Quality Cost and Six Sigma Frameworks to Improve Quality

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***Abstract*:** In today's highly competitive markets, manufacturers must provide high quality products to survive. Manufacturers can achieve higher quality levels by changing their manufacturing process and/or by inspecting products where there is often a multitude of different strategies. A quality cost approach serves as a useful framework for comparing available production processes and alternatives for inspection. Six Sigma is the powerful methodology for promoting improvements and reducing Quality Cost.

In this paper framework for Cost of Quality and Six Sigma is discussed. If frameworks of COQ and Six Sigma effectively implemented by Indian manufacturing industries then they will get the benefits such as reduction of defects, reduction in re-work, reduction in cycle time, increase in productivity, improved design, reduction in Cost of Quality, improved market share, customer satisfaction & delight, growth in revenue & profits and finally happy & satisfied stakeholders.

Keywords: Quality, Cost of Quality, Six Sigma.

I. INTRODUCTION

1.1 Cost of Quality

For nearly all manufacturing and service companies, quality has become one of the core factors aimed at winning enough orders. Improving quality is therefore considered one of the key strategies in today's complex global competitive environment to achieve customer loyalty. The studies concluded that any serious effort to improve quality would result in higher costs for of the product or service since improving quality has its own costs. As a result, measuring the cost of quality is important because it provides information about the financial consequences of adopting quality improvement programs [1].

The meaning of quality as improving the competitiveness of a company's products and functions has become more apparent in the course of time. The importance of quality can be explained to management by using quality costs. By using quality costs management's interest in quality improvement may be obtained. Today, more and more companies are providing services, and the competition on the market has intensified. These forces the companies to continuously improve their quality, and most companies today have started to undertake quality improvement activities. Companies have become aware that improved quality will lead to more satisfied customers who will return, which in turn leads to higher market shares and hopefully higher profits.

Products which are shipped out of the factory by the manufacturers should be 100 % defect free. Manufactures must ensure that the PPM defects do not exceed the limits specified. Through a well-designed process, this can be achieved. Six Sigma philosophy of building quality into processes, services and products can reduce quality costs and hence overall costs [2].

One of the most effective items that influence customer satisfaction is quality, so most of the organizations pay attention to quality and spend money to create an appropriate level of quality in their products or services. If an organization does not consider to quality they will face with direct and indirect cost resulting from remanufacturing or lost customer respectively, so organizations try to

reduce these costs where cost reduction where it is impossible to reduce costs unless they are properly recognized, measured and managed. As Dane explained “to manage we must control, to control we must measure, to measure we must define, to define we must quantify". Quality cost is the sum of conformance and non-conformance costs, the costs of conformance relate to the fees being paid for avoiding the poor quality (good quality) and non-conformance cost results in poor quality.

According to the study conducted by various COQ researchers, opinions range from 10% to 40% of the company's annual sales. The average sales industry is around 20 percent. For six sigma organizations with a sales range of 1 percent, whereas for three sigma organizations with a range of up to 40 percent, there is considerable potential for improvement for the average company. By using the basic Six Sigma tools of Statistical process control and Capability processes, the average factory can reduce poor quality costs and increase its profits [3].

1.2 Six Sigma

Six Sigma is the latest in a long line of approaches to quality and performance improvement. Six Sigma focuses on reducing defects and variations and driving towards excellence measured in terms of defects per million opportunities (DPMO). Six Sigma is a highly structured framework for process improvement that uses statistical and non-statistical tools and techniques to eliminate process variation and thus improve process performance and capability [4]. At the heart of this methodology is the reduction of defects to the level of 3.4 defects per million opportunities (DPMO) [5].

To achieve the target, this approach seeks to identify and eliminate defects, mistakes or failures in business processes by focusing on process performance characteristics [6]. Success of Six Sigma has been claimed in a wide range of organizations, ranging from the well-publicized work in Motorola and GE manufacturing to banks and hospitals [7].

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects in any process, from manufacturing to transactional and from product to service. This is achieved by using two Six Sigma sub-methodologies: DMAIC and DMADV. The Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) is an improvement system for existing processes for incremental improvement. The Six Sigma DMADV (Define, Measure, Analyze, Design, and Verify) is system for improving new processes or products.

The Indian manufacturing industry is going through severe global competition and there are reminders, failures in the field, internal rejections and internal rework. In order to be competitive globally, cost and quality cost are two very important aspects. A powerful tool for solving complex chronic problems is the Six Sigma methodology. Therefore, it is very important to study and investigate how Six Sigma methodology is used in the Indian Manufacturing Industry for process improvement or designing the product and importance of Six Sigma methodology to reduce Quality costs.

1.3 Cost of Quality and Six Sigma

Cost of Quality is not the price of creating a quality product or service. It is however the cost of not creating a quality product or service. When associated with Automobile Industry it can be safely stated that it is the cost of having an Automobile recall. Using the six sigma concept helps to keep the quality of the product controlled in a pleasant way to avoid unnecessary reduction of one’s overall profits. In cases where business quality costs begin to limit incoming profits, using the six sigma methodology to the entire operation is the best way to save everything. This can increase not only the quality of the business output, but also the morale of the employees [8].

The Six Sigma initiative's objective is to aggressively attack quality costs, e.g. cost of inspection and warranty, scrap, rework and reject, can be approximated with only 10-15 percent of overall quality costs. Remaining 85 to 90% of quality costs are usually intangible and thus overlooked and neglected in the quality cost analysis of the company. Systematic application of six sigma DMAIC tools and methodology in the production of automotive parts results with several achievements, one of them is reduced COQ [9].

The average sigma level of the company is typically around 3 sigma. In other words, 25-40% of the annual revenue of most companies is chewed up by their quality costs. Thus, if a company can improve its quality by 1 sigma, its net income will increase dramatically by approximately 10 %. [10]. Fig. 1, below shows how dramatically cost of

quality as percentage of sales decreases if process sigma improves.

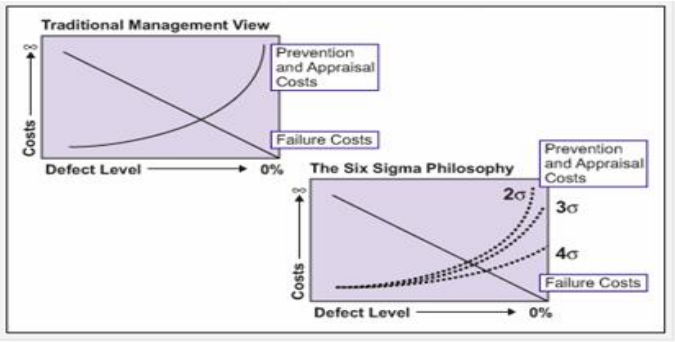

Fig. 1 Traditional Management Views v/s Six Sigma Philosophy

As a company moves to become a six-sigma corporation, COPQ will drop dramatically as a percentage of sales. The better your process control, the fewer defects you'll have, reducing poor quality costs. Table 1, shows the level of Sigma and COPQ [11].

Table 1 Sigma Level and COPQ

Sigma level	DPMO	Quality level	COPQ (% of sales)
2	309,000	69%	Over 40%
3	**67,000**	**93.3%**	**25–40%**
4	6,200	99.4%	15–25%
5	230	99.98%	5–10%
6	3.4	99.997%	0–5%

Six Sigma is ranked among quality enhancement and overall quality management initiatives. The benefits of quality improvement initiatives argue that customer satisfaction can be enhanced by improving product quality and reducing production costs by reducing costs associated with poor quality [12].

II. FRAMEWORKS

2.1 Framework for Cost of Quality

The snapshot below (Fig. 2) highlights the use of quality cost and improvement in quality. This framework explains the voice of customers and businesses which are the primary inputs mentioned in Phase 1 and then it captures the secondary input Phase 2. Phase 3 covers the assessment of quality cost and then applies quality improvement programs/methods/tools/techniques to reduce Quality Cost (covered in Phase 4). The results can be seen in tangible and intangible form in the final phase. It is a process that is dynamic and continuous; this cycle continues to repeat. The framework is validated by seniors/experts [13].

In the initial phase of COQ assessment and implementation, the first step is to convince top management to implement the customer / business voice-based action plan that is critical to quality and critical to processes, reflecting how quality costs need to be reduced to sustain the current competitive global market.

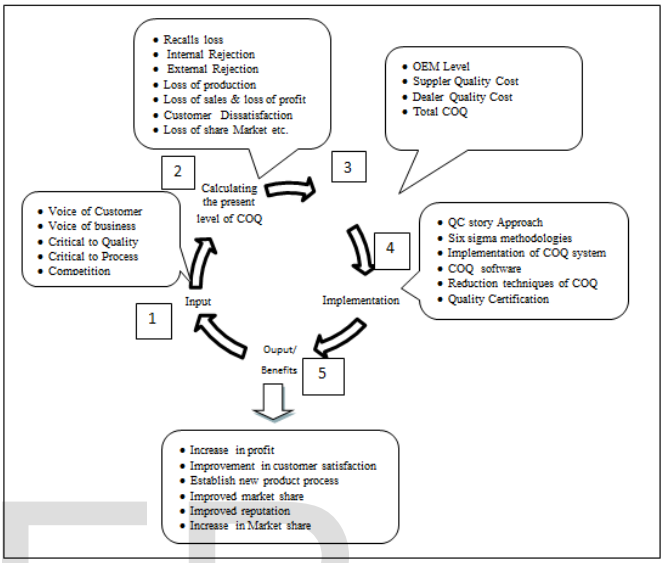

Fig. 2 Framework for assessment and reduction of Quality Cost

In the next step, managers should calculate in detail plant wise, supplier wise, and dealer wise the current level of COQ in their organization. They should assess and calculate the total recalls loss, internal & external failure costs, and production loss due to rejection, loss of profit, effect on the share market, brand image and finally the overall effect on customer goodwill. After calculating the present level of COQ in the organization, the next step is analysis of the data.

In the analysis stage, managers should analyze the OEM level cost of quality and then analysis should be carried out supplier wise, dealer wise and finally the total Cost of Quality including appraisal cost, prevention cost and internal / external failure cost should be worked out. The next step, after stage wise analysis, is to suggest the action plan to reduce such direct – indirect or hidden quality cost that hinders the organization's profitability and the final customer's goodwill.

The first step in the action plan to reduce such COQ should be the adoption of six sigma methodologies at the design stage (DFSS) and at the process improvement stage (DMAIC) by the practitioner / managers. This improves the quality

of all supply chain processes by reducing costs and increasing levels of customer satisfaction. Six-Sigma integration is believed to become a standard practice for any business application seeking advantage in this highly competitive globalization era. Suppliers are encouraged to be certified in accordance with ISO / TS 16949 quality management system standard to supply the OEMs with parts / commodity.

OEMs should adopt the tools and techniques to develop supplier quality and reduce COQ such as, Lean Mfg., Six Sigma, QC story, Dealership five star rating programme, Corrective action and preventive action (CAPA), Lean principles, DFSS (Design for Six Sigma), Mistake-proof applications, Statistical Process Control (SPC), Quality Management System based on ISO 9001, supplier performance assessment. Following the implementation of the action plan and the above-mentioned techniques by OEMs at supplier level, dealer level and in their in-house activities, the expected results would be profit maximization, improvement of productivity by lowering the rejection rate, improvement of customer satisfaction in terms of quality and reliable product, establishment of new product process and improvement of market share and reputation of the organization, which are essential to survive in the global competitive market.

2.2 Framework for Six Sigma

Fig.3 highlights the Framework for Six Sigma. This framework consists of the following steps.

Identify and Define:

The Identify and Define phase is the foundation block of Six Sigma initiative and entails identifying and defining the current undesired status of the business. This phase is characterized by top management's commitment towards the implementation of the Six Sigma methodology throughout the business. By showing their commitment management must create an awareness and commitment to the need for improvements. It can be facilitated by utilising tools i.e. baseline measurements, voice of the customer, voice of the business, key performance indicators, benchmarking etc. The identified undesired status should set the scene for setting the firm's strategic goals.

Present and explain Six Sigma fundamentals:

This involves awareness training to all levels in the firm. This training should explain to the employee how Six Sigma can be utilized to move from the undesired status defined in the previous component. It can be established through i.e. Six Sigma workshops, information sessions etc. Thus, when an employee is incorporated in a Six Sigma project team he/she is already familiarized with the Six Sigma methodology. Change management is a very important success factor for Six Sigma deployment.

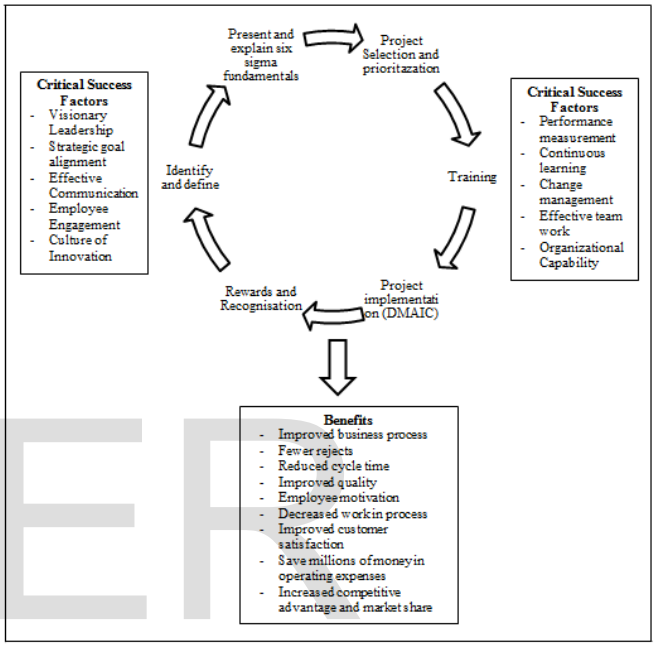

Fig.3 Framework for Six Sigma

Project selection and prioritisation:

This involves the selection of the right projects for Six Sigma improvement. Top management should be responsible for, or alternatively appoint a selection committee for the selection of projects that are aligned with the firms' strategic goals. This involves defining the projects scope and committing the necessary required resources (financial or human resources). They must also prioritize the projects according to a defined criteria i.e. high financial leverage, quality improvement, or waste reduction projects etc. The team should also regularly review the project progress and by doing this they will express their commitment towards the process.

Training:

Based on the project selection the right people can be identified for the required training at different

levels. Top management should implement a training strategy aligned with its strategic goals. It is important to provide training at all stages of Six Sigma deployment. The selection and training of black and green belts are based on their process involvement and impact. Training should however not be limited to the black belt or green belt training but should include the following;

- change management training
- project management
- diversity management
- basic supply chain management
- specific training in the data gathering and analysis tools utilized

These training criteria's should be categorized according to the different levels of the project member's involvement. Top management should also be trained in the essentials of the Six Sigma methodology in order to be effective in their participation during the process.

Project Implementing Stage:

This component contains the problem-solving road map (DMAIC) specific to the Six Sigma methodology, see Fig. 3 When a specific Six Sigma project is launched; the customer satisfaction goals have likely been established and decomposed into sub goals such as cycle time reduction, cost reduction, or defect reduction. Once an effort or project is defined, the team methodically proceeds through Measurement, Analysis, Improvement, and Control steps. A Six Sigma improvement team is responsible for identifying relevant metrics based on engineering principles and models. With data/information in hand, the team then proceeds to evaluate the data/information for trends, patterns, causal relationships and "root cause," etc. If needed, special experiments and modeling may be done to confirm hypothesized relationships or to understand the extent of leverage of factors; but many improvement projects may be accomplished with the most basic statistical and non-statistical tools. It is often necessary to iterate through the Measure-Analyze-Improve steps. When the target level of performance is achieved, control measures are then established to sustain performance.

Reward and Recognition:

People expect their performance to be recognized and rewarded. Positive behaviour (effort) is reinforced by rewarding and recognizing people and results in added performance. To strengthen the performance outcome relationship further, it is necessary to ensure that rewards and recognition are seen as significant. If a reward is not attractive it has far less value and will not contribute to a motivating climate. The reward and recognition system must be designed to keep employees dedicated to the Six Sigma implementation. Based on the defined measurement system, successes should be celebrated and rewarded to maintain a level of employee motivation.

The proposed framework for the successful implementation of Six Sigma has been constructed by combining the most critical success factors (CSFs) for Six Sigma and elements of the Six Sigma methodology. Although there are other CSFs and elements, the ones identified in the framework should be regarded as the most crucial for successful Six Sigma implementation. The framework can however be modified to fit each firms unique circumstances but the CSFs and elements identified should form the minimum requirement (basis) for Six Sigma implementation. The CSFs (core of framework) should be integrated with each step of the Six Sigma process.

III. Conclusion

- Quality helps the organization expand its borders and be competitive in the global marketplace. Improving quality is an ongoing process. For companies that aim to win orders, quality has become one of the core factors. Improving quality is therefore considered one of the key strategies in today's global competitive environment to achieve customer loyalty.
- To improve quality, an organization must consider the costs associated with achieving quality, as the goal of continuous improvement programs is not only to meet customer requirements, but also to do so at the lowest cost. Quality cost helps quantify specific levels of quality and ultimately enhance productivity.
- In order to compete with global firms, Indian firms need to be on par in all areas of business. Cost and quality are two very important aspects to be competitive globally, capturing market share, retaining business customers and achieving business excellence.

- If the Indian manufacturing industry implements Framework for assessment and reduction of Quality Cost (Fig. 2) then they will be benefited with an increase in profit; improvement in customer satisfaction; establish a new product process; improved market share; improved reputation and increase in market share.
- If the Indian manufacturing industry implements the Framework for Six Sigma (Fig. 3) then they are getting benefits such as fewer rejects; reduced cycle time; improved quality; employee motivation; decreased work in process; improved customer satisfaction; save millions of money in operating expenses; increased competitive advantage and market share.
- If the Indian manufacturing companies implements the Frameworks for Six Sigma and Cost of Quality effectively can be helpful to Indian Industry to identify the various initiatives towards implementation of COQ and Six Sigma for manufacturing excellence which are essential to survive in the global competitive market.

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