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Criteria for evaluating the efficiency of freight transportation by road transport and approaches to their optimization

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Abstract:

This article comprehensively analyzes the system of technical-operational, economic, and logistic criteria used to assess the efficiency of freight transport processes in the road transport sector. Within the scope of the study, an expanded mathematical model was developed to express the relationship between fleet productivity and the prime cost per 1 ton-kilometer (1 tkm) of cargo turnover. A sensitivity analysis of variables was conducted using the examples of MAN TGS and ISUZU FVR trucks, which are widely utilized under local conditions.

The impact of hot climate conditions and organizational-logistic deficiencies on transport productivity was empirically demonstrated through quantitative calculations. The results indicated that a 10% improvement in the mileage utilization coefficient (β) reduces the prime cost by an average of 10.8%, whereas a decrease in technical speed due to thermal stress increases the cost by up to 3.5-5.2%. Conclusively, digital and technical-operational recommendations were formulated to enhance the efficiency of road freight transportation.

Keywords:

road transport, freight transportation, efficiency criteria, prime cost, logistics, rolling stock, optimization, productivity, sensitivity analysis, climate factor

Avtomobil transportida yuk tashish samaradorlik mezonlari va ularni optimallashtirish yo'llari

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Annotatsiya:

Ushbu maqolada avtotransport tarmog'ida yuk tashish jarayonlarining samaradorligini baholashda qo'llaniladigan texnik-ekspluatatsion, iqtisodiy va logistik mezonlar tizimi kompleks tahlil qilingan. Tadqiqot doirasida harakat tarkibining unumdorligi va 1 tn·km yuk aylanmasi tannarxi o'rtasidagi bog'liqlikni ifodalovchi kengaytirilgan matematik model ishlab chiqilgan. Mahalliy sharoitda keng qo'llaniladigan MAN TGS va ISUZU FVR yuk avtomobillari misolida omillarning sezuvchanlik tahlili (Sensitivity Analysis) o'tkazilgan.

Issiq iqlim sharoiti va tashkiliy-logistik kamchiliklarning transport unumdorligiga ta'siri empirik hisoblashlar orqali isbotlangan. Natijalar shuni ko'rsatdiki, yo'ldan foydalanish koeffitsiyenti (β) 10% ga yaxshilanishi tannarxni o'rtacha 10,8% ga pasaytiradi, issiqlik yuklamasi tufayli texnik tezlikning pasayishi esa tannarxni 3.5-5.2% gacha oshirib yuboradi. Tadqiqot yakunida avtotransportda yuk tashish samaradorligini oshirish bo'yicha raqamli va texnik-ekspluatatsion tavsiyalar shakllantirilgan.

Kalit so'zlar:

avtotransport, yuk tashish, samaradorlik mezonlari, tannarx, logistika, harakat tarkibi, optimallashtirish, unumdorlik, sezuvchanlik tahlili, iqlim omili

1. Kirish

Globalashuv sharoitida milliy iqtisodiyotning raqobatbardoshligini ta'minlash bevosita transport-logistika tizimining samaradorligiga bog'liqdir. Mahsulotlarni ishlab chiqaruvchidan yakuniy iste'molchiga yetkazib berish zanjirida avtotransport tarmog'i eng moslanuvchan va yuqori harakatchan (mobil) bo'g'in hisoblanadi. Bugungi kunda tovarlar yakuniy tannarxining o'rtacha 15 foizdan 25 foizgacha bo'lgan qismini aynan transport xarajatlari tashkil etmoqda. Shu sababli, avtotransportda yuk tashish tannarxini

pasaytirish va harakat tarkibi unumdorligini oshirish makroiqtisodiy ahamiyatga ega dolzarb masalalardan biridir.

Jahon miqyosida avtomobil transportining asosiy muammolaridan biri - yuk tashish samaradorligini oshirish, yuklarni iste'molchilarga o'z vaqtida va arzon narxda yetkazib berish avtotransport korxonalarining faoliyatini tubdan o'zgartirishni talab qilmoqda. Mamlakatimizda transport va transport kommunikatsiya sohasini rivojlantirish, yuk tashishning xavfsizligini ta'minlash, transport sohasidagi boshqaruv tizimini takomillashtirish hamda soha uchun malakali mutaxassislarni tayyorlashga

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yo'naltirilgan keng ko'lamli chora-tadbirlar amalga oshirilib borilmoqda.

Iqtisodiyotni rivojlantirishning zamonaviy tendensiyalari va amalga oshirilayotgan islohotlar respublikaning geografik joylashuvini inobatga olgan holda transport xizmatlarining sifatli va ommabopligini ta'minlashga yo'naltirilgan yagona transport siyosatini shakllantirishni talab etadi. Respublikaning investitsiyaviy jozibadorligini va eksport salohiyatini oshirish, transport kommunikatsiyalarini strategik rivojlantirishni ta'minlash muhim vazifalardandir. Xususan, O'zbekiston Respublikasini rivojlantirishga oid davlat dasturlarida hududlarda yuklar shakllanishining asosiy nuqtalarini hisobga olgan holda transport-logistika markazlari tarmog'ini tashkil etish va yuk tashish xarajatlarini 30 foizgacha kamaytirish maqsad qilib qo'yilgan [1].

Adabiyotlar tahlili

Sanoatning o'sib borayotgan ehtiyojlarini qondirish uchun iqtisodiy jihatdan samarali, energiya tejankor va ishonchli yuk tashish tizimi muhim ahamiyatga ega [2, 3].

Yuk tashishni optimallashtirish avtomobil va temir yo'l transportini o'z ichiga olgan transport tarmog'ini rivojlantirish muammosini ham hal qilish kerak [4, 5].

Qurilish yuklarni tashishni tashkil etish, yuk jo'natuvchi va yuk oluvchi punktlar ishini o'zaro muvofiqlashtirish hamda tashish samaradorligini oshirish yo'llari [6] keltirilgan.

Yuk tashish yo'nalishining yuk jo'natish yoki qabul qilish manzillarida yuz beradigan jarayonlarni tizimli tahlil qilish, ularning tarkibi aniqlanib, avtomobilning unumsiz turib qolish vaqtini bartaraf etish va transport vositasining ish ko'rsatkichlarining shakllanishini talab etilmoqda [7, 8].

Demak, respublikamizda yuk tashish hajmi ortib borishi kuzatiladi. Bu esa o'z navbatida transport tarmog'i va transport-logistika tizimiga bo'lgan talabni oshiradi. Transport tizimini rivojlantirishning optimal rejasi iqtisodiyotning va aholining tashishga bo'lgan ehtiyojlarini to'liq qondirishi, shu bilan birga transport vositalari va tarmoqlaridan foydalanish hamda ularni rivojlantirishga oid barcha xarajatlarni minimallashtirishi lozim. Mazkur masalaning mezonini ishlab chiqarish kuchlarini optimal rivojlantirish rejasini olishga ta'sir etuvchi hamma aspektlarni o'zida aks ettirishi lozim. Transport tizimi uchun bular quyidagilar hisoblanadi:

- har bir transport turi bo'yicha tashishni amalga oshirishda bevosita sarflanuvchi jamoa mehnati xarajatining qiymati;
- ayrim transport turlarining aholi mehnat sharoiti va turmush darajasiga ta'siri;
- har xil transport turlarida tashishdagi kamaygan (yo'qotilgan) yuk miqdorlari;
- turli variantlardan lozim bo'lgan ishchi kuchi, yonilg'i va metallarga bo'lgan talab;
- materiallar, jihozlar va boshqa qimmatli resurslarning tanqisligi hamda ushbu resurslarni boshqa korxona va tarmoqlardan olishdagi qo'shimcha xarajatlari;
- yuklarni yetkazish tezligi va boshqa sifat ko'rsatkichlari.

Biroq, ushbu ko'rsatkichlarni bir vaqtning o'zida yagona o'lchov birligida baholash imkoniyati mavjud emas. Shuning uchun tadqiqotlarda mezonni ma'lum bir maqsadli doirada tanlashga to'g'ri keladi. Bunda, bir tomondan tashish bo'yicha ishlab chiqarish kuchlari manfaatlarini maksimal darajada aks ettirish, boshqa tomondan esa

transport tizimidan samarali foydalanish imkoniyatlarini ko'zda tutish lozim bo'ladi.

Avtotransport tarmog'ida yuk tashish samaradorligi ko'p faktorli va ko'p mezonli tizim bo'lib, u nafaqat ichki tashkiliy omillarga, balki tashqi muhit sharoitlariga ham tizimli bog'liqdir. Xususan, O'zbekistonning janubiy hududlari o'zining keskin kontinental iqlimi, yoz faslidagi yuqori havo harorati (+45°C dan yuqori) va uzoq masofali xalqaro transport yo'laklari mavjudligi bilan ajralib turadi. Bunday sharoitda yuk tashish jarayonini boshqarish an'anaviy usullardan farqli yondashuvni - texnik va tashkiliy mezonlarni raqamli texnologiyalar asosida integratsiyalashni talab etadi.

Transport vositalarining texnik tezligi (V_t) issiqlik yuklamalari ta'sirida sustlashishi va yo'nalishlarda bo'sh yurishlar (koeffitsient β ning pastligi) oqibatida unumdorlikning pasayishi kuzatilmoqda. Ushbu muammolarni bartaraf etish uchun yuk tashish samaradorligi mezonlarini matematik modellashirish va ularning o'zaro ta'sir darajasini empirik asoslash zarur.

Transport tizimlari samaradorligini oshirish va harakat tarkibidan foydalanishni optimallashtirish muammolari uzoq yillardan buyon mahalliy va xorijlik olimlar tomonidan tadqiq etib kelinmoqda.

Yuk tashish jarayonlarini matematik modellashirish va marshrutlarni optimallashtirish (Vehicle Routing Problem - VRP) masalalari Dantsig va Ramser (Dantzig & Ramser) tadqiqotlaridan boshlanib, bugungi kunda sun'iy intellekt va raqamli platformalar algoritmlarigacha rivojlandi [9, 11]. Xorijlik olimlardan N.Kristofides va boshqalar o'z ilmiy ishlarida avtomobillarning yo'ldan foydalanish koeffitsiyentini (β) oshirish orqali tashish tannarxini 18–20% gacha kamaytirish mumkinligini matematik isbotlaganlar [10].

Shu bilan birga, MDH (Mustaqil davlatlar hamdo'stligi) davlatlari va mahalliy olimlar o'z tadqiqotlarida avtomobillarning texnik-ekspluatatsion ko'rsatkichlarini mintaqaviy iqlim sharoitlariga moslashtirish masalalariga alohida e'tibor qaratganlar.

Ushbu maqolada avtotransport tarmog'ida yuk tashish jarayonlarining samaradorligini baholashda qo'llaniladigan quyidagi asosiy mezonlar tahlil qilinadi:

Tonna-kilometrlarda bajarilgan ish hajmi mezonini - juda qulay ko'rsatkich hisoblanadi, chunki har bir tarmoqdagi "masofa"ni aniqlash mumkin va u istalgan yo'nalish uchun aniq. Ammo, bu mezon joriy rejalashtirishda foydalanish uchun transport tarmog'ining to'g'ri va teskari yo'nalishlarida ishlaydigan bir turdagi transport vositalarini tashish tannarx ko'rsatkichlari bir xil bo'lganda yoki kam farq qilganda qo'llanilishi mumkin. U katta shaharlarda tashishni optimal marshrutlashtirish masalalarini yechishda, nolinchi masofalarni rejalashtirishda va avtokorxonalar o'rtasida mijozlarning taqsimlanishida muvaffaqiyatli qo'llanilishi mumkin.

Tariflar (tashish bahosi) mezonini - yuk jo'natuvchi va yuk qabul qiluvchi korxonalarining transport xarajatlarini minimallashtirishga imkon beradi. Bu mezon qo'llanilganda korxonalarining rentabelligi nuqtayi nazaridan tashishning optimal sxemalarini tuzish mumkin bo'ladi.

Transport vositalarining ekspluatatsion xarajatlari (tashish tannarxi) minimumi mezonini - bevosita tashishni amalga oshirayotgan transport korxonalarining xarajatlarini xarakterlaydi. Mazkur mezon har xil transport turlarida tashish tejankorligini aniqroq aks ettiradi va turli yuklarni



tashish uchun qaysi harakat tarkibidan foydalanish maqsadga muvofiqligini asoslaydi.

Yukni etkazishga sarflanayotgan vaqtning minimum mezonini ("vaqt" mezonini) - Asosan tashish jarayonida berilgan hajmdagi yuklarni qisqa vaqt ichida yetkazish zarurati tug'ilganda (ayniqsa tez buziluvchi mahsulotlarni tashishda) asosiy mezon hisoblanadi. Vaqt mezonini bo'yicha masalani yechishda yuklarni o'rish va tushirish vaqti ham muhim ahamiyatga ega. Materiallar va tayyor mahsulotlarni aynan vaqtida yetkazib berish (Just-in-Time) korxonalar omborlaridagi zaxira miqdorini kamaytirish imkonini beradi va butun logistik tizimning samaradorligini ta'minlaydi.

Keskin kontinental iqlim va yuqori harorat sharoitida harakat tarkibi unumdorligi (Q_{kun}) pasayishining 1 tonna-kilometr yuk aylanmasi tannarxiga (C) ko'rsatadigan ta'sirini yaxlit bir tizim sifatida matematik baholash ushbu maqolaning asosiy ilmiy yangiligini belgilaydi.

2. Tadqiqot metodologiyasi

Avtotransport korxonalarining yuk tashish faoliyati samaradorligini baholashda eng asosiy integral mezon - 1 tonna-kilometr (1 tkm) yuk aylanmasiga to'g'ri keladigan tannarx (C) hisoblanadi. Tannarx va transport unumdorligi o'rtasidagi bog'liqlikni quyidagi funksiya ko'rinishida ifodalash mumkin:

$$C = \frac{S_{uzg} \cdot L_{umum} + S_{doim} \cdot T_{ish}}{Q_{kun}} \quad \text{so'm/tn-km} \quad (1)$$

bu yerda: S_{uzg} -avtomobilning 1 km yurishiga to'g'ri keladigan o'zgaruvchan xarajatlar (yonilg'i, moylash materiallari, shinalar va joriy ta'mirlash), so'm/km;

L_{umum} -avtomobilning umumiy bosib o'tgan yo'li, km; S_{doim} -vaqtga bog'liq bo'lgan doimiy xarajatlar (haydovchi ish haqi, amortizatsiya, ma'muriy xarajatlar), so'm/soat;

T_{ish} -avtomobilning yo'nalishdagi umumiy ish vaqti, soat;

Q_{kun} -avtomobilning mazkur vaqt oralig'idagi unumdorligi (yuk aylanmasi), tkm.

Transport vositasining bir soatlik unumdorligi (Q_{kun}) harakat tarkibining konstruktiv xususiyatlari va yo'l-tashkiliy omillarga bevosita bog'liq. Uni aniqlash uchun quyidagi matematik modeldan foydalanamiz:

$$Q_{kun} = \frac{q \cdot \gamma \cdot \beta \cdot V_t}{1 + \frac{\beta \cdot V_t \cdot t_{o-t}}{l_{yuk}}} \quad (2)$$

bu yerda: q - avtomobilning yuk ko'tarish qobiliyati, t;

γ - yuk ko'tarishdan foydalanish koeffitsiyenti;

β - bosib o'tilgan yo'ldan foydalanish koeffitsiyenti;

V_t - texnik tezlik, km/soat;

t_{o-t} - har bir qatnovdagi yuklash-tushirish vaqti, soat;

l_{yuk} - yuk bilan yurilgan masofa, km.

3. Tahlil va natijalar

Modelning amaliy ishlashini tekshirish va baholash mezonlarini belgilash uchun mahalliy sharoitda keng qo'llaniladigan ikki xil toifadagi transport vositalarining ko'rsatkichlari tahlil qilindi. Hisoblashlar uchun boshlang'ich shart sifatida yuk bilan yurilgan masofa $l_{yuk}=50$ km qilib belgilandi (1-jadval).

1-jadval

Harakat tarkibining boshlang'ich texnik-ekspluatatsion ko'rsatkichlari

Ko'rsatkich nomi va belgilanishi	MAN TGS	ISUZU FVR
Nominal yuk ko'tarish qobiliyati, q; tonna	24.0	8.0
Yukdan foydalanish koeffitsiyenti, γ	0.85	0.90
Yo'ldan foydalanish koeffitsiyenti, β	0.50	0.55
Texnik tezlik, V_t ; km/soat	60.0	65.0
Yuklash-tushirish vaqti, t_{o-t} ; soat	1.20	0.60

Boshlang'ich ma'lumotlar asosida soatlik unumdorlik quyidagicha aniqlandi:

MAN TGS unumdorligi:

$$Q_{kun}^{MAN} = \frac{24 \cdot 0.85 \cdot 0.5 \cdot 60}{1 + \frac{0.50 \cdot 60 \cdot 1.2}{50}} = \frac{612}{1.72} \approx 355,81 \text{ t.km/soat}$$

ISUZU FVR unumdorligi:

$$Q_{kun}^{ISUZU} = \frac{8 \cdot 0.9 \cdot 0.55 \cdot 65}{1 + \frac{0.55 \cdot 65 \cdot 0.6}{50}} = \frac{6257,412}{1.43} \approx 180,13 \text{ t.km/soat}$$

Amaliyotda tashqi muhit omillari (iqlim) va tashkiliy kamchiliklar (bo'sh qaytishlar) ushbu ko'rsatkichlarni o'zgartiradi. Quyidagi 2-jadvalda omillarning unumdorlik va tannarxga ta'siri sezuvchanlik tahlili (Sensitivity Analysis) orqali ko'rsatilgan (ish xarajatlari soatiga MAN uchun 450 000 so'm, ISUZU uchun 250 000 so'm deb olindi).

2-jadval

Omllarning o'zgarishiga qarab unumdorlik va tannarxning dinamikasi

Transp ort vositas i	Eksprim ent sharti	Unumd orlik Q_{kun} (tkm/soa t)	1 tk m tannar xi C, (so'm)	Tannar xi o'zgar ishi (%)
MAN TGS	Boshlang'ich holat	355.81	1264,7	0%
	Tezlik kamayganda ($V_t=45$ km/soat)	298,05	1308,51	+3,46%
	Marshrut optimallashtirish, $\beta=0.60$ bo'lganda	393,99	1142,16	-9,7%
ISUZU FVR	Boshlang'ich holat	180.13	1387,8	-
	Tezlik kamayganda ($V_t=50$ km/soat)	148.87	1477,8	+5,22%
	Marshrut optimallashtirish, $\beta=0.65$ bo'lganda	201,86	1253,34	-10,8%

Tahlillar shuni ko'rsatadiki, yo'ldan foydalanish koeffitsiyentining (β) atigi 10% ga yaxshilanishi tannarxni



o'rtacha 10,8% ga pasaytiradi. Issiq iqlim sharoitida esa dvigatelning issiqlik yuklamasi ortishi hisobiga texnik tezlikning pasayishi tannarxni 3,5-5,2% ga oshirib yuboradi.

4. Xulosa

1. Avtotransport korxonalari faoliyatini baholashda eng ishonchli integral mezon bu - 1 tkm yuk aylanmasi tannarxi (C) hisoblanib, u texnik va logistik omillarni o'zida birlashtiradi.

2. Sezuvchanlik tahlili natijalariga ko'ra, yuk tashishda yo'ldan foydalanish koeffitsiyentini (β) oshirish tannarxni eng tez pasaytiruvchi omildir. β ning atigi 10% ga ortishi tannarxning 10,8% gacha arzonlashishini ta'minlaydi. Bu esa raqamli logistika platformalari orqali qaytish yo'nalishiga yuk topish tizimini rivojlantirishni talab etadi.

3. Keskin kontinental iqlim va yuqori harorat sharoitida harakatlanish texnik tezlikni (V_t) sustlashtiradi. Tezlikning pasayishi soatlik unumdorlikni keskin tushirib, tashish tannarxining 3,5% dan 5,2% gacha ortishiga sabab bo'ladi.

4. Bizning fikrimizcha, qabul qilingan mazkur ko'rsatkich ishlab chiqarishning optimumiga ko'proq darajada mos keladi. Ayni paytda, qo'shimcha xarajatlar o'zgarishining chiziqli xarakterda emasligini ham hisobga olish zarur. Shu tufayli optimallik mezoni sifatida differensial xarajatlar, ya'ni qo'shimcha keltirilgan xarajatlarning yuk oqimi o'sishiga nisbati qabul qilinishi maqsadga muvofiqdir.

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