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An empirical study of a quality cost system implementation: case study in a Brazilian machine tools manufacturer

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ABSTRACT
In order to service the demand for competitiveness, many companies have been restructuring their manufacturing systems, searching for better ways to minimize the required investment related to the implementation, maintenance and improvement of these systems. In this sense, one of the most important tasks in many companies is to manage quality systems in order to achieve the Total Quality Assurance. The objective of this paper is to show and discuss the implementation of quality costs measurement system in one of the most important Brazilian Manufacturers of Machine Tool, in order to measure the performance of manufacturing process. To apply this proposal, it was selected one specific manufacturing process. Quality costs were identified through the primary process function using the PEF approach. One the most important pieces of information obtained with the quality costs evaluation concerned the internal inspection rate of components and materials from the suppliers of process.

Keywords: Quality Cost, Quality Management, Continuous Improvement, Process Management.

Un estudio empírico de implementación de un sistema de costes de la calidad: estudio de caso en una empresa brasileña fabricante de máquinas herramientas

RESUMEN
Para atender la demanda de competitividad, muchas compañías han reestructurado sus sistemas industriales, buscando mejores maneras de minimizar la inversión requerida relacionada a la aplicación, mantenimiento y mejora de estos sistemas. En este sentido, una de las tareas más importantes en muchas compañías es manejar los sistemas de calidad para lograr Calidad Total. El

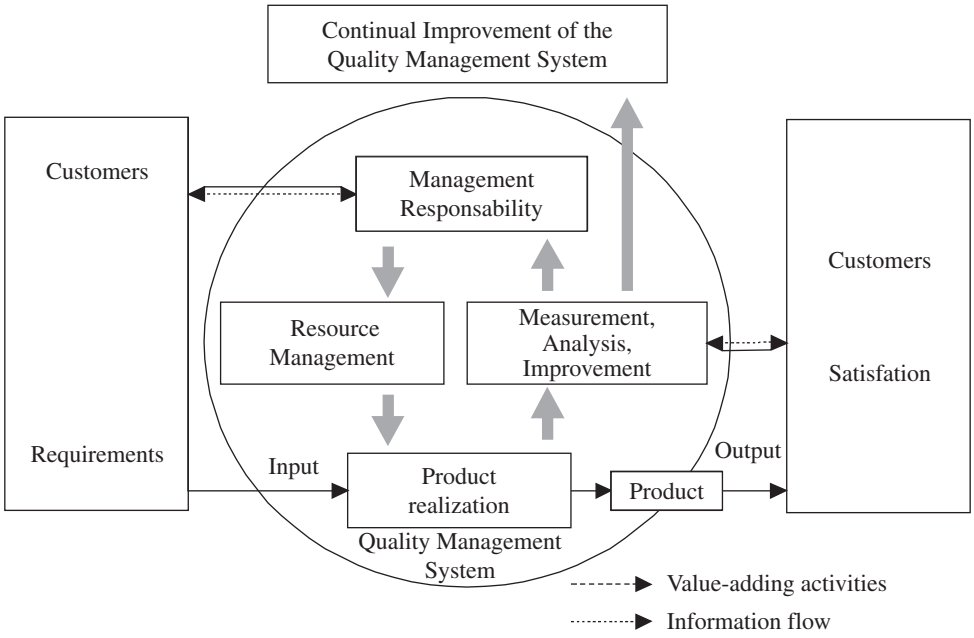
objetivo de este trabajo es mostrar y discutir la aplicación del sistema de medidas de costes de la calidad en uno de los más importantes Fabricantes brasileños de Herramienta Maquinaria para medir la actuación del proceso de fabricación. Para aplicar esta propuesta, se seleccionó un proceso industrial específico y se identificaron los costes de la calidad a través de la función del proceso primaria con el modelo PEF. Una de las informaciones más importantes obtenida con la evaluación de costes de la calidad involucró la proporción de la inspección interior de componentes y materiales de los proveedores de proceso.

Palabras Clave: Costes de la Calidad, Dirección de la Calidad, Mejora Continua, Dirección del Proceso.

1. INTRODUCTION

Market globalization has increased the world competition. This competition pressure has led the organizations to increase the confidence on quality and an improvement in the results. The organizations have identified the need of focusing on the improvement of quality and the satisfaction of the customers as an efficient manner to face this

Figure 1: Model of a Process-Based Quality Management System



Source: NBR ISO 9001 (2000).

challenge. To supply this demand, many organizations around the world have dealt with this matter seeking a certification of their quality management system in an international standard, being the ISO 9001:2000 the most known. This standard uses an approach of quality management processes, example given through a model of generic processes shown in macro level in the Figure 1.

The manufacturing processes obtain the specification of a product that will meet the customers' needs. The manufacturing of the product and the satisfaction of the customer should be reached through a proper planning (Management Responsibility and Resource Management). The product and measurement process will provide information to be analyzed and promote a continuous improvement of the quality management system.

The process is affected by three management actions: planning, maintenance and continuous improvement of the performance. To identify opportunities of improvement in these processes, the organizations always try to introduce quality control tools. This initiative should be seen from the management point of view through processes to avoid the proliferation of tools; waste of resources; the confusion of people trying to understand how each effort is related; dispute among the experts because they may consider their tool to be one deserving more resources; sometimes making the employee feel as if the organization is not deeply committed to none of them (Hammer, 2002). Among the quality control tools to guide the improvement in the organization, the quality costs can be mentioned because it has been employed in several industrial branches (Mattos y Toledo, 1999).

The goal of this task is to present some of the main approaches of structuring the quality costs to identify, collect and analyze these costs through examples found in the literature. Through this knowledge an action-research has been developed where the authors were directly involved, trying to insert the quality costs in the quality management system. The results of this work, as well the conclusions about this research are presented.

2. OVERVIEW

The first time the scientific approach on quality costs got any attention was during the 1950s, when they started to study the behavior of those quality costs and the lack of them, going beyond the costs related to the quality department (Juran y Gryna, 1991).

Since then many authors have studied the quality costs (Crosby, 1994; Feingenbaum, 1994). Several certified companies have made use of the quality costs to improve the quality management system, to evaluate the performance and to control the costs (Moori y Silva, 2003; Oliver y Qu, 1999), however this is not a mandatory requisite of the standard ISO 9001:2000.

The information about the quality costs make possible for us to indicate that a company may be spending more than 20% of the total sales to find and correct failures comparing to the 10% of the sales in companies that control quality costs (Feingenbaum, 2001). This represents that the companies which have developed a quality cost system and have made use of this information to investigate and eliminate the causes may be able to save significantly.

After having established a quality cost system, this may be associated to the iceberg analogy. When it is estimated the deficiency of the visible part of the costs they may reach between 4% and 5% of the total, in a way that, when it is considered the invisible part of these costs they may reach between 15% and 25% of the total sales (Defeo, 2001).

Finally, the quality costs may be used as a support tool in a Six Sigma approach on the selection of the projects, and show profit and loss coming from the improvement of the quality (Harry y Schroeder, 2000).

3. APPROACHES ON QUALITY COSTS

Many authors have studied this subject and suggested many approaches of identification, collection and analysis of the information about quality costs. Which is the best approach? What are the criteria to be used on the selection of these approaches? The difficulty to select the approach to be employed is connected to the products and processes of the company, limitation of the information system and the culture of the company (Dale and Wan, 2002). That is why every company should set its quality system according to its need.

Even when the company has selected an approach on the pilot implementation, if the quality costs are increased, it is possible to seek for another approach to reduce the time of implementation to meet the goals of the company. An example of this case was a company which started the implementation on the PEF approach and in the expansion of the system was employed to the process cost approach (Goulden and Rawlins, 1997).

3.1. APPROACH PEF (PREVENTION, EVALUATION AND FAILURE)

One could say that this is a classical approach to quality costs where most of the work is concentrated (Halis and Oztas, 2002; Papa and Calarge, 2003). The PEF approach places the expenses on the prevention category, evaluation and failures. In this approach it is emphasized that the investments in prevention and evaluation minimize the expenses with internal and external failures. These are the categories:

— Prevention costs - they are the costs of activities to assure that the unsatisfactory or defective products will not be manufactured.

— Evaluation costs - they are the costs for determination and checking the degree of product conformity made on specifications.

— Internal failure costs - they are the costs associated with defection found before the product is transferred to the customers.

— External failure costs - they are associated with defection found after the product is delivered.

The difficulty to apply this model is on the classification of the categories, lack of recorded information in this, and the implantation difficulty in management activities (Dale and Wan, 2002; Gulden and Rawlins, 1997). The results are presented in percentage values in each category and total cost is divided among a reference base (total sales, direct manpower cost and others) to check its evolution along the time (Papa and Calarge, 2004).

3.2. PROCESS COST APPROACH

This approach classifies the costs in (Dale and Plunket, 1995):

— Conformity cost – It is the cost to meet the expressed and unexpressed customer needs in the absence of flaws during the given process.

— Nonconformity cost – It is the cost inflicted due to the process failure.

This approach tries to broaden the quality cost view considering the total cost of the process, which is the cost of doing the activities correctly plus the activity of correcting failure. It can be applied to any organization process. The cost classification is related to conformity and nonconformity.

In this approach it is emphasized the need of definition of the inputs and outputs of the process and the activities throughout the process. This is the most demanding and time consuming part during the implementation, mainly when it is a very extensive process, leading to a reduction of the target to a sub process level. This structuring activity can be simplified when the company is structured by process.

These are the steps to structure the quality cost based on the process cost appproach: identify the processes to be mapped and the people responsible for those; create a team; identify the key activities of the process and map the cost components; prepare a cost report using the categories of conformity and nonconformity costs and develop a plan to reduce the nonconformity costs (Dale and Wan, 2002).

3.3. MAYNARD-BLAND APPROACH

Maynard-Bland approach (Bland, Maynard and Herbert, 1998) was developed to identify the total cost of the process, as well the costs inside the department. The costs are placed in one of eight categories: productive work – activity of changing the inputs to outputs; verification – activity related to final inspection, reception inspection; deficient systematic – activity used to avoid error on the following process or unnecessary activities carried out when a given work is unfitted to be sent to the next activity, internal error – time spent on the error classification during the process; external error – time spent classifying errors caused by suppliers and customers; projects – time spent by specific design employees; support – time spent during the training process, acquisition, price estimate, meetings among others; waste – inactive time due to equipment stopping. The following project categories: support and waste, are considered only to activities carried out by the department.

The steps to develop this approach are similar to those of the process cost approach: process definition, setting a cost model, results and analysis, reporting and the beginning of the management actions. This approach application is restrict to the management processes making it harder to be used in the productive processes because of the level of details and the difficulty of collecting data.

3.4. PROBLEM-SOLVING APPROACH

The success of improvement project is measurable employing the principle of quality costs in which, to reduce failure, it is necessary a preventive investment. The problem-solving approach (Robison, 1997), seeks integration of the quality cost elements during the process of problem solutions associated to people ability in analyzing the processes and eliminate the failure that may be more profitable to the company. This approach can be divided in ten steps:

- Step 1 – Get support from the high management and create a multifunctional team;
- Step 2 – Problem selection;
- Step 3 – Calculate the failure occurrence total cost;
- Step 4 – Calculate the cost of a particular failure;
- Step 5 – Classification of failure according to the failure value;
- Step 6 – Selection of the problem and action plan proposal;
- Step 7 – Establish a goal to reduce the failure occurrence;
- Step 8 – Calculate the ROI (Return on Investment) the payment period;
- Step 9 – Make a presentation to the first level of management to get the necessary resources;
- Step 10 – The solution implementation, supervise the progress and repeat the process seeking the implementation of the improvement projects.

The quality cost processes make the surveying problem easier, giving priority to the solution of them. Furthermore, it allows the investigation of the improvement actions and presents to the first level of management the successful results on continuous improvement and failure reduction accomplished by the teams.

The table 1 shows the main caracteristics of each approach that was previously described.

Table1: Approaches on Quality Costs

APPROACHES	FOCUS	COSTS CLASSIFICATION	MAIN FEATURES	MAIN PROBLEMS
PEF	• The prevention actions are conducted to avoid internal and external failures • There is an emphasis in the product conformity	• The costs are sumarized in 04 categories: preventions costs, evaluation costs, internal faiulure costs and external failure costs.	• Must be compared with overall company costs in order to check its evolution along the time.	• The adequated classification of the costs in the four categories.
Process Costs	• Identify and reduce the nonconformities in the process.	• The costs are sumarized in 02 categories: conformity cost and nonconformity cost.	• The two categories of costs are presented as a percentual of the total costs.	• Demand a very intensive understanding of the process. • Takes time to describe complex process.
Maynard & Bland	• Identify and eliminate the unnecessaries activities in the processes and inside the departaments.	• The costs are sumarized in 08 categories: productive work, verification, deficient systematic, internal error, external error, project, support and waste.	• The eight categories of costs are presented as a percentual of the total process and departament´s costs.	• Demand a very intensive understanding of the process and the departament. • Takes time to describe all details related with process and departament.
Problem Solving	• Analyze and prioritize the solutions that are most profitable to the company.	• There is no specific categories and the costs are evaluated according a particular failure.	• Establish a goal to reduce the failure incidence and calculate the ROI (Return on investment) that results from these actions	• The problem that generate higher value of ROI could not be sometimes the most important for the process improvement.

Source: Elaborated by the authors.

4. METHODOLOGY

Concerning the scope of this paper, the present research project presents characteristics of an action research approach (Thiollent, 1996), since one of the authors was directly involved with the studied company. However, it was decided that this research project should be categorised as a case research (Yin, 1994; Voss et al., 2002). The rationale is because this research project was not methodologically planned as an

action research, although it did have intervention. In order to characterise a project as an action research the researcher must considering a specific action research planning phase (Coughlan & Coghlan, 2002).

This project intends to investigate a unit of analysis (quality cost system development) within the context it is in (machine tools manufacturer). Therefore, the relevance of this study is a result of the need of a company to structure its processes, particularly the quality costing process in order to promote a continuous improvement of the quality management system and, as a necessity pointed out in the theoretical background of this paper.

Concerning its objectives, a research can be classified as exploratory, descriptive, or explanatory (Gil, 2002). The present work is exploratory since it is an initial study that aims at better formulating the problem of structuring a development process in a machine tools manufacturer company.

For data gathering, it was necessary the use of interviews with members of diferent areas of the company, common in case research (Yin, 1994), despite the narrow relationship of one of the authors with the company. Besides this, the involvement enabled to access company archival documentation in order to conduct a document analysis using various sources not yet analysed (Gil, 2002), such as technical reports, memos, meeting minutes, etc.

The data analysis followed the inductive logic, where the rationale is from the specific to the general nature (Andrade, 2002). That means an attempt to develop theory based on specific data of a particular study in order to reach general understanding and from this to develop a theoretical model. Table 2 presents a methodological summary of the present research project.

Table 2: Research classification

TIPOLOGY	CLASSIFICATION
Nature of variables	Qualitative
Scope	Case Study
Objetives	Explanatory
Interpretative approach	Inductive
Data gathering techniques	Interviews
	Direct and indirect documentation
	Participative observation

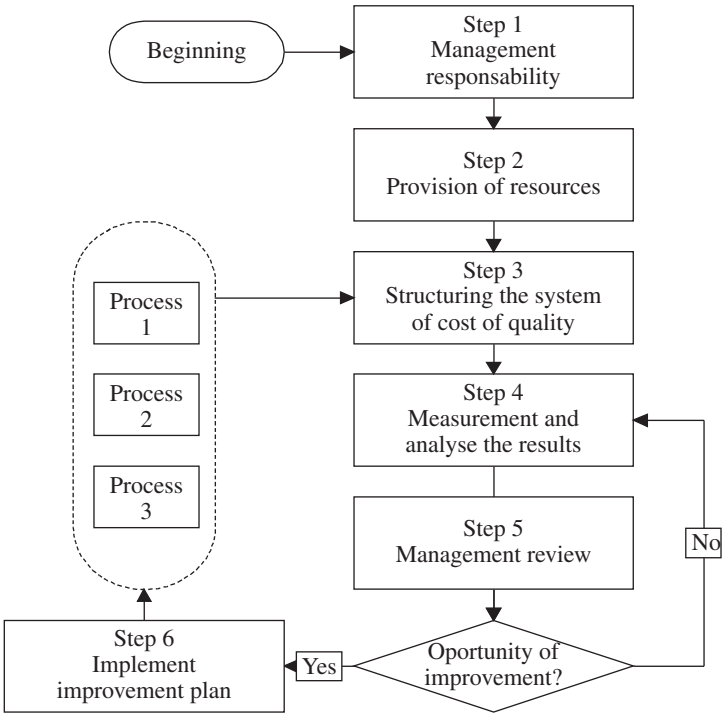
Source: Elaborated by de authors.

5. PROPOSAL TO EVALUATE THE QUALITY COSTS

A proposal to evaluate the quality costs was divided into several steps according to the flow charts in Figure 2. This flow chart is an adaptation of the standard NBR ISO/TR 10014:2000 (NBR ISO/TR 10014, 2000).

The Step 1, named as "Management Responsibility" has as the main goal that the high board of company assure the objectives including those necessary to satisfy the requests of quality cost, guarantee in pertinent functions and levels of the organization.

Figure 2: Proposal of the methodology for the development



Source: Elaborated by the authors.

Then, this step consists in the awareness of the first-level management and the commitment to the quality cost measuring. It could be considered as an indicator of the quality management system and provide information to set the goals to met. From then on, can set the quality cost targets; decide which approach and the performance indicators to be used.

Other considered premises were that the quality cost system to be established should have a low invest in its implementation, as well as it would not substitute the conventional cost system already functioning in the company, but it would work as a support system to that one in practice. Also a pilot study should be preliminarily carried out in the company and after the evaluation to be expanded to others processes.

Considering these premises and the quality cost approaches presented beforehand in the topic 2, the PEF approach was chosen mainly because it could meet in the company the following factors:

— The cost quality system could be oriented to the satisfaction of internal and external customers;

— It would be possible to include the cost quality data considering the process management approach, which it was already implemented;

— The PEF was the most appropriate approach, because it was orientated towards the company culture where the staff can assimilate quickly the concepts, with simplicity and objectivity;

— The visibility of the collected data in the PEF approach would permit to show how the company is investing its resources on prevention and evaluation actions, and how much is being spent on non-conformities.

Concerning the other approaches of quality costs, in the case of the company under investigation the following limitations were found.

— The Problem Solving Model was limited to the process solving problems, turning the analysis limited for the strategic objectives which the company aimed concerning quality costs.

— The Maynard-Bland Model was considered inadequate for the improvement approach of processes adopted by the company.

— The Process Cost Model was unfeasible for the time necessary to implement because it would need a review of processes in the Quality Management System in the company in order to classify them with more detail in sub-processes.

After that, it was established three levels of performance indicators.

The level 1 is the quality cost of the organization which is the result of the addition of the prevention, evaluation and failure costs of the quality management system divided by the net sales.

The level 2 is the total cost of the category resulted from the addition of the every cost of the prevention, evaluation and internal and external failure category and presented as a percentage of the total cost.

The level 3 is the quality cost of the process calculated through the addition of the prevention, evaluation of flaw costs of the process divided by the net sales and by a referential monetary unit.

The Step 2, named "Provision of resources", consists in the setting of a multifunctional work team and training in the main concepts of quality costs and the others correlated. The main goals of this step is: to define the objectives of work; to highlight the importance of measuring quality costs; to review concepts related to approaches by processes; to define aspects related to collection and analysis of data in order to define quality costs; and finally to integrate the measuring of quality costs within the procedures of ISO 9001: 2000. In carrying out training it was sought to enable the staff to apply the method using conceptual leveling among members of work team, as well as to establish an adequate environment to involve, motivate and commit the work team with the evaluation proposal of quality costs in the company.

The Step 3, named "Structuring the system of quality costs", has as main goals the shaping the quality cost systems, data collecting and organizing the information

from the items that should be considered to obtain the expected results. The surveying proposal has the goal to simplify which items should be selected to identify and afterwards to calculate the quality costs, seeking the facilitation of the definition on the reach of the system to be built. That is why it was based on the primary function of the process, which is to make the product according to the specifications. In order to collect data, four questions were asked to identify these costs in each category.

- Costs related with the Prevention: what has to be done in order to prevent that the result the process attain conformity with the specifications?

- Costs related with the Verification: what has to be done in order to verify whether the result the process is in conformity with specifications?

- Costs related with internal non-conformity: what are the losses occurred in the product of process and what measures were taken to correct and avoid their re-incidence?

- Costs related with external non-conformity: what are the losses occurred in the product of process identified in client process and what actions were taken to correct and avoid their re-incidence?

In order to facilitate the identification of items of quality costs related to the primary function of the process, a Survey Table of Quality Cost in the Process was developed, where are listed the items to be evaluated and which method defined to collect data. This was carried out in consultations: computing system information, documental research in data records of quality control and estimates of technicians in the involved sectors.

The Step 4, named "Measurement and analysis of results" has as main aim to define aspects related to measurement and analysis of quality costs. Such rules employed to monitor quality costs must respect measurement and monitoring procedures of processes of quality management system in the organization. For this, it is necessary to define: frequency of data collection and analysis; responsibility for data analysis and estimated time to attain the betterment goals established.

In Step 5, named "Management review", the main goals are to analyze the pertinence, suitability, and efficacy of quality costs according to the quality management system, aiming to reach the established goals. During these meetings it is evaluated the performance of processes for the previously established objectives and thus identify improvement opportunities, as well as establish new goals.

The Step 6, named "Implement improvement plan" has as main goal to generate conditions for a continuous improvement of performance in processes, involving the following phases: definition of objectives and planning of improvement project; analysis of present process; definition and planning of process improvement; implementation of betterment; verification and validation of improvement process; and evaluation of attained betterment.

At the end of the period, the first level management of the company performs a preset critical analysis to check if the goals were reached and to propose new challenges

to the following year. If some improvement opportunities are detected, the monitoring of the indicator of the Step 4 should be kept. If the opposite happens, an improvement process should be initiated during the Step 6 to identify the causes and set the needed plan of action that will result in some changes in the processes of the quality management system.

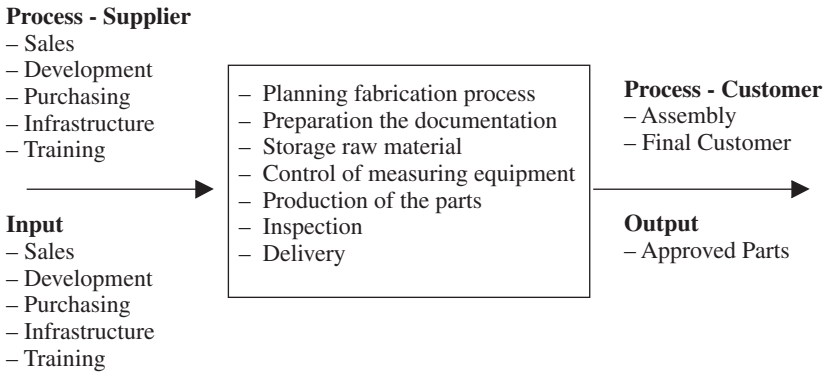
6. IMPLEMENTATION ASPECTS AND THE MAIN RESULTS

The organization where the proposal to the quality cost evaluation was developed belongs to the machine and equipment field and it is the Brazilian and South American market leader in the manufacturing of machine tools. It has total sales of about U$ 300 million a year (reference year 2006). The quality management system is certified in conformity to standard ISO 9001:2000. A set of performance indicator to each process of the quality management process is established and monthly directed to the progress towards the goal. This project was born from the need of the first level of the management in knowing the quality costs and was developed in an university-company partnership program.

A process called Manufacturing Process was selected to the validation of the proposal. The choice criterion involved aspects such as: the manufactured parts are complex, with an aggregated high value and their specifications directly interfere in the operation of the finished product.

The Manufacturing Process produces parts to different machine models and it is structured in the management activity processes which include planning activity process, implementation process, analysis of the indicators and implementation of actions of improvement according with the results and, operational activities related with that ones shown in the Figure 3. The table 1 shows how the quality costs were classified and what measurement indicator was defined for each one of them.

Figure 3: Representation of the operational activities of the manufacturing process



Source: Elaborated by the authors.

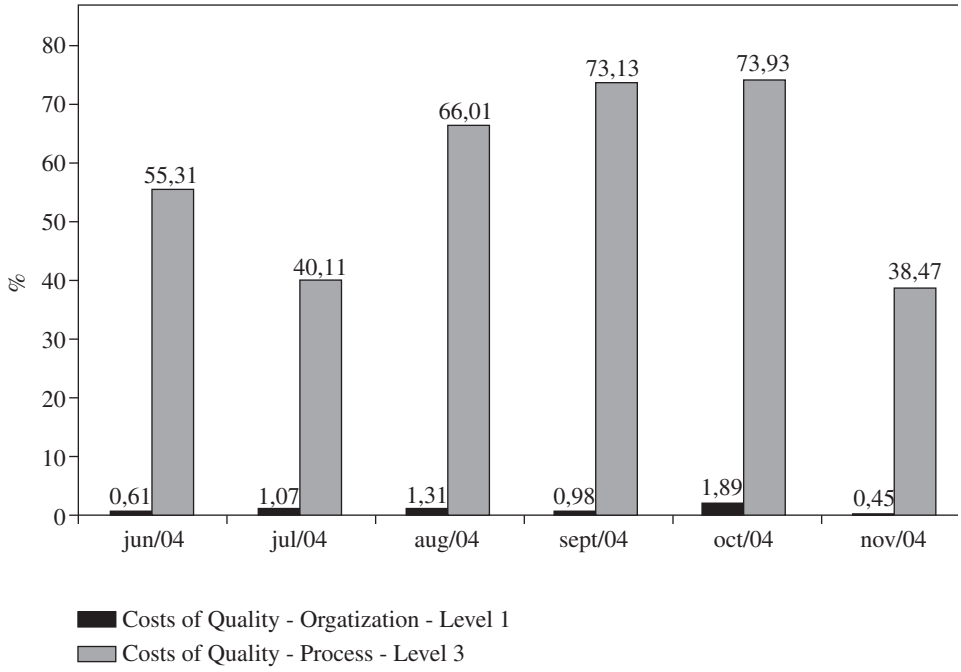
Table 3: Measures for the quality costs data collecting

Process Quality Costs Data Collecting		
Process: Manufacturing **Process function:** produce parts according specifications		
COSTS CATEGORIES	**DESCRIPCION**	**MEASUREMENT DATA (ET: EXPENDED TIME)**
Prevention Costs	– Planning the manufacturing process	ET to elaborate and check the process
	– Manufacturing data elaboration	ET to elaborate the manufacturing data
	– Prevention action	ET to implement Prevention action + costs related of expended resources
	– Training people involved	ET to trainning people
	– Process measuring / monitoring	ET per occurence
	– Continuous improvement	ET to implement the action + + costs related of expended resources
Evaluation Costs	– Part inspection	ET in the inspection activity
	– Purchasing of measuring equipment/ device	Price of the measuring equipment/device
	– Calibration of measuring equipment/ device	ET to calibration activities
Internal Nonconformity Costs	– Scrapping	ET of production process that was lost + costs related with raw material
	– Check, describe and act	ET per occurence
	– Reworking	ET of process activities caused by reworking
	– Rework inspection	ET per occurence
	– Check, describe and act	ET per occurence
	– Analyzing the deviation solicitation	ET per occurence
	– Implementing corrective actions	ET to implement the action
External Nonconformity Costs	– Scrapping	ET of production process that was lost + costs related with raw material
	– Check, describe and act	ET per occurence
	– Reworking	ET of process activities caused by reworking
	– Rework inspection	ET per occurence
	– Check, describe and act	ET per occurence
	– Implementing corrective actions	ET to implement the action

Source: Elaborated by the authors.

The results of the 6-month period of surveying are presented next. Figure 4 summarizes the participation of the quality costs related to a comparative monetary reference, identifying the indicators of company quality costs and the quality costs in the process. The quality cost of the organization, classified as level 1, was calculated related to the net sales which undergo a monthly fluctuation. The index of August was the most significant due to the increase in the category costs and a decrease in the total

Figure 4: Costs of Quality related to a comparative referential



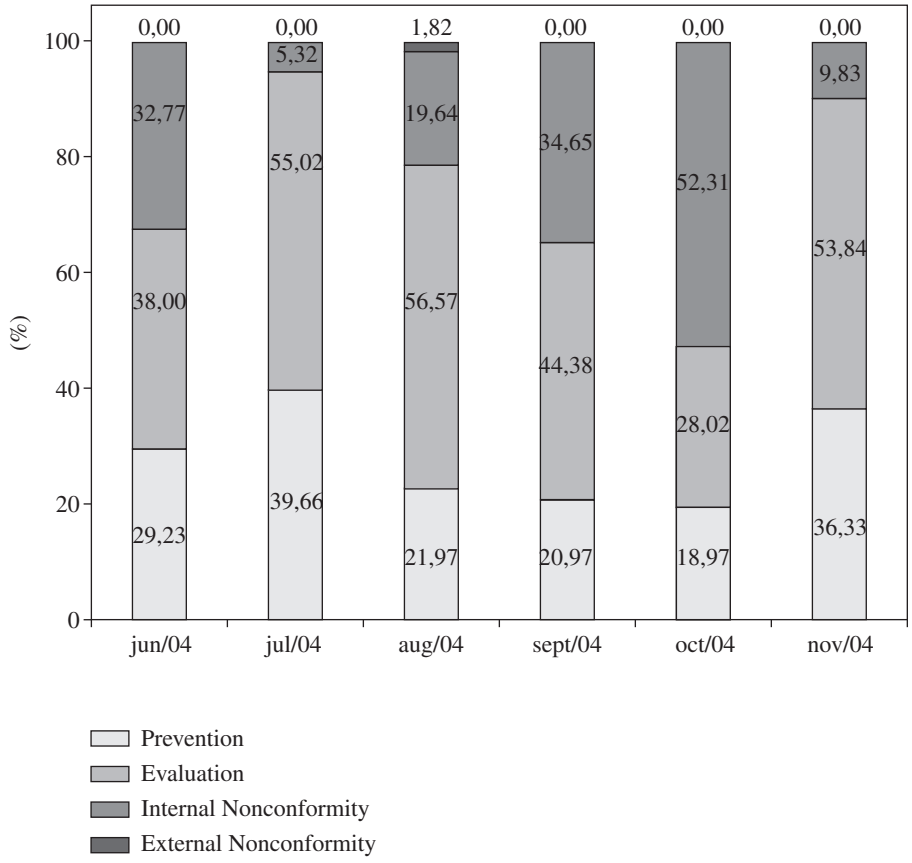
Source: Elaborated by the authors.

sales. The quality cost in the process, level 3, was calculated having as a comparative referential the direct manpower cost, which is an estimated value the year and it is not subjected to any variation. These values show a participation of the quality costs in relation with the direct manpower due to the complexity of the parts manufacturing and that all investment or waste has a significant impact in this indicator.

The participation of each category in the total cost is shown in Figure 5, and each one of the costs represents the indicator of level 2. It is possible to notice a greater participation of the prevention and checking costs showing the importance of these costs in the company. This is an indicator that there is an optimization potential of the activities carried out for prevention and evaluation. For evaluation, all the manufactured lots are surveyed by the operator and the final inspection is carried out by the quality sector. The amount of time spent to make the measurement by the operator was not considered as it is included in the amount of time to do the activity.

Throughout the data surveying, most of the occurrences of non-conformities were identified by the own operator, before they go to the final inspection. That is why, it is considered that there is a potential to the improvement in the measurement method to simplify the procedures, doing, for example, a specific audit to improve the measurement system and product surveying. The table 3 shows how the quality costs were classified and what measurement indicator was defined for each one of them.

Figure 5: Participation of the Quality Costs by Category



Source: Elaborated by the authors.

The table 5 shows the results obtained in every items of each category. Some of these items do not present any occurrence during the checking period. The verification index showed a more elevated value in October, due to the acquisition of new measurement and inspection apparatus that represented a little more than $^{1}/_{4}$ of the total.

In the nonconformity item that refers to scrapping, through the analysis of the reports of nonconformity, can see that the occurrence of non-conformities are of the different types there was not either any specific parts that repeated the same problem during the analysis period. The external nonconformity was an elapsed case of a redone work in a part delivered to the final assembling process of the machines and has not reached the final customer. Basing on these results may infer that the organization is concerned about the prevention activities of the nonconformity occurrences and with the activities of verification retaining the problems in the process, stopping them from reaching the customer.

Table 5: Detailed results by item in each category

	JUNE 2004	JULY 2004	AUGUST 2004	SEPTEMBER 2004	OCTOBER 2004	NOVEMBER 2004
Prevention Costs						
Planning the process	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Training people involved	2,37%	3,49%	0,00%	3,35%	0,71%	0,23%
Continuous improvement	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Prevention action	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Process measuring / monitoring	0,51%	0,71%	0,43%	0,01%	0,01%	0,03%
Manufacturing data elaboration	26,34%	35,46%	21,54%	17,61%	18,25%	36,07%
Total	**29,23%**	**39,66%**	**21,97%**	**20,97%**	**18,97%**	**36,33%**
Evaluation Costs						
Part inspection	28,08%	38,73%	23,53%	21,24%	21,02%	40,38%
Calibration of measuring equipment	9,36%	12,91%	7,84%	7,08%	7,00%	13,46%
Purchasing of measuring equipment	0,56%	3,38%	25,19%	16,06%	0,00%	0,00%
Total	**38,00%**	**55,02%**	**56,57%**	**44,38%**	**28,02%**	**53,84%**
Internal Nonconformity Costs						
Scrapping	32,58%	4,64%	16,22%	34,36%	52,17%	7,25%
Reworking	0,00%	0,35%	3,02%	0,10%	0,06%	2,17%
Analyzing the deviation solicitation	0,08%	0,18%	0,31%	0,08%	0,08%	0,15%
Meeting with internal suppliers	0,11%	0,15%	0,09%	0,11%	0,00%	0,15%
Total	**32,77%**	**5,32%**	**19,64%**	**34,65%**	**52,31%**	**9,83%**
External Nonconformity Costs						
Scrapping	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
Reworking	0,00%	0,00%	1,82%	0,00%	0,70%	0,00%
Total	**0,00%**	**0,00%**	**1,82%**	**0,00%**	**0,70%**	**0,00%**
General Total	**100,00%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**	**100,00%**

Source: Elaborated by the authors.

The majorities of losses occurred were caused by the suppliers during the manufacturing process and it represents more than 75% of the total losses in the verified period. The components related to the losses are identified in the table 6. As the organization had a quality management system in conformity to ISO 9001:2000, the non-conformities occurred are analyzed in meetings with internal and external suppliers, to deal with the problematic parts individually.

7. CONCLUDING REMARKS

The quality cost evaluation allows people to analyze the activities and the materials and they started to have a better understanding on how the process works. In this sense, an organization which has a certificate of quality management system in conformity to the norm ISO 9001:2000 may have some advantages over an organization that does not

Table 6: Costs related to non-conformities

LOSS ITEMS	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	TOTAL
Raw material	7,30%	47,55%	29,84%	6,85%	1,36%	6,76%	8,07%
Losses caused by the supplier	73,18%	11,11%	40,53%	81,61%	87,67%	58,80%	75,91%
Losses caused by the processes	19,52%	41,34%	29,63%	11,54%	10,97%	34,44%	16,03%
Total	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**	**100,00**

Source: Elaborated by the authors.

have structured system due to the preset processes and a wide range of information available that can be used in the measurement of the quality costs. The work carried out shows the importance of analyzing the costs completely and not only some flaws. After having studied several approaches it was considered the PEF approach as being the effective because of the results presented and it was shown that most of the costs were concentrated in the prevention and assessment category. Through the presented results it can be said that the company has a good development of its quality management system and the system proposed here has the purpose of surveying periodically the quality costs and analyze the information in the context of the quality management of the organization, not being a tool employed only sporadically to survey improvement opportunities.The methodology of research employed here and the selected PEF approach have showed that it can be used in a specific process or in all quality management processes and it will be able to help the process responsible people and the first level of management in the following aspects: evaluation of the process performance; a tool to identify where the biggest costs are concentrated ; enhance the commitment of the people in showing how the processes are operating in financial aspects and drawing attention to the quality problems; allow the first level of direction the opportunity of setting goal to reduce the quality costs and; allow the quality improvement through cost reduction. Finally, concerning to the implementation, the use of a team work to carry out the research allowed them to speed up the making of the activities due to knowledge of the processes and the commitment to the fundamental factor on the implementation of any quality tool.

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