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INTEGRATION OF A QUALITY MANAGEMENT SYSTEM (QMS) IN MANUFACTURING: ENHANCING EFFICIENCY AND PROCESS STANDARDIZATION

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ABSTRACT

The article discusses the role of Quality Management Systems (QMS) in manufacturing processes, with a focus on improving efficiency and standardization. The integration of QMS with other corporate systems, such as Enterprise Resource Planning and Manufacturing Execution System, is emphasized, enabling effective quality control throughout the production process. Principles such as customer orientation, process approach, and continuous improvement, as well as international standards like ISO 9001, are examined. Successful QMS implementation examples from large companies are provided, demonstrating the effectiveness of the standardization process within QMS.

KEYWORDS: *Quality Management Systems (QMS), integration, standardization, Enterprise Resource Planning, Manufacturing Execution System, ISO 9001.*

INTRODUCTION

The modern production firms are in the era of increasing competition, where efficient operations are becoming the causes of success. The quality control is not only becoming the way to achieve it but also the strategy route indicating the long-term competitiveness of organizations. Amongst the most widespread means of dealing with the problems pertaining to quality are the adoption of quality management systems (QMS). It is a set of processes, means and methods employed to ensure that products are up to specified standards. Scientific curiosity about QMS stems from the fact that it ensures standardization of processes, reduces the cost of production and improves customer satisfaction. Theoretical foundation of QMS exists in fundamental management principles like customer focus, process approach and continuous improvement, which are the pillars to build and implement a systematic approach to quality management.

The aim of this paper is a theoretical study of the role of QMS in integration with other aspects of production management. Particular attention is paid to the relationship of QMS with such systems as ERP (Enterprise Resource Planning) and MES (Manufacturing Execution Systems), as well as theoretical justifications for the effectiveness of standardization.

MAIN PART. ASPECTS OF QUALITY MANAGEMENT

Quality management is a complex process that includes not only organizational and technological aspects but also principles that guarantee stability, development, and improvement in all levels of production activities. One of the key elements of quality management theory is the principle of the **process approach.** According to this principle, an organization should be treated as a system of interrelated processes, where each process influences the results of the whole enterprise. The strategy of quality management at the process level allows control of the inputs and outputs with minimum risk of defects and deviation from the standard.

One of the important components is the **principle of customer orientation**, which in the context of globalization and highly competitive markets is acquiring special significance. According to many studies, an organization that focuses on customers' needs and tries to make their expectations correspond to real facts increases its competitiveness and retains customers. In particular, in the USA, **Ford Company** actively applies an approach focused on meeting customer requirements that contributes not only to the increase in market share, but also to strengthening of the brand in the international arena [1]. Consumer expectations turn into the main criterion according to which the success of the QMS is estimated.

The second important aspect is continuous improvement. This principle is expressed by using techniques such as the **Deming Cycle** (Plan – Do – Check – Act, PDCA), which includes planning, doing, checking and adjusting processes. It provides a basis for continuous improvement of all production processes and products. The use of this approach provides corporations with room to adapt to external environment shifts and internal realignments,

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such as technological innovations or policy reform. For example, **General Electric** uses its proprietary development Proficy. Software written on the basis of PDCA principles and integration of MES. The system allowed the manufacturer to reduce inspection costs by 40%, and the beverage manufacturer to reduce the downtime of the bottling line by 39% [2].

The basis for integrating these theoretical principles is the implementation of **quality standards** such as **ISO 9001**, which are internationally recognized. These standards provide a structured approach to quality systematization, describing requirements for process documentation, control methods, and evaluation of results (fig. 1).

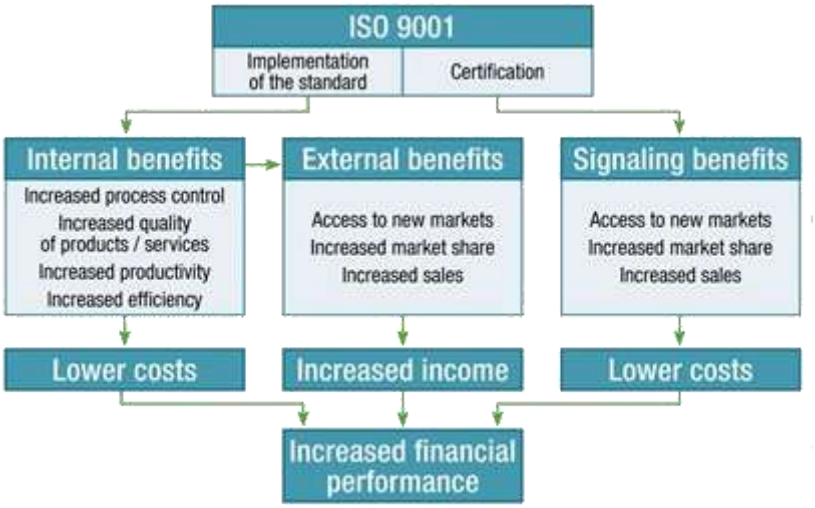

Figure 1. Relationship between ISO 9001 and financial performance [3].

Their application allows organizations to create a clearly defined system of criteria assessing quality and further development. One should also notice that the standards contribute not only to the improvement of product quality but also to an increase in trust on the part of consumers and partners, which turns into a decisive factor in the establishment of long-term business relationships.

In quality management, various analysis tools and methods are distinguished, such as statistical process control (SPC), the **Six Sigma** method, and others. Based on statistical data, all these tools enable the identification of deviations in the process, predict possible defects, and minimize them. The implementation of such methods requires from an organization not only professional knowledge and experience but also the implementation of advanced technologies for data collection, analysis, and interpretation. They actively function in the USA for industries such as automotive manufacturing, where accuracy and compliance to set standards are paramount to ensuring product quality and safety [4].

The theoretical bases of quality management, in such a way, are to be seen as a multilevel system of principles and tools that provide the organization with a stable process of continuous improvement, compliance with customer requirements, and efficient use of resources. Technological and organizational innovations, together with the application of international standards, are organic parts of the successful implementation of quality management theory in practice.

INTEGRATION OF QMS INTO PRODUCTION SYSTEMS

Implementation of QMS in production systems is a complex process of interaction of various factors to reach efficiency, reduced defects and optimization of work processes. In theory and practice of quality management, QMS is not only viewed as an autonomous system, but as an organic part of an integrated system of enterprise management, such as resource management, manufacturing flows and structures. The most significant aspect of introducing QMS to production systems is the potential to reconcile current production processes and the requirements of the quality standard harmoniously.

Among the fundamental requirements of successful integration are the application of information technology and automated systems of monitoring and quality control at each production stage. These include **ERP** and **MES** kind systems, not only providing resources and process management, but which also provide quality data integration at all levels. ERP systems provide centrally maintained product quality information, whereas MES provide for

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quality monitoring and control in real-time, necessary for intervention at the right time in the event of variations (table 1).

Table 1. The role of technologies in supporting the QMS system [5, 6].

Technology	Role in QMS	Advantages	Restrictions
ERP	Centralized process management, data integration across all areas of the enterprise.	Automation of processes, improved coordination between departments, improved accounting and quality control.	High costs of implementation and support, difficulty in customizing for specific needs.
MES	Operational monitoring and management of production processes, quality control at every stage.	Real control over the production process, reduction of defects, prompt response to problems.	Need for integration with other systems, high cost of implementation.
Big Data	Processing and analysis of large volumes of data to predict defects and identify patterns.	Forecasting problems, analyzing quality trends, optimizing production processes.	Requires significant computing resources, data quality issues for analysis.

The implementation of these systems within the framework of QMS integration allows for a significant increase in flexibility and accuracy in decision-making. For example, **Intel** uses such systems to integrate quality control in its production chain. Among other things, it has developed a special **OpenVINO** application, which allows for prompt response to possible defects and deviations, minimizing production losses [7].

No less important is the synchronization of quality standards and production processes. Within the framework of QMS integration, it is necessary to take into account the specifics of production, the size of the company and the degree of automation. QMS, such as ISO 9001, are incorporated into the organizational structure, which allows not only standardizing processes, but also optimizing them for the specific production conditions. The combination of all these principles within a single system allows for decreasing the rework cost of products and speeding up the new product development process.

QMS integration process also requires addressing the issue of **quality culture** at all business levels. Unless there is active worker participation, their involvement in quality improvement and developing right benchmarks, integration cannot be achieved effectively. Involving workers in quality monitoring and improvement processes through feedback, training and use of modern analytical tools makes the whole organization efficient. Additionally, it is required to consider that the quality culture must be implemented at all levels: from top management to operational personnel, which must be accordingly trained.

An important aspect is also the use of data analysis methods to evaluate the efficiency of QMS integration into production systems. Modern technologies for processing big data and SPC allow not only to track current indicators, but also to predict possible problems before they arise. The use of such methods allows to identify patterns that could remain unnoticed with the traditional approach to quality control.

The integration of QMS into the production system should therefore be done holistically, involving information technology, adaptation of quality standards, development of quality culture, and introduction of analytical methods. This approach secures compliance of products not only with international standards but also provides significant improvements in production efficiency and process sustainability.

IMPROVING EFFICIENCY THROUGH STANDARDIZATION AND QUALITY MANAGEMENT

Among the most important aspects of QMS implementation in production systems is the ability to standardize processes, which increases the efficiency of the enterprise manyfold. Standardization is not only a tool for quality assurance but also a powerful driver of improvements at all levels, from operational to strategic. It enables you to integrate the work processes, reduce errors and variations, and promotes better collaboration among various departments and vendors.

The most important activity in the process of standardization is the definition of the **key performance indicators (KPI)** enabling tracing and monitoring the results of QMS implementation. Standardization of these indicators at all stages of production contributes to a decrease in the variability of processes and enhances the predictability of the results [8]. In particular, standardized methods of quality control can be implemented by an organization in order to reduce the percentage of defective products. For example, **Boeing** applies standardized KPI in its Quality

Management System (QMS) to maintain rigorous oversight of its aircraft manufacturing processes. By using uniform quality control practices, the company has enhanced process predictability and reduced variability, contributing to higher safety and reliability standards in its products.

As mentioned earlier, another critical feature contributing toward enhanced efficiency with regard to standardization is management based upon best practice models, namely the **Six Sigma** model which focuses on reducing the amount of variability and defects. This system is already actively used by **Motorola Corporation**, which, with the help of **Six Sigma**, has managed to increase significantly the quality and substantially reduce production costs [9]. The application of this methodology in different types of manufacturing industries has become possible due to standardization of processes and methods of data analysis, which allow not only improving quality but also increasing general production efficiency.

In addition, process standardization helps optimize resource consumption. When work and control processes are standardized, it becomes possible to more accurately predict resource requirements, which minimizes their unnecessary use. This, in turn, helps companies achieve significant reductions in production costs.

An important aspect of increasing efficiency through standardization is also **continuous improvement of processes**. In the context of standardization, the methods are the PDCA cycle. Standardization makes these improvements not only more structured, but also more predictable, which reduces the time for taking corrective measures. Importantly, standardized processes open up opportunities for benchmarking, which allows comparing the organization's efficiency with the best global practices and implementing these methods for further improvement.

Thus, standardization of processes through a QMS becomes the most important tool for increasing efficiency. It allows minimizing deviations, improving resource management, reducing production losses and increasing product quality. Examples of such successful implementations in large companies demonstrate that standardization within the QMS not only contributes to quality improvement, but also helps to achieve high economic results and improve overall production efficiency.

CONCLUSION

Integrating QMS into production processes is an important step towards improving efficiency and standardization. Using QMS helps reduce production costs, minimize defects and deviations, and improve interaction between different departments and partners. Implementing tools such as the PDCA cycle, ISO 9001 systems, Six Sigma methodology allows organizations to achieve high product quality, improve production efficiency, and improve process sustainability.

Successful examples of companies such as Boeng, Motorola, General Electric, Ford, Intel show that process standardization and continuous improvement are the most important factors contributing to the reduction of defects, optimization of resource consumption and cost reduction. An important component of QMS integration is the use of information technologies and analytical methods for monitoring and analyzing data in real time, which allows for prompt detection and elimination of deviations in the production process. In general, the implementation of a QMS in production not only improves the quality of products, but also contributes to the achievement of high economic results, ensuring long-term competitiveness of enterprises in the market.

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