

Development of operational safety of the Baku-Tbilisi-Ceyhan (BTC) main pipelines, based on the improvement of methodical approaches to the study of the leakage problem

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Abstract: *One of the urgent problems of the main oil pipelines is to ensure safe operation of the line part, which is solved primarily by carrying out repair works on the scene of accidents identified as a result of proper monitoring. In order to choose adequate measures for warning about disasters and accidents, it is necessary to create scientific-methodical and relevant technical bases for a quantitative assessment of the risk of their detection. In these conditions, it is impossible to solve the key technical problems of the safe operation of pipelines without the use of methodology and a risk-oriented approach.*

That is why the choice of modern techniques and methods to ensure the safety of main pipelines based on risk analysis, depends on the development of scientifically based methods adapted to the given problem.

Therefore, the aim of the research is to increase the safety of the operation of Baku-Tbilisi-Ceyhan (BTC) main pipelines, based on improving methodical approaches to the study of accidents on pipelines, in particular leakage.

KEYWORDS: OIL PIPELINE, GAZ PIPELINE, ENVIROMENTAL IMPACT, RISK, THREAT.

1. Introduction

The Baku-Tbilisi-Ceyhan (BTC) pipeline is among the greatest engineering achievements of the new millennium. Its length is 443 kilometers through Azerbaijan, 249 kilometers through Georgia, and 1076 kilometers to the sea terminal of Ceyhan in Turkey. The pipeline is buried in the ground along its entire length. At its highest point, where it crosses the Caucasus Mountains, the pipeline reaches a height of 2800 meters above sea level. It can handle one million barrels of oil per day and meets the export requirements for the full development of the Azeri-Shiragi-Gunashli oil field.

BTC is one of the longest pipelines in the world. Its construction in Georgia was completed in 2005. The BTC pipeline was put into full operation in 2006. The flow of oil through the pipeline has been growing steadily, and last year, about 800,000 barrels of oil per day were delivered to world markets.

For the environmental and technical safety of the pipeline, the following works were carried out: restoration and landscaping works along the pipeline route following high standards. In 2006, the construction of additional facilities also began after the completion of the pipeline safety base on Kodiana's mountain section.

The construction of the oil emergency drain-down facility (EDDF) was also completed. This facility is an 8,500-cubic-meter reservoir, placed in another concrete underground, where, in the event of an accident, oil spilled from the BTC pipeline from anywhere in the Kodiana section will be captured and stored.

A central control room was established and located at the Sangachal Terminal. To connect with it as an emergency response center, a high-level communication network (telephone/email) has been established between the Sangachal Terminal and the existing emergency response center (BP offices at Vila Petrolea, Baku).

The pipeline operates according to international rules and standards, but it should be noted that the main foundations of pipeline transport, as well as the entire infrastructure, are aging. Thus, the most important task for ensuring the safe operation of pipeline systems is the continuous monitoring of the technical condition of the oil pipelines with the help of internal diagnostic examination of the working main pipes and the annual diagnosis of the oil pipelines.

A solid compromise must be found in the „relationship“ between the Baku-Tbilisi-Ceyhan oil pipeline transport systems and the natural environment. No engineering structure is as closely related to the environment as pipeline systems. This is explained by the wide geography of pipeline transport, the long length of the oil pipeline, the above-ground and underground location of the linear part, as well as the location of pumping and compressor stations in areas with difficult natural and climatic conditions, which often

leads to damage to pipelines, leakages, and often to the failure of the entire system.

So here, it is very important to monitor pipelines for the timely detection or even prediction of leakages at an early stage.

Leakage detection at an early stage will allow us to stop oil spills and reduce possible losses, damages to pipelines, and other serious social and environmental factors[24].

In recent decades, several pipeline leakage detection methods with different working principles and approaches have been proposed. The existing leakage detection methods include acoustic emission [1-3], fiber optic sensor [4-6], ground penetrating radar [7-8], negative pressure wave [9-11], pressure point analysis, dynamic modeling, vapor sampling, infrared thermography, digital signal processing, and mass-volume balance.

2. Research

Our research presents: methods of steam sampling, visual/biological, remote control, and autonomous underwater vehicles.

Vapor Sampling Method. Vapor sampling is commonly used to determine the amount of hydrocarbon vapor in a pipeline. Although it is used in gas storage tank systems, it is also suitable for determining gas emissions in the surrounding area of the pipeline. Oil spills can be determined by measuring the recorded gas concentration as a function of pumping time and, therefore, the absorption rate [12]. In cases of pipeline leakages, the diffusion of vapor or gas in the pipeline is a result of the concentration gradient, which, after a certain period of time, produces an accumulated signal indicating the presence of hydrocarbons in the pipe environment [13].

As the gas concentration increases, the leakage peak also increases. The higher the gas concentration in the pipe, the higher the leakage peak. [12]. Different types of pipeline leakage monitoring systems based on steam sampling are proposed in the literature. According to the study [2], a hose sensor should be placed under the pipeline to detect leakage from the pipes. Figure №1 illustrates the sensor hose that is placed in the pipeline in order to maximize system effectiveness.

The advantages of vapor sampling systems include the ability to detect small leakages independent of pressure or flow balance and their high efficiency for leakage detection in multiphase flow applications. In addition, the sensor can withstand significant hydrostatic pressure. However, one of the main drawbacks of this technique is the response time. It usually takes a lot of time to respond to leakages.[12],

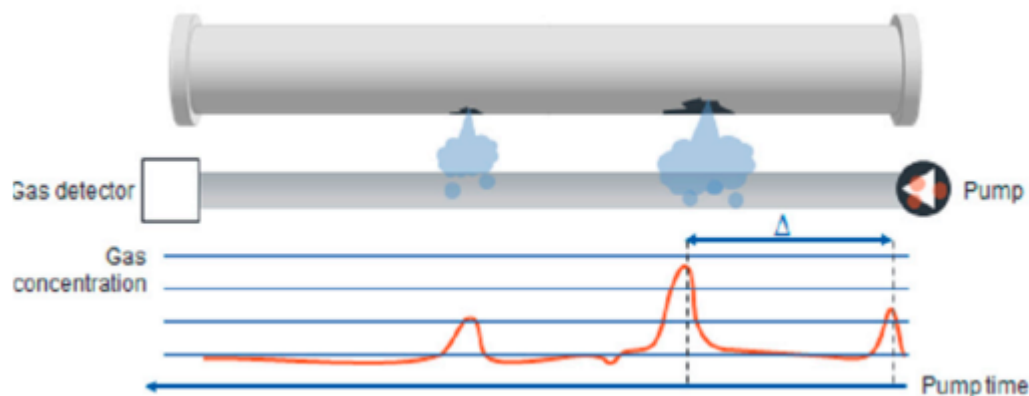


Figure 1. Sensor hose positioning in the pipeline to maximize system efficiency.

Oil spills in the pipeline area will be detected using trained dogs, skilled personnel, smart pigging, or helicopters/drones [2].

This method uses trained personnel who can detect a leak through visual observation or a smell coming out of a crack. Dogs and smart pigging are also used. They are sometimes equipped with sensors and data recording devices such as fluorescent, optical or video cameras with a large sensitivity range at high visibility levels.

A trained dog is more sensitive to the smell of certain gases than a human [17-18]. But, dogs are ineffective when working longer than 30-120 minutes due to fatigue [19]. In addition, the time and duration of detection also depend on the frequency of inspections, which in some countries, such as the USA, are at least once every three weeks [21].

The way oil transportation operators work has been changed by the advent of **Remotely Operated Vehicles (ROVs)**. These tools have been proven to be more robust to underwater pipeline inspection tasks and operate in deep sea areas inaccessible to dogs, pigging, or humans [22].

The working principle of the ROV is based on remote control, which involves the master-slave system. The ROV is designed to cope with extreme environments, such as dangerous

underwater environments, by controlling the movement of a slave robot using devices such as joysticks or haptic devices.

The recent development of remotely operated vehicles (ROVs) has changed the operation way of offshore oil transportation operators. It is shown that ROVs are suitable for performing subsea pipeline inspection tasks and operate in deep water beyond the reach of dog, pigging, or human divers [20].

All Robot Sensors 2019, 19, 2548 14 of the 36 commands, sensory feedback, and power are sent via an umbilical cable that connects the ROV and the deployment vessel.

The emergence of **autonomous underwater vehicles (AUVs)** has changed the degree of human operator involvement in pipeline inspection and monitoring, thereby reducing casualties.

Although the principle of operation of an AUV is similar to that of a remote control ROV, it differs only to a limited extent. It should be noted that more qualified operators are needed for AUV dispatching [21].

There are many types of AUVs and ROVs commercially available for monitoring oil and gas infrastructure, as shown in Figure №2.



Figure 2. Available systems for oil and gas infrastructure monitoring.

The advantage of using unmanned vehicles for pipeline inspection lies in lower maintenance costs and higher operational safety due to the remote operation system, making it suitable for monitoring in more hazardous environments.

However, unfortunately, these systems also have some drawbacks. For example, the cost of purchasing or leasing an AUV/ROV is very high. In addition, during bad weather conditions like clouds, wind etc., the performance of these machines is restricted. Also, in some specific areas, there are legal restrictions

on the use of unmanned systems due to safety concerns, as unmanned vehicles usually do not have the ability to proactively detect and avoid other AUVs on board [22].

It should be noted that much effort has been devoted to the study of underwater robotic sensing and navigation methods in order to create fully autonomous AUV pipeline inspection and monitoring systems that will result in minimal human presence.

3. Conclusion

In our research, an analysis of the use of modern techniques and methods was carried out on the example of ensuring the safety of the Baku-Tbilisi-Ceyhan main pipeline. In particular, various approaches to pipeline leakage detection are discussed, such as: vapor sampling, visual/biological, remote control, and autonomous underwater vehicle methods.

4. References

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