V International Scientific and Technical Conference Actual Issues of Power Supply Systems

Integration of information technology into the enterprise's energy management system in accordance with the ISO 50001:2018 standard

AIPCP25-CF-ICAIPSS2025-00396 | Article

Integration of information technology into the enterprise's energy management system in accordance with the ISO 50001:2018 standard

Paraxat Matyakubova[1], Gaybulla Boboyev[1,2,a)], Mirolim Mahmudjonov[1], Ruslan Kuluyev[1], Xolmurodjon Mo'minov[1]

[1]*Tashkent state technical university named after Islam Karimov, Tashkent, Uzbekistan*
[2] *Almalyk State Technical Institute, Almalyk, Uzbekistan*

[a)] *Corresponding author: gaybulla.bobyev1281@gmail.com*

Abstract. This article analyzes the formation of a modern product quality management system based on detailed research and prioritization of the enterprise's business processes, documenting reorganized processes in the form of model representations, and organizing information support. Key principles and tactics for applying information technology in quality management using CALS technologies are also considered. The design and management of a quality system based on CALS approaches are substantiated. In addition, the article is devoted to the study of the implementation of information technologies in the energy management system in accordance with the ISO 50001:2018 standard, including monitoring energy consumption, developing energy policy, determining energy efficiency indicators (EnPI), and forming an energy consumption database (EnB).

INTRODUCTION

The modern approach to quality management involves a fundamental restructuring of the enterprise's activities, encompassing practically all tasks facing it in areas such as strategy, organizational structure, business processes, personnel management, and automation [1-2].

In today's realities, it is difficult to imagine a sphere of human activity where information technologies are not applied. The automation of various procedures, the equipping of workplaces with computer equipment, and the introduction of advanced methods for processing, using, and exchanging information represent powerful tools for increasing work efficiency and improving people's interaction within society [3-4].

The introduction of modern information technologies into the production sector has made it possible to optimize the solution of complex engineering problems and develop innovative methods and technical means for their implementation. These changes stimulated the development of advanced technological processes designed to produce more complex and science-intensive products [5-6].

In today's environment, improving energy efficiency is becoming an important area of enterprise development. The international standard ISO 50001:2018 establishes requirements for the creation of an energy management system (EMS) aimed at the rational use of energy resources, reducing energy costs, and enhancing the environmental sustainability of the enterprise. Integrating information technology into energy monitoring and analysis processes can significantly improve the efficiency of energy management [7-8].

Today, companies implement international quality standards ISO 9001:2015 to ensure the efficient operation of their departments. Based on practical experience and statistical research, the most popular quality management system models of all existing options are ISO 9001:2008, TickIT, and SEI SWCMM [9-10].

In addition to the quality management system, the ISO 50001:2018 energy management system, which offers an ordered method for improving the energy efficiency of enterprises, is gaining increasing importance. Unlike ISO 9001, which focuses on product quality, ISO 50001 focuses on energy resource management, identifying key aspects of energy consumption, defining energy goals and indicators, and continuously improving energy efficiency [11-12].

Modern quality management represents a comprehensive tool aimed at improving and controlling all operations within the organization, including management operations. The presence of an international certificate confirming the compliance of the quality management system is a universally recognized confirmation of the company's high level of technological development and its compliance with current scientific and technical standards. This certificate, valued worldwide, demonstrates the organization's commitment to best practices and innovation [13-14].

Today, the implementation of a quality management system is voluntary, but at the same time, no reputable company in Europe will contract with a company that has not achieved ISO 9001:2015 certification. To create an effective quality system based on the ISO 9001:2015 series, companies typically also utilize additional industry standards and their own regulatory documents and developments [15-16].

The effectiveness of the application of modern information technologies is determined by the correspondence between the levels of quality management and the areas of application of computer technologies [17-18].

The most important areas of using computer technologies at various levels of quality systems include [19-25]:

- control place at the control point, computer technologies are used to control and determine measured values when working with control machines and measuring machines. They are also used to operate simple measuring instruments to receive measured values, eliminating transmission errors caused by human error. Increasing automation leads to the wider use of computer technologies. At the same time, the boundary between humans and the processing computer system for determining the values of the characteristics being tested is becoming increasingly clear.

- quality control management.The quality control management layer ensures the transfer of necessary information and serves to consolidate the data obtained at a single control point. This consolidation can be accomplished in three ways:

a) by determining the values of the characteristics being tested from the measured values by calculation or comparison with the specified values;

b) processing of the verified characteristics using statistical methods;

c) the derivation of correction parameters for process regulation. Control-level tasks can be expressed by algorithms and, therefore, are easily accomplished using computers.

- organization management. At this level, which includes storing data obtained during control, determining control costs, and analyzing products, information technology is used to transmit information. At the same time, it is necessary to conduct market research, understand changing needs, and determine necessary product requirements.

- quality management. The primary task at the quality management level is the evaluation of inspection data. This is typically performed by organizational personnel who utilize computer data in their work. Within factory networks, it is necessary to integrate a quality data transmission system and emphasize multimedia computer technologies.

Work on the development and implementation of CALS technologies has been underway abroad for over 25 years. Significant results have been achieved in this area. CALS technologies are currently considered a beneficial global economic strategy across all industries [26-27].

The term CALS (Continuous acquisition and lifecycle support) means a set of principles and technologies for information support of the product life cycle at all its stages [1-2, 28-29].

EXPERIMENTAL RESEARCH

The goal of implementing CALS is to minimize costs during the product life cycle, improve its quality and competitiveness [30-31]. In today's landscape of resource stewardship, enhancing energy efficiency is emerging as a key strategic goal for businesses. Adopting an energy management framework aligned with ISO 50001 offers a pathway to reduce energy expenditures throughout a product's entire journey. This standard mandates a thorough examination of energy usage, pinpointing major consumption points, formulating a clear energy strategy, building a comprehensive energy data repository, and defining metrics for tracking energy performance (EnPIs).To ensure information integration, CALS uses IGES and STEP standards as data formats. CALS also includes standards for electronic data exchange, electronic technical documentation, and process improvement guidelines [32-33].

In developed countries, CALS is considered as a comprehensive systemic strategy for improving the efficiency of processes associated with knowledge-intensive industrial products, which directly affects their quality and competitiveness [34-35].

CALS Strategy The CALS method involves the creation of an enterprise information space that enables the storage of information electronically and serves as a single data source for all participants in the product lifecycle. The CALS method defines the enterprise information space (IS) as a repository of all product information, the sole source of product data (direct data exchange between lifecycle participants is excluded), and is based on international, national, and industry standards [36-37].

Likewise, ISO 50001 mandates a centralized information hub for energy consumption data storage and analysis. IT solutions empower automated data acquisition from devices, live monitoring of energy use, statistical insights into energy patterns, and the creation of improvement strategies for greater efficiency. The CALS strategy involves two stages of creating a unified information space [38-40]:

- automation of individual processes of the product life cycle and presentation of data on them in electronic form in accordance with international standards;
- integration of automated processes and related data within a single information space.

The following methods are used to implement the CALS strategy [41-45].

1. Business process analysis and reengineering technologies are methods for restructuring enterprise operations. These technologies enable a smooth transition from paper-based to electronic document management and the implementation of new product development methods (parallel engineering, interdisciplinary working groups, etc.) within the automation process.
2. Technologies for presenting product data - methods for standardized electronic presentation of data related to individual processes of the product life cycle.
3. Product data integration technologies - methods for integrating automated life cycle processes and related data.

Product data management systems are used to integrate all data within an IP. Their purpose is to accumulate all information generated by application systems into a single model. The interaction between these systems and application systems is based on standard interfaces, which can be roughly divided into four groups [46-49].

1. Functional standards - track the organizational procedure for interaction between computer systems. For example, in the IDEF (Integrate Computer Automated Manufacturing Definition) standard (IDEF0 - a family of methods and technologies for creating complex systems and designing computer systems), IDEF0 is a functional modeling standard.
2. Information standards – provide a data model used by all lifecycle participants. For example, ISO 10303 STEP.
3. Software architecture standards – define the architecture of software systems necessary for interaction without human intervention. For example, COBRA.
4. Communication standards – specify the method for physically transmitting data over local and global networks. For example, internet standards.

CALS methodology It is independent of the subject area and is actively used in the development of complex, science-intensive products for both military and civilian applications, whose lifespan, including various upgrades, spans decades. Typically, it is developed with the involvement of numerous subcontractors, and the CALS philosophy emphasizes transparent and easy communication between contractors and customers [50-51].

An enterprise's quality system (QS) is an element of its management activities. From this perspective, the QS is viewed as a subsystem of the enterprise, tightly integrated with the information environment. Therefore, CALS technologies can be applied to its design, creation, operation, analysis, and reengineering (reorganization). Similarly, an energy management system (EMS) is part of the overall enterprise management system. It integrates with existing information systems and enables automation of processes for monitoring, analyzing, and optimizing energy consumption [52-53].

To implement organizational and regulatory-methodological support for SC CALS technologies, it is necessary to use functional models of enterprise processes from the point of view of quality assurance [54].

Clearly, the QS must be based on an information system that supports automated documentation of quality assurance processes at all stages of the product lifecycle and automated management of these processes. This means that all data circulating in the QS must be presented in formats regulated by CALS standards and comprise a set of information models that are part of the enterprise's integrated information system [55-56].

The use of CALS technologies in the field of creating quality control systems at all stages of the product life cycle facilitates continuous quality improvement and allows enterprise management to ensure that all technical, administrative, and human factors affecting the quality of manufactured products are under control, and that quality control management takes into account consumer needs and expectations and ensures the enterprise's competitiveness [57-58].

RESEARCH RESULTS

Development and management of a quality system based on the principles of CALS technologies.Management of organizational and technical systems based on CALS technologies refers to the field of science and technology, which includes a set of methods and means of human activity aimed at the analysis, design and management of complex organizational and technical systems and the processes of their functioning based on modern computer systems and technologies [59-60].

The objects of development and management of organizational and technical systems are the modeling of organizational and technical systems, namely: organizational, technological and production processes; after-sales service processes; their functioning on the basis of automated control and monitoring systems, mathematical, information, technical and software support, i.e. those production objects that should be covered by a quality system created on the basis of modern computer technologies [61-62].

Therefore, to develop a quality system based on CALS technologies, covering the above-mentioned production facilities, it is necessary to complete [63-65]:

– construction of mathematical models of technical systems, technological processes and production as objects of automation and control, including the use of numerical methods for studying systems and operations and combinatorial analysis;

– development of models and methods for solving problems of analysis and synthesis of organizational and technical systems and their operational operations, as well as the refinement of algorithmic and software support for automation and control systems for objects of various physical natures under the conditions of a specific enterprise;

– implementation and refinement of modern hardware and software for research, design, technical diagnostics and industrial testing of automation and control systems and equipment;

– analysis of information, methods of its storage, processing and transmission using methods of combinatorial analysis;

– analysis of the features of mathematical calculations implemented in automated design and project management systems, as well as in logistics support systems using methods of mathematical analysis, operational calculus, probability theory and mathematical statistics;

– to provide directions for improving the technology of system modeling using the fundamentals of mathematical logic and the theory of logical inference;

– take into account the problematic issues of establishing the uncertainty of the states of organizational and technical systems and the operations of their functioning.

Conducting an energy analysis in accordance with ISO 50001 and identifying significant areas of energy consumption [40-49]:

– development of energy policy and energy goals of the enterprise;

– determination of energy indicators (EnPI) and formation of an energy database (EnB);

– implementation of energy consumption monitoring and measurement systems using digital technologies;

– analysis of risks and opportunities associated with energy consumption.

For the effective operation of quality management systems created on the basis of CALS technologies, it is also necessary to implement a number of organizational measures, such as [51-59]:

– development of conceptual and formal models of organizational and technical systems and processes of their functioning, using probability-theoretical methods of calculation and study of the characteristics of organizational and technical systems;

– organization of the development process and solution of problems of management of organizational and technical systems based on the principles and methods of object-oriented modeling technology through automation systems and management of a given quality;

– organizing the work of a team of developers of a quality management system in a unified information space,

– making management decisions based on current and reliable data provided by the product lifecycle support system (PLM system), as a component of the CALS technology software;

– planning the phased development and implementation of automation and control systems and tools based on a PLM system;

– selection of technology, tools and computing equipment in organizing the processes of research, design, technical diagnostics and industrial testing of automatic and automated control and management systems.

Ensuring the operability of the PLM system in a single information space, organizing the object management system in the PLM system based on solving the problems of studying the efficiency of the functioning of organizational and technical systems [60-70]:

– training of personnel within the framework of the adopted organization process of development and implementation of automation and control systems and tools.

– organization of monitoring and measurements of energy consumption in accordance with the requirements of ISO 50001;

– conducting internal audits of the energy management system;

– ensuring continuous improvement of the energy performance of the enterprise based on data analysis.

CONCLUSIONS

The above approaches to developing a quality system based on CALS technologies will allow us to obtain real data on the progress of production processes, based on which we can make timely, informed decisions to improve their quality, and, consequently, the quality of manufactured products.

Therefore, building a modern product quality management system should be based on a thorough analysis and reengineering of enterprise processes, documenting the restructured processes in the form of models, and creating information support for the quality management system. Its use will enable every enterprise to obtain an effective tool for improving the quality of its products.

Integrating ISO 50001 standards into an enterprise's information system enables systematic energy management, increases production energy efficiency, and reduces costs. The use of digital technologies makes energy monitoring processes more transparent, and energy resource management more efficient and cost-effective.

REFERENCES

1. P.M.Matyakubova, P.R.Ismatullayev, N.I.Avezova, M.Mahmadjonov. *Algorithms for increasing the reliability of primary measurement information*. Journal of Physics: Conference Series, 2036(1), **012002**, (2021). DOI 10.1088/1742-6596/2036/1/012002

2. Sh.M.Masharipov, K.R.Ruzmatov, S.A.Rahmatullayev, ... M.M.Mahmudjonov, A.G.Isaqov. *Assessment and investigation of measurement uncertainty of standard samples of substances and materials in physicochemical measurements based on standard test methods*. Journal of Physics: Conference Series, 2094(5), **052011**, (2021). DOI 10.1088/1742-6596/2094/5/052011

3. P.M.Matyakubova, Kh.Sh.Zhabborov, Sh.A.Kadirova, M.M.Mahmudjonov. *Study of the main parameters of the capacitive converter*. Journal of Physics: Conference Series, 2036(1), **012001**, (2021). DOI 10.1088/1742-6596/2036/1/012001

4. P.M.Matyakubova, P.R.Ismatullaev, N.I.Avezova, M.M.Makhmudzhonov. *Block Diagram of APCS of Installations for Wet-Heat Processing of Grain Products*. Journal of Engineering Physics and Thermophysics, **96(6),** (2023), pp.1652-1657. DOI 10.1007/s10891-023-02835-5

5. P.M.Matyakubova, P.R.Ismatullaev, N.I.Avezova, M.M.Mahmudjonov. *Mathematical Modeling of a Thermal Converter with a Cylindrical Heat Pipeline and a Lumped Heat Source*. Journal of Engineering Physics and Thermophysics, **96(1)**, (2023), pp.178-187. DOI 10.1007/s10891-023-02674-4

6. P.M.Matyakubova, P.R.Ismatullaev, Z.U.Shamuratov. *Oscillatory Viscometer for Measuring the Viscosity of Liquids*. Journal of Engineering Physics and Thermophysics, **97(1)**, 2024, pp.134-141. DOI 10.1007/s10891-024-02876-4

7. G.Boboyev, M.Mirshomilova. *Analysis of metrological supply problems in electricity generation*. E3S Web of Conferences, 461, **01088**, (2023). https://doi.org/10.1051/e3sconf/202346101088

8. G.G.Boboev, M.M.Mahmudjonov, and ofters. AIP Conference Proceedings, 2432, **030042**, (2022), https://doi.org/10.1063/5.0089626

9. B.Ametova, G.Boboyev, N.Djumaniyazova. *Implementation of an integrated management system in calcium soda production*. E3S Web of Conferences, 434, **02029**, (2023). https://doi.org/10.1051/e3sconf/202343402029

10. G.Boboyev, G.Mirpayzieva. *Modern technologies of calibration with measuring devices of electrical quantities*. E3S Web of Conferences, 461, **01087**, (2023). https://doi.org/10.1051/e3sconf/202346101087

11. P.M.Matyakubova, G.G.Babaev. *Moisture Meter for Loose Materials*. J Eng Phys Thermophy, 97, (2024), pp.504-505. https://doi.org/10.1007/s10891-024-02917-y

12. A.T.Rakhmanov, G.G.Boboev. *Developing the Technology for Manufacturing Ohmic Contacts and Sealing Semiconductor Temperature Converters*. Journal of Engineering Physics and Thermophysics, 98(3), (2025), pp.841-845. https://doi.org/10.1007/s10891-025-03163-6

13. G.Boboyev, N.Nurmukhamedov, O.Zaripov. *Improvement of means of measuring the main parameters of electricity*. AIP Conference Proceedings, 3331, **040039**, (2025). https://doi.org/10.1063/5.0305861

14. G.Boboyev, N.Inatova. *The importance of implementing energy management systems for manufacturing enterprises in the Republic of Uzbekistan*. AIP Conference Proceedings, 3331, **040047**, (2025). https://doi.org/10.1063/5.0305865

15. N.I.Avezova, P.R.Ismatullayev, P.M.Matyakubova, G.G Boboyev. *Multifunctional Heat Converter Moisture Content of Liquid Materials*. International Conference on Information Science and Communications Technologies Applications Trends and Opportunities Icisct 2019, 9012041, (2019). DOI: 10.1109/ICISCT47635.2019.9012041

16. N.Ibodullaevna, M.P.Mayliyevna and B.G.Gafurovich. *Ways To Develop Innovative Processes In Grain Production*. 2019 International Conference on Information Science and Communications Technologies (ICISCT), (2019), pp.1-4. doi: 10.1109/ICISCT47635.2019.9012034

17. M.Sadullaev, E.Usmanov, R.Karimov, D.Xushvaktov, D.Xalmanov, Y.Shoyimov, D.Khimmataliev. *Mathematical Models and Calculation of Elements of Developed Schemes of Contactless Devices*. AIP Conference Proceedings, 3331(1), **040043**, (2025), https://doi.org/10.1063/5.0305748

18. E.Yuldashev, M.Yuldasheva, A.Togayev, J.Abdullayev, R.Karimov. *Energy efficiency research of conveyor transport*. AIP Conference Proceedings, 3331(1), **040030**, (2025), https://doi.org/10.1063/5.0305742

19. A.Nuraliyev, I.Jalolov, M.Peysenov, A.Adxamov, S.Rismukhamedov, R.Karimov. *Improving and Increasing the Efficiency of the Industrial Gas Waste Cleaning Electrical Filter Device*. AIP Conference Proceedings, 3331(1), **040040**, (2025), https://doi.org/10.1063/5.0305751

20. M.Sadullaev, E.Usmanov, R.Karimov, D.Xushvaktov, N.Tairova, A.Yusubaliev. *Development of Contactless Device Schemes for Automatic Control of the Power of a Capacitor Battery*. AIP Conference Proceedings, 3331(1), **040042**, (2025), https://doi.org/10.1063/5.0305879

21. M.Sadullaev, E.Usmanov, R.Karimov, D.Xushvaktov, N.Tairova, A.Yusubaliev. *Review of Literature Sources and Internet Materials on Contactless Devices for Reactive Power Compensation*. AIP Conference Proceedings, 3331(1), **040041**, (2025), https://doi.org/10.1063/5.0305878

22. M.Sadullaev, M.Bobojanov, R.Karimov, D.Xushvaktov, Y.Shoyimov, H.Achilov. *Experimental Studies of Contactless Devices for Controlling the Power of Capacitor Batteries*. AIP Conference Proceedings, 3331(1), **040044**, (2025), https://doi.org/10.1063/5.0307195

23. E.Usmanov, M.Bobojanov, R.Karimov, D.Xalmanov, N.Tairova, S.Torayev. *Contactless Switching Devices Using Nonlinear Circuits*. AIP Conference Proceedings, 3331(1), **040031**, (2025), https://doi.org/10.1063/5.0305744

24. K.Abidov, A.Alimov, M.Gafurova. *Transients in Devices of Control Systems With Excitation Winding*. AIP Conference Proceedings, 3331(1), **040033**, (2025), https://doi.org/10.1063/5.0305756

25. K.Abidov, E.Abduraimov, M.Gafurova. *Possibility of Applying Methods of Analysis and Synthesis of Linear Electrical Circuits to Some Nonlinear Circuits*. AIP Conference Proceedings, 3331(1), **040034**, (2025), https://doi.org/10.1063/5.0305757

26. O.Ishnazarov, N.Khamudkhanova, K.Kholbutayeva, K.Abidov. *Energy Efficiency Optimization in Irrigation Pump Installations*. AIP Conference Proceedings, 3331(1), **040036**, (2025), https://doi.org/10.1063/5.0305844

27. K.Abidov, A.Alimov, N.Khamudkhanova, M.Gafurova. *Determination of the Permissible Number of Pumping Units Supplied From the Transformer of the Amu-Zang-I Substation, Selection of the Power of Static Capacitors*. AIP Conference Proceedings, 3331(1), **040029**, (2025), https://doi.org/10.1063/5.0305754

28. F.Akbarov, R.Kabulov, A.Alimov, E.Abduraimov, D.Nasirova. *Dependence of Output Parameters of Photovoltaic Module Based on CIGS Solar Cells on External Temperatures*. AIP Conference Parameters, 3331(1), **040046**, (2025), https://doi.org/10.1063/5.0305885

29. A.Alimov, K.Abidov, E.Abduraimov, F.Akbarov, H.Muminov. *Generalized Model of Nonlinear Inductance and its.* AIP Conference *Parameters*, 3331(1), **040035**, (2025), https://doi.org/10.1063/5.0305883

30. E.Abduraimov, M.Peysenov, N.Tairova. *Development of Contactless Device for Maintaining the Rated Voltage of Power Supply Systems*. AIP Conference Proceedings, 2552, **040012**, (2022). https://doi.org/10.1063/5.0116235

31. E.Abduraimov, D.Khalmanov, B.Nurmatov, M.Peysenov, N.Toirova. *Analysis of dynamic circuits of contactless switching devices*. Journal of Physics Conference Series, 2094(2), **022072**, (2021). DOI 10.1088/1742-6596/2094/2/022072

32. E.Abduraimov. *Automatic control of reactive power compensation using a solid state voltage relays*. Journal of Physics Conference Series, 2373(7), **072009**, (2022). DOI 10.1088/1742-6596/2373/7/072009
33. E.Abduraimov, D.Khalmanov. *Invention of a contactless voltage relay with an adjustable reset ratio*. Journal of Physics Conference Series, 2373(7), **072010**, (2022). DOI 10.1088/1742-6596/2373/7/072010
34. Y.Adilov, A.Nuraliyev, M.Abdullayev, S.Matkarimov. *Dynamic Performance Model of a Hybrid Power System*. AIP Conference Proceedings, 3331(1), **040038**, (2025). https://doi.org/10.1063/5.0305909
35. Y.Adilov, M.Khabibullaev. *Application of fiber-optic measuring current transformer in control and relay protection systems of belt conveyor drives*. IOP Conference Series Earth and Environmental Science, 614(1), **012022**, (2020), doi:10.1088/1755-1315/614/1/012022
36. R.Yusupaliyev, N.Musashayxova, A.Kuchkarov. Methods of Purification of Polluted Water from Ammonia Compounds at Nitrogen Fertilizer Plants. E3S Web of Conferences, 563, **03085**, (2024). https://doi.org/10.1051/e3sconf/202456303085
37. R.Yusupaliev, N.Kurbanova, M.Azimova, N.Musashaikhova, A.Kuchkarov. Establishing a Water-chemical Regime and Increasing the Efficiency of Combustion of a Mixture of Fuel Oil and Gas in a DE 25-14 GM Boiler: A Case Study of the Kokand Distillery. AIP Conference Proceedings, 2552, **030026**, (2022), https://doi.org/10.1063/5.0130471
38. R.Yusupaliev, B.Yunusov, M.Azimova. The composition of natural waters of some source rivers of the republic of Uzbekistan, used in the thermal power engineering and the results of the experimental researches at preliminary and ion exchange treatment of water. E3S Web of Conferences, 139, **01083**, (2019), https://doi.org/10.1051/e3sconf/201913901083
39. R.Yusupaliev, N.Kurbanova, M.Azimova, N.Musashaikhova, A.Kuchkarov. Establishing a Water-chemical Regime and Increasing the Efficiency of Combustion of a Mixture of Fuel Oil and Gas in a DE 25-14 GM Boiler: A Case Study of the Kokand Distillery. AIP Conference Proceedings, 2552, **030026**, (2022). https://doi.org/10.1063/5.0130471
40. M.Azimova, N.Kurbanova, D.Rakhmatov. Large-scale environmental benefits of biogas technology. AIP Conference Proceedings, 3152(1), **060007**, (2024), https://doi.org/10.1063/5.0218937
41. M.Jalilov, M.Azimova, A.Jalilova. On a new technology of preparation of hot drinking water. Energetika Proceedings of Cis Higher Education Institutions and Power Engineering Associations, **60(5)**, (2017), pp.484-492. https://doi.org/10.21122/1029-7448-2017-60-5-484-492
42. S.Amirov, A.Sulliev, U.Mukhtorov. *Resonance sensors of motion parameters*. AIP Conference Proceedings, 3256(1), 050028, (2025). https://doi.org/10.1063/5.0267548
43. K.Turdibekov, A.Sulliev, O.Iskandarova, J.Boboqulov. *Experimental and statistical methods for studying the modes of electric power systems under conditions of uncertainty*. E3S Web of Conferences, 452, **04002**, (2023), https://doi.org/10.1051/e3sconf/202345204002
44. S.Kasimov, A.Sulliev, A.Eshkabilov. *Optimising Pulse Combustion Systems for Enhanced Efficiency and Sustainability in Thermal Power Engineering*. E3S Web of Conferences, 449, **06006**, (2023), https://doi.org/10.1051/e3sconf/202344906006
45. S.Amirov, A.Sulliev, S.Sharapov. *Study on differential transformer displacement sensors*. E3S Web of Conferences, 434, **02011**, (2023), https://doi.org/10.1051/e3sconf/202343402011
46. S.Amirov, A.Sulliev, K.Turdibekov. *Investigation of biparametric resonance sensors with distributed parameters*. E3S Web of Conferences, 377, **01002**, (2023), https://doi.org/10.1051/e3sconf/202337701002
47. M.Yakubov, A.Sulliev, A.Sanbetova. *Modern methods of evaluation of metrological indicators of channels for measurement and processing of diagnostic values of traction power supply*. IOP Conference Series Earth and Environmental Science, 1142(1), **012010**, (2023), doi:10.1088/1755-1315/1142/1/012010
48. K.Turdibekov, A.Sulliev, I.Qurbanov, S.Samatov, A.Sanbetova. *Voltage Symmetration in High Speed Transport Power Supply Systems*. AIP Conference Proceedings, 2432, **030084**, (2022), https://doi.org/10.1063/5.0089958
49. K.Turdibekov, M.Yakubov, A.Sulliev, A.Sanbetova. *Mathematical Models of Asymmetric Modes in High-Speed Traffic*. Lecture Notes in Networks and Systems, **247**, (2022), pp.1051-1058. DOI:10.1007/978-3-030-80946-1_95
50. S.K.Shah, L.Safarov, A.Sanbetova, and etc. *Investigation on composite phase change materials for energy-saving buildings*. E3S Web of Conferences, 563, **01003**, (2024), https://doi.org/10.1051/e3sconf/202456301003
51. A.Sanbetova, A.Mukhammadiev, A.Rakhmatov, Z.Beknazarova. *Study on cultivation of environmentally friendly seed potatoes based on electrical technology*. E3S Web of Conferences, 377, **03001**, (2023), https://doi.org/10.1051/e3sconf/202337703001

52. M.Mirsadov, B.Fayzullayev, I.Abdullabekov, A.Kupriyanova, D.Kurbanbayeva, U.Boqijonov. *The mutual influence of electromagnetic and mechanical processes in dynamic modes of inertial vibrating electric drives*. IOP Conference Series Materials Science and Engineering, 862(6), **062081**, (2020). doi:10.1088/1757-899X/862/6/062081

53. I.Abdullabekov, M.Mirsaidov, F.Tuychiev, R.Dusmatov. *Frequency converter – asynchronous motor – pump pressure piping system mechanical specifications*. AIP Conference Proceedings, 3152, **040007** (2024). https://doi.org/10.1063/5.0218880

54. I.Abdullabekov, M.Mirsaidov, Sh.Umarov, M.Tulyaganov, S.Oripov. *Optimizing energy efficiency in water pumping stations: A case study of the Chilonzor water distribution facility*. AIP Conference Proceedings, 3331, **030107**, (2025). https://doi.org/10.1063/5.0305780

55. M.Bobojanov, F.Tuychiev, N.Rashidov, A.Haqberdiyev, I.Abdullabekov. *Dynamic simulation of a three-phase induction motor using Matlab Simulink*. AIP Conference Proceedings, 3331, **040012**, (2025). https://doi.org/10.1063/5.0305750

56. M.Tulyaganov, Sh.Umarov, I.Abdullabekov, Sh.Adilova. *Optimization of modes of an asynchronous electric drive taken into account thermal transient processes*. AIP Conference Proceedings, 3331, **030084**, (2025). https://doi.org/10.1063/5.0305786

57. Sh.Umarov, Kh.Sapaev, I.Abdullabekov. *The Implicit Formulas of Numerical Integration Digital Models of Nonlinear Transformers*. AIP Conference Proceedings, 3331, **030105**, (2025), https://doi.org/10.1063/5.0305793

58. J.Safarov, A.Khujakulov, Sh.Sultanova, U.Khujakulov. S.Verma. *Research on energy efficient kinetics of drying raw material*. E3S Web of Conferences, 216, **01093**, (2020). https://doi.org/10.1051/e3sconf/202021601093

59. J.Safarov, Sh.Sultanova, G.Dadayev, Sh.Zulponov. *Influence of the structure of coolant flows on the temperature profile by phases in a water heating dryer*. IOP Conf. Series: Materials Science and Engineering, 1029(1), **012019**, (2021). doi:10.1088/1757-899X/1029/1/012019

60. Sh.Sultanova, A.Artikov, Z.Masharipova, A.Tarawade, J.Safarov. *Results of experiments conducted in a helio water heating convective drying plant*. IOP Conf. Series: Earth and Environmental Science, 868(1), **012045**, (2021). doi:10.1088/1755-1315/868/1/012045

61. Sh.Sultanova, J.Safarov, A.Usenov, D.Samandarov, T.Azimov. *Ultrasonic extraction and determination of flavonoids*. AIP Conference Proceedings, 2507, **050005**, (2023). https://doi.org/10.1063/5.0110524

62. Dj.Saparov, S.Sultonova, E.Guven, D.Samandarov, A.Rakhimov. *Theoretical study of characteristics and mathematical model of convective drying of foods*. E3S Web of Conferences, 461, **01057**, (2023). https://doi.org/10.1051/e3sconf/202346101057

63. Sh.Sultanova, J.Safarov, A.Usenov, T.Raxmanova. *Definitions of useful energy and temperature at the outlet of solar collectors*. E3S Web of Conferences, 216, **01094**, (2020). https://doi.org/10.1051/e3sconf/202021601094

64. Sh.Zulpanov, D.Samandarov, G.Dadayev, S.Sultonova, J.Safarov. *Research of the influence of mulberry silkworm cocoon structure on drying kinetics*. IOP Conf. Series: Earth and Environmental Science, 1076, **012059**, (2022). doi:10.1088/1755-1315/1076/1/012059

65. A.Tarawade, D.Samandarov, T.Azimov, Sh.Sultanova, J.Safarov. *Theoretical and experimental study of the drying process of mulberry fruits by infrared radiation*. IOP Conf. Series: Earth and Environmental Science, 1112, **012098**, (2022). doi:10.1088/1755-1315/1112/1/012098

66. S.M.Turabdzhanov, J.M.Tangirov, P.M.Matyakubova, N.S.Amirkhulov, S.S.Khabibullaev. *Methods of providing metrological supply when pumping water into wells in oil fields.* AIP Conference Proceedings, 3045(1), **030073**, (2024), https://doi.org/10.1063/5.0197355

67. P.Matyakubova, P.Ismatullaev, J.Shamuratov. *Development of vibration viscometer for industry purpose and experience of its practical*. E3S Web of Conferences, 365, **05012**, (2023), https://doi.org/10.1051/e3sconf/202336505012

68. N.I.Avezova, P.M.Matyakubova, P.R.Ismatullaev, S.A.Kodirova. *Design and Practical Application of Thermal Humidity Converters for Liquid Materials.* Journal of Engineering Physics and Thermophysics, 96(1), (2023), pp.206-214. DOI: 10.1007/s10891-023-02677-1

69. N.I.Avezova, P.R.Ismatullaev, P.M.Matyakubova, Sh.A.Kodirova. *Mathematical model of a heat transducer with a cylindrical heat pipeline and with a focused heat source.* Journal of Physics Conference Series, 1686(1), **012063**, (2020), DOI: 10.1088/1742-6596/1686/1/012063

70. O.Khakimov, P.M.Matyakubova, G.A.Gaziev, R.R.Jabbarov. *Evaluation of ultrasound reflection coefficient measurement result and its uncertainty by the method of linearization.* Proceedings of the International Conference on Advanced Optoelectronics and Lasers Caol, 9019476, (2019), pp.721-723, DOI: 10.1109/CAOL46282.2019.9019476