

MUHANDISLIK

& IQTISODIYOT

№12

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

2025
dekabr

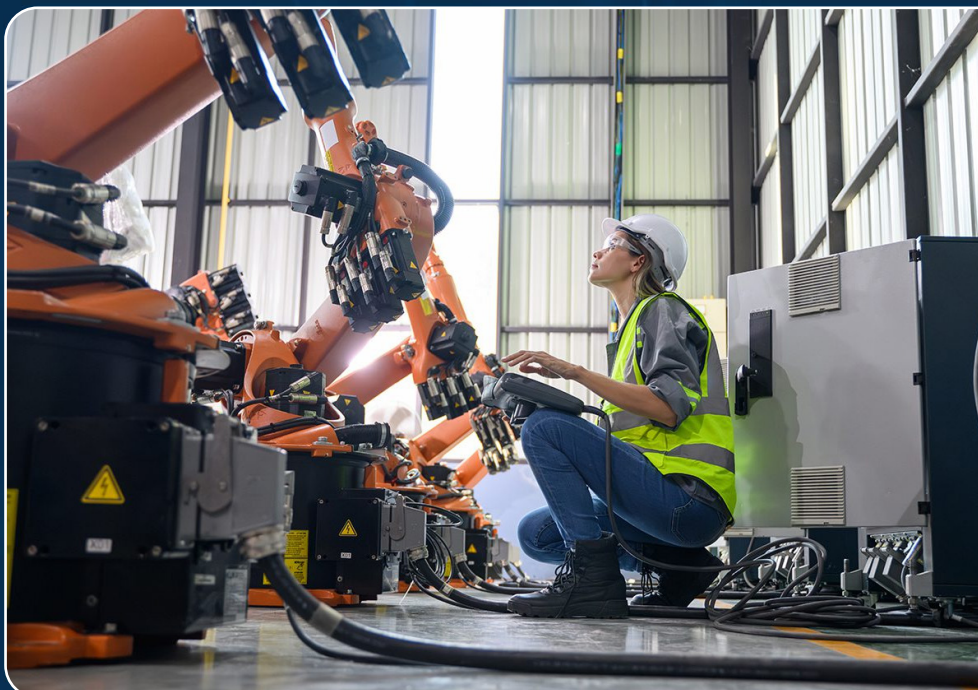


Milliy nashrlar

OAK: <https://oak.uz/pages/4802>

05.00.00 – Texnika fanlari

08.00.00 – Iqtisodiyot fanlar



Google Scholar

OPEN ACCESS

ULRICHSWEB[®]
GLOBAL SERIALS DIRECTORY

Academic
Resource
Index
ResearchBib

ISSN
INTERNATIONAL
STANDARD
SERIAL
NUMBER
INTERNATIONAL CENTRE

CYBERLENINKA

OpenAIRE

ROAD

INDEX
COPERNICUS
INTERNATIONAL

BASE

Crossref

НАУЧНАЯ ЭЛЕКТРОННАЯ
БИБЛИОТЕКА
LIBRARY.RU



ISSN: 3060-463X

РЭУ.РФ
РОССИЙСКИЙ ЭКОНОМИЧЕСКИЙ УНИВЕРСИТЕТ
ИМЕНИ Г.В. ПЛЕХАНОВА
ТАШКЕНТСКИЙ ФИЛИАЛ



muhandislik & iqtisodiyot

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

Elektron nashr, 807 sahifa.
2025-yil, dekabr

Bosh muharrir:

Zokirova Nodira Kalandarovna, iqtisodiyot fanlari doktori, DSc, professor

Bosh muharrir o'rinbosari:

Shakarov Zafar G'afforovich, iqtisodiyot fanlari bo'yicha falsafa doktori, PhD, dotsent

Tahrir hay'ati:

Abduraxmanov Kalandar Xodjayevich, O'z FA akademigi, iqtisodiyot fanlari doktori, professor

Sharipov Kongratbay Avezimbetovich, texnika fanlari doktori, professor

Maxkamov Baxtiyor Shuxratovich, iqtisodiyot fanlari doktori, professor

Abduraxmanova Gulnora Kalandarovna, iqtisodiyot fanlari doktori, professor

Shaumarov Said Sanatovich, texnika fanlari doktori, professor

Turayev Bahodir Xatamovich, iqtisodiyot fanlari doktori, professor

Nasimov Dilmurod Abdulloyevich, iqtisodiyot fanlari doktori, professor

Allayeva Gulchexra Jalgasovna, iqtisodiyot fanlari doktori, professor

Arabov Nurali Uralovich, iqtisodiyot fanlari doktori, professor

Maxmudov Odiljon Xolmirzayevich, iqtisodiyot fanlari doktori, professor

Xamrayeva Sayyora Nasimovna, iqtisodiyot fanlari doktori, professor

Bobonazarova Jamila Xolmurodovna, iqtisodiyot fanlari doktori, professor

Irmatova Aziza Baxromovna, iqtisodiyot fanlari doktori, professor

Bo'taboyev Mahammadjon To'ychiyevich, iqtisodiyot fanlari doktori, professor

Shamshiyeva Nargizaxon Nosirxuja kizi, iqtisodiyot fanlari doktori, professor,

Xolmuxamedov Muhsinjon Murodullayevich, iqtisodiyot fanlari nomzodi, dotsent

Xodjayeva Nodiraxon Abdurashidovna, iqtisodiyot fanlari nomzodi, dotsent

Amanov Otabek Amankulovich, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD), dotsent

Toxirov Jaloliddin Ochil o'g'li, texnika fanlari bo'yicha falsafa doktori (PhD)

Qurbonov Samandar Pulatovich, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD)

Zikriyoyev Aziz Sadulloyevich, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD)

Tabayev Azamat Zaripbayevich, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD)

Sxay Lana Aleksandrovna, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD), dotsent

Ismoilova Gulnora Fayzullayevna, iqtisodiyot fanlari nomzodi, dotsent

Djumaniyazov Umrbek Ilxamovich, iqtisodiyot fanlari nomzodi, dotsent

Kasimova Nargiza Sabitdjanovna, iqtisodiyot fanlari nomzodi, dotsent

Kalanova Moxigul Baxritdinovna, dotsent

Ashurzoda Luiza Muxtarovna, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD)

Sharipov Sardor Begmaxmat o'g'li, iqtisodiyot fanlari bo'yicha falsafa doktori (PhD)

Sharipov Botirali Roxataliyevich, iqtisodiyot fanlari nomzodi, professor

Tursunov Ulug'bek Sativoldiyevich, iqtisodiyot fanlari doktori (DSc), dotsent

Bauyetdinov Majit Janizaqovich, Toshkent davlat iqtisodiyot universiteti dotsenti, PhD

Botirov Bozorbek Musurmon o'g'li, Texnika fanlari bo'yicha falsafa doktori (PhD)

Sultonov Shavkatjon Abdullayevich, Kimyo fanlari doktori, (DSc)

Jo'raeva Malohat Muhammadovna, filologiya fanlari doktori (DSc), professor.

Yusupov Maxamadamin Abduxamidovich, iqtisodiyot fanlari nomzodi (DSc), professor

muhandislik & iqtisodiyot

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

- 05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
- 05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
- 05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
- 05.01.03 – Informatikaning nazariy asoslari
- 05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
- 05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
- 05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
- 05.01.07 – Matematik modellash
- 05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
- 05.02.00 – Mashinasozlik va mashinashunoslik
- 05.02.08 – Yer usti majmualari va uchish apparatlari
- 05.03.02 – Metrologiya va metrologiya ta'minoti
- 05.04.01 – Telekommunikatsiya va kompyuter tizimlari, telekommunikatsiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
- 05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
- 05.05.05 – Issiqlik texnikasining nazariy asoslari
- 05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
- 05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
- 05.08.03 – Temir yo'l transportini ishlatish
- 05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
- 05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
- 10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
- 10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti
- 08.00.01 – Iqtisodiyot nazariyasi
- 08.00.02 – Makroiqtisodiyot
- 08.00.03 – Sanoat iqtisodiyoti
- 08.00.04 – Qishloq xo'jaligi iqtisodiyoti
- 08.00.05 – Xizmat ko'rsatish tarmoqlari iqtisodiyoti
- 08.00.06 – Ekonometrika va statistika
- 08.00.07 – Moliya, pul muomalasi va kredit
- 08.00.08 – Buxgalteriya hisobi, iqtisodiy tahlil va audit
- 08.00.09 – Jahon iqtisodiyoti
- 08.00.10 – Demografiya. Mehnat iqtisodiyoti
- 08.00.11 – Marketing
- 08.00.12 – Mintaqaviy iqtisodiyot
- 08.00.13 – Menejment
- 08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
- 08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
- 08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
- 08.00.17 – Turizm va mehmonxona faoliyati

Ma'lumot uchun, OAK

Rayosatining 2024-yil 28-avgustdagi 360/5-son qarori bilan "Dissertatsiyalar asosiy ilmiy natijalarini chop etishga tavsiya etilgan milliy ilmiy nashrlar ro'yxati"ga texnika va iqtisodiyot fanlari bo'yicha "Muhandislik va iqtisodiyot" jurnali ro'yxatga kiritilgan.

Muassis: "Tadbirkor va ishbilarmon" MChJ

Hamkorlarimiz:

1. Toshkent shahridagi G.V.Plexanov nomidagi Rossiya iqtisodiyot universiteti
2. Toshkent davlat iqtisodiyot universiteti
3. Toshkent irrigatsiya va qishloq xo'jaligini mexanizatsiyalash muhandislari instituti" milliy tadqiqot universiteti
4. Islom Karimov nomidagi Toshkent davlat texnika universiteti
5. Muhammad al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universiteti
6. Toshkent davlat transport universiteti
7. Toshkent arxitektura-qurilish universiteti
8. Toshkent kimyo-texnologiya universiteti
9. Jizzax politexnika instituti



MUNDARIJA

RASMIY RIVOJLANISH YORDAMI (OFFICIAL DEVELOPMENT ASSISTANCE, ODA) ORQALI O'ZBEKISTONDA DAVLAT MOLIYASINI BOSHQARISH (PUBLIC FINANCIAL MANAGEMENT, PFM) TIZIMINI TAKOMILLASHTIRISH	24
Pulatov Dilshod Haqberdiyevich, Ulug'ova Maftunabonu To'liqinovna	
INNOVATIVE TECHNOLOGIES IN LEADING WHEAT-PRODUCING COUNTRIES.....	28
Turayeva Gulizahro	
BLOKCHEYN TIZIMLARI UCHUN XESH FUNKSIYALARNI TANLASH MEZONLARI VA SAMARADORLIK KO'RSATKICHLARI TAHLILI	32
Abduraximov Baxtiyor, Allanov Orif, Turdibekov Baxtiyor	
RIVOJLANGAN DAVLATLAR TAJRIBASI ASOSIDA KICHIK KORXONALARDA ISHLAB CHIQARISHNI SAMARALI TASHKIL ETISH MODELLARI: NAMANGAN VILOYATI MISOLIDA	39
Xonto'rayev Obbosxon Kamolxon o'g'li	
ISSIQLIK AKKUMULYATORINING RAZRYADLANISH JARAYONIDA SUYUQLIK QATLAMLARIDA HARORAT TAQSIMLANISHINING BIR O'LCHOVLI MODEL	43
B.A. Hikmatov, M.S. Mirzayev	
ISLOM MOLIYASI TAMOIYILLARI ASOSIDA YASHIL LOYIHALARNI MOLIYALASHTIRISH IMKONIYATLARI.....	49
Safarova Nasiba Gulmurod qizi	
ПРИМЕНЕНИЕ ИНТЕЛЛЕКТУАЛЬНЫХ СИСТЕМ В ОБУЧЕНИИ СПЕЦИАЛИСТОВ ПО ИНФОРМАЦИОННЫМ ТЕХНОЛОГИЯМ.....	54
Даниярова Улбосын Куатбаевна	
YANGI TURDAGI IKKI QATLAMLI TRIKOTAJ TO'QIMALARI KO'RSATKICHLARINI KOMPLEKS BAHOLASH	58
Ergasheva Rashida Abdug'aniyevna	
HALQALI YIGIRISH MASHINASIDA BURAM UCHBURCHAGINING IP UZILISHIGA BOG'LIQLIGINI TADQIQI.....	62
Soliyev Azizbek Kamoldinovich	
НОВЫЕ ТЕНДЕНЦИИ ТУРИЗМА 2030: СТРАТЕГИЧЕСКИЕ ОРИЕНТИРЫ И РЕКОМЕНДАЦИИ ДЛЯ УЗБЕКИСТАНА	69
Голышева Елена Вячеславовна	
STRATEGIK JARAYONNING MODELLARI	76
Musayeva Dilnoza Dilshatovna	
МАТЕМАТИЧЕСКИЕ МОДЕЛИ ОЦЕНКИ СТОИМОСТИ КВАРТИР В МНОГОЭТАЖНЫХ ДОМАХ.....	81
Уринов Адхамжон Акбарович	
MATERIALLARNI MURAKKAB YASSI TRAEKTORIYALAR BO'YICHA DEFORMASIYALANTIRISHDA PLASTIK DEFORMASIYALANISH JARAYONLARI	88
A.Xakimov, X.Xakimov	
TIJORAT BANKLARI TOMONIDAN LOYIHALARNI ISLOM MOLIYA INSTRUMENTLARI ORQALI MOLIYALASHTIRISH YO'LLARI.....	95
Xaitov Shaxzod Sharipboyevich	
SANOAT KORXONALARINING RAQOBATBARDOSHLIGINI OSHIRISH CHORA-TADBIRLARINING KETMA KETLIGI	102
Xusanova Maloxat Mengnorovna	
TO'QIMACHILIK KORXONALARIDA LOGISTIKA XARAJATLARI TAHLILI	107
Saidova Kamola Xoshimovna	



OZIQ-OVQAT SANOATINI IQTISODIY RIVOJLANTIRISHDA EKOLOGIK MUAMMOLAR VA ULARNI YECHISHNING METODOLOGIK YONDASHUVLARI	111
Tleuv Niyetulla Raxmanovich	
YUQORI MUSTAHKAM KOMPOZIT ARMATURALARDAN FOYDALANILGAN TEMIRBETON KONSTRUKSIYALARINING YUK KO'TARUVCHANLIGI VA UZOQ MUDDATLI DEFORMATSIYALARINI BAHOLASH	114
Mamajanova Odina Alisher qizi	
KORXONALARDA DAROMADLILIK KO'RSATKICHLARINI BAHOLASHNING ZAMONAVIY YONDASHUVLARI	119
Farog'at Xo'jabekova, Eshankulova Nafisa Komiljon qizi	
TEMIR YO'L INFRATUZILMASIDA YASHIL IQTISODIYOT TAMOIYILLARINI QO'LLASH: CSR, ESG VA PRI ASOSIDA BARQAROR RIVOJLANISH STRATEGIYASINI SHAKLLANTIRISH	124
Abduraxmanova Muqaddas Toxtasinovna	
THE ROLE OF ARTIFICIAL INTELLIGENCE IN OPTIMIZING MARKETING AND EDUCATIONAL PROCESSES IN HIGHER EDUCATION	128
Sadikov Shoxrux Shuhratovich	
BANK FAOLIYATIDA "YASHIL" MOLIYAVIY VOSITALARDAN FOYDALANISHNING NAZARIY ASOSLARI.....	133
Abduraxmonov Alimardon Sodiq o'g'li	
TIJORAT BANKLARI TOMONIDAN LOYIHALARNI ISLOM MOLIYA INSTRUMENTLARI ORQALI MOLIYALASHTIRISH YO'LLARI	139
Xaitov Shaxzod Sharipboyevich	
BOSHQARUV PSIXOLOGIYASIGA DOIR MUAMMOLARNI BARTARAF ETISHNING ZAMONAVIY YO'NALISHLARI	145
Aripov Oybek Abdullayevich	
TADBIRKORLIK SUBYEKTLARIDA INNOVATSIYALARNI JORIY ETISHNING IQTISODIY SAMARALARI	150
Karimov Nodirbek	
УТИЛИЗАЦИЯ ПОБОЧНЫХ ПРОДУКТОВ ПЕРЕРАБОТКИ ХЛОПКА ДЛЯ СИНТЕЗА АНТИКОРРОЗИОННЫХ КОМПОЗИЦИОННЫХ ПОКРЫТИЙ.....	155
Ситмуратов Тулкинбек Сабирбаевич, Баходиров Худайберган Баходир угли	
SANOAT KORXONALARIDA MOLIYAVIY BARQARORLIKNI TA'MINLASHNING METODOLOGIK ASOSLARI.....	163
Ergashev Muhibbek Aslam o'g'li	
O'ZBEKISTON TO'QIMACHILIK SANOATIDA XORIJIY INVESTITSİYALAR SAMARADORLIGINI OSHIRISH YO'NALISHLARI	168
Nazarova A.N.	
АВТОМАТИЗИРОВАННАЯ СИСТЕМА РАСЧЁТА ПОКАЗАТЕЛЕЙ ЭФФЕКТИВНОСТИ СОТРУДНИКОВ ОРГАНИЗАЦИИ	172
Шухратов Мамуржон Шухрат угли	
BLOCKCHIAN, IOT (INTERNET OF THINGS) NING IQTISODIY SOHALARDA QO'LLANISHI	178
Avazov Ergash Xidirberdiyevich	
O'ZBEKISTONDA INVESTITSİYALARNI MOLIYAVIY BOSHQARISHNING JORIY HOLATI VA EKONOMETRIK TAHLILLAR ASOSIDA KELGUSI YILLAR PROGNOZI.....	182
Ismailov Dilshod Anvarjonovich	
QISHLOQ XO'JALIGI KLASSTERLARI MOLIYAVIY HOLATINING NAZARIY JIHATLARI	190
Dildora Yuldasheva	
TURIZM SOHASIDA TRANSPORT XIZMATLARINING HOLATI	194
Xalimov Shaxboz Xalimovich	
MAHALLA BUDJETI VA SOLIQLARNING YIG'ILUVCHANLIGINI OSHIRISH YO'LLARI	200
Abdullayev Zafarbek Safibullayevich	



BUDJET TASHKILOTLARIDA QURILISH-TA'MIRLASH XARAJATLARI HISOBINING USLUBIY JIHATLARI.....	206
Azizova Zilola Lochinovna	
KOSHI – BUNYAKOVSKIY – SHVARS INTEGRAL TENGSIZLIGI VA UNING IQTISODIYOTDAGI ROLI.....	212
Saipnazarov Shaylovbek Aktamovich	
ИНТЕГРАЦИЯ ПРИНЦИПОВ ЦИРКУЛЯРНОЙ ЭКОНОМИКИ В АГРОПРОДОВОЛЬСТВЕННЫЙ СЕКТОР УЗБЕКИСТАНА: ЭКОНОМИЧЕСКАЯ ЭФФЕКТИВНОСТЬ, ПЕРЕРАБОТКА БИОМАССЫ И СТРАТЕГИИ СОКРАЩЕНИЯ ПОСТУБОРОЧНЫХ ПОТЕРЬ	219
Эгамбердиев Хумоюн Хамрокулович	
HOVUZ BALIQCHILIGI XO'JALIKLARIDA REJALASHTIRISHNING MUDDATLARI VA BOSQICHLARI	227
Dosmuratova Shaxista Kengashovna, Menglikulov Bakhtiyor Yusupovich	
O'ZBEKISTON SHAROITIDA KICHIK BIZNESNI QO'LLAB-QUVVATLASH TIZIMINI TAKOMILLASHTIRISH YO'LLARI	233
Ergashev Jamshid Jamoliddinovich	
KON-METALLURGIYA KORXONALARINING KORPORATIV BOSHQARUV TIZIMIDA KPINING O'RNI VA AHAMIYATI.....	237
Ergashov Botirjon Ergashovich	
SANOAT KORXONALARIDA INNOVATSION TEXNOLOGIYALARNI JORIY ETISHNING IQTISODIY SAMARADORLIGI.....	245
Ahmadjanov Ilyosbek	
ACCELERATING SOCIOECONOMIC DEVELOPMENT IN RURAL AREAS THROUGH DIGITAL TECHNOLOGIES: A COMPREHENSIVE ANALYSIS	250
O.Q. Xudayberdiyeva, Z.B. Negmatullayeva	
ISSIQXONALARDAN FOYDALANISHNING OZIY-OVQAT XAVFSIZLIGIGA TA'SIRI BO'YICHA MUAMMONI ASOSLASH VA UNING MILLIY MANFAATLARGA ALOQADORLIGINI ANIQLASH.....	256
Otavullaev Sukhrob Sa'dullo o'g'li	
NAMANGAN VILOYATIDA DON MAHSULOTLARI NARXLARINI SHAKLLANTIRISHDA BOZOR TAJRIBASI	260
Bahriddinov Jahongirbek Ravshanjon o'g'li	
RAQAMLI IQTISODIYOTGA O'TISHNING JAHON TAJRIBASI: MUAMMO VA ISTIQBOL	264
Mamadaliyev Akmaljon	
ПОВЫШЕНИЕ СОЦИАЛЬНОЙ ЗНАЧИМОСТИ НАЛОГОВ В НОВОЙ ЭКОНОМИЧЕСКОЙ СИТУАЦИИ.....	269
Зайналов Джахонгир Расулович	
FARG'ONA VODIYSIDA KICHIK BIZNES VA TADBIRKORLIK SUBYEKTLARI FAOLIYATINI RIVOJLANTIRISHNING HUDUDIIY XUSUSIYATLARI	274
Murodxiyeva Feruza Majidovna	
TOG' VA TOG'OLDI HUDUDLARIDA IQLIM O'ZGARISHI SHAROITIDA QISHLOQ XO'JALIGI BARQARORLIGINI TA'MINLASH STRATEGIYALARI.....	280
Abduliyeva Gulshan Maxmudovna	
LABOR MIGRATION IN UZBEKISTAN: SOCIO-ECONOMIC TRENDS AND DEVELOPMENT PROSPECTS	285
Razakova Barno Sayfiyeva	
U-NET BASED POLYP SEGMENTATION ON KVASIR-SEG DATASET: PERFORMANCE EVALUATION AND COMPARISON WITH STATE-OF-THE-ART METHODS	289
Mukhriddin Arabboev, Shohruh Begmatov, Sukhrob Bobojanov	



IQTISODIYOT TARMOQLARI VA SOHALARI RIVOJLANISHIDA SUN'IIY INTELLEKTDAN FOYDALANISH MASALALARI	300
Davletov Islambek Xalikovich, Normirzayev Ulmasjon Muzaffarjon o'g'li	
IQTISODIYOTDA SAMARALI RAQOBAT MUHITINI SHAKLLANTIRISH SHART-SHAROITLARI VA OMILLARI	304
Karimova Iroda Abdusattarovna	
"MENING MAKTABIM" LOYIHASINI OMMALASHTIRISH BO'YICHA XORIJIY MAMLAKATLAR TAJRIBASI	311
Dilshod Pulatov, Xamidaxon Akbarova, Dildora Mirzayeva	
ISSUES OF SUSTAINABLE DEVELOPMENT IN THE EDUCATION MARKET	320
Inomiddin Imomov	
СОВЕРШЕНСТВОВАНИЕ МЕТОДА ОЦЕНКИ ИННОВАЦИОННОЙ ДЕЯТЕЛЬНОСТИ С УЧЕТОМ СТЕПЕНИ НОВИЗНЫ И ЭФФЕКТОВ	324
Алиева Эльнара Аметовна	
ИНТЕГРАЦИЯ ЦИФРОВЫХ БИЗНЕС-МОДЕЛЕЙ В СИСТЕМУ КОНКУРЕНТНЫХ ПРЕИМУЩЕСТВ ПРЕДПРИЯТИЙ В УЗБЕКИСТАНЕ	331
Назарова Гулчехра Нурмуханбетовна	
ECONOMIC GROWTH: THEORETICAL AND PRACTICAL ASPECT	336
Bustonov Mansurjon Mardonakulovich	
AGROKLASTERDAGI XO'JALIK YURITUVCHI SUBYEKTLAR O'RTASIDAGI O'ZARO ALOQALAR MEKANIZMINING BUGUNGI HOLATI	342
Xaydarov Sardor Komil o'g'li	
SIMSIZ ALOQA TEXNOLOGIYALARI YORDAMIDA TEMIR YO'L STANSIYALARIDA POYEZDLAR HARAKATINI TASHKIL ETISH	350
Jonikulov Egamberdi Shavkat o'g'li	
GENDER SIYOSATI VA DEMOGRAFIK O'SISHNING INSON KAPITALIGA TA'SIRI	357
Ruzmetova Gulira'no Atabekovna	
СОСТОЯНИЕ ВИТАМИННО-МИНЕРАЛЬНОГО ОБМЕНА (ВИТАМИН D, КАЛЬЦИЙ, МАГНИЙ, ФОСФОР) У ДЕТЕЙ РАННЕГО ВОЗРАСТА С ОСТРОЙ ПНЕВМОНИЕЙ НА ФОНЕ ВЕГЕТАТИВНЫХ ДИСФУНКЦИЙ	364
Абдурахмонов Жасур Нематович, Шарипова Олия Аскаровна, Бахронов Шерзод Самиевич	
YASHIL IQTISODIYOTNING MOHIYATI VA TARKIBIY TUZILISHI	373
Kalandarova Elnura Muzaffar qizi	
ОСНОВНЫЕ НАПРАВЛЕНИЯ ОЦЕНКИ ФИНАНСОВОЙ УСТОЙЧИВОСТИ АО ХУДУДГАЗТАЪМИНОТ	377
Хусанов Дурбек Нишанович	
ТЕМИР YO'L TRANSPORTIDA NAZORAT GABARIT QURILMALARINING ZAMONAVIY HOLATI, TAHLILI VA HARAKAT TAKRIBI GABARITLARINI ANIQLASH USULINI TAKOMILLASHTIRISH	384
Xidirov Erkin Irgashovich	
QISHLOQ XO'JALIGIDA SUV RESURSLARIDAN FOYDALANISH VA SAMARALI TAQSIMLASHDA RIVOJLANGAN XORIJIY MAMLAKATLAR TAJRIBALARI	391
Amanbaev Amanali Ortazbaevich	
GLOBAL DARAJADA FAOLIYAT YURITADIGAN BRONLASH TIZIMLARINING ILG'OR XORIY TAJRIBALARI	396
Ismatillaeva Sitara Sayfidin qizi	
DAVLAT-XUSUSIY SHERIKLIGI ASOSIDA INFRATUZILMA LOYIHALARNI MOLIYALASHTIRISHNING NORMATIV-HUQUQIY ASOSLARI	403
Akmal Shodiyev	
QISHLOQ XO'JALIGI MAHSULOTLARI ISHLAB CHIQUVCHI KORXONALARDA LIZING MUNOSABATLARI HISOBİ	408
Inamov Abdusalom Muhamadovich, Inomov Sardor Abdusalomovich, Inomov Hasanboy Abdusalom o'g'li	



O'TKIR BRONXOLIT BILAN KASALLANGAN BOLALARDA KATAMNEZNING EKOLOGIK OMILLAR TA'SIRIDA UZIGA XOS KECHISHI.....	412
Azimova Kamola Talatovna	
THEORETICAL ASPECTS OF STUDYING CONCEPTS RELATED TO YOUTH TOURISM	416
Norboyev Allayor Ismoilovich, Mansurova Zebuniso Abdurashidovna	
THE ESSENTIAL STRATEGIES WAYS OF SERICULTURE INDUSTRY OF THE REPUBLIC OF UZBEKISTAN.....	420
Khojimatov Ravshanbek Rasuljonovich	
BLENDED LEARNING PLATFORMASI KANSEPSIYASI, ARXITEKTURASI VA FUNKSIONAL TUZILMASI.....	425
Qobulova Madina Tuxbatillo qizi, Mirzaaxmedov Muxammadbobur Karimberdiyevich	
ASALARICHILIKNI RIVOJLANTIRISHNING AHOLI DAROMADLARI VA FAROVONLIGIGA TA'SIRI: IQTISODIY TAHLIL VA EKONOMETRIK BAHOLASH	430
Kuanishbay Berdimuratov	
MARKETING EKOTIZIMINI SHAKLLANTIRISHGA OID XORIJIY YONDASHUVLAR TAHLILI	434
Sobirov Azizbek Avazbekovich	
УЧЕТНО-АНАЛИТИЧЕСКОЕ ОБЕСПЕЧЕНИЕ УПРАВЛЕНИЯ ДЕНЕЖНЫМИ ПОТОКАМИ ОРГАНИЗАЦИИ	443
Бабахонов Бабуржон Шухрат угли	
KICHIK BIZNES SUBYEKTLARIGA SOLIQ IMTIYOZLARINI QO'LLASH MASALALARI.....	449
Ibroximov Muxammadjon Abdullajanovich	
QISHLOQ XO'JALIGIDA LOGISTIKA BOSHQARUVINING RAQAMLI MODEL VA UNING SAMARADORLIGI	453
Olimova Bahora Shuxratovna	
СУЩНОСТЬ И ЭКОНОМИЧЕСКОЕ СОДЕРЖАНИЕ ФИНАНСОВЫХ РЕЗУЛЬТАТОВ ПРЕДПРИЯТИЯ.....	463
Муминходжаева Дилноза Рамизовна	
ИННОВАЦИОННЫЕ МЕТОДЫ УПРАВЛЕНИЯ ФИНАНСОВЫМИ РИСКАМИ В СЕЛЬСКОМ ХОЗЯЙСТВЕ НА ОСНОВЕ ЦИФРОВЫХ ТЕХНОЛОГИЙ И АНАЛИТИЧЕСКИХ ПЛАТФОРМ	468
Дурманов Акмал Шаймарданович	
УПРАВЛЕНИЕ ИННОВАЦИОННЫМ РАЗВИТИЕМ СОЦИАЛЬНОГО СЕКТОРА ЭКОНОМИКИ: ВЫЗОВЫ И НАПРАВЛЕНИЯ РЕФОРМ В СФЕРЕ ОБРАЗОВАНИЯ И ЗДРАВООХРАНЕНИЯ УЗБЕКИСТАНА.....	477
Холмуратов Джахонгир Салимбек угли	
O'ZBEKISTONDA XORIJIY INVESTITSİYALARNI JALB ETISHDA TIJORAT BANKLARINING ROLI.....	483
Yuldashev Erkin Xusanovich	
MINTAQAVIY INVESTITSIYA-INNOVASION JARAYONLARGA TA'SIR ETUVCHI OMILLAR	489
Xamrayev Quvvat Iskandarovich	
AGROKLAFTERLARDA ICHKI SOTISH JARAYONIDA TRANSFERT BAHOLARNI BELGILASH USULLARINI TAKOMILLASHTIRISH	495
Eshmuradov Ulug'bek Tashmuratovich	
INTERNATIONAL EXPERIENCE IN THE DEVELOPMENT OF MICE TOURISM AND ITS ADAPTATION TO THE CONDITIONS OF THE REPUBLIC OF UZBEKISTAN.....	501
Ilkhomova Gulnoza Zayniddin kizi	
MUHANDISLIK KONSTRUKSIYALARIDA MURAKKAB SIRT LARNI CHIZMA GEOMETRIYA YORDAMIDA TAHLIL QILISH.....	507
Qutbtiddinov Hikmatillo Qudratillo o'g'li	
TADBIRKORLIKNI QO'LLAB-QUVVATLASHNING ZAMONAVIY MEXANIZMLARI VA ULARNING IQTISODIY RIVOJLANISHGA TA'SIRI	512
Umarova Munira Muxitdinovna	



JINDA ARRALI SILINDR TISHLARIDAN TOLANI AJRATISH JARAYONINI HAVO OQIMI ASOSIDA OPTIMALLASHTIRUVCHI ENERGIYA TEJAMKOR QURILMANI MODELLASHTIRISH.....	516
Mirzakarimov Mirsharofiddin Mirzaabdurahimovich	
TADBIRKORLIK SUBYEKTLARI TOMONIDAN ISHLAB CHIQUARILGAN MAHSULOTLARNI XORIJGA EKSPORT QILISH MEKANIZMLARI	524
Matkarimov Anvar Tajimatovich	
MUHANDISLIK KONSTRUKSIYALARIDA MURAKKAB SIRTLARNI CHIZMA GEOMETRIYA YORDAMIDA TAHLIL QILISH	528
Qutbtiddinov Hikmatillo Qudratillo o'g'li	
SOLIQ TO'LOVCHILAR FAOLIYATINI SOLIQ NAZORATINI AMALGA OSHIRISHNING NAZARIY ASOSLARI	533
Ismailov Bobir Salomovich	
QISHLOQ XO'JALIK KORXONALARIDA KAPITAL QO'YILMALAR XUSUSIYATLARI VA ULAR AUDITINI TAKOMILLASHTIRISH	540
Baxriyev Muxiddin Sheraliyevich	
QISHLOQ XO'JALIK KORXONALARIDA ASOSIY VOSITALAR VA ULAR BUXGALTERIYA HISOBINING XUSUSIYATLARI.....	545
Fayzullayev Murodjon Nematulayevich	
O'ZBEKISTONDA KLASSTER IQTISODIYOTI: INVESTITSİYALAR, EKSPORT VA SANOAT ISHLAB CHIQUARISHINING ZAMONAVIY TENDENSIYALARI (2022-2024-YILLAR KESIMIDA).....	550
O'rinboyev Ulug'bek Otabekovich, Jabbarov Majidbek Erzodovich, Ruzmetova Gulira'no Atabekovna	
GLOBAL YASHIL IQTISODIYOT SHAROITIDA XIZMAT KO'RSATISH SOHASINI SAMARADORLIGINI BAHOLASHDA EKOLOGIK, IJTIMOY-IQTISODIY OMILLARNING TAHLILI	556
M.M.Muminova	
RAQAMLI TRANSFORMATSIYA VA SMART TURIZM SHAROITIDA TURIZM INFRATUZILMASINI RIVOJLANTIRISHNING XORIJIY TAJRIBASI VA O'ZBEKISTON ISTIQBOLLARI	565
Najmidinov Azizbek Bahrom o'g'li	
ТЕКУЩИЕ УГРОЗЫ И ВЫЗОВЫ, СВЯЗАННЫЕ С МИГРАЦИОННЫМИ КРИЗИСАМИ	571
Бегматов Хусанбек	
ELEKTRON TIJORAT SEKTORI UCHUN ONLAYN REKLAMA SAMARADORLIGINI BAHOLASH	575
Rajabova Dilbar Ixtiyor qizi	
RAQAMLI TRANSFORMATSIYA SHAROITIDA O'ZBEKISTON MEVA-SABZAVOTCHILIK SOHASIDA MAHSULOT YETISHTIRISHDAN TORTIB UNI BOZORGA CHIQUARISHGACHA BO'LGAN JARAYONDA NEYROMARKETING TEXNOLOGIYALARINI QO'LLASHNING NAZARIY VA AMALIY JIHATLARI	582
Sadiy Shukrillo Asatillo o'g'li	
YOSH TADBIRKORLAR FAOLIYATIDA INNOVATSION G'OYALARNING AMALIY AHAMIYATI	590
Ergashev Oybek Xaydaraliyevich	
ТЕХНОЛОГИЯ НЕТРАДИЦИОННОГО СБАЛАНСИРОВАННОГО КОМБИКОРМА, С ОБОГАЩЕННЫМ БЕЛКОМ И ФЕРМЕНТАМИ СОСТАВОМ ИЗ ГРИБКА PLEUROTUS OSTREATUS.....	594
Ниезов Хусан Ниез угли	
MINTAQAVIY RIVOJLANISH INDIKATOR TIZIMINING AHAMIYATI	601
Turdiyev Ulug'bek Qayumovich	
RAQAMLI IQTISODIYOT SHAROITIDA EKSPORTNI RAG'BATLANTIRISH BO'YICHA DAVLAT SIYOSATI	608
Abdug'aniyev Murodjon Shavkat o'g'li	
TO'QIMACHILIK KORXONALARINING RAQOBATBARDOSHLIGINI BOSHQARISH JARAYONI VA TIZIMI	612
Xonkeldiyeva Komilaxon Ravshanjon qizi	



SPORT SANOATINING INNOVATSION RIVOJLANISHIGA OID XORIJIY TAJRIBALAR TAHLILI.....	616
Xamraqulov Ixtiyor Baxtiyorovich	
MARKAZLASHTIRILGAN DISPETCHERLIK TIZIMIDA POEZDLAR HARAKATI XAVFSIZLIGINI TA'MINLASHDA AVTOMATLAR NAZARIYASIGA ASOSLANGAN INTEGRATSIYALASHGAN MATEMATIK MODEL.....	620
Muhiddinov Obidjon Omonjon o'g'li	
ПРОЦЕНТНЫЙ РИСК ПО КРЕДИТАМ: АНАЛИЗ, ОЦЕНКА И УПРАВЛЕНИЕ.....	627
Абдуллаев Шахобиддин Шамсиддинович	
REDUCTION OF GREENHOUSE GAS EMISSIONS: EMISSION QUOTAS OR MANDATORY CONTROL TECHNOLOGIES	633
Bobonov Doston Abdumo'min o'g'li, Qozoqboyev Jasur Abduvali o'g'li	
AYOLLAR TADBIRKORLIK FAOLIYATINI BAHOLASH METODOLOGIYASINI TAKOMILLASHTIRISH (NAMANGAN VILOYATI MISOLIDA).....	637
Raximova Moxigul Isroiljonovna	
ПОЛУЧЕНИЕ СТОМАТОЛОГИЧЕСКОГО ЦЕМЕНТА С ИСПОЛЬЗОВАНИЕМ ВОЗОБНОВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ.....	643
Арипова Мастура Хикматовна, Ташбаев Джахангир Назим угли	
МОДЕЛИРОВАНИЕ ПРОМЫШЛЕННЫХ ГОРЕЛОК И ИССЛЕДОВАНИЕ ИХ ТЕПЛОВОЙ НАГРУЗКИ	652
Ражабов Азамат Тоирович	
QISHLOQ XO'JALIK TEXNIKALARI MARKETINGI VA UNING SAMARADORLIK KO'RSATKICHLARI.....	658
Xolmirzayev Bobur Mansurovich	
ПРИМЕНЕНИЕ СУБСИДИАРНОЙ ОТВЕТСТВЕННОСТИ НА ДОСУДЕБНОЙ СТАДИИ АНКРОТСТВА: ЗАРУБЕЖНЫЙ ОПЫТ И ВОЗМОЖНОСТИ ВНЕДРЕНИЯ В УЗБЕКИСТАНЕ	663
Хамзина Динара Рашатовна	
YASHIL REKREATSION TURIZM KONSEPSIYASINI JORIY ETISHNING ILMIY-AMALIY JIHATLARI.....	669
Baxriyeva Zarina Nasimovna	
KORXONALARDA DIVERSIFIKATSIYA SIYOSATINI SHAKLLANTIRISHDA IQTISODIY MEXANIZMLARINING O'RNI	672
Mirzarayimova Feruza Zokirjon qizi, Levakov Izzatulla Nematillayevich	
QALINLIGI 2 MM BO'LGAN TASMALI LISTLARNI SOVUQ HOLATDA PROKATLASH TEXNOLOGIK JARAYONINI ISHLAB CHIQISH	679
Yusupov Abdulaziz Abdullajanovich, Saydumarov Botir Muradovich, Arslonov Asadbek G'aybulla o'g'li	
HUDUDIIY TARMOQLANGAN AVTOMOBIL YO'LLARI MUHANDISLIK INSHOOTLARI KOMPLEKSINI LOYIHALASH VA QURISH JARAYONLARINI MODELLASHTIRISH.....	682
Zikrayev Akmaljon Alimovich	
TIJORAT BANKLARI FAOLIYATIDA DAROMADLARNI OSHIRISH YO'LLARI.....	688
Ostonaqulova Gulchehraxon Muhammadyoqub qizi	
"MIKROSIMULYATSION MODELLAR" VA ULAR YORDAMIDA IQTISODIY SIYOSATGA OID QARORLARNING TADBIRKORLIK SUBYEKTLARIGA TA'SIRINI BAHOLASHDAGI AHAMIYATI.....	694
Mualliflar Pulatov Dilshod Xaqberdiyevich, Raxmonov Doniyor Ixtiyorjon o'g'li, Ortiqova Niginabonu Alisher qizi, Raxmonov Jo'rabek Hamroyevich	
MINTAQADA SANOAT KORXONALARI TUZILMAVIY KO'RSATKICHLAR TIZIMI VA TAMOIYILLARI.....	702
Jabborov Elbek Erkin o'g'li	
MOLIYAVIY REJALASHTIRISH VA TARTIBGA SOLISH	707
Sharoxmatov Abduraxim Abdulamitovich	



SMART SOATLAR YORDAMIDA BEMORLAR SALOMATLIGINI NAZORAT QILISH.....	712
Alimqulov Nurmuhammad Muqumjon o'g'li, Eraliyev Humoyun Ma'mirjon o'g'li, Madaminova Mahliyo Bahodirjon qizi	
PENSIYA JAMG'ARMASI FAOLIYATINI TARTIBGA SOLISHDA DAVLATNING ROLI	718
Sherjonov Doniyor Sapparbayevich	
TOG'-KON SANOATI KORXONALARIDA BARQAROR RIVOJLANISH IMKONIYATLARINI BAHOLASH.....	722
Karimov Ma'ruf Ixtiyorovich	
MINTAQA IQTISODIYOTINI RIVOJLANTIRISHDA ISLOM MOLIYASINING AHAMIYATI	726
Sultonov Baxtiyor Baxodirovich	
UCH FAZALI IKKI CHULG'AMLI MOYLI TRANSFORMATORLARNING ISSIQLIK HISOBINI MODELLASHTIRISH VA TADQIQ QILISH	731
Taniyev Mirzoxid Xurramovich, Bekishev Allabergen Yergashevich, Omonboyev Dilrux Nuraddin o'g'li	
ERKIN IQTISODIY ZONALARNING RIVOJLANISHI BOSQICHLARI	736
Mamadiyev Elyor Akmalovich, Sharipov K. A.	
MOLIYAVIY INKLYUZIYANING IJTIMOIIY TABAQALANISHGA TA'SIRINING NAZARIY JIHATLARI.....	740
Adashaliyev Baxtiyorjon Valisher o'g'li	
ВОПРОСЫ ТРАНСФОРМАЦИИ БУХГАЛТЕРСКОГО УЧЁТА ОСНОВНЫХ СРЕДСТВ К МЕЖДУНАРОДНЫМ СТАНДАРТАМ БУХГАЛТЕРСКОГО УЧЁТА	746
Муҳидинов Аюббек Нуритдинович	
РОЛЬ КОЛЛЕКТОРНО-ДРЕНАЖНЫХ СИСТЕМ В СЕЛЬСКОМ ХОЗЯЙСТВЕ	753
Жангабаев Данияр Мансурович, Хожамуратова Роза Тажимуратовна	
ASSESSMENT OF ESG INDICES OF PRESTIGIOUS HOTELS IN UZBEKISTAN	759
Saidova Madina Xayrullo qizi	
FISKAL SIYOSATDA MAHALLIY BYUDJETLAR MUSTAQILLIGINI OSHIRISHNING MOLIYAVIY INSTRUMENTLARI	765
Muxitdinov Sidikxo'ja Akobirxo'ja o'g'li	
TRANSFORMATSIYALASH JARAYONIDA TIJORAT BANKLARI KREDITLASH AMALIYOTINING XORIIY TAJRIBASI.....	771
Jabbarov Nodir Umirovich	
AKSIZ SOLINISHNING IJTIMOIIY-IQTISODIY TA'SIRI	775
Abdulxayeva Shaxnoza Muxammadiyevna	
O'ZBEKISTONDA QISHLOQ XO'JALIGINING IQTISODIY-STATISTIK TAHLILI VA UNI RIVOJLANTIRISH ISTIQBOLLARI	781
Shavkat Djumaniyazov	
EKISHDA CHIGITNI BIR XIL TARQATISH VA OPTIMALLASHTIRISH USULLARI.....	787
Imomov Shavkat Jaxonovich, Nuritov Ikrom Rajabovich, Babamuradov Anvar Baxtiyorovich	
KICHIK BIZNES VA XUSUSIY TADBIRKORLIKDA KOMPLEKS IQTISODIY TAHLIL TIZIMINI JORIY ETISH	790
Akbarov Akramjon Ibroximjonovich	
INNOVATION FAOLIYAT XARAJATLARINING BUXGALTYERIYA HISOB VA AUDITINI TAKOMILLASHTIRISH.....	793
Mustafoev Akbar Mustafo o'g'li	
INTELLIGENT SYSTEM FOR MONITORING AND MANAGEMENT OF THE VEGETABLE OIL REFINING PROCESS	798
Ortiqov Elbek Elmirza o'g'li	



INTELLIGENT SYSTEM FOR MONITORING AND MANAGEMENT OF THE VEGETABLE OIL REFINING PROCESS

Ortiqov Elbek Elmira o'g'li

Tashkent State Technical University

Associate Professor, PhD

Department of Automation of Production Processes

ORCID: 0009-0009-9049-2953

Abstract: This article examines the development and implementation of a system for optimal management of the multi-stage technological process of refining vegetable oils based on predictive models and virtual quality analyzers. It has been shown that traditional automatic control systems, based primarily on PID regulation, do not provide the required level of quality and energy efficiency under conditions of uncertainty in parameters, nonlinearity, and multidimensionality of the control object. An approach to building an improved management system using Model Predictive Control (MPC) methods and virtual analyzers that provide an operational assessment of product quality indicators in real-time has been proposed. The results of modeling and pilot production tests, confirming the increase in the stability of the technological regime, the quality of the final product, and the reduction of specific energy costs, are presented.

Key words: vegetable oil refining, optimal management, MPC, forecasting model, virtual analyzer, automation, product quality.

Annotatsiya: Maqolada bashoratli modellar va virtual sifat analizatorlari asosida o'simlik moylarini qayta ishlashning ko'p bosqichli texnologik jarayonini optimal boshqarish tizimini ishlab chiqish va amalga oshirish masalalari ko'rib chiqiladi. Asosan PID-rostlashga asoslangan an'anaviy avtomatik boshqaruv tizimlari parametrlarning noaniqligi, chiziqli emasligi va boshqaruv ob'ektining ko'p o'lchovliligi sharoitida talab qilinadigan sifat va energiya samaradorligini zarur darajada ta'minlamasligi ko'rsatilgan. Real vaqt rejimida mahsulot sifati ko'rsatkichlarini tezkor baholashni ta'minlaydigan Model Predictive Control (MPC) usullari va virtual analizatorlardan foydalangan holda takomillashtirilgan boshqaruv tizimini yaratishga yondashuv taklif etiladi. Modellashirish va tajriba-ishlab chiqarish sinovlari natijalari keltirilgan bo'lib, ular texnologik rejim barqarorligini, yakuniy mahsulot sifatini va o'ziga xos energiya sarfini pasayishini tasdiqlaydi.

Kalit so'zlar: o'simlik moylarini rafinatsiyalash, optimal boshqarish, MPC, bashoratlovchi model, virtual analizator, avtomatlashtirish, mahsulot sifati.

Аннотация: В статье рассматриваются вопросы разработки и реализации системы оптимального управления многостадийным технологическим процессом рафинации растительных масел на основе прогнозирующих моделей и виртуальных анализаторов качества. Показано, что традиционные системы автоматического управления, основанные преимущественно на ПИД-регулировании, не обеспечивают требуемого уровня качества и энергоэффективности в условиях неопределенности параметров, нелинейности и многомерности объекта управления. Предложен подход к построению усовершенствованной системы управления с использованием методов Model Predictive Control (MPC) и виртуальных анализаторов, обеспечивающих оперативную оценку показателей качества продукции в режиме реального времени. Приведены результаты моделирования и опытно-производственных испытаний, подтверждающие повышение стабильности технологического режима, качества конечной продукции и снижение удельных энергозатрат.

Ключевые слова: рафинация растительных масел, оптимальное управление, MPC, прогнозирующая модель, виртуальный анализатор, автоматизация, качество продукции.



INTRODUCTION

In the modern world, the oil and fat industry faces a growing demand for high-quality products, energy-saving technologies, and stable operation of production lines, taking into account the variability of raw material resources. The process of refining vegetable oils is a complex multi-stage system in which heat and mass transfer are closely intertwined with chemical, physicochemical, and hydrodynamic processes occurring in close interdependence. At any stage of refining, if the technological characteristics do not meet the standards, this will inevitably affect the properties of the finished product and the financial results of production [1-3].

In the traditional automation of refining vegetable oils, local control systems are used, most often with PID regulators designed to maintain the stability of individual quantities: temperature, reagent consumption, and level in reactors. However, such systems do not have the ability to analyze and adjust complex nonlinear relationships between process parameters, final product properties, and technological/economic factors. The control system operates reactively, which does not allow achieving optimal operating modes in the presence of interference and uncertainty [4,5].

Monitoring the quality of vegetable oils, including acid number indicators, the level of free fatty acids, phospholipids, and residual substances, presents us with specific tasks. Although laboratory analysis methods provide high accuracy, they are characterized by significant inertia. Such a shortcoming does not allow the application of the obtained results for the operational regulation of the process in dynamics, which leads to delays in making management decisions and reduces the overall effectiveness of management.

Recent years have witnessed the rapid development of Advanced Process Control (APC) systems, which actively utilize forecasting models and optimization approaches. Among APC methods, Model Predictive Control (MPC) management deserves special attention. This approach allows for the calculation of optimal control commands, taking into account not only the current state of the system, but also its future forecasts for a certain time interval. At the same time, MPC takes into account limitations that can be applied to both managed and controlled variables [6-8].

The real-time management system implemented using MPC relies on a forecasting model created based on existing experimental data. The accuracy and predictability of this model play a key role in ensuring the effectiveness of automatic control of the object.

With each cycle of the control system's operation, the following operations are performed:

- the control system receives current values of controlled parameters and recorded interference from sensors and automated systems.
- output characteristics are determined, which are an anticipatory forecast of the object's dynamics for future time intervals.
- the best set of control actions acting during the given forecast period is determined.
- in the absence of changes in the control actions compared to the current stroke, the adjustment of the control is not applied. Otherwise, management is transferred to the executive mechanism management systems.

To enhance the effectiveness of such systems, it is useful to use virtual quality analyzers. They are software systems that indirectly assess complex measurable indicators using existing data. Virtual analyzers ensure constant quality control of products and allow for the inclusion of quality indicators in the management system.

Creating and implementing a control system for refining vegetable oils using predictive models and virtual analyzers is a significant scientific and technical task with significant practical potential for the oil and fat industry.

REVIEW OF LITERATURE ON THE SUBJECT

The vegetable oil refining process is a complex, multi-stage technological system that requires continuous monitoring and precise control of key process parameters. Product quality, resource efficiency, and operational stability in oil refining are strongly dependent on the effectiveness of process control systems. Conventional control methods often fail to ensure stable performance due to process nonlinearity, multivariable interactions, time delays, and limited availability of real-time quality measurements. As a result, the development of intelligent monitoring and management systems has become a critical research direction in modern oil-processing industries.

The theoretical foundations of advanced process control are comprehensively presented in the works of Markman A. L. and Dozortsev V. M., who demonstrate that Advanced Process Control (APC) systems significantly improve stability, adaptability, and efficiency in complex industrial processes. Their studies emphasize the importance of model-based control, predictive algorithms, and integrated decision-making mechanisms, which are particularly relevant for multi-stage refining technologies characterized by strong interdependencies between technological variables.

The physicochemical principles of vegetable oil refining are thoroughly described in the fundamental work by Gunstone F. D., Harwood J. L., and Dijkstra A. J. Their research details the technological essence of degumming, neutralization, bleaching, and deodorization stages, as well as the factors affecting oil quality parameters. This knowledge forms the scientific basis for constructing reliable process models and selecting appropriate control variables within intelligent monitoring systems.

A significant contribution to the analysis of vegetable oil refining technology has been made by Samadov E.E., who conducted detailed studies of technological modes and multi-stage refining processes. His research highlights the dynamic behavior of refining systems, the influence of operating conditions on product quality, and the limitations of traditional measurement methods. These findings justify the need for intelligent systems capable of real-time monitoring and adaptive control.

An important direction in intelligent process management is the application of virtual analyzers. Samadov E.E. developed and experimentally validated virtual analysis methods for assessing refined vegetable oil quality indicators without direct laboratory measurements. His studies demonstrate that virtual analyzers enable real-time estimation of key quality parameters, thereby enhancing the responsiveness and reliability of control systems. Such tools play a central role in intelligent monitoring architectures by reducing delays in decision-making and improving overall process transparency.

The issues of modeling and optimization of edible oil refining processes were investigated by Gupta S. K. and Bhatia S., who proposed mathematical models for optimizing operating conditions. Their work shows that proper optimization of technological parameters can significantly improve product quality while reducing energy and material consumption. These approaches provide a methodological foundation for embedding predictive and optimization modules into intelligent control systems.

From an economic perspective, modern control strategies such as Economic Model Predictive Control (EMPC), developed by Grosso J. M. and Ocampo-Martinez C., offer effective tools for balancing technological performance and economic efficiency. EMPC integrates process dynamics with economic objectives, allowing industrial systems to minimize costs while maintaining product quality. This concept is particularly valuable for vegetable oil refining, where energy efficiency and raw material utilization are critical performance indicators.

Additionally, the joint work of Yusupbekov N.R. and Samadov E.E. demonstrates the successful implementation of APC systems based on virtual analyzers in industrial conditions. Their results confirm that the integration of intelligent monitoring tools with advanced control algorithms enhances process stability, improves quality management, and supports compliance with modern industrial standards.

Overall, the reviewed literature indicates that the integration of advanced process control, virtual analyzers, mathematical modeling, and economic optimization provides a strong scientific and practical basis for developing intelligent systems for monitoring and management of vegetable oil refining processes. The convergence of these approaches enables real-time quality control, improved resource efficiency, and sustainable operation of modern oil-refining facilities.

RESEARCH METHODOLOGY

The technological cycle of multi-stage refining of vegetable oils is analyzed. It includes phospholipid hydration, alkaline neutralization of unsaturated acids, washing procedures, adsorption purification, and filtration. This process is characterized by complex hydrodynamics, interaction of various phases, and rapid heat and mass transfer processes [9,10].

The research is based on the principles of a systematic approach, which is applied to the analysis and synthesis of automated systems that control complex technological processes. The work utilized mathematical models of chemical-technological processes, concepts of automatic control theory, methods for identifying dynamic systems, as well as concepts borrowed from artificial intelligence.

Modeling the neutralization dynamics of free fatty acids is based on a system of nonlinear differential equations that account for both chemical reactions and transport phenomena. The adsorption refining model takes into account the sorption characteristics, temperature, and parameters of the adsorbent.

$$\frac{dC_{FFA}}{dt} = -k(T) \cdot C_{FFA} \cdot C_{NaOH}, \quad (1)$$

where: C_{FFA} – concentration of free fatty acids, C_{NaOH} – concentration of alkaline solution, $k(T)$ – temperature-dependent reaction coefficient.

The reaction coefficient, which determines the rate of a chemical reaction, changes with temperature, and this relationship is expressed using the Arrhenius equation:



$$k(T) = k_0 \exp\left(-\frac{E_a}{RT}\right), \quad (2)$$

where: E_a – activation energy, R – universal gas constant.

Adsorption purification is modeled using Langmuir's isotherm equations that describe adsorption processes:

$$q = \frac{q_{max} \cdot K \cdot C}{1 + K \cdot C}, \quad (3)$$

where: q – amount of adsorbed substance, C – concentration of impurities, K – adsorption constant.

As a tool for assessing the quality of vegetable oils, virtual analyzers built on neuro-fuzzy models proposed by Takagi and Sugeno are used. These models input parameters such as temperature, pH level, chemical consumption, and processing time, and output the acid number and impurity concentration in the oil as a result. Their training was conducted using experimental and production data, using methods of parametric determination and improvement of parameters.

Predictive control is implemented using an MPC controller, which determines the best control signals. For this, it uses an optimization approach, minimizing the objective function. This function takes into account both the difference between the actual and specified values of the regulated parameters, and the restrictions imposed on the control actions.

$$J = \sum_{i=1}^{N_p} (y_{ref}(k+i) - y(k+i))^2 + \lambda \sum_{i=0}^{N_c} \Delta u(k+i)^2, \quad (4)$$

where: N_p – forecasting horizon, N_c – management horizon, λ – weighting factor.

MPC, based on a predictive model, represents a type of adaptive control system where self-regulating elements act as regulators. These systems are characterized by the application of an internal model that predicts the future status of the system within a given timeframe (forecasting horizon). To achieve optimal control, the system calculates a number of control values within the control horizon, striving to minimize the objective function. In practical application, only the first value of the obtained sequence is used, which is equivalent to using the long-term forecasting horizon.

Figure 1 shows the structural diagram of the control system, where the forecasting regulator plays a key role. This regulator consists of two interdependent components: a forecasting model and an optimizer (Figure 1).

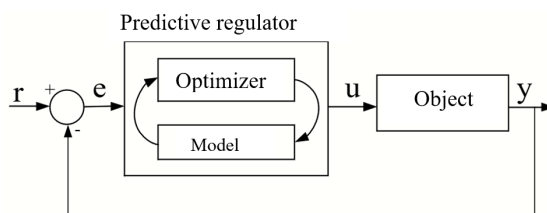


Figure 1. Block diagram of the control system with a forecasting regulator

Forecasting regulators are presented in several modifications, each of which has a unique set of characteristics. Their differences are manifested in aspects such as the applied model, model parameter setup algorithms, and optimization problem-solving algorithms.

ANALYSIS AND RESULTS

The study of current approaches to the theory and practice of real-time monitoring for objects controlled by automated systems revealed several promising directions for improving the accuracy of monitoring and forecasting.

Diagnostics, first in order, can be characterized as identifying the root causes of changes recorded during distributed parameter monitoring. Its peculiarity lies in the expansion of measurement boundaries and the complication of the process of analyzing controlled quantities at technological posts. This approach necessitates limited implementation of effective distributed monitoring and accurate diagnostics systems in earlier versions of systems responsible for optimization and operational management.

Another approach involves advanced preventive diagnostics, where independent algorithms identify defects in the early stages of their appearance at each control point. This approach allows for preventative management of the development of identified defects throughout the object's life cycle. For the effective implementation of preventive diagnostics monitoring, it is necessary to improve the methods of analysis and synthesis, as well as to increase the number of measurement and control units. The absence of the need to configure measuring transducers for signals opens the way to more advanced systems. Instead of traditional simplified systems focused on emergency protection, we can transition to distributed monitoring systems capable of predicting and preventing malfunctions [11].

The modern architecture of systems that track the technological processes of refining vegetable oils and fats, as shown in Figure 2, includes a number of interconnected components. These include local systems responsible for control and management, operational dispatch platforms (MES, ERP, EAM), the core of the automated technological process control system (ATPCS), data visualization systems, real-time information storage facilities, and programmable input-output controllers (Figure 2).

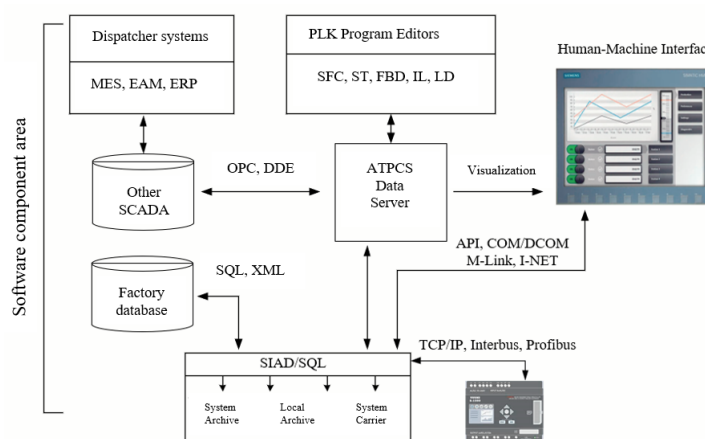


Figure 2. Generalized architecture of distributed monitoring systems for technological processes and production

The development of distributed monitoring software is not critical for computational resources, however, it is necessary to adhere to the parameters on a real time scale, ensuring reliability and accessibility. Information, which makes the selection of components and their interaction algorithms open during the integration of system components.

Figure 3 shows the dynamics of pH during neutralization and change in acid number using various control strategies (Figure 3).

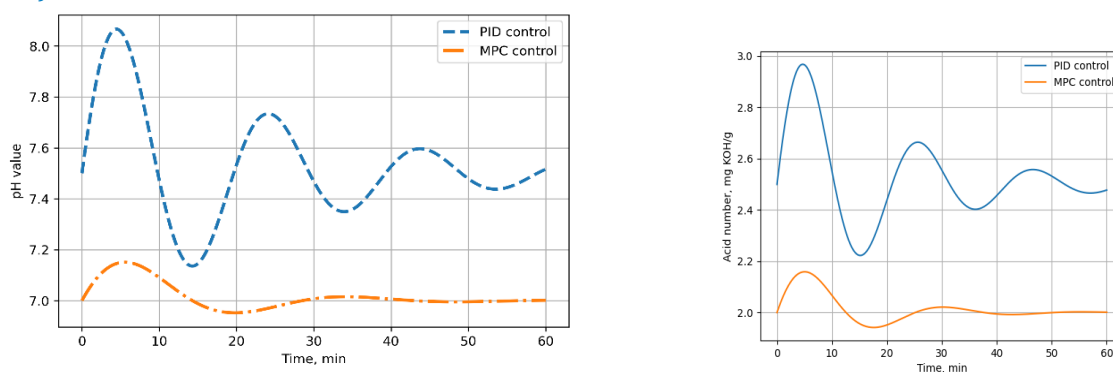


Figure 3. pH dynamics in the neutralization process and acid number under PID and MPC control

Mathematical models and numerical calculations confirmed the effectiveness of the optimal control system based on predictive models for refining vegetable oils. Using such a system made it possible to significantly increase the dynamic and static parameters of this process. Among the results achieved are: reduction of the change in the acid number of the finished product, enhancement of the stability of the technological cycle, and reduction of the duration of transient phases.

The practice of applying mathematical models of virtual analyzers mainly reduces to the use of regression equations. Although this approach has its own time costs, a significant drawback is the possibility of the



constructed model not corresponding to the object being studied by the time it is completed. The modeling process includes the stage of statistical data analysis and subsequent selection of regression methodology, culminating in obtaining finite regression functions. This model is applicable only within certain limits of the object's functioning. Any significant change in the properties of the modeled object requires adjustments to the model used, which entails a repeated, labor-intensive process of its development.

Virtual analyzers, as a rule, are integrated into systems designed to improve management efficiency. Thanks to them, it is possible, in the shortest possible time, with partial automation, to conduct an analysis of the object under study, determine the cause-and-effect relationships, identify zones for optimization, and implement the found solutions in the form of recommendations or regulators. Later, the model is adjusted online or offline based on its own accuracy indicators and data obtained from a virtual analyzer, as well as laboratory tests. When creating a large-scale ATPCS complex, the key point is the consistent implementation of each stage based on the analysis of statistical indicators and comparison with the current management system. To conduct such an analysis, it is effective to use the Proficy CSense software from GE Intelligent Platforms. The successful completion of the analysis, confirming its effectiveness, opens the way for the implementation of the next stage, which ultimately contributes to improving the performance of the optimal management system [12].

The introduction of virtual analyzers has ensured constant monitoring of product quality, replacing traditional laboratory methods. Thanks to this, it was possible to adjust the neutralization and adsorption parameters more precisely, which led to a reduction in the consumption of alkaline reagents and adsorbents.

The virtual analyzer can be integrated into the automated technological process control system (ATPCS) or operate autonomously, acting as an intelligent component of the control system. Usually, this is a software-algorithmic system capable of extracting important information from existing data, determining patterns in the dynamics of ongoing processes, and displaying them graphically on the displays of operational personnel (Figure 4).

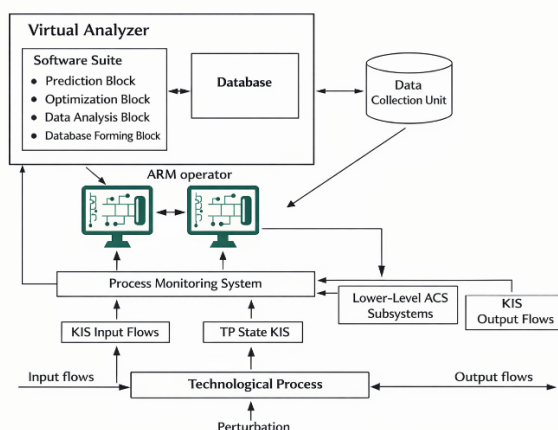


Figure 4. Diagram of interaction between the technological process, ATPCS and virtual analyzer

In this regard, its functionality is available on any network machine that has the ability to receive data on the current state of the TP, online analyzers, and laboratory measurements of material flows.

Figure 5 shows a comparison of the alkali reagent flow rate under different control algorithms (Figure 5).

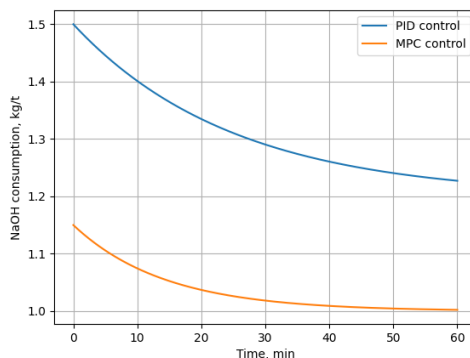


Figure 5. Comparison of NaOH consumption under PID and MPC control

Intelligent virtual analyzers additionally extract information from knowledge bases. Such databases can exist as classical databases or act as information repositories where technological experience is accumulated in multidimensional data. It can be implemented in various ways, combining different approaches. For example, it can be constructed using a multidimensional thematic data window that will function as a superstructure over the relational base [13-15].

Practical tests conducted under industrial production conditions have shown that the mathematical models and predictive control algorithm operate accurately and effectively. As a result, it was possible to reduce energy consumption per unit of product and improve the quality stability of the resulting refined oil (Figure 6).

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^N (y_i - \hat{y}_i)^2} \leq 5\%$$

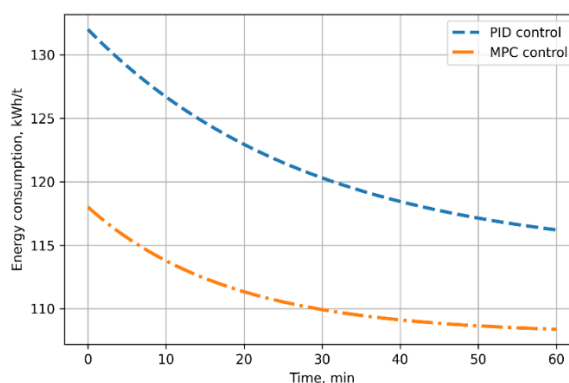


Figure 6. Energy consumption with different management strategies

During the pilot production tests, a reduction in the consumption of the alkaline reagent by 8-12% due to more precise dosing, as well as a reduction in specific energy consumption by 6-9%, was recorded.

The application of optimal control systems based on predictive models in the process of refining vegetable oils demonstrates a high degree of efficiency. This method, unlike outdated regulating systems, allows for comprehensive consideration of the interdependencies between various parameters of the technological process and the properties of the final product.

The use of virtual analyzers plays a key role in implementing distributed quality monitoring online. This approach allows for the prompt detection of deviations in the technological process and the introduction of corrective measures, preventing the emergence of defective products.

The implementation of such systems is justified, as the achieved results, such as improving product quality and reducing operating costs, justify the costs. It is important to understand that for successful implementation, a well-developed measurement base and reliable data for accurate model identification are required. The application of the MPC method demonstrates high efficiency in conditions where raw material markets and external factors are subject to fluctuations, which is a typical feature of the oil and fat industry.

CONCLUSIONS AND SUGGESTIONS

The study made it possible to create and confirm the effectiveness of a control system for refining vegetable oils, which is based on predictive models and virtual quality control systems. The application of MPC algorithms and intelligent data processing approaches contributes to increasing the stability of the technological cycle, improving the characteristics of the final product, and optimizing the use of material and energy resources.

The obtained results can be used in the design and modernization of automated control systems for technological processes in the oil and fat industry and related industries.

List of used literature:

1. Camacho E. F., Bordons C. Model Predictive Control. London: Springer-Verlag, 2013. - 405 p. DOI: 10.1007/978-1-4471-2338-3
2. Samadov E.E. Developing advanced process control system for manufacturing processes using virtual analyzer // Journal Chemical Technology, Control and Management: -№4. -2021: DOI: <https://doi.org/10.51346/tstu-02.21.6-77-0053>
3. Samadov E.E. Instrumental and analytical implementation of a virtual analysis of the output product quality - refined vegetable oil // Special issue of the International scientific and technical "Chemical Technology, Control and Management". -№4-5(106-107). -2022. -PP.183-187. (05.00.00, №12, Scopus, Решение БАК №471 от 30.09.2022).



4. Markman A. L., Dozortsev V. M. Системы усовершенствованного управления технологическими процессами. Москва: ИКЦ «Академкнига», 2015. -412 с.
5. Gunstone F. D., Harwood J. L., Dijkstra A. J. The Lipid Handbook. 3rd ed. Boca Raton: CRC Press, 2007. - 888 p.
6. Samadov E.E. Analysis of vegetable oil refining technology // Chemical Technology, Control and Management: №1, -2023: PP.18-26. DOI: <https://doi.org/10.59048/2181-1105.1443>.
7. Gupta S. K., Bhatia S. Modeling and optimization of edible oil refining process. Journal of Food Engineering, 2007, Vol. 79, No. 1, pp. 112-119.
8. Grosso J. M., Ocampo-Martinez C. Economic MPC for industrial processes. Journal of Process Control, 2014, Vol. 24, No. 8, pp. 1200-1211.
9. Samadov E.E. Study of technological multi-stage modes of refining vegetable oils // Chemical Technology, Control and Management: №5, -2023. - PP.17-21.
10. Юсупбеков Н.Р., Самадов Э.Э. Создание APC-усовершенствованной системы управления с использованием виртуального анализатора // «Проблемы государственной системы технического регулирования национальной инфраструктуры качества в преодолении технических барьеров в международной торговле и ее актуальные научные и практические вопросы» Октябрь 14, 2021 г. - Ташкент, 2021. -С. 11-17.
11. Yusupbekov N.R., Samadov E.E. Improving the technology of neutralization of free fatty acids in the production of vegetable oils // VII international scientific conference. "Development of science in the XXI century". Dortmund, Germany. 03-04.08.2023. 70 p. DOI: <https://doi.org/10.5281/zenodo.8229312>
12. Yusupbekov N.R., Samadov E.E. Improvement of vegetable oil refining processes // VII international scientific conference. "Development of science in the XXI century". Dortmund, Germany. 03-04.08.2023. 70 p. DOI: <https://doi.org/10.5281/zenodo.8229312>
13. Yusupbekov N.R., Avazov Yu.Sh., Samadov E.E. O'simlik moylarini rafinatsiyalash jarayonida o'simlik moyi mahsulot sifatining kislotali sonini nazorat qilish uchun dasturiy ta'minot // EHM uchun yaratilgan dasturning rasmiy ro'yxatdan o'tkazilganligi to'g'risidagi guvohnoma. DGU 28030, 13.10.2023y.
14. Yusupbekov Nadirbek, Avazov Yusuf, Samadov Elyor, Khojiyeva Nasiba, Shodiev Marufjon, Bazarbaev Qabilbek. Study of the technological process of vegetable oil refining as an object of monitoring, control and management // 4th International Conference on Advances in Science, Engineering, and Digital Education, ASEDEU 2024, DOI: 10.1063/5.0257158
15. Shukhrat Gulyamov, Yusuf Avazov, Elyor Samadov, Khojiyeva Nasiba, Bazarbaev Qabilbek. Some issues of increasing energy efficiency of advanced process and production control systems // AIP Conf. Proc. 3331, 060009 (2025) <https://doi.org/10.1063/5.0305712>

muhandislik **& iqtisodiyot**

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

Ingliz tili muharriri: Feruz Hakimov

Musahhih: Zokir Alibekov

Sahifalovchi va dizayner: Iskandar Islomov

2025. № 12

© Materiallar ko'chirib bosilganda "Muhandislik va iqtisodiyot" jurnali manba sifatida ko'rsatilishi shart. Jurnalda bosilgan material va reklamalardagi dalillarning aniqligiga mualliflar ma'sul. Tahririyat fikri har vaqt ham mualliflar fikriga mos kelamasligi mumkin. Tahririyatga yuborilgan materiallar qaytarilmaydi.

"Muhandislik va iqtisodiyot" jurnali 26.06.2023-yildan
O'zbekiston Respublikasi Prezidenti Adminstratsiyasi huzuridagi
Axborot va ommaviy kommunikatsiyalar agentligi tomonidan
№S-5669245 reyestr raqami tartibi bo'yicha ro'yxatdan o'tkazilgan.
Litsenziya raqami: №095310.

**Manzilimiz: Toshkent shahri Yunusobod
tumani 15-mavze 19-uy**





+998 93 718 40 07



<https://muhandislik-iqtisodiyot.uz/index.php/journal>



t.me/yait_2100