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Industrial IoT Brings Benefits and Opportunities for Rotating Equipment Suppliers and Plant Operators

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ABSTRACT

The evolution of the Industrial Internet of Things (Industrial IoT) and the increasing availability and affordability of constituent technologies such as sensors, gateways, networks, platforms, and analytics brings with it new opportunities for industrial operators to connect once isolated plant equipment and obtain real-time information on asset operation and asset health.

The benefits, such as improved operating performance, higher availability and less unplanned downtime, from connecting plant assets into an Industrial IoT system are clearly magnified in the case of critical and costly rotating equipment such as pumps and compressors.

As well as a valid and ROI-friendly technology investment for plant operators, Industrial IoT enables rotating equipment suppliers to stay connected to their assets and, consequently, develop new and lucrative business models, where service is not an afterthought as with the conventional product sale, but a much more significant component of the supplier offering and one that not only drives new revenue streams but also enables much deeper and longer customer relationships.

The asset connectivity enabled by Industrial IoT is increasingly enhanced by advances in analytics technology, particularly machine-learning based solutions, which means basic remote monitoring evolving to much more sophisticated predictive maintenance solutions. The early warning of equipment issues and expected failure triggers timely intervention, avoiding the disruption and expense of sudden downtime.

INTRODUCTION

The Internet of Things (IoT) is one of the most highly significant technology developments in this decade, garnering growing interest and attention from a wide array of constituencies, including hardware and software suppliers, systems integrators, consultancies, end users, governments, conference and exhibition organizers, and the news, business and trade media, to name just a few.

While IoT definitions abound, the ITU's "The Internet of Things is a network of physical objects or things embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data" is quite appropriate.

In simple terms, IoT can be thought of as extending the use of the Internet from its 25-year history of (essentially) connecting people to the newer concept of connecting things. For example, booking a flight ticket in pre-Internet 1987 was a quite a different experience than it is now in 2017, with cumbersome visits or calls to airlines and travel agents now replaced by quick, convenient online interactions facilitating extensive choice and price comparison. As products as diverse as bicycles, streetlights, toothbrushes tennis racquets, thermostats and vending machines increasingly get IoT connected, we see the phenomenon of previously dumb, isolated products transforming to smart, connected products and so enabling similar benefits in efficiencies and value-add that the Internet (of people) has made commonplace.

For instance, dockless bicycle sharing, which has taken off in a big way in major cities across the world over the last 12-18 months, is only possible because of IoT technology, which has enabled a new business model based around revenues from short-duration rentals and transformed the perception of a bike (at least in central urban areas) from an asset to be individually owned and maintained to one provided as a short-term transportation service.

IoT applied in the industrial realm is referred to as the "Industrial Internet of Things", normally referred to as Industrial IoT or IIoT. ARC Advisory Group defines IIoT as follows: "The transformation of industrial products, operations, value chains, and aftermarket services that is enabled through the expanded use of sensors, digitization, networking, and information systems."

So instead of a consumer item like a toothbrush of tennis racquet, a "thing" in the industrial context is an asset normally involved in plant operations. Adding sensing and communications/processing capabilities allows it to be referenced as a digital asset within the IIoT system. The data can then be transferred via a network to software (increasingly cloud based) for processing and analysis.

Two broad opportunities arise from the emergence of Industrial IoT and application of the technology. One concerns the plant itself and the owner operator, who is now able to improve and enhance operations by having much greater visibility on resources such as parts, machinery and people, allowing optimization of both maintenance and operations activities.

The other is to do with OEM-supplied plant equipment, which can now be developed and delivered as smart, connected products and, consequently, provides the equipment manufacturer with the opportunity to offer a much higher level of service through being able to stay connected to the asset now out at the customer site. Increasingly, those connected plant assets are turbomachinery such as pumps, compressors, and turbines.

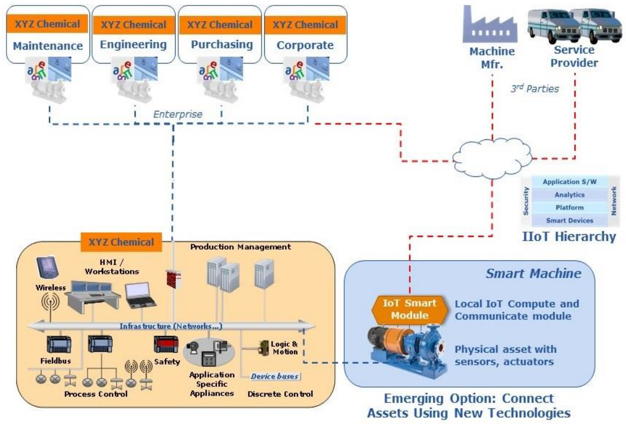

Figure 1. Smart machines are the foundation of the IIoT connected plant

IMPORTANCE OF UPTIME

The oil & gas industry, a primary end market for turbomachinery, experienced its own "oil shock" this decade with a price collapse of almost $100 a barrel peak-to-trough. As recently as January 2016 oil was trading at less than $29/barrel. While prices have recovered somewhat, the industry has seen significant expenditure cuts, business closures, job cuts and stalled projects. With longer term, demand-side issues such as the growth of renewable energy and the move to electric vehicles, it appears unlikely that the heady days of $100/barrel will return any time soon.

One positive outcome, however, of the industry's woes is a renewed focus on operational efficiency, which is the level of inputs e.g. energy, labor, materials, machines, required to produce a given level of output e.g. a barrel of oil. At $100/barrel, operational efficiency is less of a concern because the break-even price is easily cleared. But at lower price levels, the onus is on attaining higher levels of operational efficiency to realize profits in a price-constrained environment.

A major cause of low operational efficiency is equipment downtime, especially unplanned downtime. An ARC Advisory Group survey of senior executives and engineering, operations and maintenance managers in the oil & gas industry puts the annual production loss from unplanned downtime at 3-5 % of total yearly production. Across the process industries a whole, with an aging asset base, the impact of unscheduled downtime runs into billions of dollars a year.

Aside from lost production, unplanned downtime impact can be felt in added costs for labor and spares inventory, and in customer issues such as delayed deliveries. Maintenance that is not anticipated is also far more expensive – around 10 times more – than planned maintenance. And of course, the more critical the asset us to operations the greater the ramifications, and turbomachinery generally falls into this category. So clearly, how owner operators manage and maintain their plant assets is extremely important, and has a direct impact on company profitability.

MAINTENANCE MATURITY

While most companies would not be wholly unaware of the ramifications of unplanned downtime, the equipment maintenance strategies in place in the majority of plants do little to improve asset performance to a level to where it needs to be. Referencing the ARC Asset Management Maturity Model (Figure 2), only a small minority of companies have evolved beyond conventional maintenance strategies, with the reactive and preventive approaches still very much in the majority.

However, companies able to move to the higher levels of predictive and prescriptive maintenance can get much closer the goal of almost zero unplanned downtime. While predictive maintenance provides early warning of impending equipment failure, prescriptive maintenance not only tells you a failure is on the way but also diagnoses the cause(s) and informs what you need to do to prevent its actualization.

Approach	Description	Asset Attributes
Prescriptive	Pattern identification points to explicit diagnosis of root cause and indicates precise action to change outcome	Complex assets requiring advanced skills for problem diagnosis
Predictive (PdM)	Multi-variate with equipment specific algorithms or machine learning, and typically using automated data collection & analysis	Critical assets where unplanned downtime has significant business impact
Condition Based	Monitor a single data value for bad trends or other rules-based logic. Includes inspections and manual data collection.	Assets with a random or unpredictable failure pattern
Preventive	Service in a fixed time or cycle interval	Probability of failure increases with asset use
Reactive	Run to failure and then repair	Failure is unlikely, easily fixed and/or non-critical

Figure 2. The ARC Asset Management Maturity Model

APPLYING IIoT & ADVANCED ANALYTICS

Crucially, the move to higher maintenance maturity levels is enabled by adopting Industrial IoT technology, ideally along with advanced analytics. The IIoT part of this combination provides for the requisite sensing of running machine variables, such as temperature and vibration, plus the necessary processing and communications to move the data off the machine. Advanced analytics, particularly in the form of machine learning, is used to provide high-quality asset failure prediction, i.e. very early warning of impending failure, detecting previously "unknown" failures, and minimal false positives.

Machine learning (ML) is a type of artificial intelligence (AI) that enables computational capability without the need for explicit programming. So unlike traditional computers, which cannot provide decision results beyond those catered for by initially coded rules, machine learning based systems, like humans, can learn and hence adapt processing logic based on new inputs. While machine learning as a computational method is not new, the almost ubiquitous availability of cheap, fast computing power has moved it out of research labs and into commercial applications. Google correcting a misspelt search term and Amazon making book recommendations based on user behavior are popular examples of machine learning applications.

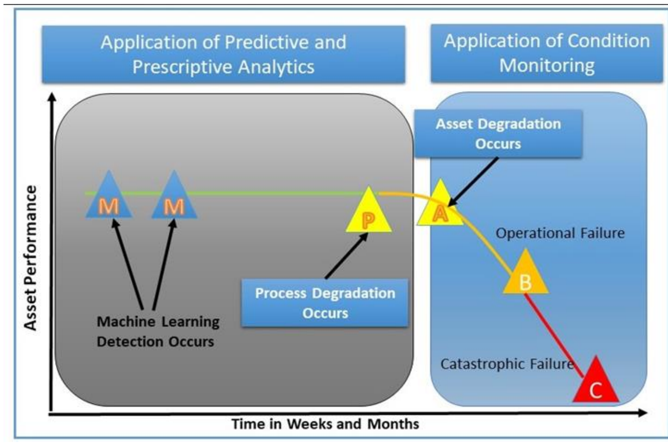

Figure 3. The early warning advantage of a machine-learning based predictive maintenance approach

Recent industrial implementations of machine-learning based predictive maintenance systems illustrate the advantages of the approach over not just conventional maintenance strategies, but also non-AI based predictive maintenance. In one case of flow control system pump monitoring, machine learning moved failure prediction to 5-6 days in advance as compared to the 3-6 hours achieved with a predictive maintenance system based on custom engineered algorithms.

In another case involving offshore wind turbines, which by their remote nature are highly expensive to repair especially in unplanned maintenance scenarios, machine learning improved degradation prediction of wind turbine gearboxes to 37 days from the previous three, with 0% false positives and negatives.

NEW BUSINESS MODELS

While owner operators can realize significant improvements in the asset performance of plant turbomachinery equipment through introducing Industrial IoT technology, suppliers of these machines can look forward to increased revenues resulting from IIoT-enabled new business models based around enhanced services provision.

For most industrial equipment suppliers, services tend to be constitute a relatively small portion of the revenue mix, which is heavily weighted towards the product sale. However, with the development of smart, connected products that take their place in an IIoT system, suppliers no longer lose sight of the equipment once it leaves the factory gates but can stay connected through an IIoT link, as indicated in Figure 1. This enables new services such as remote monitoring/diagnostics and asset optimization. As a result, the conventional product transaction model evolves to a customer relationship model in which services deliver a much larger proportion of revenue.

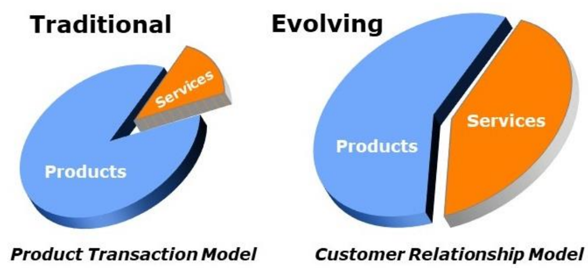

Figure 4. Industrial IoT enables turbomachinery suppliers to greatly enhance service offerings

CONCLUSIONS

Industrial IoT is highly relevant for both suppliers and users of turbomachinery. With industries under pressure to improve operational efficiencies, owner operators can raise asset performance to new heights by implementing the new smart, connected versions of rotating equipment like pumps, compressors and turbines, which are also becoming more commonly available as manufacturers increasingly perceive opportunities from IIoT-enabled business models based around deeper and longer relationships with customers.

As IIoT technology continues to evolve and the ecosystem of product suppliers, system integrators and specialist consultants expands, and as end user companies gain confidence from pilot projects and move to wider scale, digital transformation type implementations, the benefits for plant operators and the opportunities for turbomachinery equipment suppliers will only become more widespread.