TECHNOLOGY

Cargill introduces cloud solution for condition monitoring:

How Cargill enhanced its asset monitoring program through the introduction of IIoT based technologies

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Synopsis: This case study reviews the outcomes and challenges of Cargill's migration to a cloud-based condition monitoring solution to track the health of critical assets, predict the nature and timing of failure modes, and rationalize maintenance costs by planning and scheduling repairs before machines fail.

Introduction

The largest privately held company in the United States, Cargill Inc. incorporated in 1930, was established as Cargill Elevator Company in 1865. Headquartered in Minneapolis, MN, the company posted 2018 annual turnover of USD 114.7 billion. Cargill operates in 70 countries and has 155,000 employees. The company and its subsidiaries have diverse operations in food, agriculture, financial and industrial products and services. Its operations include producing and distributing a range of agricultural products including grain, oilseeds and other agro-based commodities, manufacturing of animal nutrition products and offering services to aqua, beef, dairy, pork, poultry and pet food sectors.

Cargill operates tens of thousands of machines, many critical to its production processes. Uptime is a critical to Cargill's business.

Preventing critical machinery failure, rationalizing operating costs, and scheduling maintenance at appropriate times are primary benefits of current innovations in industrial PdM applications. Cargill Inc. had been using Condition-Based Monitoring (CBM) strategies for over two decades when the company introduced IIoT tools to improve the utilization, availability, productivity and health of critical equipment and machinery.

Objectives in introducing IIoT solutions

In 2014 Cargill Inc. piloted the services of Symphony AzimaAI (SAAI) at two plants. SAAI specializes in cloud-based automated diagnostic applications of Condition Based Monitoring (CBM) using vibration analysis and advanced machine learning tools. Its technology can be used to detect emerging mechanical faults, inform plant personnel, and issue repair recommendations before defects lead to failures in a wide range of industrial rotating machinery including pumps, compressors, fans, motors, shafts and gearboxes. To collect higher resolution data in less time, teams from Cargill, SAAI and a third-party sensor supplier deployed off-the-shelf triaxial sensors paired with customized mounting pads to expedite a traditionally labor intensive, manual data collection process.

The new data and faults detected by the cloud-based automated diagnostic engine were compared to historical data and faults detected by the traditional alarm banding method of fault detection. 10% fewer faults were identified (eliminating related maintenance costs), with no increase in machine failures.

Solution

Cargill first tested the solution at two grain processing plants. It was imperative that the machinery responsible for grinding grain delivered the highest yield without failure or downtime for maintenance during critical production cycles. A single instance of an unplanned shutdown could adversely affect Cargill's grind output. To prioritize the care of critical production assets, an in-house ranking methodology categorizing assets by importance to the manufacturing process was used. The most important assets were designated "black" assets while low importance assets were designated "white" and moderately important assets designated "grey". Only "black" and "grey" assets were tested, with the former tested more frequently.

Cargill's previous approach to data analytics involved manual data collection performed by local plant-based analysts. The old, single axis sensors required more labor hours to collect data, and the absence of an automated diagnostic engine meant the data from every machine test required manual review and analysis by the onsite analyst. The investment in time and manpower was significant. The pilot project ran in collaboration with a third-party service company at two sites with over a hundred machines. The third-party service company collected data, which was mirrored to the cloud. The data was screened in the cloud by an automated diagnostic system, quality controlled by SAAI domain experts, and returned to Cargill for follow-up maintenance action if indicated.

The pilot project achieved material improvements in diagnostic accuracy and reduced Cargill's maintenance spend. The solution was subsequently expanded to more and larger sites. Today, the remote diagnostic service covers more than 15,000 Cargill "black" and "grey" industrial assets supported by a team of five domain experts who coordinate the program through the cloud.

Fig.1 Large Direct Driven Wet Corn Mill

Technology/Infrastructure investment

Since the inception of the pilot, Cargill has expanded the project to improve the speed, accuracy and efficiency of the program by addressing discrete aspects of the solution:

Hardware

A new type of sensor was used to measure the vibration of rotating equipment. Single axis sensors were replaced by triaxial sensors able to collect more data in less time. These were integrated into customized collection pads, which produced actionable data by standardizing the location and orientation of the collection points, and a quick-connect sensor mechanism to accelerate route collection times. The introduction of a larger number of more expensive mounting pads meant a higher upfront cost for Cargill, justified by the time savings in deployment and improvement in data quality and consistency.

Data Processing and Analytics

The job of Cargill's plant floor technician is done once the data is collected and the tests are uploaded via Wi-Fi to the cloud. New data is screened on arrival by SAAI's cloud-hosted 'Expert Automated Diagnostics System' (EADS), which characterizes each machine test as healthy, slight, moderate, serious or extreme. In the case of a detected fault, the system identifies the component and/or conditions inducing the fault, sets a severity level, and generates a repair recommendation. Typically, new data sets from mature PdM programs rarely reveal more than 10-20% of tested machines as experiencing mechanical faults of any severity. This means 80% to 90% of tested machines are healthy and require no attention. The EADS eliminates 80% to 90% of the manual review and diagnostic work load that would be required if analysts were working onsite without it. More importantly, the domain experts tasked with reviewing tests can prioritize their attention to the "black" and "grey" assets.

Implementation and operation

Cargill and SAAI launched the pilot by recreating Cargill's database of every "black" and "grey" asset selected for monitoring. The database included photos of the machines, nameplate information and machine operating parameters such as rotational speed and power. This information was used to ensure that data sets matched the assets from which they were captured, and that the design, configuration, and performance characteristics of that asset were understood. With the hardware and connectivity infrastructure in place, Cargill personnel were trained to: 1) collect and transmit data from the machines to the cloud, and 2) use the SAAI web portal to access the machine test results and repair recommendations that are the actionable insights the system is designed to deliver.

Optional Features and Capabilities

The data collection device "TRIO" operates on an off-the-shelf windows industrial tablet that:

- retains an updated database identical to the cloud-hosted database,
- provides text fields for observations technicians may wish to note as they collect data,
- is remotely accessible via "log-me-in" by SAAI analysts and/or SAAI tech support for trouble-shooting software updates, and to configure special machine tests,
- can host a local copy of the automated diagnostic engine for onsite domain experts.

"We don't blindly chase technology. We take an outside-in view, not just thinking internally but outside-in, to understand emerging opportunities [to improve]. I think it is probably one of the bigger factors in setting new performance standards."

Flexibility to scale without regard to location or availability of onsite experts was crucial for the project.

This was enabled with local and cloud database mirroring, and the ability to delegate diagnostics and recommendations to remote experts, or to perform the same functions locally.

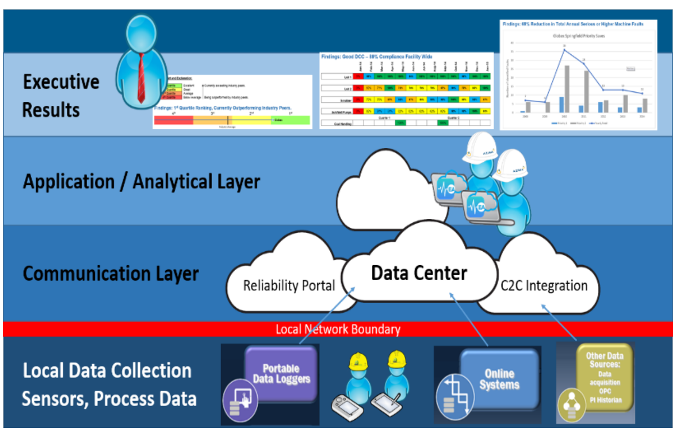

Fig.2 data flow from field technician to plant executives

Dealing with challenges

Implementing a remote, cloud-based condition monitoring solution presented challenges related to hardware, data quality, database management, business processes, and information handling (delivering actionable insights to the right parties in a timely manner).

Hardware modifications

The working environment, with low temperature high humidity, and abrasive dust, induced corrosion for the sensors and measuring equipment. This required a change in design specifications for continued monitoring. The sensor supplier and Azima collaborated to redesign the equipment to the harsh conditions in which it operates.

Data handling and management

As the quality of existing data was found to be unusable, SAAI had to create new database of baseline readings and machine profiles from scratch.

To do this a range of inputs from the monitored machinery, from configuration, to horsepower, RPMs and various other performance and mechanical attributes had to be recollected.

On the operational side, creation of a steady stream of generated data on variable speed operation of the motors under observation was found to be challenging. Effective data analysis relies on the raw data and its refinement. Different operating conditions for electrical equipment needs accurate data points and informative assessment of the issue. To address this, the motor was set to a constant speed at different operating conditions and measurements were recorded in each case creating the baselines for operation that could be set.

The scale of Cargill's industrial operations – the number of sites and machines, and the frequency of detected faults and repair recommendations, made reviewing each detected fault through a web portal impractical. Cargill modified the procedure for reviewing machine tests with a daily email with embedded links to the results for machines with detected faults. "Serving" operators with timely and actionable insights was more effective than asking them to search remote databases for results.

Finally, certain "black" assets were found to have unusual degradation curves and failure modes. The ability to pull data from different databases representing disparate sites to compare the failure patterns of similar assets accelerated the process of improving monitoring practices and reducing failures in such assets.

Data Security

Some of the security measures Cargill have in place when working with the cloud include:

- Advanced encryption protocols used for transmission of data to the cloud.
- Use of independent Wi-Fi networks ensure to ensure no return path for malware.

Organizational change

Shifting from a relatively large number of onsite analysts to many fewer analysts working remotely to screen large volumes of data meant fundamentally changing workflows and practices. Cargill understood from the outset that success depended on widescale, uniform adoption of new practices, and this meant engaging stakeholders at both the site and enterprise level, including regional, business unit, plant, and area leaders, managers, operators, technicians and staff. Expectations were managed by communicating changes in advance and introducing necessary training. In addition, goals and expected benefits were well-defined and outlined from the start.

Outcomes for Cargill

By going to a cloud-based remote diagnostic machine health solution, Cargill improved both the efficiency and effectiveness of its predictive maintenance program in the following ways:

- Reduced detected faults by 10% compared to traditional predictive maintenance tools, with no increase in machine failures, implying a reduction in false positives and mitigating unnecessary maintenance costs.
- Remote diagnostic on-condition solutions have resulted in significant cost optimization.
- Achieved a 40% cost saving in manpower by relying on a centralized team of 5 analysts to review results from 15,000 machines.
- Reduced unplanned downtime.

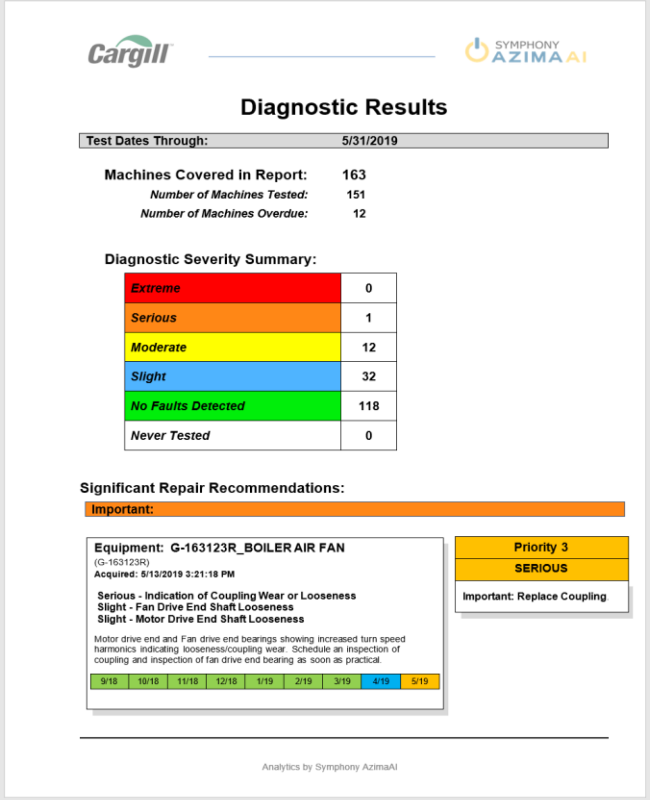

Fig.3 Example diagnostics report

The road ahead

The next step for Cargill is to build a global reliability dashboard that offers a worldwide view of plant reliability and performance. Working with SAAI, Cargill is creating the transparency for plants, regions and business units to benefit from operating and reliability practices to optimize performance and rationalize costs across operations.

In the future the data collected by Cargill may eventually be used to influence relationships with its Original Equipment Manufacturers (OEMs). With better knowledge of how various industrial assets perform over time and in different locations, Cargill will have a clearer view of its return on capital investments. This may eventually become the source of important design changes and guide vendor selection.

Fig.3 A Cargill plant - Photo courtesy Enterprise Media Group

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