Information-measuring system for monitoring the location of underground gas pipelines on the basis of improved acoustic resonance method

S A Nazarychev¹, S O Gaponenko², A E Kondratiev², R Z Shakurova²

¹Kazan Federal University, 18 Kremlyovskaya str., Kazan 420008, Russian Federation
²Kazan State Power Engineering University, 51 Krasnoselskaya str., Kazan 420066, Russian Federation

E-mail: nazarichev.sa@gmail.com

Abstract. Instrument established on the basis new method of detection hidden channels and gas pipelines, made of both metal and non-metallic materials. For the operation of the information-measuring complex was developed and created soft-ware and hardware. Laboratory and in-situ studies have been conducted to confirm the performance of the proposed technical solution.

1. State of problem
The problem of damage to existing pipelines is important when laying new communications, performing construction work or drilling wells. A damaged gas pipeline poses a serious danger when working on any objects [5-9, 10-14].

When carrying out earthworks, it is recommended to use specialized devices for detecting hidden communications, based on the registration of electromagnetic fields. There is a question about the possibility of detecting non-metallic objects [1,2, 5-9, 10-14].

There are quite a number of methods to control the location of underground gas pipelines and communications. However, some methods have a limited scope, as they «see» only pipelines made of metallic materials, others have a weak selectivity, especially in the case of a large number of different communications that are laid next, others are difficult to implement.

2. Technical map of the work (description of development)
In this paper, we propose the low-frequency vibroacoustic method for monitoring the location of hidden channels and underground gas pipelines made of both metallic and non-metallic materials. The method is described in more detail in the patent for invention No. 2482515 RU, see Fig. 1. According to the authors, as well as the conducted studies suggest that the proposed technical solution is selective, simple and low-cost compared to other control methods[1-3].
The device that implements the proposed method of determining the location of the pipeline (1 – personal computer; 2 – digital-to-analog converter (DAC); 3 – signal amplifier; 4 – dynamic emitter; 5 – well; 6 – pipeline; 7 – sensitive element; 8 – analog-to-digital converter (ADC)).

The selectivity of control is increased due to the fact that the resonant frequency of the test object is excited, which makes it possible to determine the location of underground gas pipelines in a more simplified way. Due to this, it is possible to detect both metallic and non-metallic underground gas pipelines with high reliability.

To implement the proposed low-frequency vibroacoustic method of control, an information-measuring complex was developed and created [1-3].

3. Description of the information-measuring complex
The exterior view of the information-measuring complex is shown in Fig. 2.

For the operation of the information-measuring complex in the LabVIEW software package, the software and hardware “Software complex for monitoring the location of hollow objects by their resonant frequency” was developed and created [1-3, 10].

The front panel of the program is shown in Fig. 3.
In the continuation of the research topic, laboratory and full-scale tests of the information-measuring system were carried out, see Fig. 4.
The investigated objects (pipelines) were placed in the ground. The depth of occurrence was 0.7; 1; 1.3 and 2 m (from the pipeline wall to the edge of the soil). Along the pipeline axis along the surface of the soil, studies were conducted with an interval of 10 cm. 5 measurements were made at each control point in order to obtain an average amplitude value. The object of study was scanned by frequencies in the range from 100 to 1400 Hz, and the resonance frequency was determined by the maximum of its amplitude. The oscillations were recorded by the information-measuring complex.

Prior to the experiment, for the reliability of the results, the reference signal was calibrated by amplitude.

Testing the information-measuring system in field conditions represented in Fig. 5.

![Fig. 5. Testing the information-measuring system: 1 – PC, 2 – ADC/DAC, 3 – dynamic, 4 – piezoelectric sensor.](image)

Studies were conducted on various pipelines made of various materials (polyethylene, polypropylene, steel). As an example, a pipeline with geometric parameters: length 2000 mm, diameter 125 mm, wall thickness 3.1 mm, material polyethylene, see Fig. 6.

![Fig. 6. Polyethylene pipeline 2000x125x3.1.](image)

According to the results of the research, the main resonant frequency (informative) was obtained, which depends only on the diameter of the pipeline. In continuation, this frequency was generated, and the oscillations were picked up on the ground surface. In continuation, this frequency was generated, and measurements of oscillations were made on the ground surface, see Fig. 7.
Figure 7. Measuring point No.1.

Figure 8 shows the oscillation spectrum of the pipeline at measuring point No. 1, see Fig. 7, (10 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.294 V.

Figure 8. The oscillation spectrum of the pipeline at the point No.1.

Figure 9 shows the oscillation spectrum of the pipeline at the measuring point No. 2 (20 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.292 V.

Figure 9. The oscillation spectrum of the pipeline at the point No.2.

Figure 11 shows the oscillation spectrum of the pipeline at the measuring point No. 3, see Fig. 10, (30 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.298 V.
Figure 10. Measuring point No.3.

Figure 11. The oscillation spectrum of the pipeline at the point No.3.

Figure 12. Measuring point No.4.

Figure 13 shows the oscillation spectrum of the pipeline at the measuring point No. 4, see Fig. 12, (40 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.292 V.
Figure 13. The oscillation spectrum of the pipeline at the point No.4.

Figure 15 shows the oscillation spectrum of the pipeline at the measuring point No. 5, see Fig. 14, (50 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.301 V.

Figure 14. Measuring point No.5.

Figure 15. The oscillation spectrum of the pipeline at the point No.5.

Figure 17 shows the oscillation spectrum of the pipeline at the measuring point No. 6, see Fig. 16, (60 cm from the beginning of the pipeline to the installation of the sensitive element - piezo sensor) with a frequency of 743 Hz and an amplitude of 0.3 V.
4. Conclusion
1) The method for monitoring the location of underground gas pipelines on the basis of low-frequency vibroacoustic method was developed and implemented in the form of information-measuring complex [1].
2) The software and hardware support for the management of the information-measuring complex was developed in the LabVIEW package [1].
3) Laboratory and field studies were carried out confirming the operability of the proposed technical solution.

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