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Development of Temperature Monitoring and Performance Evaluation System for Electrical Contactors

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Abstract- Electrical contractors in industrial automation and control systems face rigorous operating conditions that can lead to performance degradation and potential failures. To address this, a comprehensive temperature monitoring and performance evaluation system has been developed. This system uses advanced sensor technologies and data analytics techniques to continuously monitor the thermal behavior of critical components within contactors, including main contacts, auxiliary contacts, and coil. By collecting and analyzing real-time temperature data, the system can detect anomalies such as excessive heat generation, indicating potential issues like contact erosion, arcing, or overheating. This early detection allows for proactive maintenance, enhancing reliability and safety. Additionally, monitoring temperature can prevent wear and tear on contactors, extending equipment lifespan and reducing the frequency and cost of replacements. This project uses modern techniques like industrial automation to automate temperature rise tests on electrical contactors, reducing human intervention, improving test accuracy, and increasing operational efficiency.

Keywords- electrical contactors, performance degradation, monitoring, temperature rise, industrial automation, testing, performance, power BI, safety.

INTRODUCTION

The proposed system is designed for the testing division of the industry, primarily aimed at testing and detecting the contactor's temperature rise. Contactors are electrical devices used to turn circuits on and off, and relays are subsets of electromagnetic switches. These contactors typically undergo manual testing, with workers entering parameters into an Excel file and storing them in the system.

The system automates the process, gathering necessary information and tabulating it at the appropriate time. Power BI is used to transform the collected data into statistical data. Test automation is used in regression testing, device functionality testing, performance testing, and load testing, enhancing efficiency and accuracy while reducing time and expense. It involves developing test cases or data that can be executed automatically. The temperature rise test, also known as the heat run test, is used on devices with higher rated coils to measure the temperature rise of different devices. The operational economy relies heavily on these findings to show the performance of contactors in fields. The ambient temperature, or testing room temperature, is monitored during the controlled test. The industry can automate the testing procedure with the help of the suggested method. The objective is to do hardware testing in a timely and reliable manner. By guaranteeing that the system is extensively tested prior to release, automated testing lowers the possibility of errors and problems in production, which is crucial for accomplishing this goal. Unlike manual testing, it can detect problems and save time. Where manual testing would have taken a long time, automation is used. It entails writing test cases or scripts that can be executed automatically as opposed to manually. The system improves the industry's production side's efficiency.

PRIMARY OBJECTIVE OF PROPOSED SYSTEM

It expands item improvement quality while providing enterprises with improved security and reduced costs. Possessing these advantages helps businesses increase production line efficiency and benefits. Compared to manual testing, this automation guarantees a rise in product production while cutting down on testing time. It allows human labor to concentrate on more complex tasks. By using computers and systems to do activities in place of human intervention, it seeks to streamline and optimize operations. Enhanced accuracy is because they are human, manual testers are prone to errors, whereas automation reliably runs scripts accurately and logs comprehensive data. By removing human error brought on by weariness, neglect, or other circumstances, automation guarantees greater accuracy. More thorough heuristics and reports can be obtained through automation testing than through human form completion. Reduction of labour. Over time, automated testing becomes more cost-effective. Repetitive tests, such as regression testing, are difficult for manual testers to do, and their workload escalates as software expands. Even though it takes some initial work, automation testing improves time quality and reduces errors while speeding up test completion, which eventually lowers costs.

METHODOLOGY

The suggested system is an industrial project that tests electrical contactors for temperature rise, records data, and builds a database. The suggested system is an industrial automation system that uses sensors and controllers to measure the testing contactors' coil temperature. The N type thermistor is used to measure temperature, including coil temperature and ambient temperature. The temperature rise test standards are used to formulate the measured temperature. The computed parameters are entered with the appropriate time in a Microsoft Excel spreadsheet database. Finally, Microsoft Power BI is used to convert the gathered data into business statistical data. To assess and monitor the temperature increase across the electrical contactor's contacts, coils, and terminals under rated working circumstances (voltage, current, and environmental factors).To ensure safe and dependable performance, make sure the contactor's temperature rise stays within the manufacturer's stipulated bounds. Select an electrical contactor sample for testing. Typical operating conditions (such as contactor size, type, and rating) should be reflected in the sample.

1.1 Am bient Temperature it determine and regulate the test's ambient temperature, which is normally 25°C unless otherwise noted. Test Bench Choose a test configuration that makes it simple to connect measuring tools and reach the contactor's terminals. A dependable power source, measuring devices, and a way to keep an eye on the contactor's performance should all be part of this configuration. Power Supply it is a reliable supply of AC or DC power that can give the contactor the rated voltage and current. High-accuracy thermocouples they are used to measure the temperature at different locations on the contactor, such as across contacts, coils, and terminals to gauge the amount of current passing through the contactor.

TESTING PROCEDURE

Adjust the outside temperature to the typical test setting, such as 25°C. At the beginning of the test, make sure the contactor is off, or unenergized. To simulate operating conditions, apply the rated voltage to the coil and the rated current to the contacts to activate the contactor. The manufacturer's recommended current and voltage for the contactor should be used for the test. Under these circumstances, let the contactor run constantly. To achieve a steady-state temperature increase, the test usually takes one to two hours.

Make that the system is stable and the appropriate current is applied while testing under various load conditions (for example, 1.25x rated current for overload testing). Keep a close eye on the temperature at all the contactor's measurable locations, including the contacts, coil, and terminals.

At regular intervals (e.g., every 10 minutes), note the temperature data. To determine how the contactor reacts to various environmental circumstances, the test may occasionally additionally involve replicating various ambient temperatures or humidity levels. Check the recorded temperature increase against the manufacturer's recommended temperature rise limits, which are usually described in ANSI/IEEE or IEC 60947-4-1 standards (for low-voltage contactors).

Depending on the contactor's rating, the temperature at its contacts, coils, and terminals should not increase over the permitted limits, which are normally between 50°C and 60°C above room temperature.

Fig 1.1 Picture of testing the data in Microsoft excel sheet

4.1 Post testing analysis and data analysis

1. Review of Temperature Data: Look for any unusual temperature increases by analyzing the recorded temperature data. The test shall be deemed unsuccessful if any component of the contactor exceeds the stated limitations.
2. Contact Wear and Damage Inspection: Examine the contactor visually for any indications of insulation damage, contact wear, or overheating following the test. If necessary, measure the contact resistance to look for deterioration.
3. Post-Test Temperature Check: After the contactor has been switched off and allowed to drop to room temperature, take another measurement at key locations. This helps guarantee that any excessive heating is temporary and that the contactor cools down properly.

4.2 Documentation and Reporting:

1. Test Results: Include the test parameters (rated current/voltage, ambient temperature), all recorded temperatures, and any anomalies that were noticed.

2. Failure Analysis: Provide a thorough analysis of the components that exceeded their temperature limitations and possible reasons if the contactor fails the temperature rise test.

3. Conclusion: Using the temperature rise test, determine if the contactor satisfies the operational and safety standards. Using the established criteria, indicate if it passed or failed the test.

5. BLOCK DIAGRAM

A block diagram is a graphic depiction of a system that shows the various parts or phases of the system using straightforward, named blocks and arrows to show how information or signals move between the blocks. Here there is the block diagram of the proposed system.

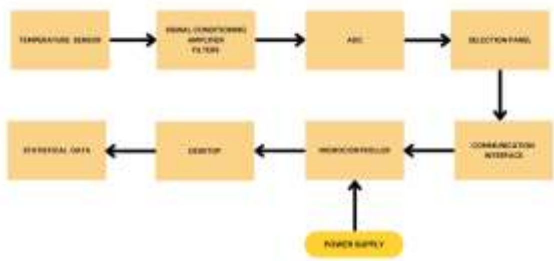

Fig 1.2 block diagram of proposed system.

A temperature monitoring and measurement system's block diagram is displayed in the picture. Here is a quick summary of the procedure:

The temperature sensor delivers the data to the following step after detecting the temperature.

Signal conditioning (Amplifier & Filters): To guarantee precise measurement, the sensor signal is amplified and filtered. The analog-to-digital converter, or ADC, transforms the sensor's analog signal into a digital representation.

Selection panel: Users can select particular choices for data processing or display using the selection panel.

Microcontroller: Communicates with other parts of the system and processes digital temperature data.

Communication: Data flow between the microcontroller and external devices is facilitated by the communication interface.

Desktop: Gets the processed data and shows it for analysis.

Statistical data: Data for statistical analysis is stored and presented here.

Power supply: The system is powered by the power supply.

The system incorporates a desktop configuration for statistical analysis and data visualization, a communication interface for data transmission, and a power source to maintain the components.

6. FLOW CHART

The essential processes of the temperature rise test are depicted in this flow diagram temperature sensing, conversion, processing, decision-making based on threshold levels, data transmission to a PC, and finally logging or displaying the data for additional analysis. If required, the procedure is repeated in a loop, enabling real-time temperature change monitoring.

Start/End (Terminator): This designates the start and finish of a procedure and is symbolized by an oval or rounded rectangle. Steps of flow chart: Process Steps (Actions): Shown as rectangles, these indicate certain actions or activities inside the process. Decision Points: Usually with "Yes" or "No" answers, these points are symbolized by diamonds and represent decisions that have a variety of possible outcomes. Data Inputs/Outputs: Data entering or exiting the operation is represented by parallelograms or other symbols, such as data from sensors.

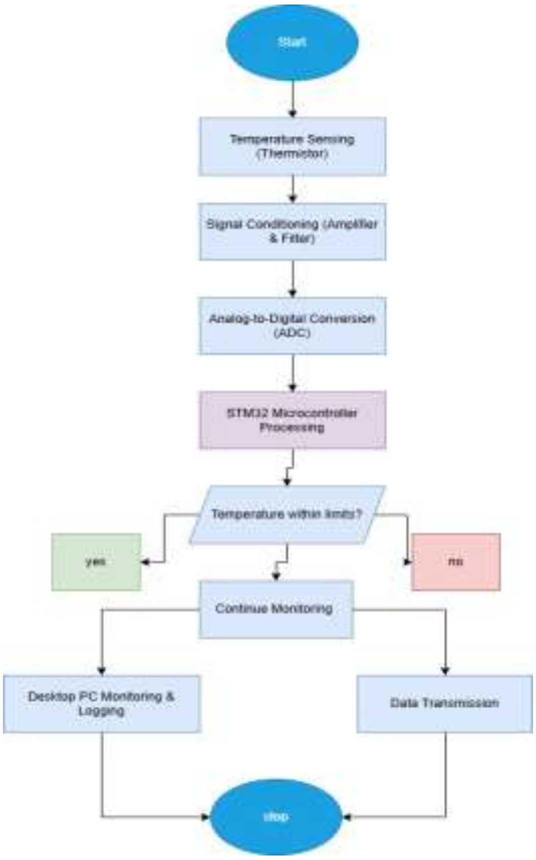

Fig 1.3 Flow Chart of Proposed System

7. SIMULATION OF PROPOSED SYSTEM

This proposed system outcomes are obtained and stored as business statistical data. These results are displayed in Microsoft excelsheet as well as in power BI business intelligent app. The primary result of this test is the rise in temperature above room temperature at different contactor locations. When electrical connections are created, the temperature rises at the contact surfaces or poles. An increase in the electromagnetic coil's temperature may have an impact on its performance and insulation. Usually expressed in degrees Celsius (°C), these temperature rise measurements are compared to standard limits established by standards such as UL or IEC 60947-4-1. An excessive increase in temperature may be a sign of danger or subpar performance.

Before the test begins, the initial ambient temperature is noted. As the difference between the end temperature and the ambient temperature, this aids in determining the temperature rise. The contactor is tested for a predetermined amount of time, usually several hours, while carrying its rated operating current. The results of temperature rise tests give manufacturers vital information regarding the thermal performance of contactors, assisting them in guaranteeing the dependability and safety of their products in practical applications.

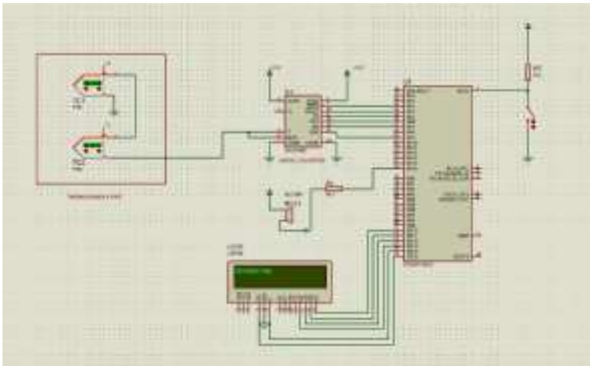

Fig 1.4 Simulation Circuit

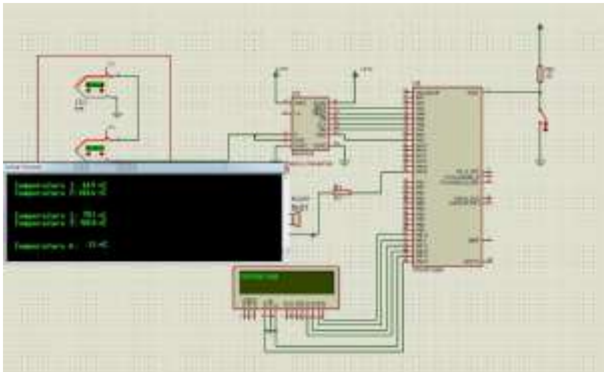

Fig 1.5 Simulation Result

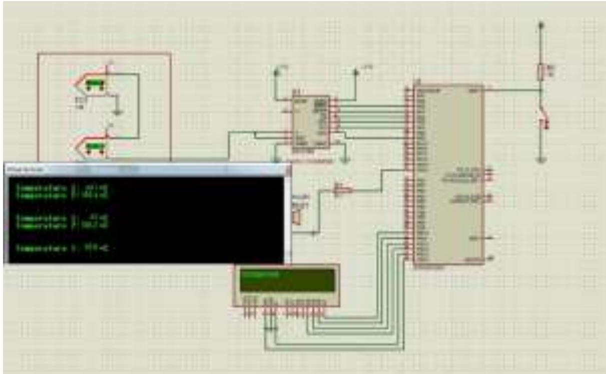

Fig 1.6 Different Outcomes of Simulation

Component	Temperature Rise (°C)	Standard Limit (°C)	Pass/Fail
Contact Points	45	60	Pass
Terminals	50	70	Pass
Coil	55	65	Pass
Enclosure Surface	30	40	Pass

Fig 1.7 Tabulation of Proposed System

8. CONCLUSION

Electrical contactors must pass the temperature rise test to ensure that they can function safely under rated load levels while staying within acceptable temperature ranges. Passing the temperature rise test signifies adherence to global standards that outline maximum temperature rise limitations, such as IEC 60947-4-1 or UL standards.

This lowers the possibility of overheating, insulation damage, and possible fire threats while ensuring the contactor satisfies industry safety standards. For electrical components to last a long time, proper thermal control is crucial. The test reduces the possibility of thermal degradation that could cause an early failure by confirming that temperature rise stays within acceptable bounds, hence confirming the contactor's dependability and durability over time. Any component that raises the temperature above the permitted level could be a sign of poor thermal design, bad material choices, or insufficient cooling.

In certain situations, the contactor design can require modifications, such the use of materials with greater temperature tolerance, better ventilation, or higher-quality insulation. Since too much heat can cause energy loss and affect performance, keeping the temperature within certain bounds guarantees that the contactor runs effectively. The effectiveness of the contactor in managing its rated current is confirmed by a successful temperature rise test.

9. REFERENCES

i. Fjeld, E., Rondeel,W.G.J., Attar, E., Singh, S.: Estimate the temperature rise of medium voltage metal enclosed switchgear by simplified heat transfer calculations. IEEE Trans. Power Delivery 36, 853–860 (2021).

ii. Nur, S., Mohd, A.Rosli, R.A., Ghafar, H.,Abdullah,N.S.,Hyie,K.M. Temperature rise effects on busbars used in low voltage switchgear. Proceedings of Mechanical Engineering Research Day 2018, pp. 273–274, May (2018)

iii. Ali, H., Kumar, P., Smith, J., and Brown, T. Design and implementation of real-time temperature monitoring system for electrical contactors International Conference on Power Electronics and Drive Systems, pp. 456–460, June 2020.

iv. Chen, Y., Zhang, W., Lin, F., and Zhou, X. Performance evaluation of thermal management in electrical contactors using IoT-based monitoring systems, Journal of Electrical and Computer Engineering, vol. 35, no. 2, pp. 123–130, Mar. 2021.

v. Khan, M.R., Singh, R.K., and Patel, A. Development of an intelligent temperature control and monitoring system for electrical contactors in industrial applications IEEE Transactions on Industrial Electronics , vol. 67, no. 8, pp. 5897–5905, Aug. 2019.

vi. Qian Liang, "Research on temperature rise test method of switchgear [J]", *Scientific and technological innovation*, no. 17, 2018.

vii. Du Zhengguo, Wang Shangbin and Jiang Honglong, "Study on temperature rise test method of switchgear [J]", *Shandong industrial technology*, no. 08, pp. 182, 2019.

viii. Ma Danrui, Jin Lijun and Zhao Gang, "Research on Digital Measurement and Prediction System for Temperature Rise Test of Electrical Equipment [J]", *Dian Gong Electrical*, no. 11, 2015.

ix. Yong Hu. "Transformer Temperature Rise Test of Microcomputer Control". Electronic Technology [J], vol. 6, pp. 9-