JOURNAL OF TRANSPORT

ISSUE 2, 2026 vol. 3
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 3, ISSUE 2
JUNE, 2026

jot.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

JOURNAL OF TRANSPORT

SCIENTIFIC-TECHNICAL AND SCIENTIFIC INNOVATION JOURNAL

VOLUME 3, ISSUE 2 JUNE, 2026

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.

Investigation of the mechanism and factors influencing the process of dephosphorization during the smelting of 20GL steel

N.K. Tursunov[1][a], A.A. Saidirakhimov[1][b], N.K. Kodirova[1], Z.F. Rakhmatova[1]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: This article investigates the mechanism of the phosphorus refining (dephosphorization) process during the furnace melting of 20GL grade cast structural steel, as well as the main factors that influence it. Specifically, the standard Gibbs energy was derived based on the chemical reaction of the dephosphorization process, and the equilibrium constant was determined at various temperatures. Furthermore, the distribution coefficient of phosphorus between the metal and slag phases was studied in relation to the slag composition and quantity during the dephosphorization process. In this research, the interaction parameters of chemical elements within the metal on phosphorus activity were calculated. As a result of experiments and calculations, the activity and distribution coefficients of phosphorus were determined. The results obtained are of significant importance for improving the dephosphorization process in the production of 20GL grade cast steel.
Keywords: 20GL grade steel, refining, Gibbs energy, dephosphorization process, activity coefficient, distribution coefficient, slag basicity

---

20GL markali po‘lat eritishda defosforatsiya jarayonining mexanizmi va ta’sir omillarini tadqiq etish

Tursunov N.Q.[1][a], Saidiraximov A.A.[1][b], Qodirova N.Q.[1], Raxmatova Z.F.[1]
[1]Toshkent davlat transport universiteti, Toshkent, O’zbekiston

Annotatsiya: Ushbu maqolada 20GL markali quyma konstruksion po‘latni pechda eritish jarayonida fosfordan rafinirlash (defosforatsiya) jarayonini mexanizmi va unga ta’sir etadigan asosiy omillar tadqiq etilgan. Xususan, defosforatsiya jarayonini kimyoviy reaksiyasi asosida, standart Gibbs energiyasi keltirib chiqarildi hamda turli haroratlarda muvozanat konstantasi aniqlandi. Bundan tashqari metall va shlak fazalari o‘rtasidagi fosforning taqsimlanish koeffitsiyenti defosforatsiya jarayonidagi shlak tarkibi va miqdori bo‘yicha o‘rganilgan. Tadqiqotda metall tarkibidagi kimyoviy elementlarning fosfor aktivligiga ta’sir parametrlari hisoblangan. Tajriba va hisob-kitoblar natijasida fosforning aktivlik va taqsimlanish koeffitsiyenti aniqlangan. Olingan natijalar 20GL markali quyma po‘latning ishlab chiqarishda defosforatsiya jarayonini takomillashtirish uchun muhim ahamiyatga egadir.
Kalit so‘zlar: 20GL markali po‘lat, rafinirlash, Gibbs energiyasi, defosforatsiya jarayoni, aktivlik koeffitsiyenti, taqsimlanish koeffitsienti, shlak asosililigi

1. Kirish

Bugungi kunda metallurgiya sanoati jadal rivojlanib borayotgan tarmoqlardan biri bo‘lib, yuqori sifatli quyma konstruksion po‘latlarga bo‘lgan talab ortib bormoqda. Transport mashinasozligi, xususan, temir yo‘l va avtomobilsozlik sohalarida qo‘llaniladigan mas’uliyatli detallar uchun yuqori darajadagi xavfsizlik, uzoq xizmat muddati, mustahkamlik, zarbiy qovushqoqlik hamda ishonchlilik xususiyatlariga ega bo‘lgan materiallar talab etiladi. Shu nuqtai nazardan, mazkur tarmoqlarda keng qo‘llaniladigan quyma po‘latlar muhim konstruksion materiallardan biri hisoblanib, ularning sifati mexanik va texnologik xossalari, shuningdek, kimyoviy tarkibidagi legirlovchi elementlar ([Si], [Mn], [Cr], [Ni], [Ti], [Cu] va bosh.) hamda zararli va keraksiz qo‘shilmalar ([S], [P], [O], [N], [H]) miqdoriga bevosita bog‘liqdir.

Zararli elementlar orasida fosfor alohida ahamiyatga ega bo‘lib, u po‘latning sovuq mo‘rtligini oshiradi, plastiklik xossalarini va zarbiy qovushqoqligini pasaytirib yorilishga moyillikni kuchaytiradi. Ayniqsa, harorat nisbatan past sharoitlarda ishlovchi detallar uchun fosfor miqdorini yuqori bo‘lishi jiddiy muammo hisoblanadi. Shu sababli po‘lat eritish jarayonida fosforni kamaytirish, ya’ni defosforatsiya jarayonini samarali tashkil etish muhim vazifalardan biri hisoblanadi.

Defosforatsiya metall va shlak o‘rtasida kechadigan murakkab fizik-kimyoviy jarayon bo‘lib, unda metall tarkibidagi fosfor oksidlanuvchi sharoitda yani temir oksidi (FeO) ishtirokida reaksiyaga kirishib, shlak tarkibiga o‘tadi. Jarayon samaradorligi haroratga, shlak tarkibi va asosliligi,

[a] https://orcid.org/0009-0008-7910-3980
[b] https://orcid.org/0009-0004-1440-7458

kislorod potensiali hamda aralashtirish darajasiga bog‘liq. Yuqori asosli (kalsiy oksidiga boy) shlaklardan foydalanish defosforatsiya jarayonini yaxshilaydi, biroq haroratning ortishi muvozanatga salbiy ta’sir ko‘rsatadi.

20ГЛ - bu transport mashinasozligida keng foydalaniladigan, kam uglerodli va kam legirlangan, quyma yo‘li bilan olingan konstruksiyon po‘latdir. Ushbu markali po‘lat uchun defosforatsiya jarayoni o‘rganish alohida ahamiyatga ega, chunki uning mexanik hamda ekspluatatsion xossalari yuqori darajada bo‘lishi talab etiladi. Fosfor miqdorini kamaytirish metall sifatini oshirish va uning xizmat muddatini uzaytirishda muhim rol o‘ynaydi. Shu sababdan ishning maqsadi - 20ГЛ markali po‘lat eritishda defosforatsiya jarayonini va mexanizmini o‘rganish hamda unga ta’sir etuvchi asosiy omillarni aniqlashdan iborat.

2. Tadqiqot metodologiyasi

Defosforatsiya jarayonini termodinamik tahlil qilish uchun 20ГЛ markali po‘lat tanlab olingan. 1-jadvalda ushbu po‘latni va shlakning kimyoviy tarkibi 720 ta erish jarayonidagi tarkibning o‘rtachasi olinib, termodinamik hisob-kitoblar tahlil qilingan.

1-jadval

Defosforatsiya jarayonidagi metall va shlakning o‘rtacha kimyoviy tarkibi

20ГЛ markali po‘latning kimyoviy tarkibi, % (mass.)						
C	Si	Mn	P	S	Al	Fe
0,16	0,08	0,12	0,045	0,04	0	qolgani
Defosforatsiya jarayonida 20ГЛ markali po‘latning eritishdagi shlak tarkibi, % (mass.)						
CaO	SiO_2	MnO	Al_2O_3	MgO	FeO	Umumiy
50	16	6	3	10	15	100
Shlakdagi kationlarning molyar ulushlari						
56	60	71	102	40	72	n_i
Shlakdagi har bir komponentning molyar miqdori						
0,893	0,267	0,085	0,029	0,250	0,208	$\sum n_i$ =1,761
Metall ionlarining umumiy ionlar yig‘indisidagi ulushi						
0,507	0,151	0,048	0,033	0,142	0,118	1

Defosforatsiya jarayoni (1) reaksiya orqali yozilib, bu reaksiyani Gibbs energiyasi (2) ifodaga tengdir:

$$[P] + 2{,}5(FeO) \leftrightarrow (PO_{2,5}) + 2{,}5Fe \quad (1)$$

$$\Delta G_{um} = 20537 + 24{,}65T \quad (2)$$

Pechdagi suyuq metall haroratini 1800 Kdan 1925 Kgacha 25K qadam bilan o‘zgartirildi. Muvozanat konstantasi Vant-Goff tenglamasidan foydalanib keltirib chiqarildi. Vant-Goff tenglamasi yoki izoterma reaksiya tenglamasi deb nomlanuvchi bu formula kimyoviy reaksiyaning standart Gibbs energiyasi (ΔG_{um}) va muvozanat konstantasi (K) o‘rtasidagi bog‘liqlikni ifodalaydi va (3) ifodadan topiladi:

$$\lg K_P = -\frac{\Delta G_{um}}{2{,}3RT} = -\frac{(20537+24{,}65T)}{2{,}3 \cdot 8{,}314 \cdot T}; \quad (3)$$

bu yerda: $R = 8{,}314$ J/(mol·K) - universal gaz doimiysi;

$T = (1800 \ldots 1923)$К - harorat.

Ikkinchi tarafdan, 4-tenglamaga ko‘ra muvo-zanat doimiysi (3) ifodaga teng va quyidagicha topiladi.

$$K_P = \frac{a_{PO_{2,5}} \cdot a_{Fe}^{2,5}}{a_P \cdot a_{FeO}^{2,5}} = \frac{x_{P^{5+}}}{[P]} \cdot \frac{\gamma_{P^{5+}}}{f_P \cdot a_{FeO}^{2,5}} \Rightarrow$$

$$\begin{bmatrix} a_{Fe} = X_{Fe} = 1 & a_{PO_{2,5}} = X_{P^{5+}} \cdot \gamma_{P^{5+}} \\ a_P = [P] \cdot f_P & X_{P^{5+}} = 2 \cdot \frac{(P_2O_5)}{\mu_{P_2O_5}} = \frac{(P)}{\mu_P \cdot \sum n_i} \end{bmatrix} \Rightarrow$$

$$\frac{(P)}{\{P\}} \cdot \frac{\gamma_{P^{5+}}}{31 \cdot \sum n_i \cdot f_P \cdot a_{FeO}^{2,5}}; \quad (4)$$

bu yerda: $a_{PO_{2,5}}, a_{FeO}, a_P, a_{Fe},$ – fosfor va temir oksidi, fosfor hamda temir aktivligi;

$[P]$, – metal tarkibidagi fosfor va kislorodning miqdori, %;

f_P – fosforning aktivlik koeffitsiyentlari. 2-tenglamadan foydalanib turli harorat uchun muvozanat konstantasi hisoblanadi. Fosforning aktivlik koeffitsiyentini turli harortlarda hisoblash uchun 5- ifodadan foydalanildi.

$$lg f_P = \frac{T}{1873} \cdot (e_P^C[C] + e_P^{Mn}[Mn] + +e_P^{Si}[Si] + e_P^P[P] + e_P^S[S] + e_P^{Al}[Al]); \quad (5)$$

bu yerda: $e_P^R[R]$ – metal tarkibidagi [R] komponentning fosfor bilan ta‘sirlashish parametri.

Metall tarkibidagi komponentlarning fosfor bilan ta‘sirlashish parametrlari 2-jadvalda keltirilgan.

2-jadval

Birinchi tartibli ta’sirlashish parametrlari

e_P^R	[C]	[Si]	[Mn]	[P]	[S]	[Al]
e_P	0,13	0,12	0	0,062	0,028	0

Fosforning taqsimlanish koeffitsienti formulasi quyida keltirilgan:

$$L_P = \frac{(P)}{\{P\}}; \quad L_P = \frac{31 \cdot K \cdot \sum n_i \cdot f_P \cdot a_{FeO}^{2,5}}{\gamma_{P^{5+}}} \quad (6)$$

Metall va shlak orasidagi fosforning taqsimlanish koeffitsiyentini (L_P) bilgan holda metalldagi $[P]_{ox}$ va shlakdagi $(P)_{ox}$ fosforning oxirgi konsentratsiyalarini topish mumkin. Buning uchun (7) hamda (8) formulalardan foydalanib tenglamalar sistemasi tuziladi:

$$L_P = \frac{(P)_{ox}}{[P]_{ox}} \quad (7)$$

$$m_m[P]_b + m_s(P)_b = m_m[P]_{ox} + m_s(P)_{ox}; \quad (8)$$

bu yerda: m_m va m_s - metall va shlak massasi;

$[P]_b$ va $(P)_b$ - metall va shlakdagi fosforni boshlang‘ich konsentratsiyalari;

$[P]_{ox}$ va $(P)_{ox}$ - metall va shlakdagi fosforning oxirgi konsentratsiyalari.

Ma’lumki, (8) ifoda materiallar balansi tenglamasi bo‘lib, fosfor gaz fazasiga ajralmasdan, faqat metall va shlak orasida qayta taqsimlanishi sharti bilan tuzilgan. Agar eritish jarayonida m_m va m_s kattaliklar o‘zgarmasa, u holda (7) va (8) tenglamalar sistemasini yechib, metalldagi fosforning oxirgi miqdorini hisoblash ifodasini (9) tenglama bo‘yicha topiladi:

$$[P]_{ox} = \frac{100[P]_{bosh} + \lambda(P)_{bosh}}{100 + \lambda L_P} \quad (9)$$

bu yerda $\lambda = m_{sh}/m_{met}$ - shlak karraligi, %.

Defosforatsiya darajasini (10) formula yordamida topiladi:

$$\eta_P = \frac{[P]_b - [P]_{ox}}{[P]_b} \cdot 100\%;$$

yoki

https://doi.org/10.56143/2181-2438-2026-2-54-57 Research, Innovation, Results

$$\eta_P = \frac{\lambda(L_к - (P)_b/[P]_b)}{1+0{,}01\lambda L_к} \qquad (10)$$

Agar shlakning tarkibi defosforatsiya shartlarini va metall va shlak takibidagi elementlarning o‘rtasida taqsimlanishining moddiy muvozanatini qoniqtirmasa, masala iteratsion yaqinlashish usuli bilan yechiladi. Agar element taqsimotining materiallar balansi mos kelmasa - jarayon sharoitida qabul qilingan kuyish koeffitsiyentini o‘zgartirish kerak. Agar shlak tarkibi defosforatsiya sharoitini qoniqtirmasa temir oksidi (FeO) miqdorini oshirish talab etiladi. Shlak tarkibi tuzatilgandan so‘ng, jarayonni takrorlash zarur.

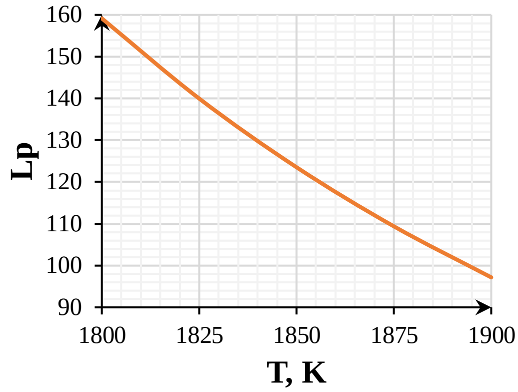
Ushbu usul bo‘yicha, masalan, fosforni, oltingugurtni va boshqa elementlarning ham pechda va pechdan tashqarida rafinirlash uchun shlak miqdorini, qattiq shlak aralashmasining sarfini, tizimning zarur oksidlanishini, jarayon haroratini hamdaa defosforatsiya jarayonining boshqa texnologik parametrlarini hisoblash mumkin.

3-jadval

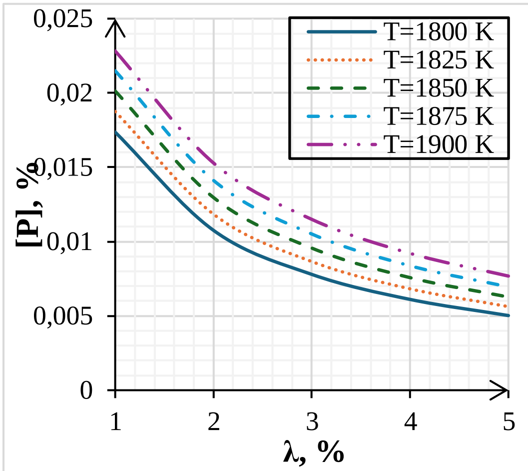
Defosforatsiyadagi barcha jarayonlarning haroratga bog’liqligi

Ko‘rsat-kichlar	Absolyut harorat (T), K				
	1800	1825	1850	1875	1900
G^T, J/mol	23836	24452	25069	25685	26301
lgKp	-0,693	-0,701	-0,709	-0,716	-0,724
Kp	0,203	0,199	0,196	0,192	0,189
∑ni	1,761	1,761	1,761	1,761	1,761
$\ln\gamma_{Fe}^{2+}$	0,762	0,752	0,742	0,732	0,722
γ_{Fe}^{2+}	2,143	2,121	2,100	2,079	2,059
$\ln\gamma_P^{5+}$	-6,013	-5,931	-5,850	-5,772	-5,696
γ_P^{5+}	0,0024	0,0027	0,0029	0,0031	0,0034
lgfp	0,036	0,035	0,035	0,034	0,034
fp	1,086	1,084	1,083	1,082	1,081
a_{FeO}	0,254	0,251	0,248	0,246	0,244
L_P	159	140	124	109	97
Metalldagi fosforni oxirgi miqdori [P] (λ), %					
λ=1 %	0,017	0,019	0,020	0,021	0,023
λ=2 %	0,011	0,012	0,013	0,014	0,015
λ=3 %	0,008	0,009	0,010	0,011	0,011
λ=4 %	0,006	0,007	0,008	0,008	0,009
λ=5 %	0,005	0,006	0,006	0,007	0,008
Defosforatsiya darajasi, η (λ), %					
λ=1 %	61	58	55	52	49
λ=2 %	76	74	71	69	66
λ=3 %	83	81	79	77	74
λ=4 %	86	85	83	81	80
λ=5 %	89	87	86	85	83

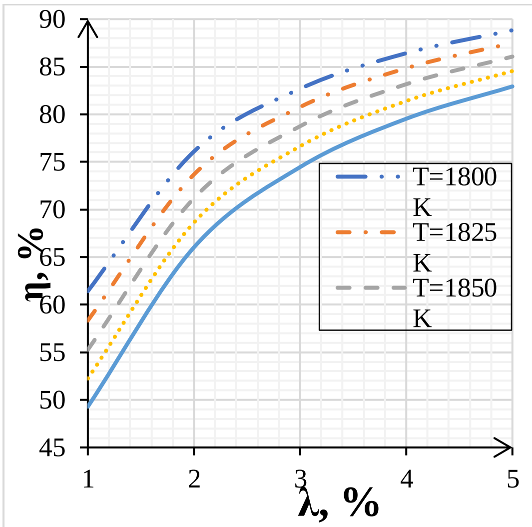
Quyidagi jadvaldagi ko‘rsatkichlardan foydalanib, defosforatsiyadagi ba‘zi asosiy jarayonlarning harorat ta‘sirida qanday o‘zgarishini 1-2-3-grafiklardan aniqroq tushunib olishimiz mumkin.



1-rasm. Fosforning taqsimlanish koeffitsiyentining haroratga bog‘liqlik grafigi



2-rasm. Turli haroratlarda metalldagi fosforning oxirgi konsentratsiyasining shlak karraliligiga bog‘liqlik grafigi



3-rasm. Turli haroratlarda shlak karraliligiga bog‘liq holda defosforatsiya darajasi o‘zgarishi grafigi

Hisobiy jadval va grafiklardan ko‘rinib turibdiki, harorat 1800K dan 1900K gacha ortishi bilan fosforning taqsimlanish koeffitsiyenti kamayadi. Ushbu haroratlarda shlak karraliligi foizi ortishi bilan metalldagi fosforning oxirgi konsentratsiyasini miqdori kamayadi, bu esa defosfaratsiya darajasini oshishiga olib keladi.

3. Xulosa

Termodinamik tahlillar yordamida, 20GL markali quyma po‘latni tarkibidagi legirlovchi elementlarning (C, Si, Mn, Cr, Ni, Cu, Al) fosfor aktivligiga ta’siri o‘rganildi. Aniqlanishicha, po‘lat tarkibidagi uglerod (0,20%) va kremniy (0,35%) elementlari fosforning aktivlik koeffitsiyentini oshirib, uning metall fazasidan shlak fazasiga o‘tishi uchun qulay termodinamik sharoit yaratadi. Tadqiqotlar natijasida fosforning muvozanat konsentratsiyasi harorat ko‘tarilishi bilan chiziqli ravishda kamayishi kuzatildi. Harorat 1525°C dan 1625°C gacha o‘sishi bilan fosforning shlakka o‘tish samaradorligi pasayadi. Bu esa defosforatsiya jarayonining ekzotermik tabiatini tasdiqlaydi va jarayonning yakuniy bosqichida metall haroratini 1540...1550°C atrofida ratsionallashtirish zarurligini ko‘rsatadi. Bundan tashqari, fosforning metall va shlak fazalari o‘rtasidagi taqsimlanish koeffitsiyenti L_P shlakning asosiyligi va oksidlanish salohiyatiga bevosita bog‘liqligi o‘rganildi. Shlakning asosiyligi (B) 2,8…3,2 oralig‘ida bo‘lganda, L_P ko‘rsatkichining eng yuqori qiymatlariga erishilishi, bu esa metall tarkibida fosfor miqdorini minimal darajaga tushirish imkonini berishi isbotlandi. Aniqlangan qonuniyatlar 20GL markali po‘latdan tayyorlanadigan transport detallarining sovuqqa chidamlilik, zarbiy qovushqoqlik xususiyatlarini oshirishga va ularning past haroratlarda ishonchliligi va umrboqiyligini ta’minlashga xizmat qiladi.

Foydalangan adabiyotlar / References

[1] Лунев В.В., Аверин В.В. Сера и фосфор в стали. М.: “Металлургия”, 1988 г. -256 с.

[2] К.В. Григорович, Т.В. Шибаева, А.М. Арсенкин. Влияние технологии раскисления трубных сталей на состав и количество неметаллических включений. Металлы. 2011. № 5. С. 164–170.

[3] Григорян В. А., Стомахин А. Я., Уточкин Ю. И. и др. Физико-химические расчеты электросталеплавильных процессов: Сб. задач с решениями. – 2-е изд., перераб. и доп. – М.: МИСиС. - 2007. – 318 с.

[4] Raxmatova, Z., Qodirova, N., & Tursunov, N. (2025). Cho ‘yan turlarining kimyoviy tarkibi, mexanik xossalari va mikrotuzilishining kompleks tahlili. Journal of Transport, 2(4), 172-175.

[5] Инновационное производство высоко-легированной стали и сплавов: теория и технология выплавки стали в индукционных печах: учеб. пособие / А.Е. Семин, Н.К. Турсунов, К.Л. Косырев. – М.: Изд. Дом НИТУ «МИСиС», 2017. – 166 с.

[6] Tursunov, N., Qodirova, N., & Raxmatova, Z. (2025). 20GL markali po ‘latning desulfuratsiyalash jarayonini tadqiq qilish. Journal of Transport, 2(4), 75-78.

[7] Tursunov, N., Qodirova, N., Raxmatova, Z., & Urazbayev, T. (2025). 20ГЛ markali po‘latni oksidsizlantirish va desulfuratsiyalash jarayonlarining termodinamik tahlili. Journal of Transport, 2(4), 268-272.

[8] Urazbayev, T., Tursunov, N., & Tursunov, T. (2024, March). Steel modification modes for improving the cast parts quality of the rolling stock couplers. In AIP Conference Proceedings (Vol. 3045, No. 1, p. 060015). AIP Publishing LLC.

[9] Valieva, D., Yunusov, S., & Tursunov, N. (2023). Study of the operational properties of the bolster of a freight car bogie. In E3S Web of Conferences (Vol. 401, p. 05017). EDP Sciences.

[10] Kayumjonovich, T. N. (2022). Non-metallic inclusions in steel processed with modifiers. Web of Scientist: International Scientific Research Journal, 3(5), 1848-1853.

[11] Toirov, O. T., Tursunov, N. Q., Nigmatova, D. I., & Qo’Chqorov, L. A. (2022). Using of exothermic inserts in the large steel castings production of a particularly.

[12] Турсунов, Н. К., & Тоиров, О. Т. (2021). Снижение дефектности рам по трещинам за счёт применения конструкции литниковой системы..

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

Tursunov Nodirjon / Nodirjon Tursunov	Toshkent davlat transport universiteti “Materialshunoslik va mashinasozlik” kafedrasi mudiri, t.f.d., professor Tel.:+998712990169 https://orcid.org/0009-0008-7910-3980
Saidiraximov Azizjon / Azizjon Saidirakhimov	Toshkent davlat transport universiteti “Materialshunoslik va mashinasozlik” kafedrasi doktoranti E-mail: azizsaidrahimov94@gmail.com Tel.: +998904052928 https://orcid.org/0009-0004-1440-7458
Qodirova Nodira / Nodira Kodirova	Toshkent davlat transport universiteti “Materialshunoslik va mashinasozlik” kafedrasi magistranti E-mail: nodiraqodirova300@gmail.com Tel.:+998933807767
Raxmatova Zarifa / Zarifa Rakhmatova	Toshkent davlat transport universiteti “Materialshunoslik va mashinasozlik” kafedrasi magistranti E-mail: zarirakhmatova@gmail.com Tel.:+998999439905

CONTEXT / MUNDARIJA