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RESEARCH, INNOVATION, RESULTS



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Methodology for calculating the strength of the pressure beam of freight cars

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Abstract:

This article presents the results of research aimed at analyzing and eliminating malfunctions arising in the overhead beam of freight cars. In order to ensure reliable and high-quality delivery of goods on railway transport and the effective use of the existing rolling stock, the designs of freight cars are being improved.

In the study, the main malfunctions arising in the overhead beam of freight cars were identified. These include beam fatigue, casting defects, and cracks that occur during operation as a result of maximizing load-bearing capacity. It is noted that such malfunctions can affect the safety of train traffic and lead to accidents and incidents.

In order to improve the design of freight cars, 3D models were created using SolidWorks and HyperWorks engineering programs and analyzed using the finite element method. The results made it possible to determine the values of stresses arising in the beam under load. Various load diagrams were analyzed, and optimal design parameters for increasing the strength of the overhead beam were proposed. The research results showed the need to use new materials and technological solutions in the design of the overhead beam. And this will increase the service life of the wagons and ensure traffic safety.

Keywords:

freight cars, overhead beam, fault analysis, railway transport, design improvement, SolidWorks, HyperWorks, finite element method, stress analysis, strength, materials and technological solutions, traffic safety

Yuk vagonlarini nadressor balkasini mustahkamligini hisoblash metodikasi

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Annotatsiya:

Ushbu maqolada yuk vagonlarining ressor usti balkasida yuzaga keladigan nosozliklarni tahlil qilish va ularni bartaraf etishga qaratilgan tadqiqot natijalari keltirilgan.

Tadqiqotda yuk vagonlari ressor usti balkasida yuzaga keladigan asosiy nosozliklar aniqlangan. Ular qatoriga yuk ko'tarish qobiliyatidan maksimal foydalanish natijasida balkaning charchashi, quyma nuqsonlari va ekspluatatsion jarayonda yuzaga keladigan yoriqlar kiradi. Bu kabi nosozliklar poezd harakati xavfsizligiga ta'sir ko'rsatib, halokatlar va avariyalarga olib kelishi mumkinligi ta'kidlangan.

Yuk vagonlari konstruksiyasini takomillashtirish maqsadida SolidWorks va HyperWorks muhandislik dasturlari orqali 3D modellar yaratildi va chekli elementlar usulida tahlil o'tkazildi. Natijalar yuklangan holatda balkada paydo bo'ladigan kuchlanish miqdorlarini aniqlash imkonini berdi. Turli yuklanish sxemalari tahlil qilinib, ressor usti balkasining mustahkamligini oshirish uchun optima konstruksiya parametrlari taklif qilindi.

Tadqiqot natijalari ressor usti balkasini loyihalashda yangi materiallar va texnologik echimlardan foydalanish zarurligini ko'rsatdi. Bu esa vagonlar xizmati muddatini oshirish va harakat xavfsizligini ta'minlash imkonini yaratadi.

Kalit so'zlar:

yuk vagonlari, ressor usti balkasi, nosozliklar tahlili, temir yo'l transporti, konstruksiya takomillashtirish, SolidWorks, HyperWorks, chekli elementlar usuli, kuchlanish tahlili, mustahkamlik, materiallar va texnologik echimlar, harakat xavfsizligi

1. Kirish

Jahonda temir yo'l transportida yuklarni dunyo bozoriga mahsulot sifatini saqlagan holda, ishonchli tarzda etkazib berish, mavjud temir yo'l xarakatlanuvchi parkidan samaradorligini oshirishda zamonaviy usullar va texnologiyalarni joriy etishga alohida e'tibor qaratilmoqda.

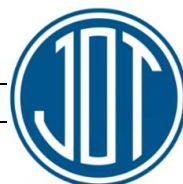
Bu borada, yuk vagonlari elementlariga tashuvchi yuklar hosil qiluvchi dinamik va statik ta'sirlari, yo'l profillarining egrilik, hamda qiyalik darajalari ko'rsatgichlarini inobatga olgan holda, yuk vagonlarining konstruksiyalarini takomillashtirish, ularning xizmat muddatini oshirishga katta axamiyat berilmoqda. Temir yo'l tizimi transportida yuklarni tashish qobiliyatini oshirish, yuklarni o'z vaqtida

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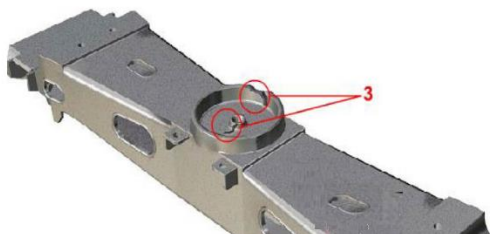
etkazish, temir yo'l izlarining turli profillarida poezdlarning barqaror harakatlanishi harakatlanuvchi tarkibning konstruksiyalarining ishonchligiga bog'liqdir. "O'zbekiston temir yo'llari" AJ tasarrufida yangi temir yo'l liniyalarini qurilganligi, hamda ushbu temir yo'llarning nishablik ko'rsatgichi va egrilik darajasi katta ekanligini inobatga olgan holda, yuk vagonlarining konstruksiya elementlariga tushadigan dinamik kuchlarning ortishiga olib kelmoqda. SHu sababli, xozirda "O'zbekiston temir yo'llari" AJ tassarrufidagi "Vagonlar va vagon xo'jaligi" boshqarmasining asosiy vazifalaridan biri mavjud vagon parkidagi yuk vagonlarining asosiy mexanik qismi bo'lgan aravalarining rama va balkalari konstruksiyalarini dinamik va statik yuk ko'taruvchanlik qobiliyatini oshirishga alohida e'tibor berilmoqda.

Tadqiqot ishlarini olib borishda, asosan mavjud yuk vagonlarining resor usti balkasida xozirgi kunda vujudga keladigan nosozliklar tahlilini olib borish maqsadga muvofiqdir.

2. Tadqiqot metodologiyasi

Olib borilgan tadqiqotlar shuni ko'rsatadiki, yuk vagonlaridagi resor usti balkalarida vujudga keladigan nosozliklar quyidagi xolatlarda yuzaga keladi:

1. Hozirgi kunda vagon parkidan foydalanish vagonlarning yuk ko'tarish qobiliyatidan maksimal darajada foydalanish va yuqori harakat tezligi sharoitida amalga oshirilmoqda. Natijada, hatto to'g'ri yo'l uchastkalarida, katta bo'lmagan tezliklarda yuk vagonlari harakatlanayotganda ham, inersiya kuchi maksimal qiymatlari vujudga kelishi natijasida, resor usti balkasining asosiy kuchni qabul qilish qismi, ya'ni podpyatnik sirtida va podpyatnik bo'rtig'ida ko'chishlar yuzaga keladi (1-rasm).



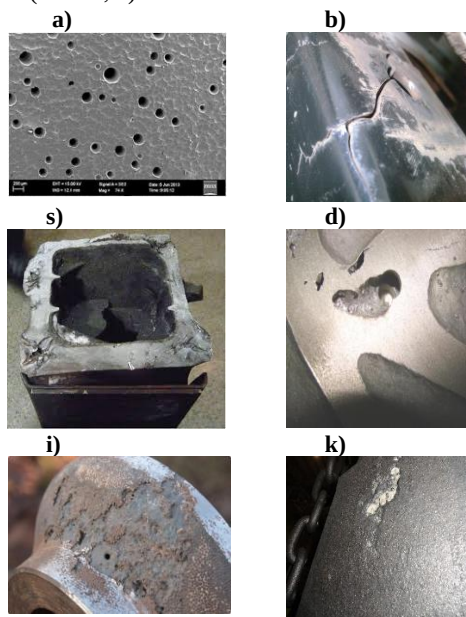
1-rasm. Resor usti balkasining podpyatnik qismida vujudga keladigan nosozliklar

2. Yuk vagoni resora usti balkasining quyma nuqsonlari - bu detal (quyma)ni tayyorlash jarayonida hosil bo'ladigan kamchiliklar. Ularning ba'zilar quyidagilar:

- Gazli kovak. Metalldan ajralib chiqqan yoki metallga kirgan gazlar hosil qilgan bo'shliq ko'rinishidagi nuqson (2-rasm, a);
- "Issiq" yoriq. Qotish harorati oralig'ida paydo bo'lgan kirishish natijasida quyma tanasida hosil bo'lgan yorilish yoki uzilish ko'rinishidagi nuqson (2-rasm, b);
- Sovutgichlarning yaxshi qovushmagan joylari. Quyma metallining sovutgichlar yuzasi bilan ularning ifloslanishi, massalarning mos kelmasligi, quyilayotgan metall haroratining pastligi natijasida to'liq qovushmasligi ko'rinishidagi nuqson (2-rasm, s);
- Qumli kovak. Qolip materiali bilan to'liq yoki qisman to'ldirilgan bo'shliq ko'rinishidagi nuqson (2-rasm, d);

- Kirishma kovak. Metall qotayotganda kirishishi natijasida yuzasi g'adir-budir bo'lgan ochiq yoki yopiq bo'shliq ko'rinishidagi nuqson. (2-rasm, i)

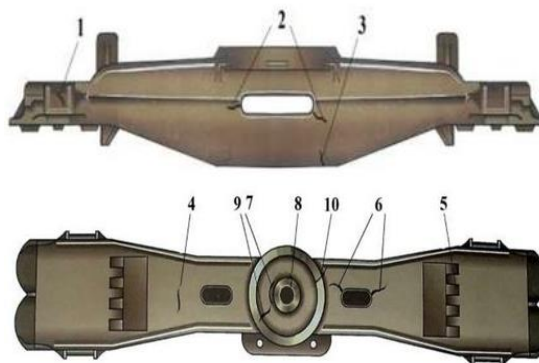
- Cho'kma. Qotish paytida metallning kirishishi natijasida quyma yuzasida hosil bo'lgan, chetlari yumaloqlangan chuqurcha ko'rinishidagi nuqsonlar yuzaga keladi (2-rasm, k).



2-rasm. Quyish jarayonida hosil bo'ladigan nuqsonlar

3. Yuk vagoni resor usti balkasi metallining charchashi natijasida, darzlar resora usti balkasining cho'zilish zonasida joylashgan pastki belbog'ida hosil bo'ladi. Ishlash sharoitiga ko'ra, balka bir tomonlama egilishga uchraydi.

Yuk vagonining resora usti to'sinining sinishi va charchashdan emirilishi turli sabablarga ko'ra sodir bo'lishi mumkin. Bu asosan aravacha qismlarining haddan tashqari yuklangan holatlarda ishlashi yoki quyish jarayonida yuzaga kelgan nuqsonlar tufayli ro'y beradi.



3-rasm. Resor usti balkasida yuzaga keladigan sinish va yoriqlar

Resor usti balkasining ba'zi sinish va yorilishi mumkin bo'lgan joylari (3-rasm):

- 1. Qiya tayanch sirtidagi yoriq;
- 2. Yon belbog'ning yorig'i;
- 3. Pastki belbog'ning yorig'i;
- 4 va 6. Yuqori belbog'ning yorig'i;
- 5. Sirpanuvchi tayanch yorig'i;

- 7,8,9,10. Pyatnik tagidagi tayanch yuzasidagi yoriq.

Yuk vagonlaridan uzoq muddatli foydalanish jarayonida asosan detal va uzellarida charchash natijasida yoriqlar xam yuzaga keladi (4-rasm).



4-rasm. Ressor osti balkasida charchash natijasida yuzaga keladigan yoriq

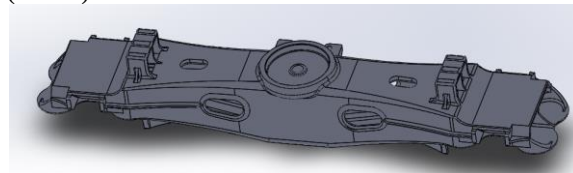
Charchash yoriqlar ressora usti balkasining cho'zilish sohasida joylashgan pastki qismida hosil bo'ladi. Ishlatish sharoitlariga ko'ra, balkada bir tomonlama egilish yuzaga keladi. Xorijiy olimlarning olib borgan tadqiqotlar shuni ko'rsatadiki, yuk vagonlarining ressor usti balkasida yuzaga keladigan yoriqlarning 10,52% ko'rsatgichida halokatga va 1,52% ko'rsatgichi esa avariya olib kelgan [1-2]. Bundan ko'rinib turibdiki yuk vagonlarning uzel va detallaridagi nosozliklar poezdni krusheniyasiga (halokatiga) olib keladi.

Yuqorida olib borilgan tahlillar asosida aniqlangan nasozliklarning ma'lum qismi bo'lgan quyish jarayoni natijasida yuzaga keladigan nosozliklarni bartaraf etish uchun xorijiy va yurtimiz olimlari tadqiqotlar olib borishgan. Ular tomonidan yuk vagonlarining yon ramasini quyish uchun resurstejamkor texnologiyalar va texnika vositalarining yangi ilmiy-texnikaviy echimlarini, temir yo'l harakat tarkibi yuk vagonlarining yon ramalarini quyish texnologiyasini takomillashtirish orqali energiya va resurslarni tejash, po'lat eritma uchun optimal qolip turini tanlash, po'latlarni quyish texnologiyasi uchun sovutish tizimini yaxshilash, parametrlari va ish rejimlarini asoslash, ularning fizik-mexanik, texnologik, ekspluatatsion xossalarini yaxshilash borasida ilmiy-tadqiqot ishlari olib borishgan. SHu bilan birga yuk vagonlari uchun mas'uliyati yuqori quyma detallarni ishlab chiqarishda 20GL markali po'latning kimyoviy tarkibi, uning quyish texnologiyasiga ta'siri, quyish jarayonida ichki sovutgichlarning geometrik parametrlarini quymadagi kristallanish jarayoniga ta'sirini nazorat qilish, quyma detallarining chidamligini oshirish bo'yicha texnik parametrlarini asoslash borasida ilmiy-tadqiqotlar olib borishmoqda [3-6].

Ushbu tadqiqot ishimizda, asosan yuk vagonlarning yuk ko'tarish qobiliyatidan maksimal darajada foydalanish natijasida, ressor usti balkasi materialining charchashi natijasida yuzaga keladigan nosozliklarni oldini olishga qaratilgan tadqiqotlar olib borish nazarda tutilgan. Olib borilgan adabiyot taxlillari shuni ko'rsatadiki, yuk vagoni ressor osti balkasini nosozligini olish uchun, asosan devor qalinliklari, egrilik radiuslarida xosil bo'ladigan kuchlanishlarni aniqlash lozim. Ushbu kuchlanishlarning maksimal qiymati bo'yicha balkaning ko'ndalang kesim yuzasini optimal qiymatini aniqlash, balka uchun materialning mexanik xossalari yaxshilangan turini tanlash imkonini beradi.

Xozirgi kunda, dunyo olimlari o'zlarining tadqiqot ishlari zamonaviy muhandislik dasturlaridan foydalangan holda, ishonchlilik va samaradorligi yuqori bo'lgan tadqiqot natijalariga erishimoqda.

Tadqiqot ishimizda, "O'zbekiston temir yo'llari" AJ tasarrufidagi "Quyuv mexanika zavodi" AJ da maxalliy xom-ashyolar asosida quyilayotgan ressor osti balkasida statik va dinamik yuklanish darajasini aniqlash usullari keltirib o'tilgan. Bunda, zamonaviy muxandislik Solidworks dasturidan foydalanib ressor usti balkasini modeli yaratildi (5-rasm).



5-rasm. Solidworks dasturida ressora usti balkasini modellash

SolidWorks muhandislik dasturi murakkab geometrik ob'ektlarni loyihalashda va 3D modellarni yaratishda eng qulay dasturlardan biri hisoblanadi. Modellash jarayoni quyidagilarni o'z ichiga oladi:

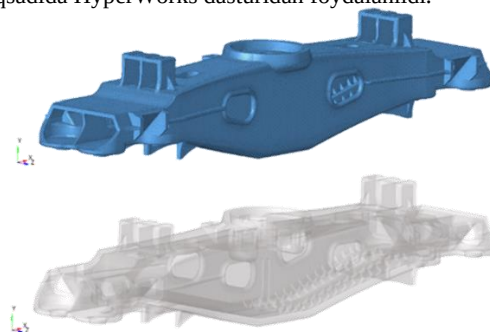
1. Eskizlar tayyorlash - balkaning geometrik xususiyatlarini inobatga olgan holda uning tashqi chegaralarini chizish.

2. CHO'zish va kesish operatsiyalari - detalning asosiy hajmini shakllantirish hamda zarur kesimlarni yaratish.

3. Mustahkamlash elementlarini qo'shish - qattqlik qovurg'alari, mahkamlash uchun teshiklar.

4. Materiallarni qo'llash - foydalanish talablariga qarab po'lat yoki kompozit materialni tanlash.

Ushbu hisobotda temir yo'l balkasidagi kuchlanishlar taqsimoti tadqiq etiladi. Hisob-kitoblarni chiziqli-elastik materialdan foydalangan holda to'qqizta turli vaziyat uchun amalga oshirilgan. Tadqiqot ishlari aniqligini oshirish maqsadida HyperWorks dasturidan foydalanildi.



6-rasm. HyperWorks dasturida chekli elementlar usulini modellash

Bunda, Solidworks dasturida yaratilgan 3D modelni HyperWorks dasturida chekli elementlar usulini modellash uchun dastlabki ma'lumotlar tanlab olindi:

Elastiklik moduli — 213000 N/mm²;

Puasson koeffitsienti — 0,3;

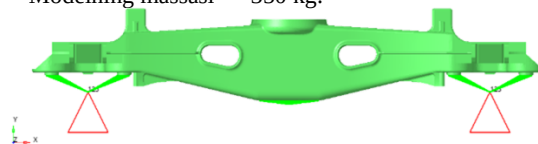
CHekli elementning maksimal uzunligi — 15 mm;

CHekli element uzunligi — 1 mm;

Tugunlar soni — 3287469;

Elementlar soni — 2006125;

Modelning massasi — 350 kg.

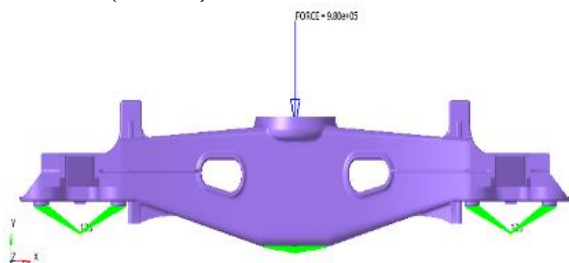


7-rasm. Chegaraviy shartlar

Modelni raqamli tadqiqotlar olib borish uchun chegaraviy shartlarni belgilash lozim bo'ladi (7-rasm).

HyperWorks dasturidan foydalanilib, turli xil yuklanish sxemalari uchun tadqiqot natijalari olindi.

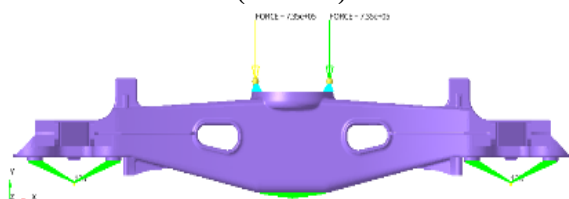
Yuk vagonlari to'liq yuklangan holatida, statik yuklanishda bo'ladi. Bunda, tadqiqot olib borilayotgan reszor usti balkasining yuklanishni qabul qilish yuzasi, ya'ni pyatnikning tayanch yuzasiga vertikal yo'nalishda kuch ta'sir etadi (1-sxema).



1-sxema. Podpyatnikning tayanch yuzasi bo'ylab bir tekisda $P_0 = 4P_0$ kuch ta'siri

Bu xolatda, agar yuk vagoning o'qiga 23,5 tn va 25 tn yuk tushgan holatida balkaning xafvli kesimlarida xosil bo'ladigan yuklanish $140 \div 223$ MPa oralig'ida xosil bo'lishi aniqlandi.

Temir yo'l xarakatlanuvchi tarkib yuk vagonlari asosan avtulgichlarni ulanishi natijasida bir-birini tortib harakatga keltiradi. Bunday holatlarda, reszor usti balkaning yukni qabul qiluvchi yuzasi pyatnik bo'rtiqlarida navbatma-navbat kuchlar ta'sir ko'rsatadi (21-sxema).



2-sxema. Pyatnik tagi bo'rtiqlariga navbatma-navbat $P_{kr.p} = 3P_0$ kuch ta'siri

Natijada, agar yuk vagoning balkasining pyatnik bo'rtig'iga ta'sir ko'rsatuvchi kuchning qiymati $690 \div 735$ kN ni tashkil etsa, u holda balkaning pyatnik tagi qismi va reszor uzeli bilan kontaktda bo'ladigan yuzada $100 \div 132$ MPa oralig'ida kuchlanish xosil bo'lishi aniqlandi.

Balkaning sirpanish kronshteynlariga $P_{(sk)} = P_0$ kuchi ta'sir ko'rsatuvchi sxemani ko'rib chiqaylik (3-sxema).

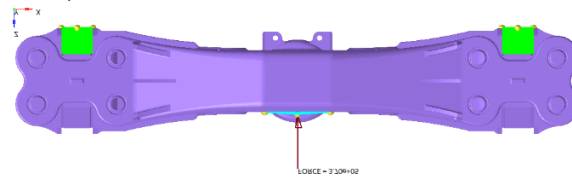


3-sxema. Balkaning sirpanish kronshteynlariga navbatma-navbat $P_{(sk)} = P_0$ kuch ta'siri

HyperWorks dasturida chekli elementlar usulini modellashtirish orqali, bunday holatda reszor usti balkasining xafvli kesimlaridagi kuchlanish miqdori, agar kuchning qiymati $230 \div 245$ kN ni tashkil etganada, kuchlanish $50 \div 231$ MPa oralig'ida ekanligi aniqlandi.

Yuk vagonining reszor ustki balkasining vertikal devorlariga xam vagonning yuk og'irligi natijasida $T =$

$1,5P_0$ kuchga teng miqdorda yuklama ta'sir ko'rsatadi (4-sxema).



4-sxema. Balkaning vertikal devorlariga $T = 1,5P_0$ kuch ta'siri

Bunday holatlarda vertikal devorlarida $14750 \div 231$ MPa oralig'ida kuchlanishlar yuzaga kelishi, modellashtirish orqali aniqlandi.

3. Xulosa

Ressorra usti balkasining yangi modeli - konstruksiyaning og'irligini kamaytirish, mustahkamligini oshirish va texnologik xususiyatlarini yaxshilashga qaratilgan ilmiy-texnik echimning mahsuli hisoblanadi. U zamonaviy yuk aravachalarida qo'llanilib, ekspluatatsion ishonchlilik va uzoq muddat xizmat qilishni eng yaxshi darajada ta'minlaydi. Ressor usti balkalarini loyihalashda SolidWorks va HyperWorks dasturlarini qo'llash konstruksiyalarni samarali ishlab chiqish va tahlil qilish, ularning mustahkamligi va ishonchliligini oshirish bo'yicha aniq echimlarni olish imkonini beradi. Chekli elementlar usuli loyihalash bosqichidayoq xafvli kesimlarning joylarni aniqlash va konstruksiyani takomillashtirish imkonini beradi. Bu esa mahsulotlarni sinash va modernizatsiya qilish xarajatlarini sezilarli darajada kamaytiradi.

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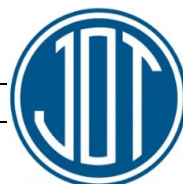
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