# Non-Destructive Oil-Gas Pipeline Corrosion Monitoring

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***Abstract***—This paper proposes an in-line corrosion monitoring of oil-gas pipeline and evaluating the associated risks in minutes through real time data logging. The rapid changes in the resistive layer of the steel pipeline when it gets corroded are taken in account. When corrosion begins, thickness of the material of the pipeline decreases. The current passing through the layer varies and hence the potential. This change in the potential is measured and processed so that the control station is alerted about the progressive changes and necessary measures are taken to solve the issue. The proposed work saves the economic loss by preventing the digging of the whole area. It implies a kind of non-destructive approach. This is a long time process and whenever the system finds some rapid changes in the rate of corrosion, an alert is made so that it can facilitate in taking necessary measures to control the situation.

***Keywords***- *Corrosion, Steel pipeline, Silver electrode, Teraterm, Inline monitoring, Pipeline hazards.*

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## I. INTRODUCTION

Oil and gas pipelines play a major role in country economy. Pipelines (petroleum and natural gas) are used not only as an element of trade. They play a major role in geopolitics and international security. Their construction, placement, and maintenance requires extreme concern. High pressure underground pipelines are typically protected with barrier coatings and cathodic protection systems. When the coatings become 'disbonded', pipelines become susceptible to corrosion. Eventually it leads to leak or catastrophic failure. Maintaining the vast network of pipelines that carry oil and gas across the country is a massive task. Millions of dollars are spent every year in regular assessment to detect corrosion issues. Also digging up the pipelines is very expensive.

Throughout the world, pipelines are used as a means of transporting gases and liquids over long distances from their sources to the ultimate consumers. The operating pipelines are buried beneath the ground. Its presence is shown only at compressor stations, pumping stations or terminals. The failure of pipelines while carrying the oil and gas can be dangerous and costly. It can cause vast environmental consequences. The major cause of pipeline failure is thinning of walls due to erosion or internal and external corrosion.

Manual inspection and monitoring techniques to keep track of corrosion are expensive and time consuming. Also critical measurement areas are located in difficult and expensive-to-access locations and thus the inspection becomes much more difficult. Billions of dollars are spent every year for corrosion control programs. Almost all current methods basically focus on detecting if failure has happened or not.

The objective of this paper is to present a solution that can help in predicting the pipeline failures so that appropriate action can be taken before failure. The metal loss in pipeline during corrosion leads to rapid changes in its thickness. The change in the potential of the metal is considered as the measuring parameter. This work is aimed at developing an embedded system which can contribute in monitoring the pipeline corrosion in a cost effective way and thereby reducing the chance of pipeline hazards.

## II. LITERATURE SURVEY

Recent researches in the field of oil-gas pipeline corrosion monitoring reveal that many ways are being adopted in various sectors to minimize the rate of corrosion. Over the last decade, several electrochemical techniques were provided to assist the engineers with the means to monitor corrosion. Techniques to reduce corrosion are expensive and consume more time. The literature survey analysed the different scenarios of corrosion.

In marine environment, the corrosion and the protection behavior of reinforced concrete piles are revealed by carrying out various electrochemical techniques [1]. The cathodic prevention method using Zn-mesh sacrificial anode for the protection potential measurements is fairly effective in marine pile environment.

The propagation of corrosion of steel embedded in cement paste can be analyzed by applying external anodic current [2]. The crack patterns and the propagation of the corrosion products are measured by microCT. The analysis of the mechanisms is allowed in real time.

In harsh marine environments, corrosion under insulation is a serious issue and it causes destructive consequences [3]. Non-destructive testing and evaluation methods are adopted to indicate the issues. Statistically significant data is developed to evaluate the corrosion.

Considering the pipeline corrosion damage kinetics, the building of pipelines itself and the technological effects causes the corrosion situation [4]. In different ground-climatic conditions, many difficulties are there to determine real corrosion danger.

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## III. METHODOLOGY

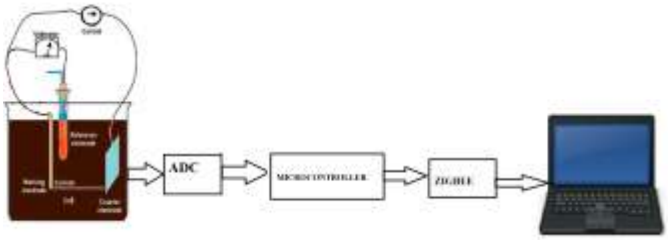


Figure1. Block Diagram of the System

In the proposed work, the specimen of the steel pipeline acts as the working electrode. Silver electrode is used as the reference electrode which provides a reference voltage to measure the change in the potential of the working electrode. The working electrode and the reference electrode are placed close to each other. A counter electrode is used in this setup to complete the circuitry. Stainless steel is used here as the counter electrode. The three electrodes are immersed in the soil that acts as the electrolyte. Current is passed between the working electrode and the counter electrode.

When the metal starts corroding, there will be a rapid change in the resistive layer of the pipeline material and hence the thickness decreases rapidly. Hence the rapid variation in the potential difference is taken in to account and it is the indicating parameter that the metal started corroding. The data is sent to the control station continuously. Here the data is sent wirelessly through zigbee.

## IV. EXPERIMENTAL SETUP

The experimental setup is done first using the non-corroded steel pipe as the working electrode immersed in soil. When current is passed between the pipe and the counter electrode, the value of potential difference between the working electrode and the reference electrode is processed using arduino microcontroller and sent wirelessly to the control station through zigbee. At the control station, the data is received using mbed LPC11U24 board and the values are viewed using teraterm. Teraterm is the free software that acts as a terminal to view the data received through serial port. The same experiment is done using the corroded steel pipe of same size, material and dimension of the non-corroded type. When the potential value changes in a rapid manner from the previous values, alert will be given to the control station to take necessary preventive actions. The system cannot completely control corrosion but it continuously monitors and gives way to predict the vulnerability of pipeline failure. The process continues for years. The status of the pipeline is continuously being monitored.

### *A. Silver Electrode*

Figure2. Silver Electrode

It is a reference electrode used in electrochemical measurements owing to the stable potential. It is simple, inexpensive and non-toxic. The potential difference between the working electrode and the silver electrode is measured and the data is processed and sent through zigbee.

### *B. Aurduino Uno*

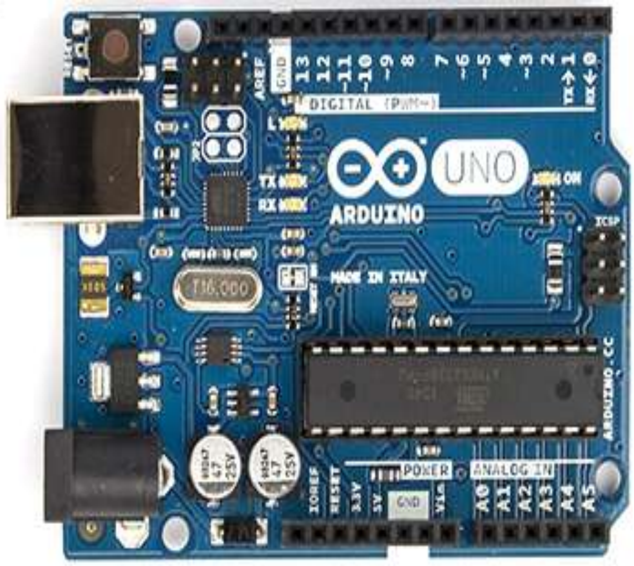


Figure3. Aurdino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. The analog data of potential difference between the working electrode and the silver electrode is processed and sent through zigbee using Arduino Uno. The values are continuously monitored using the board.

### *C. Mbed LPC11U24*

The value of potential difference is received through zigbee using the Mbed LPC11U24 controller. The controller then analyses the data continuously and gives alert to the control station if there is a rapid change in the potential value.

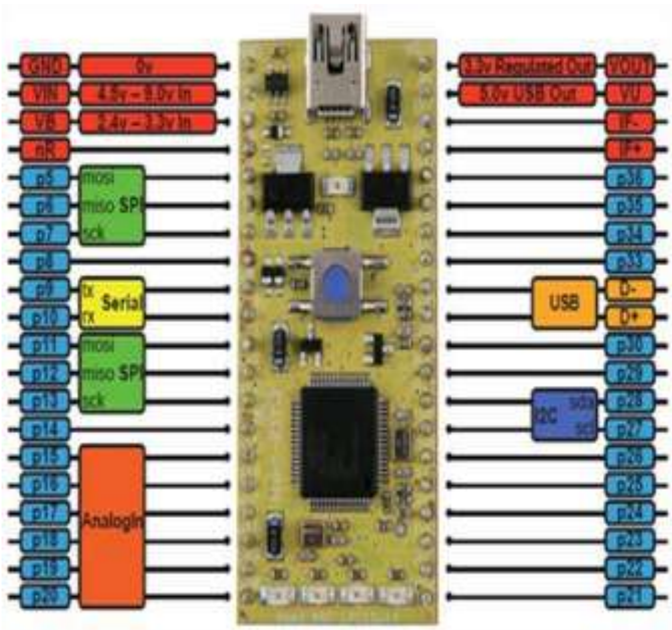


Figure4. mbed LPC11U24

### *D. Zigbee module*

Figure5. Xbee module

The XBee module is used for the wireless data transfer from the three electrode electrochemical cell to the control station. Zigbee operates in a radio band of 2.4GHz. Both the modules are configured to transmit and receive using the software XCTU with a baud rate of 9600.

## V. RESULTS AND DISCUSIONS

After passing current through the genuine non-corroded pipe, the potential of the steel pipe is measured with respect to the silver electrode. The measured potential was processed in the Arduino board and the value of about 0.25 to 0. 3V range Vs. silver electrode. This value sent through zigbee was received using the mbed board and viewed in teraterm.

Figure6. Three electrode cell using non-corroded steel

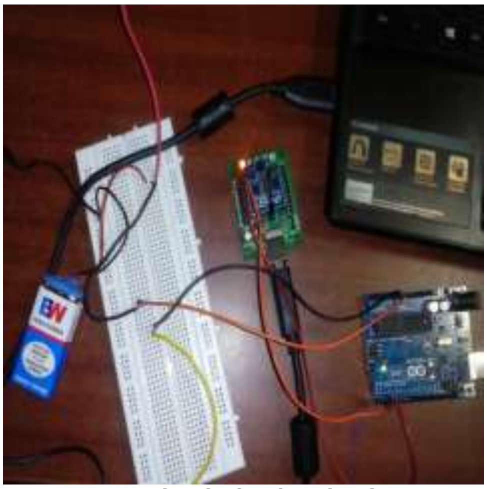

Figure7. Sending the data through zigbee

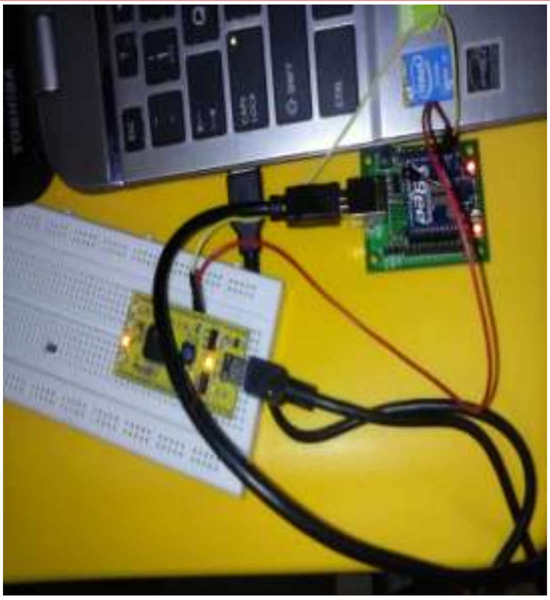

Figure8. Receiving the data

Similarly the same procedure was carried out using the corroded steel pipe of same size, material and dimension of the non-corroded type. Then a rapid change in the value was observed in 0.55 to 1V range. Thus an alert is issued by means of blinking the LED.

Figure9. Corroded steel as working electrode

Figure10. Values received through zigbee and led blinking

The change in the value of potential difference is due to the change in the thickness of the resistive layer of the pipeline material. The inline monitoring of the corrosion through real-time data logging is based on this fact. The proposed system is placed between specified distances, say 1km apart, so that preventive measures like replacing the pipeline etc can be taken within that location only instead of digging an entire area. The

system can be implemented in real time operating systems in the near future and can be transformed to online platform too where the data and the alert can be received online. The researches based on corrosion monitoring are a vast field and more new technologies will be brought to it in the near future.

## VI. CONCLUSIONS

This paper presents the concept of inline monitoring of the corrosion through real-time data logging. The continuous monitoring of oil-gas steel pipelines is very necessary in the case of safety and economy of a country. The world countries are spending lots of money in the prevention of pipeline corrosion. The proposed work implies how the change in the potential of the steel metal is used as a measuring parameter to indicate the corrosion. The behavior of the steel pipeline when current passes through it changes when it starts getting corroded. The technique is cost effective and reliable. The work can be extended in an elaborate way to bring more flexibility and ease.

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