$$u_2(x) = \begin{cases} 0, x \in V_R \\ u(x), x \in R^n \backslash V_R \end{cases}$$

shartlarni qanoatlantiradigan $u(x) = u_1(x) + u_2(x)$ ikkita funksiyani yig‘indisi ko‘rinishida ifodalaymiz. $u_1(x)$ funksiya [10]da isbot qilingan asosiy teorema shartlarini qanoatlantiradi, chunki $u_1(x)$ funksiya $R^n \backslash (\partial V_R \cup E)$ da garmonik, $u_1(\infty) = 0$ va $\partial V_R \cup E$ kompakt lokal bog‘lamli.

O‘lchov uchun quyidagi o‘lchovni qaraymiz

$$d\mu(x) = ds(x) + \sum_{p=1}^{k} \delta(x - a_p)dx,$$

bu yerda δ – Dirak funksiyasi. Demak,

$$u(x) = \sum_{p=1}^{k} \sum_{|\alpha|=0}^{\infty} \frac{c_\alpha^{(p)}}{\alpha!} \frac{\partial^{|\alpha|}}{\partial x^\alpha} K(x - a_p) + \sum_{|\alpha|=0}^{\infty} \frac{1}{\alpha!} \int_{\partial V_R} \frac{\partial^{|\alpha|}}{\partial x^\alpha} K(x - y) f_\alpha(y) ds(y) + u_2(x),$$

bu yerda,

$$u_0(x) = \sum_{|\alpha|=0}^{\infty} \frac{1}{\alpha!} \int_{\partial V_R} \frac{\partial^{|\alpha|}}{\partial x^\alpha} K(x - y) f_\alpha(y) ds(y) + u_2(x)$$

R^n da garmonik. 2-teorema isbot bo‘ldi.

Xulosa. Agar $u(x)$ – funksiya berilgan sharda garmonik funksiya bo‘lsa, u holda bu funksiya berilgan shartlarda ushbu

$$u(x) = \sum_{|\alpha|=0}^{\infty} \frac{1}{\alpha!} \int_{V_R} \frac{\partial^{|\alpha|}}{\partial x^\alpha} K(x - y) f_\alpha(y) ds(y),$$

yoyilma shaklida tasvirlash mumkin.

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BURALISH-EGILISH TO‘LQININI QOVUSHOQ-ELASTIK STERJENGA TARQALISHI XUSUSIYATLARI

Annotatsiya. *Bu ishda buralish-egilish to‘lqinini qovushoq-elastik sterjenga tarqalishida soddalashtirilgan tenglamasini olish masalasi ko‘riladi. Sterjenni differensial yondashuv bo‘yicha olingan tenglamalarini turlicha soddalashtirilgan holidagi bir va ikki o‘lchamli tenglamalari olingan. Materiallarning qovushoqligi irsiy, ya’ni, Boltsman-Volterra integral munosabati bilan olingan. Qovushqoq yadrosi sifatida uch parametrli relaksatsiya yadrosi olingan. Dispersion tenglama olinib, uni sonli yechishi topilib tahlil qilingan.*

Kalit so‘zlar. *sterjen, buralish-egilish to‘lqini, qovushoq-elastiklik, inersiya momenti, buralish burchagi.*

ХАРАКТЕРИСТИКИ РАСПРОСТРАНЕНИЯ КРУТИЛЬНО-ИЗГИБНОЙ ВОЛНЫ В ПОРИСТОМ УПРУГОМ СТЕРЖНЕ

Аннотация. *В данной работе рассматривается задача получения упрощенного уравнения распространения крутильно-изгибной волны в вязкоупругом стержне. Получены одномерные и двумерные уравнения стержня, полученные дифференциальным методом в различных упрощенных случаях. Вязкость материалов определяется с помощью наследственного, то есть интегрального соотношения Больцмана-Вольтерры. В качестве ядра вязкости используется трехпараметрическое ядро релаксации. Получено дисперсионное уравнение, найдено и проанализировано его численное решение.*

Ключевые слова: *стержень, кручение-изгибная волна, вязкая упругость, момент инерции, угол кручения.*

CHARACTERISTICS OF THE PROPAGATION OF A TORSIONAL-FLEXURAL WAVE IN A POROUS-ELASTIC ROD

Annotation. *This work deals with the problem of obtaining a simplified equation for the propagation of a torsional-flexural wave in a viscous-elastic rod. One-and two-dimensional equations of the rod obtained by the differential approach in various simplified cases are obtained. The viscosity of materials is obtained by the hereditary, that is, Boltzmann-Volterra integral relation. A three-parameter relaxation kernel is taken as the viscous kernel. The dispersion equation is obtained, its numerical solution is found and analyzed.*

Keywords*: rod, torsion-bending wave, viscous elasticity, moment of inertia, torsion angle.*

Kirish. Sterjenlar elastiklik nazariyasining uch o‘lchovli tenglamalarini bir o‘lchovli tenglamalarga keltirishning eng umumiy g‘oyasi sifatida qaraladi va konstruksiyalarning ixtiyoriy nuqtadagi kuchlanish – deformatsiya holatini aniqlash masalasi ko‘riladi [1,2]. Buning uchun yangi o‘zgaruvchilar kiritib hosil bo‘lgan tenglamalar sterjenlarning dinamik tenglamalari olingan [3,4]. Sterjenlarning ko‘ndalang o‘lchamlari, odatda, xarakterli to‘lqin uzunligiga nisbatan kichik bo‘lgani uchun, kesimlardagi deformatsiya jarayonlarini kvazistatik deb hisoblash mumkin [5]. Bu, xususan, ma’lum bir deformatsiya turi uchun mos keladigan statik masalani yechish orqali sterjen kesimi bo‘ylab siljishlar va yo‘nalishlarning taqsimlanishini izlash imkonini beradi. Qalinligi bo‘yicha siljishlarni yaqinlashtirishning yana bir usuli bu muammoning aniq yechimini topish hisoblanadi [6,7]. Qovushoq-elastik struktura dinamikasi muammolarida an’anaviy ravishda sterjenlar va ularning tizimlarida egiluvchan, burama va bo‘ylama to‘lqinlarning tarqalishiga katta e’tibor berilgan [8,9]. Sterjenlar uchun tenglamalarni chiqarishda variatsion tamoyillarni qo‘llash uchun normal yo‘nalishda cheksiz miqdordagi erkinlik darajalaridan chekli miqdordagi erkinlik darajalariga chekli polinomlar bo‘yicha siljishlarni yaqinlashtirish orqali o‘tish eng qulaydir. Ushbu bo‘limchada egiluvchan - burama to‘lqinning tarqalishi ko‘rib chiqamiz. Differensial yondashuv orqali olingan differensial tenglamalalar sistemasidan dispersion tenglamani olish masalasi ko‘riladi.

Masalani qo‘yilishi va yechish metodikasi. Geometrik nochiziqlilikni hisobga olmagandagi, sterjenlarda egiluvchan va burama to‘lqinlarning o‘zaro ta’sirini ifodalovchi tenglamalar tizimi quyidagi ko‘rinishda bo‘ladi:

$$\begin{aligned}
&\frac{\partial^2\theta}{\partial t^2} - c_\tau^2\Gamma_G\frac{I_s}{I_\rho}\frac{\partial^2\theta}{\partial x^2} - \frac{I_\psi}{I_\rho}\overline{\Sigma}_{c_s}\frac{\partial^2\theta}{\partial x^2} + \frac{\vec{I}_{\nabla\psi}}{I_\rho}\overline{\Sigma}_{c_s}\frac{\partial^2\vec{W}}{\partial x^2} = 0,\\
&\frac{\partial^2\vec{W}}{\partial t^2} - \frac{I}{F}\overline{\Sigma}_{c_s}\frac{\partial^2\vec{W}}{\partial x^2} + \frac{\vec{I}_{\nabla\psi}}{F}\overline{\Sigma}_{c_s}\frac{\partial^2\theta}{\partial x^2} = 0.
\end{aligned} \tag{1}$$

Bu yerda, $\vec{W}\begin{pmatrix}\upsilon & w\end{pmatrix}^T$ – ko‘ndalang ko‘chishni ifodalovchi ustun matritsa bo‘lib, υ – va w –, mos ravishda, xoy va xoz tekisligidagi ko‘chishi; buralish burchagi; $\vec{I}_{\nabla\psi} = \begin{pmatrix} I_{\psi z} \\ I_{\psi y}\end{pmatrix}$-deplanatsiya momenti ustun vektori; $I_{\psi z} = \iint \psi_{,z}^2 dF$, $I_{\psi y} = \iint \psi_{,y}^2 dF$ - o‘q bo‘yicha moment deplanatsiyasi – deplanatsiya

momenti; I_ρ - qutib inertsiya momenti; I_ρ - o‘q bo‘yicha inersiya momenti; F – sterjen ko‘ndalang kesimi yuzasi; c_τ – siljish to‘lqinini tarqalish tezligi; c_s – bo‘ylama to‘lqin tarqalish tezligi.

$$\Sigma_{c_s} = (\frac{\partial^2}{\partial t^2} - c_s^2 \frac{\partial^2}{\partial x^2})$$

Yuqorida keltirilgan (1) differensial tenglamalar sistemasini yechish uchun ko‘chishni x_{0z} tekisligida ko‘ramiz. Buning uchun parametrlarni o‘lchamsiz holatiga keltiramiz:

$$\tilde{X} = \frac{x}{X}, \tilde{W} = \frac{W}{W_0}, \tilde{\theta} = \frac{\theta}{\theta_0}$$

Shunday qilib, $t = T\tilde{t}, x = X\tilde{x}, W = W_0\tilde{W}, \theta = \theta_0\tilde{\theta}.$

Bularni (1) tenglamaga qo‘ysak, quyidagicha o‘lchamsiz parametrlar orqali berilgan tenglamani olamiz:

$$\begin{aligned}
&\frac{\theta_0}{T^2}\frac{\partial^2\tilde{\theta}}{\partial\tilde{t}^2} - c_\tau^2\Gamma_G\frac{I_s}{I_\rho}\frac{\theta_0}{X^2}\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} - \frac{I_\psi}{I_\rho}\frac{\theta_0}{X^2}(\frac{1}{T^2}\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{1}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} + \\
&+\frac{I_{\psi z}}{I_\rho}\frac{W_0}{X^2}(\frac{1}{T^2}\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{1}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\vec{W}}{\partial x^2} = 0, \\
&\frac{W_0}{T^2}\frac{\partial^2\tilde{W}}{\partial\tilde{t}^2} - \frac{I}{F}\frac{W_0}{X^2}(\frac{1}{T^2}\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{1}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{W}}{\partial\tilde{x}^2} + \\
&+\frac{I_{\psi z}}{F}\frac{\theta_0}{X^2}(\frac{1}{T^2}\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{1}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} = 0.
\end{aligned} \tag{2}$$

Oxirgi olingan (2) tenglamani birinchisini $\frac{T^2}{\theta_0}$ va ikkinchisini $-\frac{T^2}{W_0}$ ga ko‘paytiramiz, natijada quyidagi tenglamalar sistemasini olamiz:

$$\begin{aligned}
&\frac{\partial^2\tilde{\theta}}{\partial\tilde{t}^2} - c_\tau^2\Gamma_{\lambda\mu}\frac{I_s}{I_\rho}\frac{T^2}{X^2}\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} - \frac{I_\psi}{I_\rho}\frac{1}{X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{T^2}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} + \\
&+\frac{I_{\psi z}}{I_\rho}\frac{W_0}{\theta_0 X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{T^2}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\vec{W}}{\partial\tilde{x}^2} = 0, \\
&\frac{\partial^2\tilde{W}}{\partial\tilde{t}^2} - \frac{I}{F}\frac{1}{X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{T^2}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{W}}{\partial\tilde{x}^2} + \\
&+\frac{I_{\psi z}}{F}\frac{\theta_0}{W_0}\frac{1}{X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\Gamma_{\lambda\mu}\frac{T^2}{X^2}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} = 0.
\end{aligned} \tag{3}$$

Agar $\frac{X^2}{T^2} = c_s^2\Gamma_{\lambda\mu}\frac{I_s}{I_\rho}$ bo‘lsin deb faraz qilinsa, u holda (3) tenglama quyidagi ko‘rinishni egallaydi:

$$\begin{aligned}
&\frac{\partial^2\tilde{\theta}}{\partial\tilde{t}^2} - \frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} - \frac{I_\psi}{I_\rho}\frac{1}{X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\frac{I_\rho}{c_\tau^2 I_s}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2} + \\
&+\frac{I_{\psi z}}{I_\rho}\frac{W_0}{\theta_0 X^2}(\frac{\partial^2}{\partial\tilde{t}^2} - c_s^2\frac{I_\rho}{c_\tau^2 I_s}\frac{\partial^2}{\partial\tilde{x}^2})\frac{\partial^2\vec{W}}{\partial\tilde{x}^2} = 0,
\end{aligned} \tag{4}$$

$$\frac{\partial^2\tilde{W}}{\partial\tilde{t}^2}-\frac{I}{F}\frac{1}{X^2}\left(\frac{\partial^2}{\partial\tilde{t}^2}-c_s^2\Gamma_{\lambda\mu}\frac{I_\rho}{c_\tau^2\Gamma_\lambda I_s}\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{W}}{\partial\tilde{x}^2}+$$

$$+\frac{I_{\psi z}}{F}\frac{\theta_0}{W_0}\frac{1}{X^2}\left(\frac{\partial^2}{\partial\tilde{t}^2}-c_s^2\Gamma_{\lambda\mu}\frac{I_\rho}{c_\tau^2\Gamma_\lambda I_s}\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}=0.$$

Agar $c_s^2\frac{I_\rho}{c_\tau^2 I_s}$ ifodani c^2 deb belgilab olsak hamda kutib inersiya momenti I_ρ va buralishdagi inersiya momenti I_s bir xil tartibda deb olsak va $c^2>1$, e'tiborga olsak, u holda (4) tenglamalar sistemasini soddalashtirish mumkin bo'ladi. Faraz qilamiz: $X^2=\frac{I_\psi}{I_\rho}$ va $\theta_0=\frac{W_0}{X}$, u holda,

$$\frac{\partial^2\tilde{\theta}}{\partial\tilde{t}^2}-\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}-\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}+$$

$$+\frac{I_{\psi z}}{I_\rho}\sqrt{\frac{I_\rho}{I_\psi}}\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\vec{W}}{\partial\tilde{x}^2}=0, \tag{5}$$

$$\frac{\partial^2\tilde{W}}{\partial\tilde{t}^2}-\frac{I}{F}\frac{I_\rho}{I_s}\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{W}}{\partial\tilde{x}^2}+\frac{I_{\psi z}}{F}\frac{I_\rho}{I_\psi}\sqrt{\frac{I_\rho}{I_\psi}}\left(\frac{\partial^2}{\partial\tilde{t}^2}-c_s^2\Gamma_{\lambda\mu}\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}=0.$$

Yuqorida keltirilgan $\frac{I_{\psi z}}{I_\rho}\sqrt{\frac{I_\rho}{I_\psi}}$ va $\frac{I_{\psi z}}{F}\frac{I_\rho}{I_\psi}\sqrt{\frac{I_\rho}{I_\psi}}$ ifodalar bir xil tartibli bo'lishini inobatga olib, elliptik ko'ndalang kesimli sterjen olinsa, u holda tenglamani quyidagicha yozish mumkin:

$$\frac{\partial^2\tilde{\theta}}{\partial\tilde{t}^2}-\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}-\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}+\varepsilon\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\vec{W}}{\partial\tilde{x}^2}=0,$$

$$\frac{\partial^2\tilde{W}}{\partial\tilde{t}^2}-\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{W}}{\partial\tilde{x}^2}+\varepsilon\left(\frac{\partial^2}{\partial\tilde{t}^2}-c^2\Gamma_c\frac{\partial^2}{\partial\tilde{x}^2}\right)\frac{\partial^2\tilde{\theta}}{\partial\tilde{x}^2}=0. \tag{6}$$

Bu tenglama chegaraviy va boshlangich shartlar asosida analitik yechiladi.

Buralish-egilish to'lqin uchun dispersion munosabatni olish. Oxirgi olingan (6) differensial tenglamalar sistemasining yechimni harakatlanuvchi garmonik to'lqinlar ko'rinishida izlaymiz:

$$\theta=\theta_0e^{i(\omega t-kx)},W=W_0e^{i(\omega t-kx)} \tag{7}$$

Bu yerda: ω - aylana chastotasi, to'lqin davrini T = 2π/ω belgilaydi; k - to'lqin soni, λ - to'lqin uzunligi (fazoviy davr) bilan bog'liq to'lqin soni: λ = 2π/k; , W_0 - amplitudalar. Agar (7) ni (6) ga qo'yish orqali kompleks koeffitsiyentli algebraik tenglamalar sistemasini olamiz:

$$\theta_0(-\omega^2+k^2-\omega^2k^2+c^2k^2\Gamma_c)+W_0(\varepsilon\omega^2k^2-\varepsilon c^2\Gamma_ck^4)=0,$$

$$\theta_0(\varepsilon\omega^2k^2-\varepsilon c^2\Gamma_ck^4)+W_0(-\omega^2-\omega^2k^2+c^2\Gamma_ck^4)=0. \tag{8}$$

Yuqorida keltirilgan kompleks koeffitsiyentli algebraik tenglamalar sistemasini asosiy aniqlovchisini nol bo'lishidan kompleks parametrli dispersion tenglama olinadi. Uni sonli yechish orqali dispersiya egri chiziqlari ko'riladi. Agar sterjen elastik bo'lsa, u holda qovushoqlik yadrosi amplitudasi nolga teng bo'ladi. U holda dispersiya tenglamasi qu'yidagicha bo'ladi

$$\omega^4(1+2k^2+(1-\varepsilon^2)k^4)-\omega^2(k^2+(1+2c^2\Gamma_c)k^4+$$

$$+2c^2\Gamma_c(1-\varepsilon^2)k^6)+(c^2\Gamma_ck^6+c^2\Gamma_c(1-\varepsilon^2)k^8)=0. \tag{9}$$

Dispersiya tenglamasi (9) to‘rtinchi tartibli ω va k da sakkizinchi tartibli tenglamadir. Uni ikki kvadrat tenglama sifatida yechib, biz to‘lqin chastotasi ω ning k to‘lqin soniga bog‘liqligini olamiz. Bu (9) tenglamaning yechimi quyidagicha bo‘ladi:

$$\omega = \sqrt{\frac{a \pm \sqrt{a^2 - 4bd}}{2b}},$$

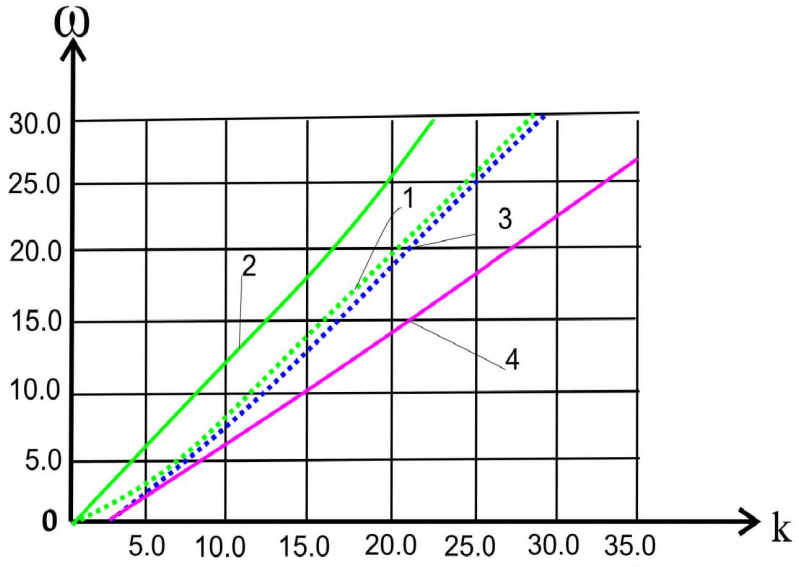
Bunda:

$$a = k^2 + (1 + 2c^2)k^4 + +2c^2(1-\varepsilon^2)k^6,$$

$$b = 1 + 2k^2 + (1-\varepsilon^2)k^4,$$

$$d = (c^2k^6 + c^2(1-\varepsilon^2)k^8.$$

Materiallarning qovushoqlik xususiyatlari hisobga olinsa, u holda (9) tenglama transendent tenglamaga aylanadi. U tenglamani faqat sonli usullar orqali yechiladi. Hisoblashlarda Koltunov-Rjanitsinning uch ko‘rsatkichli yadrosidan foydalanilgan: $R(t) = Ae^{-\beta t}/t^{1-\alpha}$, $A = 0{,}048;\ \beta = 0{,}05;\ \alpha = 0{,}1$ Qovushqoq-elastik yarim tekislikda joylashgan aylanasimon ko‘ndalang kesim yuzali silindirga garmonik to‘lqin tarqalishi va tashqi ta’sirda hosil bo‘ladigan kuchlanganlik-deformatsiyalanganlik holati masalasi natijalari 1-rasmlarda keltirilgan. Sonli hisob natijalarini olish uchun yuqorida ta’kidlanganidek po‘lat sterjen va Koltunov-Rjanitsinning uch ko‘rsatkichli yadro relasatsiyasi qiymatlaridan foydalanilgan. Qobiqdagi maksimal yuqorida keltirilgan (8) dispersion tenglama sonli Myuller usuli bilan yechildi.



1-rasm. Xos rezonans chastotalarini ω_R haqiqiy (1,3) va $-\omega_I 10^{-2}$ mavhum (2,4) qismlarini to‘lqin soniga bog‘liq o‘zganishi keltirilgan. 1,3 xos rezonans chastotaning haqiqiy qismi; 2,4 xos chastotani mavhum qismi.

Yuqoridagi 1-rasmda xos rezonans chastotalarini ω_R haqiqiy va $-\omega_I 10^{-2}$ mavhum qismlarini to‘lqin soniga bog‘liq o‘zgarishi keltirilgan. Rasmda 1,3 xos rezonans chastotaning haqiqiy qismi; 2,4 xos chastotani mavhum qismi. Rasmdan ko‘rinib turibdiki, to‘lqin soni kichik qiymatlarida birinchi va ikkinchi chastotani haqiqiy va mavhum qismlari bir xil xarakterga ega ekan. To‘lqin sonini ortib borishi ular orasidagi farqni juda sekin ortib borishiga olib kelar ekan.

Xulosa. Shunday qilib, bu ishda sterjenni soddalashtirilgan tenglamasi va uning dispersion tenglamasi olinib, sonli yechildi. Olingan sonli natijalar asosida to‘lqin soni kichik qiymatlarida birinchi va ikkinchi chastotani haqiqiy va mavhum qismlari bir xil xarakterga ega ekanligi topildi. To‘lqin sonini ortib borishi ular orasidagi farqni juda sekin ortib borishiga olib kelishi aniqlandi.

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