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DIGITAL TWINS APPLICATION OF PREDICTIVE MAINTENANCE IN INDUSTRY

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Abstract- ***This paper proposes a Digital Twin approach for predictive maintenance in industry. Several sectors are progressing due to the concept of predictive maintenance, which helps with equipment development and operation and enables a more thorough explanation and defense of maintenance schedules. This study uses data from two different 3 phase motors to offer multiple ways to describe how long a given part will be usable for motor maintenance. Rapid technological advancements are enabling enterprises to gather ever-more precise information about their equipment and processes.***

By predicting collected data digital twins provides alert alarms and engineers concluded that given motors needs urgent maintenance. With the use of AI prediction and decision-making support, manufacturing may be managed in the "near future" thanks to technological advancements that foster innovation. The establishment of a physical-virtual connection between a product and its digital twin facilitates real-time monitoring during the product's entire life cycle.

Key words- Data-based prediction, IOT, Digital twins, artificial intelligence, Sensors.

INTRODUCTION.

Digital twins are virtual representations of physical assets that are made possible by data and simulators and are used to improve prediction, optimization, control, and decision-making in real time. This work applies the digital twin concept to electric motors. Utilizing this technology specifically demonstrates how to address broad issues pertaining to the use of electric motors in the automotive sector, such as estimating driving torque and internal rotor temperature to enhance cooling control. Results from the proof-of-concept demonstrate the soundness of the chosen approach and the potency of the suggested remedy. A frequent motor trip issue or motor damage occurring in manufacturing industries due to the over load current, bearing damages, over heating or any kind of abnormal sound generated in the motor then digital twins observed that abnormality and produce alert alarm. And engineers reduce breakdown occur in industry. In pharmaceuticals industry there are many motors such as ID fan, FD fan, CA fan, cooling towers, vacuumed blowers are trip due to current over load or heating so, this tripping issue can be resolved by using digitals twins' concepts. Since they are often networked with sensors and data sources, digital twins can obtain real-time data from their physical counterpart. In order to make sure the virtual model accurately represents the actual system's current state; this data is used to improve and update it. Advanced analytics, machine learning, and simulation techniques are employed by digital twins to analyze gathered data and model various scenarios. As a result, decisions can be made with greater knowledge and accuracy regarding the behavior of the physical system. The digital twin can be interacted with by users to see, track, and manage the real system. Better comprehension and management of the real-world counterpart are made possible by this interactivity. Machine learning algorithms are used in digital twin technology to sift and find patterns in the vast amounts of sensor data. Data on performance optimization, maintenance, emissions outputs, and efficiency are provided by artificial intelligence and machine learning (AI/ML). Throughout the whole manufacturing lifecycle, from planning and designing to sustaining current facilities, digital twins are used. With a digital twin prototype, you can keep an eye on your machinery and examine performance data that illustrates how your plant as a whole or a specific component is operating. Digital twins are used by the automotive industry to generate digital replicas of automobiles. Digital twins, in addition to software, mechanical, and electrical models, can provide you with information on the physical behavior of the vehicle. Predictive maintenance is useful in this context as well because a digital twin can notify a user or service center when it detects a problem with a component's performance.

I. *How does a digital twin work?*

A digital twin operates by creating an exact digital duplicate of a real asset's features, behavior, and performance in a virtual environment. Smart sensors that gather data from the product are used to produce a real-time digital depiction of the asset. The representation can be used at any stage of an asset's lifecycle, from early product testing to actual use And decommissioning.

A digital model of an asset is produced by digital twins using a variety of technologies. Among them are the following.

- ***Internet of things***

The phrase "internet of things" describes a mass of networked gadgets as well as the technology that enables communication between devices and the cloud, as well as between devices. With the development of low-cost computer chips and high-bandwidth connectivity, billions of devices are now online. In order to transfer data from the real-world object into the digital-world object, digital twins rely on IoT sensor data. The data is fed into a dashboard or software platform so you can observe real-time data updates.

- ***Artificial intelligence***

Artificial intelligence (AI) is the branch of computer science that focuses on finding solutions to cognitive issues like learning, problem solving, and pattern recognition that are typically connected to human intelligence. Machine learning (ML) is an artificial intelligence (AI) technique that creates statistical models and algorithms that enable computer systems to carry out tasks using patterns and inference rather than explicit instructions. Machine learning algorithms are used by digital twin technology to process and find patterns in the vast amounts of sensor data. Data insights on efficiency, maintenance, emissions outputs, and performance optimization are provided by artificial intelligence and machine learning (AI/ML).

- ***Comparing simulations with digital twins***

Though virtual model-based simulations, digital twins and simulations differ significantly from one another. Usually, simulations are utilized for offline optimization and design. In order to observe what-if possibilities, designers input modifications into simulations. Conversely, digital twins are intricate virtual worlds that you can interact with and see real-time updates to. Their scope and utility are greater.

II. *Twins of electric motor*

Consider the following Fig. a showing the flow of data and generating the alarm by observing abnormal conditions in the motor. Data source consists of many sensors such as vibration sensors, temperature sensors, digitals twins collects this and generates digitals replica of electric motor. If any abnormality occurs in the physical motor then digitals twins generates alerts alarm.

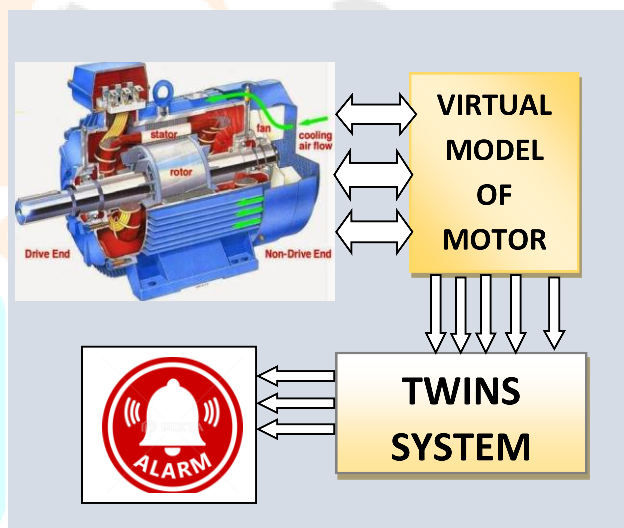


Figure. a. Functional diagram of digital twins

III. *Piezoelectric accelerometer*

So, what is the relationship between vibration amplifiers and piezoelectric accelerometers? Piezoelectric accelerometers are used to measure any type of vibration, regardless of frequency or time, in contrast to the majority of conventional vibration transducers. As a result, they are the most precise, dependable, and adaptable vibration transducers available. However, for direct signal transmission to data gathering and analysis tools, they rely on vibration preamplifiers. Vibration preamplifiers can, in fact, serve a number of crucial functions in the measuring chain of piezoelectric transducers. They are able to:

- Adjust the measurement device's input sensitivity to correspond with the accelerometer's output;
- To achieve the required level of overall sensitivity, increase the vibration signal;
- Obtain displacement and velocity signals by integrating the accelerometer output;
- Alert me about overloads on the input and output sides;
- Filter out unwanted signals by using both high- and low-frequency techniques.

IV. *Microcontroller*

Whole projects will be based on the microcontroller chip i.e. ATMGA328P Combining 32 KB ISP Flash memory with read-while-write capabilities, 1024B EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external components, this high-performance Microchip picoPower® 8-bit AVR® RISC-based microcontroller. This feature demonstrates that even in the event that the microcontroller's power supply is cut off, it will still be able to store data and produce results after it has been given electricity.

V. *PCB Design of Digital twins*

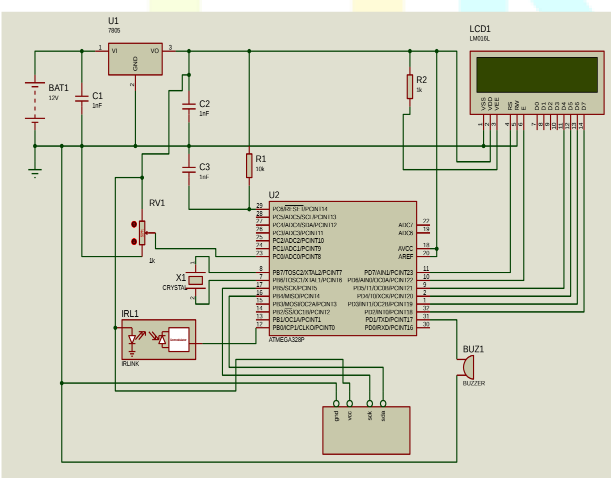


Fig. b. PCB lay out

WAYS OF DETECTING VARIOUS FAULTS

A PIC microcontroller-powered Global Service Mobile (GSM) modem, along with several sensors, make up the suggested monitoring system. The analog-to-digital converter (ADC) of the embedded system is used to record the finding parameters once it is installed at the three-phase devices. The system memory is used to process and store the obtained parameters. Short messaging service (SMS) messages are sent to pre-designated mobile phones with information on abnormalities, and the system will trip in the event of an emergency or anomaly.

1) *Measurement of Over voltage:*

A PIC microcontroller-powered Global Service Mobile (GSM) modem, along with several sensors, make up the suggested monitoring system. It is mounted at the 3-phase devices, and the embedded system's analog-to-digital converter (ADC) is used to record the discovery parameters. The system memory stores the processed and recorded parameters that were obtained. The system generates a tripping signal and sends SMS (short messaging service) messages with information about any abnormalities to authorized mobile phones in the event of an emergency or other anomaly.

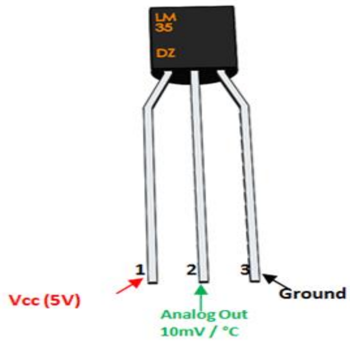
2) *Single Phasing:*

With the use of a single phasing preventer, single phasing can be avoided. Just one phasing the three-phase electronic-operated electrical equipment that are protected against single-phase cut-off, phase reversal, and phase imbalance by a preventer are electronic circuits.

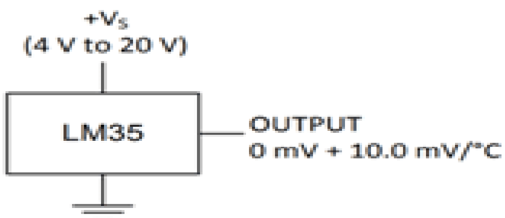
3) *Temperature Monitoring:*

Thermocouples are mounted externally on the motor to enable online monitoring. They give real-time temperature information at different points on the motor. An instrument that senses heat and cold and turns it into an electrical signal is called a temperature sensor. A ceramic/metal composite's resistance qualities are used by an NTC thermistor, a temperature sensor, to determine the temperature. When it comes to temperature detecting, NTC sensors have numerous benefits, such as small size, superior long-term stability, high accuracy, and precision.

LM35 Temperature Sensor:



The temperature surrounding the LM35 precession integrated circuit temperature sensor affects its output voltage. This tiny, inexpensive integrated circuit (IC) has a temperature measurement range of -55°C to 150°C. Any microcontroller with an ADC function or any development platform like PIC can be readily interfaced with it. Applying a controlled voltage, such as +5V (VS), to the input pin of the integrated circuit and connecting the ground pin to the circuit's ground would power it. As seen below, you can now measure the temperature as a voltage.



The output voltage will be zero volts if the temperature is zero degrees Celsius. For every degree Celsius that the temperature rises, there will be a rise of 0.01 V (10 mV). The following formulas can be used to convert voltage into temperature:

$$V_{OUT} = 10\ mv/^{\circ}C \times T$$

where

- V_{OUT} is the LM35 output voltage
- T is the temperature in °C

PREDICTIVE MAINTENANCE METHOD.

Condition-based maintenance is typically included in predictive maintenance. Determine the current state of the equipment, forecast its future development trend, and create predictive maintenance plans in advance based on the equipment's potential failure modes and status development trend through routine (or continuous) condition monitoring of system components. Currently, residual life prediction, fault diagnosis, equipment status monitoring, and maintenance decision-making are among the specialized components of predictive maintenance. The model's definition of predictive maintenance covers data collection and processing, state identification, fault localization and identification, health prediction, maintenance management, and maintenance execution.

ADVANTAGES: Real time perception: The digital twin model of the equipment is built on the foundation of real-time perception. The primary distinction between PdMDT and typical predictive maintenance is its capacity for real-time perception, real-time regulation, and real-time prediction. More specifically, PdMDT benefits greatly from the creation of virtual digital twins. Every element in real-time perception: Every element the data interplay between digital twins and physical entities is also known as real-time perception. The secret to all factors real-time perception, as opposed to the emphasis on high real-time data interaction, is that data gathering is focused toward all factors and several forms of data. Data sources include equipment, application, history, status, and other forms of information that digital twins are able to observe in real time.

DISADVANTAGE: There are various present difficulties with digital twin technology. A significant obstacle to its efficient implementation is the absence of data, input and output, and system coordination. Another drawback is the poor terminology used in digital twins, which can cause miscommunication and disorientation. The deployment of Digital Twins is also hampered by technical problems, such as missing data and model standards. Moreover, challenges may arise from a lack of knowledge and professionals in Digital Twin initiatives. Due to the difficulties in utilizing the current techniques and tools to create a digital twin, the adoption of digital twins has been slower than expected, particularly among small and medium-sized manufacturers.

SCOPE OF DIGITAL TWINS

After almost ten years of initial discussion, the majority of companies are now aware of Industry 4.0's potential to revolutionize our way of working. The majority of manufacturers worldwide have initiated pilot programs to verify the benefits of utilizing data and sophisticated analytics, implementing self-sufficient solutions such as predictive maintenance to enhance their operational efficiency. More advanced automated systems with data-driven analytics, improved networking, and AI-based predictive capabilities will be a feature of digital twin technology in the future. Digital twins, which offer real-time insights and alerts of possible future issues, will become an important part of companies' predictive maintenance processes. The major scopes of digital twins in predictive maintenance of three phase motor is to detected three phase faults occurs in three phase supply, some time in R,Y,B. phase one of the phase may loss so, in such case motor may damage. For the protection of such damages introduced the digital twin-based predictive maintenance technique. You may be certain that your product and production will function exactly the way you expected and planned by looking at "what if" situations for motors and using the Digital Twin to predict future performance.

CONCLUSION

We have introduced the digital twin-based predictive maintenance technique. which is a predictive maintenance approach that leverages digital twin technology to enhance weaknesses. It offers three distinct features, all based on digital twin technology: high fidelity model, high confidence simulation prediction, and real-time perception. The key characteristics high real-time data interaction, all-factors real-time perception, intelligent decision-making ability, multi-application scenario real-time simulation, high fidelity virtual model, multi-physical model fusion, fault detection and fault prediction are made clear by analyzing the roles of traditional predictive maintenance and digital twin.

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