# Subsea Pipeline Corrosion Monitoring System Using IOT

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**Abstract:**

Under water pipelines are important for transporting oil and gas over long distances. It, on the other hand, face numerous risks, including corrosion and leakage. Corrosion of pipelines has long been a subject of worry in the oil and gas (O&G) industry, as it has a negative impact on infrastructure in exploration, development, refining, and transportation, resulting in substantial financial costs and safety concerns[6]. As a measure, pipeline safety monitoring must be carried out. Theability to track corrosion electronically until structural integrity is damaged will make a big difference in avoiding catastrophic corrosion events. This paper presents a IoT sensor, which will monitor the properties of pipeline and sea and record the data for predicting and alarmingthe pipe's vulnerability to corrosion.[4]

**Keywords:**

Corrosion Monitoring; Pipeline Corrosion;Subsea Corrosion Monitoring; Corrosion Detection; sensors.

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## I. Introduction:

Subsea pipelines are the lifeblood of the offshore petrochemical industry, transporting oil and gas to onshore facilities for further processing. There arecurrently 3.5 million kilometers (2.17 million miles) of pipelines in use around the world. For example, from 1952 to 2017, the United States' Gulf of Mexico (GoM) hosted the construction of over 45,000 miles (72,000 km) of pipelines, 26,000 miles (42,000 km) of which are now operational. Subsea pipelines can reach incredible depths, with one of the world's deepest pipelines built in the US GoM at 9500 feet (2,900 meters). Anotherexample is the Nord Stream pipeline, which stretches 761 miles (1220 kilometers) across the Baltic Sea. While subsea pipelines are constructed with multiple protection layers to reduce the effects of the external environment, the protection layers are weakened or disbonded over time as a result of harsh underwater conditions. These underwater pipelines must be inspected on a regular basis for corrosion, fractures, and leaks in order to ensure the safe and continuous transportation of extracted oil.[9]

## II. Corrosion of Pipelines

The oxidation process is started when water molecules come into direct contact with the pipeline's metallic surface. The oxidation leads to corrosion on the pipeline's exterior surface, compromising its integrity and causing cracks and leaks. Corrosion of pipelines can be divided intotwo groups. Internal corrosion, which accounts for about 12% of all pipeline accidents, occurs on the inside of the pipe,while external corrosion, which accounts for about 8% of all pipeline incidents, occurs on the outside. Subsea pipeline corrosion is a serious issue in the offshore petrochemical industry. The percentage of corrosion nearly 60 to 80, which is more compared to other damages caused to a pipeline.

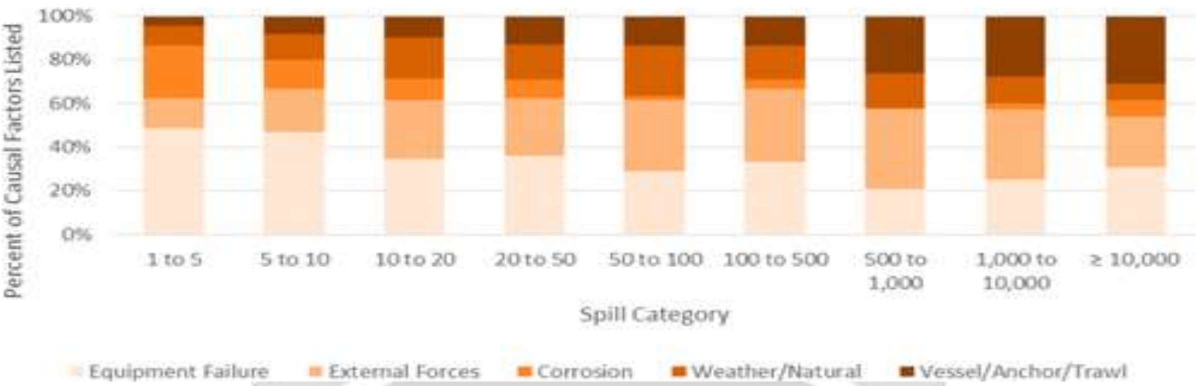


**Figure 1.** Harm caused by oil leaks from subsea pipelines at various depths is distributed.

Corrosion in a pipeline can result in leaks, which can have serious consequences for the environment and public safety, as well as financial risk and decreased transportation capability. Pipeline corrosion costs the United States $7 billiona year, according to the National Association of Corrosion Engineers (NACE).

Continuously monitoring pipelines for possible causes of failure is one way to reduce the amount of harm caused by pipeline failure. Inspection and control ofsubsea pipelines is difficult due to numerous problems and obstacles.[7][6]

## III Monitoring pipeline corrosion.

Corrosion monitoring's key goal is to 'inspect' the infrastructure's integrity to ensure that corrosion damage does not jeopardize the asset's existence. Corrosionmonitoring can also be used in a corrosioncontrol sense to figure out what is causingthe corrosion and how to improve the control methods, such as testing and enhancing corrosion inhibitors. Other corrosion monitoring goals can include:

1. determining the remaining life orextending the life of infrastructures.
2. preventing unplanned plant shutdowns by providing the condition of operating equipment.
3. product quality control by reducingcorrosion contamination.
4. preventing safety failures andpossible disasters, and so on.

Understanding the process of corrosion and the factors that cause it will aid in thedevelopment of more accurate and promising corrosion monitoring sensors. We addressed ultrasonic method for corrosion detection in this study.

## IV Methodology

For inspection and monitoring of subsea pipelines, a staggering number of differenttechnologies are available and being built.Electrical, optical, radiographic, chemical,[9] and acoustic domains are among the physical concepts covered by sensor technologies. Each technology has its own set of advantages and disadvantages, so a holistic evaluation of pipeline health also necessitates the use of several technologiesat the same time. We want to focus on the most popular methodology used in corrosion detection sensors, i.e., Ultrasonic[13]

Ultrasonic corrosion monitoring is a formof non-destructive testing (NDT) used to track the progression of corrosion. High- frequency acoustic waves (sound waves) are used in this monitoring method to calculate or map the internal structure, thickness, and other properties of the material being monitored.

Ultrasonic corrosion control techniquesmay be used for a variety of purposes, including:

1. Identifying and evaluating flaws
2. Dimensional measurements
3. Characterization of the material

The ultrasonic corrosion control techniqueuses electromagnetic acoustic sensors to capture, and measure reflected waves (pulse-echo) or transmitted waves (through-transmission).

The following are the components of a standard ultrasonic corrosion monitoringsystem:

1. Pulser/receiver
2. Transducer
3. Display device

In order to detect tiny cracks (on the order of millimeters), the ultrasound wave frequency must be designed such that the wavelength is close to the crack size. Sincefrequency is inversely proportional to wavelength, ultrasound frequencies for NDT in solids can range from 0.5 to 25 MHz. The two modes of ultrasound[16] propagation in solids are, longitudinal waves (compression waves, pressure waves), in which the energy of the wave travels in the same direction as the wave propagation, and shear waves (transverse waves), in which the energy travels perpendicular to the wave propagation direction. When ultrasound waves impinge

on an interface (e.g., the boundary betweenthe pipe surface and the surrounding water), they can convert between longitudinal and shear modes, but for shortdistances, such as across the pipe wall, only one mode (typically longitudinal) is sufficient.

Non-destructive ultrasound works by sending an ultrasonic wave through a material and looking for echoes that occurwhen the wave hits a physical boundary, such as a crack in a homogeneous mediumor an interface between two different mediums. Assume t1 is the time it takes for ultrasonic waves to reflect back from an object's outer surface, t2 is the time it takes for ultrasonic waves to reflect back from an object's inner surface, and c is thesound velocity in the object. As a result, the object's thickness δ is:

$$\delta=\frac{1}{2}c(t2-t1)=\frac{1}{2}c\Delta t$$

An ultrasound pulse can be produced, andan echo should be obtained within a certain time for a healthy pipe wall, as shown in Figure 2, depending on a collection of known conditions (e.g., pipe wall material and thickness, temperature, and wave properties). A map of a segmentof pipeline wall can be tracked using an array of ultrasonic transducers.

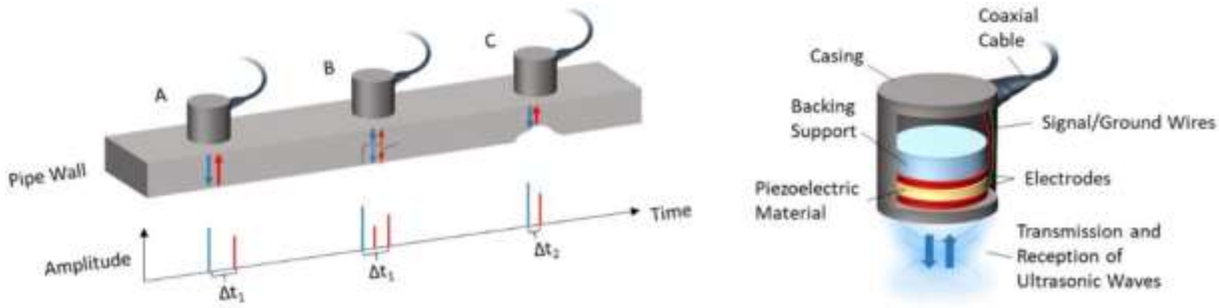


**Figure 2.** (Left) Under various conditions, ultrasound transmission and reflection. A: At time Δt1, a healthy pipe wall was detected with a far wall echo. B: A crack produces an initial reflection, which is accompanied by the predicted far wall echo. C: Corrosion/erosion thins the far wall, causing it to reflect too soon, resulting in Δt2. (Right) A typical ultrasoundtransducer diagram.

Ultrasonic sensors are commonly used in avariety of applications. The sensor can be used to emit an unfocused, divergent beamof ultrasound in a straight trajectory as a single crystal. The sensors can form a sensing array of multiple crystals that can recreate a cross-sectional picture of the monitored structure.[12][1] Furthermore, the overall wavefront can besteered (Figure 3) by changing the time delay (i.e. phase) of when each crystal emits the ultrasound wave. This allows theoverall wavefront to cover a greater area and detect a broader range of defect orientations.[15]

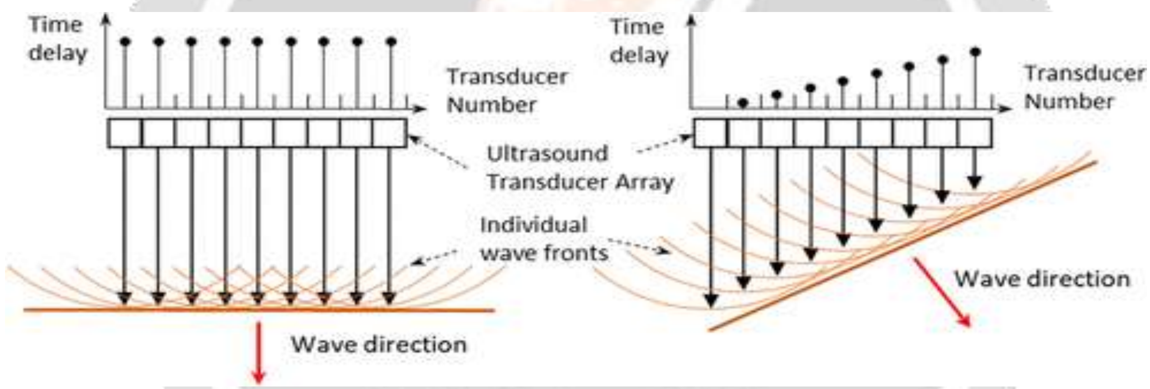


**Figure 3.** Time-delayed excitation of ultrasonic elements in an array is used to guide anultrasonic wavefront in various directions, as seen in this diagram.

## IV Literature Review

Based on one of the methodologies of monitoring system technologies, multi- crystal ultrasonic monitoring, a three- tiered system has been implemented to detect pipeline wall corrosion at a specific oil and gas station. The field data collection, data relay, and data control center of an oil and gas station make upthe majority of it.

The thickness of key points in the circumferential direction is monitored using a multi-crystal ultrasonic wavesensor.

The echo signal detected by this sensor mounted in the pipeline wall is converted to thickness ratio and then sent to the fielddata relay, where it is processed before being sent to the data control center. The entire system is based on the C/S (Customer/Service) model. This requires heavy hardware implementation and overhead costs which may not be feasible in all scenarios.

## V Conclusion

Owing to the vital significance of quicklydetecting and repairing pipeline damage before loss of life and property can occur due to pipeline failure, there is now a vastecosystem of inspection and monitoring

technologies are available. Based on modern ultrasonic monitoring technologies, the feasibility and reliability of an ultrasonic monitoring device for pipeline corrosion in a specific oil and gasfield has been investigated in this paper. Researching the gathered real time data and mining the data gives more insights into tackling the corrosion monitoring.
There is also scope for analyzing and understanding why and how corrosion happens, how the environment around the pipeline affects the corrosion, the chemistry behind it. There is a lot of room for research and development and this paper later could be extended to handle thesame.

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