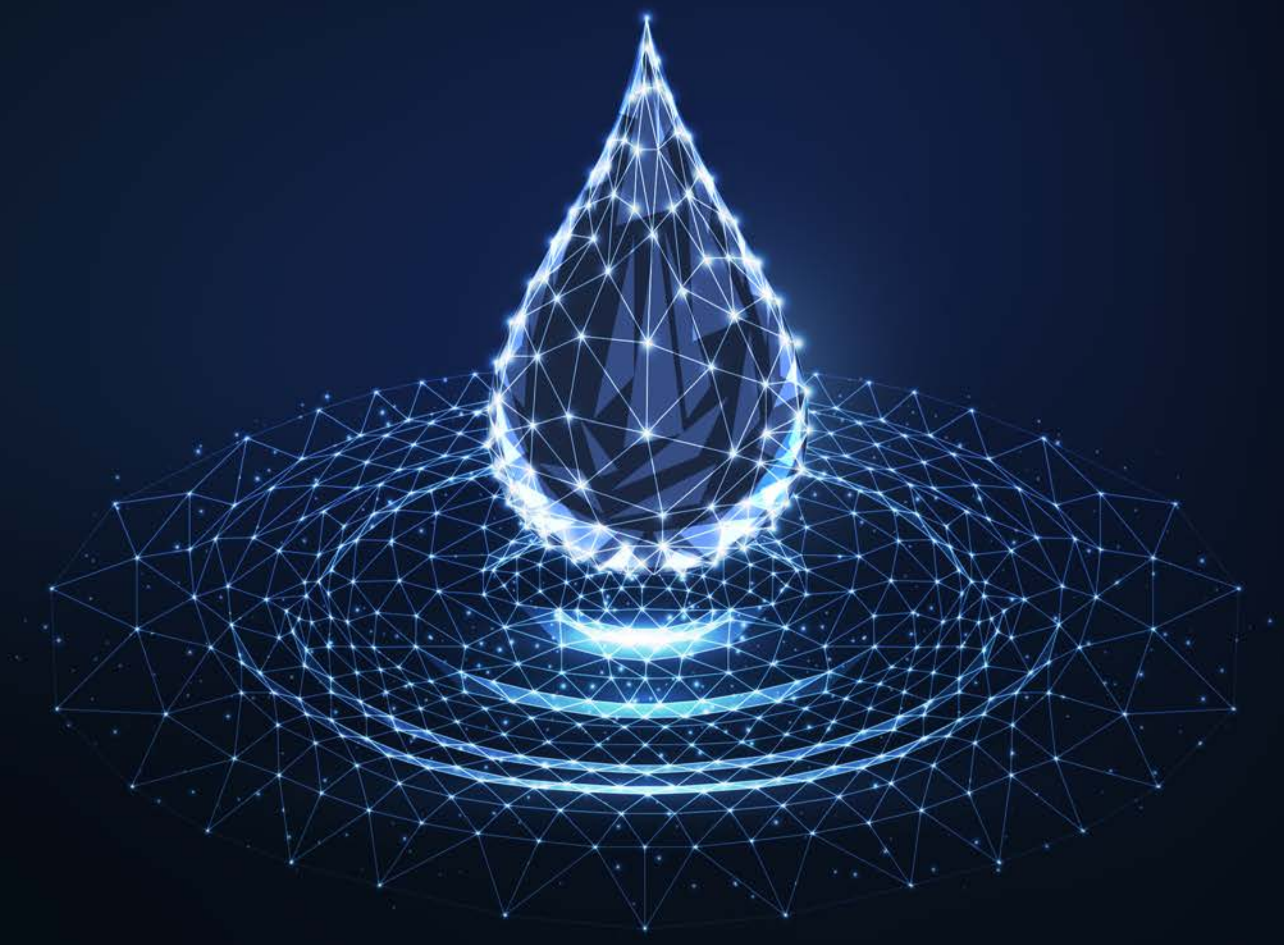
FOUR WAYS TO DIGITALISE DOWNSTREAM WASTEWATER



Alfredo Lorenzo, Siemens Water Solutions, USA, presents four ways in which digitalisation can best be applied to refinery and petrochemical wastewater treatment plants.

In 2019, worldwide refinery capacity was estimated to be 106 million bpd of oil.[1] In turn, refining requires about 1.5 gal. of fresh water on average for every gallon of oil processed,[2] so that is potentially more than 6.7 billion gal. of water used each day, most of it for distillation cooling towers and boiler feed water. In a world of growing freshwater shortages, the industry must conserve this resource as much as possible.

While much of that water is lost to evaporation and re-enters the earth's water cycle, significant amounts of production wastewater are still generated and need treatment. Sources of the latter include boiler blowdown, process-contaminated water or condensate, cleaning, drainage, and contaminated stormwater. Among production contaminants are oil and grease, of course, as well as organics, total suspended solids, sulfur compounds, and heavy metals.

To treat these toxic wastewaters for reuse or environmentally responsible and regulatory-compliant discharge, refineries and petrochemical plants have made significant capital investments in onsite wastewater treatment plants (WWTPs). These facilities typically include deoiling and a wide range of biological treatment capabilities as well as speciality treatment systems incorporating such technologies as hydrothermal, electro-oxidation, and advanced oxidation.

Key ROI metric

Like any plant asset, WWTP utilisation and availability are key metrics underlying a plant's return on those investments. Unplanned outages can be costly in terms of production disruptions, so conducting proper and timely maintenance on WWTP infrastructure is critical to its uptime and availability. But what is considered 'proper and timely' WWTP maintenance can vary from plant to plant, putting production at risk of disruption.

Traditionally, reactive maintenance (i.e., 'break/fix') and scheduled preventive maintenance have been the primary modes to care for WWTP infrastructures. The former implies a disruption has occurred; the latter can incur unnecessary costs due to scheduled part replacements even if the part still functions to its engineered specifications with no degradation in performance. In many downstream operations, both approaches are predominately managed manually and dependent on operator experience. This can be inefficient, time-consuming, error-prone, and lacking real-time visibility into the details and context of the asset's performance and maintenance history.

In recent years, increasing levels of digitalisation have allowed refinery and petrochemical plant operators to implement a more comprehensive lifecycle management model for their WWTPs. This approach considers maintenance less as an activity that is carried out on an operational asset and more as an integral part of the performance management and optimisation of such an asset over the many decades of service that it is designed and engineered to provide.

Digitalisation enables data-driven predictive and proactive maintenance dimensions to supplement preventive maintenance programmes in an asset lifecycle management model, while also necessarily retaining reactive break/fix capabilities. After all, despite the advanced reliability engineering of parts in WWTP systems today, they can fail and need replacement.

Data-driven, actionable intelligence to reduce disruption risk

The difference from traditional preventive maintenance, however, is that with the application of smart sensor technology and analytics employed by predictive and proactive maintenance approaches, WWTP operators in refineries and petrochemical plants can be alerted to potential failures long before they occur. They can pull actionable intelligence from web-based, data-driven dashboards to make better-informed decisions about mitigation or remediation. Importantly, they can securely access this information from practically anywhere, anytime, and via any device.

Of course, human experience and intuition still retain their value in a digitally supported lifecycle management maintenance model. Equally, operators can use empirical data to augment and validate their insights and conclusions instead of solely relying on 'gut instincts' or anecdotes. Alternatively, data can be used to interrogate those insights, if a wide gap exists between what the data shows and what might otherwise be concluded given the particular set of circumstances.

Implementing a digitally supported lifecycle management model for existing WWTP infrastructure involves increasing the levels of digitalisation across the following four building blocks, each of which will be described in greater detail:

1. Asset documentation.
2. Asset maintenance and preservation.
3. Process-specific, microbiological activity sensors.
4. Asset health monitoring with digital analytics and visualisation.

The first requires WWTP operators to clarify precisely what physical systems they have by improving the quality of and access to relevant asset documentation. The second enhances the availability and performance of their assets via data-driven predictive and proactive maintenance approaches, reducing or eliminating paper-based workflows. The third adds smart sensors to WWTP assets to correlate the microbiological activity in wastewater streams to chemical oxygen demand (COD) levels as a way to assess asset effectiveness and note any performance degradations. The fourth applies sensor technology to existing assets where possible and collects real-time data from it, populating databases of key performance indicators (KPIs) with parameters set to alert and alarm, if parameters are approached or exceeded.

Asset documentation

Field studies of existing refinery and petrochemical WWTP infrastructures have found that asset documentation can vary widely. The older the infrastructure, the more likely that modifications have been made over the years. Some will be well-documented with the new documentation added to the original as-built documentation. In many cases, however, the documentation will not be detailed, will be mostly paper-based, and some of it may be missing, leading to time-consuming and error-prone guesswork among maintenance engineers and technicians.

Often these field personnel are not well-trained in the full range of diverse process equipment. This can be for a variety of reasons, such as training not being available to newly hired staff, or refresher sessions not being available. Even if comprehensive training is carried out, including refresher training, the knowledge may not be regularly used.

Access to documentation, whether paper or in digital media, such as CD-ROM, can be problematic, too. No matter what form it takes, not having it well-indexed and available when and where it is needed can result in field personnel wasting time searching for relevant information to guide their maintenance or diagnostics. If the latter, in the case of a production shutdown, such delays can dramatically increase the cost of disruption by drawing out the time to resolution.

Should spare parts be needed, it can take time and knowledgeable individuals to identify the right part and its source for ordering, if not already in the onsite inventory. Again, this can add even more time to the resolution of an unplanned shutdown.

Solution

The first step is to conduct a thorough assessment of existing documentation to identify what is missing, then source the missing documentation or, if unavailable, recreate it. Durable asset identification tags, such as scannable QR or barcodes, should be affixed to each asset. These can provide field personnel with anytime, anywhere access to cloud-based digital versions of operation and maintenance manuals as well as the spare parts list, data books, video operation demos, and recorded training and operational videos.

Figure 1. QR codes are used to access asset documentation from the field as well as maintenance and service histories.

Benefits

Ultimately, the digitalisation of asset documentation will increase the efficiency and productivity of field personnel, better preparing them to mitigate problems before an unplanned outage occurs. If an outage does occur, it is easier to quickly diagnose and resolve its root cause(s), helping to minimise production disruptions and potential WWTP non-compliance.

Figure 1 shows an entry point to the asset-related information through a QR code attached directly to the asset, based on a data-collection and asset-management platform from Nektar, Inc.

Asset maintenance and preservation

In many cases, WWTP preventive and corrective maintenance activities are not always or consistently recorded into a centralised registry, much less a digital one. Paper-based work orders, manual workflows and handoffs, and inspection reports are especially prone to errors and being misplaced or misfiled, so subsequent access to their information becomes a problem.

For example, the lack of a centralised, digital registry can make the traceability of work orders and inspection reports difficult and time-consuming, if not impossible. As a result, troubleshooting of future operating issues can be that much more of a challenge. This can make root cause analysis difficult, significantly extend times to resolution, and raise the costs of an unplanned outage.

Solution

A solution is to deploy a centralised, secure, and cloud-based digital registry for both issuing and recording work orders involving preventive and corrective maintenance tasks. Records should include information about the asset, its location, and condition; what tasks were specifically done; who did them and when; what spare parts, if any, were used; and any relevant images. Field personnel can scan an asset's tag to access all of its pertinent and up-to-date information. Maintenance scheduling and reporting can also be managed from this platform.

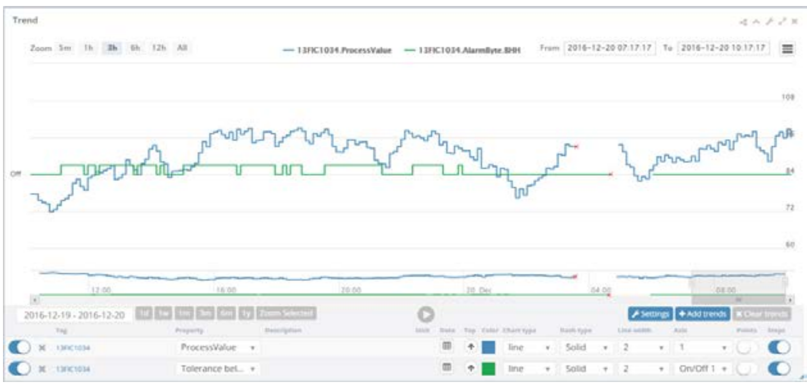


Figure 2. Process-specific variables can be pulled together for root cause analysis, for example, microbiological activity and streams flowing in, in real-time.

Benefits

Work order activities can be tracked from start to finish with timestamps, across single or multiple plant facilities, so management can closely monitor parts usage and labour costs. Traceability data for any equipment asset can be quickly and securely accessed onsite or remotely anytime, from anywhere and over any device using a web browser.

Technicians can add their comments, images, and any other information to the asset's maintenance activity. Preventive maintenance triggers and alerts can be set and automated, ensuring required maintenance gets done, while predictive

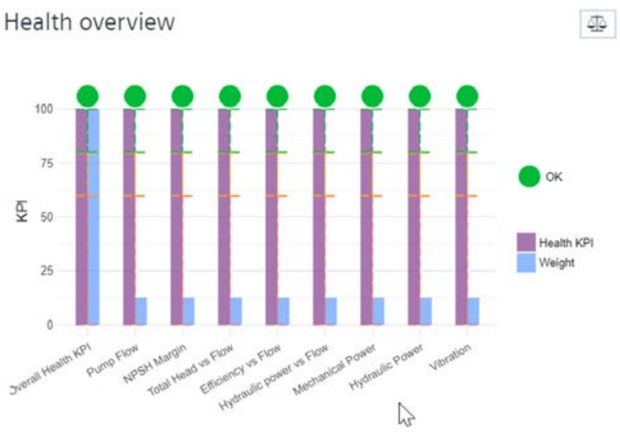


Figure 3. Asset health can be visualised on web-based dashboards based on KPIs for condition-based performance monitoring of specific WWTP assets.

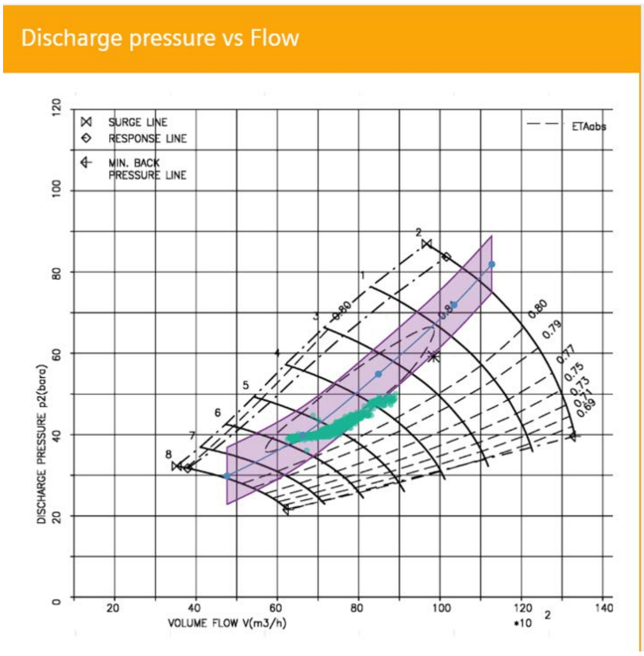


Figure 4. Asset health is related to the conjunction of several operational variables of the asset.

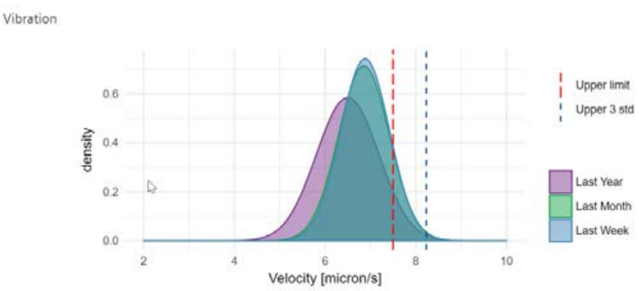


Figure 5. Deviations and tendencies of vibration levels of a pump as one asset health KPI.

and proactive maintenance protocols can be integrated. All of this can extend asset lifespans and enable more efficient use of time, labour, and other resources.

Process-specific, microbiological activity sensors

COD is a gauge of water and wastewater quality, often used to quantify the number of organic pollutants in water and, by extension, to monitor WWTP efficiency. COD is typically expressed in milligrams per litre (mg/l).

Traditional approaches to assessing COD levels involve the manual collection of samples that are then analysed using laboratory-based testing methods. These can be time-consuming and not done in real-time, enabling spikes in COD levels to occur unnoticed during periods between sampling.

Solution

Digital smart sensors have made manual COD sampling and laboratory testing obsolete. WWTP operators can install in-line measurement systems along a WWTP's streams to monitor microbiological activity, enabling the continuous, indirect measurement of COD levels in real-time. Figure 2 shows a graph of a sensor's data over 24 hours, showing a spike in microbial activity due to the presence of cleaning agents in the wastewater stream.

Benefits

This digital sensor system saves time and potential errors compared to periodic manual wastewater sampling and laboratory analysis to determine COD levels. Because it monitors COD levels continuously with real-time reporting available, significant deviations beyond preset parameters can trigger operator alerts. Secure, 24/7 remote access to the data can help operators determine appropriate responses to prevent detrimental impacts to biological treatment systems.

Asset health monitoring with digital analytics and visualisation

Relying only on traditional reactive and preventive maintenance approaches to plant asset management has shortcomings. One is that the replacement of parts at regular time intervals or running hours can lead to unnecessary costs because the parts are not at the end of their service lifetimes. Another issue is running a WWTP's asset until it breaks, causing treatment disruptions. This can require keeping an extensive spare parts inventory, tying up valuable capital.

Operating only in experience-driven reactive and preventive maintenance modes limits the monitoring of a WWTP's performance to the seasoned judgements of skilled field personnel, who can evaluate asset signals, such as sounds, vibrations, and temperatures, and infer performance levels and potential operating issues from them. An individual's memory is required to correlate specific signals with impending problems and know how to address them with the appropriate corrective action. Many of these personnel are retiring, taking their experience, and mitigation/remediation know-how with them.

Solution

Deploying smart sensors to a WWTP's assets can effectively create an intelligent sensing fabric spanning its entire operation for continuous real-time health condition monitoring. This enables the accurate acquisition and registering of data and events, so a precise analysis of the simultaneous occurrence of values and events can be done. Cybersecurity safeguards can protect data from intrusion or corruption.

Added to this can be the use of KPIs and contextualised data to assess asset health levels by analysing multiple variables impacting asset performance. Graphical dashboards, remotely and securely accessible via web browsers on any connected device, can then represent the tendencies of the health condition of each equipment, subsystem, and system visually, so deviations can be easily visualised and highlighted, before an alarm or system fault can occur. These can lay the foundation for artificial intelligence-enabled machine learning to facilitate advanced analytics. The latter can be used to predict potential problems that can be mitigated or remediated before they manifest in degraded performance or unplanned shutdowns. Figures 3 – 5 show sample graphic representations of an asset health visualisations.

Benefits

Asset health monitoring with digital technology can enable both predictive and proactive maintenance approaches to expand the scope of a WWTP's systems management to an entire lifecycle model. Considerable cost savings can be gained by replacing parts only when data suggests an impending failure. Related reductions in keeping large spare parts inventories can conserve capital. Actionable intelligence can help to drive more informed and, therefore, better maintenance and operating decisions.

Conclusion

Digital lifecycle management for the equipment and system assets of WWTP facilities in refineries, chemical, and petrochemical plants can provide real returns on investment in terms of fewer disruptions, optimised performance, greater operating visibility, reductions in spare parts inventories, greater productivity of field personnel, and overall lower total cost of asset ownership. Cybersecurity safeguards can protect data in transit and at rest, whether on-premise – either on the asset itself or at the plant network's edge – or in the cloud.

While greenfield deployments of the technologies to enable WWTP asset lifecycle management are to be expected, brownfield deployments are possible via end-to-end expert asset assessments and retrofits.

References

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