

Cost of Quality (COQ) implementation Methodology: A case study in Medium Sized Manufacturing Enterprise

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Abstract

Presently, the greatest challenges faced by the Indian manufacturing enterprises are global competition, higher focus on quality from customer side and increasing cost of manufacturing due to inflationary pressures from economy in that order. These challenges are partially overcome by adopting advanced technology and following latest trends in manufacturing management. To overcome the cost pressure industries try to tap different cost reducing avenues. In search of these, one of the options, which was not popular till recently, is being considered now. The option is to identify measure, analyze and reduce the "Cost of quality" (COQ).

Evolution of cost of quality studies and COQ practices started nearly six decades ago. Today quality costing is essential part of every modern enterprise's quality plan. The present study focuses on suitable methodology for implementation of COQ. The motivation of study is to enable development of a sound quality cost management system (QCMS) for varied sizes and types of enterprises working in continuously advancing manufacturing environment. The intended QCMS refers to the practices, policies and procedures followed by an enterprise that relates to collecting, measuring and classifying quality costs data. In addition it should work in tandem with accounting system employed by organization for selecting, using and maintaining the quality related financial matrices. Paper reviews the present state of art of COQ practices reported in literature and industry with more emphasis on manufacturing industry in India. Based on the information obtained a methodology for COQ implementation is devised and illustrated using a case study.

Keywords — Cost of quality (COQ), methodology for coq implementations, medium sized manufacturing enterprise

I. INTRODUCTION

This Owing to liberalization of the Indian economy, Indian industry is also experiencing an increasing pressure for improvement in quality of its products and services, for which it is adopting tools and techniques of quality improvement. In general, there has been an appreciable improvement in adoption of quality concepts in recent years in the

Indian industries. In the research undertaken [1], which was empirical in nature, the focus was on the study of quality management practices in Indian manufacturing organizations to find the relationship between main quality management practice dimensions and superior product quality outcomes. The results of this study show that the majority of the Indian companies are well aware of the modern quality management concepts and philosophies.

In the present scenario of manufacturing enterprises, it is vital to measure their quality efforts as everybody involved in manufacturing enterprise knows the impact quality has on customer satisfaction and therefore affects the benefits. But many of them may not have true reflection of effect of lack of quality to the inefficiency and ineffectiveness of quality management. On the other hand, management acts only if a proposal is brought with presentation linking cause and effect in term of money. This is evident from the migration of all the manufacturing enterprises: small, medium and large from conventional technology to induction of advanced technology. In general, advancement of technology is adopted first in vital functions of enterprise such as design followed by manufacturing processes. Slowly it percolates to all the functions and departments across the organization including quality. To this end, "Cost of Quality" (COQ) concept comes in handy for co-relating the investments required to the returns on investment for suitably enhanced quality function to cope up with advanced manufacturing environment from conventional.

This paper attempt to summarize an overview of the COQ practices in Indian manufacturing enterprises through discussion on the research and case studies reported in literature. With a motive to develop a generic framework for COQ measurement in present era, as a first step, a case study is done in a rapidly growing medium sized manufacturing enterprise where different quality management systems are in place but formal COQ system is not implemented. The paper describes basics of COQ practices, methodology adopted for implementation, details of steps followed and conclusions drawn.

II. BASICS OF COST OF QUALITY (COQ)

A. Need of COQ Practices

It is clear that the goals of achieving quality, implementing continual improvements, and cutting operational costs are common to modern industry. It is also clear that the approach industry takes to achieve these goals is often limited to the implementation of Quality Systems and the application of Lean manufacturing principles. The unfortunate reality is that, another program that shares these lofty goals, quality costing (a program dedicated to understanding, measuring, and controlling the total COQ), seems to be less widely practiced. The absence of quality costing programs is a function of the difference between systems to track costs of quality activities, as opposed to those traditionally developed to track the expenses of production. The increased importance of COQ can be explained by the changed customer behaviour from buying whatever is offered into buying only products that matches their functional requirements and desired price, caused by the global competition. This has made the customer orientation much more important for companies and therefore also increased the importance of reduction and financial measurement of non-conformance.

B. Definitions and Categories of COQ

The definition of quality costs is as important as that of quality. Unfortunately, the definitions of quality costs and the constituent elements differ from author to author. After comparing different definitions of quality costs it can be found that most of them are similar. Mainly two different groups of terms exist:

1. Cost of Quality – either abbreviated COQ or CoQ
2. Cost of Poor Quality – abbreviated COPQ. This term also include Poor-Quality Costs – PQC

The both terms Cost of Quality and Cost of Poor Quality are essentially synonymous and both can be used to describe quality. In this subject, literature points out that, many writers imply their own definitions of quality related costs and much of the literature on the subject is on how to interpret or define quality costs.

Critical issues for effective COQ implementations are:

- To categorize various quality costs and make sure that all costs are capture
- To collect and analyze data and quantify all quality costs accurately
- To identify areas of poor performance on basis of the data analysis
- To allocate responsibility for the overall cost

Two different objectives with quality costing as stated in [2] are:

- Estimate the Quality costs as a one-shot study and use the result from the study to start projects of improvement.

- Expand the accounting system and continuously present the cost as a scoreboard and make this drive the starting of improvement projects.

Each of the below categories should be identified as a cost driver and quantified. The sum of all these (and any others needed) would be the Cost of Quality [3].

1. Prevention Costs: The costs of all activities specifically designed to prevent poor quality in products or services. Examples include:
 - Quality planning and programs
 - Training
 - Designing in quality and reliability
 - Process controls
 - Quality audits
 - Qualifying suppliers
 - Preventive maintenance
2. Appraisal Costs: The cost associated with evaluating or auditing products or services to assure conformance to quality standards and performance requirements. Examples are:
 - Incoming inspection
 - In-process testing
 - Diagnostic tests, including the cost of testers and test development
 - Final testing
 - Internal quality audits
 - Field quality audits
 - Corrective actions on all of above
 - Equipment test and calibration
3. Internal Failure Costs: All costs resulting from products or services not conforming to requirements or customer/user needs which occur before delivery/shipment of product, or the furnishing of a service. Examples include:
 - Rework
 - Diagnostics (the cost of discovering what is wrong)
 - Re-inspection of rework
 - Scrap is the value up to that point of whatever cannot be reworked
 - Value of replacement materials and parts
 - Purchasing actions to procure replacements materials/parts
 - Analysis of quality problems
 - Cost of planning and corrective actions
 - Supplier corrective actions and change-induced quality costs
4. External Failure Costs: Cost incurred when customer finds failure. These can be:
 - Dealing with customer complaints
 - Refund/compensation/allowance costs
 - Returned goods
 - Warranty costs
 - Recall, retrofit, and dispatch costs
 - Penalties
 - Liability costs

- Goodwill, reputation degradation

5. Many researchers have proposed various approaches to measuring COQ. In agreement with the majority of previous researchers COQ models can be classified into five discrete generic groups which are: P-A-F or Crosby’s model, opportunity cost models, process cost models and ABC models. These models are summarized in Table I.

TABLE I : GENERIC COQ MODELS AND COST CATEGORIES

Generic model	Cost/activity categories
P-A-F models	(Prevention + appraisal + failure)
Crosby’s model	(Prevention + appraisal + failure + opportunity)
Opportunity or intangible cost models	(Conformance + non-conformance) (Conformance + non-conformance + opportunity Tangibles + intangibles) (P-A-F (failure cost includes opportunity cost))
Process cost models	(Conformance + non-conformance)
ABC models	(Value-added + non-value-added)

III. COST OF QUALITY PRACTICES IN INDIA

The literature published in last decade is reviewed to get insight of the COQ practices followed in India. A survey of north Indian industries was conducted to find out various costs of quality practices followed by them [4]. The study reflects the true state of COQ practices followed by the industries in north India. Those can be summarized as: the awareness of employees about COQ and level of support of top management about COQ implementations are not consistent within all responding industry groups; No proper data collection methods were followed while collecting /estimating data of COQ related activities; The industries were not analysing the costs of quality data properly and employees of industries were not fully aware about benefits of COQ programs.

In the work [5], author claims the study as first to publish COQ implementation in Indian SME sector. This case study shows the steps needed for the implementation of COQ practices in an organization. The author also proposed two indices for COQ which are ratios of external failure costs to total quality costs and ratio of current year’s total quality cost to that of previous years. These matrices were found to be useful for tracing the progress and sustenance of the program.

In the similar types of studies [6], [7], it was found that P-A-F methodology for COQ study were proposed and implemented. It is important to note that, these studies were conducted in different types of organizations, working in different locations. Because of difference in nature of business and quality systems and policies in place in these

organizations, there are case specific findings for the target area for improvement in quality performance and reduction in total COQ. The study reported in [9] was focused on a manufacturing company with ISO 9000 certification, making a proprietary foundry sand additive, from a total quality cost perspective. The study concentrated on the quality cost aspects of the TQM initiative and outcomes. In addition to proposing basic steps for implementation of COQ system, they have extended the exercise to quantify by regression analysis, the effect that changes in one cost category have on other categories and on the total quality costs (TQC). The work reported is a step forward towards using the COQ analysis for achieving the organizational goal of quality enhancement and improved customer satisfaction through a well designed framework for COQ practices. An integrated simple model of COQ implementation for small scale industry was proposed and implemented in [10]. It can be concluded that, the methodology suggested is simple and suitable for implementation in micro, small or medium sized organization.

However there are few studies which adopt models other than conventional P-A-F model. It will be interesting to note the factors which made researchers to go for other models or modify the models. Process cost modeling is used for quality costing for a paper industry in the study cited in reference [8]. The work used the five steps, as mentioned in the BS6143: Part2, 1992, for process cost modeling. It is claimed that, after successful implementation of Quality Costing System, it can be used for: Performance indication; as a planning and control tool; and a budgeting tool. In the work reported in [9], a slightly unstructured approach was used to account for cost of poor quality in a continuous casting steel plant. Among the various factors contributing to COQ, hidden costs such as opportunity costs are difficult to quantify. In this paper, an approach for quantifying the opportunity costs is presented.

The overview of the COQ practices followed by Indian industries as reflected in published literature is given by [10]. This study gives a feeling that, there is a need for proper mechanism to educate, facilitate and implement the COQ practices in target industries. It can be thought over to make some regulations to report COQ to stakeholders of the enterprises for an improved adoption of COQ practices in addition to regular financial reporting which is mandatory. It is equally important to know the reasons of non implementation of the COQ practices by so many industries. There is a case for developing a proper model of COQ implementation and usage for those industries in gradual manner. And for the enterprises, where COQ practices are already implemented, there should be a continuous refinement to get the desired benefits and sustenance

of the system. Efforts should be directed towards utilization of available information technology infrastructure for implementation and sustenance of COQ practices.

IV. METHODOLOGY FOR CASE STUDY

A. About the Enterprise Under Study

The company identified for implementation of Cost of Quality Practices was Clad Metals India Pvt. Ltd., Waluj, Aurangabad a part of Kale Group of Industries, Aurangabad, for flagship product “Roll bond panel”. The Kale group consists of four manufacturing companies with facilities located at six plants. The combined turnover of the group was Rs 150 plus crores in 2013-14. The group achieved a growth from Rs 30 crores turnover to present state in a matter of five years. The group is tier one supplier of roll bond panels and other pressed components to companies viz. Samsung, LG, Haier, Videocon, Godrej etc. Group employs a workforce of 500 plus including technicians and engineers. The company has a strong business and quality culture responsible for a rapid growth. The company was selected for the study because it was not using Cost of Quality practices but the management was open to undertake new concepts for improvement and was willing to cooperate for the study.

B. Steps followed for Study

1) Explanation of Study Background::

As the concept of COQ was not known fully, a combined meeting with M.D. and all concerned department personnel was taken. The focus of meeting was to elaborate on: What is COQ and methods available, Why it is essential, what others are doing, How to go about it and tentative roles of different departments. This meeting was followed by discussion with each department head during the course of study as and when needed.

2) Obtained Detailed Information of the Plant :

- Organization structure
- Functional workgroups
- Product groups
- Manufacturing steps
- Process flow for conduct of business
- Quality policies and practices followed
- Information available in existing ERP system
- Identified other data sources

Although group is involved in large number of product manufacturing, there main product is roll bond panel assemblies for different customers which account for 90% of Clad Metals turnover and approximately 65% of group turnover. Hence the study was focused on the roll bond panel assembly manufacturing. The manufacturing steps for the roll bond panel can be summarized as panel making, panel assembly and powder coating. The inspection data is generated at five steps in panel making and at

the end of assembly and painting stage respectively. This data is input to ERP system through quality department at the end of every shift. Process and Quality policies and practices followed include: Process Flow Analysis, Potential Failure Mode and Effect Analysis(FMEA) , Process Control Plan, Gauge Repeatability & Reproducibility Study, Analysis of Measurement Study, Statistical Process Capability, Tool Inspection Report, C.M.R. (Counter Measure Report)(For failure at customer end), N.C.R. (Non Conformity Report)(Internal Failure), Deviation Request note, F.P.A. (First Piece Approval: Before start of Production Line and Change of Model), Improvement Initiatives by 4M study (Man , Machine , Material ,Method) and New Product development. The Organization structure of the Quality Department consists of: Manager central quality, Manager Quality shop floor and team of engineers, technicians and inspectors. Activities Carried out routinely by department were:

- Date wise, stage wise inspection data recording (Rejection Data)
- Rejection Analysis: Model wise, Month wise , Cumulative defect wise
- Defects data collection at customer end (ppm) and analysis
- Improvement initiatives

The activity missing was, Absence of formal Cost of Quality Practices, for which reason quoted was, not aware about the details as well as benefits. But open to adopt if feasible and useful. Hence were actively involved in the case study and co-operated.

3) Data collection for case study:

It was decided to collect data required for P-A-F: Conventional COQ system with following components

- Appraisal Cost
- Prevention Cost
- Internal failure Cost
- External Failure Cost

The data sources identified were:

- ERP system
 - Departments: Quality, Stores, Production, HR, Sales and Marketing, purchase
- The data collection formats were: Spread sheets from ERP system, Information from different departments in Excel, word and other formats, Notes taken during meetings with different persons.

The details of information/data collected from various sources are:

Information available in existing ERP system:

- Date wise finished goods production(Model , Quantity and rate)
- Date wise semi finished (TIG Welding) production (Model , Quantity and rate)
- Date wise rejection data (Model, Quantity, Reason)

- Date wise sales data (model, Quantity, Gross amount)
Quality department:
- Model wise rejection data (Date, Stage, Defect type , Quantity)
- Counter measure reports (Customer , Complaint description, root cause, action taken)
Other Departments:
- HR and Accounts department: Employee details, salary and other expenses such as training etc.
- Purchase and Marketing: cost of time, resources incurred on quality issues with supplier and customers
- MD office: External resources deployed for quality issues and vital inputs on resource sharing between functions, departments and manufacturing facilities.

4) Cost of Quality Calculations:

Although, large numbers of heads are available under each cost category, major expenses are considered for pilot study in line with standard industry practice. The percentage of salary for the different quality cost categories was decided after detailed discussions and inputs from all concerned department heads, direct observation and referring the documents available.

From the data collected, it was found that number of data elements can be directly attributed to different costs as per P-A-F classification, e.g. internal failure cost calculation requires the number of rejections and cost of rejection, which was available at two different sources in ERP system on real time basis, hence direct calculation could be done. However 10% salary of engineers is also considered in internal failure cost. This allocation is the most typical part of the exercise. The problem was to appropriately allocate the pay roll cost incurred on quality department staff (Inspectors, workers etc.), engineers and managers looking after quality functions in different capacities and sections. Being a mid-sized enterprise, multitasking was found to be very common. For example the quality manager was supposed to look after preventive measures as well as online quality checking and have to give input to new product development team on quality aspects simultaneously. These functions cater to different cost classification and reflected in the following values. The approach used was a simplified one, wherein, by observation and discussion with concerned engineers and managers over a period of two weeks, approximate time spent in different quality activities was noted. These figures are bifurcated in different heads after due explanation

In addition to the conclusion related with COQ data following important observations/conclusion about adopting the COQ practices in case industry are worth noting:

and deliberations with quality in-charge, production head and managing director. In his approach the trade-off was completeness over accuracy. Being pilot study, without consuming resources for the exercise, it was felt that coverage of all possible cost was more important over accuracy of calculation of few cost heads.

- Prevention Cost:
60% of Salary of Engineers in quality department
- Appraisal Cost:
30% of Salary of Engineers in quality department
100% Salary of quality dept. staff (technicians and inspectors)
5% salary of purchase dept staff
- Internal Failure Cost:
10% of Salary of Engineers in quality department
Cost of rejection (Rejection quantity X Cost)
Cost of rework (Rework quantity X cost of rework)
- External Failure Cost:
Cost of rejection at customer end (Rejection quantity X Cost)
Cost of attending customer complaints (Includes, time resources, actual traveling and other incidental expenses)

Data shared by different departments was for different period. For this study data from April 2014 to December 2014 was considered for cost calculations. As per the request from organization actual data is not disclosed but the final outcome of the complete exercise is given in table 2 in percentage form which is sufficient to draw conclusions. All the components of quality costs shown are in terms of percentage of TCOQ.

V. OBSERVATIONS AND CONCLUSIONS

Following conclusions can be drawn from the cost of quality (COQ) calculated:

- Average TCOQ is 3.48 % of gross sales which is higher than reported by other industries surveyed by author but less than reported in literature
- Major component of Quality costs is IFC where lot of scope is there for improvement.
- PC and AC are much less than the usual proportions mentioned in literature.

In conclusion although the case industry is developing with rapid pace and adopting automation in processes (Paint Shop) still there can be number opportunities where cost cutting can be done with the help of COQ analysis.

- Almost all the data required for COQ is available; but in different formats and places.

- Nearly 80% information is available in ERP system day wise. It is possible to calculate COQ weekly or even daily if proper interface to existing ERP is designed and maintained
- For improving accuracy of the whole exercise, the allocation of payroll costs of engineers, managers and other overheads should be done dynamically instead of average figures as taken in this study. This may require design of elaborate system which may need additional resources.
- Allocation of overheads is difficult presently as few resources are shared by other plants also.

Due to product diversity, fluctuations in the production as the demand is seasonal, new product development on continuous basis it is difficult to get true picture and exact pinpointing of causes of higher TCOQ using conventional PAF model, which may be just sufficient to get an overall idea.

ACKNOWLEDGMENT

S.G.M. thanks Mr. Ashok Kale, M.D., Kale Group of Industries, for granting permission to undertake the case study in Clad Metals Pvt. Ltd., Waluj, Aurangabad. Thanks are also due to his complete team who have whole heartedly supported by providing vital data and information. The authors would like to extend special thanks to reviewers of the paper.

Table 2 : Cost Of Quality Statistics
Tcoq: Total Cost Of Quality (Percentage Of Gross Sales)

	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Average
TCOQ % of Sales	3.48	3.02	2.83	2.28	3.37	4.92	2.36	2.95	4.51	3.48
PC	1.69	2.28	3.26	7.81	7.17	2.95	4.76	10.82	5.96	1.69
AC	2.51	4.00	5.94	9.82	8.59	4.62	8.01	11.37	9.28	2.51
IFC	67.24	88.70	82.03	72.97	23.02	56.97	79.59	66.87	62.10	67.24
EFC	28.56	5.01	8.77	9.40	61.23	35.45	7.64	10.94	22.66	28.56

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