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Asset Management KPIs with Industry 4.0

By Ralph Rio

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Industry 4.0 applications with IoT and analytics impact the maintenance function and the associated business processes, providing the potential for radical improvements in KPIs.

Summary

How will Industry 4.0 impact asset maintenance KPIs? A recent discussion with Sachin Bhavsar, Industry 4.0 Leader and Practitioner, TCS, added focus on some current trends that offer the potential to drive a step-function improvement in the maintenance function for higher asset reliability. This includes the potential for no unplanned downtime for critical assets.

Digital Transformation in Maintenance Management

Maintenance management has started down a path of digital transformation, which offers the potential to significantly improve key performance indicators like mean time between failure (MTBF) and mean time to repair (MTTR). With remote monitoring using Internet of Things (IoT) and predictive analytics, maintenance can be scheduled when it is truly needed i.e., when an issue is known to exist and prior to failure. This dramatically improves the traditional KPIs like MTBF, MTTR and others. Also, dreaded unplanned downtime for critical assets can approach near zero.

Problems with Reactive and Preventive Maintenance

Currently, most maintenance work involves reactive (run-to-failure) and preventive (time- or cycle-based) maintenance. For critical assets, reactive maintenance is expensive due to the interruption of production and associated lost revenue. Also, a failure in a component often cascades into a much costlier repair. This is akin to allowing low oil level in your car's engine to cause the engine to seize, and then require a costly engine replacement.

Preventive maintenance avoids failures by scheduling maintenance before the asset's probability of failure starts to increase. Unfortunately, the probability of failure increases with age for only 18 percent of assets. The other 82 percent of assets have a random failure pattern.[1] For these assets, preventive maintenance is not an appropriate strategy because the equipment will likely deteriorate and fail between the maintenance occasions.

Expanded Maintenance Strategies with IIoT

Traditionally, maintenance practices have been classified into three levels: reactive, preventive, and condition-based. Now, IIoT and analytics enable two higher levels: predictive and prescriptive. Adoption of these technologies expands the range of available maintenance strategies.

Strategy:	Description	Asset Attributes	Car Analogy
Prescriptive	Model and knowledge base identify an issue and what to do for repair. Uses multiple equipment and process data variables (multi-variate)	Complex assets requiring advanced skills for problem diagnosis. May need knowledge of process dynamics	Dealership-level diagnostic equipment
Predictive (PdM)	Equipment-specific algorithms or machine learning. Multi-variate and automated data collection	Critical assets where unplanned downtime has significant business impact	Battery management system in electric cars
Condition-based (CBM)	Alerts for bad trends or other rules-based logic using a single data value. Includes inspections and manual data collection	Assets with a random or unpredictable failure pattern	Oil pressure, coolant temp., and OBDII indicators
Preventive	Service in a fixed time or cycle interval	Probability of failure increases with asset use or time	Replace engine oil every 5,000 miles
Reactive	Run to failure, and then repair	Failure is unlikely, easily fixed/replaced, or non-critical	Radio run-to-failure
Knowledge base: Underlying set of facts, assumptions and rules to solve a problem *Algorithm*: A formula, process or set of rules to be followed in calculations *Machine learning*: Software that provides computers with the ability to learn © ARC Advisory Group			

Expanded Range of Maintenance Strategies with IoT and Analytics

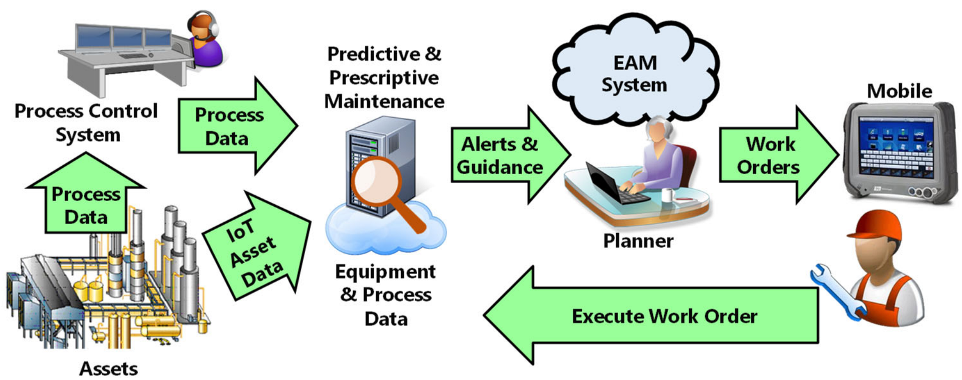
[1] *APM 2.0 with Industrial IoT*, Ralph Rio, ARC Advisory Group, Sept. 2015, pg. 14

FMEA Rises in Importance

A typical asset has multiple failure modes. For example, common issues with an electric motor include bearing failure, winding burnout, and fan damage. Each failure mode has its own cause. Thus, a critical electric motor may require multiple predictive maintenance algorithms. Failure Mode and Effects Analysis (FMEA) is used to identify the key modes. This practice becomes more important with predictive maintenance to assure the critical assets are identified and the leading failure modes addressed.

Automated Business Process

IoT enables automated data collection to monitor the health of an asset in real time. Analytics puts the IoT data into mathematical algorithms for predictive maintenance (PdM). An issue is identified as it emerges, and, by creating an alert, a repair can be scheduled prior to a failure. The maintenance planner assesses the alert, prioritizes, and schedules the work order. Depending upon the failure and its repair time, production schedule can be modified, resources realigned so that it results in zero production loss.



Automated Business Process Prevents Downtime and Production Losses

PdM Adoption Accelerates with Commoditization of IoT

In the past, predictive maintenance applications were expensive and brittle. The project included creating the IT infrastructure and programming custom software. It interfaced with other systems (usually the historian) to obtain data and send alerts. Changes in any of the integrated systems (such as an upgrade) were likely to break the application. Since the resources rarely remained in place to support the system, users simply went back to the old way of doing things.

With IIoT platforms, predictive maintenance applications have become easier to develop and support. The host IT infrastructure is in the cloud and the platform manages the connected devices, data acquisition, data management, and authorized users. Most of the development involves configuring these services and other microservices for the various types of analytics. The application developers focus on developing the predictive algorithms and creating alerts – which provide the value add.

Radically Improved Maintenance KPIs with Industry 4.0

What is an asset failure? Simply stated, this is when an asset no longer performs its intended function and ceases to support the production of the product or service. With PdM, the issue is identified prior to a failure.

MTBF

With advance notice, maintenance planning schedules the work order when the asset is not needed for production – during an opening in the schedule or off shift. Since production is not affected, a failure is avoided. Unplanned downtime thus approaches zero and MTBF approaches infinity.

MTTR

The "time to repair" in MTTR is defined as the length of time for which production is interrupted. By applying Industry 4.0 technologies like IoT and analytics, MTTR reaches an optimum level that minimizes production losses. Maintenance can be scheduled when the asset is not needed for production.

Maintenance Costs

Maintenance costs could also be improved radically. PdM identifies an issue in a component before it can cascade into a much bigger problem. For example, chips from a failure of a single gear in a gearbox will typically cascade into every gear causing a massive problem. Also, the advance notice allows maintenance planners to avoid costly emergency events. PdM allows maintenance to be scheduled when truly needed. This contrasts with preventive maintenance, which is not needed most of the time.

Benefits of IIoT-enabled PdM:

Unplanned downtime is prevented.

MTBF approaches infinity.

MTTR goes to an optimum level.

Avoid costly emergency repairs.

Perform maintenance when truly needed.

Production rescheduling avoids production downtime.

Industry 4.0 Needs New KPIs

New KPIs associated with the parameters of predictive maintenance rise in importance. Some examples are:

- PdM coverage: Portion of critical asset failure modes covered by PdM
- Alert success rate: How often the repair occurs before failure
- False positive rate: Portion of alerts that are not valid

An Advanced Alert System (AAS) provides enough advanced notice using PdM to reschedule production plans and resources to prevent production loss.

Advanced Time of Notice for PdM Alert Prior to Failure

The length of time prior to asset failure for a PdM alert depends on the data collected and associated algorithms. The optimum alert time is driven by the production system including a buffer that provides availability of unscheduled production time and flexibility for scheduling work in process. A well-designed advanced alert system can avert nearly all production loss.

Improved Revenue for PdM Project Justification

Engineers focus the business benefit of PdM and Industry 4.0 on maintenance technician time and materials. Getting a high enough ROI for project justification is difficult.

Increased uptime also increases capacity with higher production and revenue. The increase in both revenue and profits usually provides a sound justification. This approach directly affects the KPIs of executives which are in the financial reports for profit and loss (P&L) and balance sheet. Improving these KPIs gets executive attention and support.

TCS Domain Knowledge in PdM

As a well-known global service provider, Tata Consultancy Services (TCS) provides technology services, consulting, and business solutions. The company is part of the Tata Group, one of India's largest industrial conglomerates. TCS was established in 1968 as a division and was incorporated as a separate entity in 1995.

TCS offers a consulting-led portfolio of business, technology and engineering services and solutions. This is delivered through its location independent agile delivery model which is recognized for excellence in software development.

Among its many services, TCS offers a broad portfolio of solutions, services, and domain expertise in asset management for enterprise asset management

(EAM), reliability, and Industry 4.0. This includes a practice area dedicated to applying IoT and analytics to predictive maintenance and the associated business processes.

Conclusion

Applying IoT and analytics for predictive maintenance provides the basis for digital transformation in maintenance and is consistent with the objectives of Industry 4.0. When coupled with the business processes for initiating, scheduling, and managing maintenance work orders, this can improve KPIs radically, supporting key maintenance objectives. These include improvements in uptime, asset longevity, cost control, safety, and quality (or yield). Based on ARC research and analysis, we recommend the following actions:

- For the existing critical equipment, end users should develop predictive maintenance applications using IoT and analytics. Start with a machine or work cell that is known to be problematic; a win here will be noticed and will provide credibility.

- For new equipment purchases, end users should include IoT-enabled remote monitoring and predictive maintenance services in their selection criteria.

- OEMs should adopt IoT and analytics to provide customers with services for predictive maintenance and optimization of operational performance. Equipment suppliers should assess their capabilities to manage and execute field service throughout the business process of alert generation, internal call centers, and independent dealers.

- Project justification based on increased capacity, revenue and profitability gets executive attention and support.

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