CASE STUDY REGARDING THE MANAGEMENT OF TOTAL QUALITY COST

Mitica Afteni[1,2], Cezarina Chivu[1], Gabriel-Radu Frumusanu[1], Florin Susac[1]

[1] "Dunarea de Jos" University of Galați, Department of Manufacturing Engineering
[2] Rulmenti S.A. Bârlad, Romania
mitica.afteni@ugal.ro, cezarina.afteni@ugal.ro, gabriel.frumusanu@ugal.ro, florin.susac@ugal.ro

Abstract: *Nowadays, companies focus their strategies considering the efficiency of the internal processes and activities. The structure of the cost should be identified to define the most suitable solution for cost control. Considering that one of the main impacts on a company result is the quality of its products, there should be identified which are the quality cost and the non-quality cost. The management team has a difficult job in identifying the individual impact of each total quality cost component (prevention, detection and non-quality analysis). The strategy for total quality cost management is then identified based on product status - conform or non-conform to technical specifications. The main purposes of the present case study are the building of a database coming from industrial environment and the defining of a working algorithm, which can support the managerial decisions related to the total quality cost control. An integrated approach of total quality cost structure, using the proposed algorithm, will enable us to reduce both analysis time and related expenses.*

Keywords: *total quality cost structure, processes efficiency, decision making algorithm*

1. Introduction

In the actual economical context finding the most suitable strategies for a company becomes a difficult job for company management team. Considering that behind the applicable requirements for the products and services provided by the company there are also a lot of other requirements, which involve expenses and supplementary resources. To ensure a sustainable development of the company and its products and processes, the managers should identify the cost components and then identify and apply actions to reduce the ones with important impact on company results, as much as possible.

The cost estimation system is an integral part of the management system [1]. Knowing that one of the survival and development factors of a company is assured by the quality of the products and services provided on market, it is important to have clear algorithms to identify the status of the products from quality point of view. Different studies were developed to quantify and to propose different approaches for identification of quality costs. When we discuss quality cost, this should be clearly identified based on both quality and legal requirements applicable to a specific product.

The total cost of quality contains main sources such as prevention costs, detection costs and non-quality costs. During the development phases of a product, different risk analyses are performed based on:

- Historical data,
- Knowledge about the potential failures of the product during manufacturing,
- Level of scrap from past orders,
- Level of complaints and associated costs,
- Level of expenses coming from field return, internal rate of rejection and other potential failures modes.

The risk analyses mentioned have the main purpose of preventing the failure occurrence.

Companies have defined and implemented different tools and devices able to detect the status of a product from quality point of view. When managers perform internal analysis for resource planning, there should be also considered tools and actions for detection of the failures before starting the production. When companies decide to manufacture a new product, it is assumed that there will be some expenses during the development phases of both product and the related processes. Technical changes for solving non-quality problems perceived by customers have to be introduced at all stages, searching for solutions with minimum development cost and less impact on final cost of the product [2].

These expenses could come from different tests performed before series production. In the paper [3], the quality costs are classified in three categories as follows:

- Voluntary costs accepted by companies to achieve a defined level of quality for products and services,
- Involuntary costs generated by the non-conforming products, and
- The cost associated to lost of opportunities.

In actual financial systems they are registered the consumption of resources as: energy, raw materials, human resources, and other physical resources.

The research in field of quality should approach also the hidden costs, consisting of different treatments of quality issues. The identification of the main cost components has become a difficult job for both engineers, on one side, and financial people, on the other side. The paper [4] identifies three primary cost factors of organizational non-quality elements:

- Infrastructure and maintenance of quality,
- Failure costs, detected in-house or at customer site,
- Damages incurred by external bodies, such as suppliers of raw material or of services, either commercial or public.

The paper [5] presents a study aiming to evaluate and analyze the importance of non-quality costs on companies' results, considering the market situation with the focus on prioritization of quality improvements.

In the paper [6] it was developed a comparative analysis of the main models for evaluating the performance of quality management systems. Also, the performance indicators related to the quality costs are described. These costs may refer to:

- Customer returns,
- Repairs performed on in-warranty products - number and cost,
- Downtime expressed in financial terms and physical terms,
- Cost due to unusable supply,
- Product downgrading costs,
- Scrap,
- Inspection activities,
- Client losses expressed in financial terms,
- Marketing and research related costs,
- Costs related to audits to suppliers,
- Rework of defective products,
- Employee training costs,
- Insurance premium related costs).

The paper [7] presents a review, which highlights that hidden quality cost is an area of research that has not been extensively explored.

The paper [8] deals with a study regarding the quality costs models, which reveals that there is a standardization of the quality costs models is needed and, at the same time, useful to improve the efficiency and the quality cost. The study investigates the business environment related to the automotive industry. There also should be developed an algorithm to integrate the losses from entire product life cycle, by considering the tangible and non-tangible components of the quality costs.

In the paper [9] it is presented a study regarding the techniques that are used to identify the tendency in analysis of quality costs. The most used technique was identified as being the Pareto analysis.

In the paper [10] was developed a study regarding the quality cost influence on quality improvement, realized in the case of a Chinese company. One of the main problems (also revealed by other research studies) is that, in the accounting documents, only general expenses are registered, and the hidden quality cost cannot be easily identified.

The integrative approach of the different methods enables the identification of activities which impact on the total quality costs for a certain company. The implementation of quality costs provides just the input for a closed loop quality feedback system which triggers continuous quality improvements [11]. To conclude, one of the main issues which was identified in analyzed literature is that most organizations are aware about the quality costs, but it still remains a gap, or the management team does not have an integrated system and a defined algorithm to identify the hidden cost of quality, based on data collected from past company activity.

A method applicable for optimizing the manufacturing processes was developed and validated in [12], based on the identification of different levels of activities. In [13] the identification and selection of the optimal process flow for bearing components, including quality inspection steps, was presented. Considering the previous studies mentioned, a similar approach will be used in the case of quality-related activities and their associated costs, aiming to identify the levels of occurrence and their positive or negative impact on cost efficiency and strategic decision-making.

Starting from here, this paper presents a case study, which was developed to define a working algorithm, dedicated to support managers' decisions related to the total quality cost control, based on a database coming from the industrial environment.

An integrated approach to total quality cost structure using the proposed algorithm could help companies to improve the quality management system in terms of both efficacy and efficiency.

The paper is structured in four sections. Following this introduction, Section II presents a method applicable for data collecting and analysis regarding the quality-related expenses. Section III develops a case study to identify the activities and the cause-effect relationships between sub-activities and expenses in the case of quality cost in an industrial company. Finally, Section IV deals with obtained results and discussions related to these.

2. Data collecting methodology

In this chapter, a structured method applicable to identify the total quality cost structure for the companies which act in the industrial environment is presented.

Different levels of activities are identified, and a flow diagram was designed as basis for the definition of the working algorithm (see Table 1).

In Figure 1, the main types of quality activities, considered for quality cost evaluation, and consisting in prevention, detection and correction (and their generic sub-activities) are depicted.

In Figure 2, the main types of quality-related activities are split into sub-activities and finally associated with the expenses generated by each of them.

Table 1: *Database regarding the non-quality cost components split in sub-components*

Activity levels	**Level A - *Prevention***		**Level B - *Detection***		**Level C - *Correction***	
Sub-activities	A1.	Risk analysis	B1.	Prototype	C1.	Internal correction
	A2.	Product requirements	B2.	Serie Production	C2.	At customer site correction
	A3.	Quality requirements	B3.	In-process inspection	C3.	Returns from field
			B4.	At customer site inspection		

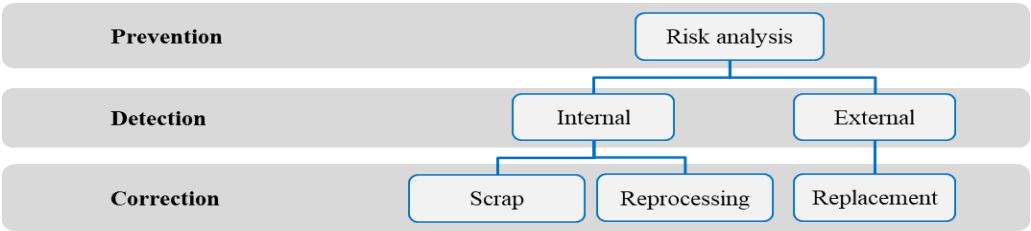

Figure 1: *Quality-related activities and their generic sub-activities.*

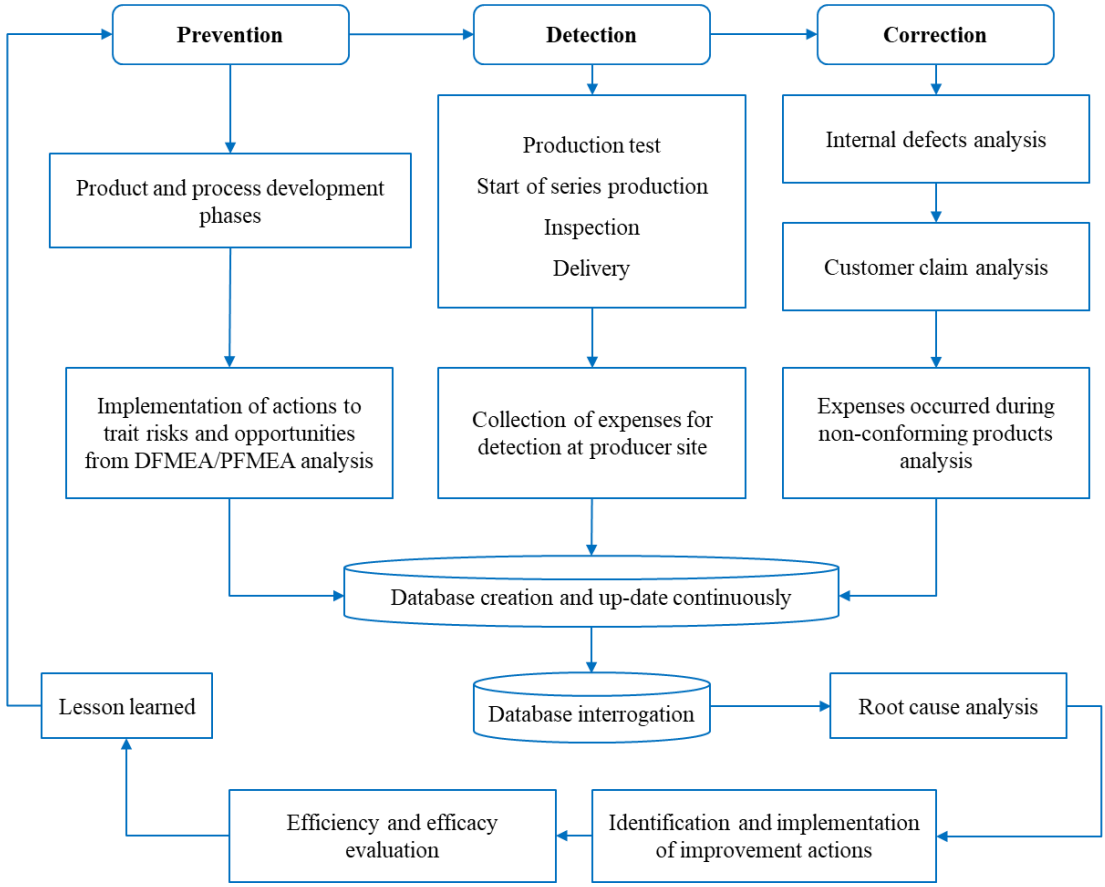

Figure 2: *Proposed algorithm for database creation*

3. Case study

A database including data collected from the industrial environment during a 9 years period was created by considering the flow of activities and the cause-effect relation between sub-activities and expenses.

The main variables, considered as reflecting the total quality costs, are:

- Personnel expenses, as percentage of the salary paid for *Quality and Engineering* personnel,
- Displacement expenses – including the expenses for service activities and complaints solving at customer site,
- Invoices related – sorting activities of products at customer site, external audits, purchasing of standard and other mandatory documents, product certifications, payments to customer or supplier as penalties,
- Other expenses: investment in machines and equipment for quality improvement purposes, measurements instruments, internal scrap value, replacement of damaged products at customer site, transport for replaced products,
- Invoices from customer related to complaint solving – normally are the payment of a neutral party for sorting or correct the non-conforming products, and
- Training expenses for quality personnel – internal trainings and external trainings expenses.

The mentioned variables are registered based on their accounting values, and then the amount of each category is considered for: prevention (P), detection (D) and correction (C) (see Table 2).

The non-quality costs were identified based on the above information, as can be observed in Table 3.

Table 2: *Database regarding the quality cost components*

Quality cost components / Year	P	D	C
2016	805,300.50	434,224.80	832,698.00
2017	394,994.67	421,066.00	911,826.60
2018	565,811.23	643,040.80	1,828,015.56
2019	740528.60	699080.80	1996326.60
2020	385,440.08	412,170.90	734,036.80
2021	282,351.64	417,286.80	967,155.00
2022	4,902,199.31	1,789,695.80	609,647.70
2023	2,794,022.84	3,234,850.66	1,526,838.49
2024	1,777,670.51	2,519,183.33	969,281.35

Table 3: *Database regarding the non-quality cost components split in sub-components*

Non-quality cost components / Year	1. Scrap [lei]	2. Correction with deviation request [lei]	3. Replaced products [lei]	4. Transport for solving claimed products [lei]	5. Customer invoices due to claimed products [lei]
2016	2450170	77749	33449	12902	55554
2017	2766386	280637	23619	3671	99529
2018	4794964	71947	225	12441	28980
2019	6223749	145444	0	4024	458021
2020	2588206	35955	52	16732	28791
2021	2670289	75733	3757	0	24092
2022	3875070	4027	2481	0	0
2023	3075656	58269	0	0	0
2024	1281042	11509	0	0	0

4. Results and discussions

The technological and economic development from last decades involves new approaches of manufacturing processes in terms of technological aspects, economical aspects and sustainability aspects. One of the most important indicators of company performance is the degree of resources usage and, in this context, it becomes necessary to also analyze the cost of all activities needed for product execution.

The analysis of quality control requirements sometimes requests the allocation of financial resources for:

- Training of involved personnel both in production processes and inspection activities,
- Purchasing different inspection tools and equipment, and
- Outsourcing some inspection activities even in case of non-quality detected in earlier stages in-house or at customer site.

In the present paper a database with data from industrial environment was created and a structural identification of quality cost components based on their impact and expenses is proposed.

Based on the database content and the structural identification of activities, sub-activities and related expenses, a working algorithm was developed. The proposed algorithm can be used as a support tool for managers to identify in a short period the activities which impacts both the quality aspects and quality expenses and then to identify using known tools as ICHIKAWA, 5Why, FTA the root cause of high amount of expenses and action plans needed to eliminate the root cause or to reduce their impacts.

ACKNOWLEDGEMENTS

The authors acknowledge the technical support of Rulmenti S.A. for the development of this study.

References

1 [Alsada,2022] Alsada, R., Kumar, Y., *A measurement of quality costs in industrial organizations*, Cogent Business and Management, vol. 9, no. 2128253, pp. 1–23, 2022.

2 [Gobetto,2014] Gobetto, M., *Operations Management in Automotive Industries*, Springer Series in Advanced Manufacturing, Dordrecht, Netherlands, pp. 1–258, 2014.

3 [Diamandescu,2014] Diamandescu, A., Popescu, F., and Ioniță, V.L., *Economic impact of non-quality costs in organizations*, Management Intercultural, vol. XVI, no. 2(31), 2014.

4 [Halevy,2000] Halevy, A. and Naveh, E., *Measuring and reducing the national cost of non-quality*, Total Quality Management, vol. 11, no. 8, pp. 1095–1110, 2000.

5 [Mone,2019] Mone, R., Maisano, D.D., *Breakdown and categorization of production wastes into poor-quality cost*, Master thesis, Politecnico di Torino, 2019.

6 [Firescu,2015] Firescu, V., Popescu, J., *The costs of quality: An important decision tool*, International Journal in Economics and Business Administration, vol. III, no. 4, pp. 44–52, 2015.

7 [Walston,2025] Walston, J.D., Badar, M.A., Kluse, C.J., Rostom, R., *A Review Analysis of Cost of Quality, Cost of Poor Quality, and Hidden Quality Cost*, Journal of Technology Studies, vol. 50, no. 1, pp. 1–13, 2025.

8 [Hedeșiu,2012] Hedeșiu, D.M., Popescu, S.G., and Dragomir, M., *Critical analysis on quality costs models*, Quality Management, vol. 13, no. 131, pp. 71–76, 2012.

9 [Popescu,2006] Popescu, D. Gîrboveanu, S., *The quality cost analysis*, Management & Marketing, pp. 85–90, 2006.

10 [Brekke,2007] Brekke, J.A., Franzen, H., *Quality Costs? Using quality costing to promote quality improvement in a Chinese company*, Master's thesis, Luleå University of Technology, Suedia, 2007.

11 [Ocakci,2021] Ocakci, E., Niemann, J., Luminosu, C., Artene, A., *Quality Cost and Economic Analysis. A Synthesis in the Manufacturing Systems*, MATEC Web of Conferences, vol. 343, no. 05008, pp. 1–8, 2021.

12 [Afteni,2020] Afteni, C., Frumusanu, G.R., Afteni, M., and Paunoiu, V., *Structural identification of the bearing manufacturing process – Case-study*, IOP Conf Ser Mater Sci Eng, vol. 968, no. 012015, pp. 1–11, 2020.

13 [Chivu,2024] Chivu, C., Afteni, M., Frumusanu, G.R., Susac, F., *Study regarding the selection of the optimum process flow at bearing rings manufacturing*, Acta Technica Napocensis, vol. 67, no. Special III, pp. 1027–1036, 2024.