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ELEKTROVOZ BOSH RAMASINI TAKOMILLASHTIRISHNING MATEMATIK MODELINI TUZISH

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ABSTRACT

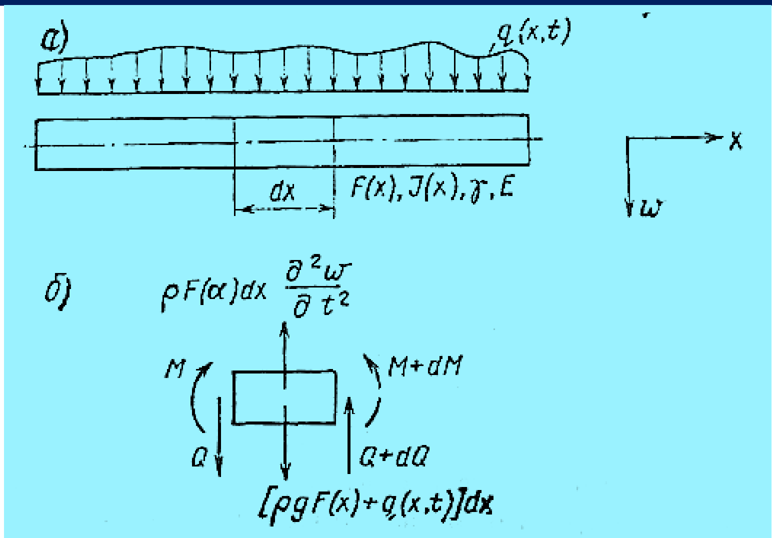
Maqolada VL-80 elektrovozining yangilangan asosiy ramkasining matematik modeli keltirilgan. Raqamli tadqiqotlar MATHCAD 15 dasturlash muhitida approksimatsiya va spline interpolyatsiya usullaridan foydalangan holda amalga oshirildi.

Elektrovoz poyezd bilan harakatlanishida uning ekipaj qismi elektrovozdan tarkibga tortuv (tormozlash) kuchlarini (siqilish va cho'zilish) uzatadi, shuningdek elektrovoz burilishlar va yo'lning notekis uchastkalaridan harakatlanishida yuzaga keluvchi dinamik kuchlarni qabul qiladi. Bunda elektr harakat tarkibi aravachalari ramalari va kuzovning bosh ramasi kattaligi bo'yicha sezilarli va yo'nalishi bo'yicha turlicha bo'lgan dinamik kuchlar ta'sirida bo'ladi, ular esa tabiiy yedirilish bilan bir vaqtda alohida uzellarning shikastlanishini keltirib chiqarishi mumkin [1,2,3].

Elektrovozning mexanik qismi quyidagi talablarga javob berishi kerak [1,2,3,4]:

- foydalanishdagi mustahkamlik va ishonchlilik;
- statik, dinamik va zarb xarakterli yuklamalarga chidamlilik;
- lokomotivlarning ma'lum ilmiy asoslangan dinamik sifat ko'rsatkichlarini ta'minlash;
- elementlari bilan bir qatorda yo'lning ustki qurilmalari bo'yicha o'rnatilgan xizmat muddatini ta'minlash;
- alohida elementlarning foydalanish va ta'mirlashdagi qulayligini ta'minlash;
- konstruksiyasi o'ta murakkab va qimmat bo'lmasligini ta'minlash.

Elektrovozlarning bosh ramalarini balkalarning ko'ndalang tebranishlarning differensial tenglamasini hisoblanayotganda, balkalarning barcha nuqtalari ko'ndalang yo'nalishda ω harakatlanmoqda deb hisoblab turamiz (rasm 1.1,a). Balka bu yo'nalishda o'z vaznidan kelayotgan taqsimlangan og'irlik kuchi $\rho g F$ hamda tashqi taqsimlangan q (x,t) kuchlarni ta'sirida bo'ladi [2,3,4].



Rasm 1. Elektrovozlarning bosh ramalarini balkalarning qayriluvchan tebranishlarining differensial tenglamasini chiqarish uchun hisoblash tuzilishi (sxemasi).

Elektrovozlarning aravachalarini balkadan kesib olingan dx o'lchamidagi kichik qismning muvozanatini Dalamber usuli orqali ko'rib chiqamiz (rasm 1.1,b). Kesib olingan qismga M va M+dM reaktiv holatlari, Q va Q+dQ kuchlari, $\rho F\,(x)\,dx\frac{\partial^2\omega}{\partial t^2}$ inersiya kuchi, ρ$gF\,(x)$ dx og'irlik kuchi va q (x,t) dx ga teng bo'lgan taqsimlangan og'irlik kuchi ta'sir qiladi.

Bu holatda F (x) yoki F – bu balkaning ko'ndalang kesimining uzunlik bo'yicha o'zgaruvchan yoki doimiy maydoni (yuzi). ω yoyi bo'yicha qismga ta'sir qiluvchi kuchlarni loyihalashtirishda quyidagilarni olamiz

$$\rho\, F\,(x)\,dx\frac{\partial^2 t}{\partial t^2}+dQ-\rho gF\,(x)\,dx-q\,(x,t)\,dx=0. \qquad (1)$$

Q ko'ndalang kuchning x ning qayrilish paytidagi hosilasiga tengligini bilgan holda, xususan:

$$Q=\frac{\partial M}{\partial x}, \qquad (2)$$

quyidagini aniqlaymiz

$$dQ=\frac{\partial Q}{\partial x}dx=\frac{\partial^2 M}{dx^2}dx. \qquad (3)$$

(3) dagi ifodani (1) dagi tenglamaga qo'ygan holda, balkaning ko'ndalag tebranishlarining tenglamasini quyidagi qo'rinishda olamiz

$$\frac{\partial^2\omega}{\partial t^2}=g-\frac{1}{\rho F(x)}*\frac{\partial^2 M}{\partial x^2}+\frac{1}{\rho F(x)}q(x,t). \qquad (4)$$

(4) tenglamasidagi M qayrilish paytini quyidagi tartibda ifodalanishi mumkin:

$$M=EJ\,(x)\left(\frac{\partial^2\omega}{\partial x^2}+\mu_\omega\frac{\partial^3\omega}{\partial x^2\partial t}\right), \qquad (5)$$

va bunda E - birinchi qatorning elastiklik moduli,

$J\,(x)$ - balka kesimining inersiya payti (bu holatda u x koordinatalariga bog'liq), μ_ω - jismning qayriluvchan tebranishlardagi elastik bo'lmagan qarshiligi koeffitsiyenti.

Shunday qilib, (4) hamda (5) tenglamalar tizimi o'zgaruvchan kesim balkasining qayriluvchan tebranishlarining matematik modelidir. Bu tizimni o'z navbatida ba'zi holatlarda

(5) va (4) tenglamalarni quyidagi ko‘rinishga olib kelgan holda yagona differensial tenglamaga keltiriladi

$$\frac{\partial^2\omega}{\partial t^2} = g - \frac{E}{\rho F(x)}\ \frac{\partial^2}{\partial x^2}\left[J(x)\left(\frac{\partial^2\omega}{\partial x^2} + \mu_\omega \frac{\partial^3\omega}{\partial x^2 \partial t}\right)\right] + \frac{1}{\rho F(x)}\ q(x,t). \qquad (6)$$

Agar (4) va (5) tenglamalarda *F (x)=F=const* va *J (x) =J=const* qo‘yib chiqilsa, ya’ni doimiy ko‘ndalang kesim balkasining qayriluvchan tebranishlarini ko‘rib chiqilsa, quyidagi kelib chiqadi

$$\frac{\partial^2\omega}{\partial t^2} = g - \frac{1}{\rho F}\ \frac{\partial^2 M}{\partial x^2} + \frac{1}{\rho F}\ q\ (x,t); \qquad (7)$$

$$M = EJ\ \left(\frac{\partial^2\omega}{\partial x^2} + \mu_\omega\ \frac{\partial^3\omega}{\partial x^2 \partial t}\right). \qquad (8)$$

Bu holatda (6) differensial tenglamasi quyidagi ko‘rinishga aylanadi.

$$\frac{\partial^2\omega}{\partial t^2} = g - a_\omega^2\ \left(\frac{\partial^4\omega}{\partial x^4} + \mu_\omega\ \frac{\partial^5\omega}{\partial x^4 \partial t}\right) + \frac{1}{\rho F}\ q(x,t), \qquad (9)$$

bunda $a_\omega = \sqrt{\frac{EJ}{\rho F}}$ - qayriluvchan tebranishlardagi elastik to‘lqinning fazali tezligi.

(9) differensial tenglamasi qisqartirilgan holda operatorlik ko‘rinishida yozilishi mumkin.

$$\frac{\partial^2\omega}{\partial t^2} = g - a_\omega^2\left(1 + \mu_\omega\ \frac{\partial}{\partial t}\right)\frac{\partial^4\omega}{\partial x^4} + \frac{1}{\rho F}\ q(x,t), \qquad (10)$$

Elektrovozlarning bosh ramalarini balkalarning qayriluvchan tebranishlarini o‘rganish uchun muvozanatning differensial tenglamalarining ikki xil usuli ishlatilishi mumkin, ya’ni (4), (5) shaklida yoki (7), (8) xususiy holatida hamda (6) yoki (9) ko‘rinishida. Birinchi holatda ω (x,t) va M (x,t) funksiyalari, ikkinchi holatda esa faqat ω (x,t) funksiyasi masalaning yechimidir. Elektrovozlarning bosh ramalarini balkalarning qayriluvchan tebranishlari vazifasi berilgan boshlang‘ich hamda chegara shartlari uchun ko‘rib chiqilayotganini sababli, ω (x,t) va M (x,t) yechimlari yuqoridagi shartlarni qoniqtirishi lozim.

Amaliyotda balkalarni mahkamlashning oddiyroq shartlari ham uchrab turadi, masalan qattiq oshiq-moshiqli tirgovich yoki muhr sifat mahkamlash jismi. Bu holatda chegara shartlari tirgovichdagi harakatlanish va qayrilish holatini yoki burilish kesimining harakatlanish va burilish burchagi ni 0 ga tenglashtiradi: $\omega = 0$ va $M = 0$ oshiq-moshiqli tirgovich uchun (11) va ω =0 va $\frac{\partial\omega}{\partial x} = 0$ qattiq muhr sifat mahkamlash jismi (12).

MATHCAD 15 dasturiy muhitida charchoq darzlar yuzaga kelgan kuzov bosh ramasi detallaridagi payvand choklaridagi amaldagi kuchlanishlarni aniqlash bo‘yicha hisobiy tadqiqotlar asosida VL-8s elektrovozlari aoavachalari ramalari detallari uchun murakkab konfiguatsiyali kuchaytiruvchi qoplamalar uchun maqbul o‘lchamlar tanlangan [5,6,7,8].

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