JOURNAL OF TRANSPORT

ISSUE 4, 2025 vol. 2
E-ISSN: 2181-2438
ISSN: 3060-5164

SLIB.UZ
Scientific library of Uzbekistan

RESEARCH, INNOVATION, RESULTS

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI

Tashkent state transport university

JOURNAL OF TRANSPORT

RESEARCH, INNOVATION, RESULTS

E-ISSN: 2181-2438

ISSN: 3060-5164

VOLUME 2, ISSUE 4

DECEMBER, 2025

jot.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

JOURNAL OF TRANSPORT

SCIENTIFIC-TECHNICAL AND SCIENTIFIC INNOVATION JOURNAL

VOLUME 2, ISSUE 4 DECEMBER, 2025

The **"Journal of Transport"** established by Tashkent State Transport University (TSTU), is a prestigious scientific-technical and innovation-focused publication aimed at disseminating cutting-edge research and applied studies in the field of transport and related disciplines. Located at Temiryo'lchilar Street, 1, office 465, Tashkent, Uzbekistan (100167), the journal operates as a dynamic platform for both national and international academic and professional communities. Submissions and inquiries can be directed to the editorial office via email at jot@tstu.uz.

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.

Published quarterly, the journal provides a broad spectrum of high-quality research articles across diverse areas, including but not limited to:

- Economics of Transport
- Transport Process Organization and Logistics
- Rolling Stock and Train Traction
- Research, Design, and Construction of Railways, Highways, and Airfields, including Technology
- Technosphere Safety
- Power Supply, Electric Rolling Stock, Automation and Telemechanics, Radio Engineering and Communications
- Technological Machinery and Equipment
- Geodesy and Geoinformatics
- Automotive Service
- Air Traffic Control and Aircraft Maintenance
- Traffic Organizatsion
- Railway and Road Operations

The journal benefits from its official recognition under Certificate No. 1150 issued by the Information and Mass Communications Agency, functioning under the Administration of the President of the Republic of Uzbekistan. With its E-ISSN 2181-2438, ISSN 3060-5164 the publication upholds international standards of quality and accessibility.

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.

Optimization of maneuver movements at railway stations

D.T. Dulobov[1][a], Sh.U. Saidivaliev[1][b], D.R. Abdullaev[2]
[1] Tashkent state transport university, Tashkent, Uzbekistan
[2]"Uzbekistan Temir Yullari" JSC, Tashkent, Uzbekistan

Abstract: Optimizing maneuvering movements at railway stations is an important task aimed at increasing operational efficiency and reducing fuel and energy resource costs. A significant portion of the operating costs of stations is attributed to the maneuvering work, making the development of energy-saving technologies both economically and environmentally relevant. The work examines the main directions for reducing fuel consumption during maneuvers. One of the key approaches is the selection of optimal operating modes for shunting locomotives based on the criterion of minimum energy consumption. For this purpose, it is proposed to use mathematical modeling and simulation algorithms that allow determining the rational parameters of speed, acceleration and braking times, as well as optimal movement routes. Additionally, attention is paid to the issues of rational distribution of time for the delivery and cleaning of wagons by station facilities. The correct organization of shunting operations contributes to the reduction of downtime, the reduction of unnecessary movements, and the more uniform loading of locomotives and crews. The implementation of the proposed solutions allows not only to reduce fuel consumption, but also to reduce the level of harmful emissions, improve environmental indicators, and extend the service life of rolling stock. Thus, the implementation of measures to optimize shunting movements provides a comprehensive effect: saving operating costs, increasing station productivity, and achieving environmental standards. The obtained results can be used in the development of practical recommendations and programs for modernizing the operation of stations in modern conditions of transportation volume growth.

Keywords: railway station, maneuvering work, optimization, energy saving, fuel costs, mathematical modeling, traffic modes, rational time allocation, environmental efficiency, operating costs

Temir yo'l stansiyalarida manyovr harakatlarini takomillashtirish

Do'lobov D.T.[1][a], Saidivaliyev Sh.U.[1][b], Abdullayev D.R.[2]
[1]Toshkent davlat transport universiteti, Toshkent, O'zbekiston
[2]O'zbekiston temir yo'llari AJ, Toshkent, O'zbekiston

Annotatsiya: Temir yo'l stansiyalarida manyovr harakatlarini optimallashtirish muhim vazifa hisoblanib, foydalanish samaradorligini oshirish va yoqilg'i-energetika resurslari sarfini kamaytirishga qaratilgan. Stansiyalarning ekspluatatsiya xarajatlarining katta qismi aynan manyovr ishlariga to'g'ri keladi. Bu esa energiya tejovchi texnologiyalarni ishlab chiqishni ham iqtisodiy, ham ekologik jihatdan dolzarb ekanligini ko'rsatadi. Ushbu ishda manyovrlarni bajarishda yoqilg'i sarfini kamaytirishning asosiy yo'nalishlari ko'rib chiqiladi. Asosiy yondashuvlardan biri energiya sarfini minimal darajaga tushirish mezoni asosida manyovr lokomotivlarining optimal ish rejimlarini tanlashdir. Bu maqsadda tezlik, tezlanish va sekinlanish vaqtining maqbul parametrlarini hamda harakatlanishning eng qulay yo'nalishlarini aniqlash imkonini beruvchi matematik modellashtirish va imitatsion algoritmlardan foydalanish taklif etiladi. Shuningdek, stansiya obyektlari bo'ylab vagonlarni yetkazib berish va olib ketish vaqtini oqilona taqsimlash masalalariga ham e'tibor qaratiladi. Manyovr ishlarini to'g'ri tashkil etish lokomotiv va brigadalarning bekor turib qolish vaqtini qisqartirishga, ortiqcha harakatlarni kamaytirishga yordam beradi. Taklif etilgan yechimlarni joriy etish nafaqat yoqilg'i sarfini kamaytirish, balki zararli chiqindilar miqdorini pasaytirish, ekologik ko'rsatkichlarni yaxshilash va harakatlanuvchi tarkibning xizmat muddatini uzaytirish imkonini beradi. Shunday qilib, manyovr harakatlarini optimallashtirish bo'yicha chora-tadbirlarni amalga oshirish quyidagi kompleks samarani beradi: ekspluatatsiya xarajatlarini tejash, stansiya unumdorligini oshirish va ekologik me'yorlarga erishish. Olingan natijalar tashish hajmi o'sishining zamonaviy sharoitida stansiyalar ishini takomillashtirish bo'yicha amaliy tavsiyalar va dasturlarni ishlab chiqishda qo'llanilishi mumkin.

Kalit so'zlar: temir yo'l stansiyasi, manyovr ishlari, optimallashtirish, energiya tejamkorligi, yoqilg'i sarfi, matematik modellashtirish, harakat rejimlari, vaqtni oqilona taqsimlash, ekologik samaradorlik, ekspluatatsiya xarajatlari

[a] https://orcid.org/0009-0005-7757-0874
[b] https://orcid.org/0000-0002-4461-4093

1. Kirish

Stansiyalarda manyovr ishlari uchun yoqilg‘i sarfi qiymati stansiyalarning ekspluatatsion xarajatlarining sezilarli qismni tashkil etadi. Shu sababli, energiyani tejaydigan texnologiyalarni joriy etishga qaratilgan chora-tadbirlarni ishlab chiqish dolzarb hisoblanadi. Manyovr ishlari uchun yoqilg‘i sarfini kamaytirish minimal energiya sarfi mezoniga ko‘ra maqbul rejimlarni tanlash hamda vagonlarni yetkazib berish va olib ketish uchun obyektlar bo‘yicha harakat vaqtini taqsimlash orqali erishiladi.

Bugungi kunda temir yo‘llar tarmog‘ida teplovozlarning poyezd va manyovr ishlarida dizel yoqilg‘isi sarfini ishonchli baholash tizimi yo‘q, chunki lokomotivga bevosita o‘rnatiladigan ishonchli qurilmalar mavjud emas.

Ushbu kamchiliklarni bartaraf etish maqsadida quyidagi ko‘rsatkichlar asosida lokomotiv haqida axborot bazasini yaratish taklif etilgan [1,9]:

1) teplovozning dizel-generator qurilmasi (DGU) ishlab chiqargan elektr energiyasi miqdori (bu miqdorni kuch zanjiriga o‘rnatilgan hisoblagich yordamida o‘lchash orqali, kVt. soat);

2) dizelning umumiy ishlash vaqti va DGUning yuklanma ostida ishlash vaqti (tegishli hisoblagichlarni o‘lchash orqali);

3) komplekt sarf o‘lchagichlarni o‘rnatish orqali dizel yoqilg‘isi sarfini aniqroq o‘lchash natijasida uning miqdorini aniqlash.

Ushbu ko‘rsatkichlar manyovr lokomotivlarining yoqilg‘i sarfini asosli me’yorlash va ekspluatatsiyani takomillashtirish zaxiralarini izlash imkonini beradi.

2. Tadqiqot metodologiyasi

Dizel yoqilg‘isini tejashning yo‘llaridan biri manyovr teplovozlarini boshqarish rejimlarini tashkil etishdir. Optimal boshqarishning vazifasi yoqilg‘ining minimal sarfi bilan manyovr tarkiblarining harakatlanishini ta’minlaydigan mashinist nazoratchi pozitsiyasining modelini ishlab chiqishdan iborat. Shuni ta’kidlash kerakki, optimal rejimni sintez qilish teplovozning tortish kuchi va yoqilg‘i sarfi bo‘yicha o‘tish jarayonlarini hisobga olgan modelda amalga oshiriladi. Bu esa tortish kuchi va yoqilg‘i sarfi bo‘yicha o‘tish jarayonlarining ekspluatatsion egri chiziqlaridan foydalanishdan iboratdir. [2,10,13]

Manyovr paytida lokomotivni optimal boshqarishni baholash yoqilg‘i sarfi hamda manyovr operatsiyalari va ularning elementlari davomiyligi bo‘yicha amalga oshiriladi. Bunday turli xil mezonlar bo‘yicha boshqaruvni optimallashtirish murakkab hisoblanadi.

Vaqt mezoni bo‘yicha masalani yechishni vagonlarning yetishmovchiligi hollarida amalga oshiramiz. Shunga qaramay, har bir manyovr operatsiyasini maksimal rejimlarda bajarishga mexanik ravishda intilish iqtisodiy jihatdan o‘zini oqlamaydi.

Manyovr lokomotivini boshqarishni optimallashtirish ko‘plab parametrlar bilan tavsiflanadi [2,4,6-9].

Maqsad funksiyasi umumiy ko‘rinishda quyidagicha taqdim etiladi:

$$К_{пр}=f_1(R,V_p,m)+f_2(V_n,t_n,m)+f_3(t_p,m)+f_4(t_i,m,V_j)+f_5(t_i^{o\text{ж}},t_j^{o\text{ж}},t_z^{o\text{ж}}) \quad (1)$$

bu yerda R - berilgan tezlanish rejimida nazoratchi pozitsiyasining optimal qiymati;

V_p - tezlanish tezligi km/soat;

$f_1(R,V_p,m)$ – manyovr tarkibini tezlashtirishda xarajatlarning turli omillarga bog’liqligi;

V_n,t_n – o‘rnatilgan tezlik va ushbu tezlik bilan harakatlanish vaqti;

$f_2(V_n,t_n,m)$- o‘rnatilgan tezlikda harakatlanish uchun sarflanadigan xarajatlar;

t_u- manyovr tarkibining inersiya bilan harakatlanish vaqti;

$f_3(tp,m)$ – inersiya bilan harakatlanish xarajatlari;

t_i,V_j - tormozlanish boshlanadigan vaqt va tezlik;

$f4(t_i,m,V_j)$- manyovr tarkibini tormozlash bilan bog’liq xarajatlar;

$f5(t_i^{o\text{ж}}, t_j^{o\text{ж}}, t_z^{o\text{ж}})$ – boshqa transport vositalarining kechikish davomiyligiga bog’liq qo‘shimcha xarajatlar.

Maqsad funksiyasining murakkabligi sababli, optimallashtirishning birinchi bosqichida optimallashtirish nazariyasini va olingan bog‘liqliklarni umumiy ko‘rinishda asos qilib olib, alohida punktlarda poyezdlarning kesishishi bilan bog‘liq bo‘lgan aniq tarkibiy elementlarning mazmunini o‘rganamiz. Yuqoridagi formuladan ko‘rinib turibdiki, f ning barcha elementlari asosan uzatish masofasi L, manyovr tarkibining massasi, manyovr harakatlarining vaqti (yoki tezligi)ga bog‘liq. Shuning uchun funksional jihatdan quyidagi ko‘rinishda yozish mumkin:

$$U(L,Q,T)=a\cdot L(t)+b\cdot Q(t)+c\cdot T(t) \quad (2).$$

bu yerda a, b, c - hisoblash yo‘li bilan aniqlanadigan koeffitsiyentlar.

3. Tahlil va natijalar

Yoqilg‘i sarfining yuqorida sanab o‘tilgan omillarga bog‘liqligi tajriba yo‘li bilan hisoblab olindi. Shunday qilib, ba’zi hisoblash nuqtalarida berilgan yoqilg‘i sarfi funksiyasining jadval ko‘rinishi olindi.

Masala funksiyaning jadvaldagi hisoblash tugunlaridan boshqa nuqtalardagi qiymatlarini topishdan iborat. Shunday qilib, masala uch o‘zgaruvchili funksiyani approksimatsiyalashga keltiriladi. Approksimatsiyani chiziqli funksiyalar yordamida amalga oshiramiz, bunda approksimatsiyalovchi funksiya quyidagi ko‘rinishga ega bo‘ladi (3):

$$U(L,Q,T)=a_1\cdot L(t)+a_2\cdot Q(t)+a_3\cdot T(t)+a_0 \quad (3)$$

bu yerda a_1, a_2, a_3, a_0 –hisoblangan koeffitsiyentlardir.

Ushbu a_1, a_2, a_3, a_0 koeffitsiyentlarni topish uchun quyidagi to‘rtinchi tartibli chiziqli algebraik tenglamalar sistemasini yechish zarur:

$$\begin{cases} F(A) = x_a \cdot a_1 + y_a \cdot a_2 + z_a \cdot a_3 + a_0 \\ F(B) = x_b \cdot a_1 + y_b \cdot a_2 + z_b \cdot a_3 + a_0 \\ F(C) = x_c \cdot a_1 + y_c \cdot a_2 + z_c \cdot a_3 + a_0 \\ F(D) = x_d \cdot a_1 + y_d \cdot a_2 + z_d \cdot a_3 + a_0 \end{cases} \quad (4)$$

bu yerda A, B, C, D - olingan ma’lumotlar jadvalidagi izlanayotgan nuqtaga eng yaqin tugunlardir.

Izlanayotgan nuqtaga eng yaqin tugunlarni topish uchun izlanayotgan nuqtadan har bir tugungacha bo‘lgan masofani quyidagi formula yordamida aniqlash mumkin:

$$d = \sqrt{(x - x_a)^2 + (y - y_a)^2 + (z - z_a)^2} \qquad (5)$$

bu yerda x, y, z - izlanayotgan nuqtaning koordinatalari.

Shundan so‘ng izlanayotgan nuqtadan eng qisqa masofada joylashgan to‘rtta nuqtani tanlab olamiz.

Olingan tizimning yagona yechimga ega bo‘lishi uchun quyidagi shart bajarilishi lozim:

$$\nabla = \begin{bmatrix} x_a & y_a & z_a & 1 \\ x_b & y_b & z_b & 1 \\ x_c & y_c & z_c & 1 \\ x_d & y_d & z_d & 1 \end{bmatrix} \neq 0 \qquad (6).$$

Agar determinant nolga teng bo‘lsa, boshqa nuqtalarni tanlash kerak. Nuqtalar tenglama nolga teng bo‘lmaguncha tanlanadi. Tenglamalar sistemasi(4) yagona yechimga ega ekanligiga ishonch hosil qilingach, uni Gauss usuli yordamida yechamiz.

Gauss usuli chiziqli algebraik tenglamalar sistemasini yechishda qo‘llaniladi. Gauss usuli sistemani yechishning to‘g‘ridan-to‘g‘ri usullariga kiradi. Usul algoritmi ikki bosqichdan iborat. Birinchi bosqich usulning to‘g‘ri yo‘li deb atalib, u tenglamalardan a_1 dan boshlab noma’lumlarni ketma-ket chiqarib tashlashdan iborat. Tenglamalar sistemasini yechishning ikkinchi bosqichi Gauss usulining teskari yo‘li deb ataladi va a_0 noma’lumdan boshlab a_1 gacha bo‘lgan a_k noma’lumlarni ketma-ket aniqlashdan iborat [11,12].

a_1, a_2, a_3, a_0 koeffitsiyentlar topilgandan so‘ng, olingan koeffitsiyentlarni (3) tenglamaga qo‘yamiz va har bir elementga (1) yoqilg‘i sarfini aniqlovchi omillarning berilgan qiymatlarida funksiyaning qiymatlarini topamiz. Har bir yangi kiritilgan nuqta uchun unga mos yangi koeffitsiyentlar yuqorida keltirilgan algoritm orqali aniqlanadi.

Yuqorida qo‘yilgan masalani yechish algoritmi Delphi muhitida ishlab chiqilgan dasturda amalga oshiriladi. Dastur universal imkoniyatga ega, ya’ni dastur cheklanmagan miqdordagi o‘zgaruvchilarni o‘z ichiga olishi mumkin [3,5].

Ushbu pozitsiyada kontrollerning kechikish vaqtiga qarab, yoqilg‘ining umumiy sarfini quyidagi formula bo‘yicha hisoblash mumkin:

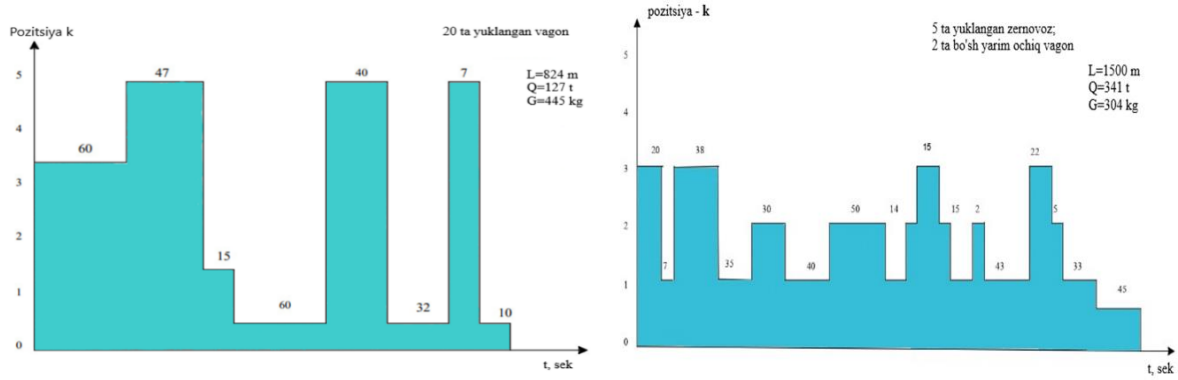
$$f(L,Q,T)=\Sigma q_{ij} \cdot t_{ij}, \qquad (7)$$

bu yerda t_{ij} - kontrollerning ushbu pozitsiyada ushlanib qolish vaqti, daqiqa;

k - kontroller pozitsiyalarining o‘zgarish soni;

q_{ij} - kontrollerning muayyan pozitsiyasidagi yoqilg‘i sarfi.

Ma’lum vaqt davomida berilgan hajm bo‘yicha: og‘irlik (brutto), masofa va vaqtga nisbatan harakatlanuvchi tarkibning nazoratchi pozitsiyasi qiymatlari xronometraj usuli bilan o‘lchab olindi (1-rasm).



1-rasm. Berilgan ish hajmi uchun kontrollerning o‘zgarishi va holatini tavsiflovchi grafiklar

4. Xulosa

Xulosa qilib aytganda har bir yuk obyekti uchun berilgan vagonlar soni va vagonlarning tegishli og‘irligi (brutto) bo‘yicha shunday xarakterli grafiklarni tuzish yoqilg‘i sarfini aniqroq belgilash mumkinligini ko‘rsatmoqda.

Berilgan vagon oqimi uchun yuk stansiyalaridagi manyovr ishlari xarajatlarini shu tarzda modellashtirish haqiqiy yoqilg‘i sarfini aniqlash imkonini beradi. Bu esa kutilmagan yoqilg‘i xarajatlarini hisobga olish va kamaytirishga hamda prognoz qilinayotgan davrning ushbu tashish hajmi uchun yoqilg‘i resurslari sarfini oldindan hisoblab berishga yordam beradi.

Foydalangan adabiyotlar / References

[1] Михаилиди К.Г. Предложения по ресурсосбережению на основе создания информационной базы о работе маневровых тепловозов. В сб. «Ресурсосберегающие технологии на железнодорожном транспорте. М.: МИИТ. 2000г.

[2] [Гончаров Н.Е. Повышение качества и эффективность управления транспортными средствами. Киев, Будивельник, 1976г.

[3] Туляганов У., Мацкель С.С. Рациональное использование маневровых средств на станциях. Ташкент, УзИНТИ, 1972г.

[4] Агеев, В. И. Организация и управление маневровой работой на железнодорожных станциях. – М.: Транспорт, 2015. – 280 с.

[5] Григорьев А.В., Ковалев П.Н. Энергосберегающие технологии на железнодорожном транспорте. – СПб.: Изд-во ПГУПС, 2018. – 312 с.

[6] Иванов, С. М. Оптимизация маневровых процессов на сортировочных станциях.–Новосибирск: Наука, 2016.–224 с.

[7] Пузанов, Е.П., Чумаченко, Д.С. Математическое моделирование маневровой работы на

железнодорожных станциях // Вестник транспорта. – 2019. – №4. – С. 45–52.

[8] Федоров, И. А. Повышение эффективности маневровой работы за счет внедрения энергосберегающих технологий // Железнодорожный транспорт. – 2020. – №7. – С. 12–18.

[9] Мацкель С.С. Проектирование сортировочных устройств на железнодорожных станциях [Текст]: Учеб.-метод. пособие / С.С. Мацкель, У.Т. Туляганов, А.К. Петрова; Ташк. ин-т инженеров ж.-д. транспорта, Кафедра ж.-д. станций и узлов. - Ташкент: [ТашИИТ], 1975. - 28 с.,

[10] Kozlov, N., Petrov, A. Optimization of Shunting Operations in Railway Stations // Transportation Research Procedia. – 2021. – Vol. 54. – P. 190–198.

[11] Saidivaliev, Sh.U. A new method of calculating time and speed of a carriage during its movement on the section of the first brake position of a marshaling hump when exposed headwind / Sh.U. Saidivaliev, R.Sh. Bozorov, E.S. Shermatov // STUDENT eISSN: 2658-4964. 2021, №9.

[12] Jamshid Renatovich Kobulov, Jamshid Sayfullayevich Barotov, Diyor Shomurotovich Boboyev. Improvement of the cooling system during storage in the process of agricultural products. Journal of Tashkent Institute of Railway Engineers. 16(2), 2020, 200-204.

[13] Хаджимухаметова М.А., Абдуллаев Р.Я., Саидивалиев Ш.У. Инновационные решения для совершенствования транспортных процессов и параметров сортировочных станций // Ташкентский государственный транспортный университет. Ташкент, 2025.

Mualliflar to‘g‘risida ma’lumot/ Information about the authors

Do‘lobov Doston Tojiyevich / Dulobov Doston	Toshkent davlat transport universiteti, “Yuk transport tizimlari” kafedrasi tayanch doktoranti E-mail:doston.dolobov1994@gmail.com Tel.: +99890 985 06 94 https://orcid.org/0009-0005-7757-0874
Saidivaliyev Shuxrat Umarxodjayevich / Shukhrat Saidialiev	Toshkent davlat transport universiteti, “Yuk transport tizimlari” kafedrasi dotsenti (PhD) E-mail: shuxratxoja@mail.ru Tel.: +99897 462 21 29 https://orcid.org/0000-0002-4461-4093
Abdullayev Jamshid Rustamovich / Jamshid Abdullaev	Toshkent davlat transport universiteti “Yuk transport tizimlari” kafedrasi dotsenti (PhD) E-mail:rasulovabdullaev@mail.ru Tel.: +99893 544 12 40

CONTEXT / MUNDARIJA