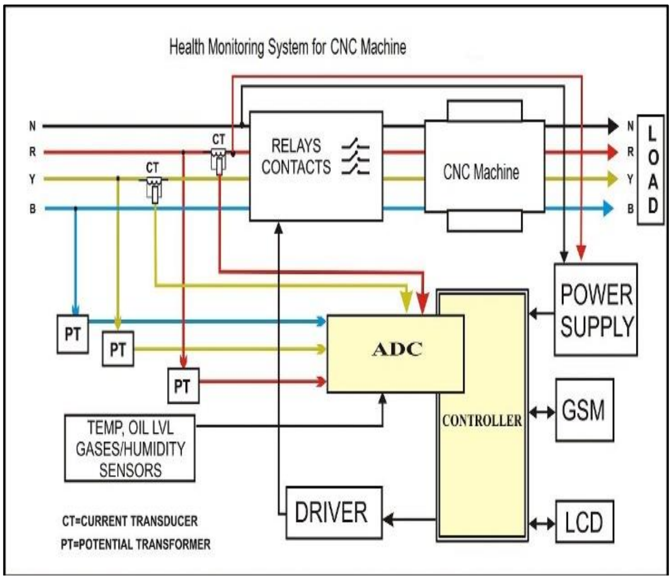

Fig 2 Block Diagram

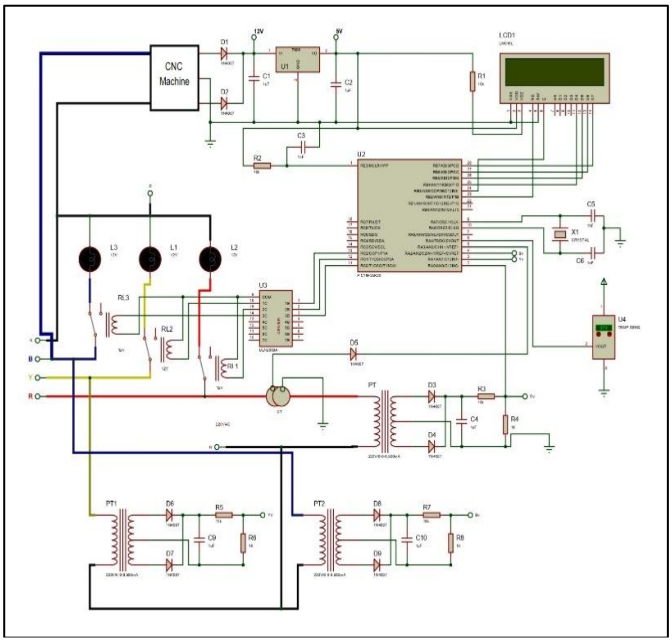

Fig 3 Circuit Diagram

IV. VARIOUS FAULTS IN CNC MACHINE

Single phasing occurs when one phase in a three-phase power system is absent, often due to a tripped breaker or another issue. With only two hot lines present, there's no phase rotation, resulting in single-phase power delivery to the load. This can significantly impair the performance of most three-phase loads, leading to reduced power and continuous current draw, which is highly undesirable.

Temperature fluctuations, particularly noticeable during hotter summer months, can significantly impact the performance of CNC machines. These machines often operate continuously for hours without interruption to complete a single part, leading to excessive heat buildup in the workpiece, tool, and the machine itself.

Bearing faults in CNC machines are identified through training and testing using various classifiers. To evaluate the effectiveness of a High-Speed Data (HSD)-based methodology for diagnosing bearing faults in rotary machinery, a 5-fold cross-validation approach is utilized for training, testing, and validating the diagnostic model.

Overvoltage occurs when the voltage in a circuit exceeds its upper limit, posing potential hazards. Overvoltage events can be transient, like voltage spikes, or permanent, leading to power surges. Electronic and electrical devices are designed to operate within specified voltage ranges, and exposure to higher voltages can cause considerable damage. Malfunctioning of circuit breakers or other accessories may occur due to overvoltage, potentially leading to system collapse. Hence, monitoring for such faults is imperative.

V. WAYS OF DETECTING VARIOUS FAULTS

The proposed monitoring system comprises a GSM Modem, PIC microcontroller, and various sensors. It is designed to be installed at three-phase devices to monitor parameters using an Analog to Digital Converter (ADC) embedded within the system. The acquired data is processed and stored in the system memory. If any abnormality or emergency situation arises, the system generates a tripping signal and sends SMS messages to designated mobile phones, providing details about the issue.

➢ *Overvoltage Measurement:*

To measure overvoltage, a step-down transformer is utilized. This transformer is connected across each phase (R, Y, B) and neutral. It steps down the voltage from a maximum of 300V AC to 5V AC. The AC voltage is then rectified to DC and fed into the ADC, which converts it into digital signals for the microcontroller. The microcontroller compares these signals with predefined thresholds for overvoltage (260V) and undervoltage (180V). If the voltage exceeds 260V or falls below 180V, the microcontroller triggers a contactor to trip, indicating an abnormality. Additionally, if a phase failure occurs, it's treated as an undervoltage situation since the absence of any phase implies a voltage below 180V, leading to the same tripping action.

➢ *Single Phasing:*

Single phasing is prevented using a single phasing preventer, an electronic circuit designed to safeguard three-phase electronic devices from issues like single phase cutoff, phase reversal, and phase imbalance.

➢ *Temperature Monitoring:*

For online monitoring, thermocouples are placed externally on the transformer to provide real-time temperature data from various points. Elevated temperatures in the main tank may indicate issues such as oil deterioration, insulation degradation, or water formation.

➢ *Moisture Monitoring:*

Online monitoring can enhance the accuracy of moisture detection in transformer oil. Specialized moisture sensors are capable of identifying the presence of moisture, aiding in early detection and prevention of potential issues.

VI. CONCLUSION

Developing a health monitoring system for CNC (Computer Numerical Control) machines is essential for ensuring their optimal performance and avoiding costly downtime. Continuous monitoring of critical parameters like temperature, vibration, and lubrication enables early detection of potential issues, facilitating timely maintenance and reducing the risk of equipment failure. This proactive strategy not only enhances machine reliability but also boosts overall productivity and efficiency in manufacturing processes.

REFERENCES

[1]. Abbas Hussian , Taha AI Muhammade Janjua , Anjum Naeem Malik , Antash Najib , shaherjar Atta khan " Health Monitoring of CNC machining processes using machine learning and wavelet packet transform , Vol. 212, 15 April 2024.

[2]. Abhishek D. patange , R. Jagedeshwaran " Application of Bayesian family classifiers for cutting tool inserts health monitoring of CNC milling. Vol.11 no.2(2020).

[3]. Daniel Newman, Mahmoud Parto , Kyle Saleeby , Thomas Kurfess " Development of a Digital Architecture for Distributed CNC Machine Health Monitoring , 2019.

[4]. D.A.Tobon- mejia , K. Medjaher , N. Zerhauni " CNC Machine tool health assessment using dynamic Bayesian Networks