Evaluation on the Ultrasonic Technique for Lekeage Detection in Onshore Oil and Gas Pipelines

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Pipelines are currently considered the safest means of transporting hydrocarbons. However, accidents with leaks in pipelines are still recurrent, despite safety regulations. Therefore, there is a need to detect these leaks efficiently and adapt to the environment. This article evaluates the possibilities that the ultrasonic technique presents for leaks detection in pipelines. An algorithm was used to divide into steps of importance, concepts such as technical feasibility, suitability, and capability. The method proves to be quite versatile and promises to be very accurate, an alternative for detecting leaks in long pipelines.

Keywords: Ultrasonic. Leakage. Pipelines. Evaluation. Hydrocarbons.

Introduction

Currently, pipelines are considered the safest means of transporting fuel. Today there are about 2.5 million kilometers of these pipelines transporting hydrocarbons [1]. However, even built and operated within the maximum international safety standards of the oil and gas industry, the pipelines are subject to construction problems, deterioration processes, and third-party interference, which lead to leaks [1,2]. Pipeline leaks are one of the most common types of accidents and one of the causes of large losses and soil contamination [1,3].

Environmental Issues Caused by Oil and Gas Leaks

Due to the discovery of new oil and natural gas deposits in Tabasco in Mexico, there has been an increase in infrastructure investments at the place, due to the abundance of hydrocarbons, reaching around 1,388 barrels per day [4]. So, the exploration and extraction of hydrocarbons have caused major damage to the environment due to the organic compounds generated by the oil spill at the site, generating several social impacts for residents of regions close to the deposits [4,5]. In 2018, around 1,600 hectares of soil contaminated by oil spills were recorded, where one of the causes is leakage in pipelines [4].

Ultrasonic Method

The ultrasonic method is characterized by a hardware-based, non-invasive acoustic method [3]. A common way to use this method is to use a pulsar, a transducer, and a device to display the captured signals. The pulsar is responsible for generating ultrasonic waves that travel along the walls of the ducts. Part of the energy of these waves will be reflected, and these signals will be captured by the receiving transducer [5]. If a leak occurs, the fluid into the pipe will be disturbed. Therefore, these waves will cause a significant variation in the voltage picked up by the transducer. The method has high sensitivity, characteristic of the acoustic method, and because of that, it can produce a higher rate of false alarms [3]. Also called lamb wave, the wave generated by the pulsar in steel pipes can be redirected and can propagate over a distance of 1km. Because of this, the ultrasonic technique presents itself as an ideal alternative for monitoring long ducts [6].

This article aims to analyze the ultrasonic technique for detecting leaks in oil and gas pipelines, using a method that allows the reader to understand in which situations the method is applicable.

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Materials and Method

To evaluate the ultrasonic leak detection technique for oil and gas pipelines, we used the algorithm shown in Figure 1. The algorithm allows separating the evaluation criteria in stages and order of importance.

Results and Discussion

Technical Feasibility

To insert a method into an environment, it is first necessary to know if it can adapt to the characteristics of the location [7]. Table 1 shows some of the possibilities offered by the ultrasonic method.

The ultrasonic method has no restrictions to any material, location or type of duct [3]. However, it behaves better in pipelines made of steel. Because in steel pipes the lamb waves can be redirected and can propagate over a distance of 1km [6].

Table 1. Technical feasibility criteria [3].

Criteria	For Ultrasonic Method
Pipeline type	Without restriction
Material type	Without restriction
Location type	Without restriction
Access requirement	Power energy
Pipeline conditions	No data
Pipeline sizes	Evaluate according the equipment
On-line inspection/ Off-line inspection	Evaluate according the equipment

Pipeline size and types of inspection will vary according to the type of equipment. In addition, no restrictions on the conditions of the pipeline for the use of this technique are reported in previous research.

Technical Suitability

At this point, it is evaluated whether the method can meet the specific needs, using the criteria in Table 2. The measured parameters are the frequencies of waves that are reflected as they travel through the pipeline [6]. The purpose of the method is to detect leaks and identify the place of rupture, which can be detected to an accuracy of inches. Furthermore, it is a sensitive technique (Table 3), because the method can identify micro leaks (previously research, the method has detected leaks of 0.02L/min) [8].

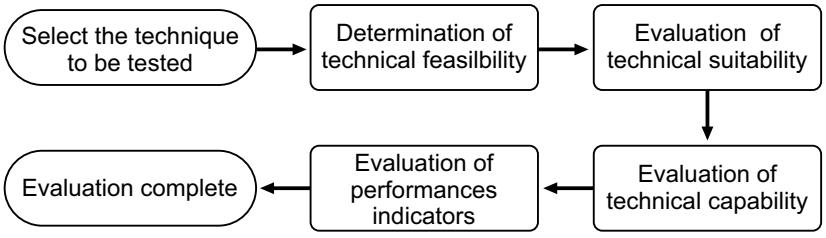
Technical capability

In this step, it is necessary to evaluate what the technique requires for the place where it will be inserted. The analog signal received by the receiving transducer needs to be converted to be

Table 2. Technical suitability criteria [3].

Criteria	For Ultrasonic Method
Measured parameters	Ultrasound requency
Detection purpose	Leakage detection
Cooperate with other techniques	Not necessary
Detection efficiency	It may vary depending on the equipment used

Figure 1. Algorithm to evaluate a technique [7].



analyzed. For this, a DSP module is used, which is equipped with a large number of flash RAMs, so it demands a structure that has high processing power, to result in a fully digital signal to be analyzed, and this can be an important restriction for the operation in remote sites [8].

Evaluation of Performances Indicators

Table 3. Performances indicators of ultrasonic technique [3].

Indicators	Classification
Adaptive ability	Can
Positioning accuracy	General
Response time	Fast
Sensitivity	High
Continuous monitoring	Can
False alarm rate	General
Maintenance requirement	General
Cost	Low

Conclusion

The ultrasonic technique is an excellent alternative for detecting leaks in oil and gas pipelines, due to its ability to adapt to different environments, in states of matter, and can detect micro leaks. Especially when the ducts are made of steel since in these cases the pulses can be redirected and propagate about 1km, which makes it a choice for detecting leaks in long-distance ducts. However, the technique has negative points depending on the equipment used, there will be a need to process at least part of these signals on the edge, if it is not possible to have equipment for processing the signals, it may be that the ultrasonic method is not the ideal, as it would require high bandwidth, depending on a more detailed cost assessment, between the cost of processing and sending data. The ultrasonic leak detection technique in oil and gas pipelines has shown potential for the hydrocarbon transport sector, mainly due to its ability to detect micro leaks and monitor pipelines over long distances.Despite the high processing power that the technique requires to process your data, with technological advances this technology may become a viable alternative for the market in the coming years. However, the lack of studies and the limitations of them that prove the efficiency and safety of the technique is an impasse for the adhesion to this technology. Following studies are recommended for future research on this subject.

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