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MAINTENANCE, RELIABILITY AND INSPECTION

Harness the power of asset performance management to transform reliability

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As the energy industry navigates the shifting energy landscape and macroeconomic uncertainties, it must adopt collaborative and innovative solutions to enhance the productivity and quality of value chain operations, while also remaining focused on efficiency improvement projects that protect the bottom line. Optimizing reliability and maintenance is key to navigating the challenges of market volatility and environmental, social and governance (ESG) compliance. Spurred by this need for increased resilience and recent advancements in artificial intelligence (AI), the market is seeing growth in the deployment of asset performance management (APM) solutions.[1] Top disruptors that can be avoided with improved asset health strategies include production offsets and increased emissions events, elevated operational costs and safety risks.

Production disruptions. Planned and unplanned startup and shutdown events limit a plant's operational flexibility and throughput, ultimately impacting production rates. Furthermore, unplanned turnarounds can stress the integrity of adjacent equipment, causing a cascading effect on overall asset availability and future variance.

Operational expenditure (OPEX) costs considerations. According to a study by McKinsey, reliability-related lost profit opportunities can range from $20 MM/yr–$50 MM/yr for a mid-size refinery.[2] As maintenance and reliability costs represent a substantial portion of a plant's operating budget, incremental improvements in a company's maintenance strategy can provide meaningful benefits.

Environmental impacts. In addition to significant penalties associated with increased emissions due to emergency shutdowns, startups and malfunctions, industry processes often require additional energy input, lowering the overall thermal efficiency of the plant and leading to higher carbon intensity.

Safety risks. Routine maintenance, equipment startup/shutdown events and malfunctions increase the requirement for personnel intervention and, therefore, increase exposure to hazardous materials, temperatures, pressures and complex equipment.

Key inhibitors to a robust maintenance program. In addition to general wear and tear, several key factors can adversely affect equipment reliability. These include changing ambient conditions due to seasonal variability, feedstock quality changes, shifting product portfolio distributions over time, aging infrastructure, assets running above nameplate capacity and unplanned events such as extreme weather. Changing workplace demographics can also significantly impact equipment reliability, with industry or subject matter experts transitioning to a new job or exiting the workforce altogether, leaving less experienced workers to assume greater responsibility managing assets.

Comprehensive APM. Robust APM solutions enable companies to safeguard performance, improve asset health and integrity, and optimize profitability while overcoming the challenges mentioned above. They provide the opportunity to capitalize on enhanced maintenance strategies by recognizing leading indicators of potential asset health and performance degradation. APM solutions collect operational data from disparate sources including online sensors, instrumentation systems, distributed control systems, data historians and Internet of Things (IoT) platforms. Accurate and reliable insights are then achieved by contextualizing, integrating and cleansing the data. With this refined data, maintenance teams can quickly analyze routine equipment and process behaviors under dynamic operating conditions while also identifying historical failure patterns. Advanced solutions can also detect anomalies and failure patterns, provide insights into root cause analysis and give sufficient lead time to analyze the warnings, evaluate business impacts and proceed with proactive intervention if deemed necessary (**FIG. 1**).

Agents for monitoring asset integrity. Integrated failure and anomaly detection agents combine engineering and data science expertise to monitor asset integrity, while continuously learning and adapting to operational changes to maintain model integrity. The best maintenance solution provides engineering and reliability teams with a variety of insights to bolster online monitoring of asset integrity (**FIG. 2**), such as:

- Sensor and calculated sensor data are monitored in real time. An alert is signaled when a sensor reports data out of a prescribed range or when there is an indication of degradation.
- Physics-based calculations guided by fundamental engineering principles are incorporated to assess asset health and operational reliability.
- Failure mode effects and analysis (FMEA) libraries are available for commonly used equipment; these can be imported to help identify potential problems more rapidly, prioritize the implications to the product, process or system, and define the severity of probable outcomes.
- Advanced pattern recognition algorithms are embedded to predict asset vitality over time, identify reoccurring patterns for improved robustness of the maintenance platform and detect emerging anomalies. Machine-learning (ML) enables these agents to adjust to evolving operational modes, ensuring they can adeptly identify failure conditions.
- Algorithms custom-created by local data scientists can also be incorporated to leverage expertise.

Enhanced workforce capabilities can be achieved without significant personnel, expertise or customization requirements by leveraging predefined asset templates that capture design specifications, construction materials and expected operating condi-

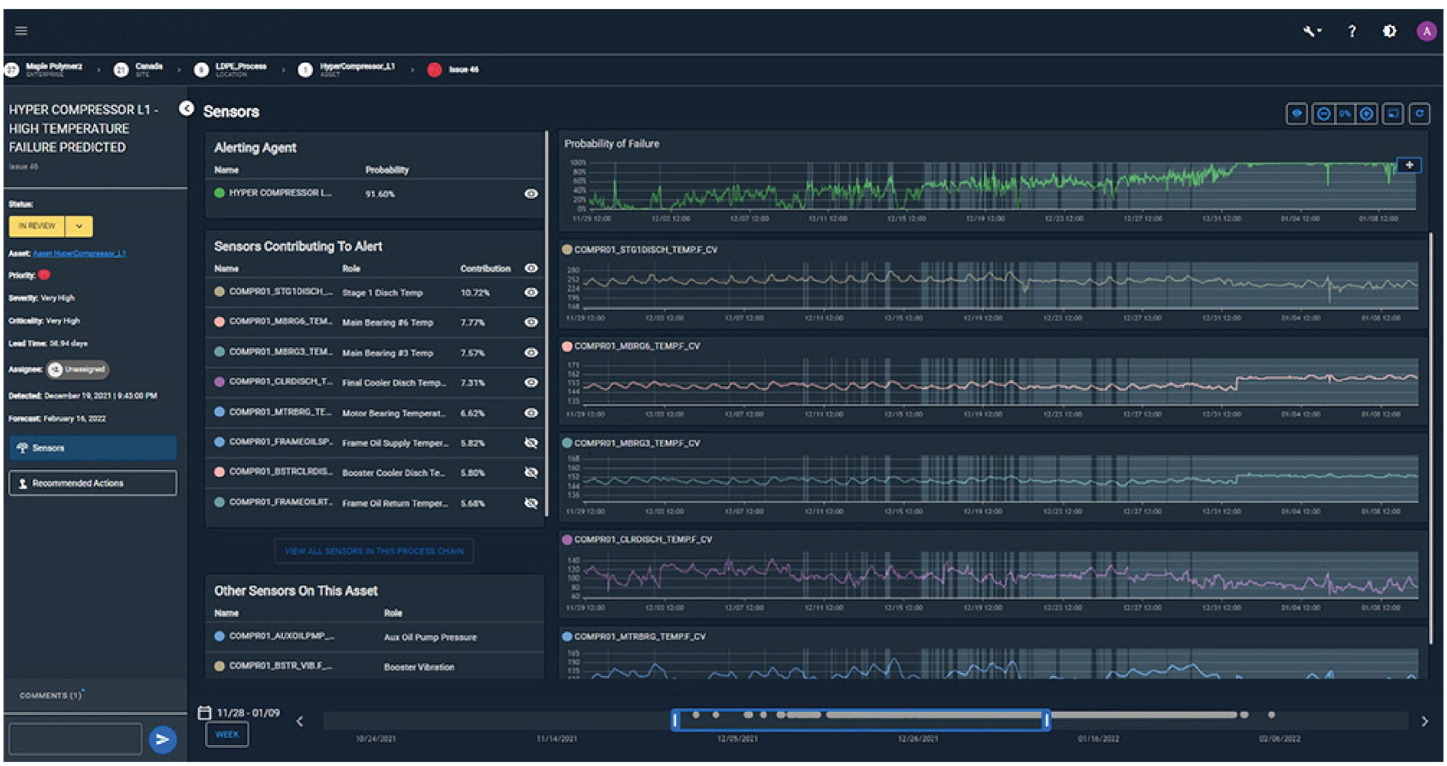

FIG. 1. Robust APM solutions can detect anomalies and failure patterns, provide insights into root cause analysis and give sufficient lead time to analyze the warnings, evaluate business impacts and proceed with proactive intervention if deemed necessary.

tions for standard equipment when implementing these agents. Furthermore, AI technology can enable the building of agents by automating much of the data selection, cleaning and preparation required to generate robust models. AI streamlines data preparation by prioritizing the most important sensors, developing signatures for normal and anomaly modes, monitoring for recurring patterns to protect against similar adverse behaviors, and identifying correlations between insights that are related. In addition, it can select hyperparameters to control ML algorithms. This functionality enables the technology to run in the background nearly autonomously, letting experts focus on project execution rather than data analysis. The AI functionality can also learn from degradation and anomaly patterns rather than relying on deviations from routine trends to raise awareness, and provides prescriptive guidance on remediation activities based on asset behaviors.

Centralize asset health management. Asset health visualization dashboards (**FIG. 3**) can help streamline access to data and insights, increase collaboration across an enterprise and improve organizational efficiency by creating a centralized solution for monitoring asset and process integrity. These dashboards also help integrate maintenance insights and schedules with other monitoring systems, creating a unified platform to increase visibility across the value chain and guide optimal decision-making. For example, integrating maintenance strategies with a digital twin for process optimization empowers energy companies to maintain process integrity, prioritize tradeoffs between production and maintenance, enhance energy efficiency and reduce emissions by increasing the visibility into changing performance over time and asset downtime. Any insights gained can be used to further improve the robustness of maintenance programs by leveraging a plant scheduling tool to strategically plan maintenance and turnarounds.

Accelerate alert resolution. Enterprise asset management (EAM) systems are digital tools that help organizations manage the lifecycle of their physical assets. These systems house a wealth of information that is often underleveraged, such as maintenance schedules, work order details and equipment mean time between failures (MTBF) insights. Maintenance solutions integrate with EAM systems to fast-track the detection of underperforming equipment and qualify maintenance costs by asset and failure mode, enabling a highly value-focused approach to maintenance. This bilateral functionality can raise flags and warnings to the EAM system for review and can recommend corrective actions automatically based on current and predicted conditions. In doing so, the prioritization of work orders in coordination with upcoming scheduled maintenance can be achieved when feasible. Aligning current and predicted asset health with planned maintenance activities also allows teams to identify work that could be deferred and monitor any developing risk. When action is taken, the EAM system captures the outcomes and details, enabling AI-based so-

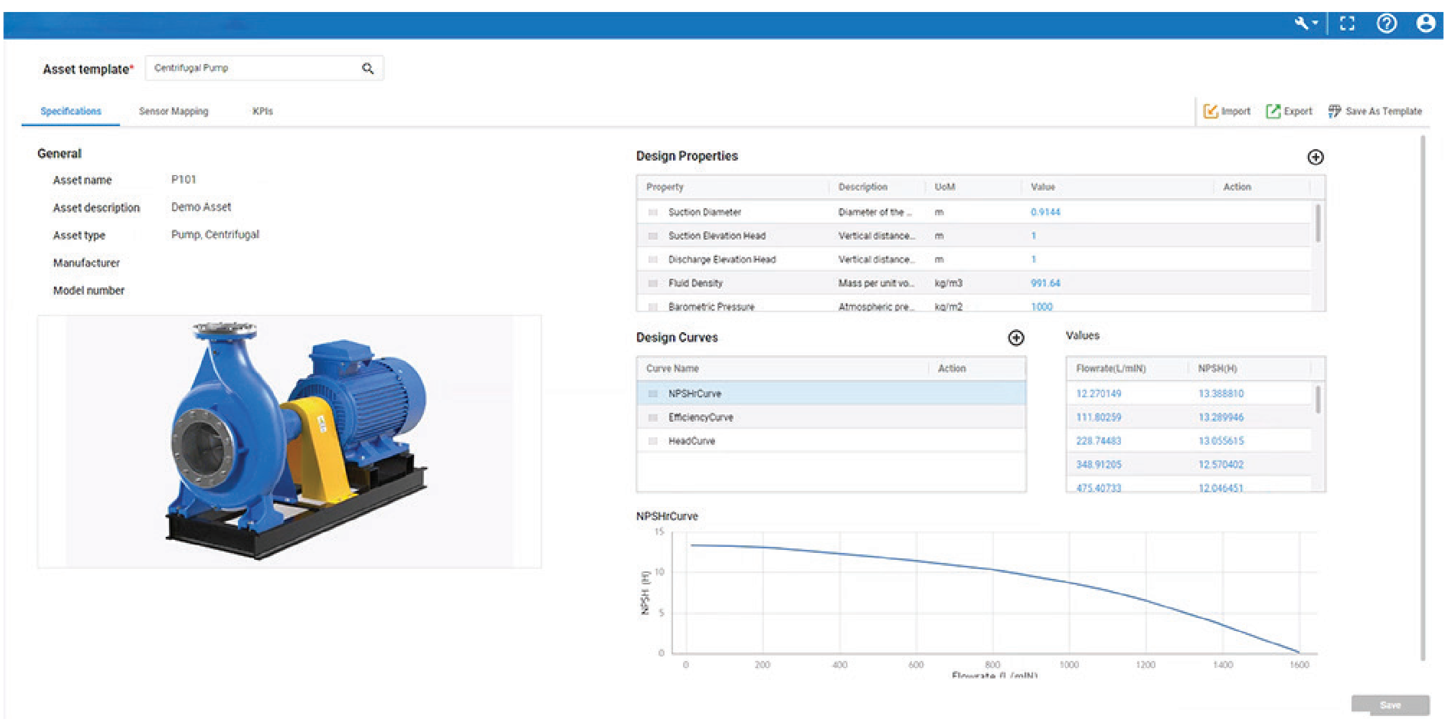

FIG. 2. The best maintenance solution provides engineering and reliability teams with a variety of insights to bolster online monitoring of asset integrity.

lutions to continuously learn from historical activities. This integration empowers sites to transform their maintenance strategies from time and reactive strategies into data-driven, proactive maintenance with a high return on investment.

Augment data infrastructure with industrial data fabric. A key challenge in implementing a robust APM program is the need to ensure data security while realizing seamless integration with existing systems. An industrial data fabric can help address these challenges by contextualizing disparate data and consolidating it into actionable information. These solutions process data from sources and enable plant-wide operational components and information technology (IT) systems to be connected. By enhancing data collection, integration and scrubbing, an industrial data fabric can support the deployment of robust solutions to monitor asset health and reliability, enabling the implementation of a digital technology that can scale readily across an enterprise.

Realized asset integrity and reliability. A prescriptive maintenance approach can promote the reliability of critical equipment and optimize asset uptime, enabling energy companies to maximize profitability by adhering to scheduled turnaround plans, decreasing OPEX and closing the planned/actual production rate gap. In addition, minimizing the number of startups and shutdowns mitigates sitewide greenhouse gas emissions. The following are examples of key refining assets that can derive value from a prescriptive maintenance approach.

Charge pumps. The authors' company's asset health and reliability solution[a] can track a pump's pressure, power input, vibrations and other key variables that are leading performance indicators. OCP Ecuador, a midstream oil and gas company, leverages this technology to continuously monitor 22 main pumps, five booster pumps and four generators across its pipeline network for anomaly behaviors, resulting in improved production stability and a 25% reduction in maintenance costs.

Compressors and turbines. The authors' company's solution[a] monitors changes in compressor and turbine activity that could impact the durability of critical equipment such as valves, cylinders, motors or bearings. At a refinery in Latin America, the solution[a] detected the degradation of a steam turbine powering the fluid catalytic cracking unit's (FCCU's) main air blower. This early warning provided the local team with a 60-d lead time to plan and execute the turbine replacement, preventing a major disruption to refinery throughput.

In another example, an American multinational energy company leveraged the solution[a] to minimize economic penalties resulting from a reoccurring failure of a hydrogen compressor. Retroactively, the company evaluated the viability of a predictive maintenance program, which identified degradation in performance with more than a month's lead time. Had the program been

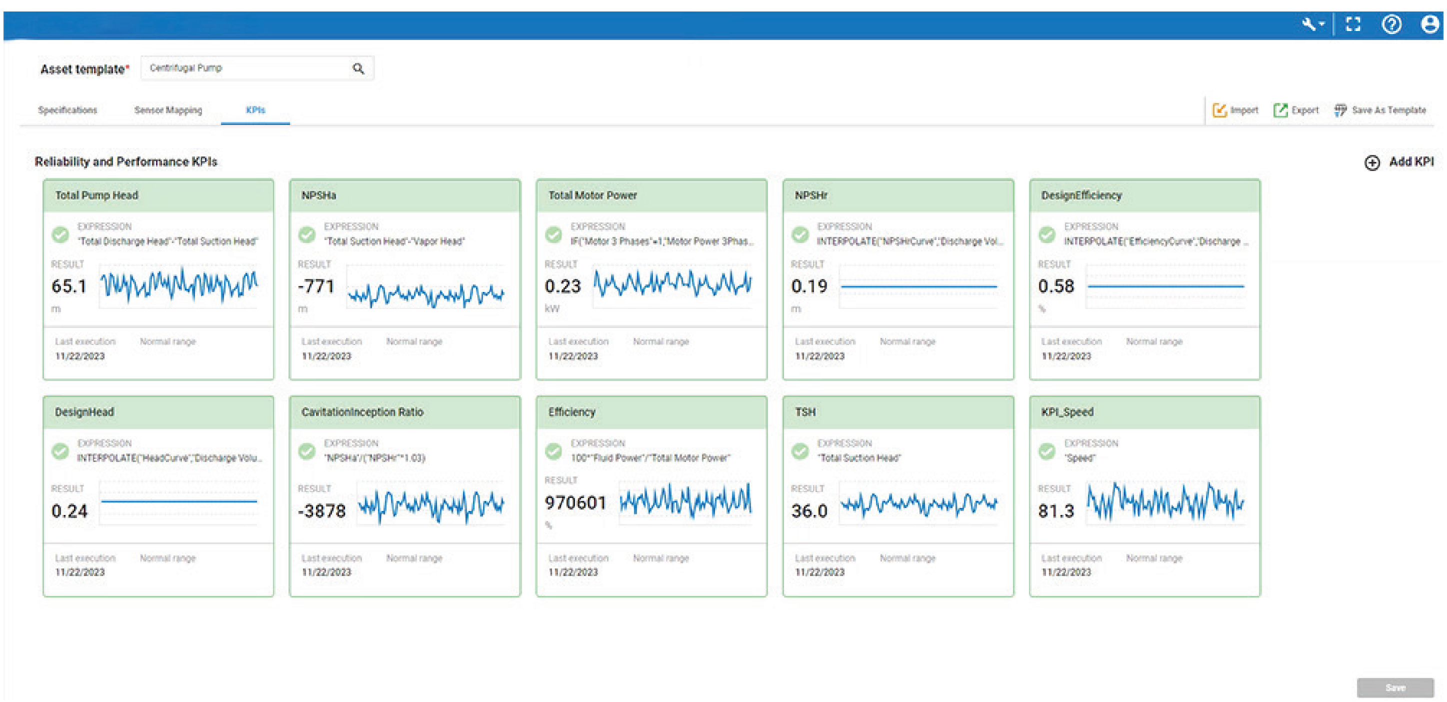

FIG. 3. View of an asset health visualization dashboard.

implemented before the failures occurred, the plant estimated that combined production and maintenance savings from three events alone would have equaled almost $75 MM.

Main cryogenic heat exchanger. Tube leaks are a common failure caused by thermal stress during cooldown and warmup operations. Asset health monitoring can provide early warning of decreased thermal efficiency and help offset the potential for an environmental excursion or need for increased furnace firing.

Refining processes are also subject to entrained process contaminants that can negatively impact overall asset performance. For example, naphthenic acids and entrained saltwater can cause significant corrosion concerns if not appropriately managed. Conversely, solids and destabilized asphaltenes can settle out of the liquid phase and cause fouling issues, limiting heat transfer efficiency and throughput. Asset health and reliability and multivariate analysis tools can work in tandem to elucidate and contextualize historical data and provide better insight into future potential events so mitigating actions can be taken.

YPF's development of a robust enterprise-wide reliability program. Argentina's largest oil and gas company partnered with the authors' company to digitally transform its operations, aiming to boost production of refined products and liquefied natural gas (LNG) exports while increasing earnings before interest, taxes and amortization (EBITA). To enhance its value chain stability, YPF developed an automated asset maintenance solution leveraging ML to improve the operational reliability of rotating equipment and strategically prioritize maintenance activities. The solution currently monitors critical pumps, compressors, heat exchangers and reactors across all three YPF refineries, interpolating data from > 3,000 data sources for accurate analysis. For YPF, this state-of-the-art prescriptive maintenance solution enables real-time monitoring and actionable insights, saving the company 10 d of production within the first 18 mos of implementation.

A key example of improved asset integrity management is the authors' company's solution[a]'s proactive detection of impending failure in the FCCU's primary air blower. Early alert of deviations in vibration patterns from normal operating conditions empowered the local team to preemptively address faults in the axial turbocompressor's couplings. In addition, YPF avoided five days of lost production, enhanced future risk management by learning the anomaly behavior and averted an unnecessary discharge of emissions to the environment.

Adopting digital solutions imperative for tomorrow's refining. Today's global energy industry faces unprecedented transformation as it aims to boost profitability against a rapidly changing energy, economic and geopolitical landscape, increased governmental regulations and unpredictable consumer demand. Energy companies are increasingly implementing digital solutions to face these headwinds by improving operational resilience. At the forefront are technologies that proactively identify signs of degradation in performance or physical infrastructure. This increased visibility into operational health is instrumental in prioritizing maintenance schedules and capital project decisions, meeting production targets, improving safety, driving competency development and reducing the potential for environmental excursions. HP

NOTE

[a] Aspen Mtell®

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