A Literature review on Quality and Productivity Improvement in foundry industry

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Abstract : Indian industries need overall operational excellence in today's era of global competitiveness. Especially, the basic manufacturing sectors such as foundries and other metalworking/forming industries need breakthrough improvements in quality as well as in productivity. Metal casting industries are actively involved to reduce the scrap rejection and rework during the manufacturing process of the components. To achieve this, the production concerns must follow the quality control procedures correctly and perfectly without any negligence. Timely implementation of the modified techniques based on the quality control research is a must to avoid defects in the products. Six Sigma is one of the most effective breakthrough improvement strategies having direct impact on operational excellence of an organisation. It addresses efficiency and effectiveness of the industry thus improving quality and productivity, both simultaneously. In this review paper, some of the solutions and quality control aspects are explained in a simplified manner to eliminate the unawareness of the foundry industrial personnel who work in the casting manufacturing quality control departments. This paper also explains phase wiz application of define–measure–analyse improve–control methodology and ultimately shows how breakthrough improvement can be brought in quality and productivity in a foundry industry.

Keywords-Quality, Productivity, Six sigma, DMAIC, foundry industry.

I. INTRODUCTION

Quality is defined as the fitness for use or purpose at the most economical level. It is an integral part of the process of design, manufacture and assembly. It can be assured by having effective procedures and controls at various stages.
In the age of globalisation, producing castings as per the international standards needs multidirectional competitiveness. To compete globally, foundry men have to move ahead from the slogan of 'satisfying customer' and adopt and rigorously endeavour for 'customer delight'. Meeting customer demands will not be sufficient, requirements will be to exceeding them through quality and productivity improvement.
Gaining competitive edge is the constant quest for the foundry industries worldwide. For that they are using many tools and techniques that have long been flaunted as a way to beat the competitions.
For global competitiveness, foundry industries are trying many techniques such as quality circles, total quality management (TQM), International Organisation for Standardisation certifications, etc. All these techniques are well capable of producing the desired results, but the darker side of the coin is the issues related with their implementation and longer time span to realise the benefits. Moreover, these are good for certain specific problems.
Darshak Desai [3] suggested that Meeting the customers' requirements at minimum possible cost and time is the main mantra of success for any sort of business. To put it in more technical terms, achieving functional requirements of the product at competitive cost within the specified schedule is the basic recipe for organisational success. And that comes through overall operational excellence. Six Sigma is one such technique available to bring the breakthrough improvements almost in every sector through overall operational excellence. The pinpointed attack of this technique on root causes guarantees the targeted results, both in terms of improvements desired and time span fixed.

II. METHODOLOGY OF SIX SIGMA APPLIED BY A RESEARCHER

There are mainly 5 Phases in DMAIC Six Sigma methodology e.g. Define, Measure, Analyse, Improve and Control.

a. Define phase

This is one of the most critical phases of DMAIC methodology. Therefore, if required, maximum time and efforts should be allocated to this phase. This phase identifies critical customer requirements and links them to business needs. It involves Problem Statement and CTQ Tree.

- Problem Statement- The problem statement should be specific and measurable, since it is forming the base for improvement efforts.
- CTQ Tree-Depending upon the nature of the problem, customers of the project in question is the ultimate customers who are receiving the products of the company and paying the bills. For identifying requirements of the customers, the CTQ tree being the most effective one.

b. Measure phase

This is basically a data collection phase wherein present situation data are collected and then current sigma level is calculated for the process in question. Sigma level can be calculated by different methods, based on the type of data. For discrete data defects per million opportunities (DPMO) number is calculated and then sigma level is ascertained from the DPMO-sigma level table.

$$\text{DPMO} = \frac{\text{No. of defects} * 10^6}{\text{No. of opportunities} * \text{number of units}}$$

Where,
Number of defects = number of rejections (i.e. at least one defect exists to impute the product as defective).
Number of opportunities = number of CTQs.
Number of units = number of units produced.

c. Analyse phase

This is investigation phase. Here, course of action is created to close the gap between how things currently work and how they should work to meet improvement goals. All root causes are investigated and analysed and the most critical ones are fixed for improvements.

Following tools and techniques were adopted during this phase to uncover the most critical root causes.

- Cause and Effect diagram- When there is a recurring issue or problem, it is important to explore all reasons that could cause it, before you start to think about a solution. That way the problem can be solved completely. Cause and Effect Analysis gives a useful way of doing this.
- Multi Voting- In here supervisors and workers were asked to vote each cause based on their understanding of the most probable to least probable root cause for the problem in hand. The causes were voted by the team on a scale of 1–5, with 5 as the most probable root cause for the problem on hand and 1 as the least probable cause.
- Pareto chart- Pareto analysis refers to the tendency for the bulk of the problems to be due to a few of the possible causes. Hence, by isolating and correcting the major problem areas, obtain the greatest increase in efficiency and effectiveness. The Pareto chart is a graphic display that emphasizes the Pareto principle using a bar graph in which the bars are arranged in decreasing magnitude.
- Why-Why Analysis- It is a method of questioning that leads to the identification of the root cause(s) of a problem. A why-why is conducted to identify solutions to a problem that address it's root cause(s), rather than taking actions that are merely band-aids, a why-why helps to identify how to really prevent the issue from happening again.

d. Improve phase

The Why-Why analysis become basis for this phase. Here, processes and product performance characteristics are improved for achieving desired results and goals. This phase involves application of scientific tools and techniques for making tangible improvements in quality and productivity. The approved thumb rule of 50% improvement in the first effort of Six Sigma drive is Applied generally to set targets which should result from the improve measures. Accordingly, target sigma levels are calculated.

e. Control phase

The basic objectives of this phase are to ensure that our processes stay in control after the improvement solution has been implemented and to quickly detect out of control state and determine the associated causes so that actions can be taken to control the problem before non-conformances are produced.

III. LITERATURE REVIEW

The following are brief review of literatures on "Quality and Improvement improvement" concept.

1. T.R.Vijayaram *et. al* suggested various Quality control aspects and future hopes for reducing rejection and rework. Some basic rules for Quality control are as follows.
   - Start with a good quality melt.
   - Avoid bubble entrainment by properly designed offset step pouring basin and a well designed gating system.
   - Avoid core blows by adequate venting.
   - Avoid shrinkage.
   - Reduce segregation, particularly the channel segregation.
   - Provide location points for pickup for dimensional checking and machining.
   - Implementation of quality circle, Quality assurance.
   - Various kinds of inspection like go- and no-go checking, functional test, visual inspection, 100% inspection and sampling inspection may be used.
   - Most importantly, consistent motivations to the workers are required for Quality control and assurance.
2. Darshak.A.Desai introduced Six Sigma DMAIC Approach in small scale foundry industry to increase Bottom-line or Overall profit. They found 3 products namely Cooler plate, Hammer, Nose-ring segment in which rejection rate were higher. The No. of rejection per year was 125, 175 and 155 respectively. After applying DMAIC methodology, No. of rejections were reduced to 70, 90 and 120 respectively. Hence, Annual financial savings were improved up to 44%, 45% and 22.5% respectively.
3. Darshak.A.Desai introduced Six Sigma methodology to improve Quality and Productivity in small scale foundry. They found that 2 products namely Grey Flange and S.G. Flange casting in which rejection rate were higher and Process time of Hardening was much more. After applying DMAIC methodology, the sigma level of grey iron flange casting improved from 1.979 to 2.260 and that of S.G. iron flange casting improved from 1.638 to 1.954. And the overall cycle time was reduced to 17.34 hr from 23.76 hr due to reduction in cycle time by 27%.

4. Gijo, E.V introduced Six Sigma DMAIC approach to improve productivity in small scale foundry industry. They found that Hardening process of leaf spring were taking much more time than expected. With the help of DMAIC approach, the process parameters were optimized and measures for sustainability of the results were incorporated in the process. And hence, the overall rejection was reduced from 48.33 to 0.79 per cent, which was a remarkable achievement for this small-scale industry.
5. Mallikarjun Koripadu *et. al* utilise three basic tools namely Ishikawa diagram, Pareto chart and Why-Why analysis in problem solving management in IT industry. They found that volume of calls and incidents were very much higher. And after using of three basic QC tools in improvement process, call volumes dropped by 60% and also improved average quality improved from 75% to 92% with reduced utilization from 100% to 88%.

IV. CONCLUSION

In this era of globalization, small foundry industries need breakthrough improvements in Quality as well as Productivity to stay in competition. To compete globally, foundry men have to move ahead from the slogan of 'satisfying customer' and adopt and rigorously endeavour for 'customer delight'. Meeting customer demands will not be sufficient, requirements will be to exceeding them through quality and productivity improvement. The foundry men thus need a breakthrough strategy, which can have multidirectional benefits in shorter duration. Six Sigma is one of the emerging techniques available to bring the breakthrough improvements almost in every sector through overall operational excellence. The implementation of Six Sigma resulted in understanding the problems from all aspects, qualitatively as well as quantitatively. And its phase wise guidelines (DMAIC) help to improve efficiency as well as effectiveness.

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