Transverse vibrations of viscoelastic beams of variable length, taking into account the action of damping forces

Литвинов В.Л.[1], *Литвинова К.В.*[2]
1 - Самарский государственный технический университет, Самара, Россия, *E-mail: vladlitvinov@rambler.ru*; 2 - Московский государственный университет имени М.В.Ломоносова, Геологический факультет, Кафедра теоретических основ разработки месторождений нефти и газа, Москва, Россия, *E-mail: vladlitvinov7777@rambler.ru*

The resonance characteristics of viscoelastic beams with moving boundaries using the Kantorovich - Galerkin method are examined in the article. The phenomenon of resonance and steady passage through resonance are analyzed. Approximate method of Kantorovich - Galerkin is developed in relation to the accounting effect on the system of the resistance forces, viscoelastic properties. This method also allows us to consider a wider class of boundary conditions compared to other approximate methods for solving boundary value problems with moving boundaries.

One-dimensional systems whose boundaries move are widely used in engineering [1-11]. The presence of moving boundaries causes considerable difficulties in describing such systems. Exact methods for solving such problems are limited by the wave equation and relatively simple boundary conditions. Of the approximate methods, the Kantorovich-Galerkin method described in [11] is the most efficient. However, this method can also be used in more complex cases. This method makes it possible to take into account the effect of resistance forces on the system, the viscoelastic properties of an oscillating object, and also the weak non-stationarity of the boundary conditions.

The paper considers the phenomena of steady-state resonance and passage through resonance for transverse oscillations of a beam of variable length, taking into account viscoelasticity and damping forces.

Performing transformations similar to transformations [11], an expression is obtained for the amplitude of oscillations corresponding to the n-th dynamic mode. Expressions are also obtained that describe the phenomenon of steady state resonance and the phenomenon of passage through resonance.

The expression that determines the maximum amplitude of oscillations when passing through the resonance was numerically investigated to the maximum. The dependence of the beam oscillation amplitude on the boundary velocity, viscoelasticity, and damping forces is analyzed.

The results of numerical studies allow us to draw the following conclusions:

- with a decrease in the velocity of the boundary, viscoelasticity and damping forces, the amplitude of oscillations increases;

- as the boundary velocity, viscoelasticity and damping forces tend to zero, the oscillation amplitude tends to infinity;

In conclusion, we note that the above results make it possible to carry out a quantitative analysis of the steady state resonance and the phenomenon of passage through the resonance for systems whose oscillations are described by the formulated problem.

References

1) Vesnitsky A.I., Potapov A.I. Transverse vibrations of ropes in mine hoists // Dynamics of systems. Bitter: Bitter. un-t, 1975. Number 7. S. 84–89.

2) Anisimov V.N., Litvinov V.L. Longitudinal vibrations of a viscoelastic rope of variable length // Tr. 4th All-Russian. scientific conf. “Mathematical models of mechanics, strength and reliability of structural elements. Mathematical modeling and boundary value problems. " Samara: SamSTU, 2007. Part 1. P. 25–27.
3) Goroshko O.A., Savin G.N. Introduction to the mechanics of deformable one-dimensional bodies of variable length. Kiev: Science. Dumka, 1971.290 s.
4) Litvinov V.L., Anisimov V.N. Transverse vibrations of a rope moving in the longitudinal direction // Bulletin of the Samara Scientific Center of the Russian Academy of Sciences. 2017. V. 19. No. 4. - S.161-165.
5) Anisimov B.H., Litvinov B.L. Investigation of the resonance properties of mechanical objects with moving boundaries using the Kantorovich – Galerkin method // Tomsk State University Journal. Samara State Technical University. Ser. Phys. – mat. science. 2009. No. 1. P. 149–158.
6) Litvinov V.L., Anisimov V.N. Mathematical modeling and study of oscillations of one-dimensional mechanical systems with moving boundaries: monograph / V. L. Litvinov, V. N. Anisimov - Samara: Samar. state tech. un-t, 2017. - 149 p.
7) Litvinov V.L. The study of free vibrations of mechanical objects with moving boundaries using the asymptotic method // Zh. Middle Volga Mathematical Society. 2014. V. 16. No. 1. P.83–88.
8) Litvinov V.L. Transverse vibrations of a viscoelastic rope of variable length with bending stiffness taking into account the influence of the resistance forces of the medium. // Modern problems of the theory of functions and their applications. Voronezh: Publishing house Scientific book. 2014.S. 153–157.
9) Anisimov V.N., Litvinov V.L. Calculation of natural frequencies of transverse vibrations of a viscoelastic rope moving in the longitudinal direction and having bending stiffness // Tr. 5th All-Russian. scientific conf. "Mathematical modeling and boundary value problems." Mathematical models of mechanics, strength and reliability of structural elements. Samara: Samara State Technical University, 2008. Part 1. P. 38–42.
10) Anisimov V.N., Korpen I.V., Litvinov V.L. Resonance properties of a rope of variable length with bending stiffness taking into account the action of damping forces // Tr. 8th All-Russian. scientific conf. "Mathematical modeling and boundary value problems." Mathematical models of mechanics, strength and reliability of structural elements. Samara: Samara State Technical University, 2011. P. 15–20.
11) Litvinov V.L., Anisimov V.N. Application of the Kantorovich – Galerkin method for solving boundary value problems with conditions on moving boundaries // Bulletin of the Russian Academy of Sciences. Solid mechanics. 2018. No2. S. 70–77.