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CONFERENCE ON INTERNATIONAL SCIENTIFIC DEVELOPMENTS: INSIGHTS INTO MODERN SCIENCE AND INNOVATIVE PRACTICES

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TABLE OF CONTENTS

1.	**Гелдибаев Бегенч Егендурдыевич**, ОБЗОР ИССЛЕДОВАНИЙ VISION-LANGUAGE MODELS ДЛЯ ЗАДАЧ ВИЗУАЛЬНОГО РАСПОЗНАВАНИЯ	**5**
2.	**Ergashov Ziyodullo Bobir og'li**, O‘ZBEKISTON HUDUDIDA QADIMGI SIVILIZATSIYALARNING SHAKLLANISHI	**10**
3.	**L.K. Jamolova, H.Sh.Sharifov**, FACTORS AFFECTING THE EFFICIENCY OF SOLAR PANELS	**15**
4.	**X.R. G‘afforov**, DIAGNOSIS OF THE LEVEL OF FORMATION OF PROFESSIONAL COMPETENCIES OF STUDENTS OF TECHNICAL HIGHER EDUCATION INSTITUTIONS	**18**
5.	**Sag‘dullayeva Zuhra Ne’matulla qizi**, KOMPENSATSIYAVIY YONDASHUV ASOSIDA OLIY TA’LIM MUASSASALARIDA FRANSUZ TILINI O‘QITISH METODIKASI	**22**
6.	**Astanakulov Ulugbek Khusanovich**, PEDAGOGICAL APPROACHES TO TEACHING WRITING IN EFL: A COMPARATIVE THEORETICAL ANALYSIS	**28**
7.	**Нуруллаева Фарангиз Толибжон кизи**, КОГНИТИВНО-СЕМАНТИЧЕСКИЕ МЕХАНИЗМЫ КОНЦЕПТУАЛЬНОЙ МЕТАФОРЫ В СОВРЕМЕННОМ РУССКОМ ЯЗЫКЕ	**32**
8.	**Zikirullayeva Nilufar Dilmurod kizi**, THE IMPORTANCE OF GREEN ECONOMY IN WORLD ECONOMIC DEVELOPMENT	**35**
9.	**Mansurova Rayxona Adham qizi, S. Chimpo‘latova**, XX ASR MISR ADABIYOTINING YIRIK NAMOYANDASI YOZUVCHI YAHYO HAQQINING HAYOTI VA IJODI	**40**
10.	**Abdiqodirova O'g`iloy Abdirayim qizi**, RAQAMLI TA’LIM TEXNOLOGIYALARI YORDAMIDA TALABALARDA MUSTAQIL TA’LIM KO‘NIKMALARINI RIVOJLANTIRISHNING PEDAGOGIK ASOSLARI	**44**
11.	**Kodirova Dilfuza**, SATIRICAL ELEMENTS IN THE POLITICAL AND SOCIAL CRITICISM OF JONATHAN SWIFT	**49**
12.	**Meliyeva Sevara Faxriddin qizi**, THE CONNOTATIVE FIELD OF SUBSTANDARD UNITS IN UZBEK AND ENGLISH	**52**
13.	**Муратбаева Азиза Даулетбаевна**, СПОСОБЫ И МОДЕЛИ ОККАЗИОНАЛЬНЫХ ПРЕОБРАЗОВАНИЙ В ПЕРИОДИЧЕСКОЙ ПЕЧАТИ	**57**
14.	**Rustamov Akbar Askarovich**, TAKING INTO ACCOUNT THE AGE-RELATED CHARACTERISTICS OF 6–7-YEAR-OLD CHILDREN IN THE PROCESS OF INDIVIDUALIZED CHESS INSTRUCTION	**62**
15.	**Махамадалиева Н.Р., Хамидуллаева Ф.И., Бабаджанова Н.Т.**, ЦИТОКИНОВЫЙ ПРОФИЛЬ СМЕШАННОЙ СЛЮНЫ КАК МАРКЕР РИСКА РАЗВИТИЯ ГИНГИВИТА У ПОДРОСТКОВ ПОСЛЕ ПЕРЕНЕСЁННОЙ COVID-19 ИНФЕКЦИИ	**70**

16.	**Salimov Nurali Ramazon o`g`li**, O‘ZBEKISTONDA SUN`IY INTELLEKT TEXNOLOGIYALARIDAN FOYDALANGAN HOLDA KIBERXAVFSIZLIKNI RIVOJLANTIRISH ISTIQBOLLARI	**73**
17.	**Muxammedova Dilshoda Nodir qizi**, PUBLITSISTIK USLUBDA QO‘LLANUVCHI TOPONIMIK PERIFRAZALARNING SINONIMIK XUSUSIYATLARI	**78**
18.	**Safoyev Nodirjon Nematjon o‘g‘li**, O‘ZBEK TILIDAGI AVTOMATIK TARJIMA SIFATINI OSHIRISH UCHUN TAKOMILLASHTIRILGAN BERT YONDASHUVLARI	**84**
19.	**Mustafayeva Matlubaxon Ilhomjon qizi**, SPECIFIC FEATURES OF IDIOMS IN ENGLISH AND RUSSIAN LITERARY TEXTS	**88**
20.	**Умаров Бобурбек Носир угли, Жураев Ахтам Хамроевич**, ИССЛЕДОВАНИЕ ОСНОВНЫХ ПОКАЗАТЕЛЕЙ ВЕРМИКУЛИТА В КАЧЕСТВЕ АДСОРБЕНТА	**93**
21.	**Нуров С.С., Мусаев А.Х.**, МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ГАЗОПЕРЕКАЧИВАЮЩЕГО АГРЕГАТА ДЛЯ СИНТЕЗА СИСТЕМЫ АВТОМАТИЧЕСКОГО УПРАВЛЕНИЯ В СРЕДЕ MATLAB/SIMULINK	**95**
22.	**Nazarov Alimardan Kamol o’g’li**, OTA-ONA VA O‘SMIR MUNOSABATLARINI O’GANISHGA OID METODIKALARINING ILMIY ASOSLARI	**100**
23.	**Hamidova Nozima Sirojiddin qizi, Temirova Matlab Ibodovna**, ISHLATILGAN O‘SIMLIK YOG‘LARINI QAYTA ISHLASH ORQALI QO‘SHIMCHA QIYMATLI MAHSULOTLAR OLISHNING TEXNOLOGIK IMKONIYATLARI	**102**
24.	**Azamat Orunbayev**, THE EFFECTS OF AEROBIC-STEP AND PILATES EXERCISES ON STRENGTH, FLEXIBILITY, ANAEROBIC POWER, BALANCE, AND BODY COMPOSITION	**106**
25.	**Saminbayev Mashhurbek Ravshanbek o‘g‘li, Qobulov Boburmirzo Ulug‘bek o‘g‘li**, ANIME YOSHLAR DUNYOQARASHIDA O‘LIM VA HAYOT FALSAFASINING TRANSFORMATSIYASI	**112**
26.	**Yuldasheva Sevara Bakhodir kizi**, THE SPECIFIC FEATURES OF THE OGHUZ LANGUAGE IN WRITTEN MONUMENTS OF THE 11TH-12TH CENTURIES	**116**
27.	**Журакулов Санжар**, КРИТЕРИИ И ПОКАЗАТЕЛИ ОЦЕНКИ ЭФФЕКТИВНОСТИ САМОСТОЯТЕЛЬНОГО ОБУЧЕНИЯ ФИЗИКЕ СТУДЕНТОВ ТЕХНИЧЕСКИХ НАПРАВЛЕНИЙ НА ОСНОВЕ ЦИФРОВЫХ ТЕХНОЛОГИЙ	**121**
28.	**Yuldoshov Elchinbek Qosim ugli, Khayitov A.A.**, DISPENSARY EXAMINATION FOR ENT DISEASES	**124**
29.	**Nuraliyev Islom Saidaliyevich**, BO‘LAJAK O‘QITUVCHILARDA TESTOLOGIK KOMPETENTLIKNI RIVOJLANTIRISHNING AMALIY HOLATI VA XORIJIY TAJRIBANING QIYOSIY-PEDAGOGIK TAHLILI	**129**
30.	**Qazoqov Jo‘rabek Roziqovich, Uvayzov Saidjon Komilovich, Mizomov Muhammad Saydulla o`g`li**, OPERATOR INTERFEYSLARINI ISHLAB CHIQISHDA ERGONOMIK YONDASHUVLAR	**135**

31.	**Maxkamova Xilolaxon Xasanxon qizi**, FORUM FOCUSED INSTROCTION IN COMUNICATIVE ENGLISH CLASSES: BENEFITS AND LIMITATIONS	**139**
32.	**Boboyeva Zebo Hasanovna**, OLIY TA'LIM TIZIMIDA PEDAGOGIK MADANIYATNI SHAKLLANTIRISHNING INNOVATSION YONDASHUVLARI	**142**
33.	**Yarasheva Dilnoza Ismoil qizi**, METHODOLOGY FOR DETERMINING FLEXIBILITY IN FEMALE HANDBALL PLAYERS	**147**
34.	**Serikbayeva Dina Altinbayeva**, BOSHLANG‘ICH SINFLARDA MATEMATIK TAFAKKURNI RIVOJLANTIRISHDA INNOVATSION YONDASHUVLAR	**151**
35.	**Atamurodova Guljon Komilovna, Abdullayeva Maryambibi Jumaniyazovna**, TALABALARDA IJTIMOIY FAOLLIKNI INNOVATSION PEDAGOGIK TEXNOLOGIYALAR ASOSIDA RIVOJLANTIRISHNING METODIKASI	**155**
36.	**Abdullayva Mohlaroyim Nodirbek qizi, Rustamova Fotima Umidjon qizi, Rustamova Zuhra Umidjon qizi**, THE INFLUENCE OF DIET ON OVULATORY FUNCTION IN WOMEN AFTER OVARIAN CAUTERIZATION: A LITERATURE REVIEW	**159**
37.	**Kuchkarov Anvarbek Shermirzayevich**, SCIENTIFIC AND PEDAGOGICAL FOUNDATIONS FOR IMPROVING PHYSICAL EDUCATION AND SPORTS PEDAGOGY IN THE CONTEXT OF DIGITAL TRANSFORMATION	**163**
38.	**Ne’matjonov Turg‘unpo‘lat Shokirjon o‘g‘li**, ANALYSIS OF HISTORICAL TOPONYMS IN THE BABURNAMA	**168**
39.	**Mamatov Axadbek**, BUXORO VOHASIDA NAQSHBANDIYLIK TA'LIMOTINING SHAKLLANISH BOSQICHLARI	**171**
40.	**To‘rayeva Charosxon Shavkat qizi**, MAKTABGACHA YOSHDAGI BOLALARNING INTELLEKTUAL RIVOJLANISHIDA MONTESSORI METODIKASINING SAMARADORLIGI	**177**
41.	**Tosheva Kamola Komiljon qizi**, TRAINING LOAD PLANNING FOR HIGHLY SKILLED FEMALE WEIGHTLIFTERS	**183**
42.	**Khamraeva Zamira, Razhabov Rustam, Khovaylo Vladimir**, MAGNETIC PROPERTIES AND ELECTRICAL RESISTIVITY OF FE(NI)-MN-AL MELT-SPUN RIBBONS	**189**
43.	**Sirojev Shoxrux Fayzullo o‘g‘li**, THE ROLE OF VOLLEYBALL IN DEVELOPING PHYSICAL AND PSYCHOLOGICAL READINESS	**191**
44.	**Otabek Turlibekov , Oliy Akhmedov , Avazbek Taniberdiyev**, SYNTHESIS, PROPERTIES AND POTENTIAL APPLICATIONS OF QUATERNARY AMMONIUM DERIVATIVES OF CHITOSAN OBTAINED FROM PLEUROTUS OSTREATUS	**194**
45.	**Курамбаева Дилафруз Шаукатовна**, ОБРАЗ УМАЙ В МИФОЛОГИЧЕСКИХ ПРЕДСТАВЛЕНИЯХ КАРАКАЛПАКОВ	**202**
46.	**Keldibekov Jahongir Vali o'g'li**, XOSMAS INTEGRALLAR KONVERGENTLIGINING YANGI SHARTLARI HAMDA ULARNING DIFFERENSIAL TENGLAMALAR MODELLARIGA TATBIQI	**207**

47.	**Sharipov J.R.**, BILATERAL VERTEBRAL ARTERY HEMODYNAMIC RESPONSE IN ARTERIAL HYPERTENSION COMPLICATED BY ISCHEMIC HEART DISEASE	**212**
48.	**N.B. Saidmurodova , G.U. Lutfullaev**, MICROBIOLOGICAL CHARACTERISTICS OF THE NASAL MUCOSA IN PATIENTS WITH CHRONIC SUBATROPHIC RHINITIS ASSOCIATED WITH TYPE 2 DIABETES MELLITUS	**215**
49.	**Narbayeva Sofiya Murod qizi**, SUN'IY INTELLEKTGA ASOSLANGAN PEDAGOGIK TEXNOLOGIYALAR ORQALI OLIY TA'LIMDA TALABALARNING AKADEMIK MUVAFFAQIYATINI OSHIRISH	**225**
50.	**Sattarova Muhabbat Alijanovna**, DEVELOPING THE CREATIVE POTENTIAL OF STUDENTS IN PEDAGOGY PROGRAMS	**230**
51.	**Sattarova Muhabbat Alijanovna**, MENTORSHIP MODEL FOR WORKING WITH GIFTED STUDENTS	**232**
52.	**Sattarova Muhabbat Alijanovna**, STRUCTURAL COMPONENTS OF AN INNOVATIVE PEDAGOGICAL MODEL	**235**
53.	**Sodiqova Vazira Yaxyoqul qizi**, CURVATURE CORRESPONDING TO A SQUARE: DEFINITION AND GEOMETRIC MEANING	**237**
54.	**Xoldarova Dilfuza Komiljon qizi**, MUAMMOLI TA’LIM ASOSIDA KOGNITIV VA METAKOGNITIV O‘ZLASHTIRISH TEXNOLOGIYALARINING O‘ZIGA XOS JIHATLARI	**240**
55.	**Dusmurodova Muhayyo Faxritdin qizi**, TA’LIM JARAYONIDA SHAXSIYLASHTIRILGAN O‘QITISH ORQALI SHAXS RIVOJLANISHINI TA’MINLASH USULLARI	**247**
56.	**Jumaboyev Azizjon Sayfiddin o‘g’li**, SAMARQAND O‘LKASHUNOSLIK JAMIYATLARI FAOLIYATIDA MADANIY MEROSNI ASRASH MUAMMOLARI (XX ASRNING 20–80-YILLARI)	**253**
57.	**Файзиев М.М.**, МАТЕМАТИК РЕЖАЛАШТИРИШ АСОСИДА МАРКАЗДАН ҚОЧМА КУЧ ТАЪСИРИДА ЮҚОРИ ЭКСПЛУАТАЦИОН ХУСУСИЯТЛАРГА ЭГА БЎЛГАН АНИЗОТРОП СТРУКТУРАЛИ ЦИЛИНДРСИМОН ФИЛЬТРЛАР ОЛИШ ТЕХНОЛОГИЯСИНИНГ ОПТИМАЛ ПАРАМЕТРЛАРИНИ АНИҚЛАШ	**256**
58.	**Бабажанова Навбахор**, “ПСИХОЛОГИЧЕСКАЯ ПРИРОДА ОБРАЗА «ЛИШНЕГО ЧЕЛОВЕКА” В РОМАНЕ И. С. ТУРГЕНЕВА “ДНЕВНИК ЛИШНЕГО ЧЕЛОВЕКА”	**260**
59.	**Абдурахимова Зарнигора Бахтийор кизи, Абдураимова Н.Р.**, РОЛЬ ОБРАЗОВАНИЯ И ПРОФЕССИОНАЛЬНОЙ ПЕРЕПОДГОТОВКИ ЖЕНЩИН В УСЛОВИЯХ РАЗВИТИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА	**262**
60.	**Sultonov Bobirxon Muhammadxonovich**, FUQAROLIK HUQUQIDA MAJBURIYATLARNING BAJARILISHINI TA'MINLASHNING O'ZIGA XOS XUSUSIYATLARI	**267**
61.	**Akramov Ibrohimjon Oxunjon o‘g‘li**, OILAVIY MUNOSABATLARDA TENG HUQUQLILIK PRINSIPI HUQUQIY MAZMUNI	**270**

62.	**М.М. Файзиев**, ПЛАСТМАССА МАҲСУЛОТЛАРИНИ ИШЛАБ ЧИҚАРИШ ЖАРАЁНИДА МОЙДАН ҚАТТИҚ ЗАРРАЧАЛАРНИ АЖРАТИБ ОЛИШ УЧУН ФИЛЬТР ЭЛЕМЕНТЛАРИНИ ОЛИШ ТЕХНОЛОГИЯСИ	**274**
63.	**Turaev Ahmed Kholmominovich**, DIRECTIONS THAT INFLUENCE THE FORMATION OF TESTOLOGICAL COMPETENCE	**277**
64.	**Ixtiyor G‘aniyevich Jalilov**, THE HISTORICAL EXPERIENCE OF THE MAHALLA INSTITUTION AND PUBLIC OVERSIGHT IN SOUTHERN UZBEKISTAN	**280**
65.	**Ixtiyor G‘aniyevich Jalilov**, FACTORS INFLUENCING THE DEVELOPMENT OF FAMILY ENTREPRENEURSHIP IN THE MAHALLAS OF SOUTHERN UZBEKISTAN	**285**
66.	**Yuldashev G‘ulomjon, Qosimov Bekzod Ulug‘bek o‘g‘li**, KARKIDON SUV OMBORI ATROFI TUPROQ PROFILIDA TUZLAR REJIMI VA MIKROELEMENTLARNING RADIAL-LATERAL DIFFERENSIATSIYASI	**289**
67.	**Kamol Akbarov,** KARKIDON SUV OMBORI ATROFI TUPROQ PROFILIDA TUZLAR REJIMI VA MIKROELEMENTLARNING RADIAL-LATERAL DIFFERENSIATSIYASI	**295**
68.	**Jo’rabekova Gulshoda,** KOGNITIV USLUBNING YOSHGA BOG’LIQ XUSUSIYATLARI	**298**
69.	**Sharobiddinova Gulshodaxon Rustamjon qizi,** IKKI O’LCHOVLI SIMPLEKSDAGI ALMASHTIRILGAN VOLTERRA OPERATORLARINING DINAMIKASI HAQIDA	**301**
70.	**Аминова Моҳирахон Мўминжон қизи,** СОЗДАНИЕ ХИМИЧЕСКИХ ПРЕПАРАТОВ ДЛЯ ЗАЩИТЫ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КУЛЬТУР НА ОСНОВЕ ПРОМЫШЛЕННЫХ ОТХОДОВ И ИХ ПРИМЕНЕНИЕ	**304**
71.	**Rakhmanova Nozimakhon Ibrokhimjon qizi,** NATIONAL-CULTURAL UNITS IN ENGLISH AND UZBEK: A CROSS-LEVEL COMPARATIVE ANALYSIS OF THEIR SEMANTIC, LINGUOCULTURAL, AND PRAGMATIC FEATURES ABSTRACT	**307**
72.	**Dehqonova Shahnoza Anvar qizi,** MAKTABGACHA TA’LIM TASHKILOTI RAHBARINING BOSHQARUV KOMPETENSIYASINI RIVOJLANTIRISH: ZAMONAVIY YONDASHUVLAR VA SAMARALI MEXANIZMLAR	**320**
73.	**Feruz Yuldashev,** ENTREPRENEURIAL DEVELOPMENT OF HIGHER EDUCATION INSTITUTIONS IN UZBEKISTAN: COMPARATIVE EVIDENCE FROM PUBLIC AND PRIVATE UNIVERSITIES	**325**
74.	**Nurullayev Mirxon Muhammadovich,** AGENTLI SUN’IY INTELLEKT TIZIMLARIDA AXBOROT OQIMI XAVFSIZLIGIGA TAHDIDLAR TASNIFI VA HIMOYALASH USULLARINING QIYOSIY TAHLILI	**329**
75.	**Soibov Johongir Ergash o`g`li,** HUDUDIY ISHLAB CHIQARISH MAJMUALARINI SAMARALI ENERGIYA BILAN TA'MINLASH SXEMALARINI TANLASH MASALALARI	**335**

76.	**Shukurova Ozoda Odil qizi,** RAQAMLI PLATFORMALARDA XIZMAT KO‘RSATISH SHARTNOMALARINING ELEKTRON SHAKLI VA UNI TASDIQLASH MUAMMOLARI	**337**
77.	**Qosimov Oybek Abdumannon o‘g‘li,** PAST INERSIYALI ENERGIYA TIZIMLARIDA GIBRID SHAMOL-QUYOSH ELEKTR STANSIYALARINING CHASTOTA BARQARORLIGIGA TA’SIRINI BAHOLASH	**341**
78.	**Teshaboyev Rivojiddin Ibrohimjon o‘g‘li,** KUCH TRANSFORMATORLARIDA ENERGIYA ISROFLARI VA ULARNI KAMAYTIRISH USULLARI	**346**
79.	**Ergasheva Zilola Ko‘paysin qizi,** MUSIQIY-DIDAKTIK O‘YINLAR VOSITASIDA MAKTABGACHA YOSHDAGI BOLALARNING MUSIQIY QOBILIYATLARINI RIVOJLANTIRISH METODIKASI	**348**
80.	**To`lqinova Gulsanam Bahtiyor qizi,** TEMIR-BETON KONSTRUKSIYALARNING ZILZILABARDOSHLIGINI OSHIRISHNING ZAMONAVIY, AMALIY USULLARI	**354**
81.	**To‘xtaraliyev Sohibjon Murodjon o‘g‘li, Xolmatov Dilshod Sottorjonovich,** TEXNOLOGIK CHANG XOSSALARINI TAVSIFLASH VA CHANG TOZALASH QURILMASI SINOVLARINI METODIK ASOSLASH	**358**
82.	**G`oziyev Islomjon Ravshanovich, N.N.Umaraliyev,** GAZ GENERATORI REAKSIYA ZONASIDAGI HARORATNI MASOFADAN O‘LCHASH VA MONITORING QILISH TIZIMINI YARATISH	**362**
83.	**Xudoynazarova Nodira Shaydullayevna,** O‘ZBEKISTONDA HUDUDIY (SHAHAR VA QISHLOQ) AYOLLARINING TADBIRKORLIK IDENTIKLIGI VA MOTIVATSION SOHASI QIYOSIY TAHLILI	**366**
84.	**Бобобекова Шохисита Хоззиржон кизи,** МЕТОДИЧЕСКИЕ ОСНОВЫ ПЕРСОНАЛИЗАЦИИ ОБУЧЕНИЯ В ЦИФРОВОЙ ОБРАЗОВАТЕЛЬНОЙ СРЕДЕ ОБЩЕОБРАЗОВАТЕЛЬНОЙ ШКОЛЫ	**369**
85.	**Berdiyorova Mohira Nurali qizi,** MAHALLIY MINERAL QO‘SHIMCHALAR ASOSIDA GIPS BOG‘LOVCHILARINING FIZIK-MEXANIK XOSSALARINI YAXSHILASH	**376**
86.	**Ashurova Sevara Ilxom qizi,** UMUMIY O‘RTA TA’LIM MAKTABLARIDA O‘QUVCHI-QIZLAR O‘RTASIDA VOLEYBOL SPORT TURINI OMMALASHTIRISHNING PEDAGOGIK SHART-SHAROITLARINI TAKOMILLASHTIRISH	**383**
87.	**Muradova Shodiya Zokir qizi,** CHO‘LPON HIKOYALARIDA AYOLLAR ERKI G‘OYALARI («NOVVOY QIZ» VA «QOR QO‘YNIDA LOLA» HIKOYALARI ASOSIDA)	**388**
88.	**Norboyeva Farangiz Alisher qizi,** BOSHLANG‘ICH SINF O‘QUVCHILARINING NUTQIY FAOLLIGINI RIVOJLANTIRISHDA NUTQNI TANISH TEXNOLOGIYALARIDAN FOYDALANISH METODIKASI	**391**
89.	**Orifjanov Shavkatbek Shuxratbek o’g’li,** TEXNOLOGIK JARAYONLARDA NOSOZLIKLARNI SUN’IY INTELLEKT ASOSIDA OLDINDAN PROGNOZLASH USULLARI	**397**

90.	**Khaydarova Ziyodaxon Azimjon qizi,** AN IMPLICIT UPWIND DIFFERENCE SCHEME FOR THE BOUNDARY CONTROL PROBLEM OF HYPERBOLIC SYSTEMS	**402**
91.	**Boynazarova Munojat,** BO‘LAJAK BOSHLANG‘ICH TA’LIM PEDAGOGLARINI TAYYORLASHDA INTEGRATIV YONDASHUVNING XORIJIY TAJRIBA BILAN UYG‘UNLASHUV IMKONIYATLARI	**405**
92.	**Qosimov Fazliddin,** ENERGETIKA TIZIMLARI VA MAJMUAlARINING BARQAROR RIVOJLANISHIDA RAQAMLI BOSHQARUV VA MOSLASHUVCHAN ENERGIYA MAJMUAlARINING O‘RNI	**412**
93.	**T.B.Xakimov,** IKKILAMCHI ISSIQLIKNI ELEKTR ENERGIYASIGA AYLANTIRUVCHI SAMARALI TERMOELEKTROGENERATORLAR	**420**
94.	**Shukurova Saida Qudratovna,** YOSHLAR TARBIYASI SAMARADORLIGINI OSHIRISHDA OILA, MAHALLA VA TA’LIM MUASSASASI HAMKORLIGINING PEDAGOGIK MEXANIZMLARI	**424**
95.	**Yo'ldoshev Otabek,** BETON VA ASFALT ZAVODLARIDA DOZALASH JARAYONLARINI PLC VA SCADA ASOSIDA AVTOMATLASHTIRISH	**432**
96.	**Baxshilloyev Habibulloxon Umarovich,** XAVFSIZLIK HODISALARINI TAHLIL QILISH VA XAVFNI BAHOLASH USULLARINING ZAMONAVIY HOLATI	**437**
97.	**Berdiyorova Mohira Nurali qizi,** MAHALLIY XOMASHYOLAR VA MODIFIKATSIYALANGAN GIPS BOG'LOVCHILARI ASOSIDA G'OVAKLI NAMLIKKA CHIDAMLI DEVORBOP MATERIALLAR TARKIBINI VA TEXNOLOGIYASINI ISHLAB CHIQISH	**442**
98.	**Rasulova Oygul Salom qizi,** VIRUSLAR EVOLUTSIYASI VA MUTATSIYALARINING YANGI INFEKSION KASALLIKLAR PAYDO BO'LISHIDAGI AHAMIYATI	**448**
99.	**Namazova Luiza Zavqi qizi,** INNOVATSION PEDAGOGIK TEXNOLOGIYALAR ORQALI O'QUVCHILARNING MUSTAQIL FIKRLASHINI RIVOJLANTIRISH	**453**
100.	**Jo'rayeva Yoqutxon A'zamxo'ja qizi,** BOLALAR INTENSIV TERAPIYASIDA MARKAZIY VENOZ KATETERIZATSIYANI UTT-NAVIGATSIYASI OSTIDA BAJARISH: ASORATLAR PROFILAKTIKASI VA GEMODINAMIK KO'RSATKICHLAR MONITORINGI	**459**
101.	**Urazova Azadaxan Tursinbayevna,** TOG‘AY MUROD QISSALARIDA MIF VA AFSONALAR TALQINI.	**465**
102.	**Iroda Berdiyorova Shuhrat qizi,** KOREA'S UNI-PASS ELECTRONIC CUSTOMS AND SINGLE WINDOW: RECOMMENDATIONS FOR UZBEKISTAN	**468**
103.	**Xudayberdiyeva O'g'iloy Hasan qizi,** CHANGLANISHNING FOTOELEKTRIK MODULLAR ENERGIYA ISHLAB CHIQARISHIGA TA'SIRI VA O'ZBEKISTON SHAROITIDA TOZALASH STRATEGIYALARI	**472**

CHANGLANISHNING FOTOELEKTRIK MODULLAR ENERGIYA ISHLAB CHIQARISHIGA TA'SIRI VA O'ZBEKISTON SHAROITIDA TOZALASH STRATEGIYALARI

Xudayberdiyeva O'g'iloy Hasan qizi

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Annotatsiya. Tezisda fotoelektrik modullar yuzasining changlanishi (soiling) ularning energiya ishlab chiqarishiga qanday ta'sir qilishi xalqaro va O'zbekistonda bajarilgan tadqiqotlar asosida ko'rib chiqiladi. Changlanish ba'zi sharoitlarda energiya yo'qotilishini kuniga 1% dan ortiq qilishi, tozalash optimallashtirilganda ham global miqyosda quyosh energiyasi ishlab chiqarilishini kamida 3–4% ga kamaytirishi va yiliga kamida 3–5 mlrd yevro daromad yo'qotilishiga olib kelishi ko'rsatiladi. O'zbekiston sharoiti uchun modellashtirish natijalariga ko'ra chang yuklamasi 0,1 g/m² dan 80 g/m² gacha ortganda samaradorlik taxminan 16% dan 4% gacha pasayadi. Tozalash strategiyalarini texnik-iqtisodiy asoslash va mahalliy sharoitda changlanish yo'qotishlarini o'lchash bo'yicha tadqiqot rejasi taklif etiladi. Tezisda muallifning o'z eksperimental ma'lumotlari keltirilmagan.

Kirish

Changlanish – fotoelektrik (FE) modullar yuzasida chang va boshqa ifloslantiruvchi moddalarning to'planishi bo'lib, u modulga tushayotgan nurlanishni kamaytiradi va ishlab chiqarilayotgan energiyani pasaytiradi. Sarver va hammualliflarining sharhida changlanish ko'pincha e'tibordan chetda qoladigan yoki kam baholanadigan, lekin quyoshga boy hududlarda qurilmani samarasiz qilib qo'yishi mumkin bo'lgan muammo sifatida tavsiflangan; sharh taxminan yetmish yillik texnik tarixni va chang hamda chang-namlik aralash sharoitlarini qamrab olgan [1].

O'zbekiston iqlimi kontinental bo'lib, yozda kunduzgi harorat 48 °C gacha yetishi mumkin, yog'in miqdori markaziy cho'llarda taxminan 100 mm ni tashkil etadi va, ayniqsa janubda, biroz kamayish tendensiyasiga ega [2]. Bu sharoit modullarning yuzasida chang to'planishini tabiiy yog'in bilan tozalanishdan sustroq qilishi mumkin (muallifning mulohazasi). Tezisning maqsadi – changlanishning FE modullar

energiya ishlab chiqarishiga ta'sirini adabiyot ma'lumotlari asosida ko'rib chiqish va O'zbekiston sharoitida tekshirish rejasini taklif etish.

1. Changlanish jarayoni va uning ta'sir mexanizmi

Ilse va hammualliflari changlanish yorug'likni yutish va qaytarish orqali modulga tushayotgan nurlanishni kamaytirishini, changlanishga ko'plab o'zaro ta'sir qiluvchi omillar ta'sir qilishini va bu omillar joydan joyga sezilarli farqlanishini ko'rsatadi; ayniqsa chang ko'p bo'lgan quruq va yarim quruq hududlarda changlanish quyosh energiyasi ishlab chiqarishini sezilarli kamaytiradi [3]. Shu sababli bir hudud uchun olingan natijani boshqa hududga to'g'ridan-to'g'ri qo'llash mumkin emas (muallifning mulohazasi).

Maghami va hammualliflari changlanishdan quvvat yo'qotishni «yumshoq» va «qattiq» soyalanish deb ikki turga ajratadi: yumshoq soyalanish (masalan, havo ifloslanishi) modul beradigan tokka ta'sir qiladi, kuchlanish esa deyarli o'zgarmaydi; qattiq soyalanish (to'planib qolgan chang) esa nurni to'sadi va uning ta'siri hujayralarning bir qismi yoki hammasi soyalanganiga bog'liq: qisman soyalanishda chiqish kuchlanishi kamayadi, ammo soyalanmagan hujayralar baribir quvvat beradi [4]. Mualliflar shuningdek changlanishning oldini olish uchun bir nechta tozalash usullarini ko'rib chiqadi [4].

Changlanishni baholashda ikki jihatni ajratib ko'rish foydali (muallifning mulohazasi): birinchisi – yuzada to'plangan chang miqdori (masalan, g/m² hisobida), ikkinchisi – uning natijasida yuzaga keladigan optik va elektr yo'qotishlar (nur o'tkazuvchanligi, tok, quvvat). Ushbu tezisda ko'rib chiqilgan O'zbekiston bo'yicha tadqiqotlar aynan chang yuklamasi bilan samaradorlik yoki quvvat o'rtasidagi bog'liqlikka tayanadi [5; 6], global baholar esa energiya yo'qotilishining ulushi va moliyaviy oqibatlariga e'tibor qaratadi [7].

2. Changlanish yo'qotishlarining miqdoriy baholari

Ilse va hammualliflarining texnik-iqtisodiy tahliliga ko'ra, tozalash optimallashtirilganda ham changlanish hozirgi vaqtda global quyosh energiyasi ishlab chiqarilishini kamida 3–4% ga kamaytiradi, bu yiliga kamida 3–5 mlrd yevro daromad yo'qotilishiga teng; 2023-yilga kelib bu ko'rsatkich 4–7% gacha,

yo'qotishlar esa yiliga 4–7 mlrd yevrodan oshishi mumkinligi taxmin qilingan [7]. Mualliflar changlanish ba'zi hollarda qurilmani iqtisodiy jihatdan samarasiz qilishi, tozalash xarajatlari esa ishlab chiqarilayotgan energiya narxini oshirishi mumkinligini ham ta'kidlaydi [7]. Boshqa sharhda energiya yo'qotilishi ayrim sharoitlarda kuniga 1% dan ham oshishi mumkinligi qayd etilgan [3]. Natijalar 1-jadvalda umumlashtirilgan.

Keltirilgan ko'rsatkichlarni to'g'ridan-to'g'ri solishtirish mumkin emas, chunki ular turli birliklarda berilgan: global baholar [7] yillik energiya ishlab chiqarishidagi ulush sifatida, kunlik yo'qotish [3] vaqt birligiga nisbatan, O'zbekiston bo'yicha model natijalari [5; 6] esa chang yuklamasiga bog'liq holda berilgan (muallifning mulohazasi). Shu sababli mahalliy sharoit uchun yillik energiya yo'qotilishini aniqlash uchun dala o'lchovlari zarur.

1-jadval. Changlanish yo'qotishlari bo'yicha adabiyot ma'lumotlari

Ob'ekt / baholash	Asosiy natija	Manba
Global baho (texnik-iqtisodiy tahlil)	Optimallashtirilgan tozalashda ham kamida 3–4%; kamida 3–5 mlrd yevro/yil; 2023-yilga kelib 4–7%	[7]
Changlanish jarayonlari (sharh)	Yo'qotish ayrim sharoitlarda kuniga 1% dan oshishi mumkin	[3]
Modellashtirish (Matlab/Simulink), O'zbekiston	0,1 g/m² da samaradorlik ≈ 16%; 80 g/m² da ≈ 4%	[5]
Simulyatsiya, Toshkent	10 g/m² da optik o'tkazuvchanlik ≈ 30% gacha; quvvat ≈ 130 W dan < 50 W gacha	[6]

Izoh: jadval ko'rsatilgan manbalar asosida muallif tomonidan tuzilgan; O'zbekiston bo'yicha natijalar model asosidagi.

3. O'zbekiston sharoitidagi tadqiqotlar

Safarov va Rakhmatov Matlab/Simulink modelida chang yuklamasining FE panel samaradorligiga ta'sirini o'rgangan: yuzada taxminan 0,1 g/m² chang bo'lganda samaradorlik taxminan 16% ga yetgan, 80 g/m² chang yuklamasida esa taxminan 4% gacha pasaygan; mualliflar changdan tozalash va sovutish o'zgaruvchan iqlim sharoitida energetik samaradorlikni taxminan 20–30% ga oshirishi mumkinligini

baholagan [5]. Toshov va hammualliflari Toshkent sharoiti uchun simulyatsiya qilib, chang yuklamasi ortganda optik o'tkazuvchanlik keskin pasayishini (10 g/m² da taxminan 30% gacha), maksimal quvvat taxminan 130 W dan kuchli changlanishda 50 W dan pastga tushishini va kunlik ishlab chiqarish egri chizig'i tekislanishini aniqlagan [6]. Ikkala tadqiqot ham model natijalari bo'lgani uchun dala o'lchovlari bilan tasdiqlanishi lozim.

Ikki tadqiqotdagi raqamlar bir-biriga mos kelmasligi ham mumkin: biri samaradorlikni (16% dan 4% gacha) [5], ikkinchisi maksimal quvvatni (≈ 130 W dan 50 W dan pastgacha) [6] baholagan va ular turli modul modellari va chang yuklamalari uchun hisoblangan. Ammo ikkalasi ham bir xil xulosaga olib keladi: chang yuklamasi ortishi bilan energetik ko'rsatkichlar keskin pasayadi va toza yuzani saqlash zarur [5; 6].

4. Tozalash strategiyalari va tavsiyalar

Changlanish yo'qotishlarini kamaytirish ikki yo'l bilan amalga oshiriladi: yuzani tozalash va changning to'planishini kamaytiruvchi chora-tadbirlar. Ilse va hammualliflari tozalash xarajatlarini ham, innovatsion qoplama materiallari kabi yumshatish usullarini ham texnik-iqtisodiy jihatdan baholaydi [7]; Maghami va hammualliflari esa chang to'planishining oldini olish uchun turli tozalash usullarini ko'rib chiqadi [4]. Tozalashning maqbul chastotasi tozalash xarajati bilan changlanishdan yo'qotilgan daromad o'rtasidagi muvozanatga bog'liq (muallifning mulohazasi).

Tozalash chastotasi texnik-iqtisodiy jihatdan asoslanishi kerak: Ilse va hammualliflari tozalash xarajatlari ishlab chiqarilayotgan energiya narxini oshirishi va mavjud hamda yangi yumshatish usullari (jumladan, innovatsion qoplama materiallari) texnik-iqtisodiy baholanishini ko'rsatadi [7]. Shu asosda quyidagilarni taklif etish mumkin (muallifning mulohazalari): birinchidan, tozalash jadvalini mavsumga va hududdagi yog'in miqdoriga qarab belgilash [2; 7]; ikkinchidan, changlanish yo'qotishlarini doimiy kuzatib borish uchun toza va changlangan modullarni parallel o'lchash [3]; uchinchidan, tozalash usulini tanlashda uning modul yuzasiga ta'sirini va iqtisodiy samarasini hisobga olish [4; 7].

5. Tadqiqot rejasi

O'zbekistonning quruq hududida changlanish yo'qotishlarini aniqlash uchun quyidagi reja taklif etiladi (bu bosqichlar rejalashtirilgan, natijalar olinmagan): (1) bir xil turdagi ikki guruh modulni o'rnatish: biri muntazam tozalanadigan, ikkinchisi tabiiy changlanadigan; (2) ikkala guruhning chiqish quvvati va tok-kuchlanish tavsifini, nurlanish va modul haroratini bir vaqtda qayd etish; (3) yuzadagi chang yuklamasini (g/m^2) vaqti-vaqti bilan o'lchash, chunki mahalliy modellarda aynan shu ko'rsatkichdan foydalanilgan [5; 6]; (4) toza va changlangan modullar quvvati nisbati orqali changlanish yo'qotishini hisoblash; (5) yo'qotishlarni yog'in va shamol ma'lumotlari bilan bog'lash [2]; (6) tozalashning iqtisodiy samarasini baholash [7]. Harorat ta'sirini changlanishdan ajratish uchun modul haroratini ham o'lchash kerak [6].

Kutilayotgan natija – O'zbekistonning quruq hududi uchun changlanish tufayli yillik va mavsumiy energiya yo'qotishining miqdoriy bahosi hamda tozalash jadvalini asoslash uchun ma'lumotlar. Ushbu natijalar faqat o'lchovlar o'tkazilgandan keyin tasdiqlanishi mumkin; hozircha ular ishchi gipoteza darajasida qoladi: chang yuklamasi ortishi bilan yo'qotish ortadi [5; 6], yog'insiz davr uzayishi esa bu ta'sirni kuchaytirishi mumkin (muallifning gipotezasi).

Xulosa

Adabiyot ma'lumotlari changlanish FE modullar energiya ishlab chiqarishini sezilarli kamaytirishini ko'rsatadi: global miqyosda optimallashtirilgan tozalashda ham 3–4% dan kam bo'lmagan yo'qotish, O'zbekiston sharoiti uchun model natijalariga ko'ra esa chang yuklamasi ortishi bilan samaradorlikning keskin pasayishi. Biroq O'zbekiston uchun mavjud ma'lumotlar asosan modellashtirishga tayanadi, shu sababli dala o'lchovlari va tozalashning iqtisodiy asoslanishi bo'yicha tadqiqotlar zarur. Taklif etilgan reja shu masalani hal etishga qaratilgan.

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