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The Journal of Transport showcases groundbreaking scientific and applied research conducted by transport-oriented universities, higher educational institutions, research centers, and institutes both within the Republic of Uzbekistan and globally. Recognized for its academic rigor, the journal is included in the prestigious list of scientific publications endorsed by the decree of the Presidium of the Higher Attestation Commission No. 353/3 dated April 6, 2024. This inclusion signifies its role as a vital repository for publishing primary scientific findings from doctoral dissertations, including Doctor of Philosophy (PhD) and Doctor of Science (DSc) candidates in the technical and economic sciences.

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- Economics of Transport
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- Traffic Organizatsion
- Railway and Road Operations

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Articles are published in Uzbek, Russian, and English, ensuring a wide-reaching audience and fostering cross-cultural academic exchange. As a beacon of academic excellence, the "Journal of Transport" continues to serve as a vital conduit for knowledge dissemination, collaboration, and innovation in the transport sector and related fields.

Analysis of international experience in organizing train operations on complex mountainous railway sections

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Abstract: Currently, one of the urgent problems of railway transport is the effective use of the train capacity and carrying capacity of sections by optimizing the mass and speed of freight trains on complex mountain railway sections. For this purpose, the rational use of train capacity through the introduction of resource-saving technologies into the methods of organizing train traffic on railway sections, as well as the introduction of scientifically based practical recommendations for optimizing their mass and speed, is of great importance. Based on this, based on the main qualitative and quantitative indicators of the work of railway sections, their available, required throughput capacity, sectional and technical speeds, as well as the amount of transported cargo, are calculated. For this purpose, this article provides an in-depth analysis of the practical skills of developed countries in this area.

Keywords: complex mountain sections of roads, trains, mass, speed, world experience, technology, improvement

Murakkab tog‘li temir yo‘l uchastkalarida poyezdlar harakatini tashkil etish bo‘yicha xorijiy tajribaning tahlili

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Annotatsiya: Hozirgi kunda temir yo‘l transportining murakkab tog‘li temir yo‘l uchastkalarida yuk poyezdlari massasi va tezligini optimallashtirish orqali uchastkalarning poyezd o‘tkazuvchanlik va tashuvchanlik qobiliyatidan samarali foydalanish dolzarb muammolaridan biri hisoblanadi. Shu maqsadda temir yo‘l uchastkalarida poyezdlar harakatini tashkil etish usullariga resurstejamkor texnologiyalarni tatbiq qilish, shuningdek ular massasi va tezligini optimallashtirish bo‘yicha ilmiy asoslangan amaliy tavfsiyalarni amaliyotga joriy etish orqali ularning poyezd o‘tkazuvchanlik qobiliyatidan ratsional foydalanish muhim ahamiyat kasb etadi. Bunga asoslanib temir yo‘l uchastkalari ishining asosiy sifat va son ko‘rsatkichalari bo‘yicha ularning mavjud, zaruriy o‘tkazuvchanlik qobiliyati, uchastka va texnik tezliklar, shuningdek, tashilgan yuklar miqdori hisoblanadi. Shu maqsadda aynan ushbu maqolada jahonning taraqqiy etgan davlarning ushbu yo‘nalishda amaliy ko‘nikmalari chuqur tahlili amalga oshirildi.

Kalit so‘zlar: murakkab tog‘li yo‘l uchastkalari, poyezdlar, massasi, tezligi, jahon tajribasi, texnologiya, takomillashtirish

1. Kirish

“O‘zbekiston – Qirg‘iziston – Xitoy” temir yo‘lini qurilishi Respublikamizning tranzit salohiyatini yuksalishiga xizmat qilib yuk va poyezd oqimlarini ortishiga zamin yaratadi. Bu esa Markaziy Osiyo davlatlarini Hind okeani va Fors ko‘rfazi portlariga eng qisqa masofalarda chiqish imkoniyatini yaratadi hamda Janubiy va Janubiy – G‘arbiy Osiyoni Xitoy bozorlari bilan temir yo‘llar orqali bog‘laydi. Shuni alohida ta’kidlash lozimki, “Angren – Pop” temir yo‘l uchastkasi “Xitoy – Markaziy Osiyo – Yevropa” tranzit yo‘lagida muhim bo‘g‘in hisoblanadi, ushbu uchastkadan barqaror poyezdlarni o‘tkazish esa butun yo‘nalishning samaradorligini belgilab beradi. Shu maqsadda, ushbu murakkab tog‘li yo‘l uchastkasida joylashgan “Angren – Pop” temir yo‘l tunnelining yuk tashuvchanlik va poyezd o‘tkazuvchanlik qobiliyatini tahlil qilish, ilg‘or xorijiy tajribalar asosida uning faoliyatini takomillashtirish, poyezdlar o‘tkazish texnologiyalarini takomillashtirish, uchastkada harakatlanayotgan yuk poyezdlari massasini optimallashtirish bo‘yicha ilmiy asoslangan texnik-texnologik yechimlarni ishlab chiqish muhim ahamiyat kasb etadi.

2. Tadqiqot metodologiyasi

Rivojlangan davlatlar bo‘lmish AQSH, Shveytsariya, Kanada, Xitoy va Rossiya kabi qator davlatlar transport sohasining asosiy ilmiy-amaliy yo‘nalishlaridan biri murakkab va tog‘li relyefga ega temir yo‘l uchastkalarida yuk poyezdlari massasini optimallashtirish asosida uchastkalar tashuvchanlik qobiliyatidan oqilona foydalanish sanaladi.

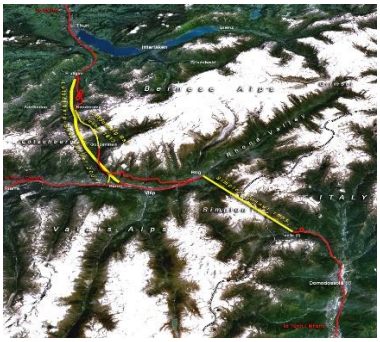
Amerika Qo‘shma Shtatlari temir yo‘llari murakkab Appalachi tog‘ tizmalari orqali o‘tganligini hisobga olib, ushbu temir yo‘llarda poyezdlar harakatini tashkil etish texnologiyalarini o‘rganish lozimdir. Aynan ushbu tog‘li uchastkalarda poyezdlarni boshqarishni takomillashgan tizimi (Advanced train control sytems – ATCS) va taqsimlanadigan energiya bloklari (Distributed power units – DPU)dan foydalangan holda poyezdlar harakati tashkillashtiriladi (1-rasm). Ushbu tizimlar yuk poyezdlari bir nechta lokomotivlarini markazlashgan boshqarish

asosida harakatni o‘zaro muvofiqlashtirish va yuk taqsimotini optimallashtirish imkonini beradi. Shuningdek, poyezdlar energiya sarfini boshqarish tizimi (Train energy management sytems – TEMS) yordamida real vaqt rejimida yuk poyezdining massasi, turli yuklamalar, tormoz masofasi va va energiya sarfi kuzatib boriladi bu esa massani xavfsiz va samarali taqsimlash imkonini beradi [9-11].

1-rasm. AQSH Appalachi murakkab tog‘li temir yo‘l uchastkalarida harakatlanayotgan yuk poyezdlari

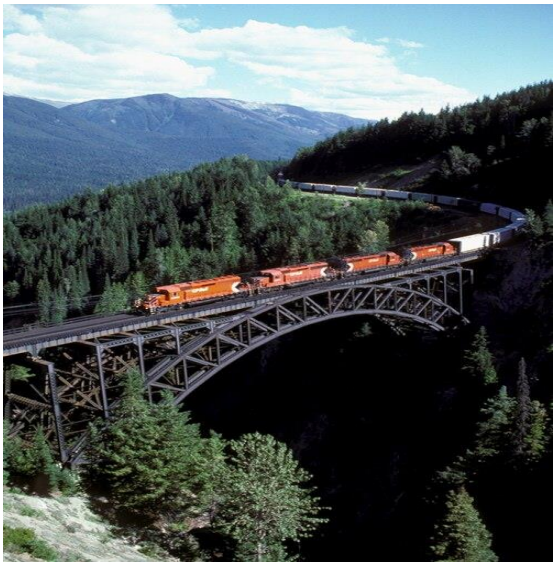
Ushbu temir yo‘llarning Janubiy tinch okeani bo‘limida qiyaligi 33 ‰gacha bo‘lgan uchastkalar uchun og‘irligi 6000 tonnadan yuqori bo‘lgan ikkilangan va uchlangan poyezdlar harakati yo‘lga qo‘yilgan. Bunda lokomotivlar soni ikkita bo‘lganida birinchisi tarkib boshiga ikkinchisi poyezd uzunligining 3/5 qismidan keyin qo‘yilishi belgilangan. Agar poyezd tarkibida uchta lokomotiv bo‘lsa birinchisi tarkib boshiga, ikkinchi va uchunchi lokomotivlar esa uchlangan tarkib o‘rtasiga birgalikda qo‘yilgan holda tashilib kelinmoqda [12].

Shveytsariya og‘ir relyef sharoitiga ega bo‘lgan Alp tog‘ tizmasi orqali yuklarni tashishga moslashgan. Ushbu temir yo‘llarda elektrlashtirilgan tortuv tizimlari va yuqori aniqlikdagi lokomotiv yuk sensor tizimlari orqali lokomotiv elementlariga tushadign yuklamalar harakat davomida qayd etib boriladi va yo‘l safarida yuk poyezdlarining massasi qat’iy nazorat qilinadi. Ushbu temir yo‘llarning har bir uchastkasi uchun yuk massasining maksimal miqdorlari belgilangan bo‘lib undan yuqori massadagi yuk poyezdlarini harakatlanishiga ruxsat berilmaydi. Shuningdek, poyezdlar harakatini rejalashtirishda sun’iy intellekt asosida modellashtirish vositalaridan ham keng miqyosida foydalaniladi. Shveytsariyaning 14,61 km uunlikka ega bo‘lgan ikki yo‘lli Lyochberg tunneli orqali 2017-yilda kuniga 110 ta poyezd o‘tgan, bundan, 80 ta poyezd og‘ir yuk poyezdlari bo‘lib, maksimal yuk tashish hajmi yiliga 35,7 million tonnani tashkil etgan (2-rasm). Yuk poyezdlarning uzunligi 1500 metrgacha massasi esa 3600 tonnagacha ruhsat berilgan [2-11].



2-rasm. Shveytsariyaning Alp tog‘ tizmalari orqali o‘tgan lyochberg temir yo‘l tunneli

Kanada temir yo‘llarida tog‘ hududlari orqali o‘tgan uchastkalarda yuk poyezdlari massasini optimallashtirish maqsadida lokomotiv va vagonlar orasidagi ulanishlarda yuklamalar tahlili amalga oshirilib boriladi. Bu usul yordamida massani bir tekis taqsimlash imkoniyati yaratiladi va avtoulagichlarga tushadigan ortiqcha yuklanishlar oldi olinadi (3-rasm). Kanada temir yo‘llari kompaniyalari, xususan Kanada tinch okeani temir yo‘li kompaniyasida (Canadian pacific railway) avtomatlashtirilgan yuk muvozanati algoritmlaridan foydalangan holda yuk massasini nafaqat texnik jihatdan, balki iqtisodiy ko‘rsatkichlar asosida optimallashtiriladi [1, 12].



3-rasm. Kanada temir yo‘llarida harakatlanayotgan og‘ir tarkibli yuk poyezdlari

Xitoy tog‘li hududlari orqali o‘tgan temir yo‘l yo‘nalishlarida og‘ir harakatda tarkiblarni tashish uchun odatda yuqori quvvatli va ko‘p o‘qli lokomotivlardan foydalanish yo‘lga qo‘yilgan. Xitoy temir o‘llari tizimida Big Data va IoT (Internet of Things) texnologiyalari asosida yuk monitoring tizimlari joriy qilingan bo‘lib, ular har bir vagonning real vaqtdagi holatini nazorat qilishga xizmat qiladi. Shu orqali ortiqcha yuklanishlar aniqlanib, massani avtomatik ravishda tenglashtirish amalga oshiriladi. AQSH temir yo‘llarida bo‘lgani kabi Xitoy temir yo‘llarida ham ko‘mir va ruda tashish maqsadida ommaviy og‘ir vaznli yuklarni tashish ommalashgan. “Datong – Tsin’xuandao” uchastkasida yuk poyezdlari og‘irligi 10000 tonna va poyezdlararo vaqt intervali 13 daqiqani tashkil etadi [1, 9-12].

Rossiya temir yo‘llari tizimida tog‘li yo‘l uchastkalari, xususan Sibir va Ural hududlari bo‘ylab yuklarni tashishda tormoz tizimlarida kompozitsiyali materiallardan, masofadan boshqariluvchi tormozlash tizimlaridan va dinamik yuk taqsimotini boshqarish tizimlari keng qo‘llanilib kelinmoqda. Yuk massasini optimallashtirishning turli matematik modellaridan, poyezdlar harakat grafigining aniq tahlili va har bir uchastka uchun mo‘ljallangan yuk aylanmasini hisobga olgan holda maksimal yuk ortish me’yorlari belgilanadi. Rossiya tajribasida yuk poyezdlarining uzunlig ham muhim omil bo‘lib, yuk poyezdi massasini poyezd uzunligi bilan muvofiqlashtirilgan amaliyoti keng qo‘llaniladi. Xususan, umumiy uzunligi 4324 kilometr bo‘lgan Baykal-Amur magistrali (BAM) yoki Transsibir temir yo‘l magistrallarining murakkab tog‘li

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yo‘llarida yuk poyezdlarining og‘irligi 4000 tonna etib belgilangan. Ushbu uchastkalarda poyezdlar ko‘pincha qo‘shimcha yordamchi lokomotivlar bilan harakalanadi, xususan ol tomonidan tortuvchi yoki ort tomonidan suruvchi.

Baykal-Amur magistrali uchun zamonaviy lokomotivlardan foydalaniladi, ya’ni massasi 7100 tonnagacha poyezdlarni tortishga qodir bo‘lgan 3 TE25K2M seriyali dizel lokomotivlari yordamida sinov yurishlari amalga oshirilgan. Shuningdek, ba’zi sharaoitlarda ushbu lokomotivlar massasi 8230 tonna bo‘lgan poyezdlarni tortgan. Qolaversa, Ural tog‘ tizmalari orqali 2011-yilda 2ES10 “Granit” rusumli lokomotivlar yordamida ushbu lokomotivlarni uch bo‘limli turidan foydalanib (uchlangan tarkib) massasi 9000 tonna bo‘lgan poyezdlar tashilgan.

4-rasm. Baykal-Amur magistralining murakkab tog‘li temir yo‘l uchastkasida harakatlanayotgan 3TE25K2M rusmli teplovoz

Sinov natijalariga asosan o‘rtacha nishablik 16 ‰ni, maksimal nishablik 20 ‰ni tashkil etgan. Yuk poyezdlari harakat tezligi 20÷30 km/soatni tashkil etgan.

3. Xulosa

Xorijiy davlatlar tajribasi shuni ko‘rsatadiki, murakkab tog‘li temir yo‘l uchastkalarida yuk poyezdlarini harakat xavfsizligini ta’minlagan holda tashkil etish dolzarb ahamiyatga ega. Shu maqsadda yuk poyezdlarini massasini optimallashtirish nafaqat texnik balki boshqaruv, logistika, raqamli texnologiyalar va modellashtirish bilan uzviy bog‘liqdir. Shu maqsadda O‘zbekiston temir yo‘llarining murakkab tog‘li yo‘l uchastkalari uchun yuk poyezdlari massasini lokomotiv tizimlari, yo‘llar holati, energiya sarfalari va yana bir qancha omillarni hisobga olgan holda me’yorlashtirish shuningdek, yuk poyezdlarini o‘tkazish texnologiyasini takomillashtirish lozim. Bu vazifalarni yechish uchun albatta taraqqiy etgan davlatlarning va mahalliy olimlarning ilmiy izlanish natijalarini tahlilini amalga oshirish lozimdir.

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