Non-Intrusive Online Corrosion Monitoring

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Abstract

Corrosion in process industries is becoming a bigger issue day by day and is also the most common cause of asset failure / forced shutdown in plants. Failure of a pipeline or vessel can be dangerous & costly and have severe environmental consequences. A typical mode of asset failure is wall thinning to a critical thickness due to erosion or internal & external corrosion. To keep track of corrosion in pipes/assets currently manual inspection and monitoring techniques are employed that are expensive and time consuming. Plus often critical measurement areas are located in difficult and or expensive to access locations that makes the inspection much more difficult. Since this data is not online, hence it is not suitable for long-term data analyses or corrosion trending.

The objective of this paper is to present a new non intrusive technology to monitor corrosion, using ultrasonic, as well the use of software to store data, monitor corrosion rates and trends, allowing a repair planning before the failure happens. This paper is divided into two parts. First part will focus on different kinds of corrosion and how it happens. Second part will talk on the corrosion monitoring techniques that includes both currently used methods and the proposed UT based solution that can help in continuous monitoring of wall thickness with installed sensors & portable or installed instrumentation.

1. Introduction

To keep assets working, industries are spending billions of dollars every year through corrosion monitoring and control programs. Irrespective of this huge spend, failures are still happening, as all the current methods used are more of reactive in nature. They focus on detecting if failure has happened or not whereas ideal way is to have solution that can help in predicting failure so that appropriate action can be taken before failure.

The current technologies to monitor corrosion in the industry are based on intrusive methods and indirect measurement of the remaining wall thickness of the pipes. They provide data on the corrosion rate of the fluid, but do not provide accurate data on the wall thickness. The metal loss in corrosion coupon is taken as indicative of the metal loss in the pipeline. The non-reliable thickness data can lead to chemical dosing that is not optimized. Based on surveys done with corrosion experts in different refineries it is estimated that by applying good corrosion control technologies there can be a saving of 20 to 25% of annual cost of corrosion.

1.1 General Corrosion

Internal general corrosion proceeds by a chemical / electrochemical reaction uniformly over the surface. Virtually all metals are to some extent subject to this type of corrosion under certain conditions. It is characterized by an even, general wasting away of metal from the corroding surface and therefore lends itself rather well to the life prediction of structures or equipment. Figure 1 indicates this type of attack is mostly found where a metal is in contact with an acid, a humid atmosphere or a solution in general. The presence of such medium is not essential as high-temperature corrosion or oxidation phenomena are also characterized by a uniform attack, but these occur in a virtually dry medium.

1.2 Internal localized Corrosion

Internal localized corrosion, or pitting, on the other hand occurs when a protective surface layer breaks down locally. An anode forms where the film has broken, and the unbroken film acts as a cathode. It accelerates localized attack and pits will develop at the anodic spots. The electrolyte inside the growing pit becomes very aggressive (acidification), which will further accelerate corrosion. The pits may range from deep cavities of small diameter to relatively shallow depressions. The larger part of the metal surface remains virtually free from corrosion. Figure 2 indicates pitting, which
is most commonly induced by chloride ions, which are destroying protective surface films (e.g., stainless steels, nickel alloys, etc).

1.3 Erosion - Corrosion

Erosion-corrosion accelerated by the relative movement between a corrosive fluid and the metal surface; resulting in specific cavities in the metal surface, ultimately lead to a pitting corrosion. Figure 3 indicates internal erosion is the recession of surfaces by repeated localized mechanical trauma as, for example, by suspended abrasive particles within a moving fluid. The factors that affect the erosion rate also include impacting particle speed, size, density, hardness, and rotation.

2. Corrosion Monitoring Technologies

2.1 Intrusive Methods

Some corrosion monitoring methods, such as: weight loss coupons, where corrosion is determined from the weigh loss over a period of time; and electrical sensors utilizing ER (electrical resistance), LPR (linear polarization resistance); are currently used to evaluate the corrosion rate, but they provide only indirect measurements. This makes it difficult to define and evaluate the real condition of an equipment or pipeline affected by corrosion. The measurement of weight loss coupon immersed on a specific fluid that runs through a pipeline allows a global evaluation of the corrosion process, but do not correlates in a direct and accurate way the corrosion on a specific part of the pipe.

2.2 Non-Intrusive Methods

The most known technique to monitor thickness is Ultrasonic. The instrument is calibrated on two thickness as reference in order to get the material sound velocity, and the thickness is calculated by the time of flight, that means the time the ultrasonic wave takes to run the pipe wall, as indicated on the Fig. 4. The measurement can be taken in service, and, depending on the transducer and equipment, it is possible to measure pipes with high temperature surfaces. It’s also possible to measure over coating.

3. On-line Corrosion Monitoring – Non Intrusive Permanent Installed Sensors

The Rightrax tool that measures thickness through the use of ultrasonic was developed as a consequence of the limitations on the use of portable thickness gauges, specially when one needs to continually follow the thickness measurements of specific points. On a manual thickness measurement using thickness gauges the data quality can be compromised for many different reasons. The operator writes the data collected on a piece of paper, which later may or may not be included on a software database. Also it is very difficult to ensure that the exact same spot on the pipeline is going to be measured over a period of time. There can be
variation on the equipment calibration, expertise of the operator, etc. There are some locations difficult to access, buried pipelines, or hazardous areas that can represent risk to the inspector. The permanent installed Sensors, Rightrax, was designed to be mounted on a pipeline and collect thickness measurement using ultrasonic always on the same spot. The data collection can be done automatically and remotely. These measurements can be stored on a software database. The system manager can evaluate corrosion trend of very specific measurement points. It’s possible to set alarms so that when the thickness reaches a critical level, the software generates an alert to the operator.

As the system collects the data automatically, the quality of data is preserved; there is no risk to the inspector. Since the sensors are permanently installed the cost of data collection is low once there is no need of scaffolding, or excavation costs.

The Rightrax wall thickness monitoring system is based on ultrasonic time of flight measurements and comes in two variations.

3.1 Low Temperature Solution

This solution is a flexible sensor strip that can be pasted over pipeline and is suitable for online thickness measurement of pipe with temperature range -40°C to 120°C. The system comprises of three basic elements: the M2 ultrasonic multi-element (14) sensor; the DL2 intelligent flaw detector and data logger, and data acquisition and data analyses software. This low temperature sensor is composed of 14 sensors elements covering 12mm x 200mm (0.5" x 7.9") inspection area. It’s not intrusive, and very simple to install. It’s permanently glued on critical spots of the pipe, especially on areas affected by corrosion or erosion, or difficult to access. The Fig. 7 indicates the sensor and the data logger and Fig. 8 shows the installation arrangement prior to the installation of insulation. Figure 9 indicates the report generated by the software.
3.2 High Temperature Solution

The system consists of four high temperature sensors having capability of operating at extremely high temperature to provide accurate and reliable wall thickness. Its current temperature capability extends up to 350°C with accuracy, which is significantly higher than other non-intrusive sensors. The system has a resolution of 0.0025 mm and is the smallest change in thickness that it can detect. A version with an enhanced temperature rating of 500°C is under testing stage and will be launched in due course. These sensors are clamped directly to pipe or vessel to be monitored and connected to a single sensor interface. This interface contains the ultrasonic instrumentation to drive the sensors and transmits received data to a local PC via an RS485 serial connection. Data collection intervals are programmable to meet specific needs and allow data on demand. A flexible software interface allows communication with a variety of...
inspection database management systems via open software interfaces and standard industry protocols such as OPC and MODBUS. As a result, sophisticated data analysis can be performed to provide accurate and reliable trending information. Both sensors and sensor interface are intrinsically safe for use in zone 1 areas. Another big advantage of this solution is that sensors are easily repositionable and hence can be shifted to other location.

3.3 Acquisition and Data analysis software

Once the data is collected from the system, it is possible to analyze in detail the measurements taken. The software does the temperature correction for the thickness data and gives the minimum/maximum and average thickness along with A-Scan. This also gives short term, long term and maximum corrosion rate that can help in decision making for keeping corrosion under control. It is possible to input nominal thickness, critical thickness, and alarms for minimal thickness of the monitored pipes. The historical data stored on the database allows the generation of trend analysis, remaining lifetime calculations, and mainly understand the process that is going on the pipe itself. For example, the repeatable measurement taken always on the same spot can demonstrate the corrosion rate on two different periods of time, and permits an evaluation of the effectiveness of a specific corrosion inhibitor. It makes it possible to establish a comparison on different inhibitor’s suppliers and verify if a more economic inhibitor has generated a higher cost on maintenance.

As the system is fully automated system, hence helps in monitoring locations that are hard access and where there is a big need for short interval monitoring of the wall thickness with a direct connection to the plant’s SCADA system. For example: Zone II hazardous areas, unmanned offshore installations, Refineries, Cross-country pipelines.

4. Current and Pilot Installation

Low Temperature Rightrax has been successfully installed on many offshore and onshore projects in Canada, USA, Scotland, India, Egypt, Nigeria, Angola, Austria, Indonesia, Italy, Brunei, UK, Saudi Arab, and Brazil. Primary application is to monitor wall thickness when the asset is subjected to sand erosion or other forms of erosion.
The High Temperature version is currently being piloted in a number of refineries in different parts of the world. A typical location would be on the overhead crude line, which is susceptible to corrosion and is a very difficult to access piping system.

Conclusions

The material loss (thickness) in pipelines is typically caused by corrosion and erosion. When the thickness reaches a critical level, it does not support the tensions and results in leakage or rupture, making monitoring into an extreme important action to ensure reliability and operation of the pipeline system. Online corrosion monitoring using ultrasound-based sensors is the most reliable and accurate means of assessing corrosion, as it's a direct method of thickness measurement. With the advancement of technology now UT sensors are available that can withstand high temperature and gives precise corrosion rates. Information technology has also helped the cause by transmitting data from hazardous/ in accessible location to control room. It gives the capability to analyze the results for decision making on taking action before failure happen. The benefits of transitioning from reactive to proactive mode of maintenance through online monitoring are huge as it reduces plant operations cost and increases safety.

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