Filipe Apóstolo, Densyx, introduces new methods for detecting electrical problems in motors and conducting predictive maintenance.

MAKING MAINTENANCE MANAGABLE

Industry media is filled with Industry 4.0 terms and concepts, and many people tend to see it as futuristic science fiction. However, Industry 4.0 is not the future; it is the present.

Many tools that benefit industry are being developed and launched every year in multiple areas, such as maintenance, management, and process control.

One of the biggest complaints heard from industry clients (cement, mining, paper, etc.) is that there are many tools for predictive maintenance that detect mechanical problems with motors, but there is a lack of effective techniques for detecting major electrical issues. Statistics from electrical motor providers show that approximately 41% of motor problems occur in the bearings, which is a mechanical issue, and there are many predictive tools to detect such issues (e.g. vibration diagnosis). However, stators and rotors, which are related to electrical problems, account for 47% of reported failures. These specific electrical problems do not have an effective predictive tool to detect them in their early stages.

Densyx aims to optimise processes and provide software and hardware solutions for industrial problems. The company uses a system to detect electrical problems in electric motors, such as those previously mentioned, and model predictive maintenance.


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Conventional electric diagnosis techniques

A conventional diagnosis of electrical problems cannot provide early detection of an electrical fault; the most common techniques force the technician to stop the motor and open it. Many maintenance technicians assume that they are performing predictive maintenance by using (i) thermography and (ii) isolation diagnosis: (i) the first forces the technician to open the motor and then point the thermo-camera at the stator or rotor in order to find hot spots. However, the time needed to open the motor will allow the motor to cool. If a hot spot is found, it means that the problem is already at a critical stage. Another disadvantage of thermography is that the technician needs to identify every electrical circuit of the motor, or else the hot point might be missed; (ii) the isolation diagnostic will give the condition of the isolation, but will not provide information on what is happening in the electrical circuit. The poorer the condition of the isolation, the greater the chance of having problems. But is there actually a problem? Does the equipment need to be changed thus stopping production for some days? If the motor is difficult to access, how much extra downtime will that cause?

Figure 1. A rotor with damage detected by the QuickServer service report.

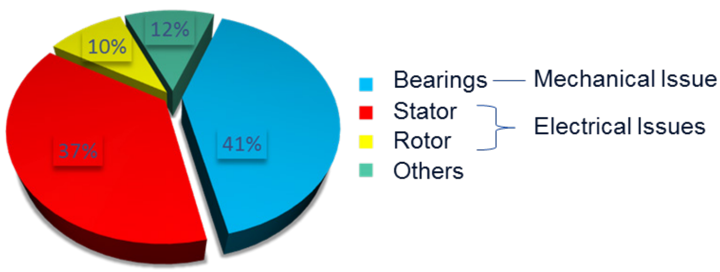

Figure 2. This diagram shows what percentage of reported failures fall under the 'mechanical', 'electrical' or 'other' bracket.

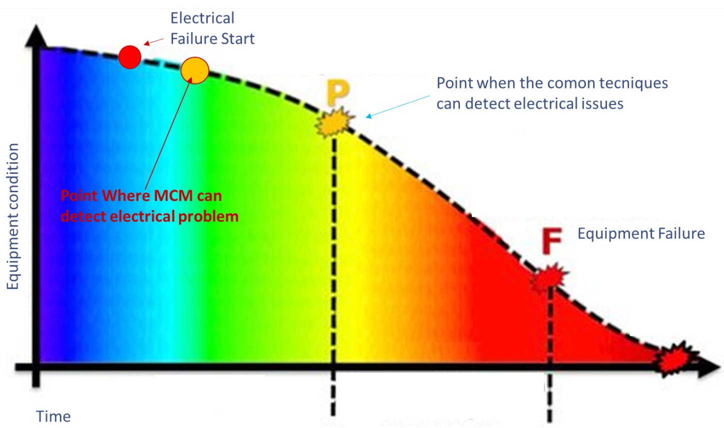

Figure 3. Condition versus time and faults curve.

Industry 4.0 predictive techniques

In the last few years, companies have been providing new techniques that enable the diagnosis of electrical problems without stopping the motor, however the results obtained need to be carefully evaluated by an expert engineer to avoid false interpretations. When an engineer suspects a rotor problem, they must remove the load from the motor to distinguish whether the problem is caused by the rotor circuit, or if it is caused by the load. These methods require human intervention and production being stopped at some point, and while they provide an excellent way to approach real predictive maintenance, they cannot be implemented online, and automatic interpretation is not possible.

Solution: EMS MCM technique

Densyx provides a technique, powered by ENGING, which enables the detection of motor electrical problems in the very early stages of the malfunction. The first step is to collect all voltages and currents of the electrical equipment. Step two passes that information on to an algorithm (Park Vector.) The third step is applying the results from step two into another algorithm which applies an FFT (fast fourier transform) to the correlation matrix obtained in step two. Step three results in a frequency spectrum; each energy peak in a certain frequency denotes a well-known problem, and the amplitude of the peak denotes its severity.

With this technique, it is possible to provide a diagnosis without stopping the motor or removing the load, as it is able to easily distinguish between load problems (mechanical problems due to load) and electrical problems (rotor/stator problems).

Because the system can easily distinguish between these classes of faults, Densyx provides an AI software platform to interpret the results automatically, eliminating any need for human interaction involved in diagnosing the following issues:

- Rotor
- Stator
- Eccentricity
- Load problems
- Power problems

The AI software calculates a value, called severity factor, for each item mentioned above. The 'severity factor' gives a value between 0.0 and 2.0, where 0.0 means that the item is in perfect condition, and 2.0 means that the item is at a potential fault risk. Each fault type has its own individual severity factor, allowing the system to display multiple potential faults in any electric motor.

MCM-Online is a solution that automatically collects the voltages and currents of the motor, sends them to the server to be processed by the AI software, and calculates all the severity factors for each collected sample. The standard acquisition period is 15 minutes, however the hardware is capable of sampling at 3 minute intervals if necessary.

Access to the system and its data is available via web browsers, smartphones, tablets, etc. As the system autonomously monitors all the data points, it will send email alerts once a fault condition becomes visible. When the maintenance department receives an email alert, they are supplied with a checklist of recommendations based on the particular fault detected.

The MCM-Online solution supplies 24-hour motor condition monitoring (MCM) and fault detection, in which trends of motor conditions can be analysed to determine the impact of the operations on the motor. Having these capabilities allows the operator to catch problems before they impact production, saving the operator time and money. In an environment of ever-tightening profit margins, this system can help maintain the operation's bottom line.

Case studies

In Brazil and other South American countries, Densyx are providing the MCM-Online solution in two ways: (i) an on-demand diagnosis and (ii) a fixed online version (diagnosis at 15 minutes). Both solutions detected real, critical problems at a very early stage where conventional detection methods failed. These detected problems were confirmed by the mechanic workshop in all cases. Since the company launched the online version (at the end of 2018), it has installed MCM-Online for 10 motors at a Brazilian Cement Group (nine different sites). In six months of operation, it has already provided savings by detecting critical problems in their early stages, as it will present in Figure 3.

Figure 3 shows the values of each severity factor for one week on one motor using the online version of MCM-Online. The motor with 4286 HP, 6600 volts and 246.1 amps was working well without problems. At some point, the rotor severity factor had some critical peaks. This showed that a rotor problem was in its early stages. After several hours of persistent critical peaks, and because this detection system was new at the plant, the Maintenance Manager decided to stop the equipment and perform conventional diagnosis. Nothing was found using the conventional diagnosis techniques. To double-check the conventional test results, the Maintenance Manager decided to contact the motor provider, who conducted some conventional tests using more precise equipment, but still nothing was found. After carrying out some more detailed tests, they found the problem in the brushes of the rotor. Because the fault was detected at such an early stage, the repair was easy and much less expensive. After the motor was put back in service, the MCM-Online system showed that the problem was resolved.

The savings made as a result of identifying and repairing the problem at a very early stage were analysed. The result was a cost saving between BRL1.5 million to BRL2.0 million or US$360 187.50 to US$480 250.00.

In the on-demand version, the diagnosis was presented in a report where the severity factors of a few samples collected with the motor in normal operation were calculated, followed by the company's conclusions and recommendations.

They calculated a value of 1.6 for the rotor, meaning that there was a problem. After the client stopped the motor to perform an inspection, they found that the rings had extreme wear. ■

About the author

Filipe Miguel Eusébio Apóstolo is the CTO and co-founder of Densyx, as well as an Electrical and Computer Engineer. Apóstolo also completed his Masters degree in Expert Control for Industrial Systems at Coimbra's University, Portugal, and has developed an expert control system which, today, is installed in more than 20 systems, including cement ball mills reducing the kWh/t by around 10 – 17%.