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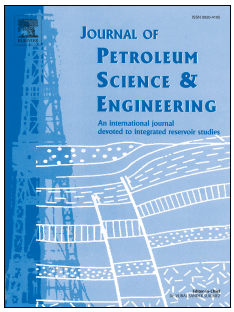

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PII: S0920-4105(17)30839-2

DOI: 10.1016/j.petrol.2017.10.059

Reference: PETROL 4382

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 19 June 2017

Revised Date: 13 October 2017

Accepted Date: 21 October 2017

Please cite this article as: Bolotina, I., Borikov, V., Ivanova, V., Mertins, K., Uchaikin, S., Application of phased antenna arrays for pipeline leak detection, *Journal of Petroleum Science and Engineering* (2017), doi: 10.1016/j.petrol.2017.10.059.

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ACCEPTED MANUSCRIPT

APPLICATION OF PHASED ANTENNA ARRAYS FOR PIPELINE LEAK DETECTION

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Abstract The paper proposes a method of passive leak detection for underwater pipelines by means of phased antenna arrays. It implies element-wise multiplication and addition of the output signals of individual array transducers. The proposed method provides a twofold increase in the resolution of the detection system in comparison with that obtained by conventional signal processing techniques and a high detection rate. The array pattern has been calculated numerically. The paper presents a version of the inspection system that implements the proposed method of signal processing using a phased antenna array, and the experimental results obtained.
Keywords: oil pipelines; gas pipelines; leakage acoustic wave; ultrasound; leak location.

1. Introduction

The length of oil and gas pipelines has been increasing year after year. The increased extent and exploitation periods of pipelines result in an increased number of accidents, which cause irreparable harm to the environment and the economy.

Pipeline damage statistics shows that 35% of all accidents are due to external factors, 24% are due to defects occurring during construction and erection work, 22% are due to pipe corrosion, 14% are due to defects occurring during pipe manufacturing, and 5% are caused by personnel [1]. To avoid accidents, it is very important to monitor pipelines for early leak detection. An early leak-detection system ensures that activities are safe and environmentally sound, and minimizes the potential interruption of oil and gas production. One of the currently most challenging projects in the petroleum industry is the exploitation of oil resources at great depths, which significantly increases the importance of early leak detection [2-4].

2. Methods of underwater pipeline leak detection

Various methods have been used for testing pipelines during their construction and operation: manometric methods, gas analysis and hydraulic mechanical methods. Authors use different mathematical and mechanical models to predict the behavior of flows in pipelines with leaks by detecting the change of pressure [2,5]. Recently, acoustic methods of leak detection [6] have received a lot of attention because they have several important advantages over other methods. Namely, they are more sensitive, require less energy, provide more information, can be conducted over a wide range of frequencies, are extremely safe, and can be recorded. For this reason, acoustic leak detectors are predominantly used for underwater pipeline testing. For these purposes, active and passive detection methods are used.

The active acoustic method

Active acoustic methods imply transmission of a probing signal in the test zone and reception of the pulse reflected from the object. Sonars with conventional circuitry and side-scan sonars with B- and C-type scanning employ this principle.

These devices provide the solution to several crucial problems:

1. The profile of the bottom under the pipeline is determined, and the data obtained are used to record the topography of the area. This information is required because of pipeline trench washout. In addition, soil erosion beneath the pipeline results in pipeline sagging and rupturing. Periodic monitoring of the topography, compiling an electronic database and its analysis allow identification of crucial changes in the bottom relief. The obtained data can be used to forecast the current state of the underwater pipeline, to work out a repair and maintenance plan, and to prevent accidents.

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