Predictive Maintenance 101
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EXECUTIVE SUMMARY

No business can afford unplanned downtime or equipment breakdowns in today’s tremendously competitive market. Such occurrences can cause delays, disappoint customers and result in lost business.

Today, organizations are constantly monitoring the condition and operating performance of their equipment to prevent unwanted downtime and to reduce costs. While focusing on assets in this way represents an area of opportunity, many organizations lack visibility into their assets’ health and performance in order to develop predictive strategies.

There are several types of maintenance processes: reactive maintenance, preventive and predictive maintenance. The type of maintenance processes the company uses can have a striking impact on avoiding equipment failure and operational interruptions.

This white paper presents the concepts of predictive maintenance and explains why companies are adopting predictive maintenance programs to maximize asset productivity.

Maintenance techniques have evolved with the advances in technology. PdM systems have developed alongside advances in IoT and other technologies, which have made it possible to gain access to detailed asset information. PdM is an approach based on various types of data that allow maintenance, quality and operational decision makers to predict when an asset will need maintenance – thus preventing equipment failure. PdM focuses not only on asset data, but also on the surrounding environment and the associated processes and resources that interact with the asset. It also provides better visibility of the asset by leveraging various analytical techniques, which leads to improved decision making.

The PdM system captures and analyzes log, measurement and failure data based on usage and wear characteristics of the asset. It then processes information and provides the following benefits:
- Identifies key factors responsible for machine failure
- Determines the probability of predictive outcomes
- Improves decision making

THE MAINTENANCE MATURITY MODEL

Few organizations in today’s competitive marketplace will survive long using the reactive maintenance model in which you wait until an asset fails before servicing it. This not only directly affects the company’s operations, it can cost a considerable amount of money and time. Now most companies have moved beyond the reactive maintenance model, however many have stalled in the second stage: preventive maintenance.

Preventive maintenance (also known as planned maintenance) is the model in which equipment maintenance is scheduled based on recommendations from the equipment maker, modified by other factors including time and age. While preventive maintenance is much more effective than the reactive maintenance model, it still does not take into account how the equipment is being used.

Contrast this with PdM, which analyzes real-time and historical data and uses statistical techniques to make predictions about the equipment and its needs. For example, a manufacturing company using PdM might analyze data captured by closely measuring equipment performance and the wear and tear on the machine. Maintenance is then determined by the current and predicted state of the asset rather than average or expected life statistics. Early detection and repair of equipment using PdM helps organizations to reduce or eliminate sudden downtime or additional expenditures.

Put more simply: PdM analyzes the asset and provides the foresight you need to provide maintenance as needed. This increases asset availability and avoids costly downtime due to deterioration in the component or equipment.

WHAT IS PREDICTIVE MAINTENANCE?

If a piece of equipment randomly fails, it can take a lot of effort, time and money to get it back up and running. In some situations, an entire operation can be shut down waiting for the equipment to go back online.

Predictive maintenance (PdM) techniques help companies keep maintenance frequency as low as possible and avoid sudden breakdown of assets through continuous monitoring and analysis. PdM provides deep visibility into assets’ health and performance and allows effective maintenance schedule to be planned before failures, and subsequent downtime, occur.
COMMON MYTHS ABOUT PDM

Myth #1: You need “high quality” data to use PdM

To start with PdM, look to see what usable data is already available to you, such as equipment performance, usage, and wear. Next, make plans to start collecting more asset-related data to gain better insight. Analytical methods are available to help companies identify the values missing so that they can proceed with PdM implementation.

Myth #2: Once the PdM system is implemented, it works like magic!

PdM must be implemented in conjunction with business objectives or it will not be useful. It must align with a company’s business goals and operations. To avoid being seen as a mere engineering project, business analysts as well as management must be on board with PdM.

Myth #3: You must hire expensive data scientists to implement PdM

With today’s software tools, business analysts can effectively understand the analytics being generated and gain detailed insights.

Myth #4: Installing a PdM system is expensive

Once in place, a PdM system will quickly deliver a return on investment (ROI). Installation costs can be recovered within months, if not weeks, for many manufacturing companies.

USE CASE: PREDICTIVE MAINTENANCE IN FIELD SERVICE

The suppliers and manufacturers of ATMs and other machines used in banks, retail chains, financial institutions and other places have an extensive customer base. They must send out field service technicians to maintain these machines as part of their scheduled maintenance program and also in case of emergency breakdowns.

To improve customer service, these ATM manufacturing companies may provide a maintenance program to inspect, clean, lubricate and adjust machines for optimal performance and a long life. This maintenance program involves the cost of inspection and servicing of the machines on the customer’s premises on a regular basis. However, it would add much more to the company’s overhead if a machine were to unexpectedly break down.

In this scenario, implementing predictive maintenance can help manufacturers significantly reduce emergency visits and provide a way to predict which machines are more prone to break down. It would also allow field service workers to approach maintenance tasks with the parts and supplies they need.

Applying mathematical modeling and forecasting techniques using the algorithms written in the R and Python programming languages, companies can analyze the historical field service data to predict future outcomes. The solution helps the organization’s management and other decision makers to quickly look up data related to machine breakdowns, time taken to fix those machines and other field service issues.

Using established PdM solutions, finding this information does not require running complicated search queries or applying specific technical skill. In this way, management has the ability to discover deeper patterns and use it to create a program of predictive maintenance. The solution also enables companies to automate this pattern discovery and incorporate it into their algorithms to come up with predictions for improved processes and service level agreements.

BENEFITS OF PDM

Failure Prediction

A company can predict the time of the next likely machine failure and maintain the equipment to prevent it, which results in more uptime and fewer emergency calls.

Inventory Acquisition Prediction

As the company can predict which parts will fail or wear out in the near future, the field technician will turn up at the call site with the correct spare parts.

Service Time Prediction

Knowing the specific service that is required, the company can predict the time it will take a technician to complete a call.

Smart Allocation

Management can suggest the most appropriate technicians for a given service call based on the type of service anticipated.

WHY DO MANUFACTURING COMPANIES NEED PDM?

In manufacturing today, managers at all levels are expected to perform to modern business standards as they work to maximize the return on assets (RoA) of the plant equipment. This is true even in the face of aging assets, rising material costs, and reduced operational and capital budgets that may limit new equipment investment.

In this environment, managers limited to old-tech tools such as spreadsheets, basic alerting systems, manual logs, and shift meetings for information exchange will find it hard to compete. Those managers with access to IoT-based PdM systems will be able to get the job done and give their company a competitive edge.

WHAT MAKES PDM FEASIBLE IN ENTERPRISES TODAY?

To carry out predictive maintenance, the company does not need to set up the entire system as part of its own infrastructure. With the availability of platforms such as Microsoft Azure, computing power and storage is cheap and scalable. These are some of the factors that make PdM feasible for most companies:

- An abundance of operational data can be generated from every aspect of machine performance with sensors.
- Identifying issues before failure extend the life of assets and reduces equipment downtime.
- Relative ease of use when it comes to generating insights from unstructured data.
- Reduced cost of computing, network, and storage technology.
GETTING STARTED WITH PDM

The process of getting started with PdM can be summarized into the following steps:

1. Prioritize problem areas
2. Uncover company-wide gaps
3. Understand your data needs
4. Analyze your data and start predicting outcomes
5. Use the insights gained
6. Have a culture of continuous improvement

Before bringing PdM into the organization, it’s important to identify and focus on solving the problems that have the most impact on the profitability, and ultimately, the organization as a whole. Once the problems have been identified, the next step is to improve the metrics on which the organization is focusing. In this process, management will play a bigger role.

At this stage, it is vital to find out organizational gaps in processes, people, or existing systems, and identify what kind of data is generated and will be needed. The company needs to line up physical assets, processes and associated stockholders, and data gathered from the sensors based on the setup and requirements.

PREDICTIVE MAINTENANCE IN BUSINESS PROCESSES

Maximize Product Quality
- High-quality output
- Reduced quality costs
- Improved root-cause identification
- Greater customer satisfaction

Optimize Inventory management
- Supplier information about spare parts
- Know the costs to attain/manufacture certain parts
- Get supplier information regarding component delivery schedules
- Information on existing work-in-progress and finished goods
- Know the expected demand of products

Financial Department stays informed
- Improved accuracy in budget plans
- Analyze customer, product, market and channel profitability to optimize financial performance
- Compliance with legislation and regulatory requirements such as OSHA and EPA
- Enable reallocation of funds for increased R&D or hiring
DATA TYPES

The most common data types are structured, unstructured and streaming data.

**Structured data** is the most common type of data available which is collected from customer relationship management (CRM) and enterprise resource planning (ERP) systems, and industrial control systems such as supervisory control and data acquisition (SCADA). It also involves the information stored in data warehouses, relational databases and spreadsheets. Examples of structured data include inventory and production line information, such as asset name, location, and records of the last time maintenance was carried out.

**Unstructured data** refers to textual information in the form of emails, maintenance and operator logs, social media data and other free-form data that does not conform to a specified format or structure. Manufacturing companies can use a text analytics program to understand the data from their operators’ logs and measure asset performance.

**Streaming data** is the most important part of a PdM program. It involves data that needs to be collected and analyzed in real time, such as information from sensors, satellites, and controllers used on machinery in factory assembly lines, resulting in telematics, measurement and weather information.

ANALYZE YOUR DATA

Various techniques are used to analyze different types of data to predict outcomes and derive meaningful results.

**Descriptive analytics** provides simple summaries and observations about the data. For example, a manufacturing machine failed five times in a day.

**Prescriptive analytics** goes beyond predicting future outcomes by also suggesting actions to take in a given situation to maximize profitable growth, showing the implications of each decision option. For example, based on the data, a water utility can predict when its water pipes are likely to burst. The utility company can have an automated decision where for certain pipes, certain valves must be replaced by the appropriate technician.

**Text mining** derives insights and identifies patterns in unstructured (textual) information via natural language processing, which helps companies derive potentially valuable business insights and improve decision making.

**Machine learning** is a subfield of computer science that monitors previous computations (including repetition and experience) and learns from the data without being explicitly programmed. It recognizes complex patterns and makes intelligent decisions while exploiting the opportunities hidden in big data. For example, when a machine fails there could be three or four factors that are responsible for the breakdown. When those factors come into play next time, the software will be able to recognize them and predict when the machine failure is likely to occur.

**Simulation** enables you to play out what-if scenarios for your assets and processes. For example, you can run a simulation on how a certain production line in your plant will react if it is run continuously for 24 hours. This method helps companies determine the failure rate of their processes.

Data mining involves the analysis of large quantities of data to uncover patterns and dependencies. This is done using these common data mining techniques:

- Anomaly detection
- Association rules
- Clustering
- Classification
- Regression

WHERE CAN YOU IMPLEMENT PDM?

Predictive maintenance is ideal for both manufacturing assets and field-level assets.

**Manufacturing assets** include production line and assembly machinery used to create a product, such as:
- CNC machines
- Welding machines
- Robotic arms

**Field-level assets** include any equipment in the field that is operated and serviced in place. This can be divided into the following categories:
- Consumer appliances and HVAC systems
- Vending machines and ATMs
- All forms of transportation
- Heavy equipment such as earthmovers and mining equipment
- Energy generation equipment such as turbines, solar panels, oil rigs and even nuclear plants
- Electrical grids, telecom and other utilities

CHOOSING AN IOT PLATFORM

There are many IoT platforms which can empower enterprises with predictive analytics and maintenance capabilities. There are several factors that companies should consider while making this choice:

- Connectivity hardware
- Communication protocols
- Firmware development tools
- Message brokers and message queueing
- Security and authentication
- Data collection, visualization, and analysis
- Device administration
- SDKs for developing action and presentation mobile apps, web apps, etc.
- Integrations with other web services

CONCLUSION

Emerging technologies, shorter product life cycles and increasing international competition are only a few challenges manufacturing companies face today. Not focusing on improvement of maintenance, repair and operations of their machinery directly adds to the company’s overhead. PdM is a great way to avoid unforeseeable machine failures while ensuring optimum performance and increasing customer satisfaction.
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