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ERKIN DARAJASI CHEKLI QOVUSHOQ–ELASTIK MEXANIK SISTEMANING ERKIN TEBRANISHI

Annotatsiya: Maqolada erkinlik darajasi oltiga teng bo'lgan, to'rtta diferensialanuvchi tayanchga o'rnatilgan paralelopiped ko'rinishidagi apparatning erkin tebranishi o'rganilgan. Aparatning xarakat tenglamasi umumiy holda lagranjning ikkinchi tur differensial tenglamasidan olingan. Chastota tenglamasi Myuller usuli bilan sonli yechilgan va natijalar tahlil qilingan.

Kalit so'zlar: chastota, elastik tayanch, xos forma, Lagranj tenglamasi, sonli yechim.

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FREE VIBRATION OF A JOINT–ELASTIC MECHANICAL SYSTEM WITH FINITE DEGREES OF FREEDOM

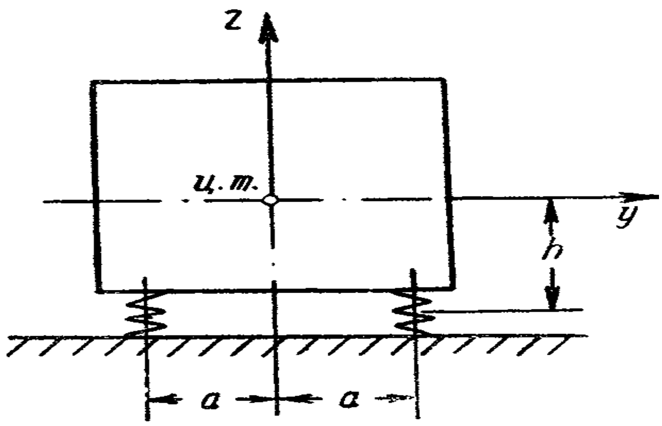
Abstract: The article studies the free oscillation of a parallelepiped apparatus with six degrees of freedom mounted on four differentiating supports. The equation of

motion of the apparatus is generally derived from Lagrange's second-order differential equation. The frequency equation is numerically solved using the Muller method and the results are analyzed.
Keywords: frequency, elastic support, eigenform, Lagrange equation, numerical solution.

Kirish. Erkin tebranish masalasi uchuvchi apparatlarga o'rnatilgan turli xil konstruksiyalarni vibratsiyadan himoyalashga ilmiy asos bo'lib xizmat qiladi. Deformatsiyalanuvchi tayanchga o'rnatilgan qattiq jismning tebranishlarini o'rganishga judda ko'p ilmiy ishlar bag'ishlangan [1,2,3]. Ular deformatsiyalanuvchi elimentlarning qovushqoqligini hisobga olib majburiy tebranishlarini o'rganishgan [4,5]. Lekin erkin tebranishlar masalasi to'liq o'rganilmagan.

Masalani qo'yilishi va yechish usuli.

Faraz qilaylik erkinlik darajasi olti bo'lgan konstruksiya berilgan bo'lsin (1-rasm). Bu konstruksiyani erkin tebranishini o'rganish masalasi qo'yilsin.



1-rasm. Xisob sxemasi.

Harakat differensial tenglamasi Lagranjning 2-tur differensial tenglamasidan olinadi va quyidagicha bo'ladi

$$
\left.\begin{aligned}
\text{¿}\beta_{11}\ddot{\delta}_1+\alpha_{11}\delta_1+\alpha_{15}\varphi_2+\alpha_{16}\varphi_3=0,\\
\text{¿}\beta_{11}\ddot{\delta}_2+\alpha_{22}\delta_2+\alpha_{24}\varphi_1+\alpha_{26}\varphi_3=0,\\
\text{¿}\beta_{11}\ddot{\delta}_3+\alpha_{33}\delta_3+\alpha_{34}\varphi_1+\alpha_{35}\varphi_2=0,\\
\text{¿}\beta_{44}\ddot{\varphi}_1+\beta_{45}\ddot{\varphi}_2+\beta_{46}\ddot{\varphi}_3+\alpha_{24}\delta_2+\alpha_{34}\delta_3+\alpha_{44}\varphi_1+\alpha_{45}\varphi_2+\alpha_{46}\varphi_3=0,\\
\text{¿}\beta_{45}\ddot{\varphi}_1+\beta_{55}\ddot{\varphi}_2+\beta_{56}\ddot{\varphi}_3+\alpha_{15}\delta_1+\alpha_{35}\delta_3+\alpha_{45}\varphi_1+\alpha_{55}\varphi_2+\alpha_{56}\varphi_3=0,\\
\text{¿}\beta_{46}\ddot{\varphi}_1+\beta_{56}\ddot{\varphi}_2+\beta_{66}\ddot{\varphi}_3+\alpha_{16}\delta_1+\alpha_{26}\delta_2+\alpha_{46}\varphi_1+\alpha_{56}\varphi_2+\alpha_{66}\varphi_3=0,
\end{aligned}\right\}(1)
$$

Bu yerda , δ_1, δ_2, δ_3 jismning og‘irlik markazining mos ravishda X, Y, Z o‘qlari bo‘yicha siljishi;$\varphi_1,\varphi_2,\varphi_3$-jismning koordinata o‘qlar atrofida aylanish burchaklari; c_x, c_y, c_z -mos keladigan o‘qlar yo‘nalishi bo‘yicha elastik elementlarning (amortizatorlar) qattiqlik koeffitsientlari;

$$\alpha_{11}=\sum c_x,\alpha_{16}=-\sum c_x y,\alpha_{35}=-\sum c_z x,\alpha_{22}=\sum c_y,\alpha_{24}=-\sum c_y z,\alpha_{45}=-\sum c_z xy,$$

$$\alpha_{33}=\sum c_z,\alpha_{26}=\sum c_y x,\alpha_{46}=-\sum c_y xz,\alpha_{15}=\sum c_x z,\alpha_{34}=\sum c_z y,\alpha_{56}=-\sum c_x yz;$$

$$\alpha_{44}=\sum\left(c_z y^2+c_y z^2\right),\beta_{11}=m,\beta_{66}=J_z,\alpha_{55}=\sum\left(c_x z^2+c_z x^2\right),\beta_{44}=J_x,\beta_{45}=-J_{xy},$$

$$\alpha_{66}=\sum\left(c_x y^2+c_y x^2\right),\beta_{55}=J_y,\beta_{56}=-J_{yz},\beta_{46}=-J_{xz}.$$

$J_x, J_y, J_z, J_{xy}, J_{xz}, J_{yz}$ jismning og‘irlik markazidan o‘tuvchi X, Y, Z o‘qlariga nisbatan inersiya momentlari va markazdan qochma inersiya momentlari. Bunday holda, XY tekisligi yelastik tayanchlar joylashgan tekislikka parallel bo‘lib, X va Y o‘qlarining yo‘nalishlari hisoblash qulayligi asosida ixtiyoriylik bilan tanlanadi; x, y, z - X, Y, Z koordinata sistemasidagi amortizatorlarning koordinatalari.(1) Differensial tenglamalar sistemasining xususiy yechimlari quyidagi ko‘rinishga ega:

$$\delta_1=A_1\cos(\text{¿}\omega t+\psi),\varphi_1=A_4\cos(\text{¿}\omega t+\psi),\text{¿¿}\delta_2=A_2\cos(\text{¿}\omega t+\psi),\varphi_2=A_5\cos(\text{¿}\omega t+\psi),\text{¿¿}$$

$$\delta_3=A_3\cos(\text{¿}\omega t+\psi),\varphi_3=A_6\cos(\text{¿}\omega t+\psi),\text{¿¿}$$

Bu yerda ω_R, ω_I-doimiy koeffitsientlar, ω-burchak chastotasi,

ψ-tebranishlarning boshlang‘ich fazasi.Ushbu yechimlarni (1) ga qo‘yib, biz quyidagi bir jinsli algebraik tenglamalar sistemasini hosil qilamiz:

$$\left(\alpha_{11}-\beta_{11}\omega^2\right)\delta_1+\alpha_{15}\varphi_2+\alpha_{16}\varphi_3=0,\left(\alpha_{22}-\beta_{11}\omega^2\right)\delta_2+\alpha_{24}\varphi_1+\alpha_{26}\varphi_3=0,$$

$$\left(\alpha_{33}-\beta_{11}\omega^2\right)\delta_3+\alpha_{34}\varphi_1+\alpha_{35}\varphi_2=0,$$

$$\alpha_{24}\delta_2+\alpha_{34}\delta_3+\left(\alpha_{44}-\beta_{44}\omega^2\right)\varphi_1+\left(\alpha_{45}-\beta_{45}\omega^2\right)\varphi_2+\left(\alpha_{46}-\beta_{46}\omega^2\right)\varphi_3=0,$$

$$\alpha_{15}\delta_1+\alpha_{35}\delta_3+\left(\alpha_{45}-\beta_{45}\omega^2\right)\varphi_1+\left(\alpha_{55}-\beta_{55}\omega^2\right)\varphi_2+\left(\alpha_{56}-\beta_{56}\omega^2\right)\varphi_3=0,$$

$$\alpha_{16}\delta_1+\alpha_{26}\delta_2+\left(\alpha_{46}-\beta_{46}\omega^2\right)\varphi_1+\left(\alpha_{56}-\beta_{56}\omega^2\right)\varphi_2+\left(\alpha_{66}-\beta_{66}\omega^2\right)\varphi_3=0.$$

Бу система $\Delta=0$ детерминанти нолга тенг бўлганда, нолдан фарқли йечимларга ега бўлади

$$\begin{vmatrix} \alpha_{11}-\beta_{11}\omega^2 & 0 & 0 & 0 & \alpha_{15} & \alpha_{16} \\ 0 & \alpha_{22}-\beta_{11}\omega^2 & 0 & \alpha_{24} & 0 & \alpha_{26} \\ 0 & 0 & \alpha_{33}-\beta_{11}\omega^2 & \alpha_{34} & \alpha_{35} & 0 \\ 0 & \alpha_{24} & \alpha_{34} & \alpha_{44}-\beta_{44}\omega^2 & \alpha_{45}-\beta_{45}\omega^2 & \alpha_{46}-\beta_{46}\omega^2 \\ \alpha_{15} & 0 & \alpha_{35} & \alpha_{45}-\beta_{45}\omega^2 & \alpha_{55}-\beta_{55}\omega^2 & \alpha_{56}-\beta_{56}\omega^2 \\ \alpha_{16} & \alpha_{26} & 0 & \alpha_{46}-\beta_{46}\omega^2 & \alpha_{56}-\beta_{56}\omega^2 & \alpha_{66}-\beta_{11}\omega^2 \end{vmatrix} 0$$

Oxirgi tenglama ($\Delta=0$) chastota tenglamasi deb ataladi. Bu determinantni yoyib, ω^2 ga nisbatan oltinchi darajali tenglamani olamiz

$$A\omega^{12}+B\omega^{10}+C\omega^8+D\omega^6+E\omega^4+F\omega^2+G=0.(2)$$

bu yerda A, B, G doimiy koeffitsientlar. (2) tenglamaning ildizlari $\omega_1,\omega_2,\dots,\omega_6$ jismning oltita xos tebranish chastotasi sistemasini tashkil qiladi.. Ushbu tenglamani qulay taxminiy usuldan foydalanmasdan hal qilish juda mashaqqatli ishdir. Biroq, amaliyotda tez-tez uchraydigan bir qator xususiy holatlarda, izolyatsiya qilingan tizimning xos chastotalarini topish juda soddalashtirilishi mumkin.

Xulosa sifatida shuni aytish mumkinki, ikkala tangensial harakat X o‘qi bo‘ylab yo‘naltirilgan ω_x chastotali sof bo‘ylama tebranishga yoki og‘irlik markazi atrofida chastotasi $\omega_{0\varphi}$ bo‘lgan sof aylanish tebranishiga o‘tadi.XZ tekisligi uchun bu yerda keltirilgan mulohaza YZ tekisligi uchun ham amal qiladi.Agar izolyatsiya qilingan jismga chastota spektri raqamli o‘qning keng oralig‘ida joylashgan davriy qo‘zg‘alish kuchlari ta’sir qilsa, u holda tebranish izolyatsiyasining yuqori samaradorligini ta’minlash uchun izolyatsiya qilingan tizimning barcha oltita xos chastotasi yoki hech bo‘lmaganda rezonansda yeng katta ampulutudaga olib kelgan holatda, ular teng yoki taxminan bir-biriga tenglashtiradi. xos chastotalarning kombinatsiyasiga amortizatorlarning qattiqligi va ularning nisbiy joylashuvini to‘g‘ri tanlash orqali erishish mumkin.

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