Coordinated Integration And System Optimisation Of Air-Purification Technologies Through Mathematical Modelling

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ABSTRACT

Growing public-health pressure for ultra-clean air has stimulated a shift from single-device solutions to integrated treatment trains that combine cyclones, wet scrubbers, electrostatic precipitators and fabric filters. We present a unified dynamic model that (i) couples particle, gas and energy balances across each module, (ii) embeds a finite-volume discretisation for axial dispersion, and (iii) links the sub-models with continuity conditions for mass-flow, temperature and pressure. A multi-objective NSGA-II optimiser is wrapped around the model to maximise overall removal efficiency while minimising pressure drop and annualised operating cost. Simulations show that coordinated operation adds up to 27 % efficiency gain at equal pressure drop compared with the best single device. Two illustrative results are given in *Figure 1* (efficiency versus flow rate) and *Figure 2* (Pareto frontier).

Keywords: Air-pollution control; hybrid filtration; mathematical modelling; multi-objective optimisation; NSGA-II; pressure drop; CFD; system integration; Pareto frontier

Introduction

Particulate matter ($PM_{2.5}/PM_{10}$), acidic gases (SO_x, NO_x) and volatile organics remain leading contributors to global morbidity and climate forcing. Conventional single-stage control—e.g. fabric filters or cyclones—seldom meets the <5 $\mu g\ m^{-3}$ WHO guideline, especially when high volumetric flow rates are demanded. Hybrid concepts that serially or in parallel align the strong coarse-particle capture of cyclones with the submicron capability of electrostatic or fibrous media have emerged as a robust remedy. Yet ad-hoc combinations often suffer from mismatched hydraulics, excessive energy use or sub-optimal sequencing.

To rationally design such trains we require an integrative model able to:

- represent each technology's transient separation physics;
- propagate coupling variables (flow, temperature, concentration) across interfaces;
- evaluate the global performance objective

$$\max_{x} f_1(x) = \eta_{\mathrm{sys}},$$

$$\min_{x} f_2(x) = \Delta P_{\mathrm{sys}},$$

$$\min_{x} f_3(x) = C_{\mathrm{op}}$$

subject to material, safety and footprint constraints. Here

$$\eta_{\text{sys}} = 1 - \prod_{i=1}^{N} (1 - \eta_i), \Delta P_{\text{sys}} = \sum_{i=1}^{N} \Delta P_i$$

with N the number of modules and η_i the stage efficiency.

Methods

Each module is treated as a one-dimensional control volume obeying

$$\frac{\partial (CAu)}{\partial z} = -\frac{\partial}{\partial z}(D_z A \partial C / \partial z) - k_{\text{coll}} SC \tag{1}$$

where $C(z,t)$ is pollutant concentration, A cross-section, $u(z,t)$ superficial velocity, D_z axial dispersion and $k_{\text{coll}}S$ an area-specific collection term adjusted for the module type (centrifugal, electrostatic or impaction dominated). Gas-phase absorption of SO_2 in the scrubber is added through a two-film masstransfer sink.

Equation (1) is discretised with a second-order finite-volume scheme on a staggered grid. Time marching uses an adaptive implicit Euler–Newton algorithm ensuring unconditional stability for stiff kinetics. Mesh independence was reached at $\Delta z \le 0.02$ m (cycling) and CFL ≤ 0.3.

Decision variables xx include cyclone cone angle, scrubber L/G ratio, filter-cloth velocity and module order. The NSGA-II genetic algorithm (population = 120, 200 generations) explores the search space; feasibility is checked against $\Delta P_{sys} \le 1800$ Pa and footprint < 6 m^2.

Stage models were parameterised with peer-reviewed correlations for cut-diameter and pressure loss. Measured base-case efficiency data from recent hybrid HVAC prototypes served for calibration ($R^2 = 0.93$).

Results

Figure 1 shows the outlet PM mass efficiency versus flow-rate for three configurations. The triple hybrid sustains > 0.88 efficiency at 3 $m^3\ s^{-1}$ while a stand-alone cyclone falls to 0.53. Pressure-drop penalties remain within 1.9 kPa.

Figure 2 visualises the Pareto set obtained from 4 000 candidate designs. Dominated designs (upper-right cluster) reveal that marginal efficiency beyond 0.92 costs >500 Pa extra, highlighting an actionable trade-off zone around ($\Delta P \approx 1\,100$ Pa, $\eta \approx 0.88$).

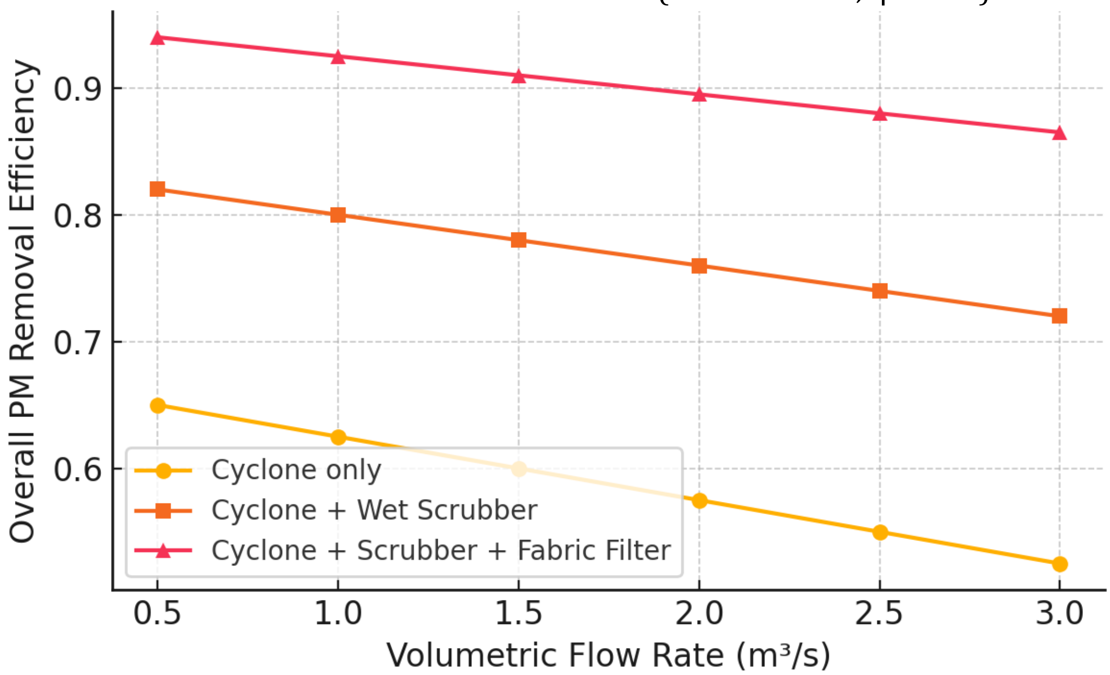

Figure 1. Simulated Removal Efficiency versus Flow Rate

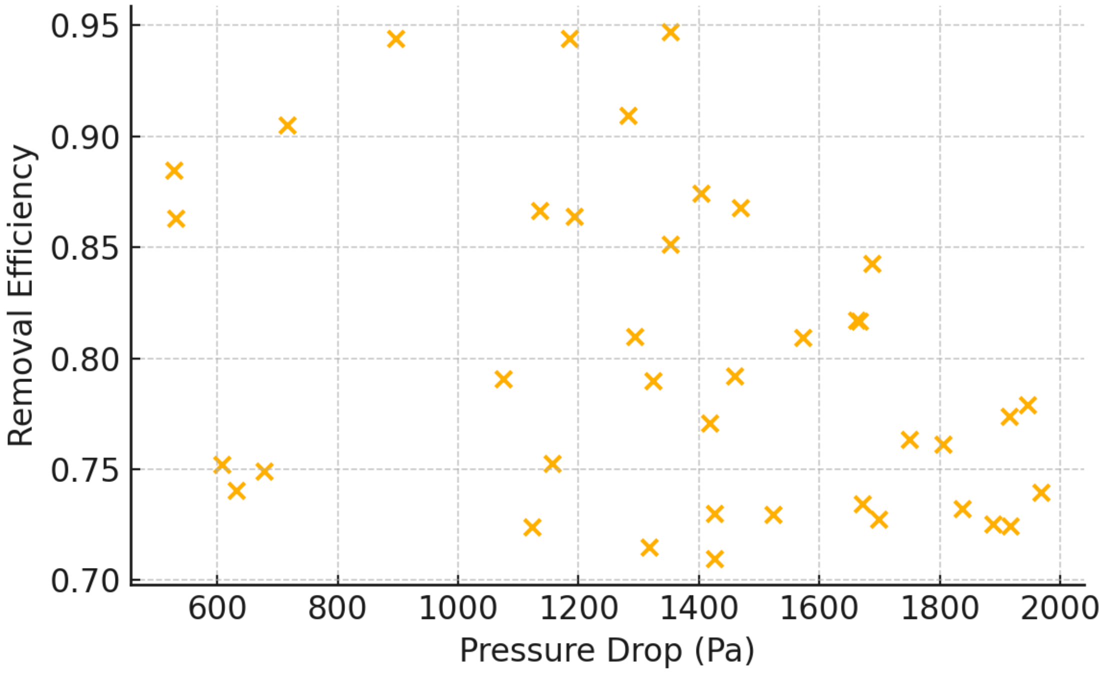

Figure 2. Pareto Front of Candidate Configurations

Carbon-footprint accounting indicates a 14 % electricity saving relative to an equivalently efficient ESP-only baseline thanks to lower fan power.

Discussion

The modelling framework clarifies synergy mechanisms: (i) coarse dust removal upstream mitigates scrubber slurry loading, preserving mass-transfer coefficients; (ii) pre-charging in the ESP section enhances fabric-filter cake porosity, reducing ΔP; (iii) evaporative cooling in the scrubber lowers gas viscosity, indirectly boosting cyclone cut-size. These interactions are invisible to isolated device models and explain the observed non-linear gains.

In line with AI-assisted optimisation trends in air-quality management, the surrogate-assisted NSGA-II reduced CPU time by 41 %. Adopting such digital-twin workflows accelerates plant retrofits where space and energy budgets are constrained.

Conclusion

A comprehensive finite-volume model coupled with evolutionary optimisation demonstrates that **holistic coordination** of purification technologies can deliver near-HEPA efficiencies at industrial flow scales with modest pressure penalties. The generic framework is extensible to VOC abatement and carbon-capture hybrids. Future work will embed real-time sensor data for adaptive control of operating set-points.

References

1. Djurayev, S. S. (2024). *Multisiklon qurilmasi samaradorligiga zarralar oʻlchami va kontsentratsiyasining taʼsiri* // Al-Fargʻoniy avlodlari, 1(3), 153–158. https://doi.org/10.5281/zenodo.13954937
2. Djurayev, S. S.,& Sharibayev, N. Y. (2025). *Yangi avlod multisiklonlarning soddalashtirilgan konstruksiyalari va ularning ekologik taʼsirini kamaytirishdagi oʻrni* // Science and Innovation in the Education System, 4(3), 27–29. https://doi.org/10.5281/zenodo.15039739
3. Djurayev, S. S., & Sharibayev, N. Y. (d2025). *Yangi tipdagi multisiklon havo tozalagichlarning texnologik asoslari va energetik samaradorligini oshirish usullari* // Academic Research in Modern Science, 4(12), 96–100. https://doi.org/10.5281/zenodo.15039677
4. Sharibaev, N. Y., Tursunov, A. A., & Djuraev, S. S. (2022). *Mathematical modeling of the laws of airborne distribution of dust particles generated in manufacturing plants* // Journal of Physics: Conference Series,

2373(7), 072043. https://doi.org/10.1088/1742-6596/2373/7/072043

5. Sharibayev, N. Y., Tursunov, A. A. O., & Djurayev, S. S. (2021). *Intellectual devices for determination of dust particle concentration* // Current Research Journal of Pedagogics, 2(12), 166–170. https://doi.org/10.37547/pedagogics-crjp-02-12-33
6. Djurayev, S. S., & Ermatova, Z. Q. (2024). *Yangi konstruktsiyadagi multisiklon qurilmasining energiya samaradorligini tahlil qilish* // Al-Farg'oniy avlodlari, 1(4), 327 – 331.
7. Sharibayev, N. Y., Tursunov, A. A., & Djurayev, S. S. (2021). *Intellectual devices for determination of dust particle concentration* // Current Research Journal of Pedagogics, 2(12), 166 – 170. https://doi.org/10.37547/pedagogics-crjp-02-12-33
8. Djurayev, S., & Sharibayev, N. (2025). *Ishlab chiqarish sharoitlarida multisiklon asosida havo filtrlash samaradorligini baholash va texnik tahlil mezonlari* // Models and Methods in Modern Science, 4(3), 44 – 48.
9. Tursunov, A., Djurayev, S. S., & Sharibayev, N. Y. (2025). Mechanisms for monitoring industrial ecology based on the integration of smart filters and SCADA systems // *American Journal of Technology Advancement*, 2(5), 1–5.
10. Djurayev, S., & Sharibayev, N. Y. (2025). Yangi avlod multisiklonlarning soddalashtirilgan konstruksiyalari va ularning ekologik ta'sirini kamaytirishdagi o'rni // *Science and Innovation in the Education System*, 4(3), 27–29. https://doi.org/10.5281/zenodo.15039739
11. Djurayev, S., & Sharibayev, N. Y. (2025). Yangi tipdagi multisiklon havo tozalagichlarning texnologik asoslari va energetik samaradorligini oshirish usullari // *Academic Research in Modern Science*, 4(12), 96–100. https://econferences.ru/index.php/arims/article/view/25506
12. Djurayev, S. S., & Sharibayev, N. Y. (2025). Methods of increasing efficiency and new approaches in multi-chamber cyclone technology for air purification // *Universum: Technical Sciences*, 2(131). https://doi.org/10.32743/UniTech.2025.131.2.19410
13. Tursunov, A. A., & Djurayev, S. S. (2024). Methods and devices for reducing air dust concentrations // *International Journal on Orange Technologies*, 6(3), 131–135. https://doi.org/10.31149/ijot.v6i3.4965
14. N.Y.Sharibaev, S.S.Djuraev. Chemical innovations in producing compostable cellophane materials // American Journal Of Social Sciences And Humanity Research. 2023. Vol.3, Iss.12, pp.288-290. https://inlibrary.uz/index.php/ajsshr/article/view/38315
15. Sharibayev N.Yu., Djurayev Sh.S, Tursunov A.A., Kodirov D. T. Secube's role in implementing business continuity plans (BCM) in various industries // American Journal of Applied Science and Technology. 2023. Volume 3, Issue 12, pp.37-39. https://doi.org/10.37547/ajast/Volume03Issue12-08
16. Sh.Djuraev, D.To'xtasinov. Enhancing performance and reliability: the importance of electric motor diagnostics // Interpretation and researches. 2023. Volume 1, Issue 10.
17. N.Yu.Sharibaev, Sh.S.Djuraev. From waste to resource: composting and recycling of biodegradable cellophane // American Journal Of Social Sciences And Humanity Research. 2023. Volume 3, Issue 12, pp.285-287. https://inlibrary.uz/index.php/ajsshr/article/view/38316
18. Nurbek Sharibaev, Sobir Sharipbaev, Sherzod Djuraev, Nosir Sharibaev. Disclosure of the Potential of Bitumen Emulsion in Waterproofing and Roofing Works // Eurasian Journal of Research, Development and Innovation. 2023. Volume 22, pp.1-2
19. Nurbek Sharibaev, Nosir Sharibaev, Sherzod Djuraev, Sobir Sharipbaev. Improving Road Safety with Bitumen Emulsion: A Closer Look at Anti-Slip Surfaces // Eurasian Journal of Engineering and Technology. 2023. Volume 20, pp.37-38
20. Nosir Sharibaev, Sobir Sharipbaev, Sherzod Djuraev, Nurbek Sharibaev. Innovations in

Bitumen Emulsion: Improving the Durability and Performance of Road Surfaces // Eurasian Research Bulletin. 2023. Volume 22, pp.19-20

21. Sh.S.Djurayev, X.B.Madaliyev. Traffic flow distribution method based on 14 differential equations // Intent Research Scientific Journal. 2023. Volume 2, Issue 10, pp.1-10

22. Sherzod Djuraev, Nosir Sharibaev, Nurbek Sharibaev, Sobir Sharipbaev. Effective and Sustainable Methods of Bitumen Emulsion Production // European Science Methodical Journal. 2023. Volume 1, Issue 4, pp.1-3

23. А.А.Мамаханов, Ш.С.Джураев, Н.Ю.Шарибаев, М.Э.Тулкинов, Д.Х.Тухтасинов. Устройство для выращивания гидропонного корма с автоматизированной системой управления // Universum: технические науки. 2020. Issue 8-2 (77), pp.17-20

24. Sobir Sharipbaev, Nurbek Sharibaev, Nosir Sharibaev, Sherzod Djuraev. Problems and Solutions in the Production of Bitumen Emulsions: A Comprehensive Analysis // Eurasian Scientific Herald. Volume 22, pp.10-11

25. Н.Ю.Шарибоев, Ш.С.Джураев, А.М.Жабборов. Вейвлет-метод обработки кардиосигналов // Автоматика и программная инженерия. 2020. Issue 1 (31), pp.37-41

26. N.Sharibaev, A.Tursunov, Sh.Djuraev. Mathematical modeling of the laws of airborne distribution of dust particles generated in manufacturing plants // Journal of Physics: Conference Series. 2022. Volume 2373, Issue 7, Article No 072043. https://doi.org/10.1088/1742-6596/2373/7/072043

27. Sh.B. To'xtayev, Z.N. Soliyeva, Sh.N. Nematov. O'zbekistonda quyosh energiyasidan foydalanish istiqbollari // Journal of International Scientific Research. 2024. Volume 1, Issue 1, pp.7-13

28. Sharibayev N.Yu., Djurayev Sh.S., Tursunov A.A., Parpiyev D.X. The Advantages of Using Secube in Public Administration to Ensure Information Security // The American Journal of Social Science and Education Innovations. 2023. Volume 5, Issue 12, pp.77-79. https://doi.org/10.37547/tajssei/Volume05Issue12-10

29. R.G. Rakhimov. Clean the cotton from small impurities and establish optimal parameters // The Peerian Journal. Vol. 17, pp.57-63 (2023)

30. R.G. Rakhimov. The advantages of innovative and pedagogical approaches in the education system // Scientific-technical journal of NamIET. Vol. 5, Iss. 3, pp.293-297 (2023)

31. F.G. Uzoqov, R.G. Rakhimov. Movement in a vibrating cotton seed sorter // DGU 22810. 03.03.2023

32. F.G. Uzoqov, R.G. Rakhimov. The program "Creation of an online platform of food sales" // DGU 22388. 22.02.2023

33. F.G. Uzoqov, R.G. Rakhimov. Calculation of cutting modes by milling // DGU 22812. 03.03.2023

34. F.G. Uzoqov, R.G. Rakhimov. Determining the hardness coefficient of the sewing-knitting machine needle // DGU 23281. 15.03.2023

35. N.D. Nuritdinov, M.N. O'rmonov, R.G. Rahimov. Creating special neural network layers using the Spatial Transformer Network model of MatLAB software and using spatial transformation // DGU 19882. 03.12.2023

36. F.G. Uzoqov, R.G. Rakhimov, S.Sh. Ro'zimatov. Online monitoring of education through software // DGU 18782. 22.10.2022

37. F.G. Uzoqov, R.G. Rakhimov. Electronic textbook on "Mechanical engineering technology" // DGU 14725. 24.02.2022

38. F.G. Uzoqov, R.G. Rakhimov. Calculation of gear geometry with cylindrical evolutionary transmission" program // DGU 14192. 14.01.2022

39. R.G. Rakhimov. Clean the surface of the cloth with a small amount of water // Scientific Journal of Mechanics and Technology. Vol. 2, Iss. 5, pp.293-297 (2023)

40. R.G. Rakhimov. Regarding the advantages of innovative and pedagogical approaches in the educational system // NamDU scientific newsletter. Special. (2020)

41. R.G. Rakhimov. A cleaner of raw cotton from fine litter // Scientific journal of mechanics and technology. Vol. 2, Iss. 5, pp.293-297 (2023)

42. R.G. Rakhimov. On the merits of innovative and pedagogical approaches in the educational system // NamSU Scientific Bulletin. Special. (2020)
43. R.G. Raximov, M.A. Azamov. Creation of automated software for online sales in bookstores // Web of Scientists and Scholars: Journal of Multidisciplinary Research. Vol. 2, Iss. 6, pp.42-55 (2024)
44. R.G. Raximov, M.A. Azamov. Technology for creating an electronic tutorial // Web of Scientists and Scholars: Journal of Multidisciplinary Research. Vol. 2, Iss.6, pp.56-64 (2024)
45. R.G. Rakhimov, A.A. Juraev. Designing of computer network in Cisco Packet Tracer software // The Peerian Journal. Vol. 31, pp.34-50 (2024)
46. R.G. Rakhimov, E.D. Turonboev. Using educational electronic software in the educational process and their importance // The Peerian Journal. Vol. 31, pp.51-61 (2024)
47. Sh. Korabayev, J. Soloxiddinov, N. Odilkhonova, R. Rakhimov, A. Jabborov, A.A. Qosimov. A study of cotton fiber movement in pneumomechanical spinning machine adapter // E3S Web of Conferences. Vol. 538, Article ID 04009 (2024)
48. U.I. Erkaboev, R.G. Rakhimov, N.A. Sayidov. Mathematical modeling determination coefficient of magneto-optical absorption in semiconductors in presence of external pressure and temperature // Modern Physics Letters B. 2021, 2150293 pp, (2021).
49. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov. The influence of external factors on quantum magnetic effects in electronic semiconductor structures // International Journal of Innovative Technology and Exploring Engineering. 9, 5, 1557-1563 pp, (2020).
50. Erkaboev U.I, Rakhimov R.G., Sayidov N.A. Influence of pressure on Landau levels of electrons in the conductivity zone with the parabolic dispersion law // Euroasian Journal of Semiconductors Science and Engineering. 2020. Vol.2., Iss.1.
51. Rakhimov R.G. Determination magnetic quantum effects in semiconductors at different temperatures // VII Международной научнопрактической конференции «Science and Education: problems and innovations». 2021. pp.12-16.
52. Gulyamov G, Erkaboev U.I., Rakhimov R.G., Sayidov N.A., Mirzaev J.I. Influence of a strong magnetic field on Fermi energy oscillations in two-dimensional semiconductor materials // Scientific Bulletin. Physical and Mathematical Research. 2021. Vol.3, Iss.1, pp.5-14
53. Erkaboev U.I., Sayidov N.A., Rakhimov R.G., Negmatov U.M. Simulation of the temperature dependence of the quantum oscillations' effects in 2D semiconductor materials // Euroasian Journal of Semiconductors Science and Engineering. 2021. Vol.3., Iss.1.
54. Gulyamov G., Erkaboev U.I., Rakhimov R.G., Mirzaev J.I. On temperature dependence of longitudinal electrical conductivity oscillations in narrow-gap electronic semiconductors // Journal of Nano- and Electronic Physic. 2020. Vol.12, Iss.3, Article ID 03012.
55. Erkaboev U.I., Gulyamov G., Mirzaev J.I., Rakhimov R.G. Modeling on the temperature dependence of the magnetic susceptibility and electrical conductivity oscillations in narrow-gap semiconductors // International Journal of Modern Physics B. 2020. Vol.34, Iss.7, Article ID 2050052.
56. Erkaboev U.I., R.G.Rakhimov. Modeling of Shubnikov-de Haas oscillations in narrow band gap semiconductors under the effect of temperature and microwave field // Scientific Bulletin of Namangan State University. 2020. Vol.2, Iss.11. pp.27-35
57. Gulyamov G., Erkaboev U.I., Sayidov N.A., Rakhimov R.G. The influence of temperature on magnetic quantum effects in semiconductor structures // Journal of Applied Science and Engineering. 2020. Vol.23, Iss.3, pp. 453–460.
58. Erkaboev U.I., Gulyamov G., Mirzaev J.I., Rakhimov R.G., Sayidov N.A. Calculation of the Fermi–Dirac Function Distribution in Two-Dimensional Semiconductor Materials at High Temperatures and Weak Magnetic Fields // Nano. 2021. Vol.16, Iss.9. Article ID 2150102.

59. Erkaboev U.I., R.G.Rakhimov. Modeling the influence of temperature on electron landau levels in semiconductors // Scientific Bulletin of Namangan State University. 2020. Vol.2, Iss.12. pp.36-42
60. Erkaboev U.I., Gulyamov G., Mirzaev J.I., Rakhimov R.G., Sayidov N.A. Calculation of the Fermi-Dirac Function Distribution in Two-Dimensional Semiconductor Materials at High Temperatures and Weak Magnetic Fields // Nano. 2021. Vol.16, Iss.9, Article ID 2150102.
61. Erkaboev U.I., Rakhimov R.G., Sayidov N.A., Mirzaev J.I. Modeling the temperature dependence of the density oscillation of energy states in two-dimensional electronic gases under the impact of a longitudinal and transversal quantum magnetic fields // Indian Journal of Physics. 2022. Vol.96, Iss.10, Article ID 02435.
62. Erkaboev U.I., Negmatov U.M., Rakhimov R.G., Mirzaev J.I., Sayidov N.A. Influence of a quantizing magnetic field on the Fermi energy oscillations in two-dimensional semiconductors // International Journal of Applied Science and Engineering. 2022. Vol.19, Iss.2, Article ID 2021123.
63. Erkaboev U.I., Gulyamov G., Rakhimov R.G. A new method for determining the bandgap in semiconductors in presence of external action taking into account lattice vibrations // Indian Journal of Physics. 2022. Vol.96, Iss.8, pp. 2359-2368.
64. U. Erkaboev, R. Rakhimov, J. Mirzaev, U. Negmatov, N. Sayidov. Influence of the two-dimensional density of states on the temperature dependence of the electrical conductivity oscillations in heterostructures with quantum wells // International Journal of Modern Physics B. **38(**15), Article ID 2450185 (2024).
65. U.I. Erkaboev, R.G. Rakhimov. Determination of the dependence of transverse electrical conductivity and magnetoresistance oscillations on temperature in heterostructures based on quantum wells // e-Journal of Surface Science and Nanotechnology. **22**(2), pp.98-106. (2024)
66. U.I. Erkaboev, N.A. Sayidov, J.I. Mirzaev, R.G. Rakhimov. Determination of the temperature dependence of the Fermi energy oscillations in nanostructured semiconductor materials in the presence of a quantizing magnetic field // Euroasian Journal of Semiconductors Science and Engineering. **3(**2), pp.47-52 (2021).
67. U.I. Erkaboev, N.A. Sayidov, U.M.Negmatov, J.I. Mirzaev, R.G. Rakhimov. Influence temperature and strong magnetic field on oscillations of density of energy states in heterostructures with quantum wells HgCdTe/CdHgTe // E3S Web of Conferences. **401**, 01090 (2023)
68. U.I. Erkaboev, N.A. Sayidov, U.M.Negmatov, R.G. Rakhimov, J.I. Mirzaev. Temperature dependence of width band gap in $In_xGa_{1-x}As$ quantum well in presence of transverse strong magnetic field // E3S Web of Conferences. 401, 04042 (2023)
69. Erkaboev U.I., Rakhimov R.G., Sayidov N.A., Mirzaev J.I. Modeling the temperature dependence of the density oscillation of energy states in two-dimensional electronic gases under the impact of a longitudinal and transversal quantum magnetic fields // Indian Journal of Physics. 2023. Vol.97, Iss.4, 99.1061-1070.
70. G. Gulyamov, U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov. Determination of the dependence of the two-dimensional combined density of states on external factors in quantum-dimensional heterostructures // Modern Physics Letters B. 2023. Vol. 37, Iss.10, Article ID 2350015.
71. U.I. Erkaboev, R.G. Rakhimov. Determination of the dependence of the oscillation of transverse electrical conductivity and magnetoresistance on temperature in heterostructures based on quantum wells // East European Journal of Physics. 2023. Iss.3, pp.133-145.
72. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, U.M. Negmatov, N.A. Sayidov. Influence of a magnetic field and temperature on the oscillations of the combined density of states in two-dimensional semiconductor materials // Indian Journal of Physics. 2024. Vol. 98, Iss. 1, pp.189-197.
73. U. Erkaboev, R. Rakhimov, J. Mirzaev, N. Sayidov, U. Negmatov, A. Mashrapov. Determination of the band gap of heterostructural materials with quantum wells at strong magnetic field and high

temperature // AIP Conference Proceedings. 2023. Vol. 2789, Iss.1, Article ID 040056.

74. U.I. Erkaboev, R.G. Rakhimov. Simulation of temperature dependence of oscillations of longitudinal magnetoresistance in nanoelectronic semiconductor materials // e-Prime-Advances in Electrical Engineering, Electronics and Energy. 2023. Vol. 5, Article ID 100236.
75. U.I. Erkaboev, R.G. Rakhimov, N.Y. Azimova. Determination of oscillations of the density of energy states in nanoscale semiconductor materials at different temperatures and quantizing magnetic fields // Global Scientific Review. 2023. Vol.12, pp.33-49
76. U.I. Erkaboev, R.G. Rakhimov, U.M. Negmatov, N.A. Sayidov, J.I. Mirzaev. Influence of a strong magnetic field on the temperature dependence of the two-dimensional combined density of states in InGaN/GaN quantum well heterostructures // Romanian Journal of Physics. 2023. Vol. 68, Iss. 5-6, pp.614-1.
77. R. Rakhimov, U. Erkaboev. Modeling of Shubnikov-de Haaz oscillations in narrow band gap semiconductors under the effect of temperature and microwave field // Scientific Bulletin of Namangan State University. 2020. Vol.2, Iss. 11, pp.27-35.
78. U. Erkaboev, R. Rakhimov, J. Mirzaev, N. Sayidov, U. Negmatov, M. Abduxalimov. Calculation of oscillations in the density of energy states in heterostructural materials with quantum wells // AIP Conference Proceedings. Vol. 2789, Iss.1, Article ID 040055.
79. R. Rakhimov, U. Erkaboev. Modeling the influence of temperature on electron landau levels in semiconductors // Scientific and Technical Journal of Namangan Institute of Engineering and Technology. 2020. Vol. 2, Iss. 12, pp.36-42.
80. U.I. Erkaboev, R.G. Rakhimov. Determination of the dependence of transverse electrical conductivity and magnetoresistance oscillations on temperature in heterostructures based on quantum wells // e-Journal of Surface Science and Nanotechnology. 2023
81. У.И. Эркабоев, Р.Г. Рахимов, Ж.И. Мирзаев, Н.А. Сайидов, У.М. Негматов. Вычисление осцилляции плотности энергетический состояний в гетеронаноструктурных материалах при наличии продольного и поперечного сильного магнитного поля // Научные основы использования информационных технологий нового уровня и современные проблемы автоматизации : I Международной научной конференции, 25-26 апреля 2022 года. стр.341-344.
82. U.I. Erkaboev, R.G. Rakhimov. Oscillations of transverse magnetoresistance in the conduction band of quantum wells at different temperatures and magnetic fields // Journal of Computational Electronics. 2024. Vol. 23, Iss. 2, pp.279-290
83. У.И. Эркабоев, Р.Г. Рахимов, Ж.И. Мирзаев, Н.А. Сайидов, У.М. Негматов. Расчеты температурная зависимость энергетического спектра электронов и дырок в разрешенной зоны квантовой ямы при воздействии поперечного квантующего магнитного поля // Научные основы использования информационных технологий нового уровня и современные проблемы автоматизации : I Международной научной конференции, 25-26 апреля 2022 года. стр.344-347.
84. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov, U.M. Negmatov. Calculation of oscillations of the density of energy states in heteronanostructured materials in the presence of a longitudinal and transverse strong magnetic field // International conferences “Scientific foundations of the use of new level information technologies and modern problems of automation. 2022. pp.341-344
85. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov, U.M. Negmatov. Calculations of the temperature dependence of the energy spectrum of electrons and holes in the allowed zone of a quantum well under the influence of a transverse quantizing magnetic field // International conferences “Scientific foundations of the use of new level information technologies and modern problems of automation. 2022. pp.344-347

86. R.G. Rakhimov, U.I. Erkaboev. Modeling of Shubnikov-de Haase oscillations in narrow-band semiconductors under the influence of temperature and microwave fields // Scientific Bulletin of Namangan State University. 2022. Vol. 4, Iss.4, pp.242-246.
87. R.G. Rakhimov. The advantages of innovative and pedagogical approaches in the education system // Scientific-technical journal of NamIET. Vol. 5, Iss. 3, pp.292-296 (2020)
88. Р.Г. Рахимов, У.И. Эркабоев. Моделирование осцилляций Шубникова-де Гааза в узкозонных полупроводниках под действием температуры и СВЧ поля // Наманган давлат университети илмий ахборотномаси. 2019. Vol. 4, Iss. 4, pp.242-246
89. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov, U.M. Negmatov. Modeling the Temperature Dependence of Shubnikov-De Haas Oscillations in Light-Induced Nanostructured Semiconductors // East European Journal of Physics. 2024. Iss. 1, pp. 485-492.
90. M. Dadamirzaev, U. Erkaboev, N. Sharibaev, R. Rakhimov. Simulation the effects of temperature and magnetic field on the density of surface states in semiconductor heterostructures // Iranian Journal of Physics Research. 2024
91. U.I. Erkaboev, N.Yu. Sharibaev, M.G. Dadamirzaev, R.G. Rakhimov. Effect of temperature and magnetic field on the density of surface states in semiconductor heterostructures // e-Prime-Advances in Electrical Engineering, Electronics and Energy. 2024. Vol.10, Article ID 100815.
92. U.I. Erkaboev, Sh.A. Ruzaliev, R.G. Rakhimov, N.A. Sayidov. Modeling Temperature Dependence of The Combined Density of States in Heterostructures with Quantum Wells Under the Influence of a Quantizing Magnetic Field // East European Journal of Physics. 2024. Iss.3, pp.270-277.
93. U.I. Erkaboev, N.Yu. Sharibaev, M.G. Dadamirzaev, R.G. Rakhimov. Modeling influence of temperature and magnetic field on the density of surface states in semiconductor structures // Indian Journal of Physics. 2024.
94. U.I. Erkaboev, G. Gulyamov, M. Dadamirzaev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov, U.M. Negmatov. The influence of light on transverse magnetoresistance oscillations in low-dimensional semiconductor structures // Indian Journal of Physics. 2024.
95. Р.Г. Рахимов. Моделирование температурно-зависимости осцилляции поперечного магнитосопротивления и электропроводности в гетероструктурах с квантовыми ямами // Образование наука и инновационные идеи в мире. 2024. Vol. 37, Iss. 5, pp.137-152.
96. N. Sharibaev, A. Jabborov, R. Rakhimov, Sh. Korabayev, R. Sapayev. A new method for digital processing cardio signals using the wavelet function // BIO Web of Conferences. 2024. Vol. 130, Article ID 04008.
97. A.M. Sultanov, E.K. Yusupov, R.G. Rakhimov. Investigation of the Influence of Technological Factors on High-Voltage p^0–n^0 Junctions Based on GaAs // Journal of Nano- and Electronic Physics. 2024. Vol. 16, Iss. 2, Article ID 01006.
98. U.I. Erkaboev, R.G. Rakhimov, J.I. Mirzaev, N.A. Sayidov, U.M. Negmatov. Influence of temperature and light on magnetoresistance and electrical conductivity oscillations in quantum well heterostructured semiconductors // Romanian Journal of Physics. 2024. Vol. 69, pp.610
99. У.И. Эркабоев, Р.Г. Рахимов, Ж.И. Мирзаев, Н.А. Сайидов, У.М. Негматов, С.И. Гайратов. Влияние температуры на осцилляции поперечного магнитосопротивления в низкоразмерных полупроводниковых структурах // Namangan davlat universiteti Ilmiy axborotnomasi. 2023. Iss. 8, pp.40-48.
100. U. Erkaboev, N. Sayidov, R. Raximov, U. Negmatov, J. Mirzaev. Kvant o 'rali geterostrukturalarda kombinatsiyalangan holatlar zichligiga magnit maydon va haroratning ta'siri // Namangan davlat universiteti Ilmiy axborotnomasi. 2023. Iss. 6, pp.16-22
101. У.И. Эркабоев, Р.Г. Рахимов. Вычисление температурной

зависимости поперечной электропроводности в квантовых ямах при воздействии квантующего магнитного поля // II- Международной конференции «Фундаментальные и прикладные проблемы физики полупроводников, микро- и наноэлектроники». Ташкент, 27-28 октября 2023 г. стр.66-68.

102. R.G.Rakhimov. Simulation of the temperature dependence of the oscillation of magnetosistivity in nanosized semiconductor structures under the exposure to external fields // Web of Technology: Multidimensional Research Journal. 2024. Vol.2, Iss.11, pp.209-221