Brief reflection on the Internet of Things and maintenance strategy: New possibilities, new paradigm

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1. INTRODUCTION

A few decades ago, maintenance was mainly carried out just on equipment that had failed or become damaged and needed corrective work. This approach was regarded at the time as the norm and was widely accepted by maintenance personnel. Gradually, however, a strategy developed, leading to what is today's norm, whereby interventions are made without waiting for equipment to fail, in the form of systematic preventive maintenance (fixed time periods or operating intervals) or condition-based maintenance (continuous monitoring of the equipment's status). From the authors' perspective and experience, at present most organizations consider preventive maintenance strategies to be adequate.

However, the rapid technological developments we have been witnessing have forced us to confront a reality that is without doubt here to stay: Industry 4.0. The paradigm starts to change again, as we trace the route towards organizations embracing a maintenance strategy based on the principle of extrapolated predictions, built upon the analysis and evaluation of parameters, of the degradation of the equipment or of a certain component – that is, predictive maintenance.

In the path of what started in the 18th century with the introduction of steam energy, followed by electricity – among other inventive paths that accelerated the industrial rhythm – and, later, of the New Technologies (at the time), here 'old lady' Industrial Revolution feeds on new concepts and formulations: the possibility of machine to machine (M2M) communication, allowing bilateral data exchange, the concept of machine learning (in which systems can learn, identify patterns and make decisions, based on data with a minimum of human intervention, automatically acquiring Information, treating and then analyzing data, and so on.

Given the relevance of a theme that has become a trend – the Internet of Things (IoT) – the authors present here some thoughts on applying this technology to the maintenance function.

2. IOT AND PARADIGM CHANGE IN INDUSTRY

The Internet Society [1] defines IoT as 'the extension of network connectivity and computing capacity to objects, sensors and other common devices not normally considered computers, allowing them to generate, exchange and consume data with minimal human intervention'. It is, therefore, a very broad concept, which can be applied to a wide range of sectors – agriculture, infrastructure, transport, retail, industry, among others. This section is dedicated to the concept of the Industrial Internet of Things (IIoT).

In industry, the focus is on productivity. As with our home appliances, industrial assets will also become increasingly connected. Indicators such as equipment availability can be greatly optimized via IIoT, thus satisfying the consideration at the beginning of this paragraph.

This rapidly evolving technology is proving increasingly attractive to the maintenance sector. The advantages and improvements it could bring include, for example, increased productivity and lifespan of equipment through both efficiency and reduced associated costs.

The economic aspect has to be highlighted, given the significant potential for saving financial resources. Indeed, taking as an example one of the advantages previously identified, a shorter downtime of assets brings clear financial benefits. Likewise, less frequent replacement of spare parts or fewer unnecessary applications of consumables will translate into a proportionate reduction in costs. Consequently, labor costs and their associated costs will also drop considerably. While a maintenance manager should not be guided entirely by economics, the fact that the

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organization will have set a maintenance budget means that it is an issue that merits attention.

The benefits for the maintenance resulting from widespread use of this technology cannot be disputed: for example, obtaining data more frequently and of a higher quality than previously, centralized technical management of assets, or less human intervention. But there are negative aspects too, particularly a high initial investment, namely the acquisition of hardware (sensors), manufacturing equipment, a maintenance team supporting programming and automotive systems, and maintenance subcontracting. Others include the potential increase in data security vulnerability, intrinsic to systems of this type. Overall, however, the advantages are considered too far outweigh the disadvantages.

Here we focus on predictive maintenance, the type of maintenance that benefits most from this technology. In fact, as mentioned above, it will become easier to adopt this type of maintenance strategy to manage the assets of any organization since, through the use of sensors and acquisition device data, among others, it is now possible to gather a large amount of data and monitor equipment continuously. This reality will lead to a significant change in the approach to assets, the moments of intervention in their life cycle and the tasks to be performed.

With the real-time analysis of the data and trends now identified, maintenance work will be undertaken with greater accuracy and assurance, taking place only when strictly necessary, as opposed to when it might be necessary, thus avoiding purely systematic preventive interventions in equipment where no type of failure or malfunction would occur.

This technology's falling costs make it possible to disseminate this maintenance strategy which, although not new, has yet to be adopted by most organizations. Actions such as replacing a bearing on a date prior to the predicted date of degradation level – a replacement date based on trend analysis through the systematic measurement of noise – will no longer be exclusive to a few companies, but may be adopted by a broader number. Therefore, the moment will come when predictive maintenance will have become common, with clear benefits for the maintenance function and for companies.

3. APPLICATION FOR THE MAINTENANCE FUNCTION

Maintenance managers may be somewhat skeptical about a possible change in strategy. The questions they should ask themselves are about their willingness to improve and optimize maintenance and, as an integral part of an organization, contribute to the increased productivity. Given this, most decision-makers will become more open to new solutions. Even if it is not decision-making based on data and information, it will be supported by the need, understanding and commitment shared across the organization to achieve overall excellence of the organization, through excellence within departmental performance.

Production will benefit from the advantages introduced by a predictive maintenance strategy, compared with other types of maintenance, as equipment and machinery downtime will be reduced, something that naturally increases the operating capacity, which is always the objective. Equipment availability will be assured for longer periods, and with quality levels in line with expectations, monitoring variations in the performance quality parameters opens up several possibilities, namely the use of reverse logic: the quality of the equipment's spare part, or any other area of the item, may lead to a tendency for the item to malfunction or fail as a result of this spare part, providing data for maintenance decision making.

Making this change is, at the very least, challenging. There may be uncertainty when the efforts and resources involved are calculated. In order to mitigate the resulting impact, the maintenance manager must clearly set out the steps to be taken and highlight the anticipated future gains and benefits.

According to Hitachi [2], predictive strategies which were successfully implemented each had similar phases. First selecting/defining as a starting point a small part of inventory as a test object (pilot equipment). This stage allows the chosen items to be measured, and the necessary design and architecture to be defined in a controlled way, that is, a place to store the collected data, and analysis platforms or possible involvement of IT service providers, such as Software as a Service (SaaS) solution providers. As soon as the base is established at a micro level, it adapts and expands to other areas, equipment, sectors, and eventually to the entire organization.

If data acquisition is relevant, its treatment and analysis are highlighted: a platform should be used so that the huge amount of data collectable through various items of equipment – Data Acquisition (DAQ) – such as sensors, converters or signal conditioners, to be obtained, processed, prepared and structured. This system should be able to recognize any part of the information coming from these data and list it as part of the whole, which will be the general framework for analyzing and monitoring the equipment inventory.

A second phase described as fundamental relates to the use of adaptive algorithms. Patterns can be identified through the two previous steps, since data acquisition and treatment are assured, providing inputs and information in a reliable and continuous manner. Comparing these patterns with ones previously identified means that rules of action can be created. In turn, the comparing these rules, and their effect, with those previously applied means having an adaptive learning process (machine learning). The more patterns, scenarios and comparisons, the greater the learning opportunities.

Time must elapse in order for these comparisons to be made. But this initial period of transformation of the maintenance strategy can be utilized to create and execute of non-adaptive algorithms, by establishing logical rules based on observed and measured parameters in the equipment. This would correspond to a stage or intermediate stage of conditioned maintenance. Observation of a reading point or measurement outside the established range would trigger any maintenance action.

The fourth stage has to do with the possibility of integrating the information which results from the acquired and processed data. This integration can be undertaken with other management systems, such as, for example, an ERP (Enterprise Resource Planning) or CRM (Customer Relationship Management).

After this fourth stage, events that trigger workflows can be established. These action sequences can be analyzed and allow improvements to the processes.

A final reported level, for transition and satisfactory implementation, will be the involvement of top management. Any organizational or technological change relies upon (real) adherence to the change, so that natural resistance can be minimized. The connection and commitment to this new strategy by a decision maker, will increase the likelihood that the project will continue, and it will also stimulate and motivate others to embrace a new challenge, without letting the setbacks and difficulties call the greater objective into question.

The paradigm shift will inevitably have a strong impact on the transformation of maintenance function processes and implementing the predictive strategy may require effort. But always bear in mind the ultimate benefits, namely better management of resources since, as already discussed above, interventions will occur only when absolutely necessary, without associated waste, with less impact on the operation and with a clear optimization of the actions and tasks to be performed, leading to visible improvements not only for the maintenance function but for the entire organization.

4. FINAL CONSIDERATIONS

The growing adoption of this maintenance strategy is based primarily on two factors: the availability of and access to technology, and the reduction in costs associated with it. For the implementation of a predictive system, the latest equipment incorporates technological advances, specifically integrated circuits to control the machine itself, and enabling parameter readings associated with its operation. This functionality allows information to be acquired and stored at lower cost.

On the other hand, converting the asset stock in order to equip it for DAQ can be achieved at relatively low values, as an increasing number of providers manufacture and supply them. Thus, the technology is available – through incorporation into the latest equipment, or conversion at relatively low cost – and its use becomes less expensive.

Still, for some organizations the initial investment may be considerable. This is one of the points identified as less positive, as well as the potential increase in vulnerability in terms of data security.

On the other hand, among the several positive points identified we highlight:

- Widespread reduction in costs and downtime;
- Efficiency and productivity gains;
- Monitoring of assets.

In the third section of this article, a set of procedures is established which, through IoT, contribute to the successful implementation of a predictive maintenance program within an organization. In brief:

- Defining pilot zones (before investing in a complete predictive maintenance program);
- Having a set of technologies to aggregate data;
- Using algorithms to monitor patterns and events in real time;
- Enabling the integration of information in other management systems;
- Establishing events that trigger effective workflows;
- Ensuring top management involvement.

Naturally, there are differences from sector to sector. But it is believed that this system synthesizes an important set of tools, capable of contributing to the successful implementation of a predictive maintenance program in an organization that wishes to move from a preventive maintenance strategy to a more evolved maintenance management.

When expanding the role of maintenance, and its subsequent effects, across the rest of the organization, we must not fail to mention the anticipated impact. As mentioned, in terms of both cost reduction and raised productivity, the benefits are real, and may amount to around 30% [3].

The use of a predictive strategy will reduce Mean Time to Repair (MTTR) and increase Mean Time Between Failures (MTBF) as equipment availability increases. This will lead to a potential increase in production capacity, since one can predict the maximum usage time for the equipment in question, reducing industrial costs associated with finished products.

At another level, data analysis may lead to improvements in production planning, the logistics chain (supply and demand) and the relationship with suppliers and customers.

Today, we are surrounded by billions of sensors. If we take advantage of the data they collect and transform it into information and, consequently, into knowledge, we can look towards an evolution and adaptation that, not so long ago, we thought was unachievable. Winning support from decision-makers is therefore much easier. So let us take advantage of this, taking better decisions and in a manner conducive to the excellence of the maintenance function in organizations.

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