

HIDDEN COSTS OF QUALITY: MEASUREMENT & ANALYSIS

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ABSTRACT

Quality is the assurance of adherence to the customer specifications and it is a measure of excellence or a state of being free from defects, deficiencies and significant variation from standards. Customer specification of the product can be met by strictly adhering to the quality control measures in the production process and can be ensured in a cost effective manner only if the quality of each and every process in the organization is well defined and ensured without any lapses. Every activity in the supply chain line to be critically verified to identify the quality deviations incurring additional expense or loss to the organization. This is in line with the continual improvement principle of TQM philosophy. The cost of quality management system acts as the most significant tool in measuring, monitoring, controlling and decision making activities in a firm which aims on business excellence.

KEY WORDS

Quality Cost, Hidden costs, Opportunity costs, Pareto Diagram, Quality Management System.

1. INTRODUCTION

A strong control over the management of utilization of resources of all categories in a manufacturing process becomes the demand of the day due to the high competition among the players of the present market. The resources-man, material, machine and time-to be utilized in a most cost effective manner to ensure the profitability of any business and at the same time no compromise in the quality is permissible. This is the highly competitive globalized market scenario today.

Hence management and financial accounting have an important role in the measurement and control of the components of manufacturing costs. On the other hand quality improvement programs for attaining continual improvements have become essential to any business organization to thrive forward profitably with enhancement in its customer base. The question is how to achieve both these objective without losing organizational interests. Cost of quality has evolved as the answer to this question. Cost of quality analysis is considered as one of the most effective management tool for gathering and analyzing the expenses in maintaining quality in a manufacturing process and also identifies the non-value added expenses. Quality improvement

programs can be critically analyzed using quality costing techniques to check the merit of the program. This helps the management to identify the areas for improvement in quality as well in reducing wastages and hence ensure profitability.

Cost of quality or quality costs in a broader sense is the expenses incurred by an organization in achieving and maintaining good quality as well as in managing poor quality throughout its line of operations with an aim to attain highest level of customer satisfaction. The cost of quality analysis triggers changes and provide proof why changes should be made. The need to improve the financial position of an organization directly correlates with the process of making quality improvements. Cost of poor quality will tend to zero, if every activities are performed well in time.

Many models of quality cost analysis have been evolved since the inception of this concept by the quality guru Dr. Joseph Juran in 1950. The classical PAF model by Feigenbaum (1956) which distinguishes quality costs into Prevention-Appraisal-Failure categories, Process Cost Model by Marsh and Ross (1976) classifying quality costs into cost of conformance and non-conformance in the manufacturing processes, Opportunity Cost Model by Sandoval- Chavez (1998) with the addition of opportunity losses to the other traditional models and the ABC-COQ integrated model by Tsai (1998) are the prominent models among them. Many more dimensions have been added to the quality cost analysis by researchers like Steve Elridge (2006) who has added knowledge management concept to quality, Sower etal (2007) who has analyzed the quality cost as a measure of system maturity with the analysis of the relationship between quality and quality costs and Ali Uyar (2008) and Zулnadi yakup (2010) who have analyzed quality cost as money invested and money lost.

The difficulties in implementation of a COQ system (Ming Tsung-2010), insufficiency in reports (Lee Hoon Tye-2011), in capability of addressing intangible costs (Assissi Jaffer-2010) and non synergy with TQM concepts (Aviora Aspinwal-2009) were addressed by many researchers.

Technological advancements in management were also effectively utilized by many researchers in analyzing quality cost. Behdad Kiani etal (2009) designed a model for analyzing the influence of costs of quality through a system dynamics approach. Mahanty. B (2012) developed a system dynamics model of quality cost in a manufacturing firm with the new features like time dependent deterioration process, formation of quality perception and market reaction. Arman Sadreddin etal (2014) developed a Cost of Quality (COQ) model for the procurement process of the construction industry to establish a general course of action for minimizing quality costs which take into account not only the internal quality costs within the company, but also the costs of its suppliers. Several different policies were designed and their effects on quality costs investigated through System Dynamics (SD) simulation.

Mathematical modeling was effectively used by NVR Naidu (2008) for analyzing quality cost categories. R K Sharma et al (2007) successfully applied a fuzzy approach to elicit expert opinion regarding the importance of cost items. The information so obtained after fuzzy synthesis is used to set up priority with respect to the processes which can provide necessary help to managers/practitioners to invest efforts in reduction of cost of non-conformances (CONC) and optimal allocation of resources. Liang-Hsuan Chen, Ming-Chu Weng, (2002) proposed a fuzzy approaches to evaluate quality improvement alternatives because of its fuzzy nature. An evidence fusion technique, namely Choquet fuzzy integral, is employed to aggregate the quality cost

information. Quality cost improvement model for analyzing conflicting goals using fuzzy sets was presented by Wang, Ming-Chu et al (2010).

Lin Zhang et al (2010) developed an extended Quality Function Deployment (QFD) approach to assess quality cost of packaging machinery from technical perspectives. Evaluation criteria for quality assurance cost, quality loss cost and comprehensive technical requirements are introduced for analyzing technical requirements that transform from customer needs and AHP is used to calculate and normalize different quality requirement weights.

The behavioral patterns of various cost categories were studied by Chopra et al (2011) and Sailaja et al (2014) using correlation and regression analysis.

Shepherd (2002) made an effective approach to the identification and measurement of quality failure costs can be integrated into a balanced score card.

But in spite of the overwhelming interest shown by the academic community in COQ studies, the industrial experts all over the world is still hesitant to utilize this tool in a fully fledged mode, as apparent from the empirical studies conducted worldwide in this regard.

Cost of quality management study from Turkish marble industry by Ozgur Akkoyun and Huseyin Ankara (2009), Survey regarding quality cost in Romanian service industries by Mariana Glavan et al (2009), Cost of quality practices among Indian industries by T Nath (2003), Aravind Chopra and Dixit Garg(2012) and Paramjit Kaur (2009) , An empirical study of quality cost system implementation in Brazilian tool manufacturing machinery by Felipe ARAÚJO CALARGE(2007),Cost of quality studies in Malaysia (Kanapathy & M Rasamanie-2011,Mukhtar che Ali- 2010), Quality costing reporting studies in Australia by Judi Oliver and Wen Qu (1999), Analytical study of cost of quality of construction projects in Dubai (Hisham M.E. Abdelsalam-2009) , cost of quality practices in Spain (Oriol Amat and John Blake-1993), Quality management through ISO certification and quality costs reporting studies in Bahraini companies (Sayed Ramadhan-2005) are few among them.

These studies shows that the industrial application of COQ methods are still limited to the traditional PAF model even though the strengths and capabilities of latest models in overcoming the limitations of PAF method is well appreciated by academic community. In most of the cases only direct and easily traceable costs only are gathered (Schiffaura- 2006).

1.1. Significance of the study

Many researchers were pointed out the requirement of analyzing all elements of quality costs to make optimal decisions that leads to competitive advantages in the highly customer driven modern market (Yang-2008). Bramford (2006) emphasize the quality cost analysis can be used as an effective tool for management only when all quality cost elements are captured. Improvements in the conventional model with the incorporation of additional cost categories were made by many researchers. Modarress & Ansari (1987) incorporated two additional dimensions viz, cost of quality design and cost of inefficient utilization. The losses incurred due to the internal inefficiencies were studied by Dahlggaard et al (1992). Sandoval-Chavez (1998) presented a modified COQ model with the inclusion of three elements –under utilization of installed capacity, inadequate material handling and poor service delivery. Giakatis (2000) analyzed the losses

incurred against manufacturing and design losses. Intangible costs like loss to society is analyzed by Teevaraprug(2004). Gary Cockins (2006) has explained the difficulty in measuring hidden costs. Yang (2008) attempted to quantify lost sales as estimated hidden cost. Soo-Jin Chea (2011) presented an action research study of tracking hidden quality costs in a manufacturing process with a focus on the resistance of employees towards implementation of COQ system. The significance of tracking and gathering hidden quality cost data were explained by Kume (1985), Sandoval (1998), Giakatis et al(2010) , Johannes Freiesleben and Suresh Krishna(2010) .

Even though these studies were well appreciated by the quality practitioners, not much practical studies found available in the literature with comprehensive data collection and analysis of all costs including hidden costs incurred against all quality improvement activities in the organization.

The practical studies in the case of hidden costs of quality are limited to hidden failure costs (Suresh Krishna-2006) and hidden costs in the manufacturing process (SooJin-Chea-2011). Not many studies are in place on opportunity costs also. Any activity which is not performed well in right time always incurs a loss to the organization. Opportunity costs are the losses incurred against a missed out opportunity of doing things right at first time. It is actually the measure of internal inefficiencies and its analysis will provide immense opportunities for improvement.

Hence an attempt is made in this research to unveil all hidden quality costs including opportunity costs right from the customer requirement analysis to after delivery support , in a manufacturing firm. In the current era, the analysis of each individual stage in the supply chain ranging from raw material acquisition to final delivery of the product is equally important (Ashish J. Deshmukh.and Hari Vasudevan 2014).

2. RESEARCH OBJECTIVE

The objective of this study is to identify measure and quantify all the hidden elements –direct, indirect and invisible elements of quality costs in all functional activities in the organization under study. Further the importance of such an analysis is ascertained by quantifying the impacts of hidden costs on the overall quality cost as well as on the organizational bottom line.

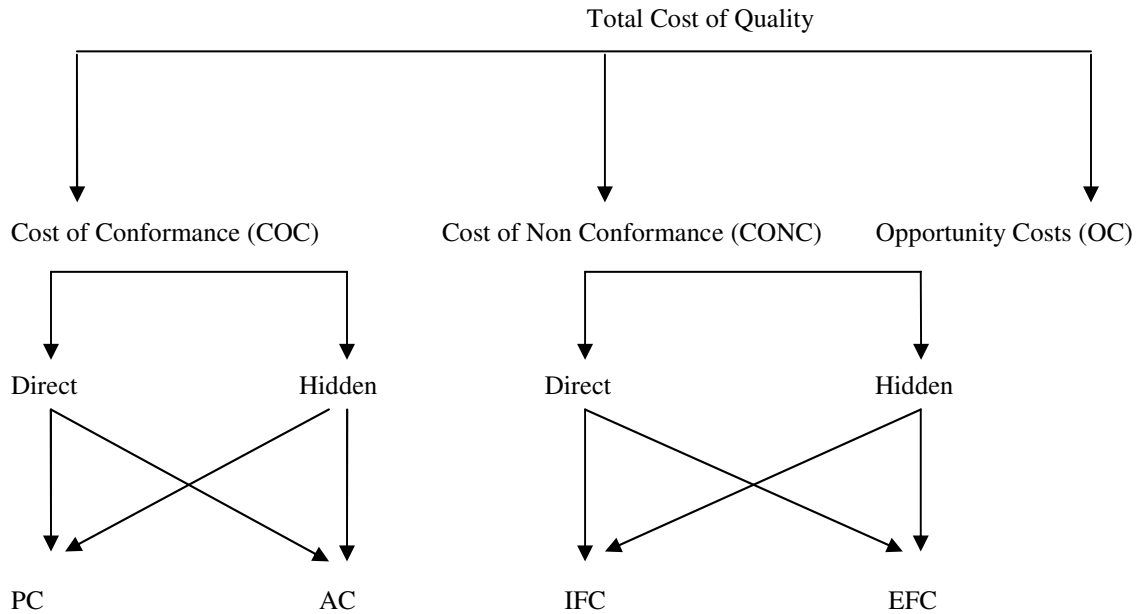
2.1. Methodology

The following methodology was adapted in this study:

1. Identification of all processes and quality cost elements in all corresponding activities, Comprehensive data collection and quantification, Grouping in to direct and hidden Cost of Quality.
2. Analysis of impact of hidden COQ on total quality cost and also on organizational bottom line.
3. Comparison of traditional COQ system with enhanced COQ with hidden costs included.

Personal interviews and discussions with the employees in each section were carried out to list out all processes, its input, output and control process as per the process cost model and all the activities in each process in the supply chain line is identified. Every activity is then analyzed critically to identify the quality lapses in each, which leads to an additional expense or loss to the organization. The missed out opportunities for improvement also listed out. The additional

resources utilized in each of this instances are systematically identified and quantified using the records like log books, route cards, registers, time study, personal interviews etc. to get the cost incurred in each. Then these cost elements are classified into direct and indirect costs as per the categorization in Figure.1. Further detailed comparative analysis is carried out between them. Finally the impact of indirect and hidden quality cost elements on the overall quality cost and to the organizational bottom line are analyzed.



(PC-Prevention Costs, AC- Appraisal Costs, IFC- Internal Failure Costs, EFC- External Failure Costs)

Figure 1. Categorization of quality cost elements

3.DATA COLLECTION AND CATEGORIZATION

The research has been carried out in a firm under electronic industry engaged in the manufacturing of electronic equipments which is already having ISO 9001:2008 certification. The PAF model of quality costing was already in practice in this firm with emphasis only on traditional P-A-F elements of quality costs which are easily and directly measurable.

During this study, a comprehensive data collection strategy has been adopted for gathering information on various quality cost elements in each activity. For this, the Process Cost Model approach has been adopted, where in each functional area is treated as a set of processes with definite input, output and control processes. Each process is critically analyzed to gather maximum information on quality deviation against all the activities which make the process complete. Then the cost incurred including indirect and hidden against these quality deviations are quantified using the records of additional resource utilization in this regard. Lost opportunities in each process also identified and corresponding cost data captured and quantified.

The traditional elements of costs of conformance and non-conformance identified and analyzed in this research are listed in Table-1.

Table.1 – Direct Quality Cost elements

Direct Conformance Costs(COC-D)		Direct Non conformance Costs(CONC-D)	
Prevention Costs (PC-D)	Appraisal Costs (AC-D)	Internal Failure Costs (IFC-D)	External Failure Costs (EFC-D)
Cost of maintenance of ISO certification	Raw material inspection	Scrap\ wastages	Trouble shooting of field failures
Training cost on quality standards, theories and practices	In-Process inspection-sub assemblies and assemblies	Internal Trouble Shooting - Repair , Re-test etc.	Expenditure on customer service dept. for support calls from customers
Cost on administration of quality issues	Final tests after integration of sub assemblies and modules	Rejections and rejection analysis	Repair of defective parts
Cost on vendor quality assurance	Pre- dispatch tests by quality assurance department	Re work	Replacement of defective parts
Preventive maintenance cost of equipments & machineries	Cost on internal as well as customer audits	Excess material drawn against rejections, scraps etc.	Product recalls.
Preventive maintenance of test jigs & tools		Interest on non moving inventory	
Cost of calibration of equipments		Machine break down	
		Materials written off due to product design changes	

The hidden quality cost elements are identified by extensive information collection by interviews, log books, records and registers kept in various activity centers with entry of time study, time cards, machine logbooks, complaint log books, attendance cards, minutes of meetings etc. and the cost elements identified in this study are listed in Table 2.

Table-2- Hidden quality cost elements

Hidden Conformance Costs(COC-H)		Hidden Non conformance Costs(CONC-H)	
Prevention Costs (PC-H)	Appraisal Costs (AC-H)	Internal failure Costs (IFC-H)	External Failure Costs (EFC-H)
Customer requirement review	Process audits at vendor premises	Engineering or design mistakes	Warranty claims
Engineering design reviews	Customer audits	Billing errors and rework on bills	Man power for field assistance on complaints

Process validation		Document procedures for raw material rejections	Emergency dispatches
		Production Planning errors	
		Raw material planning errors lead to extra raw material cost	

Similarly lost opportunities due to incapability of the system as well as inefficiencies are also listed out in each process and measurement techniques are devised by extensive data collection against each element identified after rigorous discussions with the authorities concerned. The identified Opportunity Cost (OC) elements with details are listed in Table-3.

Table 3: Opportunity Cost elements

1	Under utilization of machine capacity	Utilization below the installed planned capacity of machines due to insufficient customer orders, balanced quantity of raw materials, consumables or work force as well as planning inefficiencies.
2	Loss due to delayed payments	Delayed payments to the raw material vendors and loss of mutual trust results in demand from vendors for advance payments instead of credit purchases. Loss on account of interest against the lost credit period.
3	Customs clearance of materials	Customs demurrage charges on delayed customs clearance of materials. Also results in extra documentation , Follow up time etc.
4	Excess Financial charges by Banks	Penalties imposed by banks against insufficiency of documents for financial clearances, Losses due to foreign exchange variations due to the absence of forward contracts etc.
5	Emergency Dispatches	Extra shipping costs to meet customer urgency and to cop up with delayed dispatches.
6	Late delivery(LD)	Liquidate damages (LD)imposed by customer on late deliveries, part deliveries, delay in after sale support etc.
7	Sundry Debtors	Payment realization delays results in accumulation of sundry debtors and loss of interest or availability of sufficient fund flow.
8	Lost sales	Poor performances in product and service leads to customer dissatisfaction which in turn results in reduction in market share.

3.1 DATA ANALYSIS AND DISCUSSIONS

Based on the data collected, different quality cost elements are grouped into different cost categories and computed for a period of 3 consecutive years as summarized in Table-4 along with its percentage analysis to annual sales volume as well as to total cost of quality.

Table 4: Comparative analysis of cost categories of quality cost data

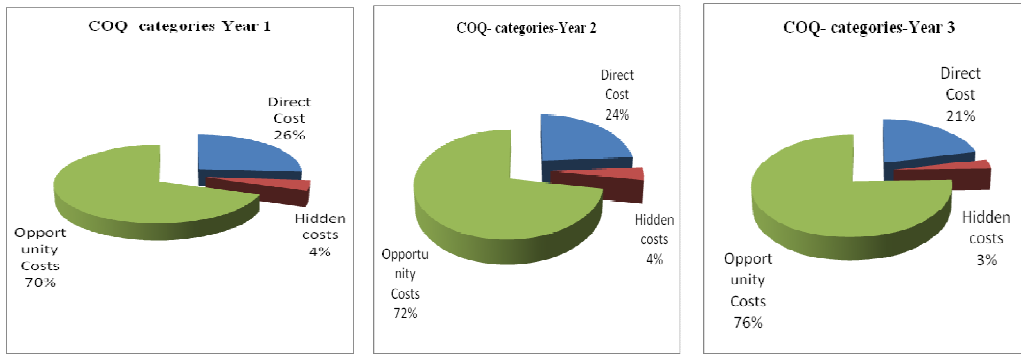
		Year 1: Sales Volume- INR 19076.00 lakhs			Year 2- Sales Volume INR 16322.00 lakhs			Year 3- Sales Volume: INR 10296.75 lakhs		
	Cost Category	Value (INR-Lakhs)	% to sales volume	% to total COQ	Value (INR-Lakhs)	% to sales volume	% to total COQ	Value (INR-Lakhs)	% to sales volume	% to total COQ
Direct Costs	PC-D	258.04	1.35%	3.98%	296.21	1.81%	4.25%	324.29	3.15%	4.46%
	AC-D	380.21	1.99%	5.86%	374.22	2.29%	5.37%	372.32	3.62%	5.13%
	IFC-D	947.34	4.97%	14.60%	821.22	5.03%	11.79%	762.11	7.40%	10.49%
	EFC-D	110.43	0.58%	1.70%	172.98	1.06%	2.48%	83.82	0.81%	1.15%
Total Direct Costs		1696.03	8.89%	26.14%	1664.63	10.20%	23.89%	1542.54	14.98%	21.24%
Hidden Costs	PC-H	6.899	0.04%	0.11%	6.72	0.04%	0.10%	7.32	0.07%	0.10%
	AC-H	7.258	0.04%	0.11%	7.31	0.04%	0.10%	8.94	0.09%	0.12%
	IFC-H	236.928	1.24%	3.65%	225.62	1.38%	3.24%	209.76	2.04%	2.89%
	EFC-H	23.579	0.12%	0.36%	39.32	0.24%	0.56%	16.22	0.16%	0.22%
Total Hidden Costs		274.664	1.44%	4.23%	278.97	1.71%	4.00%	242.24	2.35%	3.34%
	OC	4518.28	23.69%	69.63%	5023.67	30.78%	72.10%	5478.45	53.21%	75.43%
Total COQ		6488.98	34.02%		6967.27	42.69%		7263.23	70.5%	

The result shows that Cost of quality captured in the traditional systems in the year-1 is 8.89 % of sales revenue whereas the same in the enhanced system with hidden and opportunity costs included is 34.02%. The total hidden and opportunity costs amounts to 25% of sales revenue, which is around 3 times higher than the costs based on traditional P-A-F model. The traditional quality cost amounts to 26.14% of total quality cost, where as total sum of hidden quality cost is 73.86% of total quality cost, out of which major portion is contributed by the opportunity costs (69.63%).

Similar is the case with next two consecutive years under study; where in the total direct costs are 10.20% & 14.98% of sales turnover and 23.89% & 21.24% of the total COQ. Here also the opportunity costs are more than 30% & 50% of sales revenue respectively. When we analyze the

per category contributions to the total quality costs, opportunity costs shows the major category with more than 70% contribution as represented in Figure 2, Figure 3 & Figure 4. This gives a clear picture of the quantum and impacts of hidden quality costs and opportunity losses to the organization.

Figure 2, 3, 4: Category wise contribution to total Quality Cost for Year1, Year2 & Year 3



The Pareto analysis of all the identified cost elements also confirms the importance of hidden cost elements. Out of the total 43 quality cost elements identified under various categories, 8 cost elements found contributing to more than 80% of the total COQ value, out of which first three major contributors are of opportunity cost.

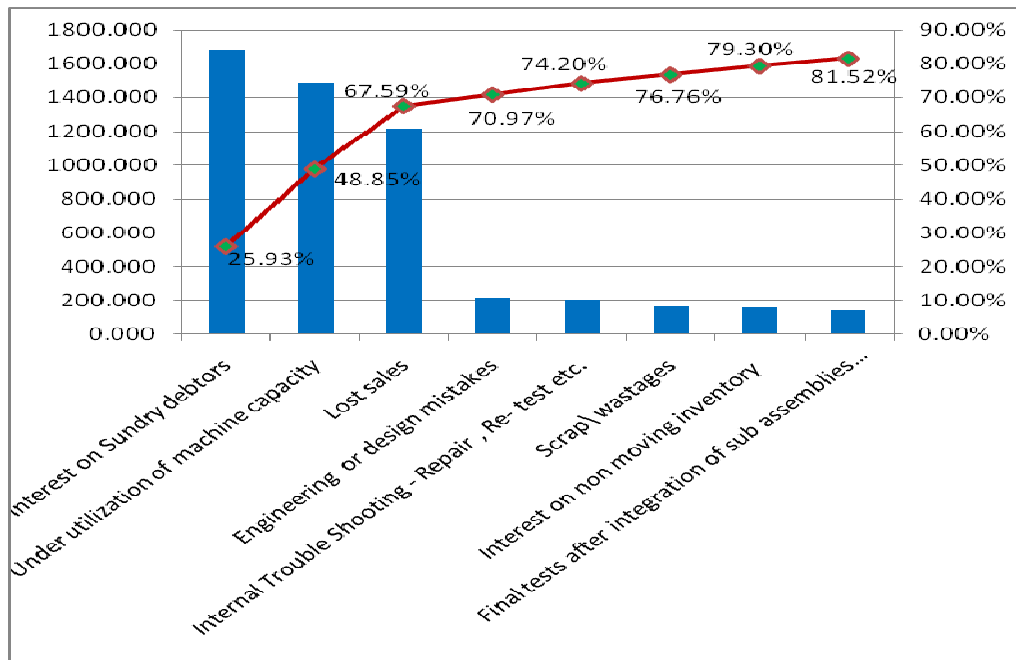


Figure 5: Pareto analysis of the opportunity costs

The Pareto chart shows that 80% of the quality costs come from 20% of the causes. The analysis shows that Interest on Sundry debtors (25.93%), under utilization of machine capacity (22.91%)

and lost sales (18.74%), are the major categories of the total quality costs. All these three elements are hidden opportunity cost elements. Figure 5 shows the Pareto analysis of these results.

As per the traditional P-A-F system of quality cost calculation, the firm under study was considered as a healthy organization with cost of quality value within an admissible limit of 10% of sales turn over in the first year of study. But this study reveals that the actual quality cost of the firm in first year itself is more than 30% of sales revenue and in the second year it has become 42% and in third year 70% which is an alarming situation. This shows the inadequacy of traditional accounting system in capturing the actual quality costs and also the importance of analyzing various hidden quality costs in a firm.

It is also found that the hidden COQ is higher than the net profit of the company. On analysis it is revealed that most of these opportunity costs can be eliminated with awareness of the impact of the lost opportunities and proper planning to eliminate the root causes. The underutilization of machine capacity can be reduced or eliminated with the proper utilization of man power, by capturing more orders by market intelligence and also by effective production planning and scheduling. The lost sales are due to the impact of customer dissatisfaction on quality of supply, delayed delivery and services. Proper and timely payment realization techniques and follow-ups can reduce the losses on account of interest on sundry debtors. Engineering and design mistakes are making many fold effects once it is identified in later stages of production process. This can be avoided by the proper and systematic verification of design requirements in the beginning itself. Most of the hidden costs can be eliminated by ensuring a smooth flow of error free information throughout the production process. This can be ensured with the help of an integrated manufacturing management system. Marketing, Customer engineering, Planning, Purchase, Manufacturing, Quality Assurance, Dispatch and Billing sections can be made integral part of this system. Manual document preparation errors and delays in procedures can be reduced with the usage of this system. Requirement of customer orders to be translated to tables of requirements by marketing department and then key parameters for production process to be identified by manufacturing method section. Subsequently planning dept. can use this data to generate raw material quantities required for production loading for fulfilling the available customer order. Procurement and receipt details of raw materials and consumables also to be updated to the same system from purchase modules. Using this data, manufacturing department can schedule the job work and dispatch information. The costs associated with all the type of manual errors including documentation, loading, scheduling and billing errors can be made zero with the usage of such a system.

This root cause analysis of opportunity costs gives an insight to the opportunities to improve the bottom line of the organization. These losses can be converted to opportunities for increasing profit margin of the firm.

4. CONCLUSIONS

In this study, a comprehensive analysis of all cost elements which contributes to the quality of products and services in the supply chain line of a manufacturing firm has been conducted. Apart from the normal prevention-appraisal-failure mode quality cost categories, more in depth analysis of all activities in the whole supply chain is done to track and measure the hidden elements of quality cost including the opportunity cost elements.

The study findings points out the fact that the hidden cost of quality is more than 3 times higher than the direct quality cost elements in the manufacturing firm and most of these hidden costs can be reduced or even eliminated by proper tracking and understanding the root causes.

This study highlights the inadequacy of traditional cost of quality system in tracking and assessing the overall costs of quality. In order to assess the overall cost of quality, the hidden costs also has to be identified, quantified, measured and analyzed. For tracing the hidden quality costs, it is necessary to move beyond the data produced by the traditional accounting system. This also gives an insight to the huge impact of hidden quality costs to the organizational bottom line and points out the gold mine of improvements. Using this data the company can formulate survival strategies in the highly intensive competitive market scenario.

Future studies in this field are recommended with the study of impacts of hidden elements on overall quality cost and development of a quality cost expert system with inclusion of hidden and opportunity cost elements.

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