OIL LEAKAGE DETECTION SYSTEMS IN PIPELINES

Liya Haidarovna Fokeeva, Ilmira Ilshatovna Akhmetova
Kazan Federal University
e-mail: fokeeva.00@mail.ru

ABSTRACT
It is necessary to carry out control of pipeline integrity for their reliable operation. When transporting hydrocarbons, except losses of the transported product, especially important requirement is restriction of environmental pollution. For this purpose pipelines are equipped with detection systems and localizations of leaks (SOU). Today such methods are developed and offered in the market of the leak detection system, working at a basis of such principles: continuous monitoring of technological information on operation of the oil pipeline in real time and identification of non-staff situations; the periodic analysis of a condition of the oil pipeline by means of diagnostic aids; continuous monitoring by means of the specialized sensors established along the oil pipeline and distinguishing leakages of a product on the basis of the analysis of change of chemical or physical properties of surrounding space or the oil pipeline from the outside. The functions of management leaning on methods of mathematical modeling find more and more broad application in modern systems of automated management. In this work systems of detection of leak of oil in pipelines are considered. The analysis of a scope of such systems is carried out and classification of classical technologies of leak detection is given. Methods of identification of leaks and their efficiency are studied. Conclusions are drawn on efficiency of use of modern systems of detection of leak of oil in oil pipelines.

Keywords: leak, leak detection system, pipeline systems, pressure wave, leak detection system, pressure sensors.

INTRODUCTION

Pipeline systems are one of the most economic and safe ways of transportation of gases, oil, oil products and other liquids. As means of transportation on long distances pipelines have high degree of safety, reliability and efficiency. The most part of pipelines in independence of the transported environment about 25 years are developed proceeding from operation term. In process of aging they begin to refuse, there are leaks in construction weak points of the connections, points of corrosion and sites having small structural damages of material.

The main task of the systems of leak detection (SDL) consists in helping the owner of the pipeline to elicit the fact of leak and to define its location [1].

The leak detection system represents the complex of program technical means processing in real time information from the sensors located on the pipeline for the purpose of identification of the fact not of tightness (leak) and definition of the place and time of emergence of leak. In system several methods of identification of leaks are used: on pressure wave, a method of volume balance, a method of the analysis of a profile of pressure [2].

METHODS AND MATERIALS

The method of identification of leaks on a wave of pressure is used for swift definition of leakages of small volume with high precision. The main idea of a method consists in the analysis of distribution of waves of pressure drop in the pipeline. For registration of waves of pressure controlled point of telemechanics is equipped with two sensors of pressure of SOU connected to the block of leak detection. Blok analyzes signals from sensors, reveals waves of pressure drop and defines their direction and time of passing. Use of the GPS receiver for synchronization of time allows achieving the highest accuracy of registration of the moment of passing of a wave. Information on the found waves is delivered to control

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center by means of system of telemechanics. Methods of volume balance and the analysis of a profile of pressure allow finding the fact and the place of emergence of leakages of large and average volumes on the basis of the analysis of change of technological parameters [2].

Classical technologies of leak detection.

Historically the first technology of expeditious detection of leak of oil on pipelines of JSC Transneft and JSC Transnefteproduct is based on comparison of pressure which is periodically received from manometers on reception and delivery lines of pump stations to the calculated values for the set productivity.

Modern means of SAU allow expanding possibilities of obtaining primary information through cyclic poll of sensors of pressure in the points of measurement dispersed on the route. The system of station automatic equipment traditionally equips all pump pumping-over stations (PPOS) of JSC Transneft and JSC Transnefteproduct.

Method advantages: the lowest cost; simplicity of an algorithm; efficiency of detection of considerable leaks (accidents, explosions, etc.)

However, the used determined methods of the set isometric modes give more than 30% of an error of calculation of distribution of operational pressure for length of pipelines [2].

Method shortcomings: low sensitivity (10... 15% of nominal productivity); application only at the set mode of operation of the pipeline; false operation during the pumping of various liquids or violation of a stream density; big error. False operation of the SOU systems first of all are caused by the level of the models used for the description of behavior of the operational site of the oil pipeline laid in a land relief.

Method of a hydraulic location of the place of leak

The physical essence of a method consists in the analysis of hydraulic characteristics of the site of the oil pipeline. The measured size in this case is manometrical pressure on the ends two specially chosen basic segments which are near the pumping-over stations. According to indications of manometers the hydrostatic pressure of a product is restored. The line of hydraulic biases drawn on levels of hydrostatic pressures in two points is extrapolated to all sites between pump stations [3]. Method advantages: low operational cost; use only of regular means of PILES; efficiency of detection of considerable leaks (accidents, gaps); additional analytical opportunities: visualization of distribution of pressure on the route. Method shortcomings: low sensitivity (5... 15% of nominal productivity), depending on an arrangement of the defective site; existence of "a dead zone" at the end of the operational site; application only at the set mode of operation of the isothermal pipeline; it is not applicable in pipeline networks with dumping and pumping;

Nevertheless, the barrocorrection principle is applied everywhere in all modern technologies of diagnostics of leaks together with other methods in view of satisfactory accuracy in definition of the place of leak and low cost of equipment rooms and software.

Method of comparison of expenses

The method is based on constancy of an instant consumption of oil product at the beginning and at the end of the section of the pipeline in the absence of leak and the set transfer mode. In case the difference of expenses exceeds the admissible limit set by the program automatically the alarm system about emergence of leak works [3].

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Advantages: it is effective for swift detection of considerable leaks at the set transfer mode on the basis of computers; providing continuity of remote control of emergence of considerable leaks; ensuring automatic processing of the arriving information; providing an automatic stop of transfer on the pipeline and overlapping of latches; let's apply irrespective of weather conditions; does not influence the transfer mode. Shortcomings: low accuracy; low sensitivity to leak size; during start-up and a stop of transfer on the pipeline the system gives false testimonies; comparators of an expense can be used only in short sections of the pipeline as do not consider the temperature amendment and heat-sink ability of the pipeline; change and repair of turbine flowmeters demands a transfer stop on the pipeline; existence of false operations.

Modern methods of leak detection.

SOU on the basis of the TraceTek cable. The system of detection of leak of TraceTek liquid represents flexible modular system with interchangeable components which can be configured variously. [4].

Controlled liquid in case of leak closes a chain of a cable and current, having passed on a line of least resistance, receives the increased tension, detecting which the device generates a signal of leak.

Advantages: lack of open metal parts; simple installation and maintenance; automatic monitoring of defeats and ruptures of cables; all cable is a sensor; the place of leak is estimated with a margin error higher than 0,1%.

Methods of negative shock waves

According to the theory of the unsteady processes, at the time of leak emergence (or selection) liquids in the pipeline arise discharge waves.

Advantages: it is effective for swift detection of considerable leaks;

Let’s apply irrespective of length and a design of the pipeline; ensuring remote automatic information transfer about emergence of leak;

Independence of weather conditions; ensuring continuous and objective control; ensuring high reliability; ensuring simplicity of a design and operation of devices.

Shortcomings: low accuracy when determining location of considerable leaks; low sensitivity to leak size; sensitivity of a method decreases at consecutive transfer of various products.

Differential method of the data of balance of expenses.

Depending on features of processing of initial information it is methodized linear balance, to a method of comparison of expenses, the method is capable to register "small" leaks (less than 1%).

According to the principle of linear balance of masses the difference of expenses of the transported product on an entrance and an exit has to be equal to changes of its quantity in the tight pipeline [5]. ATMOS which is the specialized subsidiary Shell responsible for development and introduction of systems for detection of leakages of pipelines under the ATMOS Pipe trademark uses the following method which with success is applied on the pipeline of crude oil of Baku-Tbilisi-Ceyhan.

The pipeline 1768 km long passes through a difficult mountain landscape, in Georgia in places towering more than on 2500 m, in Turkey remaining at the level from 1500 to 1600 m, and sharply decreasing at the Mediterranean Sea. In operating time of the pipeline two independent SOU in parallel work.

Statistical diagnostics: leak is determined by the statistical analysis of an imbalance of a stream calculated on measurements of an expense and pressure on all length of the pipeline.

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SOU on the basis of hydraulic model: leak is diagnosed by comparison of an expense and pressure of the simulated pipeline and an expense and pressure received from sensors. If the divergence is found - the system signals about leak [6].

Statistical SOU works at the ordinary independent personal computer in both control offices in Sangachale (SDP) and Ceyhan (DDP). SOU personal computer in SDP is coordinated with the integrated automated control system and safety of SDP, and SOU personal computer in DDP directly contacts the joint automated system at board and safety of DDP. Communication is provided on "Ethernet network, using the TCP/IP protocol.

The combination of calculations of probabilities with technology of recognition of models allowed the ATMOS Pipe system to reach very high degree of reliability in sense of minimizing of emergence of false alarms at high sensitivity to formation of leak in the transitional and stationary modes. ATMOS supports protocols of exchange with the known tools: Yokogawa, InTouch, Honeywell and of river.

However essential shortcomings of a way are its lag effect (time of detection of leak up to 20 period of poll of sensors), a big error in localizations of the place of leak and the long period of time of training of formal model when changing design data of system, properties by pumping product or external service conditions.

Fiber-optical system of detection of leakages of the Sensornet company

The digital detector of leakages of the Sensornet company is extraordinary sensitive and capable to diagnose leak even in 1 liter. Thanks to continuous updates of information the system provides a constant vigilance, in quality sensitive an element the standard (telecommunication) fiber-optical cable located in close proximity with the pipeline [7] is used.

This cable is also that linear sensor which allows to control changes of Temperature (the delta of T °) and Tension (the delta of E) in each point on all length of the pipeline. The fiber-optical cable settles down in a special fillet with the pipeline in close proximity. As soon as the carrier comes to the pipeline, the temperature of the soil surrounding the pipeline changes. If this carrier is oil, then it heats the pipeline and the soil surrounding it, also the touch optical cable, close to the pipeline, in turn heats up that is immediately displayed on the central panel. Similarly, in attempt of unauthorized connection temperature of the soil surrounding the pipeline also changes and distributed an alarm signal. Localization of an event is carried out on the basis of use of the principle of operation of the Radar - the interval of time between launch of an optical impulse in touch optical fiber and the moment of receipt of back reflected impulse on a photodetector of the measuring device is measured. Knowing the speed of distribution of light in optical fiber, it is easy to transform the received time interval to distance.

The fiber-optical cable is established on all length of the pipeline and takes readings through each meter. The system can be used on pipelines of big length with the established intermediate repeaters providing full coverage of the pipeline with a possibility of detection of a point of leak with an accuracy of 1 m.

The system can include in structure of a cable additional fibers for

telecommunications that excludes need of laying of separate cables of telecommunication and by that reduces material inputs.

System shortcomings: fiber-optical systems are effective for rather compact objects differing in the low noise level when the registered signal from violators exceeds this noise and can be quickly confirmed with other means of protection: video surveillance, a dress of protection, and repair of a vulnerable fiber-optical cable does not demand considerable time and financial expenditure. The fiber-optical system on the pipeline with big extent does not meet these conditions [8].

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The fiber-optical cable is vulnerable: its damage to one point puts out of action system on the considerable site, as a rule, between stations of processing of signals (about 100 km) or to the place of a rush. Damages can be both natural because of a soil motion, and criminal for the purpose of production of inserts [9].

The rupture of a fiber-optical cable near highways masks noise of motor transport. Besides, it is possible to tear a cable practically in any place on the pipeline as time necessary for its opening, is less than an arrival time of protection. Repair of the pipeline demands restoration of a fiber-optical cable, joints as a result appear. Attenuation of signals in joints leads to irreversible decrease in sensitivity of fiber-optical systems.

At registration of leakages of emergency character on the most responsible places - crossings of pipelines with the rivers, noise of water limits sensitivity of fiber-optical system, the small difference of temperatures of oil and water is often not sufficient for registration. Besides, the watercourse can exclude completely contact of a fiber-optical cable with the following oil, and the high thermal capacity of water leads to swift alignment of temperatures.

Infrasonic system of monitoring of pipelines

In ISMT method of registration of infrasonic fluctuations which has showed researches, extend in the pipeline (at least, with liquid products) to distances to several hundred kilometers is used. Thanks to weak attenuation of infrasonic waves this system is capable to find leak from the pipeline, mechanical impact on a pipe wall, the sources of "noise" which are formed on considerable removal from a place of registration [10].

Application of neural networks for diagnostics of leaks.

Neural networks are one of the directions of researches in the field of artificial intelligence, based on attempts to reproduce nervous system of the person. Namely: ability of nervous system to study and correct errors that has to allow simulating, though is rather rough, work of a human brain.

Neural networks found application in the most various areas of human activity - business, medicine, the equipment. Feature of neural networks is connected with the fact that they use the training mechanism, besides in many cases neural networks allow to overcome the so-called "damnation of dimension" caused by the fact that modeling of nonlinear structures in case of a large number of variables demands huge computing resources.

This type of neural network classifies data, dividing space of entrances into two parts the line. Therefore it can be applied only to linearly separable data.

RESULTS

The advantage of definition of the place of leaks on a wave of pressure is the continuity in time, efficiency, independence of weather conditions. However this method has also shortcomings. Such, as: impossibility of work in the presence of self-flowing sites on the controlled oil pipeline; relief of the area; dependence on operation of the pump equipment etc.

DISCUSSION

When determining the place of leak influence of branches on the transfer mode has to be important. For further development of a research it is necessary to construct three-dimensional charts of dependences of parameters of the main oil pipelines on parameters of a branch (insert).

SUMMARY

The list of various methods of leak detection and unauthorized inserts was presented and analyzed. The existing classifications of methods of leak detection are considered.

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The analysis of monoparametrical monitoring methods of detection of the leaks applied in the main transport of hydrocarbons shows that practically all range of available telemechanics in traditional systems and ACS of information is involved. As key parameter not only pressure and productivity, but also their derivatives on time and length are used.

CONCLUSIONS

Systems of leak detection from pipelines are of great importance for operation as allow to reduce not only idle time of the pipeline, but also to prevent irreparable consequences.

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