IoT based approach to detect Corrosion under Insulation in Oil and Gas Industry

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Abstract - Corrosion under insulation is a major problem throughout oil and gas industry. It is not only the petrochemical, power and manufacturing industries which is affected, but can occur wherever pipelines are fitted with thermal insulation. This form of corrosion occurs on steel pipelines which have been fitted with thermal insulation. It is inherently very difficult to detect, as the presence of corrosion is obscured by the insulation system. Because the corrosion develops undetected, it can lead to serious pipeline failures, which have several adverse consequences including the risk to the safety of site personnel, damage to the environment, and an economic impact in terms of the cost of cleaning up any spillage and lost production. Therefore, a considerable proportion of the large maintenance budgets allocated by operating companies are spent on the inspection for, and mitigation of CUI.

Key Words: IOT, CUI, Predix, Cloud, Corrosion, VNA.

1. INTRODUCTION

Corrosion Under Insulation (CUI) is one of the most widespread problem throughout the oil and gas industries. It is one of the main reason of pipeline failures in petrochemical Plants and detection of such corrosion is an on-going issue in chemical industries. Pipelines are insulated and the insulation is covered by a layer of metallic cladding to provide protection from the environmental damage. This cladding can decay from age or get damaged, allowing ingression of water into the insulation, which initiate corrosion of the external pipe surface. Therefore, there is a strong necessity for IOT based inspection and monitoring technique which alert us to the first ingress of water into the insulation. This can provide an early caution of areas of a pipeline at risk from CUI. It can be obtained by screening along the length the of pipeline to inspect the insulation layer for the presence of water, as water is a necessary precursor to corrosion. Water level in insulation can be detected using signals as water volumes presenting in insulation impedance contrast and producing reflections of the incident signal. Irrespective of wherever in the world we are, through IoT technology we can control the parameters and monitor water level in insulation. CUI Data will be available to authorized users via internet in a graphical model showing risk of corrosion at specific area point along the length of the pipeline.

2. Literature Survey

There are many methods used today to inspect for CUI. No one method is ever used by itself. several methods complement each other for optimal results. The most common and straightforward way to inspect for corrosion under insulation is to cut plugs in the insulation that can be removed to allow for ultrasonic testing. The other commonly used methods are radiography, and complete insulation removal. More advanced methods include pulsed eddy current. Here are the few most common methods of inspecting for CUI.

2.1 Visual Inspection

The first and simplest method of inspection is, of course, visual inspection. It involves removing the insulation, checking the surface condition of the pipe, and replacing the insulation. It's also the most expensive and time-consuming method. The logistics of insulation removal occasionally involves asbestos and attendant complications. Process-related problems may also occur if the insulation is removed while the piping is in service. Nowadays, visual inspections are usually performed with portable visual scanners, which allows for precise, traceable sizing of surface corrosion at the outer diameter. [4]

2.2 Neutron Backscatter

This method as used for Non-destructive technique (NDT) is designed to detect wet insulation in pipes and vessels. A radioactive source emits high-energy neutrons into the insulation. If there's moisture in the insulation, the hydrogen nuclei attenuate the energy of the emitted neutrons. The inspection instrument's gauge detector displays a low-energy neutron count proportional to the amount of water in the insulation. High counts per time period indicate more moisture and a higher probability of the present of CUI. [4]

2.3 Ultrasonic Thickness Measurement

This method (referred to as UT) is the non-destructive measurement of the local thickness of a solid element based on the ultrasound wave's time of flight. This type of measurement is usually performed with an ultrasonic thickness gauge. This is an effective method, but limited to small areas. Just as with partial removal of insulation, it's expensive to cut plugs out of the insulation and impractical to cut enough holes to get reliable results. The inspection plugs can compromise the integrity of the insulation and add to the CUI problem, if they are not properly recovered. [4]

3. Proposed Methodology

The basis of idea is to send signal into the insulation, then wet insulation having water ingression act as impedance, causing a partial reflection of signal. these signals are received by receiver sensor and can be used to detect the presence of water in insulation. Controlling the parameter of acquisition system remotely through IoT which collect sensor measurement data for given specification and send data files to edge Machine connected through Component Object Model. Edge machine will have predix machine running corrosion detection algorithm on sensor data to get amplitude of signal along the length of pipe and performing Data Visualization and analytics on predix cloud. These data would be used to Develop graphical alarming system to convey risk at respective plant.

3.1 Corrosion Detection Method:

pipeline acts as a coaxial waveguide, supporting the propagation of microwaves. A water patch will act as an impedance discontinuity within the waveguide, causing a partial reflection which is used to detect and locate the water patch [3].

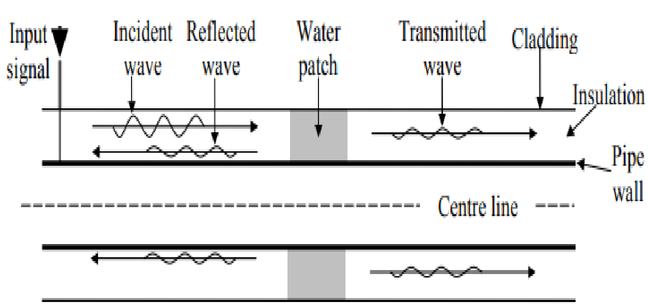

Fig1 : Water detection

- As shown in fig:1 each antenna array emits microwaves, which pass through the insulating material without reflection. When there is water or corrosion residue in the insulation, the microwaves are reflected and bounce back to the antenna array.
- Time of flight determines the distance from the antenna array to the area of the ingress or corrosion, and the level of amplitude indicates the extent of the ingress or presence of corroded material.
- The pipe with insulation and outer metal sheet acts as a signal conductor similar to a coaxial cable and is ideal for carrying high frequency microwaves.

3.2 Corrosion Data Interpretation

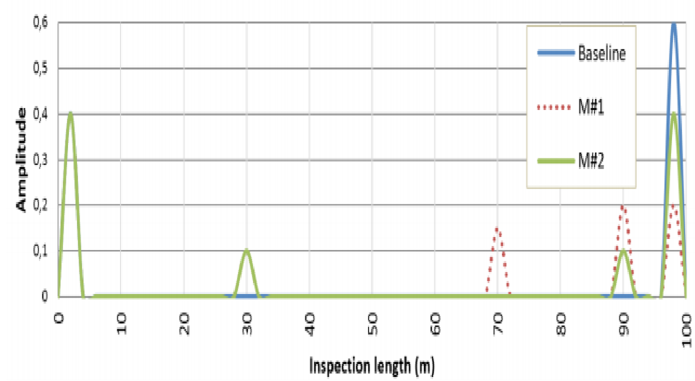

Fig 2: CUI Data Interpretation

- The above echograms illustrate how the signal changes from dry to wet insulation. The blue baseline shows the reflection without water or corrosion residue present.
- The dotted red line is the first measurement, and shows a reflection due to water at 70 and 90 metres distance. The green line is the second measurement, and tells us that water is present at 30 and 90 metres, but that at 70 metres it has dried up. At 90 metres there is still water present or corrosive residue in the insulation.
- The spikes on the far right (100m) of the echogram show the reflection from the installed reflector for the neighbouring antenna array. Note that this reflection is smaller when there is water or corrosion residue present.

4. Implementation and Output Screenshot

In the system we collect sensor data from data acquisition device and push it on cloud through restful service. Sensor data is getting stored in time series database and visualised using different API.

Fig3: CUI Home page

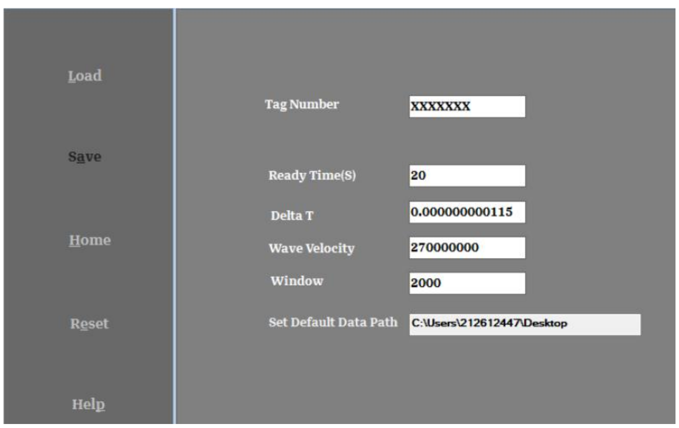

Fig4: VNA Configuration

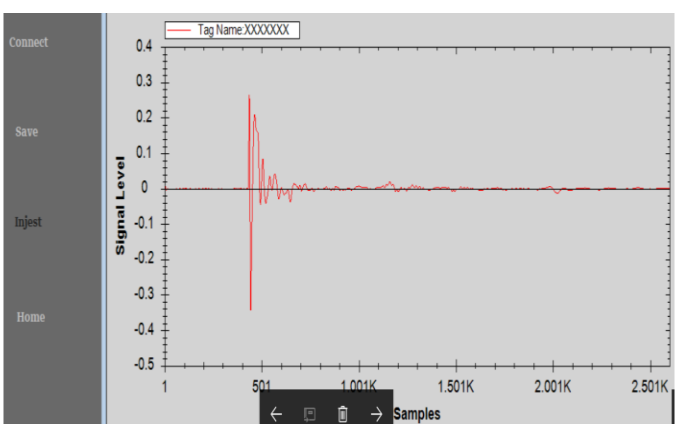

Fig5: Sensor data output

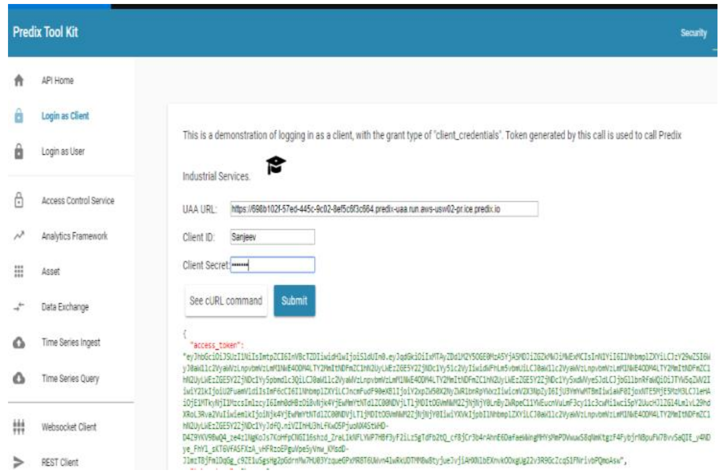

Fig6 : CUI Cloud login

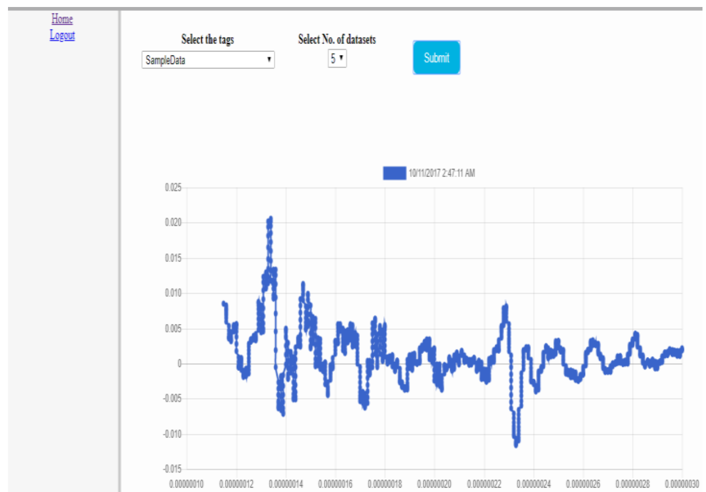

Fig7 : Online CUI Data visualization

5. Technical Requirement

Hardware Requirements: VNA, An insulated pipeline, Sensors.

Software Requirement: Predix Cloud , Visual Studio framework, Spring boot framework.

Programming Language: C#, Java, Angular JS.

6. Conclusion:

The project connects things like Data acquisition device, sensors, predix cloud over the internet in order to fetch sensor data from pipe, perform corrosion detection to detect amplitude level where water patches are available and push data on cloud for visualization. This can provide an early caution of areas of a pipeline at risk from CUI. It can be obtained by screening along the length of the pipeline to inspect the insulation layer for the presence of water, as water is a necessary precursor to corrosion. Water level in insulation can be detected using signals as water volumes presenting in insulation impedance contrast and producing reflections of the incident signal. Irrespective of wherever in the world we are, through IOT technology we can control the DAQ parameters and monitor water level in insulation. CUI Data will be available to authorized users via internet in a graphical model showing risk of corrosion at specific area point along the length of the pipeline.

7. References

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