Methodology development for implementation of quality management system within SME from the products' lifecycle point of view

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Abstract: *This paper is focused on the latest development of ISO 9000 family quality standards, Quality Management Systems (QMS) and how these relate with each phase of product lifecycle, within initial number of 50 small and medium-sized enterprises (SMEs) from Czech Republic. This paper also aims to analyze the problems encountered by quality managers when implementing QMS, in particular the ISO 9000 series standards, and tries to find answers to these problems, all in connection with the final product and its lifecycle. The product lifecycle is analyzed from three points of view, which the author considers are the most important for quality managers, i.e. serviceability, IT/IS and total costs.*

The final purpose and objective of the research is to develop a methodology, based on the results from the empirical study, which can form a base for future ISO 9000 standards improvement and thus when applied will help the quality managers, by reducing the delays of implementation and thus increasing the quality of the product, in a faster and more productive way, in order to fulfill the continuously changing requirements of the customers and of the market.

Keywords: ISO, methodology, QMS, SME, lifecycle.

1. Introduction

Through this paper, the author wants to show the connections between the QMS of the company and the product lifecycle and how managing each phase of the product lifecycle can influence the customer quality requirements for the final product. Taking in consideration that ISO 9000 and ISO 9001 certifications are widely spread quality models and that SME are an important part of the manufacturing industry, the research focuses on the relation between SME, ISO 9000 family standards and product lifecycle from three points of view: IS/IT, serviceability and costs.

SME all over the world have very heterogeneous characteristics in sector, geographical area, internal structure, where they do business as well as the experience of the workers and management training differ from one industry to another. Thus SME from the manufacturing industry were considered in this study, which is one of the most dynamic and continuously changing industries due to the technological advance but also due to the economic crisis which influenced managers to cut costs and invest in technology and quality, in order to keep their initial market share, if not to expand to other markets. In the manufacturing industry, quality is needed by SME and plays an important role because SME supply big companies with processed material, semi-finished products or even finished products which will be part of another final product (e.g. battery for the car).

Quality in today's economy is part of the firms' long term strategy and means compliance with standards, but the standards are continuously changing (improving) according to the market requirements and thus the level of quality is continuously increasing.

The Management of Product Lifecycle is aimed in driving all the particular areas, which have a direct influence on some of the lifecycle stages such as maintenance, quality, information systems, costs, R&D, production management, etc. Among the lifecycle management, there are a number of methods and techniques with different approaches regarding the necessary data input and as well as the results we get from them. The common element is the valuable information supporting the management, which helps us make the right decision and choose the optimal way of solving the economic problem, i.e. in our case the managing of the product lifecycle to correspond among others to the required quality level.

The paper is structured in two parts. The first one shows a literature review with focus on the pros and cons why a company should implement ISO 9000 series standards from the product lifecycle point of view. The second part focuses on the research which is still underway, i.e. a questionnaire was made and structured interviews were taken to key people within SME from Czech Republic where lifecycle is analyzed from three individual points of view: costs, serviceability and IS/IT and a forth, overall point of view: quality in each phase of the product lifecycle. Some starting questions which also represented the reference guide for data collection and the development of the structured interviews were:

- What do SMEs understand by "qualitative product/service"? What is their approach to quality?
- Which factors affect the quality within each phase of product lifecycle?
- Which implications can have a QMS in SME regarding the lifecycle of the product?

In the end a methodology is proposed from the abovementioned points of view with the main purpose of assuring the "right" level of quality for the final consumer.

Until now were created many tools, methods and techniques for managing the lifecycle or the quality of the product, but these tools are limited to the evaluation of certain selected specific tasks. The models have a number of assumptions and initial conditions, in order to allow universal applicability for a wide range of users. The aim of the research activities is to explore the degree of the usage of these methods and to develop comprehensive tools for design, analysis, evaluation and management of engineering products in terms of their lifecycle and quality level, as well as to eliminate the discrepancies between theory and practice for lifecycle management, with a direct focus on the level of quality required by the customer.

There are however no scientific papers which refer to the development of a methodology for implementing QMS, in direct connection to product lifecycle and the level of required quality and how one can manage the level of the quality from managing each steps of the lifecycle, from the above mentioned three points of view: serviceability, IS/IT and costs.

2. Literature review

Every day we hear the word "quality" in different areas or media. But what does "quality" mean? There are a lot of research papers from different authors where they present numerous success stories from companies which established and implemented quality programs. In their studies, authors like Garvin supported even more the early models of quality developed by the gurus of quality (Deming, Ishikawa, Juran, Shewhart, Taguchi, Feigenbaum and Crosby) by identifying five major approaches to defining the ideal meaning of quality (transcendent, product-based, user-based, manufacturing based and value-based) that however generate differences in attitude and perspective among managers, departments and even customers [1]. These models however were inconclusive and failed because of the wrong definition of the term of "quality".

In today's market "quality" is equal to the phrase "compliance with norms and standards". In this manner the ISO standards were created and more and more companies are investing money and time in getting the ISO certification as well as in finding ways of improving the productivity and efficiency of their production systems using Lean and/or Sig Sigma methods.

The definition of "quality", "quality control" and "quality management" are from the ISO 9000 family standards as follows:

- Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.
- Quality Control is the operational techniques and activities that are used to fulfill requirements for quality.
- Quality Management is the sum of all activities of the overall management function that determines the quality policy, objectives and responsibilities, and their implementation by means such as quality planning, quality control, quality assurance and quality improvement within the quality system.

Quality has also been part of the companies' long term strategy and plays an important role in the level of competitiveness on the market [2].

Among the benefits the companies can achieve as a result of ISO 9000 certification we can mention: improved documentation ([3]-[5]), quality improvement ([3], [6]-[9]), productivity improvement as well as cost and waste reduction ([3],[4]), employee motivation ([9]-[12]), etc. But some authors mention also the problems encountered through the certification process. These can include: cost and time-consuming (which can discourage particularly small companies), an increase in paperwork, an improper documentation system and poor communication among personnel ([13-17]). IT/IS solutions like: Soft computing and Internet technology were researched to solve these kinds of problems ([18], [19]).

Regarding the product lifecycle there are several research papers and books, which propose methods and tools for lifecycle management. From these we can mention the design cost, LCA - Life Cycle Assessment, LCE - Life Cycle Engineering, LCC - Life Cycle Costing, WLCC - Whole Life Cycle Costs, PDM - Product Data Management, etc ([20]-[22]).

At the time of this research there were an approximate number of 23 papers taking into consideration quality and lifecycle but not even one considering direct connection with SME from the above mentioned points of view.

Some authors consider that in tomorrow's market the product lifecycle will face some significant changes as follows:

- In order to satisfy the ever-increasing demands in product variety, quality and delivery time, both the product/process development time and launch time must be shorten significantly [23]. And this will be due to the market pressure on shortening product and process realization cycle time with a focus on the ever changing quality requirements of the customers and taking in consideration the Research and Development phase of the product, which will have to be more flexible and adaptive to the new conditions.
- Design and quality of the product should be right from the first time and the number of "improved versions" of the old product should be cut to zero. In this way Lean Six Sigma manufacturing will be possible at another level due to the total elimination of waste (rework, repair, scraps, delay in starting production, low production yield, etc.).
- Reduction of launch time for new product. Accelerating the ramp up of a manufacturing line involves rapid identification of root causes of manufacturing errors. New production launch time is crucial for the new lifecycle product management. Major efforts during launching of the new product on the market are focused on identifying root causes of the process faults. However, current industrial practice in launch time reduction is far less than satisfactory [22].
- Quality of the products should be according to the requirements and new products will be appearing on the market when a new level of quality will be requested. Thus quality and innovation will be interconnected and companies in order to innovate they should be able to increase the level of their products or services to a higher level of quality.
- The recycle phase together with the Research and Development phase will have to be as short as possible. During recycling the old product is taken out of the market and its materials are further used for a new product, but due to the environmental

problems and the fact that resources are limited, the recycling phase should be shorten to minimum, to make possible the new product to be manufactured.

Already exist a number of new manufacturing strategies in the area of product and production system development, such as, flexible manufacturing systems (FMS) [24], reconfigurable manufacturing systems (RMS) ([25],[26]), agile manufacturing (AM) [27] and quick response manufacturing (QRM) [28], which are increasingly being proposed, developed, adopted in manufacturing industry in the last decade. However, due to lack of confidence in manufacturing a quality product (here new ISO 9000 standards come in place to answer the question regarding the required level of quality by the customers!) and system performance (launch time, expected yield, and relatively long time necessary to reach it) throughout the whole product lifecycle, there was, before the worldwide spread of ISO 9000 standards, a big resistance to implement advanced technology or innovations in new product development [29].

3. Methods of research

During this research study, a number of initial 50 small and mid-size manufacturing companies were identified in Czech Republic and according to the time and availability of each target person who could have given relevant answers; accordingly a questionnaire or a structured interview was taken. A method of feedback between the interviewer and interviewee was used in order to get more relevant results and to reduce the potential subjectivity of the study related to the researcher's bias. Thus a preliminary report was written and sent by e-mail to the interviewees in order to verify whether the conclusions of the research were in line with the interviewees' comments. Also due to the great amount of manufacturing companies, it was difficult to find the right number of companies which to correspond to the initial conditions, i.e. to be a manufacturing company where serviceability and maintenance of their products is an important part of their business in order to be able to fill in the third part of the questionnaire.

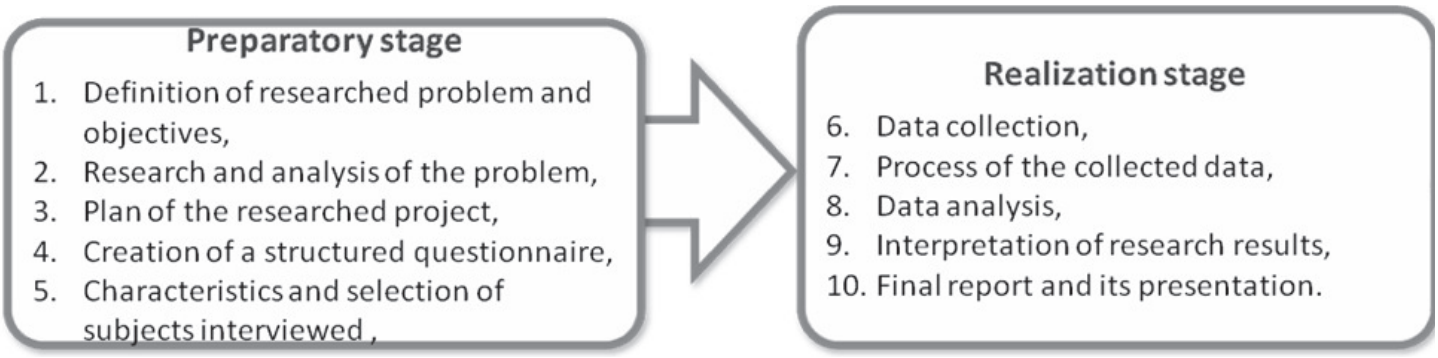
In order to define SMEs, I took as reference the definition of the European Commission, which defines micro, small and medium-sized firms as employing less than 10, less than 50 and less than 250 staff or by having turnover of not more than 2, 10 and 50 million Euros, i.e. 50, 250 and 750 million Czech Crowns (1 Euro = 25 CZK).

The survey was carried out in two phases. The first phase contained the research of domestic and foreign literature, journal articles and other information sources thematically focused on life cycle management, life cycle costs, maintenance, failure and use of information systems in the life cycle management. Based on this previous research, a structured questionnaire was created which is the main result of the first phase of our research. The second phase consisted of conducting a survey aimed in assessing the relative importance of these areas in the application of selected approaches and their relation to quality assurance and control and methods to support product lifecycle and quality management in practice. The questionnaire was made in combination with a structured interview to the responsible employees of selected industrial enterprises. The relevant data obtained by this questionnaire

are further statistically worked and according to the answers received a chart will be made from which one could easily read the usage of the present tools and methods used in the management of the product lifecycle. This research is also part of the doctoral dissertation papers of the PhD. students from the Department of Management and Economics within Faculty of Mechanical Engineering, Czech Technical University in Prague.

All the process of this unique research made at the Department of Management and Economics within Faculty of Mechanical Engineering, Czech Technical University in Prague can be structured in the following steps:

1. Definition of researched problem and objectives
2. Research and analysis of the problem
3. Plan of the researched project
4. Creation of a structured questionnaire
5. Characteristics and selection of subjects interviewed
6. Data collection
7. Process of the collected data
8. Data analysis
9. Interpretation of research results
10. Final report and its presentation.



Picture 1 – The process of research of lifecycle product management

In present the research is in the phase of data processing and interpretation.

In order to obtain information from interviewed subjects a structured questionnaire was established. This served both to collect data directly from respondents of the survey and also as a support for conducting the interview. Two methods of data collection were used:

- Questionnaire
- Structured interview

According to a survey from International Standardization Organization, Czech Republic was placed on the 7th place in the Top 10 countries worldwide with ISO 9000 growth in 2010 with a number of 2211 companies. In our survey all the companies were ISO 9000 certified and the questions were aimed in trying to find a direct correlation between the ISO requirements and product lifecycle management in order to develop a better methodology for future versions of this norm.

The data collection stated in February 2011 and is still undergoing until December 2012 when the target number of companies

is assumed to be reached. According to the initial data a methodology is proposed which will be further perfected in the future when new data is received from SME targeted people.

4. Proposed development of the methodology

The original edition of the ISO 9000 standards consisted of five documents: ISO 9000, ISO 9001, ISO 9002, ISO 9003 and ISO 9004 and from all these ISO 9000 had the instructions on how to use the rest of the documents while ISO 9004 contained guidelines on how to establish a quality management system according to the requirements from the other ISO 9001, 9002 and 9003. From 1987, when these standards were created, they have been in a continuous change and now counting all the latest versions we have the new standards ISO 9000:2005, ISO 9001:2008 and ISO 9004:2009. Although ISO 9000 is only one of the documents in the set of standards, the entire set is often referred to as "ISO 9000 (family) standards".

The standards acknowledge eight principles of quality management that can help the top management to lean an organization toward improved performance:

- Customer Focus
- Leadership
- Involvement of People
- Process Approach
- System Approach to Management
- Continual Improvement
- Factual Approach to Decision Making
- Mutually Beneficial Supplier Relationship

For future, improved versions of the standards I would add also:

- Lifecycle Approach, where according to each phase and the length of each phase the standards should be flexible in order to correspond to the products' required properties.
- Employee's Motivation Approach – due to shortening of the Research & Design, Production as well as Recycle phase, the product should be good "the first time" and the employees should be directly responsible for the quality of their work. In this manner I can suggest a more motivational approach from the management and from HR department, in order to employ the right people, the ones who are fond of their future work, because in this way they will achieve the required level of quality from their hearts and not because they are told so.

The proposed methodology is aimed not to disagree with ISO 9000 methodology but to support it and wants to prevent the possible problems with which quality managers will meet, by predicting the product quality requirements in the next decade. This methodology is proposed from three points of view regarding product lifecycle: serviceability, IT/IS and costs, which I consider are the most important areas of lifecycle management which can directly influence the quality of the final product.

According to the three points of view and to the results from the survey, where we focused on 50 SME manufacturing companies from Czech Republic, some baselines and prevention steps are drawn in the following sections.

4.1 Serviceability

This part of the questionnaire is focused on the maintenance and management of manufacturing and logistics of the firm. The

questions relate primarily to the management and maintenance planning and monitoring and evaluation costs associated with maintenance.

From the quality point of view, this is an important part of the product lifecycle because is concerning the part of the process which can be reduced if the products are qualitative enough. In other words if the product is "right the first time" the service will not be required, because it would not break so often, or even not at all. The cost associated with the maintenance will be cut off and the money could be used by the Research and Development department to innovate the product. In order to reduce or even eliminate the maintenance of the products, SME should:

- Manage the serviceability of their products by implementing maintenance in the long term strategy of the company. Maintenance should be part of the strategy of the enterprise, especially for SME, where quality should be 100% (or at least to meet the Six Sigma conditions and to allow a maximum of 3.4 defects per million opportunities!).
- Strategic maintenance can drive faster the innovation of the products, customers will be willing to pay for innovated, better, with a higher degree of free offered maintenance even faster and due to the technological innovation the manufacturing costs will be lower and companies will be forced to innovate faster the product.
- Through maintenance SME should learn from the defects which their products have in time and a feedback should be established between maintenance and R&D. Here a decisive role plays the human factor (from workers to top management), but if the strategic maintenance is fully integrated in the informational system, other departments can learn from the appeared defects and thus improve their processes, improve and innovate the product.

4.2 Information System/ Information Technology used in the company

This part of the questionnaire was about software support of product life cycle management (PLM) processes. Product lifecycle, or its management, respectively, includes many areas of enterprise management. Level of utilization of product life cycle management software support tools is closely related to company's overall IS/IT level in general. To take this into account, the questionnaire deals with aspects expressing the company's overall IS/IT level. These aspects include for example unified IS/IT strategy, centralized IS/IT management and purchase, etc.

The following part of the questionnaire was subsequently directly related to some selected tools for PLM software support - these tools include for example Knowledge Management tools, CAD/CAM, tools for maintenance planning (CMMS) and some others. Besides discovering which tools are in use, within the company, this part also emphasizes finding out main benefits and drawbacks of the abovementioned software tools with focus on a perspective of developing a portfolio of software tools related to PLM.

In the 21st century, markets when companies sell and buy using virtual shops (e-shop), the quality of their products or services must be managed through Information System using different software tools. The requirements for the IS in the future will be higher in order to: receive/buy/sell faster,

easier and worldwide. Everyone should have access to data within their work specifications and quality data will be a must in the short term strategy of SME.

First we should decide what "quality data" really means and only then we will be able to improve the IS within our enterprise. Some of the attributes of data quality should contain the answers to the following questions:

- Validity and integrity: are the data correct?
- Accessibility: are the data readily available to the right people?
- Timeliness and location: is the data available when needed and in the right department?
- Accurate content: is the data accurate and was the system accordingly updated?
- Temporal reliability: does the meaning or intent of the data collected remain consistent over time?
- Completeness: do the data contain all relevant information?
- Precision: how well do the data reflect the full details of the product lifecycle and the company's processes?
- Credibility: how credible and reliable is our Information System? Can top management rely on the information there regarding the costs of the material or maybe a worker from the Supply Department forgot to enter in the system some material or entered wrong data?

4.3 Costs of the company

This section of the questionnaire was aimed at the costs of products throughout their whole life cycle. This is an unconventional approach to costs where the costs of products are perceived as a complex of producer and consumer costs including the costs connected with the end of product lifecycle (recycle). The questionnaire wanted to verify to what extent the SME assesses and evaluates the Product Life Cycle Cost and how it uses these costs in Product Portfolio Management.

From the quality point of view, costs play an important role also because quality can be quantified according to the company in total costs for quality. They are divided in: costs for prevention (of defects), costs for quality control and quality testing and costs for inadequate work. We got the following percentage for these quality costs (approx.): 9-15%, 37-43% and 42-54%.

The following prevention steps should be implemented:

- The costs for inadequate work (rework) drop very fast if the prevention is improved. This can be done either by employing the right personnel or by investing in an Information System which eliminates the defect right after the process was finished and doesn't allow the semi-finished product to pass to the other production stage. The second option requires a big initial investment in such a system and there is little possibility for SME to do it. However the first one can be put in place if the Employee Motivational Approach is put to work.
- If the costs with prevention are very low (less than 5%) then the costs with rework will be over 60%, so a prevention system should be implemented in SME. A solution besides other already methods or tools which exist (Root-cause analysis, Lean, etc) is given by the eight principles for QMS, by implicating the top management and the process and lifecycle approach where if the organization

and its activities are analyzed as processes, it helps in gaining a good understanding of the individual processes and their interdependencies. This improves the chances of discovering possible defects within the lifecycle processes, which were missed by the quality control, and making them both effective and efficient.

- The costs for quality should be better managed by the quality department in order to be able to improve the actual state of products' quality and to be able to better manage the phases in their lifecycle, especially the Research and Development as well as Recycle part. For e.g. if the level of quality is met, when innovating the product we could be able to reuse some parts of old product, without being recycled (because they already are quality enough to be directly implemented in the new product).

5. Conclusions and implications

The main outcomes of this study show that there is a direct connection between the serviceability, IS and total costs and the quality system used in the SME but other aspects should be researched regarding the connection of the other phases of product lifecycle. In this study internal factors and external factors which could have affected the results of the questionnaire and interviews were not taken in consideration (the great amount of time and resources put in creating the questionnaire, lack of support from different people within the same company, fear to loose their jobs and willing to answer "the right way", the differences between SME regarding the technology used and level of knowledge and skills who influenced the results in a good or bad way, etc.).

To sum up I can say that quality will always be an important characteristic of the products or services the SME will offer and the standards will be in a continuous improvement process according to the ever changing conditions and requirements of the customers. In this way, this paper tried to develop a methodology for implementation QMS, on an empirical case study of 50 Czech companies, but due to the small number of SME in comparison with worldwide SME, where geographic, cultural and economic aspects can influence the results, future research should take place.

The methodology is in a continuous improvement and perfection according to the results received from the SME from Czech Republic and it will be used by the participants in the improvement of their QMS.

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