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ANIZOTROP TERMO-ELEKTRO-MAGNIT PLASTINALARNING NOCHIZIQLI KUCHLANLANGANLIK-DEFORMASIYALANGANLIK JARAYONLARINI MATEMATIK MODELI VA HISOBLASH TAJRIBALARI

Annotatsiya: Murakkab shaklga ega bo’lgan anizotrop termo-elektro-magnit plastinalarning nochiziqli kuchlanganlik deformatsiyalanganlik jarayonlarini matematik modellashtirish Gamilton-Ostrogradskiy variatsion tamoyili asosida ko’chishga nisbatan boshlang’ich va chegaraviy shartlarga ega,yuqori tartibli xususiy hosilali nochiziqli differensial tenglamalar tizimi shaklidagi matematik model ishlab chiqilgan. Matematik modelni qurishimizda biz Kirxgof-Lyav gepotizasidan foydalanib uch o’lchovli koordinatani ikki o’lchovli koordinataga o’tkazamiz bunda ko’chishlarning dastlabki ko’rinishiga ega bo’lamiz. Kinetik energiya, Potensial energiya va Tashqi kuchlar bajargan ishlarni variatsion ko’rinishi hisoblab chiqildi. Furening issiqlik o’tkazuvchanlik qonuni, Dyugamelya-Neymananing tenglamasi,Koshi munosabati,Guk qonuni,Lorens kuchi va Maksvell elektromagnit tenzor ko’rinishidan foydalanib, termo-elektro-magnit maydon ta’siri ostidagi, murakkab shaklga ega bo’lgan anizotrop termo-elektro-magnitelastik plastinalarning nochiziqli kuchlanlanganlik va deformasiyalanganlik holati o’rganildi.

Kalit so‘zlar: Model,Matemetik model, Modellashtirish,Gamilton-Ostrogradskiy tamoyili,Kirgof-Lyav gipotezasi, Furening issiqlik o’tkazuvchanlik qonuni, Dyugamelya-Neymananing tenglamasi,Koshi munosabatlari,Guk qonuni,Maksvell elektromagnit tenzori,anizotrop, plastina.

Kirish

Aviatsiya va kosmik texnologiyalarda tuzilmaviy boshqaruv,energiya boshqaruvi,harorat va elektr maydon ta'sirida energiyani samarali taqsimlash va boshqarish imkonini beradi.Energetikada termoelektrik generatorlar,elektr energiyasini o'zgartirishva elektromagnit maydon ta'sirida energiya oqimini boshqarish uchun ishlatiladi. Sensorlar va aktuatorlarda harorat, bosim va elektromagnit maydon o'zgarishlarini sezuvchi yuqori sezgir qurilmalarda qo'llaniladi,Elektromagnit maydon ta'sirida harakatni yaratish uchun ishlatiladi. Tibbiyot texnologiyalarida tibbiyotda elektromagnit maydon asosida ishlaydigan qurilmalarda qo'llaniladi,reabilitatsiya texnologiyalarida elektromagnit maydon orqali davolash usullari uchun ishlatiladi. [5].

Matematik modellashtirish

Termo-elektro-magnit maydonda joylashgan murakkab shaklga ega bo'lgan plastina uchun matematik model Gamilton-Ostrogradskiy variatsion tamoyili, Furening issiqlik o'tkazuvchanlik qonuni, Dyugamelya-Neymananing tenglamasi va Maksvell tenglamalari ko'rinishidagi elektro dinamika tenglamalari asosida, Murakkab shaklga ega bo'lgan anizotrop termo-elektro-magnit plastinalarning nochiziqli kuchlanganlik deformatsiyalanganlik jarayonlarini matematik modeli keltirib chiqarilgan. Gamilton-Ostrogradskiy variatsion tamoyilining umumiy ko'rinishi:

$$\int_t (\delta K - \delta \Pi + \delta A)dt = 0; \tag{1}$$

Bunda : $\delta -$ variatsiya amali; $K -$ kinetik energiya; $\Pi -$ potensial energiya;

$A -$ tashqi hajm va sirt kuchlari bajargan ish.

Murakkab shaklga ega plastinaning harakat tenglamalarini keltirib chiqarishda ko'chishning o'zgarish qonunlari sifatida Kirxgofa-Lyav gepotezasidan foydalanamiz [2].

$$u_1 = u(x,y,t) - z\frac{\partial w}{\partial x},\ u_2 = v(x,y,t) - z\frac{\partial w}{\partial y},\ u_3 = w(x,y,t) \tag{2}$$

Bunda: $u, v, w -$ ko'chishlar.

Gamilton-Ostrogradskiy variasion tamoyili asosida murakkab shaklga ega bo'lgan anizotrop termo-elektro-magnit plastinalarning nochiziqli kuchlanlanganlik-deformasiyalanganlik holatiga Koshi munosabatlari, Furening issiqlik o'tkazuvchanlik qonuni, Dyugamelya-Neymananing tenglamasi,Guk qonuni va Maksvell elektromagnit tenzor ko'rinishidan foydalanib, termo-elektro-magnit maydon ta'sirlari ko'riladi. Natijada ko'chishga nibatan boshlang'ich va chegaraviy shartlarga ega xususiy hosilali differensial tenglamalar tizimi ko'rinishidagi matematik model olinadi.

Natija

Yupqa murakkab shaklga ega termo-elektro-magnitelastik anizotrop plastinaning matematik modeli

Gamilton-Ostrogradskiy variasion tamoyili asosida yupqa murakkab konstruksiyaviy shakldagi termo-elektro-magnitelastik anizotrop plastinalarning geometrik nochiziqli deformasiyalanish jarayonlarida termo-elektro-magnit maydon kuchlarini hisobga olgan holda ishlab chiqilgan matematik modeli to‘liq shaklini keltiramiz.

$$
\begin{cases}
-\rho h\frac{\partial^2 u}{\partial t^2}-hC_{1111}\frac{\partial^2 u}{\partial x^2}-\frac{h}{2}C_{1212}\frac{\partial^2 u}{\partial y^2}-\frac{h}{2}C_{1111}\frac{\partial^3 w}{\partial x^3}-\frac{h}{2}C_{1222}\frac{\partial^3 w}{\partial y^3}-\frac{h}{2}C_{1112}\frac{\partial^2 v}{\partial x^2}-\frac{h}{2}C_{1222}\frac{\partial^2 v}{\partial y^2}- \\
-(hC_{1122}+\frac{h}{2}C_{1212})\frac{\partial^2 v}{\partial x\partial y}-(\frac{h}{2}C_{1122}+\frac{h}{2}C_{1212})\frac{\partial^3 w}{\partial x\partial y^2}-(hC_{1211}+\frac{h}{2}C_{1112})\frac{\partial^2 u}{\partial x\partial y}-(\frac{h}{2}C_{1112}+\frac{h}{2}C_{1211})\frac{\partial^3 w}{\partial x^2\partial y}+ \\
+h\frac{\partial}{\partial x}(\alpha_{11}(T-T_0))+h\frac{\partial}{\partial y}(\alpha_{12}(T-T_0))+N_x+R_x+q_x+T_{zx}+\theta_{Tzx}+\theta_{\mathrm{T}}=0, \\
-\rho h\frac{\partial^2 v}{\partial t^2}-hC_{2222}\frac{\partial^2 v}{\partial y^2}-\frac{h}{4}C_{1212}\frac{\partial^2 v}{\partial x^2}-\frac{h}{2}C_{2212}\frac{\partial^2 u}{\partial y^2}-\frac{h}{2}C_{1211}\frac{\partial^2 u}{\partial x^2}-\frac{h}{2}C_{2222}\frac{\partial^3 w}{\partial y^3}-\frac{h}{4}C_{1211}\frac{\partial^3 w}{\partial x^3}- \\
-(hC_{2211}+\frac{h}{4}C_{1212})\frac{\partial^2 u}{\partial x\partial y}-(\frac{h}{2}C_{2212}+\frac{h}{2}C_{1222})\frac{\partial^2 v}{\partial x\partial y}-(\frac{h}{2}C_{2211}+\frac{h}{4}C_{1212})\frac{\partial^3 w}{\partial x^2\partial y}-(\frac{h}{2}C_{2212}+\frac{h}{4}C_{1222})\frac{\partial^3 w}{\partial x\partial y^2}+ \\
+h\frac{\partial}{\partial y}(\alpha_{22}(T-T_0))+\frac{h}{2}\frac{\partial}{\partial x}(\alpha_{12}(T-T_0))+N_y+R_y+q_y+T_{zy}+\theta_{Tzy}+\theta_{\mathrm{T}}=0, \\
-\rho h\frac{\partial^2 w}{\partial t^2}-\frac{h}{2}C_{1111}(\frac{\partial u}{\partial x}\frac{\partial^2 w}{\partial x^2}+\frac{1}{2}\frac{\partial^4 w}{\partial x^4})-\frac{h}{2}C_{1122}\frac{\partial v}{\partial y}\frac{\partial^2 w}{\partial x^2}-\frac{h}{2}\frac{\partial^4 w}{\partial x^2\partial y^2}(\frac{1}{2}C_{1122}+\frac{1}{2}C_{2211}+C_{1212})-\frac{h}{4}C_{1112}\frac{\partial u}{\partial y}\frac{\partial^2 w}{\partial x^2}- \\
-\frac{h}{2}\frac{\partial^4 w}{\partial x^3\partial y}(\frac{1}{2}C_{1112}+C_{1211})-\frac{h}{2}C_{2211}\frac{\partial u}{\partial x}\frac{\partial^2 w}{\partial y^2}-\frac{h}{2}C_{2222}(\frac{\partial v}{\partial y}\frac{\partial^2 w}{\partial y^2}+\frac{1}{2}\frac{\partial^4 w}{\partial y^4})-\frac{h}{4}C_{2212}(\frac{\partial u}{\partial y}\frac{\partial^2 w}{\partial y^2}+\frac{\partial v}{\partial x}\frac{\partial^2 w}{\partial y^2})- \\
-\frac{h}{2}\frac{\partial^4 w}{\partial x\partial y^3}(\frac{1}{2}C_{2212}+C_{1222})-hC_{1211}\frac{\partial u}{\partial x}\frac{\partial^2 w}{\partial x\partial y}-hC_{1222}\frac{\partial v}{\partial y}\frac{\partial^2 w}{\partial x\partial y}-\frac{h}{2}C_{1212}(\frac{\partial u}{\partial y}\frac{\partial^2 w}{\partial x\partial y}+\frac{\partial v}{\partial x}\frac{\partial^2 w}{\partial x\partial y})+ \\
+\frac{h}{2}\frac{\partial^2 w}{\partial x^2}\alpha_{11}(T-T_0)+\frac{h}{2}\frac{\partial^2 w}{\partial y^2}\alpha_{22}(T-T_0)+h\frac{\partial^2 w}{\partial x\partial y}\alpha_{12}(T-T_0)+\frac{h}{12}C_{1111}\frac{\partial^4 w}{\partial x^4}+\frac{h}{12}\frac{\partial^4 w}{\partial x^2\partial y^2}(C_{1122}+C_{2212}+C_{1211})+ \\
+\frac{h}{12}\frac{\partial^4 w}{\partial x^3\partial y}(C_{1112}+C_{2211})+\frac{h}{12}\frac{\partial^4 w}{\partial x\partial y^3}(C_{2222}+C_{1212})+\frac{h}{12}C_{1222}\frac{\partial^4 w}{\partial y^4}+N_z+R_z+q_z+T_{zz}+\theta_{Tzz}+\theta_{\mathrm{T}}=0, \\
\lambda_{11}\frac{\partial^2\theta_{\mathrm{T}}}{\partial x^2}+\lambda_{12}\frac{\partial^2\theta_{\mathrm{T}}}{\partial x\partial y}+\lambda_{21}\frac{\partial^2\theta_{\mathrm{T}}}{\partial y\partial x}+\lambda_{22}\frac{\partial^2\theta_{\mathrm{T}}}{\partial y^2}-C_{\varepsilon}\frac{\partial^2\theta_{\mathrm{T}}}{\partial t}-\theta_{\mathrm{T}_0}\beta_{11}(\frac{\partial^2 u}{\partial x\partial t}-z\frac{\partial^3 w}{\partial x^2\partial t}+\frac{1}{2}\frac{\partial^3 w}{\partial x^2\partial t})- \\
-\theta_{\mathrm{T}_0}\beta_{22}(\frac{\partial^2 v}{\partial y\partial t}-z\frac{\partial^3 w}{\partial y^2\partial t}+\frac{1}{2}\frac{\partial^3 w}{\partial y^2\partial t})-\theta_{\mathrm{T}_0}\beta_{12}(\frac{\partial^2 u}{\partial y\partial t}+\frac{\partial^2 v}{\partial x\partial t}-z\frac{\partial^3 w}{\partial x\partial y\partial t}+\frac{1}{2}\frac{\partial^3 w}{\partial x\partial y\partial t})=0.
\end{cases}
$$

Boshlang’ich shartlar:

$$\rho h\frac{\partial u}{\partial t}\delta u\bigg|_t=0,\rho h\frac{\partial v}{\partial t}\delta v\bigg|_t=0,\rho h\frac{\partial w}{\partial t}\delta w\bigg|_t=0,\ \theta_T\bigg|_{t=0}=T_0$$

$$\rho\frac{h^3}{12}\frac{\partial^2 w}{\partial t\partial x}\delta w\bigg|_x\bigg|_t=0,\ \rho\frac{h^3}{12}\frac{\partial^2 w}{\partial t\partial y}\delta w\bigg|_y\bigg|_t=0;$$

Chegaraviy shartlar:

$$h\left[C_{1111}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1122}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1112}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{11}(T-T_0)\right]\delta u\bigg|_x=0,$$

$$\frac{1}{2}h\left[C_{1211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{12}(T-T_0)\right]\delta v\bigg|_x=0,$$

$$h\left[C_{2211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{2222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{2212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{22}(T-T_0)\right]\delta v\bigg|_y=0,$$

$$\frac{1}{2}h\left[C_{1211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{12}(T-T_0)\right]\delta u\bigg|_y=0,$$

$$\frac{h^3}{12}\left(C_{1111}\frac{\partial^2 w}{\partial x^2}+C_{1122}\frac{\partial^2 w}{\partial y^2}+C_{1112}\frac{\partial^2 w}{\partial x\partial y}\right)\delta\frac{\partial w}{\partial x}\bigg|_x=0,$$

$$\frac{1}{2}h\left[C_{1111}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1122}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1112}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{11}(T-T_0)\right]\frac{\partial w}{\partial x}\delta w\bigg|_x=0,$$

$$-\frac{h^3}{12}\left(C_{1211}\frac{\partial^3 w}{\partial x^2\partial y}+C_{1222}\frac{\partial^3 w}{\partial y^3}+C_{1212}\frac{\partial^3 w}{\partial x\partial y^2}\right)\delta w\bigg|_x=0,$$

$$\frac{1}{2}h\left[C_{1211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{12}(T-T_0)\right]\frac{\partial w}{\partial y}\delta w\bigg|_x=0,$$

$$\frac{h^3}{12}\left(C_{2211}\frac{\partial^2 w}{\partial x^2}+C_{2222}\frac{\partial^2 w}{\partial y^2}+C_{2212}\frac{\partial^2 w}{\partial x\partial y}\right)\delta\frac{\partial w}{\partial y}\delta w\bigg|_y=0$$

$$\frac{1}{2}h\left[C_{2211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{2222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{2212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{22}(T-T_0)\right]\frac{\partial w}{\partial y}\delta w\bigg|_y=0,$$

$$\frac{h^3}{12}\left(C_{1211}\frac{\partial^2 w}{\partial x^2}+C_{1222}\frac{\partial^2 w}{\partial y^2}+C_{1212}\frac{\partial^2 w}{\partial x\partial y}\right)\delta\frac{\partial w}{\partial x}\bigg|_y=0,$$

$$\frac{1}{2}h\left[C_{1211}\left(\frac{\partial u}{\partial x}+\frac{1}{2}\left(\frac{\partial w}{\partial x}\right)^2\right)+C_{1222}\left(\frac{\partial v}{\partial y}+\frac{1}{2}\left(\frac{\partial w}{\partial y}\right)^2\right)+C_{1212}\left(\frac{1}{2}\frac{\partial u}{\partial y}+\frac{1}{2}\frac{\partial v}{\partial x}+\frac{1}{2}\frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right)-\alpha_{12}(T-T_0)\right]\frac{\partial w}{\partial x}\delta w\bigg|_y=0,$$

$$h\left[\left(\Phi_{Px}+\Phi_{Txx}+\Phi_{\theta_{Txx}}\right)\delta u+\left(\Phi_{Py}+\Phi_{Txy}+\Phi_{\theta_{Txy}}\right)\delta v+\left(\Phi_{Pz}+\Phi_{Txz}+\Phi_{\theta_{Txz}}\right)\delta w\right]\bigg|_x=0,$$

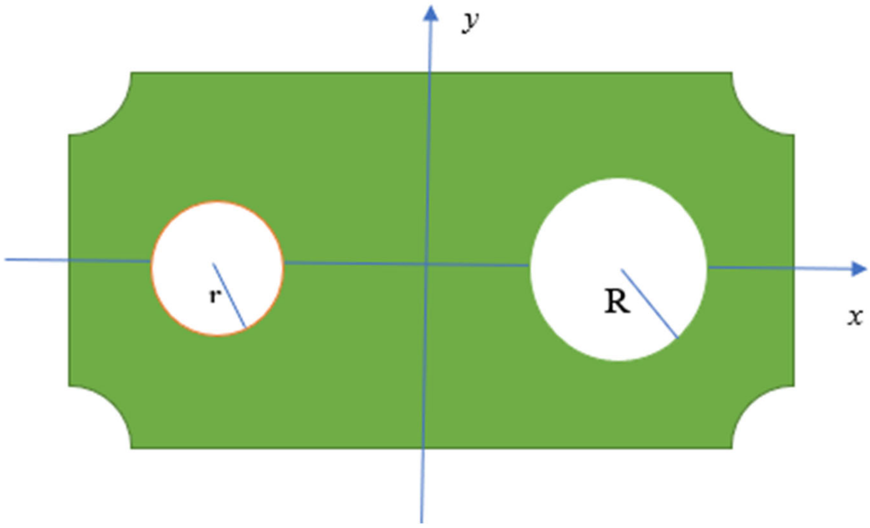
$$h\left[\left(\Phi_{Fx}+\Phi_{Tyx}+\Phi_{\theta_{Tyx}}\right)\delta u+\left(\Phi_{Fy}+\Phi_{Tyy}+\Phi_{\theta_{Tyy}}\right)\delta v+\left(\Phi_{Fz}+\Phi_{Tyz}+\Phi_{\theta_{Tyz}}\right)\delta w\right]\bigg|_y=0.$$

$$\frac{\partial\theta_T}{\partial n}+\alpha_{\theta_T}(\theta_T-T_0)=0\quad chegarada;$$

Ushbu tenglamalar tadqiq qilinayotgan murakkab shaklga ega bo'lgan plastina chegaralarini mahkamlanish usullariga qarab tegishli chegaraviy shartlarga muvofiq yechiladi.

Hisoblash tajribasi-1

Chegaralari qattiq mahkamlangan holatidagi plastina tasviri ustida hisoblash ishlarini olib boramiz.



1-rasm. Murakkab shakldagi magnitelastik nosimmetrik yupqa plastina

Hisoblash tajribasida geometrik va mexanik o'zgarmas qiymatlar quyidagicha keltirilgan: $a = 1m,\ b = 1m,\ h = 0.01m, c = 0.4m,\ d = 0.4m, R = 0.2m,\ r = 0.1m,\ \nu = 0.3,\ t = 1c,$

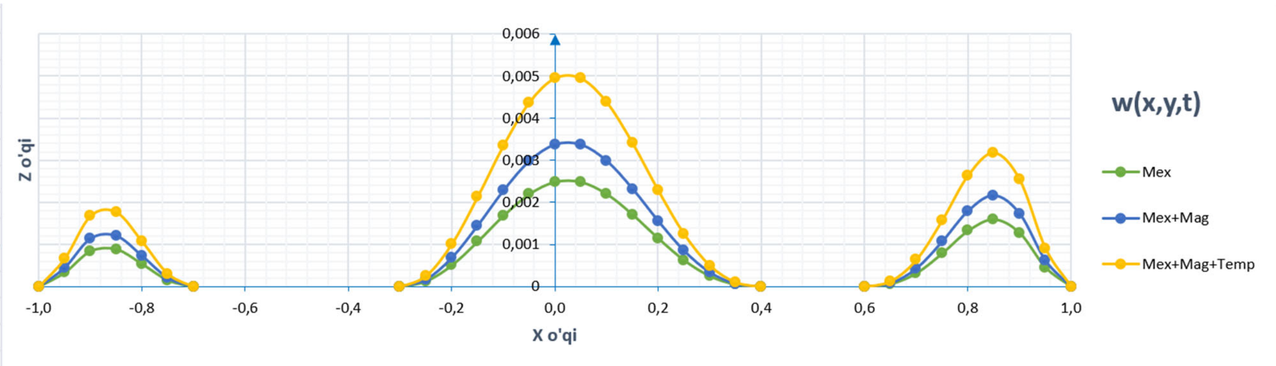
$Q = 20,\ H_x = H_y = H_z = 10\kappa Э, T = 70C.$

Elektro'tkazuvchan murakkab shaklli yupqa plastinaga mexanik kuchlar va elektromagnit maydon kuchlar ta'siri hamda harorat tasirini qo'shib hisoblash ishlari olib borilganda 1-jadvaldagi sonli natijalar olindi va natijaning grafik ko'rinishdagi tasviri 2-rasmda ko'rsatib berildi.

1-jadval. Yupqa plastinaning chegaralari qattiq mahkamlangan shartlarda olingan natijalar.

X	*y*	*Mexanik kuchlar ta'siri qaralganda* ***W(x,y,t) t=0.1***	*Mexanik kuchlar va Elektromagnit maydon kuchlar ta'siri qaralganda* ***W(x,y,t) t=0.1***	*Mexanik kuchlar va Elektromagnit maydon kuchlari, harorat ta'siri qaralganda* ***W(x,y,t) t=0.1***
-1	0	0	0	0
-0,9	0	0,000408	0,00044907	0,00052551
-0,8	0	0,000426	0,00046853	0,00054828
-0,7	0	0,000104	0,00011403	0,00013344

-0,6	0	0	0	0
-0,5	0	0	0	0
-0,4	0	0	0	0
-0,3	0	0,00008555	0,00009413	0,00011015
-0,2	0	0,000404	0,00044414	0,00051974
-0,1	0	0,00081488	0,00089658	0,00104919
0	0	0,001006	0,001107	0,00129507
0,1	0	0,00081488	0,00089658	0,00104919
0,2	0	0,000403	0,0004	0,00051974
0,3	0	0,00008555	0,00009413	0,00011015
0,4	0	0	0	0
0,5	0	0	0	0
0,6	0	0	0	0
0,7	0	0,000104	0,000114	0,00013344
0,8	0	0,000426	0,000469	0,00054828
0,9	0	0,0004082	0,0004491	0,00052551
1	0	0	0	0

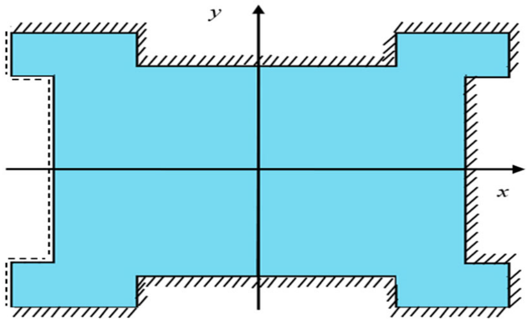


2-rasm. Magnitelastik nosimmetrik yupqa plastina chegaralari qattiq mahkamlangan sharti bo‘yicha koordinata o‘qidagi grafigi.

Xulosa qilib aytganda elektro‘tkazuvchan yupqa plastinaga mexanik kuchlar ta’siri hamda mexanik kuchlarga magnit maydon kuchlar farqi 8.1 % va harorat ta’siri ham qo‘shib hisoblash ishlari olib borilganda, va hisoblash tajribalar xulosasi shuni ko‘rsatadiki ularning o‘zaro farqi 13.5% ni tashkil qildi.

Hisoblash tajribasi-2

Yupqa plastinaning chegarasi bir tomoni erkin, qolgan tomonlari va qattiq mahkamlangan shartlar bilan olingan sonli natijalar grafik tasvir

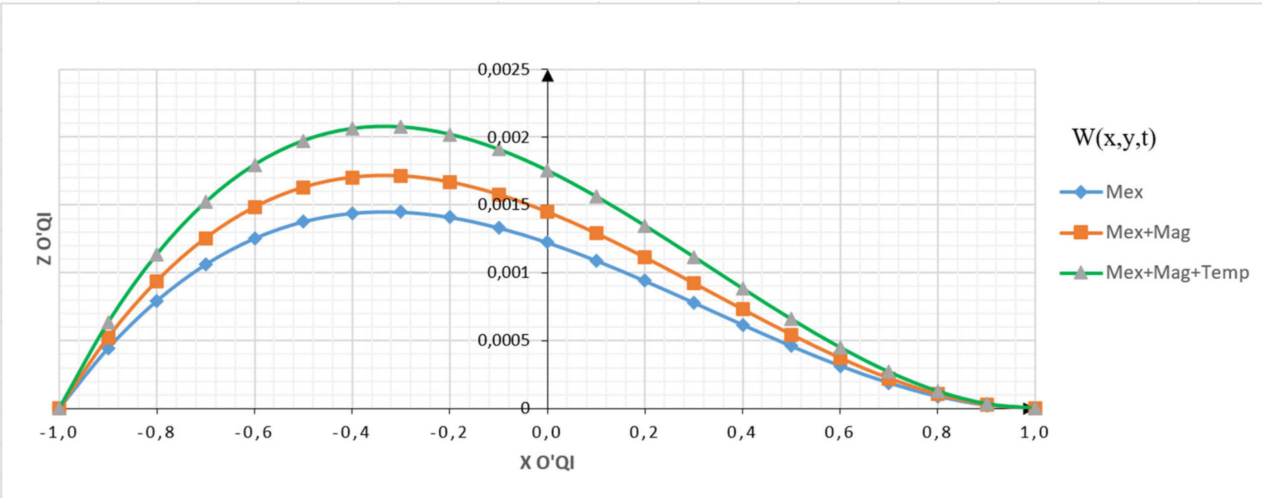


3-rasm. Chegaralari qattiq va sharnir mahkamlangan plastina

2-jadval. Yupqa plastinaning chegaralari aralash shartlarda olingan sonli natijalar.

x	*y*	*Mexanik kuchlar ta'siri qaralganda* ***V(x,y,t) t=0.1***	*Mexanik kuchlar va Elektromagnit maydon kuchlar ta'siri qaralganda* ***V(x,y,t) t=0.1***	*Mexanik kuchlar va Elektromagnit maydon kuchlari, harorat ta'siri qaralganda* ***V(x,y,t) t=0.1***
-1	0	0	0	0
-0,9	0	0,000442	0,000523	0,000633
-0,8	0	0,000793	0,000938	0,001136
-0,7	0	0,001061	0,001256	0,00152
-0,6	0	0,001253	0,001483	0,001796
-0,5	0	0,001377	0,001629	0,001973
-0,4	0	0,001439	0,001703	0,002062
-0,3	0	0,001448	0,001713	0,002075
-0,2	0	0,00141	0,001668	0,00202
-0,1	0	0,001333	0,001577	0,00191
0	0	0,001224	0,001448	0,001754
0,1	0	0,00109	0,00129	0,001562
0,2	0	0,00094	0,001112	0,001346
0,3	0	0,00078	0,000923	0,001117
0,4	0	0,000617	0,00073	0,000884

0,5	0	0,000459	0,000543	0,000658
0,6	0	0,000313	0,000371	0,000449
0,7	0	0,000187	0,000222	0,000268
0,8	0	0,000088	0,00010428	0,000126
0,9	0	0,000023	0,0000275	0,000033
1	0	0	0	0



4-rasm. Plastinaning chegaralari (sharnir va qattiq mahkamlangan) aralash shartlarda olingan sonli natijalar uchun grafik tasviri.

Yupqa plastinaga mexanik kuchlar ta’siri hamda mexanik kuchlarga magnit maydon kuchlar ta’siri ham qo‘shib hisoblash ishlari olib borilganda 16% (4.3.9-jadval, 4.3.10-rasm), va hisoblash tajribalar xulosasi shuniko‘rsatadiki ularning o‘zaro farqi 17% ni tashkil qildi.

Hisoblash natijalarini tahlil qilish natijalariga asoslanib xulosa qilish mumkinki, elektromagnit maydonlarning va harorat maydonini yupqa elektro‘tkazuvchan plastinalarning deformatsiya holatiga ta’sirini ishonchli tarzda tasdiqlash imkonini beradi.

Xulosa

Termo-elektro-magnit maydonda joylashgan murakkab shaklga ega nochiziqli anizotrop plastinalar termo-elektro-manitelastiklik masalasining matematik modeli ishlab chiqildi. Bunda termo-elektro-magnitelastik yupqa anizatrop plastinaning geometrik nochiziqli deformasiyalanish holatiga termo-elektro-magnit maydon ta'sirlari o‘rganildi;

Gamilton-Ostrogradskiy variasion tamoyili asosida Kirxgof-Lyav gipotezasi, Koshi munosabatlari, Guk qonuni,Fure issiqlik o'tkazuvchanlik qonuni hamda Maksvell elektromagnit tenzor koʻrinishlaridan foydalanib, potensial energiya, kinetik energiya va tashqi kuchlar bajargan ishning variasion koʻrinishlari aniqlanildi. Natijada koʻchishga nibatan boshlangʻich va chegaraviy shartlarga ega, xususiy hosilali nochiziqli differensial tenglamalar tizimi koʻrinishidagi matematik modeli olindi.

Ishlab chiqilgan matematik modeldan termo-elektro-magnit maydonda joylashgan yupqa murakkab shaklga ega anizotrop plastinalarning termo-elektro-magnitelastiklik masalalarini tadqiq qilishda foydalanish mumkin.

Adabiyotlar

1. Амбарцумян С. А. Теория анизотропных пластин. - М: Наука,1987.-360с.
2. Амбарцумян С.А., Багдасарян Г.Е., Белубекян М.В. Магнитоупругость тонких оболочек и пластин. - М.: Наука, 1977. - 272 с.
3. Амбарцумян С.А., Белубекян М.В. Некоторые задачи электромагнитоупругости пластин. – Ереван: 1991.–144 с.
4. Индиаминов Р.Ш. Математическое моделирование магнитоупругих колебаний анизотропной пластины на упругом основании // Пробл. мех. 2004. №5-6. – С. 15-20.
5. Корнишин М.С. Нелинейная задача теории пластин и пологих оболочек и методы их решения. - М: Наука, 1964. – 192с.
6. Кронрод А.С. Узлы и веса квадратурных формул. -М.: Наука, 1964. - 144 с.
7. Курпа Л.В. Методом R-функции для решения линейных задач изгиба и колебаний пологих оболочек. Харьков НТУ ХПИ 2009. 391 с.
8. Рвачев В.Л. Теория R- функций и некоторые ее приложения. –Киев: Наукава думка, 1982.-552с.
9. Рвачев В.Л., Курпа Л.В. R-функция в задачах теории пластин. - Киев: Наукова думка, 1987. - 176с.
10. Рвачев В.Л., Курпа Л.В., Насриддинов Х.Ф. и др. Метод R-функций в задачах нелинейного деформирования пластин // Прикл. механика. - Киев. - 1987. - 23:N 9. - С.73-78.
11. Рвачев В.Л., Курпа Л.В., Учишвили Л.А. Метод R-функций в задачах об изгибе и колебаниях пластин сложной формы. - Киев: Наукова думка, 1973. – 118с.
12. Самарский А.А., Михайлов А.П. Математическое моделирование: Идеи, Методы, Примеры. -Москва: Физматлит, -2002. - 320 с.
13. Селезов И.Т., Селезова Л.В. Волны в магнитогидроупругих средах. - Киев: Наукова думка, 1975. - 164 с.
14. Халджигитов А. А., Бабаджанов М. Р., Худазаров Р. С. Об одном подходе численного решения упругопластических краевых задач // Проблемы вычислительной и прикладной математики. 2019. -Vol. 3, № 21. -С. 75-86.