IMPLEMENTATION OF SIX SIGMA PROCESS IN IDENTIFYING AND ANALYSIS ERROR IN PIPING ISOMETRIC DRAWINGS

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ABSTRACT

Six Sigma is a business strategy that helps organizations to improve its organizational efficiency and Customer satisfaction; it decreases operating cost and increases profits. Six Sigma is a widely used method to improve processes from various industrial sectors. The target failure rate for Six Sigma projects is 3.4 parts per million. Numerous practitioner studies claim that Six Sigma improves organizational performance. However, its implementation to design process is limited. So, in this study we have implemented the six-sigma philosophy in piping design process. Piping isometric drawings, which feature their intrinsically topological relation rather than just geometrical shape, are important industrial art works in the field of Computer-Aided Design (CAD). This study suggests that the link between Six Sigma and piping design process performance can be explained and developed by integrating organizational knowledge creation processes. We have quantified the performance of a design process in terms of sigma level and tried to find the possible ways to improve it. The method used in this study is based on five main steps summarized in the acronym (DMAIC): Define Measure, Analyse, Improve and Control. Application of the method on the design process during the five phases of the method will help to reduce costs and losses of man-hours to strive for optimum results in terms of profit and quality.

Key words: Piping Engineering, Six Sigma, Piping Isometrics drawing, DMAIC philosophy, Quality, Design, Computer-Aided Design.

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1. INTRODUCTION

Piping engineering is the major branch in Plant Design. It plays a vital role in in design of Process plants, Petrochemical Refineries and Chemical Plants. The global engineering cost of these plants runs into billions of dollars. The cost of piping engineering in these plants are about 3-5% of the total engineering cost. Any Saving in this cost can run into millions of dollars. The improvement in piping design will not only save the cost but also save the time and efforts required to completely the project.

In this study, we have tried to improve the quality of piping design by using six sigma techniques. The approach we have adopted is DMAIC philosophy to improve the quality of the deliverables. Likewise, to improve the whole piping design process the same procedure can be followed on other deliverables like 3D model, Stress Report, MTO etc. Each step of DMAIC philosophy- Design, measure, Analyse, Improve and Control are used to systematically improve the piping isometric generation in project. This Paper will have focus on detail implementation of DMAIC principles on derivable generation process. The approach we have undertook here is to overcome the defects causes by feasible solution which can be implemented on the future projects. The study involves using actual data from the ongoing project and measuring the current quality of the process in terms of sigma levels. As of now there is no technique available to quantify the quality of piping design. This paper gives a method to assess the quality of design and improve it by selecting the best practices. These best practices may vary based on the existing practices of the design department and the project requirements. We have tried to give an approach to systematically quantify the quality and improve it continuously. We have used actual data to prove the application of DMAIC philosophy in improvement of the design process. Here we have considered piping Isometrics for the analysis but to improve whole process the same approach must be applied on other Piping deliverables. In fact, this technique can be applied to deliverables of other departments such as Process, Mechanical, Civil etc.

2. OBJECTIVES

The main objective of the project was reducing the defects in the deliverables. In service industry, business is having very tight profit margins due to the high competitive market wastage of man-hours and time is not acceptable. In the given scenario productivity with first time quality & cost are the main critical attributes to be successful, to sustain the business & to grow. Primary aim would be to deliver defect free drawings, Piping MTO, Stress Reports and to deliver clash free 3D Plant model to client within given project schedule & within given man-hours. To meet this vision, we need to have robust & user-friendly process like Standard Operating procedure (SOP's) & check-lists to capture all the defects before it goes to client. Here Six-Sigma helped to identify gap in today's process and come with new solutions to reduce the gap and time.

The objective of this paper is to prove the technique of using Six Sigma to improve the process of piping design. The DMAIC philosophy is used to scrutinize each step of producing deliverable i.e. Piping Isometric. The focus area of this paper is limited to improve the quality

of Piping Isometrics. The flow includes the study of information between departments, fabrication yard and execution site.

3. RESEARCH METHODOLOGY

Six Sigma is the technique which gives us measure of the performance of even routine processes that we come across in our daily life. Six Sigma is quantitative defect measurement and Analysis of the process which further gives the remedial action to correct the process and achieve the quality target. DMAIC approach is combine in the study to improve the quality of piping design process. The project will be regarding the activities and process occurring in piping engineering. In normal situation, the defect found at the end user at site which refers to design department which rectifies the error and the revision is again refereed to the site. Generally, in piping department there are few deliverables like

- Equipment layout
- Piping Isometrics,
- Stress Analysis Report
- 3D plant model
- MTO (Piping MTO, Support MTO)
- Piping GA drawings
- Nozzle Orientation

In this paper, we are only concern about improvement of Piping Isometrics drawing. Our aim is to minimize the defects occurring in the Isometrics drawing only. The same technique can be applied to other deliverables of Piping department. This study will reduce the defects in Isometrics and in turns reduce the rework in MTO and delay in piping fabrication and erection activities at site.

3.1. DMAIC Philosophy Application

3.1.1. Design

Our aim is to improve the piping design process by minimizing the time and efforts required to produce piping Isometrics. It is observed that in project lot of rework is done during detail engineering phase and later at construction site because of changes made in piping Isometrics at later stages of the project. Generally, in all projects the Isometrics are revised three times before final releasing the final revision to the site. Any changes in final drawing also increases the work of updating the Isometrics which increases complexity. The duration of the revision should be minimum to reduce the changes at site. The process starts with the inputs P&IDs, Line list, Equipment layout. The Area Engineer develops piping routing, decides equipment layout and decides requirements of civil structure. The stress analysis of critical piping is done and loading data provides to civil Engineer. General Arrangement drawings created and supporting is done by area engineer and this input is given to the 3D modeler. A modeler creates a 3D design model of the plant which is true scale model. The piping Isometrics are extracted from this model.

Piping isometric drawing are 2D CAD drawings with detailed orthographic drawings for plants in the petrochemical industry. These plants usually consist of a large number of piping which are comprised of various components. Piping isometric drawings represent the details of 3D structure of these piping in the form of 2D diagrams. It is the general practice among engineering organizations to produce isometric drawings of piping systems to represent all the details in the plant design. Hundreds and perhaps thousands of such drawings should be created for a design project. Because of their wide applications in the industry, piping isometric drawings are of great commercial and intellectual value. The study is designed to measure the

current sigma level of the ongoing projects, analysis it and improve the process. The sigma level of the project is calculated by count of the no. of defects in the Isometrics which must be reworked. For the quality check of Isometrics, the Isometric checklist and department SOPs are considered. The checklist provides holistic check in all respect of the Isometrics. The number of observation is the total number of points in the Isometric into no. of Isometrics. The DPMO is calculated by number of defeats captured in the Isometrics by checklist. The sigma level of the process is derived by referring DPMO conversion table.

3.1.2. Measure

A completed project was selected to calculate the sigma level and define the current quality level of the piping design process. The checklist used for the quality check in this project has 72 no. of points to checked in single Isometrics. The total number of sheets of Isometrics in the projects were 4305. The calculation of six sigma of the project are as follows-

The opportunities related to Isometrics = 309960

Now the defects in this Isometrics are revisions of ISOs, release of Revision Isometrics and mark-up released to site which is

Count of Defect= 461

Now the defect per opportunity is

$$\begin{aligned} \text{DPO} &= \frac{\text{Defects}}{\text{Total Opportunities}} \\ &= \frac{461}{309960} = 1.4872 \times 10^{-03} \end{aligned}$$

So, Defects per million Opportunities = $1.4872 \times 10^{-03} \times 10^6 = 1487.09$

Referring chart of Sigma and DPMO conversion table,

The current sigma level for project comes to be **4.47**

3.1.3. Analysis

To improve the current process study was conducted to list the causes of defects by studying the Isometric logs maintained by department. These defects were analyse with the help of root cause diagram and pareto analysis. The few common reasons were found with the study of root cause diagram and Pareto chart. The major reasons for defects in piping Isometrics were-

- Changes in P&IDs

This change was due to changes in the information provided in P&IDs like line size change, additional/Deletion of line, change in the process conditions.

- Change in line list

The main reason for the changes in linelist are change in line design and operating conditions like Temperature, Pressure and fluid viscosity

- Change in equipment layout

Changes in the Isometrics are because of changes in the layout. There can be many reasons of layout change like accessibility, HAZOP and Safety study.

- Change in piping layout

As in design process multiple options are available to route the pipes. The piping layout changes when most optimum design is selected.

- Inputs required not received on time

The inputs required to produce the Isometrics are delayed due to reasons like delay in Equipment GAs, Vendor items details, Interdisciplinary information delay etc

- Change in client specifications

Any change in the specification leads to major changes in all the respective Isometrics

- Changes in the assumption made

While routing the area engineer has to assume certain data in early stages of the projects. If there is any deviation in these assumptions the Isometrics are will change

- Client comments during reviews

The suggestion or changes made by client during the review has to be incorporated into the model. If all the changes are not captured in the design, in later stages it turns into major defects and rework.

3.1.4. Improve

The logs of the project were studied carefully and the defects were grouped in five Categories.

Figure 1. Root cause Analysis diagram for Piping Isometrics

For each of defective or mismatching Isometric the company maintains the log of error. The logs contain the information about the defect and the corrective action required. It also has the status of corrective action and person responsible. Most of the defects can be broadly identified as human errors. These errors were in terms of data entry, reading inputs for 3D model and other documents, misinterpretation etc. One major reason affecting the quantum of this type of

errors is individual who is checking the Isometrics. The more experienced person trends to make less error. The human errors were simple in complexity and can be corrected by automation of process. It consists of almost 60% of errors in total.

The second biggest reason of the errors in piping Isometrics is that the points to be checked is not covered in the Isometrics or does not check the actual correctness of the activity. There are few Isometrics which required certain special points to be checked like in terms of speciality item. If the checking does not cover this point it is even unnoticed and might result into mismatch. This type of error increases with increase in the complexity of the project. Not referring to the latest documents causes the errors in checking the Isometrics. Sometimes the last-minute changes cause misunderstanding and lead to defective Isometrics. A simple system was derived to check the changes and made easily available to the team with simple dashboard. The frequent changes should be avoided and proper revision summary must be maintained.

Figure 2. Pareto Analysis for Piping Isometrics

3.1.5. Control

The ideas generated in the improvement phase of this is applied and regular check of the quality level of the project was done. The checklist used for the quality check in this project has 72 no. of points to checked in single Isometrics. The total number of sheets of Isometrics in the projects were 10346. The calculation of six sigma of the project are as follows-

The opportunities related to Isometrics = 744968

Now the defects in this Isometrics are revisions of Iso, release of Revision Isometrics and mark-up released to site which is

Count of Defect= 531

Now the defect per opportunity is

$$\begin{aligned}
 \text{DPO} &= \frac{\text{Defects}}{\text{Total Opportunities}} \\
 &= \frac{531}{744912} = 7.127822 \times 10^{-4}
 \end{aligned}$$

So, Defects per million Opportunities = $7.127822 \times 10^{-04} \times 10^6 = 712.78$

Referring DPMO conversion table,

The current sigma level for project comes to be **4.69**

The suggestion generated in this study is implemented and the sigma level is observed to be better than the past project. Major errors have occurred due to mistakes in input of data into 3D model. A preliminary check before extraction of Isometrics reduces the error by huge amount. Continuous updating of Standard operating and piping Isometrics checklist reduces lots of errors. We have also suggested to modify the existing checklist before each project to include certain project specific requirements if any. Should avoid frequent changes in the input. Recheck of the assumption must be done in final stages of design. On time input for 3D model is very important which should be error free and receive on time.

4. CONCLUSION

Generally, it is observed that piping Isometrics issued to the site with defects, which further leads to rework and delay in project and cost escalates. After implementation of above point the sigma levels have increase slightly. Here with the help of this study we not only quantified the quality of the design in terms of sigma level but also improve the current process by implementation of DMAIC Philosophy on piping Isometrics. The top most priority is given to correctness of plant 3D model to ensure the defect free Isometrics. The same approach can be used to improve the quality of other deliverables like stress report, MTO etc.

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