Addressing corrosion challenges in refineries

Integrated corrosion management enables full control of refinery assets and opportunity crude processing without increased corrosion threats

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From naphthenic acid corrosion to sour water corrosion, hydrogen induced cracking (HIC) and sulphide stress cracking (SSC), corrosion and material degradation is one of the biggest challenges facing refineries today. Such corrosion brings with it threats to operational integrity, maintenance and the blending of crudes.

Threats to operational integrity/ extended operating windows

Corrosion, for example, can lead to pipeline leaks, threats to asset integrity, and unplanned interruptions and shutdowns. Typical corrosion might include general and localised internal corrosion in processing piping and vessels, corrosion under insulation, and high temperature naphthenic corrosion in distillation units and high temperature process piping. Other equipment vulnerable to naphthenic corrosion attacks might include crude feedstock heaters, furnaces, transfer lines, and heat exchangers.

Another issue relating to operational integrity and a potential catalyst for corrosion is extended operating window programmes and design envelopes. Common in many refineries today, such extended operating windows can overload critical equipment capacity, such as desalters and heat exchangers, and lead to severe corrosion.

Crude oil desalting and distillation, for example, generates considerable wastewater that contains corrosive components such as H_2S, CO_2, chlorides, and high levels of dissolved solids. Similarly, solid deposits on heat exchangers can affect heat transfer efficiency and lead to plugging. According to the Abnormal Situation Management (ASM) Consortium, 76% of equipment failure is related to managing operations outside operating boundaries (range or design envelopes).[1]

The result is threats to operational integrity and refinery capacity as well as poor risk based planning processes and the inability to plan and bring in spare equipment properly.

Rising maintenance costs

Corrosion also results in rising maintenance costs. NACE, the professional body for the corrosion control industry, predicts that the total annual cost of corrosion in the oil and gas production industry is $1.372 billion.[2]

In such cases, an increased focus on proactive corrosion management can have a strong impact on the bottom line. According to Solomon Associates, specialists in benchmarking and consulting services in refineries and petrochemicals, increased spending on reliability and best practices leads to the world's best refineries spending 20-25% less on maintenance costs than the US average.[3]

Blending opportunity crudes

Corrosion can also have a major impact on the optimal blending of crudes. Crude oil purchasing today represents over 90% of the cost structure of a refinery and is therefore a major area for achieving profitability and reducing costs.

High total acid number (TAN) crudes – normally tending to have a TAN of 1.0 or higher – are an aggressive but cheap form of crude that has high levels of acidity and, in particular, naphthenic acid content (a mixture of naturally occurring cycloaliphatic carboxylic acids recovered from petroleum distillates).

In addition to high acid value, other elements of high TAN crudes might include fewer light components, high density and viscosity, high gel asphalt content, and high salts and heavy metals content. Such crudes bring with them a greater threat of corrosion to key refinery assets.

The price of high TAN crudes, however, can be approximately 80% the price of conventional crude oil. The optimal blending of high TAN crudes and conventional crudes can therefore significantly improve refinery profitability as long as the effects of corrosion are closely monitored.

For example, an increase in opportunity crudes from 1.5% to 3.5% in a refinery with a capacity of 300 000 b/d could result in annual savings of $7-10 million based on a four-dollar price difference. This provides a compelling case for proactive corrosion monitoring.

Integrated and accurate corrosion monitoring strategy

From both an operational and financial standpoint, an integrated and accurate corrosion monitoring strategy is essential to modern day refineries and their ever-increasing focus on safety, reliability, throughput and operational integrity.

Corrosion monitoring can verify

assets and integrity, optimise corrosion mitigation and control, provide vital input to inspection planning and asset maintenance, and ensure the optimal blending of opportunity crudes.

Yet are today's technologies rising to the challenge?

Intrusive corrosion monitoring

Among the most common corrosion monitoring technologies today are in-line probes and coupons. In refinery pipelines, retractable style probes are most commonly used, in particular weight loss coupons, electrical resistance (ER) and linear polarisation resistance (LPR) probes. **Figure 1** shows Emerson's CorrLog wireless corrosion transmitter for ER and LPR probes.

Weight loss coupons are the simplest devices for intrusive corrosion monitoring. Pre-weighed steel samples are inserted into the pipe or vessel for a given period, then cleaned and weighed after retrieval. Based on the weight difference, corrosion rates, deposits and the tendency to localised attacks on the exposed coupon are calculated and reported.

LPR probe measurements are based on calculating the current response to a small polarisation of the probe's working electrode in two- or three-electrode configurations. The corrosion rate is proportional to the current response measured, and utilising theoretical and empirical factors, corrosion rates can be determined from only one measurement. It is also important to note that the LPR method requires a conductive electrolyte and is therefore recommended for water systems only.

ER probes are based on measuring changes in the resistance of the probe's measurement element. As the metal element corrodes, the thickness is reduced and the resistance increases. Reference elements inside the probe are used to compensate for temperature fluctuations.

The advantages of ER probes are that they have a high resolution (down to 10s of nanometres of metal loss) and are hence able to respond to changes in corrosion

Figure 1 Emerson's CorrLog wireless corrosion transmitter for ER and LPR probes

rates quickly. The probes are also available with a high temperature rating – important in many refineries.

Due to their high resolution and fast responses, intrusive probes are important for active corrosion management as well as the verification and optimisation of corrosion inhibitor use and facilitation of oil and gas flow in refineries.

Today, intrusive and non-intrusive corrosion monitoring are seen worldwide in refineries as means of detecting corrosion

Non-intrusive corrosion monitoring

For all the benefits of intrusive monitoring, however, measurements are still local and the probe is therefore most likely to be useful if the corrosion is uniform. It is difficult, however, to pick up localised corrosion attacks or uneven forms of corrosion such as that experienced in naphthenic acid corrosion. To this end, non-intrusive corrosion methods, directly installed on the pipe, have also become attractive to refinery operators.

One of the most popular non-intrusive monitoring techniques is electric field signature monitoring (FSM), a non-intrusive method for monitoring corrosion, erosion or localised attacks, and particularly important in estimating naphthenic acid corrosion's impact on pipeline integrity.

FSM is based on the feeding of an electric current through a selected section of the structure to be monitored, achieved through non-intrusive sensing pins distributed over the areas to be monitored. By inducing an electrical current into strategically located pipe sections, the induced electric current creates a pattern determined by the geometry of the structure and the conductivity of the metal.

Voltage measurements on each pin pair (up to 384 pins can be applied in a matrix) can then be compared to the 'field signature' that provides the initial reference, and changes in the electrical field pattern can be monitored. Conclusions can then be drawn relating to the general wall thickness and the initial signs of metal loss.

The great advantage of FSM is that it measures between the sensing pins, providing the ability to detect localised attacks and meaning that the total monitored area is covered for both uniform and localised corrosion.

FSM's ability to distinguish localised attacks and general corrosion in real time and detect corrosion rates earlier than traditional non-intrusive corrosion methods allows corrective action to be taken before damage occurs.

Jamnagar refinery, India

Today, intrusive and non-intrusive corrosion monitoring are seen worldwide in refineries as means of detecting corrosion.

One application of Emerson's FSM, for example, can be found in Jamnagar refinery in India.[4] The refinery is owned by Reliance Industries and is the world's largest.

In this case, the need was for permanent wall thickness monitoring as input to a pipe replacement plan. There was a need to detect small changes in the actual pipe wall, see the effect of opportunity crudes, and identify any changes due to naphthenic corrosion.

Emerson generated full pipeline

wall loss measurements at high temperature locations, with 58 online FSM systems installed. The FSM systems helped the operator visualise localised corrosion in 3D format and provided metal loss in detail, with the systems having a resolution within the range of 0.1% of the wall thickness. For the operator, benefits included optimal chemical injection dosages and optimal crude blending, leading to significant cost savings.

The integrity of the plant was also confirmed and maintained even when processing high TAN crudes, and the corrosion rates of the piping were assessed, providing input to future pipe replacements and upgrades.

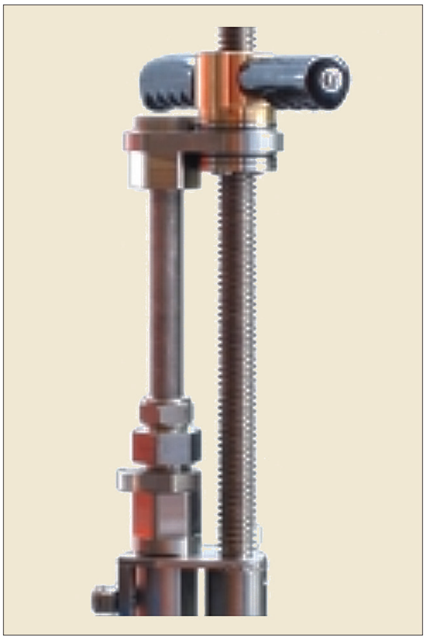

Figure 2 The Roxar Corrosion Monitoring system, consisting of wireless transmitters and high temperature probes, will provide refineries with flexible, responsive, integrated and highly accurate corrosion monitoring

The need for integration

Yet, despite examples of proactive corrosion monitoring, such as the Jamnagar Refinery, the fact remains that many older refineries still have outdated monitoring solutions with little integrated data management capabilities. Wiring costs also make upgrades to on-line corrosion monitoring cost-prohibitive.

It is with these challenges in mind that Emerson has introduced a new, wireless online corrosion monitoring system (see **Figure 2**). Combined with FSM technology, refinery operators will be able to use the new system to access more comprehensive corrosion information and corrosion rates, leading to improved operator insight and control over assets.

The system can be installed in a number of refinery applications, including side streams, cooling systems and in addressing naphthenic acid corrosion in high temperature distillation processes. It can also tackle increased corrosion triggered by high velocity and temperatures, malfunctioning desalting units and high sulphur content.

The system consists of ER and LPR monitoring functions – all available on the same instrument – with a 20 m cable providing added flexibility with respect to positioning, optimised signal routing, easier maintenance and probe replacement. The system is also compatible with the WirelessHART protocol and works alongside other Emerson solutions.

The system provides two key benefits to refinery operators. Firstly, it will ensure optimal production processes and reduced refinery downtime via its fast, integrated, high resolution and accurate corrosion monitoring.

The system will provide operators with the ability to understand the process conditions that may be influencing faulty equipment or integrity risks as well as determine the root causes of certain failures. In addition, only the necessary amount of corrosion inhibitors will be injected to meet environmental requirements.

The fact that the system is wireless based will also enable access to the plant's most critical and often inaccessible areas, as well as coming with reduced installation costs and improved data management. Asset monitoring can also take place remotely, eliminating unnecessary trips to the refinery and hazardous areas, and improved HSE.

Secondly, at a time of high crude volatility, operators will have maximum crude selection flexibility and can blend the maximum amount of opportunity/high TAN crudes into the crude mix. A baseline can be defined before introducing high TAN crudes, and the effects of changing inhibitor programmes can be monitored.

East European refinery

One such installation of the new system was on an East European refinery, where the goal was to monitor corrosion rates in a 330 t/h main crude oil stream when processing 6 t/h heavy slops of oil.

In this case, the wireless corrosion probe, detecting fluid corrosion measurements, provided early warnings of significant corrosion rate changes. Within hours, corrosion rate changes were established, allowing the refiner to manage its processing strategy and keep within material performance limits.

Conclusion

An integrated corrosion management system today is essential in order for operators to take full control of refinery assets, secure the ideal blend of crudes without increasing corrosion threats, and ensure that their production processes are operating at peak potential.

References

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