European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 07, 2020

About Research Of Spectra Of Own Oscillations Thin-Wall Plates In Magnetic Fields

Safarov Ismail Ibrahimovich[1], Esanov Nuriddin Kurbonovich[2], Almuratov Shavkat Narpulatovich[3], Safarov Ismail Ibragimovich[4], Esanov Nuriddin Qurbanovich[5], Almuratov Shavkat Narpulatovich[6]

[1]prof. Physics and Mathematics. Tashkent Institute of Chemistry and Technology. Uzbekistan Tashkent city.
[2]Teacher of Bukhara State University. Uzbekistan, Bukhara.
[3]Lecturer at Termez State University. Uzbekistan Termez.
[4]prof: Institute of Chemistry and Technology, Tashkent, Republic of Uzbekistan
[5]Teacher of Bukhara State University. Bukhara. Republic of Uzbekistan.
[6]Teacher of Termez State University. Termez, Uzbekistan,

E-mail safarov54@mail.ru, esanov-7373@mail.ru, almuratovsh@tersu.uz, safarov54@mail.ru., esanov-7373@mail.ru, almuratovsh@tersu.uz

ABSTRACT: The paper considers the problems of natural vibrations of viscoelastic plates with different boundary conditions in magnetic fields.
The aim of the work is to study the oscillations of thin-walled structural elements in a magnetic field: to calculate the spectra of natural frequencies and vibration damping coefficients of rectangular viscoelastic plates with different conditions for fixing the edges, as well as to study the effect of the transverse and longitudinal magnetic field induction on the values of natural frequencies and damping coefficients, as well as their distribution. The validity and reliability of the results of the work is ensured by the correct statement of the problems, the use of applied mathematics metathemes, modern software and the comparison of the results with the results given in scientific publications. For calculations, mathematical packages MATLAB, software environment MAPLE-18 are used.
The paper first obtained analytical solutions for calculating the complex vibration frequencies of viscoelastic plates with a different combination of boundary conditions. A numerical analysis of the oscillations of rectangular viscoelastic plates with different conditions for fixing the edges is carried out, the influence of the transverse and longitudinal magnetic fields on the spectrum of complex frequencies is studied. New effects that the magnetic field exerts on the distribution of natural frequencies and the damping coefficient of the plate element structures are found.

Keywords: Natural vibrations, plate, magnetic fields, thin-walled elements, damping coefficient, induction.

1. INTRODUCTION

The development of modern technology is closely related to theoretical and applied problems of the interaction of various bodies and fields [1,2]. Interaction problems are fundamental to the problems of motion of an elastic deformable electrically conductive body in a magnetic field [3,4,5]. The creation of optimal designs in many areas of modern technology is associated with the widespread use of structural elements such as thin-walled shells and plates, the elastic vibrations of which are significantly affected by magnetic fields [6,7]. This picture of the interaction of elastic and electromagnetic phenomena is quite complex and can be considered based on the analysis of a joint system of equations of motion of an elastic medium and equations of an electromagnetic field.

A rather large number of publications has been devoted to the problems of vibrations of thin-walled structural elements in magnetic fields, but the question of the influence of magnetic fields on the entire complex frequency spectrum remains incompletely studied [8, 9]. Based on the derived analytical relationships, a software package has been developed for designing and calculating the dynamic characteristics of elastic plates in magnetic fields. The article uses the main hypotheses and equations of vibration of elastic plates in a magnetic field.

2. PASTEON THE PROBLEM AND THE MAIN RELATIONS

Let rectangular plates with different boundary conditions oscillate in magnetic fields (with a given magnetic induction vector) (Figure 1).

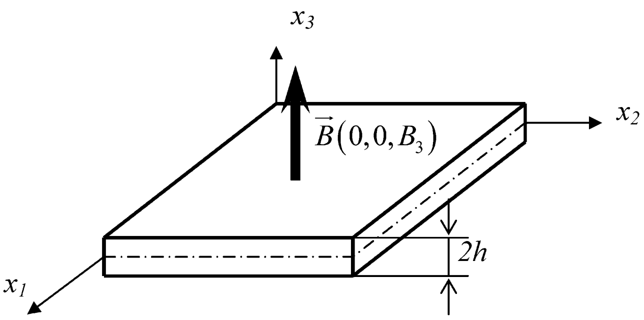

Figure 1 A rectangular plate in an external transverse magnetic field with a magnetic induction vector

The geometric parameters and the magnetic induction vector are shown in Figure 1.

$$\Delta(D(1-\Gamma^{\square})\Delta w_\kappa)-(1-\nu)\left[\frac{\partial^2}{\partial x_1^2}\left(D(1-\Gamma^{\square})\frac{\partial^2 w}{\partial x_2^2}\right)+\frac{\partial^2}{\partial x_2^2}\left(D(1-\Gamma^{\square})\frac{\partial^2 w}{\partial x_1^2}\right)-\frac{\partial^2}{\partial x_1\partial x_2}\left(D(1-\Gamma^{\square})\frac{\partial^2 w}{\partial x_1\partial x_2}\right)\right]+ \quad (1)$$

$$+2\rho h\frac{\partial^2 w_\kappa}{\partial t^2}+M_\kappa\Delta w_\kappa=0, \kappa=1,2$$

Where $D=\frac{Eh^3}{12(1-\nu^2)}$; μ - magnetic permeability; Poisson's coefficient ν ; E- elastic modulus ; ρ - plate material density; h- plate thickness; -integral operator with relaxation kernel R (t):

$\Gamma^{*} f(t)=\int_0^t R(t-\tau)f(\tau)d\tau$; t-time; τ - time preceding observation, $f(t)$ - derivative function of time [10,11], к=1, $M_1=\frac{h(\mu-1)}{4\pi\mu}\cdot B_3^2$, so к=2 , $M_2=\frac{1}{2\cdot\pi}\left(h+\frac{1}{\sqrt{k_1^2+k_2^2}}\right)\cdot B_1^2$, ,

$\Delta w_2=\frac{\partial^2 w_2}{\partial x_1^{\,2}}$.

$$D(1-\Gamma^{*})\Delta\Delta w_\kappa+2\rho h\frac{\partial^2 w_\kappa}{\partial t^2}+M_\kappa\Delta w_\kappa=0, \kappa=1,2 \qquad (2)$$

Let the plate articulated on the contour
$x_1=0,\ x_1=a$ and $x_2=0,\ x_2=a$

$$w_k=\frac{\partial^2 w_k}{\partial x_1^{\,2}}=0 \text{ при } x_1=0,\ x_1=a,$$

$$w_k=\frac{\partial^2 w_k}{\partial x_1^{\,2}}=0 \text{ при } x_2=0,\ x_2=a, \qquad (3)$$

or other conditional : $x_1=0; x_1=a$: $w_k=\frac{\partial w_k}{\partial x_1}=0$,

$$x_2=0, x_2=a:\ \frac{\partial^2 w_k}{\partial x_1^2}+\nu\frac{\partial^2 w_k}{\partial x_2^2}=0,\ \frac{\partial^3 w_k}{\partial x_1^3}+(2-\nu)\frac{\partial^3 w_k}{\partial x_1\partial x_2^2}=0. \qquad (4)$$

3. METHODS OF SOLUTION

For integral term $\Gamma^{*} f(t)=\int_0^t R(t-\tau)f(\tau)d\tau$ the freezing method is applied, then it takes the following form $\Gamma^{*} f(t)=\left(\Gamma^c(\omega_R)+i\Gamma^s(\omega_R)\right)f(t)$,

где $\Gamma^C(\omega_R)=\int_0^\infty R(\tau)\cos\omega_R\tau\, d\tau,\ \Gamma^S(\omega_R)=\int_0^\infty R(\tau)\sin\omega_R\tau\, d\tau$.

При собственных колебаниях прогиб w_k представится в виде

$$w_k=W(x_1,x_2)e^{-i\omega t},$$

где $W(x_1,x_2)$-амплитуды прогибы пластины, $\omega=\omega_R+i\omega_I$ комплексная собственная частота .Тогда уравнение(2) прнимает следующий вид

$\bar{D}\Delta\Delta W_\kappa+M_\kappa\Delta W_\kappa-2\rho hW_k=0,\ \bar{D}=D(1-\Gamma^c(\omega_R)-i\Gamma^s(\omega_R))$. (5)

To solve (5), the asymptotic method of V.V. Bolotina (AMB) allows one to consider the problems of oscillations of viscoelastic plates with different boundary conditions and the distribution of complex natural frequencies of oscillations of shallow shells in magnetic fields. In the first problem, we consider the oscillations of plates in a transverse magnetic field with a given magnetic induction vector $\vec{B}(0,0,B_3)$. Using the asymptotic method V.V. Bolotin, an expression is obtained for the natural frequencies of magnetoelastic vibrations of the plate

$$\Omega^2 = R_\mu^2((1-\Gamma^c)^2 + (\Gamma^s)^2)e^{2i\varphi};$$

$$\varphi = arctg\frac{\Gamma^s}{1-\Gamma^c}$$

$$R_\mu^2 = \left(k_1{}^2 + k_2{}^2\right)\left[\left(k_1{}^2 + k_2{}^2\right) - \frac{h(\mu-1)}{4\pi\mu\cdot D}\cdot B_3^2\right]\left(\frac{D}{2\cdot\rho\cdot h}\right)$$

$$\Gamma^c(\omega) = \int_0^\infty R(\tau)\cdot\cos\omega\tau\, d\tau \quad ; \quad \Gamma^s(\omega) = \int_0^\infty R(\tau)\sin\omega\tau\, d\tau\,,$$

$$R(t) = A\, e^{-\beta t} / t^{1-\alpha}$$

To determine the numbers k1 and k2 (the so-called wave numbers) for viscoelastic plates, the method of V.V. Swamps. Moreover, these numbers are considered valid positive value. In the general case, these quantities can be complex. Then, according to the asymptotic method of V.V. Bolotin should use the general procedure for joining solutions (taking into account the different types of edge fastening) [12]

$$\begin{aligned} k_1a_1 - m_1\pi &= \mathrm{arctg}\, U_{11}(k_1,k_2) + \mathrm{arctg}\, U_{12}(k_1,k_2), \\ k_2a_2 - m_2\pi &= \mathrm{arctg}\, U_{21}(k_1,k_2) + \mathrm{arctg}\, U_{22}(k_1,k_2), \end{aligned} \quad (6)$$

где $(m_1,m_2)\in B$,B- many targets, a_1,a_2- positive value dependent on boundary conditions ,$U_{11}(k_1,k_2)$- the formation of vibrations of elastic plates.

In the second problem, we consider the oscillations of rectangular plates in a longitudinal magnetic field with a given magnetic induction vector $\vec{B}(B_1,0,0)$.

The equation of plate oscillations at k = 2 has the form

$$D\Delta\Delta w_2 + 2\rho h\cdot\frac{\partial^2 w_2}{\partial t^2} - \frac{1}{2\pi}\left(h + \frac{1}{\sqrt{k_1^2 + k_2^2}}\right)\cdot B_1^2\frac{\partial^2 w_2}{\partial x_1{}^2} = 0$$

Using the asymptotic method V.V. Bolotin, an expression is obtained for the natural frequencies of magnetoelastic vibrations of the plate

$$\Omega^2 = R_{\mu 2}^2((1-\Gamma^c)^2 + (\Gamma^s)^2)e^{2i\varphi};$$

$$\varphi = arctg\frac{\Gamma^s}{1-\Gamma^c},$$

$$R_{\mu 2}^2 = \left[\left(k_1{}^2 + k_2{}^2\right)^2 + \frac{1}{2\pi D}\left(h + \frac{1}{\sqrt{k_1^2 + k_2^2}}\right)B_1^2 k_1^2\right]\left(\frac{D}{2\cdot\rho\cdot h}\right).$$

As in the case of a transverse magnetic field, for the determination of wave numbers and for plates with different types of edge fixing according to the asymptotic method of V.V. We will use the general procedure for the conditions for joining solutions [12] (6).

By constructing a system of transcendental equations to determine the unknown so-called wave numbers, one can calculate the spectra of the complex vibration frequencies of the plates in a transverse magnetic field with any combination of boundary conditions. The transcendental algebraic equations with a complex input parameter are solved numerically by the Mueller method

4. THE CALCULATED RESULTS

Natural frequencies were determined for square viscoelastic plates made of aluminum ($\rho{=}2700\,\text{кг/м}^3$, magnetic permeability $\mu{=}1{+}1{,}5{\cdot}10^{-5}$, elastic modulus $E{=}65\,\text{ГПа}$, Poisson's coifficent $\nu{=}0{,}25$) at various values of the transverse magnetic field induction, as well as the rheological properties of the material $A=0{,}048;$ $\beta=0{,}05;$ $\alpha=0{,}1$. When analyzing the vibrational frequency spectra of viscoelastic plates with different boundary conditions, it was found that the transverse magnetic field reduces the real and many parts of the natural vibration frequencies of the plates. A sharper decrease in the real (and many) parts of the frequencies with increasing magnetic field induction is observed in the articulated

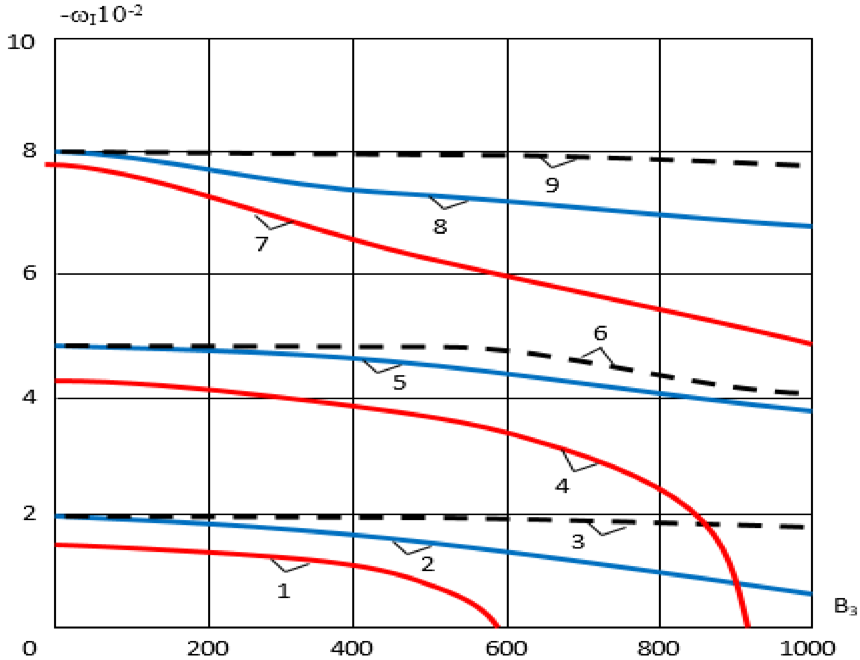

Fig. 2 The effect of transverse magnetic field induction on the natural frequencies of the vibration of a square pivotally supported plate

at various values of the relative thickness of the plate $2h/a$

$(1-\omega_{I11}^{1}, 2-\omega_{I12}^{1}, 3-\omega_{I22}^{1}-2h/a{=}1{,}5{\cdot}10^{-2}, 4-\omega_{I11}^{II}, 5-\omega_{I12}^{II}, 6-\omega_{I22}^{II}-$
$2h/a{=}1{\cdot}10^{-2}, 6-\omega_{I11}^{III}, 7-\omega_{I12}^{III}, 8-\omega_{I22}^{III} - 2h/a{=}1{,}0{\cdot}10^{-3})$

European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 07, 2020

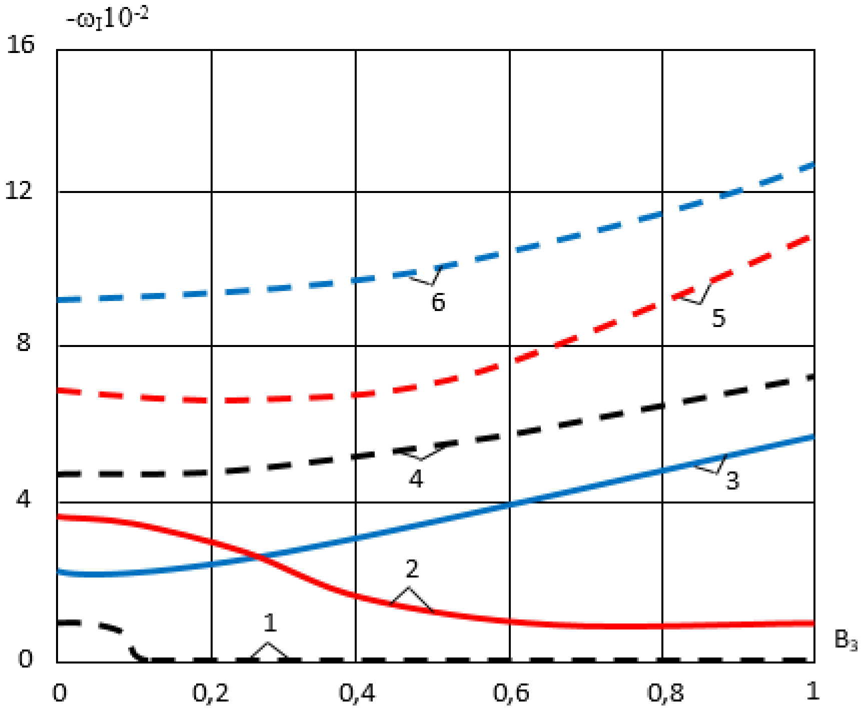

Fig. 3 Dependencies of dimensionless console frequencies and pivotally supported square plate with parameters

$2h = 1 \cdot 10^{-3}$ м, $a_1 = a_2 = 0,2$ м

$(1 - \omega_{I11}^{1} - 2h/a = 1,5 \cdot 10^{-4}$, $2 - \omega_{I11}^{K} - 2h/a = 1 \cdot 10^{-4}$,

$3 - \omega_{I11}^{K} - 2h/a = 1,5 \cdot 10^{-3}$, $4 - \omega_{I11} = 2h/a = 1,5 \cdot 10^{-3}$, $5 - \omega_{I11} = 2h/a = 1,5 \cdot 10^{-2}$ $6 - \omega_{I11} - 2h/a = 1,0 \cdot 10^{-1})$

Articulated supported viscoelastic plates, as well as plates with combined conditions for fixing the edges. Smoother - reducing the natural frequencies and damping coefficients of rigidly clamped and cantilever viscoelastic plates.

For the cantilever viscoelastic plate, there is a slight increase in the real and imaginary parts of the first natural frequency with increasing transverse magnetic field induction. Moreover, the thinner the plate, the more reducing the effect on the real and imaginary parts of the vibration frequency is exerted by the transverse magnetic field (Fig. 2), which corresponds to the results of other authors published in the literature. By constructing a system of transcendental equations for determining wave numbers, it is possible to calculate the spectra of vibration frequencies of plates in a longitudinal magnetic field with any boundary conditions.The natural frequencies were determined for square plates made of aluminum with different fixing conditions at different values of the longitudinal magnetic field induction.When analyzing the spectra of complex vibrational frequencies of viscoelastic plates with different boundary conditions, it was found that the longitudinal magnetic field increases the real and many parts of the vibration frequency of the articulated (dashed lines in Fig. 3) and pinched viscoelastic plates.For a cantilever plate, a longitudinal magnetic field lowers some real and imaginary parts of the frequency (solid lines in Fig. 3).

5. CONCLUSIONS

1. Built using the asymptotic method VV Bolotin solutions of the type of dynamic edge effects for rectangular viscoelastic plates with an arbitrary combination of conditions for fixing the edges in a transverse and longitudinal magnetic field.
2. The spectra of complex eigenfrequencies of oscillations of viscoelastic plates with various conditions for fixing the edges in a longitudinal and transverse magnetic field were calculated. It has been established that a transverse magnetic field lowers the real and many parts of the complex oscillation frequency of the plates, and a longitudinal magnetic field increases the real and many parts of the complex oscillation frequency.
3. Asymptotic estimates are obtained for the density of the real and most parts of the complex frequencies, for assessing the effect of magnetic fields on the entire spectrum of natural frequencies (real parts of the complex frequencies) and the damping coefficient (many parts of the complex frequencies) of the plate vibrations. The main effect of the transverse and longitudinal magnetic fields is exerted on the lower eigenfrequencies and the damping coefficient of oscillations.
In the region of high frequencies (real parts of complex frequencies), the asymptotic density tends to the frequency density of the oscillations of the elastic plates in vacuum (Courant density).

6. REFERENCE.

[1] Korobkov Yu.S., Krasova N.S., Khromatov V.E. Influence of a magnetic field on the frequency spectra of oscillations of rectangular plates // Electrical Engineering. 2007. No4. S. 30-34.
[2] Flugge W. Stresses in shells. - Berlin etc., 1967.
[3] Moon F.C. Magneto-solid mechanics. - N.-Y., 1984.
[4] Newmark N.M. A method of Computation for Structural Dynamics // J. End. Mech Div. Proc. ASCE. - 1959. - Vol. 85, No. 7. - P. 67–97.
[5] Truesdeil C., Noll W. The nonlinear field theories // Haudthuch der Physik Ed. S. F. Lugge. - 1960. - Vol. 3/3. R. 1-602.
[6] Molchenko L.V., Loos I.I., Fedorchenko L.N. Axisymmetric magnetoelastic deformation of a flexible orthotropic annular plate taking into account orthotropic conductivity // Prikl. Mechanics. - 2013. - T. 49, No. 3. - S. 82-88.
[7] Molchenko L.V., Loos I.I. The stress state of a flexible orthotropic spherical shell in a magnetic field when exposed to external current and magnetic field // Prikl. Mechanics. - 2013. - T. 49, No. 5. - S. 34-39.
[8] Nye J. Physical properties of crystals and their description using tensors and matrices. - M., 1967. Novatsky V. Electromagnetic effects in solids. - M., 1986.
[9] Grigorenko Ya.M., Molchenko L.V. Fundamentals of the theory of plates and shells with elements of magnetoelasticity (Ukrainian): a textbook.-K: CPI "Kiev University", 2010.
[10] Grinchenko V.T., Ulitko A.F., Shulga N.A. Electroelasticity // Mechanics of related fields in structural elements: V 5t. - Kiev, 1989.- T. 5.

[11] Guz A.N., Makhort F.G. Acoustoelectromagnetoelasticity // Mechanics of coupled fields in structural elements: 5 vol. - K., 1988.– T. 3
[12] Safarov I.I., Axmedov M.Sh. Free Oscillations of a Viscoelastic Toroidal Thin Shell with aFlowing Liquid. International Journal of Emerging Engineering Research and Technology. Volume 6, Issue 1, 2018, PP 1-14.
[13] Safarov I.I., Boltaev Z.I. Propagation of Natural Waves on Plates of a Variable Cross Section. Open Access Library Journal2018, Volume 5, e4262, PP 1-29. https://doi.org/10.4236/oalib.1104262
[14] Safarov I.I., Boltaev Z.I. Methods for Assessing the Seismic Resistance ofSubterranean Hydro Structures Under the Influence of Seismic Waves. American Journal of Physics and Applications. 2018; 6 (2): PP 51-62. doi: 10.11648 / j.ajpa.20180602.14. http://www.sciencepublishinggroup.com/j/ajpa
[15] Safarov I. I., Kuldashov N.U., Boltaev Z.I. Oscillations and Waves in a Layered Homogeneous Viscoelastic Medium. International Journal of Emerging Engineering Research and Technology. Volume 6, Issue 3, 2018, PP 27-32.
[16] Safarov I. I., Teshaev M.Kh, Ruziyev T.R. Methods for Assessing the Seismic Resistance of Subterranean Hydro Structures under the Influence of
[17] Seismic Waves. World Wide Journal of Multidisciplinary Research and Development (WWJMRD) 2018; 4 (1): 128-139. Impact Factor MJIF: 4.25. www.wwjmrd.com