

ABSTRACT

thesis of Toybaeva Shara

on the topic: «Research and development of automated control system of enterprise's quality management in Kazakhstan»,
submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D070200 –
Automation and control

Relevance of the research topic. This dissertation is devoted to the development of innovative technology for automation of the enterprise quality management system in Kazakhstan and its adaptation to the enterprise management system.

The creation of a quality management system (QMS) is one of the main tasks of any enterprise in the modern requirements of expanding competition, due to its transformation into a global basis for the success and ability of the enterprise to be on the market, meeting world-class systems. Development of a QMS for an enterprise is a labor-intensive process that requires financial, technical, organizational and information resources. For companies and enterprises of Kazakhstan, the implementation and automation of QMS is a condition for entering the world market and is an indicator of competitiveness.

Quality is one of the important strategic tools in business. The task of improving business processes is the transformation of the enterprise so that the enterprise meets the requirements of modern IT and management ideology in the aspect of the process approach. Of great importance are questions on assessing the effectiveness of the QMS of an enterprise, taking into account the specifics of quality indicators, the multi-level system, as well as the need to select the optimal number of performance indicators and assessing the state of the system, which is associated with the formation of rational decisions when managing the QMS.

In this dissertation, studies are based on the works of domestic and foreign scientists, presented below.

In the field of strategic methods of enterprise management in a volatile business environment - a balanced scorecard (MPS), much attention was paid by the authors Kaplan R., Norton D., in the work "A balanced scorecard that determines the effectiveness of the organization" considered a modern way of assessing the performance of the enterprise. MTP is used to increase the efficiency of internal and external communication processes, monitoring and improving the performance of an enterprise MSP is not a tool for forming an enterprise strategy, it is used to describe an existing strategy. In the writings of Kachalov V.A. answers to questions on the development, implementation, certification, and also improvement of the QMS on environmental management based on models of such systems that are regulated in ISO 9001: 2015 and ISO 14001: 2015.

In the field of developing automation technology for enterprise quality management systems, Kazakhstan also considers one of the most common Six Sigma modern methodologies for improving productivity, which focuses on reducing the number of marriages, processes and services. In the works of Moiseeva A.V. An analysis of software applications and applications in the field of quality management

management was carried out, a review of special software distributed to improve the main stages of the organization's business process and the automation of quality management systems was performed. The paper studies the impact of IT competence on the enterprise quality management system, which will ensure greater effectiveness of the QMS program.

Information technology contributes to a change in the relationship between consumption and production, for their interaction, information exchange is necessary in order to build organization and management for both producers and consumers.

Within the framework of ontological modeling of presentation and knowledge management in the quality management system, the monograph of B. Kubekov was studied "Organization and presentation of knowledge of planned training on the basis of ontologies", which presents the methodology for modeling knowledge components based on ontological engineering, introduced new definitions. The paper presents a methodology for modeling business processes from detailed architecture design to the implementation of business logic.

In the field of the theory of management of organizational systems by VN Burkov, a model of managing organizational systems and a technology for solving the corresponding management problems are considered. The work "Control mechanisms: a multifunctional study guide" provides basic mechanisms for managing organizational systems, presents examples of designing complex management mechanisms, as well as mathematical models of the theory of management of organizational systems and their applications. Attention is also paid to the complexity of computing solutions to optimal control problems in the models of functioning active systems, effective decision-making methods are investigated, examples of control problems using "parallelization" of decision algorithms are given. Conceptual and methodological foundations of research in the field of control systems.

In the field of quality theory of qualimetry, attention is paid to the main provisions of quality management and the qualimetric approach to determining indicators and evaluating product quality, assessing the competitiveness of enterprises and the features of IT support and computer modeling of quality management tasks. In the writings of Varzhapetyan A.G. "Qualimetry" and "Control Systems. Quality Engineering" provides an analysis of the assessment of performance and quality assurance at the design stages of complex management systems. In the work of Abaldova S.Yu. attention is paid to the terminological foundations of assessing the effectiveness, as well as the effectiveness of the QMS, and several approaches to assessing the effectiveness of the QMS are analyzed.

Analysis, modeling and prediction of the stability of complex systems is based on the Lyapunov method, which was deeply developed in the works of Bellman R., Sharshenaliev Zh.Sh., Liu Conghu and others.

Possibilities of using the theory of fuzzy logic in control systems and works Zade A.L. consider in their writings Pegat A., Wang Yu (Wang, Yujie), Chen K.-S. (Chen, K.-S.), Paul J.-F. and etc.

The theoretical approach and tools for measuring the effectiveness of QMS and quality management are reflected in the works of Deming E., Shuhart U., Jurana D.M., Crosby F.B. It is also worth mentioning the research of A. Feigenbaum, who was one

of the first to propose a systematic approach to achieving quality: “Integrated quality control is an effective system that integrates all the efforts of different groups of an organization to ensure development quality, quality of maintenance, and also to improve quality, in order to the possibility of manufacturing products or providing services in the most economical way in order to fully satisfy the consumer”.

An analysis of previous scientific research in the field of quality management management systems carried out in the world related to the topic under study revealed that among a large number of works, the works of Kazakhstani scientists are closest: Ashimova A.A., Mutanova G.M., Uskenbaeva R.K.

The studies considered above are of great theoretical and practical importance. But the existence of a number of works on the topic under study does not remove the need to further develop its theoretical and methodological foundations, and practical application in a certain field. A review of the papers published on the research topic reflects that only some aspects of the study area are discussed. For example, there is no generally accepted, standardized methodology for assessing the effectiveness and efficiency of the functioning of the QMS, and many problems in this area of automation have not been resolved.

One of the reasons for this situation is the current situation, when the creation of a QMS is limited to obtaining a quality certificate, and not a real continuous improvement in the situation of the enterprise. On the other hand, there are no products on the Kazakhstan software market that facilitate the systematic maintenance of the company's QMS. Therefore, there is a need to study and adapt automated quality management systems to improve the enterprise, reducing the complexity and costs of the system.

Thus, there is a substantial reserve for scientific research on the problem under study.

In connection with the above, the development of mathematical models and design algorithms for rational innovative technology for automation of the enterprise quality management system in Kazakhstan and its adaptation to the enterprise management system is an urgent task.

The purpose of the thesis. Research and development of a methodology for automated management of an enterprise's quality management system that automates the implementation and maintenance of QMS at enterprises in Kazakhstan and integrates with the existing automated control systems for the implementation of the most important tasks arising from the State Program on Digitalization of Economic Sectors.

The objectives of the study. To achieve the objectives of the study, the following questions are solved:

- 1) analysis of the theoretical foundations, models and methods, information technology of automated enterprise quality management systems;
- 2) to develop a methodology for automated management of an enterprise quality management system based on statistical management and an intellectual information system;
- 3) substantiate and develop the architecture of an intelligent automated system for the proposed methodology for automated management of enterprise

quality management;

4) to develop appropriate algorithms and software for an information system for automated management of enterprise quality management in accordance with the standard ST RK ISO 9001: 2015.

Object of study. The quality management system of an enterprise in Kazakhstan

Subject of study. Automated enterprise quality management system

Research Methods. To solve the problems defined in the study, the following are used in the work: basic scientific principles of control theory methods, systems analysis methods, fuzzy logic theory, methods of mathematical modeling and knowledge management.

The information base of scientific work is ST RK 9001 series of version 2015 based on international ISO standards, information from official RK statistical resources, financial and analytical provisions of enterprises, periodicals on research in the field of quality management systems, monographs, Internet resources, scientific materials practical conferences etc.

Information analysis was carried out using the following tools: ECharts interactive library, special packages for the development of fuzzy models "FuzzyTech" and "MATLAB", standard data analysis tools "MS Excel", design tools Gliffy Diagram and Rational Rose.

Scientific novelty.

1) The developed methodology for the automated management of enterprise quality management based on statistical management and information technology, which differs from the existing ones by the presence of three modules: selection and calculation of estimated indicators for quantitative assessment of the company's QMS management performance, continuous monitoring and visualization of the stability of the QMS management process, and construction of fuzzy multiple models of intelligent process control.

2) The proposed architecture of an intelligent information system for the developed methodology for automated management of enterprise quality management, including the NoSQL database, facilitating work with indicators of quality management processes obtained using the ontological approach in the form of conceptual and conceptual graphs.

3) The developed base of rules and a model of intelligent automated quality management of production and business processes of an enterprise in Kazakhstan using the Mamdani fuzzy logic apparatus.

Defense provisions. The proposed methods and models of automated management of enterprise quality management and an intelligent automated system of enterprise quality management management integrated with existing ACMS subsystems, which automate the implementation and maintenance of QMS and increase the validity, efficiency and effectiveness of management decisions by automating a number of decision-making and personnel functions.

The practical significance of the work. The proposed models and automated procedures for processing information of production and business processes of the enterprise that meet international standards of reliability, quality

and the requirements of the legislation of Kazakhstan will allow achieving effective management and functioning of the QMS with minimal labor costs of the decision-maker and staff. The software and methodological solution proposed in this study is universal, corresponds to the real achievements of science and technology in the field of modern system management and control automation, and is also customizable to the technological and production capabilities of the enterprise, providing accordingly the needs of consumers for certain types of products and services.

The developed automated enterprise quality management system was implemented and tested in Innovation & Technologies LLP (Almaty), which is confirmed by the Production Test Act of 12/26/2018. The document contains a recommendation for the use of the tested automated enterprise quality management system and indicates that the cloud-based use of the system increases scalability, simplifies management and access to software and data center.

Personal contribution of the researcher. The researcher personally solved the tasks of the thesis. A comprehensive methodology has been developed for the automated management of the quality management of an enterprise in Kazakhstan. A numerical study and experimental evaluation of the proposed models and algorithms were carried out. The architecture and program of an intelligent automated enterprise quality management system management system have been developed.

The connection of the topic of the dissertation with the plans of research work. The dissertation was carried out as part of the project “Development of scientific and methodological foundations and applied aspects of building a distributed system of information support for innovation, taking into account the specific features of each of the stages of the innovation life cycle” under grant funding from the MES RK, № AP05134019, project manager Doctor of Technical Sciences, professor, chief researcher at the IICT of the RK, Utepbergenov I.T.

The practical value of the dissertation research consists in the following results: the use of algorithmic and software tools developed when creating an automated quality management system; selection and calculation of estimated indicators for quantitative assessment of the quality of the QMS of the enterprise, the construction of fuzzy-multiple models of intelligent control of production processes, and continuous monitoring and visualization of the manageability of the QMS process.

The volume and structure of the work. The dissertation contains an introduction, 4 sections of the main content, a conclusion, a list of used literature (131 sources) and 3 appendices, the total amount of work - 132 pages, 82 figures and 29 tables.

In the introduction, the relevance of the work was determined and the problems associated with the topic were shown. The idea of the work, the purpose and objectives of the study, the scientific novelty and practical value of the study, research methods are shown.

The first chapter provides an analysis of the amount of research in the world in the direction of “Quality Management”, showing stable growth and

international interest in this area. Low efficiency of QMS implementation in the absence of automated control, including in Kazakhstan, is shown. The analysis of the modern market of specialized software aimed at organizing the business processes of the enterprise, which allows us to conclude that there are a large number of software products in this area, which partially automate the QMS of the enterprise, actually supporting workflow, is carried out.

The second chapter describes the work of developing a block diagram of an automated enterprise quality management system. A technique and algorithm for the automated management of an enterprise's quality management system based on an intelligent automated system are proposed, which differs from existing computer systems for collecting and analyzing data on the quality of enterprise processes by the presence of three modules. An approach has been developed for a quantitative assessment of the effectiveness for each process of an enterprise's quality management system based on the selection and adaptation of the weighted average method, which allows taking, on the basis of the received metrics, managerial measures for the development of CD / PD, or measures to improve the QMS. The method of statistical control of enterprise processes using control cards (graphical representations) of the status of business processes based on continuous monitoring of processes based on numerical data of experts is justified. The analysis and justification of the model of intellectual quality management of production and business processes using the apparatus of fuzzy logic Mamdani.

The third chapter shows the stages of the algorithm developed in chapter 2 and the calculated values for assessing the performance indicator of the QMS of the Innovation & Technologies LLP company and the need to develop preventive actions to analyze the occurrence of possible risks. The implementation of the algorithm for calculating statistical process control in Innovation & Technologies LLP using control cards developed in chapter 2 is shown, which shows that automated control processes using an intelligent information system by enterprise quality management are effective and are maintained within the specified limits of statistical controllability. The stages and possibilities of obtaining quantitative estimates of processes are shown in the model of intellectual quality management of production and business processes developed in Chapter 2 using the Mamdani fuzzy logic apparatus at the enterprise - Innovation & Technologies LLP. Using the program for viewing the surface of a fuzzy model, the adequacy of the constructed model and the influence of input variables on the output variable were proved.

In the fourth chapter, using the obtained results of scientific and practical studies described in previous chapters, the architecture of an intelligent automated enterprise quality management system (IAE QMS) is justified and built, for which the option of organizing a NoSQL database with MongoDB technology is selected that improves the ability to work with indicators and formalization of the quality management processes obtained, using the ontological approach in the form of conceptual and conceptual graphs. The stages of the IAE QMS configuration process at the enterprise are developed and described. The results of the introduction and testing of IAE QMS for 1.5 years at Innovation & Technologies LLP (Almaty) are shown, a recommendation is given for the use of the tested

automated enterprise quality management system.

In conclusion, the main results and conclusions of the dissertation are given and their relationship with future work is indicated.

Reliability level and testing results. The validity and reliability of the study correspond to the substantiated responsibilities of the task, the analysis of the criteria and the state of research in this area, a large number of experiments and their successful implementation in practice. The results of the dissertation were discussed and reported at the following scientific and methodological conferences:

1. International conference on modeling, simulation and applied optimization ICMSAO'15 (Turkey, 2015)

2. 9th International Conference on Application of Information and Communication Technologies -AICT2015 (Rostov-on-Don, Russia October 14-16, 2015)

3. II International Scientific Conference "Computer Science and Applied Mathematics" ("Computer science and Applied Mathematics"), (Almaty, 2017)

4. Conference "Actual issues of the development of science in the world", (Russia, Moscow, April 27 - 28, 2017)

5. II All-Russian scientific and technical conference with international participation. V.V. Gubareva, "Intelligent analysis of signals, data and knowledge: methods and means" (Novosibirsk, 2018)

6. XIV international Asian school-seminar "Problems of optimization of complex systems" (Cholpon-Ata, Kyrgyzstan, 2018).

7. International scientific conference IITT MON RK "Modern problems of informatics and computational technologies" (Almaty, 2018)

8. ICIT 2019: Recent Research in Control Engineering and Decision Making. Conference proceedings ICIT 2019 (Saratov, Russia, February 7-8, 2019)

9. Materials of the III international scientific conference "Informatics and Applied Mathematics" (September 26-29, Almaty, 2018)

10. International scientific-practical conference "Innovative IT and Smart-technologies" dedicated to the 70th anniversary of Professor Utepbergenov I.T. (Almaty 2019)

On the topic of the dissertation, 17 articles were published and 1 copyright certificate was obtained:

1. Utepbergenov I.T., Kalimoldaev M.N., Skliarova I.V., Toibayeva Sh. D., Muslimova A.K., Issabekova L.S. Intelligent management system of production and quality products for the small and medium business enterprises // *Przegląd Elektrotechniczny* (Poland), 2018. №1. – P. 152-156

2. Utepbergenov I.T., Baizylidayeva U.B., Buranbaeva A.I., Toibayeva Sh.D. The statistical research of problems of information support for innovative activity of enterprises in Kazakhstan// *Journal of Theoretical and Applied Information Technology*. - 2019. № 2(97), - P. 628-632.

3. Uvalieva I., Garifullina Z., Utegenova A., Toibayeva S., Issin B. Distributed information-analytical system of educational statistics //International conference on modeling, simulation and applied optimization «ICMSAO'15», Turkey, 2015. - C. 1-4.

4. Uvalieva I.M., Utegenova A.U., Toibayeva Sh.D. Mathematical Basis and Information System Software for Educational Institutions Ranking // 9th International Conference on Application of Information and Communication Technologies AICT2015, Rostov-on-Don, 2015. - P.594-599

5. Муслимова А.К., Утепбергенов И.Т., Склярва Ю.В., Тойбаева Ш.Д. Формализация анализа функционирования и эффективности СМК для экспертной системы // Вестник КазНУ. Алматы, 2016. – №3/1 (90). – С. 87-96.

6. Утепбергенов И.Т., Тойбаева Ш.Д., Утегенова А.У., Муслимова А.К. Применение автоматизированных систем и методология расчета основных показателей эффективности (КРІ) для обеспечения устойчивого развития в предприятия// Вестник КазНИТУ, Алматы, 2016. - №5(117), - С. 501-507.

7. Утепбергенов И.Т., Хисамиев З.Г., Тойбаева Ш.Д., Исабекова Л.С., Модель интеллектуальной системы управления камерой хлебопекарной промышленности// Вестник КазНИТУ - Алматы, 2017г. №4(112). – С. 342-346

8. Медянкина И.П., Бобров Л.К., Тойбаева Ш.Д., Нургулжанова А.Н. Сравнительный анализ состояния информационного обеспечения инноваций в России и Казахстане// Вестник КазАТК, 2018. №4 (107). –С. 239-246.

9. Тойбаева Ш.Д. Влияние автоматизации на системы менеджмента качества предприятий// XIV Междунар. школа-семинар. - Кыргызстан, Иссык-куль, п. Кара-ой, 2018. – С. 257-261

10. Утепбергенов И.Т., Тойбаева Ш.Д., Буранбаева И.Т., Коржаспаев А.Е. Подход статистическому исследованию проблем информационного обеспечения инновационной деятельности предприятий в Казахстане // Матер. научн. конф. ИИВТ МОН РК «Современные проблемы информатики и вычислительных технологий». Алматы, 2018. – С. 298-306

11. Бобров Л.К., Медянкина И.П., Тойбаева Ш.Д., Исабекова Л.С. Инновационное качество с новыми инновационными инструментами// Материалы III международной научной конференции «Информатика и прикладная математика», Алматы, 2018. - С.213-220

12. Утепбергенов И.Т., Тойбаева Ш.Д., Муслимова А.К., Исабекова Л.С. Нечеткая модель менеджмента качества технологических процессов пищевого производства// Международная научная конференция «Информатика и прикладная математика», Алматы, 2017. Ч.П. - С.374-388.

13. Утепбергенов И.Т., Хисамиев З.Г., Тойбаева Ш.Д., Исабекова Л.С., Intelligent oven control system in bakery production// Конф. «Актуальные вопросы развития науки в мире» М. «Евразийское Научное Объединение», 2017. №4(26). –С. 62-65

14. Utepbergenov I., Bobrov L., Medyankina I., Rodionova Z., Toibayeva Sh.D. About the Concept of Information Support System for Innovative Economy in the Republic of Kazakhstan// Recent Research in Control Engineering and Decision Making. ICIT 2019 Conference proceedings – Springer, Cham, 2019. Vol. 199. – P. 515-526

15. Waldemar W., Kubekov B, Naumenko V., Narynov S, Toibaeva S., Utegenova A, A.Project - Competency based approach and the ontological model of knowledge representation of the planned learning// INTL Journal of electronics and

telecommunications, 2018. V.65, № 1, - P. 45-49

16. Утепбергенов И.Т., Бобров Л.К., Медянкина И.П., Родионова З.В., Тойбаева Ш.Д. О концепции создания системы информационной поддержки инновационной деятельности в Республике Казахстан// II Всероссийская научно-техническая конференция с международным участием им. В. В. Губарева, «Интеллектуальный анализ сигналов, данных и знаний: методы и средства», г. Новосибирск, 2018г.

17. Тойбаева Ш.Д., Баймухамбетова М.К., Корнаков А.В. Автоматизированные системы управления менеджментом качества, в условиях цифровизации// Международная научно-практическая конференция «Инновационные IT и Smart-технологии», посвященная 70-летию юбилею профессора Утепбергенова И.Т., Алматы, 2019. – С. 242-250

18. Тойбаева Ш.Д., Утепбергенов И.Т., Корнаков А.В. Свидетельство о внесении в государственный реестр прав на объекты, охраняемые авторским правом «Автоматизированная система управления менеджментом качества предприятия» №3129 от 03 мая 2019 года