World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:9, No:8, 2015

Technical Determinants of Success in Quality Management Systems Implementation in the Automotive Industry

Agnieszka Misztal

Abstract**—**The popularity of quality management system models continues to grow despite the transitional crisis in 2008. Their development is associated with demands of the new requirements for entrepreneurs, such as risk analysis projects and more emphasis on supervision of outsourced processes. In parallel, it is appropriate to focus attention on the selection of companies aspiring to a quality management system. This is particularly important in the automotive supplier industry, where requirements transferred to the levels in the supply chain should be clear, transparent and fairly satisfied. The author has carried out a series of researches aimed at finding the factors that allow for the effective implementation of the quality management system in automotive companies. The research was focused on four groups of companies: 1) manufacturing (parts and assemblies for the purpose of sale or for vehicle manufacturers), 2) service (repair and maintenance of the car) 3) services for the transport of goods or people, 4) commercial (auto parts and vehicles). The identified determinants were divided into two types of criteria: internal and external, as well as hard and soft. The article presents the hard – technical factors that an automotive company must meet in order to achieve the goal of the quality management system implementation.

Keywords**—**Automotive industry, quality management system.

I. Introduction

THE global automotive market is currently made up of 40 countries producing passenger and commercial vehicles. In 2009, Japan ceased to be a long-standing leader in the production of vehicles in the world. China has expansively invaded the market (22.1 million cars produced in 2013), which is two times the achievement of car production in the United States (11.1 million). For the last three years, Japan has been in third place as a player in the automotive market (9.6 million) [1]. The widely understood automotive industry plays an especially important role in industry. This is evident in the creation of employment, new investments and the gross income of the economy. Between the automotive industry and the other sectors of the economy, there are important links related to the maintenance of vehicles, the business sector, road transport, sale of fuel, or even construction of road infrastructure.

A. Misztal is with the Poznan University of Technology, Faculty of Engineering Management, 60-965 Poznan, ul. Strzelecka 11, Poland (e-mail: agnieszka.misztal@put.poznan.pl).

II. Requirements of Quality Systems Standards for the Automotive Industry

For over two decades quality management in organizations is based on the model of the ISO 9001. With each passing year this standard becomes more and more popular, and the number of its certified implementations around the world a few years ago exceeded one million. However, the universality of the ISO 9001 has made it necessary to develop a number of standards specifying requirements in selected sectors of the economy. This also applies to the automotive industry.

A. ISO 9001

The quality management model according to the requirements of ISO 9001 is based on a process and system approach. The result is that quality management involves managing the processes identified in the company and relations that occur between them. With regards to these processes, requirements are defined for the supervision of documentation and records and to monitor any incompatibility. Defined are typical management activities such as maintaining quality policy and objectives, system documentation, appointing a management representative, conducting corrective and preventive actions, audits and management reviews. Also specified are the requirements for human and technical resources and the work environment. With regard to the main processes, requirements are specified for product realization planning, design, procurement and supervision of the realization process [2].

The amendment to ISO 9001 planned for 2015 is assumed to introduce additional requirements, such as [3]:

– risk management - company's risk management will play a key role in almost all of the chapters in the standard (from corporate planning, business processes, internal audits through to supplier management); analysing risks is also linked to opportunities for the company, which should be used;
– stakeholder approach - sustainable corporate management can only be implemented if the needs of all of the stakeholders can be included;
– process approach - process management relates to recognising the workflows in the company, but also to managing the workflows in a more specific manner;
– documentation will become more flexible; records and documents will become so-called „documented information";

- knowledge management - the requisite expertise has to be recognised, obtained, secured, and passed on internally;
- leadership-corporate management tasks are being expanded, in particular with a greater focus on the mentoring function.

B. ISO/TS 16949

With respect to the general requirements of ISO 9001, major vehicle manufacturers have developed their own specific requirements for outsourced factories and suppliers of components (QS 9000, VDA 6.1, AVSQ, EAQF). As a result of convergence between these standards, the international ISO standardization body has developed a new set of requirements to reflect the experience and standard requirements of the automotive industry suppliers.

The purpose of the Technical Specification ISO/TS 16949 is the development of a quality management system that provides continuous improvement, with a particular emphasis on the prevention of errors and reducing variation and reducing the amount of waste in the supply chain.

Along with explanatory content the main updates to ISO 9001 contained in ISO/TS 16949 include [4]:

- specification of supervision over technical documentation (p. 4.2.3.1),
- specification of requirements regarding competence in the design of the product (p. 6.2.2.1)
- specification of requirements regarding training (p. 6.2.2.2 - 6.2.2.4),
- clarification of overseeing infrastructure and contingency plans (p. 6.3.1 - 6.3.2),
- emphasis on the need to define the criteria for product acceptance, confidentiality and management of changes in planning product realization (p. 7.1.1 - 7.1.4),
- interdisciplinary approach to design (p. 7.3.1.1), clarification of input data (p. 7.3.2.1 - 7.3.2.3) and output data (p. 7.3.3.1 - 7.3.3.2) for design and a program of a prototype to validate the design (p. 7.3.6.2),
- supplier assessment methods (p. 7.4.3.1),
- development and maintenance of control plans, maintenance of documented work instructions, verification of settings, preventive maintenance, production instrumentation management, production scheduling, communication regarding maintenance (p. 7.5.1.1 - 7.5.1.8),
- analysis of measurement systems according to ISO 10012 and laboratory requirements (p. 7.6.1 - 7.6.3),
- need to use statistical methods (p. 8.1.1 - 8.1.2),
- specification of monitoring and measuring of production processes (p. 8.2.3.1),
- specification of monitoring and measuring of products (p. 8.2.4.1 - 8.2.4.2),
- specification of supervision of the nonconforming product (p. 8.3.1 - 8.3.4).

In addition, the ISO/TS 16949 specification was developed together with supporting documents, such as guidelines for the implementation, IATF rules, specific customer requirements, checklist as well as basic tools: APQP, PPAP, FMEA, MSA, SPC [5].

C. Other Standards

With regard to the nature of automotive companies with no production, at the moment there is no developed international quality management system standard dedicated to them. In response to the demand for specify the requirements of ISO 9001, the **EN 12507:2005** *Transportation services. Guidance notes on the application of EN ISO 9001:2000 to the road transportation, storage, distribution and railway good industries* standard was established. It contains guidelines for solving problems that can occur during the introduction of a quality management system according to ISO 9001 for transport organizations that do not have experience in the application of the system for the shipping market. Attention was drawn to the need to comply with the law relating to transport, such as European Regulation or ADR Directive. It also identifies examples of quality records specific for transport services. Much attention is focused on a review of the requirements related to the implementation of the service (quotations, transport agree- consignment notes). Also given are examples of providers of services and products for the needs of transport services, which must be taken into account when implementing purchases. It also refers to the validation of the process, which for transport services can be temperature controlled storage/transportation, load bearing and structural welding. It also clarifies the requirements for identification and traceability and customer property. The standard does not introduce any additional requirements; it has an explanatory nature and is not subject to certification [6].

For the purpose of quality management system certification of transport companies transporting dangerous materials, an additional standard has been developed – **EN 12798:2007** *Transport quality system. Road, Rail and Inland navigation transport. Quality management system requirements to supplement EN ISO 9001 for the transport of dangerous goods is with regard to safety.* It sets out to supplement requirements of ISO 9001. The standard draws attention to the need to update knowledge of the changes in legislation, about the product and technology in terms of safety. It also raises the issue of medical oversight of transport personnel, including the obligation to temporary staff. With regard to the purchase of services for transport services, highlighted is the need to ensure an adequate level of safety, especially for tank cleaning services. In the realm of supervision of the service, new requirements are added for the management of personal protective equipment and their use, maintenance of means of transport and equipment for loading and unloading. Also added are the requirements for securing load during loading and unloading (using proper equipment, precautionary measures, and verification), providing conditions for transport and cleaning of loading space. With regard to the identification of product, it is indicated that the company should have a system for monitoring the distribution of load, details concerning loading and loading units. It also identified the requirements for carrying out periodic inspections of tanks and installations [7].

Fig. 1 presents reference documents which form the basis of quality management system certification of companies from different areas of the automotive industry.

The number of specific supplements for production in the automotive industry indicates the need to specifically treat this group of companies as a group which should be subject to appropriate selection in terms of ability for future fulfilment of the prescribed standard requirements of quality systems.

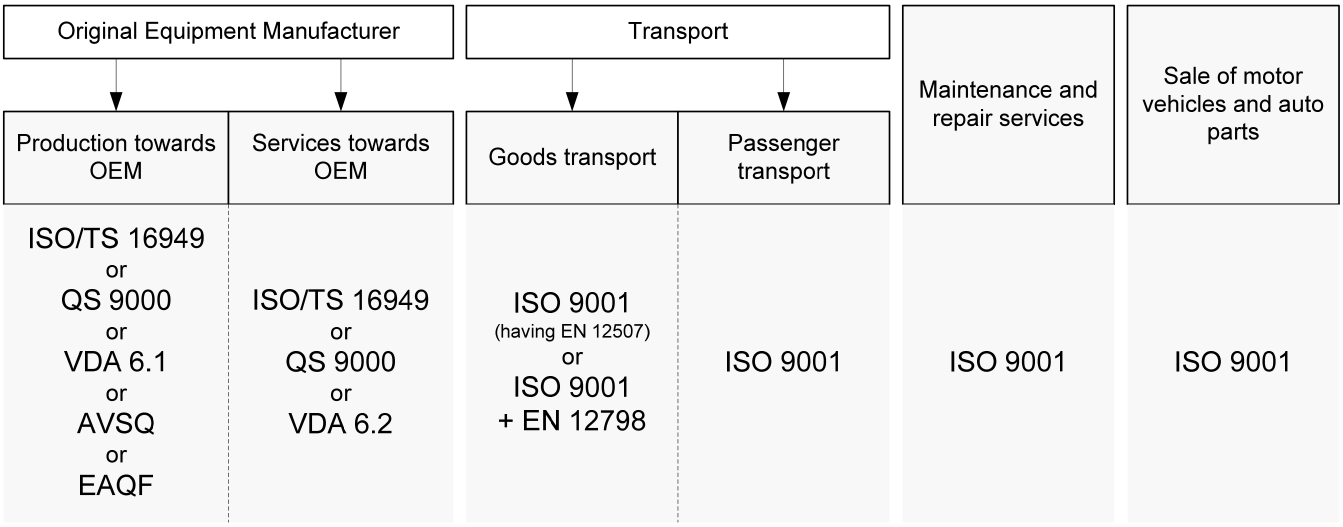

Fig. 1 Reference documents for the certification of quality management systems in the automotive industry

III. Empirical Research

The aim of the empirical study was to evaluate company performance characteristics and the consequences of these conditions in selected areas of quality management. The study was conducted in 30 small and medium-sized automotive enterprises with a certified quality management system for at least three years.

The research was focused on four groups of companies as follows:

- manufacturing (parts and assembly for the purpose of sale or for vehicle manufacturers),
- service (repair and maintenance of the car),
- services for the transport of goods or people,
- commercial (auto parts and vehicles).

The study was based on the use of so-called apagogic proof (elenctic/refutative, proof by contradiction). Apagogic proof method relies on a claim of denial of the allegation to be proven [8]. If from a false claim, one concludes a contradiction, then it is therefore considered that the claim is true. With the same reasoning one applies the following rule of proof:

$$[\sim p \Rightarrow (q \wedge \sim q)] \Rightarrow p \quad (1)$$

If the claim is an implication $p \Rightarrow q$, to prove it by bringing to absurdity, one should use the rule:

$$[(p \wedge \sim q) \Rightarrow (r \wedge \sim r)] \Rightarrow (p \Rightarrow q) \quad (2)$$

It is assumed then that $(p \wedge \sim q)$ is true, and to try to deduce a contradiction. Then the implication is considered true.

Apagogic proof also includes the use of evidence based on the law of contraposition:

$$(p \Rightarrow q) \Leftrightarrow (\sim q \Rightarrow \sim p) \quad (3)$$

Instead of proving the simple claim $p \Rightarrow q$, one strives to prove to the contrary claim $\sim q \Rightarrow \sim p$, which is equivalent to the simple one.

The research method of searching for a contradiction to claims was the Delphi method. The input data for the experts were the results of direct interview, auditing quality management system and access to documentation and quality records.

During the study plenty of evidence was collected which demonstrated that the factors studied are an indispensable factor in quality management and company management in general. However, it also collected a set of examples of unstable situations and their unambiguous negative consequences.

The identified determinants were divided into two types of criteria towards:

1) the scope of impact as follow:
   - internal,
   - external,
2) materiality dimension as follow:
   - hard (technical, materially defined, easily measurable),
   - soft (behavioural, often difficult to materially determine and quantify).

The combination of negative manifestations in selected technical areas of the company with negative consequences or barriers to the implementation of the quality management system is shown in Table I.

The results of the empirical study, which confirmed a direct impact of selected elements on the success of implementation of a quality management system, allowed for the development of a boundary criteria model for the implementation of the system.

TABLE I
EXAMPLES OF TECHNICAL SHORTCOMINGS AND THEIR CONSEQUENCES IN QUALITY MANAGEMENT

Areas	Examples of shortcomings	Consequences
state of infrastructure	- buildings unfit to protect and power the processes, - unsatisfactory traits of machinery and equipment, - high degree of wear of machinery / means of transport, - poor technical condition of machinery and equipment / means of transport	- lack of or inadequate insurance of product conformity, - inability to meet all the quality parameters of the product, - need to make corrections to the product, delay in implementing, - lack of full implementation of the transport service, - damage to product during transport LACK OF EFFECTIVE QUALITY MANAGEMENT
level of maintenance sophistication	- irrational exploitation of machinery and equipment / means of transport, - lack of a predictive approach, - lack of regularity in servicing of machinery and equipment / means of transport	- stops, delays in implementation of production, - failures during transport, lack of timely execution of services LACK OF EFFECTIVE QUALITY MANAGEMENT
level of technology, degree of service sophistication	- highly specialized production technologies, - workshop services requiring highly specialized maintenance and control equipment, as well as the imposition of the manufacturer's procedures, - comprehensive transport services of a wide range, transport of loads sensitive to mechanical energy, alive or dangerous, heavy or oversized loads	- need for highly specialized staff, - need to provide detailed implementation instructions, - need to develop a specific quality control manual EXPANDED PATH OF QMS IMPLEMENTATION REQUIRING THE PREPARATION OF INDIVIDUAL DOCUMENTATION
scope of the system	- customer property is part of the process, - processes requiring validation are performed, - design is implemented, - identification and traceability of the product is required	- required activities related to the supervision of client property, - required process validation activities, - required activities related to identification and traceability, - preparation of documentation, adaptation actions EXPANDED PATH OF QMS IMPLEMENTATION REQUIRING THE PREPARATION OF INDIVIDUAL DOCUMENTATION
place in the supply chain	- first order supplier for the automotive manufacturer assumes responsibility for the functioning of the previous links in the chain	- need to monitor product quality of earlier links in the chain, - preparation of documentation, adaptation actions EXPANDED PATH OF QMS IMPLEMENTATION REQUIRING THE PREPARATION OF INDIVIDUAL DOCUMENTATION
degree of complexity of main processes	- specific and unique requirements of customers, - wide range of existing regulatory requirements and standards, - very demanding expected level of quality, - specialized and sophisticated methods and technologies of product development, - multi-operational production / services processes	- individual planning of completing the order, - need to develop specific rules for meeting the requirements regarding the product, - increased supervision of operations and activities in between operations EXPANDED PATH OF QMS IMPLEMENTATION REQUIRING THE PREPARATION OF INDIVIDUAL DOCUMENTATION
order	- lack of order in the workplace, - absence of an employee disrupts the continuity of the work, - no set rules for correct performance of operations	- reduced ability to meet all the quality parameters by the product, - delay in the implementation of production / services LACK OF EFFECTIVE QUALITY MANAGEMENT
level of data processing and analysis	- lack of data collection for the needs of viewing the situation, - lack of data analysis for awareness of the status quo, - lack of applications supporting data analysis	- lack of full knowledge about the products and services, - making wrong decisions, - no basis for continuous improvement NEED FOR ADJUSTMENTS DURING QMS IMPLEMENTATION
approach to technological innovation	- lack of any modifications to improve the quality of workmanship, - lack of motivating employees to generate rationalizing ideas, - lack of involvement of employees in the implementation of changes, - lack of tracking changes in customer requirements or standards of suppliers, - lack of participation in trade fairs, trade exhibitions, etc.	- non-compliance with the idea of continuous improvement, - risk of not keeping up with market demands DIFFICULTIES IN QMS IMPLEMENTATION, NEED FOR CHANGE OF APPROACH

IV. TECHNICAL DETERMINANTS OF SUCCESS OF QMS IMPLEMENTATION

The implementation of the quality management system according to the standards calls for both technical and organizational preparation, as well as mental, among the employees. There are no statistics on the number of companies planning to implement a quality management system that has not coped with this challenge. Yet it is known that there are companies which in the stages of preparation and first decisions (often after the so-called pre-audit), resigned from the implementation of the assumed solutions. The rationale for withdrawal from the implementation of the quality system is the realization that the use of a quality system means not only saving and applying procedures, but also highlighting positive behaviour regarding the client and regarding the quality of the product, which exist in the company, regardless of the functioning system. This is why quality management is treated as an interdisciplinary science. It is based on knowledge of the technology and operation of machinery, maintenance, metrology, logistics, statistics, human resources management and so on.

This multiplicity of issues means that the entrepreneur implementing a quality management system is faced with the decision to take the necessary measures to adapt the current state of functioning of the various areas to reach a desired state. It may happen that the changes are required in difficult or impossible elements in the reality of the given company. Important here are the necessary for engagement financial resources, technological capabilities, technical and also cultural conditions (mental habits of employees and managers/owners) and qualifications. Apart from this, one should also take into account external conditions affecting the company, such as specificity of the industry, standardization state and societal pressures. This multiplicity of conditions can be arranged in a certain set of boundary criteria. The technical part shall consist of such issues as:

- state of infrastructure,
- level of maintenance sophistication,
- level of technology, degree of service sophistication,
- scope of the system,
- place in the supply chain,
- degree of complexity of main processes,
- order,
- level of data processing and analysis,
- approach to technological innovation.

Machinery, apparatus and equipment directly impact the performance of individual operations. The correctness of their operation depends on their properties such as: usefulness of technology, structural system, ratings, instrumentation, strength, accuracy of performance, safety of operation, ergonomics, and the degree and extent of automation [9]-[17].

The essence of maintenance is proven by the awareness that aging processes of a machine are irreversible changes, lead to deterioration of strength and interoperability of the various elements [18]. These changes are the direct result of the use of equipment and one cannot stop this process. But there should be awareness that the state of the machine can be observed and diagnosed, which will predict its continued viability. Currently the industry operates in the fourth phase of maintenance orientation, which is predictive maintenance assuming a risk analysis, preventive inspections, condition monitoring of technical condition, the role of equipment and machinery operators in maintenance, the use of TPM and RCM methods, 5S and independent surveys [19], [20].

A significant part of the technology used in the automotive industry is metal processing, due to the selection of materials for engine parts, transmission, exhaust, steering, chassis, suspension and amortization, brakes and bodywork. Part of the process is the processing of rubber and plastics. Also participating in the automotive industry is the production of glass and finishing elements, for example, upholstery. Performing such technological operations that require the employment of skilled operators and the use of a specialized infrastructure is a kind of barrier to the effective implementation of the quality management system due to the number of specific requirements.

The scope of transport services should be considered on many levels. The basic criterion for its division is the type of transport, type of load, load size and the frequency and extent of realized routes, but also the body type of the transport vehicle, freight transport susceptibility, the scope of the provision of services (private or public), as well as the frequency and repetition of the range of services.

With regard to the scope of the quality management system, the possibility of exclusion of the requirements p. 7 of ISO 9001 makes it so that virtually the entrepreneur collects arguments stating that the given requirement does not apply due to its lack of use. Controversial requirements that are excluded by the arguments of company management, and sometimes overlooked as a result of a lack of understanding of the area are:

- customer property,
- validation of processes,
- design and development,
- identification and traceability.

In addition, there are requirements that entrepreneurs do not dare to exclude, but there is a big difficulty in documenting them, or an evident lack of their use [21]. These are:

- quality planning,
- monitoring of measuring equipment,
- monitoring and measurement (especially monitoring and measurement of processes, though in ISO 9001 this requirement is contained in p. 8, from which the exclusion is impossible).

Innovation is widely recognized as the key to economic development, ever since it is considered that it has a potential positive impact on performance and competitive returns. The European Commission defines innovation as “the renewal and enlargement of the range of products and services and related markets; identification of new methods of production, supply and distribution; changes in management, organization and working conditions and skills of employees.”

There are many scientific discussions and researches on relationships between the characteristics of TQM and the degree of innovation [22]-[25]. As a result, they show that communication, leadership, teamwork and management of people with practical support, customer focus, continuous improvement, organizational culture based on trust, and sharing knowledge all have a positive impact on innovation. The study proved the strong and positive relationship between product quality and process innovation, as well as between product innovation and process innovation [24]. In addition, quality and innovation exist relative to each other in synergy and balance and one should not strive for the development of one of the areas at the expense of the other [26].

V. Conclusions

The implementation of a quality management system in the automotive industry is a serious undertaking. It is related to the need to adapt the functioning of the company to the requirements of the standard, which is often associated with expenses. In return, the management of a company and interested parties will have a certificate that the orderly system ensures complete customer satisfaction. This certification makes sense only if the quality management system is truly functioning and not fictitiously, only on paper. This is one of the reasons that the certification system in recent years has had a crisis of confidence. The authenticity of the system is, however, strongly dependent on the predisposition of the company and the degree of fulfilment of the boundary conditions for the implementation of the system. The technical conditions indicated in the article for the success of QMS give entrepreneurs knowledge for self-assessment even before making a final decision about the possibilities of implementation.

REFERENCES

[1] International Organization of Motor Vehicle Manufacturers: www.oica.net (viewed on 05.01.2015).

[2] ISO 9001:2008, *Quality management systems. Requirements*, International Organization for Standardization, Geneva, Switzerland 2008.

[3] ISO/DIS 9001, *Quality management systems. Requirements* (Draft – 12.10.2014), International Organization for Standardization, Geneva, Switzerland 2014.

[4] ISO/TS 16949:2009, *Quality management systems. Particular requirements for the application of ISO 9001:2008 for automotive production and relevant service part organizations*, International Organization for Standardization, Geneva, Switzerland 2009.

[5] N. Belu, L. Stirbu, "Phases of implementation of ISO TS 16949: 2002 Quality Management System", *Proceedings of International Scientific Conference Modern Technologies, Quality, Restructuring, T.C.M.R. – 2006*, At Jassy 2006, Volume: LII (LVI), s. 1231-1237.

[6] EN 12507:2005 *Transportation services. Guidance notes on the application of EN ISO 9001:2000 to the road transportation, storage, distribution and railway good industries*, CEN European Committee for Standardization, Brussels 2005.

[7] EN 12798:2007 *Transport quality system. Road, Rail and Inland navigation transport. Quality management system requirements to supplement EN ISO 9001 for the transport of dangerous goods with regard to safety*, CEN European Committee for Standardization, Brussels 2007.

[8] G. Polya, *How to Solve It: A New Aspect of Mathematical Method*, Princeton University Press, Princeton 2008, p. 169.

[9] A. Mazur, "Application of fuzzy index to qualitative and quantitative evaluation of the quality level of working conditions", in: *HCI International 2013 - Posters' Extended Abstracts, International Conference, HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part II*, Springer-Verlag Berlin Heidelberg, 2013, pp. 514-518.

[10] J. Łunarski, K. Ciepela, „Problemy dokładności i odbioru maszyn i urządzeń technologicznych", *Technologia i automatyzacja montażu* No. 2/2002.

[11] J. Gawlik, A. Kiełbus, „Wieloparametrowa ocena jakości urządzeń technologicznych z zastosowaniem funkcji strat Taguchi'ego", in: *Komputerowo zintegrowane zarządzanie*, (ed.) R. Knosala, Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2006, t. I, p. 401- 410.

[12] A. Górny, "The Elements of Work Environment in the Improvement Process of Quality Management System Structure", in: *Advances in Human Factors, Ergonomics, and Safety in Manufacturing and Service Industries*, (ed.) W. Karwowski W., G. Salvendy, CRC Press, Taylor & Francis Group, Boca Raton 2011.

[13] M. Butlewski, M. Slawinska, "Ergonomic method for the implementation of occupational safety systems", in: *Occupational Safety and Hygiene II* (ed.) P. Arezes, pp. 621-626, CRC Press, 2014.

[14] J. Gawlik, J. Sładek, A. Ryniewicz, M. Kowalski, A. Gąska, „Wielofunkcyjna ocena jakości urządzeń technologicznych i wyrobów", *Inżynieria maszyn* 15/3, 2010.

[15] B. Słowiński, *Inżynieria eksploatacji maszyn*, Wydawnictwo Uczelniane Politechniki Koszalińskiej, Koszalin 2011.

[16] B. Mrugalska, P.M. Arezes, „Industrial practices designed to ensure safety of machinery" in: *9th International Symposium on Occupational Safety and Hygiene (SHO)*, (ed.) P.M. Arezes, J.S. Baptista, M.P. Barroso et al., pp. 351-353, Guimaraes, Portugal 2013.

[17] L. Pacholski, A. Jasiak, "Application of system methodologies to macroergonomic diagnosing", *Advances in Industrial Ergonomics and Safety* IV Vol. 4, pp. 27-33, 1992.

[18] H. Tylicki, B. Żółtowski, *Genezowanie stanu maszyn*, Wydawnictwo Naukowe Instytutu Technologii Eksploatacji PIB, Radom 2012.

[19] A. Misztal, M. Butlewski, N. Belu, L.M. Ionescu, "Creating involvement of production workers by reliable technical maintenance", in: *2014 International Conference on Production Research - Regional Conference Africa, Europe and the Middle East and 3rd International Conference on Quality and Innovation in Engineering and Management (ICPR-AEM 2014)*, pp. 322-327, Cluj Napoca 2014.

[20] M. Jasiulewicz-Kaczmarek, P. Drozyner, "Preventive and Pro-active Ergonomics Influence on Maintenance Excellence Level", *Ergonomics and Health Aspects of Work with Computers* Vol. 6779, pp. 49-58, 2011.

[21] A. Misztal, S. Bachorz, "Quality planning of parts machine production based on housing of cylinder head milling machines", *Applied Mechanics and Materials*, Vol. 657 (2014) pp 986-990.

[22] T.D. Hoang, B. Igel, T. Laosirihongthong, "The impact of total quality management on innovation. Findings from a developing country", *International Journal of Quality & Reliability Management* Vol. 23 No. 9, 2006.

[23] A. Abrunhosa, P. Sá, "Are TQM principles supporting innovation in the Portuguese footwear industry?", *Technovation* No. 28/2008.

[24] M. Martinez-Costa, A.R. Martinez-Lorente, "Does quality management foster or hinder innovation? An empirical study of Spanish companies", *Total Quality Management*, Vol. 19, No. 3, 2008.

[25] R.Y.Y. Hung, B.Y. Lien, S. Fang, G.N. McLean, "Knowledge as a facilitator for enhancing innovation performance through total quality management", *Total Quality Management*, Vol. 21, No. 4, 2010.

[26] D.I. Prajogo, P. McDermott, M. Goh, "Impact of value chain activities on quality and innovation", *International Journal of Operations & Production Management,* Vol. 28 No. 7, 2008.

PhD. Eng. Agnieszka Misztal is Lecturer at the Poznan University of Technology, Faculty of Engineering Management, Poznan, Poland. She is lead auditor of AQAP 2110 and ISO 9001 systems. She cooperates with many manufacturing and service companies. She is involved in Quality Management, Quality Engineering, Management of Production and Automotive Industry. She is a member of Editorial Board of Science Journals of Poznan University of Technology and reviewer for several world scientific societies and international journals. She published four books and several dozen articles in different polish and international journals and proceedings.