EVALUATION OF THE ULTRASONIC TECHNIQUE FOR LEAKAGE DETECTION IN ONSHORE OIL AND GAS PIPELINES

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Abstract: 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 in which it will be inserted. This article seeks to evaluate the possibilities that the ultrasonic technique presents for the detection of leaks in pipelines. An algorithm will be used to divide into steps and in order of importance, using concepts such as technical feasibility, suitability and capability. The method proves to be quite versatile, and promises to be very accurate, a great alternative for detecting leaks in long pipelines.

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

AVALIAÇÃO DA TÉCNICA ULTRASSÔNICA PARA DETECÇÃO DE VAZAMENTO EM DUTOS DE PETRÓLEO E GÁS

Resumo: Os dutos são considerados os meios mais seguros para transporte de hidrocarbonetos. Porém, acidentes com vazamentos em dutos ainda são recorrentes, apesar das normas de seguranças. Diante disso, há a necessidade da utilização de um método para detectar vazamentos com eficiência e que consiga se adaptar ao ambiente em que está inserido. Este artigo busca avaliar as possibilidades que a técnica ultrassônica apresenta para a detecção de vazamentos em dutos. Para isso, será utilizado um algoritmo que será dividido em passos e ordem de importância, utilizando conceitos como viabilidade, aptidão e capacidade técnica. O método demonstra ser bastante versátil, e promete ser bastante preciso, uma ótima alternativa para detecção de vazamentos em longos dutos.

Palavras-chave: Ultrassônico; Vazamentos; Dutos; Avaliação; Hidrocarbonetos.

1. INTRODUCTION

Currently, pipelines are considered the safest means of transporting fuel. Today there are about 2.5 million kilometers of these pipelines transporting hydrocarbons in the world[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 can lead to leaks[1][2]. Pipeline leaks are one of the most common types of accidents and one of the main causes of large losses and soil contamination[1][3].

1.1 Environmental problems caused by oil and gas leaks

Due to the discovery of new oil and natural gas deposits in Tabasco in Mexico, there has been a large increase in infrastructure investments at the place, due to the abundance of hydrocarbons, reaching around 1388 barrels per day[4]. Under these conditions, the exploration and extraction of hydrocarbons has caused major problems to the environment due to the organic compounds that are generated with the oil spill at the site, generating several social impacts for residents of regions close to the deposits[4][5]. In 2018, around 1600 hectares of soil contaminated by oil spills were recorded, where one of the main causes is leakage in pipelines[4].

1.2 Ultrasonic Method

The ultrasonic method is characterized as a hardware-based, acoustic method and non-invasive[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. A 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, then the fluid into the pipe will be disturb. Therefore, these waves will cause a significant variation in the voltage picked up by the transducer. The method has high sensitivity, characteristic of acoustic methods 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 methodology that allows the reader to understand in which situations the method is applicable.

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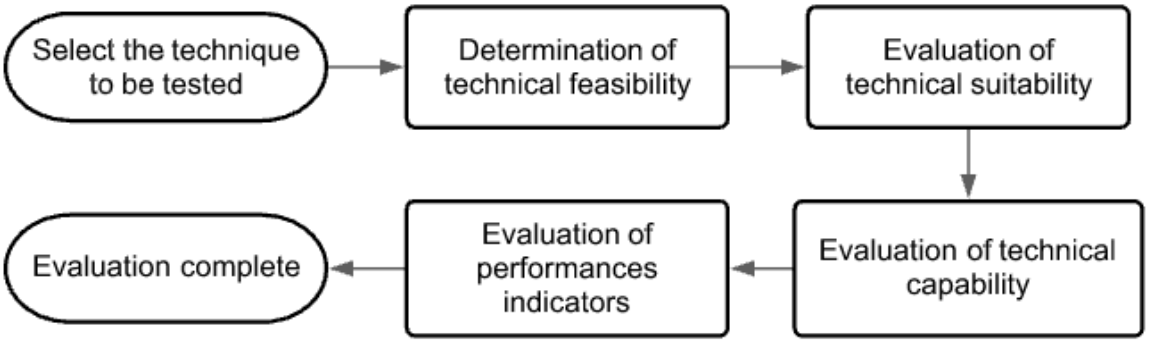
2. METHODOLOGY

In order to evaluate the ultrasonic leak detection technique for oil and gas pipelines, this article will use the algorithm shown in Figure 1, which allows separating the evaluation criteria in stages and in order of importance.

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



3. RESULTS AND DISCUSSION (ARIAL 12)

3.1 Technical Feasibility

To insert a method in 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.

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 about it
Pipeline sizen	Evaluate according to chosen equipment
On-line inspection/Off-line inspection	Evaluate according to chosen equipment

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 until 1km[6].

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.

3.2 Technical Suitability

Table 2. Technical Suitability Criteria[3].

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

At this point, it is evaluated whether the method is able to 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, as it is an extremely sensitive technique as shown in table 3, because of this the method can identify micro leaks, in previous research the method has been shown to detect leaks of 0.02L/min[8].

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

3.4 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

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False alarm rate	General
Maintenance requirement	General
Cost	Low

4. 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, states of matter and the ability to 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 great choice for detecting leaks in long-distance ducts. However, the technique has negative points, depending on the equipment used, there will be 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 it is possible that this technology will become a viable alternative for the market in the coming years. However, the lack of studies and applications that prove the efficiency and safety of the technique continues to be an impasse for the sector's adhesion to this technology. As well as studies on the limitations of this method in different materials and its efficiency for leak detection with several fluids in different states in the same pipeline. These gaps are recommended for future research on the subject.

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5. REFERENCES

[1] ABA, E. N. et al. Petroleum pipeline monitoring using an internet of things(IoT) platform. SN Applied Sciences, Springer, v. 3, n. 2, p. 1–12, 2021.

[3] GLISIC, B. Sensing solutions for assessing and monitoring pipeline systems. In: Sensor technologies for civil infrastructures. [S.l.]: Elsevier, 2014. p. 422–460.

[3] LU, H. et al. Leakage detection techniques for oil and gas pipelines: State-of-the-art. Tunnelling and Underground Space Technology, Elsevier, v. 98, p. 103249, 2020.

[4] QUIJANO, J. C.; TORRES-LóPEZ, K.; MARTíNEZ-RABELO, F. Soil contamination by petroleum in Tabasco, Mexico, and its environmental repercussions. Gaia Scientia, v. 14, p. 75–91, 12 2020.

[5] RAZVARZ, S.; JAFARI, R.; GEGOV, A. A review on different pipeline defect detection techniques. In: Flow Modelling and Control in Pipeline Systems. [S.l.]: Springer, 2021. p. 25–57.

[6] WANG, M. L.; LYNCH, J. P.; SOHN, H. Sensor technologies for civil infrastructures, volume 2: Applications in structural health monitoring. [S.l.]: Elsevier, 2014.

[7] MARLOW, D. et al. Condition assessment strategies and protocols for water and wastewater utility assets. CSIRO, 2007.

[8] FAROOQUI, M. A.; AL-REYAHI, A. S.; NASR, K. K. Application of ultrasonic technology for well leak detection. In: ONEPETRO. International Petroleum Technology Conference. [S.l.], 2007.

[9] SIQUEIRA, M. H. S. et al. The use of ultrasonic guided waves and wavelets analysis in pipe inspection. Ultrasonics, v. 41, n. 10, p. 785-797, 2004.

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