Determination of the oscillation frequencies of corrosion defects finite element methods in order to develop methods of acoustic monitoring of pipelines

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Abstract. In this paper discusses issues related to increasing the reliability of heat supply systems. To determine the diagnostic criteria for defects in the numerical modelling of pipeline components and determined the frequency ranges in which it is necessary to analyze the acoustic signals.

1. Introduction
Currently about 60 percent of the pipeline heating systems in the Russian Federation have outlived their usefulness. There is no possibility of heat supply organizations to replace a number of such pipelines. To ensure reliable heat supply way out of this situation is the use of nondestructive testing and technical diagnostics in order to timely address the causes of possible failures.

A large number of failures due to corrosion of pipelines, therefore, the development of new methods for the detection of corrosion damage to metal is an urgent task. It is now widely used methods based on the analysis of natural acoustic oscillations in various continuous media [1], [2]. When choosing a method of control is necessary to take into account the fact that the heat pipes are in operation are mostly underground and difficult to access for inspection. It is known [3], [4] that for solving such problems, acoustic control methods have advantages over other methods.

2. The method of monitoring the technical condition of pipelines
Research is devoted to the development of the method of control piping analysis of acoustic signals propagating along the transported product from fluctuations pipeline sections with reduced due to corrosion of the wall thickness.

To date, no significant defined informative frequency ranges of acoustic spectra pipelines, indicating the presence of a defect of the pipeline wall, its size, for loaded circulating fluid piping.

The complexity of identifying pipeline corrosion defects during the experiment set the task to develop methods of numerical modeling of pipelines with different corrosion defects.

In order to find in the acoustic spectrum pipelines frequency domain characteristic of corrosion defects in the software environment of ANSYS were calculated natural frequencies of pipeline sections with models of corrosion damage in the form of a round plate with different sizes.

Simulated pipeline sections (Figure 1, Figure 2) 1500 mm long with corrosion defects dimensions 50x50 mm, 100x50 mm, 150x50 mm, 200x50 mm, 250x50 mm, and different values of wall thinning.
Corrosion defects in the form of reduced wall thickness was modeled disc rigidly clamped along the perimeter. Tube material is steel density $\rho = 7860 \text{ kg/m}^3$, Poisson ratio $\nu = 0.3$ and a modulus of elasticity $E = 20 \times 10^{10} \text{ N/m}^2$.

Figure 1. Finite element model of pipeline sections.

Figure 2. Finite element model of pipeline sections with the same area of corrosion damage but a different number and size of defects.
Figure 3 shows the dependence of the change the natural frequency of the defect model of the depth of penetration into the wall material. From the above graph it is clear that with increasing depth of corrosion damage occurs reduction in the frequency of different forms of oscillation disk.

![Figure 3. Changing the natural frequency of the model pipeline corrosion defects on its depth (disc diameter 50 mm).](image)

3. Conclusions

As a result of numerical simulation to the following conclusions:

1. In the vibration spectrum faultless tubes are present primarily low frequency of 200 to 3000 Hz, and for tubes with defects increase characteristic oscillation frequencies up to 4500 Hz, and the presence of additional frequencies in the range from 6000 to 9000 Hz. The presence of small defects manifested in the higher frequency range.

2. It has been established that an increase in the number of defects in the same area affected frequency range of oscillation section of the pipeline increases. Extension of the range due to the fact that the defects, which are a kind of membrane, emit frequencies higher orders.

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References

[1] Vankov Yu V 2003 Izvestiya Vysshikh Uchebnykh Zavedenij. Aviatsionnaya Tekhnika (3) 69-71
[2] Larionov V M and Nazarenko T I 2000 Izvestiya Vysshikh Uchebnykh Zavedenij. Aviatsionnaya Tekhnika (4) 69
[3] Belov E V, Vankov Yu V, Ivshin I V, Kochergin A V, Pervukhin D N, Tunakov A P 1996 Acoustical Physics 42(1) 14-17
[4] Vankov Yu V, Kazakov R B, Pervukhin D N, 2004 Zavodskaya Laboratoriya. Diagnostika Materialov 70(3) 34-38
[5] Vankov Yu V and Kondrat'ev A E, 2004 Pribory i Sistemy Upravleniya (2) 45-53
[6] Vankov Yu V, 2004 Pribory i Sistemy Upravleniya (2) 53-58