QOVUSHQOQ - ELASTIK MUXITDAGI SFERIK QOBIQAGA GARMONIK BO‘LMAGAN TO‘LQIN DIFRAKSIYASI

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Anotatsiya. Bu ishda qovushqoq elastik muhit bilan kontaktda bo‘lgan silindrik qobiqaga nostatsionar to‘lqin difraksiyasi paydo bo‘ladigan dinamik jarayonlar o‘rganilgan. Sferik nostatsionar to‘lqinlani sferik qobiqlardagi difraksiyasi, murakkab to‘lqin maydoni hosil qilinishi ko‘rsatib berilgan. Nostatsionar to‘lqinning qovushqoq - elastik muhitda joylashgan sferik qobiqa ta’siri chiziqli ko‘yilishda yechilgan. Makolada radiusi R bo‘lgan sferik qobiq berilgan bo‘lsa uning h qalinligi , ρ zichligi , Yung moduli E va Puasson koeffitsenti v bo‘lgan qobiq olingan. Qobiq uchun polyar koordinatalarda (r,ϕ,θ) ifodalanadi, bu yerda φ— meridian burchagi, θ - azimutal burchak. Qovushqoq - elastik muhitdagi sferik jismga nostatsionar to‘lqinlar ta’siri masalasi yechilgan. Cheksiz qovushqoq - elastik muhitda qattiq deformatsiyalanuvchi sharsimon kobiq berilgan deb olingan. Bu paragrifga ikki turdagi vazifalar qo‘yiladi. Qovushqoq - elastik muhitdagi sferik deformatsiyalanuvchi jismga nostatsionar to‘lqinlar ta’siri masalasini qo‘yilishi , yechish metodikasi va sonli natijalar olingan.
Kalit so‘zlar: sferik kobiq, qovushqoq elastik muhit, nostatsionar to‘lqin, Puasson koeffitsenti, kuchlanish amplitudasi.

Аннотация. В данной работе исследованы динамические процессы, возникающие при дифракции нестационарных волн на сферической оболочке, находящейся в контакте с вязкоупругой средой. Продемонстрирована дифракция сферических нестационарных волн на сферических оболочках и процесс формирования сложных волновых полей. Задача о воздействии нестационарной волны на сферическую оболочку, расположенную в вязкоупругой среде, решена в линейной постановке.
В статье рассматривается сферическая оболочка радиуса R, имеющая толщину h, плотность ρ, модуль Юнга E и коэффициент Пуассона ν. Состояние оболочки описывается в полярных (сферических) координатах (r,ϕ,θ), где ϕ — меридианальный угол, а θ— азимутальный угол. Решена задача воздействия нестационарных волн на сферическое тело в вязкоупругой среде. Рассматривается жесткая деформируемая сферическая оболочка, находящаяся в бесконечной вязкоупругой среде. В данном разделе поставлены задачи двух типов. Представлены постановка задачи, методика решения и численные результаты исследования воздействия нестационарных волн на сферическое деформируемое тело в вязкоупругой среде.
Ключевые слова: сферическая оболочка, вязкоупругая среда, нестационарная волна, коэффициент Пуассона, амплитуда напряжения.

Abstract. This study investigates the dynamic processes arising from the non-stationary wave diffraction on a spherical shell in contact with a viscoelastic medium. The diffraction of spherical non-stationary waves on spherical shells and the formation of complex wave fields are demonstrated. The problem regarding the impact of a non-stationary wave on a spherical shell located within a viscoelastic medium is solved in a linear formulation. The article considers a spherical shell of radius R, with thickness h, density ρ, Young’s modulus E, and Poisson’s ratio v. The state of the shell is expressed in spherical coordinates (r, ϕ, θ), where ϕ represents the meridional angle and θ represents the azimuthal angle. The problem of non-stationary wave impact on a spherical body in a viscoelastic medium has been solved. A rigid deformable spherical shell situated in an infinite viscoelastic medium is examined. Two types of tasks are defined in this section. The problem statement, solution methodology, and numerical results for the impact of non-stationary waves on a spherical deformable body in a viscoelastic medium are presented.
Keywords: spherical shell, viscoelastic medium, non-stationary wave, Poisson’s ratio, stress amplitude.

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Kirish

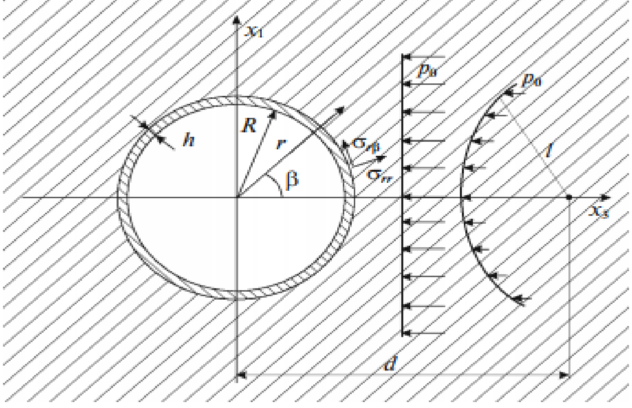
So'nggi yillarda geofiziklarning e'tiborini yerning ichki qismining bir jinsli bo'lmasligini o'rganishga bo'lgan qiziqishi tobora ortib bormoqda [1,2]. Bir jinsli bo'lmasliklarni o'rganish yer qobig'i va mantiyaning yuqori qismida sodir bo'ladigan geodinamik jarayonlarni yoritishi va yerning geologik evolyusiyasining ba'zi muammolariga oydinlik kiritilishi bilan izohlanadi [3,4]. Elastik to'lqinlarning bir sferik to'siq orqali tarqalishi va difraksiyasi uchun yechimni analitik kurinishda yoki sonli usular yordamida olish mumkin [5,6]. Bir qator bo'ylama to'lqinlarning tarqalishi klassik assarlarda keng yoritilgan. Klassik yechim hodisa va difraksiyalangan maydonlarning superpozitsiyasi orqali xosil qilingan [7,8]. Tarqaladigan sferik to'lqin xam bo'ylama yoki ko'ndalang to'lqin potensiallari orqali ifodalash mumkin. Ular xam [9] turli koordinatalar sistemasida ifodalanadi. Tushadigan to'lqinni sferik jismdagi difraksiyasini vaqtni garmonik yoki nostatsionar funksiyasi sifatida ifodalanadi [10,11]. Ular sferik jism va va uning kontagidagi shartlariga bogliq bo'ladi. Sferik qobiq (yoki bo'shliq suyuqlik bilan to'ldirilgan bo'lsa) u xolda to'lqin ta'sirida dinamik kuchlanganlik deformatsiya xodisasi ruy beradi. To'lqin funksiyalarining to'liq to'plami , asosan maxsus funksiyalar , ya'ni sferik Bessel, Neyman va Xankel funksiyalari orqali ifodalanadi [12,13]. Yechim burchak koordinatalari xam boglik bo'ladi, ya'ni Lagranj va trigonometrik funksiyalar orkali ifodalanadi. Natijalar vaqtni garmonik yoki noturgin funksiyasi bo'ladi va chastotaga bogliq bo'ladi. Difraksion maydonning kuchish potensiallari ning amplitudalari normalangan chastota va to'lqin soni funksiyasi sifatida olinadi [14,15]. Shunday qilib, yer tarkibidagi bir katlamlarni xossalani aniqlash, ularning o'lchamlari va fizik xususiyatlarini aniqlash bilan bog'liq vazifalar juda muhim va dolzarb hisoblanadi. Bu ishda silindrik krbika garmonik to'lkin difraksiyasi masalasi kuriladi.

Masalani kuyilishi va yechish metodikasi

Agar qovushqoq -elasitik muxitda sferik qobiq bo'lsa, u xolda uning harakat differensial tenglamasi qo'yidagicha bo'ladi

$$\bar{L}\vec{X} = \frac{1}{c_{01}^2}\left(\frac{\partial^2}{\partial t^2}\vec{X} - \frac{1}{h\rho_0}\vec{P}\right), \qquad (1)$$

bunda $\bar{L}-$differensial operatorlardan iborat bo'lgan kvadrat matritsa, elimentlari $\bar{L}_{ij}(i, j = 1 \div 5)$ kurilayotgan ob'ektning koordinatalariga bogliq; $\vec{X} = (u, v, w, \psi_1, \psi_2)^T; \vec{P}(p_1, p_2, p_n, 0, 0)^T; c_{01}$- oniy to'lqin tezligi, h- qobiq qalinligi, ρ_0 - qobiq materialining zichligi, T- transponirlash belgisi.



1- Rasm. Silindrik qobiqqa to'lqin yuklanishi

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Agar Timoshenko gipotezasi o'rniga Krixgof – Lyav gipotezasi qo'llansa u xolda (1) qobiq tenglamasida noma'lumlar soni 3 ta bo'ladi (u, v, w). Sferik qobiq uchun $\bar{L}$ – differensial operatorlarning elimentlari qo'yidagicha bo'ladi:

$$L_{11}=\frac{1}{r^2}\left[\frac{\partial^2}{\partial\theta^2}+ctg\theta\frac{\partial}{\partial\theta}-(\nu_0+ctg^2\theta)+\frac{1-\nu_0}{2\sin^2\theta}\right],$$

$$L_{12}=\frac{1}{2r^2\sin\theta}\left[(1+\nu_0)\frac{\partial^2}{\partial\theta\partial\varphi}-(3-\nu_0)ctg\theta\frac{\partial}{\partial\varphi}\right],$$

$$L_{13}=-\frac{1+\nu_0}{r^2}\frac{\partial}{\partial\theta};$$

$$L_{21}=\frac{1}{2r^2\sin\theta}\left[(1+\nu_0)\frac{\partial^2}{\partial\theta\partial\varphi}-(3-\nu_0)ctg\theta\frac{\partial}{\partial\varphi}\right],$$

$$L_{22}=\frac{1}{r^2}\left[\frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\varphi^2}+\frac{1-\nu_0}{2}\left(\frac{\partial^2}{\partial\theta^2}+ctg\theta\frac{\partial}{\partial\theta}+1-ctg\theta\right)\right],$$

$$L_{23}=-L_{32}=-\frac{1+\nu_0}{r^2\sin\theta}\frac{\partial}{\partial\varphi},\ L_{31}=\frac{1+\nu_0}{r^2}\left(\frac{\partial}{\partial\theta}+ctg\theta\right),$$

$$L_{33}=-\frac{h^2}{12}\Delta\Delta-\frac{2(1+\nu_0)}{r^2}, \tag{2}$$

bunda $\Delta=\frac{\partial^2}{\partial x^2}+\frac{1}{x}\frac{\partial}{\partial x}+\frac{1}{x^2\sin^2\theta}\frac{\partial^2}{\partial\varphi^2}$. Muxit uchun keltirilgan vektor ko'rinishdagi tenglamani qo'yidagi ko'rinishga yozish iuikin

$$(rot\vec{s}_j)\big|_r=2\omega_r=\frac{1}{r}\frac{\partial s_z}{\partial\varphi}-\frac{\partial s_\varphi}{\partial z},$$

$$(rot\vec{s}_j)\big|_\varphi=2\omega_\varphi=\frac{\partial s_r}{\partial z}-\frac{\partial s_z}{\partial r},$$

$$(rot\vec{s}_j)\big|_z=2\omega_z=\frac{1}{r}\left[\frac{\partial(rs_\varphi)}{\partial r}-\frac{\partial s_r}{\partial\varphi}\right].$$

Oxirgi (2) dan foydalansak quyidagicha integro-differensial tenglamalar sistemasini olamiz

$$(\tilde{\lambda}_j+2\tilde{\mu}_j)\frac{\partial\Delta}{\partial r}-\frac{2\tilde{\mu}_j}{r}\frac{\partial\omega_z}{\partial\varphi}+2\tilde{\mu}_j\frac{\partial\omega_\varphi}{\partial z}=\rho_j\frac{\partial^2 s_{rj}}{\partial t^2},$$

$$(\tilde{\lambda}_j+2\tilde{\mu}_j)\frac{1}{r}\frac{\partial\Delta}{\partial\varphi}-2\tilde{\mu}_j\frac{\partial\omega_r}{\partial z}+2\tilde{\mu}_j\frac{\partial\omega_z}{\partial r}=\rho_j\frac{\partial^2 s_{\varphi j}}{\partial t^2},$$

$$(\tilde{\lambda}_j+2\tilde{\mu}_j)\frac{\partial\Delta}{\partial z}-\frac{2\tilde{\mu}_j}{r}\frac{\partial r\omega_\varphi}{\partial r}+\frac{2\tilde{\mu}_j}{r}\frac{\partial\omega_r}{\partial\varphi}=\rho_j\frac{\partial^2 s_{zj}}{\partial t^2}, \tag{3}$$

Yuqorida keltirilgan (3) ni parametrik formadagi yozuvi qo'yidagicha bo'ladi

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$$u_r = \frac{\partial \varphi}{\partial r} + l\left[\frac{\partial^2 (r\chi)}{\partial r^2} - r\nabla^2 \chi\right],$$

$$u_\theta = \frac{1}{r}\frac{\partial \varphi}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial (r\chi)}{\partial \phi} + (l/r)\frac{\partial^2 (r\chi)}{\partial \theta \partial r},$$

$$u_\phi = \frac{1}{r\sin\theta}\frac{\partial \varphi}{\partial \phi} - \frac{1}{r}\frac{\partial (r\psi)}{\partial \theta} + (l/r\sin\theta)\frac{\partial^2 (r\chi)}{\partial \phi \partial r}. \quad (4)$$

Agar ko'chishlar ma'lum bo'lsa, u xolda Koshi munosabatlari orqali deformatsiya tenzori komponentalarini topish mumkin

$$\varepsilon_{rr} = \frac{\partial u_r}{\partial r}, \varepsilon_{\theta\theta} = \frac{1}{r}\frac{\partial u_\theta}{\partial \theta} + \frac{u_r}{r}, \varepsilon_{\phi\phi} = \frac{1}{r\sin\theta}\frac{\partial u_\varphi}{\partial \varphi} + \frac{u_r}{r} + ctg\theta\frac{\partial u_\theta}{\partial r},$$

$$\varepsilon_{r\phi} = \frac{1}{2}\left[\frac{1}{r\sin\theta}\frac{\partial u_r}{\partial \phi} - \frac{u_\phi}{r} + \frac{\partial u_\phi}{\partial r}\right], \varepsilon_{r\theta} = \frac{1}{2}\left[\frac{1}{r}\frac{\partial u_r}{\partial \theta} - \frac{u_\theta}{r} + \frac{\partial u_\theta}{\partial r}\right],$$

$$\varepsilon_{\phi\theta} = \frac{1}{2}\left[\frac{1}{r}\frac{\partial u_\phi}{\partial \theta} - ctg\theta\frac{u_\phi}{r} + \frac{1}{r\sin\theta}\frac{\partial u_\theta}{\partial \phi}\right]. + \frac{1}{x}\frac{\partial}{\partial x} + \frac{1}{x^2\sin^2\theta}\frac{\partial^2}{\partial \varphi^2} \quad (5)$$

Agar kuchish potensiallari mavjud bo'lsa, u xolda kuchlanishlar tenzori komponentalarini qo'yidagi formulalar orqali topamiz

$$\sigma_r = -\omega^2\varphi + 2\left(\frac{1}{r^2}\frac{\partial^2\varphi}{\partial\theta^2} + \frac{1}{r}\frac{\partial\varphi}{\partial r} + \frac{\partial^2\varphi}{\partial z^2} - \frac{1}{r}\frac{\partial^2\varphi}{\partial r\partial\theta} + \frac{1}{r^2}\frac{\partial\psi_z}{\partial\theta} + \frac{\partial^2\psi_\theta}{\partial r\partial z}\right),$$

$$\sigma_\theta = -(1-2k^2)\omega^2\varphi + 2\left(\frac{1}{r^2}\frac{\partial^2\varphi}{\partial\theta^2} + \frac{1}{r}\frac{\partial\varphi}{\partial r} + \frac{1}{r}\frac{\partial^2\psi_r}{\partial z\partial\theta} - \frac{1}{r}\frac{\partial^2\psi}{\partial r\partial\theta} + \frac{1}{r^2}\frac{\partial\psi_z}{\partial\theta} + \frac{1}{r}\frac{\partial\psi_\theta}{\partial z}\right),$$

$$\sigma_z = -(1-2k^2)\omega^2\varphi + 2\left(\frac{\partial^2\varphi}{\partial z^2} + \frac{\partial^2\psi_\theta}{\partial r\partial z} + \frac{1}{r}\frac{\partial\psi_\theta}{\partial z} - \frac{1}{r}\frac{\partial^2\psi_r}{\partial\theta\partial z}\right),$$

$$\sigma_{r\theta} = \frac{2}{r}\frac{\partial^2\varphi}{\partial r\partial\theta} - \frac{2}{r^2}\frac{\partial\varphi}{\partial\theta} + \frac{\partial^2\psi_r}{\partial r\partial z} - \frac{1}{r}\frac{\partial\psi_r}{\partial z} + \frac{1}{r^2}\frac{\partial^2\psi_z}{\partial\theta^2} - \frac{\partial^2\psi_z}{\partial r^2} + \frac{1}{r}\frac{\partial\psi_z}{\partial r} - \frac{1}{r}\frac{\partial^2\psi_\theta}{\partial\theta\partial z},$$

$$\sigma_{rz} = 2\frac{\partial^2\varphi}{\partial r\partial z} - \frac{1}{r}\frac{\partial^2\psi_r}{\partial r\partial\theta} + \frac{1}{r^2}\frac{\partial\psi_r}{\partial\theta} - \frac{\partial^2\psi_\theta}{\partial z^2} + \frac{\partial^2\psi_\theta}{\partial r^2} + \frac{1}{r}\frac{\partial\psi_\theta}{\partial r} - \frac{\psi_\theta}{r^2} + \frac{1}{r}\frac{\partial^2\psi_z}{\partial\theta\partial z},$$

$$\sigma_{\theta z} = \frac{2}{r}\frac{\partial^2\varphi}{\partial\theta\partial z} - \frac{1}{r^2}\frac{\partial^2\psi_r}{\partial\theta^2} + \frac{\partial^2\psi_r}{\partial z^2} - \frac{\partial^2\psi_z}{\partial r\partial z} + \frac{1}{r}\frac{\partial^2\psi_\theta}{\partial r\partial\theta} + \frac{1}{r^2}\frac{\partial\psi_\theta}{\partial\theta}.$$

Faraz qilaylik sferik qobiqa qo'yidagi ko'rinishdagi yuklanish tushsin.

$$\varphi^{(p)} = \varphi_0(t+z-1)^2 H(t+z-1), \psi_0 = 0. \quad (6)$$

Xususiy xolda $\varphi_0 = 1/2$ olingan.Turg'un bo'lmagan yuk qobiqa tushganda xam qaytgan va singan to'lqinlar cheksizlika borib so'nadi deb olinadi.Ya'ni φ va ψ - to'lqinlar uzoqlashuvchi , shuning uchun $\varphi \to 0, \psi \to 0$ agar

$$\sqrt{x^2+y^2+z^2} \to \infty.$$

Boshlangich shartlar bir jinili yoki nolga teng deb olingan. Boshlangich shartlar xam quyiladi :

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$$\vec{u}\big|_{t=0}=0;\quad \frac{\partial \vec{u}}{\partial t}\big|_{t=0}=0 \tag{7}$$

Hisob-kitoblarda biz Koltunov-Rjanitsin uch parametrli $R(t)=Ae^{-\beta t}/t^{1-\alpha}$ yadro relaksatsiyasi uchun olingan: $A=0,048;\beta=0,05;\alpha=0,1$. Noturg'un to'lqinlar sferik jismga tushganda qo'yilgan masalani yechish uchun vaqt bo'yicha Laplasning integral almashtirishi qo'laniladi ($0<t<T$),

$$f^{L}(s)=\int_{0}^{\infty}e^{-st}f(t)dt=L\left[f(t)\right] \tag{8}$$

Teskari almashtirish, ya'ni orginalni topish uchun ($f^{L}(s)$ - tasvir, $f(t)$- original) qo'yidagi formuladan foydalanamiz. Teskari almashtirish qo'yidagi integral orali amalga oshiriladi

$$f(t)=\frac{1}{2\pi i}\int_{\gamma-i\infty}^{\gamma+i\infty}e^{st}f^{L}(s)ds=L^{-1}\left[f^{L}(s)\right] \tag{9}$$

Integral maxsus nuqtadan o'ng tomonga joylashgan yo'l bo'yicha olinadi.
Laplas almashtirishi qo'llanganda (9) tushuvchi to'lqinning tasvirdagi ko'rinishi qo'yidagicha bo'ladi

$$\varphi^{(p)L}=\frac{e^{-s}}{s^{3}}\sum_{n=0}^{\infty}(2n+1)\sqrt{\frac{\pi}{2sr}}I_{n+\frac{1}{2}}(sr)P_{n}(\cos\theta). \tag{10}$$

Agar silindrik qobiq xisobga olmasak, u xolda elastik muxitdagi sferik bo'shliqni ko'ramiz. Sferik bo'shliqning kontur kuchlanishi qo'yidagi kurinishga ega

$$(\sigma_{\theta}+\sigma_{r})_{n}^{L}=s^{2}(3\xi^{2}+\frac{2}{\alpha^{2}})\begin{bmatrix}\frac{e^{-s}}{s^{3}}(2n+1)\sqrt{\frac{\pi}{2s}}I_{n+\frac{1}{2}}(s)\\ +\frac{c_{1}b_{2}+c_{2}b_{1}}{a_{1}b_{2}+a_{2}b_{1}}K_{n+\frac{1}{2}}(s)\end{bmatrix}, \tag{11}$$

Bunda

$$\xi=\frac{\nu_{0}}{1+\nu_{0}},\alpha=\frac{c_{1}}{c_{2}},a_{1}=(\xi s^{2}+\frac{3}{2\alpha^{2}})K_{n+\frac{1}{2}}(s)-$$

$$-\frac{2s}{\alpha^{2}}K'_{n+\frac{1}{2}}(s)+\frac{2s^{2}}{\alpha^{2}}K'_{n+\frac{1}{2}}(s),b_{1}=(s^{2}-\frac{3}{4\alpha^{2}})K_{n+\frac{1}{2}}(\alpha s)+$$

$$+\frac{3+4\alpha^{2}s^{2}}{2\alpha}sK'_{n+\frac{1}{2}}(\alpha s)-3s^{2}K'_{n+\frac{1}{2}}(\alpha s)-2s^{2}\alpha K''_{n+\frac{1}{2}}(\alpha s),$$

$$c_{1}=\frac{e^{-s}}{s^{2}}(2n+1)\sqrt{\frac{\pi}{2s}}\begin{bmatrix}-(\xi s^{2}+\frac{3}{2\alpha^{2}})I_{n+\frac{1}{2}}(s)+\\ +\frac{2s}{\alpha^{2}}I'_{n+\frac{1}{2}}(s)-\frac{2s^{2}}{\alpha^{2}}K'_{n+\frac{1}{2}}(s)\end{bmatrix},$$

$$\alpha_{2}=-\frac{3}{2\alpha^{2}}K_{n+\frac{1}{2}}(s)+\frac{2}{\alpha^{2}}K'_{n+\frac{1}{2}}(s),b_{2}=-\frac{3}{2\alpha^{2}}K_{n+\frac{1}{2}}(\alpha s)-s^{2}K'_{n+\frac{1}{2}}(\alpha s)+$$

$$+2s^{2}\alpha K''_{n+\frac{1}{2}}(\alpha s),\ c_{2}=\frac{e^{-s}}{s^{2}}(2n+1)\sqrt{\frac{\pi}{2s}}\left[\frac{3}{\alpha^{2}}I_{n+\frac{1}{2}}(s)-\frac{2}{\alpha^{2}}I'_{n+\frac{1}{2}}(s)\right].$$

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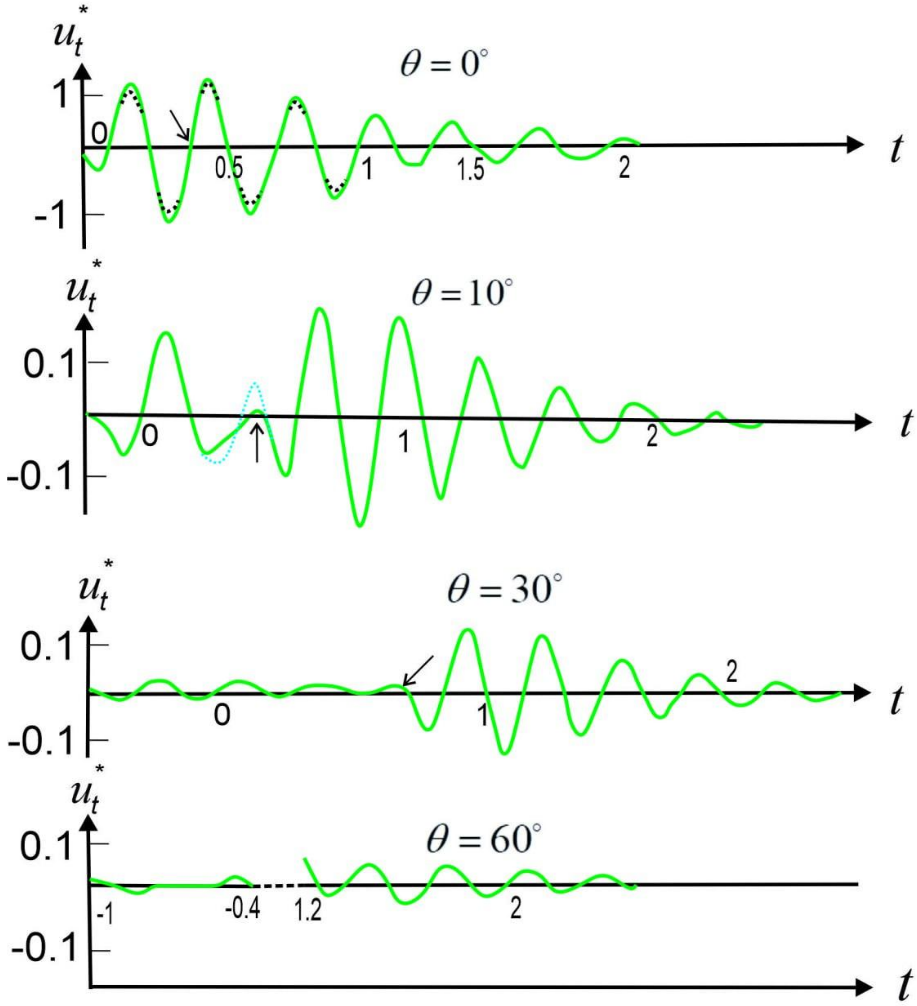
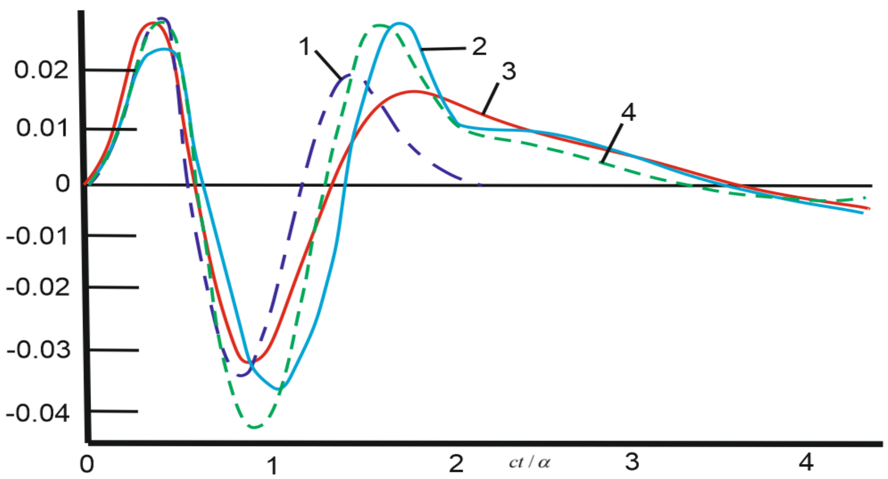
Shunday kilib sferik jismdagi noturg‘un to‘lqin difraksiyasi masalasini yechish metodikasi va algoritmi keltirilgan. Muxit kuchishi va kuchlanishlarni kiymatini topishda komleks soni modulini topish orkali baxo berdi:

$$(\mathrm{Re} + i\,\mathrm{Im})e^{-i\omega t} = \left(\mathrm{Re}^2 + \mathrm{Im}^2\right)^{1/2} e^{-i(\omega t - \gamma)}.$$



2-rasm.Kontur kuchlanishni vaqtga g‘ogliq o‘zgarishi.



3-rasm. Sferaik qobiq nuqtasini vaqtga bogliq ko‘chishi.Uch burchak formadagi tashqi yuklanish ta’siridagi sferik qobiqning 900 ko‘chishi.

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Yuqorida keltirilgan yechimdan koʻrinib turibdiki , yechim kompleks argumentli Bessel va Xankelning 1-chi va i 2-chi jinsli sferik funksiyasi bilan ifodalangan. Kompleks argumentli maxsus sferik funksiyalarni xisoblash metodikasi ishlab chikildi. Shuning bilan birgalikda maxsus katorni xisoblash jarayonida yaqinlashish oraligi xam tekshirib borildi. Xisoblash jarayonida sferik Bessel va Xankelning funksiyasining 7 gacha xadi xisoblandi. Xisoblash aniqligi 10-8 – 10-6 bulganda tuxtatildi. Yadro relaksatsiyasi sifatida uch parametirli Rjanisыn –Koltunov yadrosi olindi

$$R(t)=\frac{Ae^{-\beta t}}{t^{1-\alpha}} \tag{12}$$

bunda A,α,β - yadro parametrlari.

Faraz qilaylik sferik qobik bilan mustaxkamlanmagan toʻldiruvchili sferik boʻshliqning ichki sirtida xosil konturida xosil boʻladigan kontur kuchlanishini topamish talab etilsin. Asosiy maksad tekis frontli garmonik toʻlqin tushganda boʻshliq sirtidagi kuchanishlar konsentratsiyasini topishdan iiorat. Ta’sir etuvchi toʻlqin ta’siri kuchlanishlar deformatsiya xolati paydo boʻlali . Olingan Sonli natijalar 2 va 3 - rasmlarga keltirilgan. Sonli natijalar olishda qoʻyidagicha kattaliklardan foydalanilgan

$\nu_0=0.33;\nu_c=0.20;\nu_z=0.25;h_0/h_1=0.05;E_1/E_0=0.15;a/R=0.20;\rho_1/\rho_0=0.25;$

$A=0,048;\quad \beta=0,05;\quad \alpha=0,10$ .Natijalar oʻlchamamsiz deb olingan.

$0.001\le\alpha_1 b\le 0.45, 0.001\le\beta_1 b\le 0.45. ABC$ Yechimni ifodalovchi katorlarni yakinlashishi tekshirilgan. Oddiy ravishda kobika radial oʻqiga yoʻnaltirilgan seysmik toʻlqinlar ta’siridan tushuvchi toʻlqin yuklarning kobika kuchlanish holatiga ta’siri qonuniyatlari aniqlandi. Kobikdagi kuchlanishlarning uning diametri, devor qalinligi, zilzila intensivligi, tuproqning reologik xususiyatlariga bogʻliqligi aniqlangan.

Xulosa

Ishlab chiqilgan algoritmning toʻgʻriligi xususiy masalalar yechish va ma’lum boʻlgan natijalar bilan solishtirishlar orqali isbotlandi. Yupqa qobiq uchun Timoshenko S.P.va Krixgof Lyav gipotezasi qoʻlanganda kuchlanishlari orasidagi farq uzun toʻlqinlar soxasida 20% gacha, qisqa toʻlqinlar soxasida 10%gacha boʻlishi topildi. Sferik kobika koʻndalang va boʻylama toʻlqinlar yuklanganda kuchlanganlik deformatsiya xolatiga va zoʻriqishlarga solishtirma baxo berildi. Koʻndalang va boʻylama toʻlqinlar yuklanganda silindrik qatlamdagi kuchlanganlanishlar orasidagi farq 16-22% boʻlishi topildi.

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