DEVELOPMENT OF QUALITY COST SYSTEM IN CAST IRON FOUNDRIES

Dr.M.Arasu

Head, Department of Foundry Technology, PSG Polytechnic College,

Coimbatore – 641 004, Phone No: 0422 4344465, arasurms35452@gmail.com

ABSTRACT

In the manufacturing sector, metal casting industry is one of the basic, principal and most important industries. In the present global scenario of recession and high competitiveness among the foundry industry, cost effectiveness has a crucial role to play in determining the edge of one over the other and the industry as a whole. Cost-effectiveness does not mean a strategy that saves money and just because a strategy saves money doesn't mean that it is cost-effective. The casting process is hindered by the occurrence of various defects. High casting reject levels, both internal and customer returns have a considerable adverse effect on productivity, delivery performance, customer satisfaction and employee moral. In addition excessive rejection reduces yield, wastes valuable raw materials and involves management time in problem solving.

All foundry processes generate a certain level of rejection that is closely related to the type of casting, the processes used and the equipments available. However, in most foundries a substantial proportion of rejection result from lack of shop-floor supervision and technical control, and the use of poorly maintained and inadequate equipment. The rejected casting can only be re-melted and the value addition made during various processes such as melting, moulding, fettling and heat treatment, etc is lost irrecoverably. Keeping rejection to a bare minimum is essential to improve the yield and increase the effective capacity of the foundry unit.

Most of the foundries have no precise knowledge of the main causes of rejection because they fail to maintain a satisfactory quality control system. There is a need for an organized system of collecting information on the process parameters relating to the potential casting defects. Also, there is a need for developing a database of solutions for eliminating undesirable casting artifacts. Internal and external failure costs contribute to over 70% of the total quality costs in foundries. Quality costs in a foundry can vary between 3% and 15% of the total sales volume. Any attempt to reduce these costs is an immense benefit to the foundry industry.

The approach taken by this paper is expected to motivate the foundries to use a standard classification system to describe undesirable casting artifacts for more effective failure analysis. It will also encourage foundries to develop systems to measure process parameters relating to the defects that occur in the foundries and pool the resources of domain experts. Any reduction in the scrap and rework also positively influences the environmental impact of our industry. In this paper, it deals the various aspects of a systematic approach to understanding and development of quality cost system in cast iron foundries.

KEYWORDS: Cast Iron foundries, Cost of quality, Rejection analysis, casting defects control, Development of Quality cost system, Fault tree analysis.

1. INTRODUCTION

Today's highly competitive and cyclical manufacturing environment finds customers consistently demanding higher and higher quality while suppliers strive to reduce operating cost to remain profitable. Often, foundries respond to customers' quality demands by implementing total quality management or continuous improvement teams to identify ways to increase customer satisfaction. However, the foundries have found that the cost for increased customer satisfaction is not always justified in terms of increased market share or profitability. In these cases, the economic feasibility of making the necessary capital investment required implementing new ideas and/or equipment to improve quality is not readily apparent. In this context, quality improvements are often difficult for practicing engineers to justify and accept, when the benefits are not apparent from a strategic and economic perspective. For a cost of quality system to be effective in today's manufacturing environment, it must overcome these difficulties, and result in an increased market share, profitability, and/or lead to cost reductions. In this context, the importance of employee involvement is underscored. For the cost of quality system to be effective, it is important to understand the operational, strategic and customer-related dimensions of quality.

The objective of this paper is to present an integrative systematic approach to addressing the cost of quality based on nonconformance relative to a set of internal manufacturing standards in Cast iron foundries. By design, this approach provides a detailed corrective action path which stresses employee participation. The advocated approach is customer influence based. The value of this practical approach has been proven by an application in a foundry industry environment. In the process the organizational requirements toward implementing this approach are outlined.

2. LITERATURE ANALYSIS

Management in today's business environment understands that quality is a powerful competitive weapon. However, many organizations have not realized bottom line or market share benefits owing to their quality efforts. Shepherd (1) notes management's failure to recognize undiscovered opportunities, and suggests a cost of quality model that combines the economics of quality with activity-based management. Although Shepherd suggests that his model helps restructure an enterprise for continuous improvement, the full feedback and corrective actions that are vital to implementation are not apparent.

The linkage between quality problems and profitability in terms of market share represents a paradigm shift from the traditional view of quality cost. Schonberger and Knod (2) challenge the traditional quality cost where industries ``play the odds'' by comparing the liability of poor quality against the cost of preventing it. Schneiderman (3) notes that infinite investment is not a prerequisite for continuous quality improvement. Schneiderman suggests that the quality cost function should be viewed on the basis of incremental economics.

Economic justification of a cost of quality plan is advocated by Rust (4) who proposes a cost-benefit analysis approach to quality improvement and also advocates a system that strives to eliminate deficiencies by seeking alternative solutions to quality problems. Rust points out that poor quality costs must be traced to their source or root cause, before these costs can be eliminated. Rust suggests a four-step strategy that attacks the cost of nonconformance causes and attempts to drive them to zero. However, specific guidelines as to how to achieve a zero cost of nonconformance goal are not presented. Although Rust stresses investing in prevention measures and continuous improvement efforts, the step for corrective action are not discussed and concludes that the baseline for nonconformance cost is found in the manufacturing process.

Corradi (5) suggests that contemporary quality efforts lack a systematic approach to assigning cost data into meaningful categories and also that most management teams tend to concentrate on fixing problems rather than preventing them. Consequently, Corradi introduces a six-step plan for developing a cost of quality system. The framework he advocates stresses management involvement in the development and implementation of the cost of quality system. He contends that quality programmes are ``management tools'' which will contribute to its managerial success. However, this philosophy downplays the value of employee participation which the authors have found to be vital to the effectiveness of any quality Programme.

According to Senge (6), many initial attempts to establish quality systems in organization ultimately fail, despite making some initial progress. In most cases, this is attributed to employees' unwillingness to support this system. Corradi concludes that every rupees saved from the cost of quality can be added to the bottom line as increased profit. However, front line employees will never accept the importance of these costs until the benefits become real to them. The fundamental theme of current cost of quality efforts reflects the need for a total system approach. However, the detailed implementation path for corrective action and employee utilization has not been identified. The approach presented in this study capitalizes on the studies discussed above, while attempting to overcome their shortcomings. In addition, the approach is systematic, comprehensive and field tested.

3. DESIGN OF QUALITY COST SYSTEM

The design of quality cost system in a foundry initially to study the setting and objectives of the requirement. And then identify the solution of the requirements to incorporate the existing system and finally to development the quality cost system in the foundries. Initially to identifying opportunities toward simultaneous quality improvement and cost reductions which may in turn result in increased customer satisfaction and profitability.

3.1 Objectives of the system

Given the potential implications of manufacturing cost associated with product quality and customer service and satisfaction, the author to examine its quality efforts with emphasis on quality related costs. The objective was to identify the sources and contributing factors which can add to the cost of quality and determine the estimated cost of nonconformance to a foundry industry stated quality goals. The following objectives for the system:

(i) Design a quality system that included concern for the customer
(ii) Utilize the existing quality standards to gauge process performance and product quality
(iii) Develop a rejection diagnosis sheet to quantify nonconformance cost related to internal quality standards
(iv) Quality cost analysis

(v) Involve employees and utilize continuous improvement tools.

3.2 Development of Quality Cost System

The cost of quality system includes of cost of prevention, cost of appraisal, cost of internal failure and cost of external failure (7). In a metal casting environment, Total Quality Management teams gather quality related problem data, isolate problem areas, and establish the need for corrective actions. As a manufacturer, any organization is a quality conscious firm. It is committed to the continuous quality improvements of raw material, products, processes and services. The management team has established quality goals for each of these manufacturing related activities. The standards for these goals are based on research, experience and customer needs. The authors' proposed approach allowed management to quantify the impact of changes in these key quality indicators.

A record must be made of the number of castings inspected as well as the total produced. All castings with rejection levels of above budget should be highlighted. When the high incidence of rejection is due to a particular case, this will be clearly shown by the frequency of entries on the record sheet, giving a direct indication of where action is required.

Table 1 present's production and rejection details of a set of selected castings produced in a foundry. This type of rejection diagnosis sheet [8] is highly useful. It is used to assess the scrap performance of each casting. The information recorded typically includes the foundry rejection scrap, cause and action taken, total number or weight of castings produced and dispatched to customer. The system should ensure that the main causes of rejection levels as exceeding the budget sheet. Mutual confidence between a foundry and its customer depends upon close liaison, good communications at all levels and the maintenance of adequate records.

Table 1 Rejection diagnosis sheet

Sl. No	Part No.	Wt. of Casting (Kg)	Price Per Casting @ Rs.60/Kg (Rs.)	Total Production (Nos.)	Total rejection (Nos.)	Rejection (%)	Value of Rejection (Rs.)
1	A001	1.50	90	248	20	8.06	1800
2	A002	6.50	390	206	13	6.31	5070

3	A003	5.85	351	160	4	2.50	1404
4	A004	4.50	270	104	34	32.69	9180

The variances from goals are determined, as well as their subsequent costs, if any. The nonconformance cost is calculated and posted in terms of manufacturing cost per day and then analyzed.

This approach was also helpful in identifying a strategic direction linking quality improvements to profits through cost savings and increased production efficiency. By design, this approach provides a mechanism for determining a return on quality-related investments. As a result, this approach provides a means for quantifying the cost of quality failures. In addition, cost reduction(s) realized from improvements are translated into savings opportunities.

It is important to diagnose and record the causes of all castings rejected by customers. The supplying foundry should be aware of the high costs involved when castings have to be rejected. A casting method card for recording the main production specification and inspection details is a vital document. When a method card is being maintained, there is no need to relay on the memories of supervisors and operators for important data. It is important to use the method card for recording the dates and nature of changes in technique or of specific materials used in manufacture.

All defective castings, wherever they are arise, should be collected and segregated into

marked scrap bins or enclosures. Additional scrap return from the customer or in-house machine shop must also be segregated for inspection and subsequently incorporated in the overall scrap records. All heavy or large scrap castings should be clearly marked.

4. COST OF QUALITY ANALYSIS

To arrive at the rejection cost, let us consider component A001 (Refer Table 1).

Total number of castings produced	248
Number of castings rejected	20
Rejection	8.06%
Price per casting (Rs 60/kg)	Rs 90
Value of rejected casting	Rs 1800

Value of raw material recovered from rejected castings (Rs 20/kg) Rs 600

Net rejection cost (Rs 1800 - Rs 600) Rs 1200

In the similar way the other components are evaluated and the rejection cost for each component is given in Table 2.

Table 2 Cost of Quality Analysis in Foundry

Part No.	Value of Rejection (Rs.)	Value of Good Casting @ Rs.60/Kg (Rs.)	Recovered material cost @ Rs.20/Kg (Rs.)	Net Rejection Cost (Rs.)
A001	1800	20520	600	1200
A002	5070	75270	1690	3380
A003	1404	54756	468	936
A004	9180	18900	3060	6120
Total	**17454**	**169446**	**5818**	**11636**

The analysis of rejections in Foundry, it is observed that net rejection cost is 6.43 % of the total cost incurred in the manufacture of the component. This it imperative the adequate attention is to be paid in reducing rejections of the castings and to improve the quality of foundry processes. By using various analysis tools like Why – Why Analysis, Fault Tree Analysis, Failure Mode Effect Analysis, cause effect analysis, statistical quality control analysis, statistical process control analysis to control the rejection.

5. FAULT TREE ANALYSIS

Fault Tree Analysis (FTA) is a graphic depiction or model of the rationally conceivable sequences of events within a complex system that could lead ultimately to the observed failure or potential failure. In this case the potential failure is the defect that caused the casting to be got rejected. Since we have found out the most predominant defect of all, it gives a confined area to be focused on. With the help of Fault Tree Analysis, it would be able to derive out the root cause of the defect. To have a clear understanding of the FTA one has to know the symbols used in FTA. The symbols used in fault tree analysis are presented in Table.3 and a sample fault tree developed for the blowhole defect is presented in Fig.1.

Table 3 Symbols used in FTA

Logic gates	OR-gate	The OR-gate indicates that the output event occurs if any of the input events occur
	AND-gate	The AND-gate indicates that the output event occurs only if all the input events occur at the same time
Input events (states)		The basic event represents a basic equipment failure that requires no further development of failure causes
		The undeveloped event represents an event that is not examined further because information is unavailable or because its consequences are insignificant
Description of state		The comment rectangle is for supplementary information
Transfer symbols	Transfer out Transfer in	The transfer-out symbol indicates that the fault tree is developed further at the occurrence of the corresponding transfer-in symbol

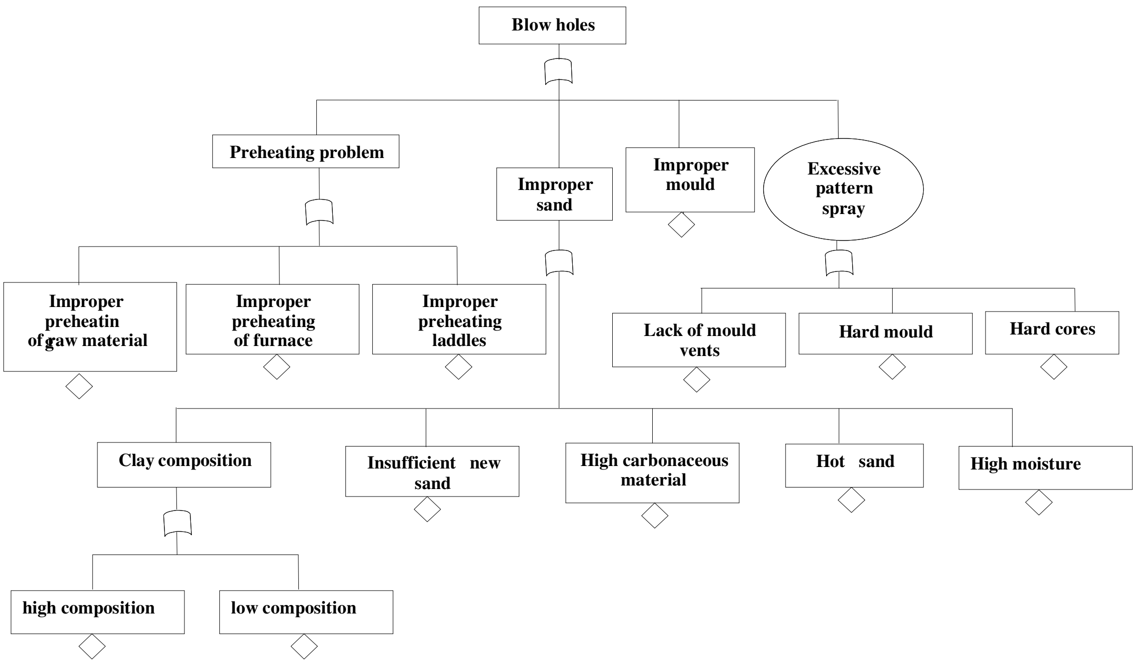

Fig. 1 Fault Tree Diagram for Blow holes

6. IMPLEMENTATION OF QUALITY COST SYSTEM

The successful implementation of this approach in one of a foundry units led management to investigate its application to other facilities. This decision was motivated by the potential cost savings and enhanced customer service owing to the approach described here. This case study clearly illustrates how the implementation of the cost of quality system. In this context, the proposed system met foundry’s management team's request to identify and list the sources and conditions which can add to the cost of quality. Also, a methodology to determine the costs of nonconformance to the stated quality standards, guidelines, procedures and specifications was successfully applied.

Results of this investigation revealed that casting manufacturing plant is successful at producing quality products. It consistently met most of its quality goals. However, it is important to note the sensitivity in terms of variances from the standards and the associated nonconformance costs for a sample of items listed in Table I. Although senior management suspected that opportunities existed for cost reduction, they were surprised at the magnitude of the annualized impact of the associated nonconformance costs. Based on the results of this investigation, the foundry decided to conduct cost of nonconformance analysis at all manufacturing facilities.

The advantage of a constant focus within the organization on adding value as opposed to cutting costs is the direct linkage of an orientation of projects to increasing customer satisfaction and shareholder value. Keeping rejections to a bare minimum is essential to improve the yield and increase the effective capacity of the manufacturing unit. This paper shows only a direction but the path has to be found and treaded by the individual foundry as per their requirement. They should analyze the rejection data with any analyzing tool like Statistical Quality Control, Failure Mode Effect Analysis, Fault Tree Analysis, etc. The foundry may set a yield target after a careful study of the present yield levels and industrial average’s. This target should take into account the current product mix of the foundry as each casting and metal has varying yield.

At the beginning of a rejection reduction process, to defect identification and terminology used should be standardized. A standard set of photographs of defects in castings, or reference made to various publications on this subject, may be very useful for this purpose. It is also important that the rejection analysis team involved in the exercise should be experienced, comprising the foundry manager, inspectors, metallurgist and methods engineer. Frequently, certain defects, particularly inclusions, cannot be accurately diagnosed visually and a metallurgical examination may be necessary to provide positive identification. Unless accurate diagnosis has been made, incorrect remedial action may be taken, which could prove costly.

Regular meetings devoted to the discussion quality and rejection can help to generate and maintain Rejection control awareness in the foundries. Adequate records, of the type described above and essential for the efficient running of such meetings. The frequencies of rejection analysis meetings, the number of people required to attend, depend on the size of the foundry and the type of castings being produced. However, in general short but frequent meetings tend to be the most effective.

7. CONCLUSIONS

The application of the cost of quality approach in the foundry industry environment provides a systematic, structured approach to the quality problem and identification of correction that focuses on unfavorable variances in operational performances. The approach presented and applied in this study, capitalizes on the system orientation of business organization, continuous quality improvement techniques, proactive managerial actions, to achieve product efficiency, customer satisfaction, and strategic effectiveness.

As noted by Shepherd, there are many undiscovered opportunities to convert quality and process improvements into bottom-line benefits. However, the details of the assessment of missed quality objectives and means for quantifying and implementing corrective actions were previously missing. The research presented here provides a significant step toward overcoming these difficulties by providing a systematic practical approach to addressing the cost of quality.

For an organization to realize the operational, strategic and customer-related benefits of the approach proposed here, it must meet the following requirements and undertake the required changes.

(a) Organizational structure-related requirements and changes:

- Change organizational structure and culture in order to promote an open system organizational structure without functional barriers
- Promote the interaction between the organization and its environment
- Promote a customer orientation based on the delivery of quality to customers throughout the organization
- Modify reward systems to reward quality and customer orientation rather than quantity

- Establish strategic alliances with suppliers and vendors to promote input quality.

(b) Technical requirements and changes:

- application of innovative techniques such as process analysis, process reengineering, benchmarking, TQM, continuous quality improvement, root cause analysis, supply chain analysis and time-based analysis
- Applications of statistical quality procedures and sampling procedures
- Understanding the relationship between quality and cost
- Understanding the different definitions and dimensions of quality.

(c) Informational requirements and changes:

- Establish a quality and cost-related information system and databases that connect the entire organization by utilizing information technology, so it can operate as a total system
- Link the organization to customers and supplies, so that can operate as an open system.

8. REFERENCES

(i) Shepherd, N., Economics of quality and activity based management: the bridge to continuous improvement, The Management Accounting Magazine, Vol. 69, No. 2, pp. 29-32, 1995.

(ii) Schonberger, R.J. and Knod, E.M. Jr, Operations Management, Fourth edition, IL and Boston, 1991.

(iii) Schneiderman, A.M., Optimum quality costs and zero defects: are they contradictory concepts?, Quality Progress, Vol. 19, No. 11, pp. 29, 1986.

(iv) Rust, K.G., Measuring the cost of quality, Management Accounting, Vol. 7 No. 2, pp. 33 - 37, 1995.

(v) Corradi, P.R., Is a cost of quality system for you?, National Productivity Review, Vol. 13, No. 2, pp. 257-270, 1990.

(vi) Senge, P.M., The Fifth Discipline, Fist edition, Doubleday, New York, 1990.

(vii) Andrew J.Czuchry, Mahmoud M. Yasin, Gregory S.Little, A Systematic Approach to Understanding Cost of Quality: A Field Study, Industrial & Data Systems, Vol.99, No.8, pp.362-366, 1999.

(viii) M.Arasu and Dr.R.Gandhinathan, Rejection Cost Control Techniques in Iron Foundries, Indian Foundry Journal, Vol.51, No.6, pp. 36 - 40, July 2005.