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Digitalization of Electric Motor Management

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ABSTRACT

Electric motors are crucial in large industrial settings, powering essential machinery and enabling critical processes across production, and processing sectors. With thousands of motors operating within many industries, the complexity of managing and maintaining these systems has grown, especially as industries increase their reliance on automation and demand higher energy efficiency. To address these challenges, there is a growing need for centralized, intelligent, and digital motor management platforms. These platforms leverage technologies such as the Internet of Things (IoT), advanced data analytics, and predictive maintenance tools to provide real-time monitoring and performance insights, reducing downtime and enhancing operational efficiency. This paper discusses the current pain points in electric motor management, including the lack of centralized digital platforms, unplanned downtime due to motor failures, and the absence of online monitoring capabilities. By developing a comprehensive motor management platform that consolidates data, incorporates machine learning (ML) models for predictive maintenance, and integrates a user-friendly, centralized dashboard, businesses can significantly improve motor reliability, reduce operational disruptions, and extend motor lifespan. A case study demonstrates how a cloud-based analytics solution helped identify inefficiencies in an industrial motor, leading to design modifications and improved performance. Ultimately, digitalizing motor management results in lower maintenance costs, higher operational reliability, and better energy efficiency, thus contributing to significant cost savings and improved asset performance.

Keywords: *Electric motor; digitalization; real time monitoring; analytic; centralized platform*

1. Introduction

In large industries, electric motors are essential as electric drivers for powering machinery and supporting critical processes, driving key operations across production, processing, and material handling sectors. The number of installed electric motors in an industry can reach thousands of units. Managing these motors has become more complex as industries rely more on automation, focus on energy efficiency, and require continuous, uninterrupted operation. Given the critical role of these devices and the presence of thousands of electric motors, there is a need for a centralized, intelligent, and digital data management platform to enable efficient and systematic monitoring of motor operations.

Digitalization of electric motor management offers a powerful solution to these challenges. This can be achieved by leveraging technologies such as the Internet of Things (IoT), advanced data analytics, and predictive maintenance tools. Digital motor management tools provide real-time

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insights into motor performance and health. This enables operators to monitor motor conditions continuously, predict potential failures, and optimize performance which contributes to reducing downtime of the motors and operating facility.

1.1 Industry Pain Points and Challenges in Electric Motor Management

1.1.1 Unavailability of a centralized platform

A centralized digital platform for motor management acts as a unified access point for essential data, including motor specifications, operating conditions, performance indicators, and more. This data is critical to maintaining the smooth, continuous operation of motors. Without such a platform, information is often stored manually in physical records across multiple locations, leading to inefficiencies and delayed access to the most current and complete information.

Tracking motor performance across various parameters becomes challenging without a central system, making it difficult for businesses to identify emerging trends that might signal potential issues or opportunities for improvement. Furthermore, decentralized storage of data increases the likelihood of errors, such as inaccurate data entry, duplicate records, or missed maintenance activities. Consolidation of information into a single repository, much of the manual effort can be automated, minimizing the risk of human error.

1.1.2 Unplanned downtime results in production loss

The occurrence of unplanned downtime due to motor failures is one of the biggest challenges in electric motor management. Motors can fail suddenly due to factors like wear and tear, overloading, or electric faults. Unplanned downtime disrupts operations and leads to significant production losses, making timely motor maintenance critical.

In the absence of advanced monitoring and diagnostic tools, business often relies on reactive maintenance leading to increased downtime and higher repair costs. Implementing proactive strategies such as predictive maintenance and development of analytic tools for motor can significantly reduce the frequency and impact of motor failures. Proactively monitoring motor performance and managing motor health not only prevents operational disruptions but also ensures a longer lifespan for motors, better motor performance, improved safety, and ultimately, significant cost savings on motor repair.

1.1.3 Lack of online monitoring capabilities

In the absence of online motor management, operators will rely on manual data entry on the motor performance and monitoring of the electric parameters for each electric motor. This requires significant human intervention, including monitoring, troubleshooting, and maintaining records which will be time-consuming and prone to human error. Operators may misinterpret motor performance data, record it incorrectly, or fail to log crucial information altogether.

Inaccurate records can lead to incorrect assessments of motor condition, making it difficult to identify patterns of deterioration or failures. Additionally, the lack of consistent data storage makes it harder to track motor performance over time and identify any emerging issues. This approach comes with several significant challenges that can hinder efficiency, increase operational risks, and lead to higher operational costs. Operators require to spend excessive time on routine tasks, such as recording operational data or inspecting motor components physically. This inefficiency not only drives up labor costs but also restricts employees from focusing on more critical or strategic responsibilities.

Manual data entry is highly susceptible to human errors. Operators may misinterpret motor performance data, record it incorrectly, or fail to log crucial information altogether. Inaccurate records can lead to incorrect assessments of motor condition, making it difficult to identify patterns of deterioration or failures. Additionally, the lack of consistent data storage makes it harder to track motor performance over time and identify any emerging issues. Development of online analytics solutions enables real-time data transmission to centralized platforms, allowing operators to monitor motor performance remotely and respond to emerging issues before they escalate.

2. Methodology

2.1 Digitalized Solution for Motors

Developing a digitalized solution for electric motors provides many benefits to users mainly to allow proactive intervention to prevent motor failure, reduce maintenance cost and optimization via efficient operation. All motors are equipped with motor protection relays or Intelligent Electronic Device (IED) and most high voltage motors are also provided with additional sensors such as bearing vibration probes or resistance temperature detectors (RTD) for stator winding temperature. The data collected from these sensors provide valuable information to the user. However, this wealth of data does not necessarily provide insight of the analytics required to predict motor failure. The general observation from most operating plants in our facilities is the underutilization of the data collected from motors for analytics due to the following reasons:

i. Motor data source is from multiples platforms and systems. For example, maintenance work orders usually reside in the Asset Management System; motor PPM and testing records are generally hardcopies while current and stator winding temperature may be connected to the motor protection relay located in the substation. There is no consolidated platform to gather information from a variety of sources to paint a clearer picture of the motor health and condition.
ii. Most of the motor data such as current, bearing vibration and temperature may be available at plant control system such as DCS. However, the DCS is for plant operations and not for equipment monitoring. For example, motor vibration and current signatures are common motor health measurements and are of more interest to the equipment specialist rather than the process operators. Therefore, availability of a dedicated platform with consolidated data from DCS and other related systems for the equipment specialist is lacking.

Due to the above limitations, a solution is required to bridge the gap from monitoring equipment on a process control platform to a dedicated platform for specialists to digitalize and diagnose motor condition. The steps to develop the solution is explained below.

2.1.1 Data consolidation

The plant data historian is essential to consolidate and centralize the motor data from multiple sources. Network infrastructure is required for data to be sent from equipment level i.e. motor control centre, motor IEDs and vibration monitoring systems to the plant historian. Based on the Purdue network model shown in Figure 1, the motors itself are located at Level 0 and therefore the motor data only resides at motor local control panel, substation or systems. For digitalization of motor management to occur, the infrastructure is required to send motor data from level 0 up to the plant historian which is located at level 3 of the network. The historians' function is to consolidate and structure data from multiple systems such as DCS, ENMCS etc. for long term storage and analysis.

Once consolidated, the data is sent to a cloud server which is at Level 4 or 5. This platform provides an overview of the motor and is accessible over the internet. Cloud-based data storage has the scalability to handle big data by managing data in a distributed manner across multiple servers and locations. This ensures high availability of data which is essential for the digitalization of motors. Once the data has been consolidated, it is then fed into a model to identify any anomalies, trends, potential incidents or failures, which will enable the maintenance team to take the necessary action.

Additionally, other relevant motor data and information can also be easily uploaded and stored securely on the cloud server. For example, maintenance and failure records from asset management system can be integrated at the cloud platform server.

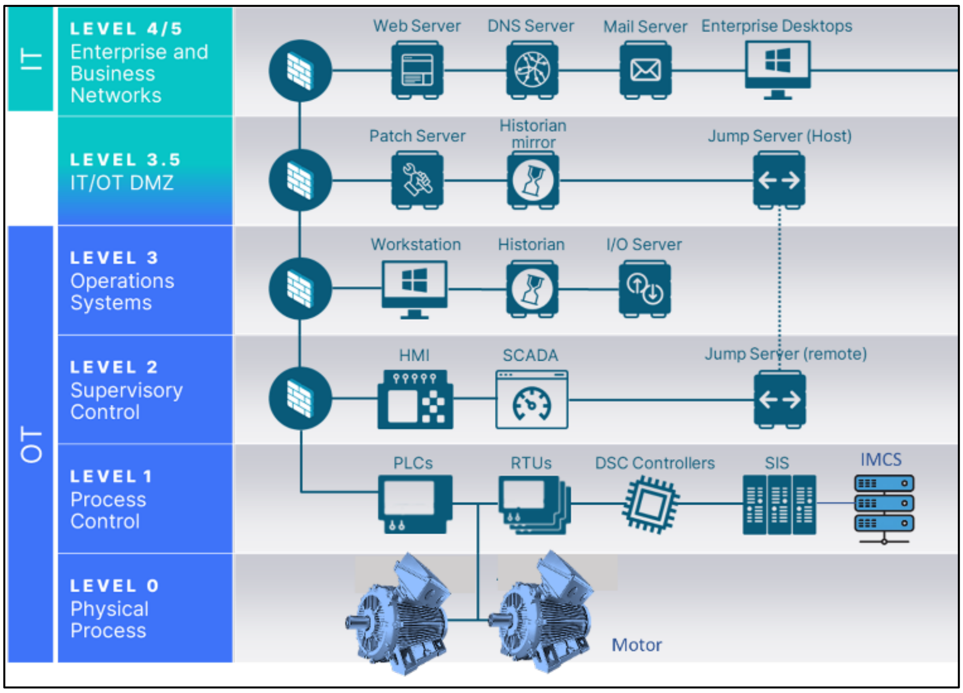

Fig. 1. Purdue network model [1]

2.1.2 Model development

Motor analytics is used for early detection of problems providing warning notifications and diagnosis of motor issues even before it fails. This will help our operating plants to reduce motor downtime which may result in economic losses and at the same time help improve reliability, performance and safety. The analytics model can either be rule-based, machine learning (ML) or a combination of both.

Rule based algorithm generally sets high and low thresholds that trigger an alarm when reached. It is simple and straight forward however it is usually reactive as by the time the alarm is triggered, operations are already out of control. Another approach of the rule based is comparing the operating parameter with the design nameplate or limits. One example is comparing the running current to the full load current. Once the motor is overloaded, the time to trip based on the thermal overload setting of the motor is triggered. With sufficient time, operators can make informed decisions such as reducing process load or perform change over to a standby motor.

Machine learning (ML) is a type of artificial intelligence that is gaining popularity in digital solutions as it simplifies complex analysis previously performed by specialists. ML uses a set of algorithms to train the program to learn and perform tasks based on pre-defined data. Once the program has learnt this task, it is able to perform similar computations and tasks with new data. Several ML approaches such as autoencoder, vector regression or tree-based model can be considered in developing the model. Each model is trained to predict healthy operating conditions and creates a baseline for detecting anomalies. Anomalies are identified when actual readings deviate from the predicted values beyond a pre-defined threshold. This allows for anomaly detection where the model can track specific parameter and raise an alert. The final model is selected based on its accuracy in predicting healthy conditions and its effectiveness in identifying anomalies.

Part of embarking on digitalization is the reduction of operating and maintenance cost. The model can also integrate energy efficiency elements. Motors are most efficient when operated at 100% load. However, there may be installations whereby the motor is operating well below full load due to process changes or oversized motor during design stage. Analytics models can identify these motors and further recommend optimized rating or operating mode for improved efficiency.

2.1.3 Centralised dashboard

Once the data is interpreted by the model to provide informative description of the motor, it can be easily displayed in graphical forms or charts. A centralized web-based dashboard is important for quick analysis and reporting. A customizable dashboard based on user requirements provides relevant information to assist users analyze their assets condition with ease.

Users can filter and request specific information to be displayed on the dashboard. For example, an overview dashboard highlighting key KPI indicators such as total failures, asset availability or motor MTBF can be selected for management reporting. At the engineer level, a dashboard focused on motor anomalies and behavior that will allow the engineer to make informed decision for action. The platform would also allow users to compare operating parameters of identical motors in the same service, view trends and prepare management reports. These features would provide users with a functional and efficient method to manage the health and performance of motors in their facilities.

2.2 Benefit of Digital Monitoring

Digital monitoring on electric motors enables consolidation of critical motor data such as current, bearing vibration, and temperature into a centralized cloud platform, allowing for continuous, remote monitoring and analysis. Motor data such as current, bearing vibration and temperature from the plant historian is sent to a cloud platform where further analysis was performed.

For instance, during the 6-month pilot monitoring, one of the HV motors driving an induced draft (ID) fan was experiencing high loading (i.e. > 95%). The analytic solution alerted the relevant engineers and further investigation was performed. The investigation found the high loading of the motor was due to the inefficient design of the existing impeller with a backward flat profile design. The ID fan was operating below the design fan curve even with maximum shaft power from the motor. To prevent motor overloading and firebox high draft pressure, the operator had to limit the plant capacity. This design also resulted in frequent motor trips during starting due to the high starting torque and long starting time.

In response to this, the maintenance team eventually replaced the impeller with a higher efficiency impeller type to achieve the required performance while maintaining the current motor rating. After impeller replacement, it was observed that the current reduced from 90% to 81% for the same flow rate. Therefore, the simple analytic solution was able to identify a problem that would have gone unnoticed.

3. Conclusions

Due to the critical role of electric motors in continuous production, efficient motor management that is accessible from any location with up-to-date information on motor performance is essential for operational success. These technologies can drastically improve how motors are managed by providing real-time monitoring, predictive diagnostics, and automation, leading to smarter and more efficient operations. As a result, businesses will be able to achieve higher levels of efficiency, reliability, and cost-effectiveness.

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