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Implementation of Six Sigma Using DMAIC Methodology in Small Scale Industries for Performance Improvement

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Abstract: *The fast changing economic conditions such as global completion, declining profit margin, customer demand for high quality product, product variety and reduced lead time etc had a major impact on manufacturing industries. To respond to these needs a new paradigm in this area of manufacturing strategies is six sigma. The six sigma has been increasingly adopted world wide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations. This paper deals with an application of six sigma using DMAIC methodology in a gas industry which provides a frame work to identify, quantify and eliminate sources of variation in an operational process in question, to optimize the operation variables, improve and sustain performance viz process yield with well executed control plans. Six sigma improves the process performance of the critical operational process, leading to better utilization of resources, decreases variations and maintains consistent quality of the process output.*

Keywords: *Control process, DMAIC, Improvement, Gas cylinder, Six sigma.*

I. INTRODUCTION

Six Sigma is business performance improvement strategy that aims to reduce the number of mistakes/defects to as low as 3.4 occassions per million opportunities. Sigma is a measure of "variation about the average" in a process which could be in manufacturing or service industry. Six sigma improvement drive is the latest and most efficient technique in quality engineering and management spectrum. It enables organizations to make substantial improvements in their bottom line and quality line by designing and monitoring everday business activities in ways which minimize customer satisfactions. While all the quality improvemet drives are useful in their own ways, they often fail to make breakthrough improvement in bottom line and quality. Voelkel, J.G contents that six sigma blends correct management, financial and methodological elements to make improvement in process and products in ways that surpass other approaches. Six sigma has a major impact on the quality management approach, while still based in the fundamental methods and tools of quality management. Six sigma is a strategic initiative to boost profitability, increases market a share and improve customer satisfaction through statistical tools that can lead to breakthrough quantum gains in quality.

Six sigma is a disciplined, data-driven methodology for eliminating defects in any process. To achieve six sigma quality a process must produce no more than 3.4 defects per million opportunities. Six sigma's basic value propositions is that principle for process improvement, statistical methods, a customer focus, attention to process and management system focusing on high return improvement project results in continuous improvement and significant gains. Six sigma is highly disciplined process that helps on focus on developing and delivering near-perfect products and service. The central idea behind six sigma is that it can measure how many "defects" you have in process, you can systematically figure out how to eliminate them and gets as close to "zero defects" as possible. Sigma is a measurement that indicates how a process is performing. Six sigma stands for six standard deviations from mean. Six sigma methodology provides the technique and tools to improve the capability and reduce defects in any process. Six sigma is fact-based, data-driven philosophy of improvement that values defect prevention over defect detection.

1.1 Concepts of Six Sigma

The word " Sigma" is a statistical term that measures how far a given process deviates from perfection as a new methodology using old tools. Six sigma is a comprehensive system for achieving, maintaining and maximizing business success. The basics of six sigma is a detailed knowledge of customer requirements, disciplined use of facts and objective data, statistical analysis and ongoing efforts focused on optimizing business processes. Six sigma revolves around a few key concepts:

1. Critical to Quality: Attributes most important to the customer;
2. Defect: Failing to deliver what the customer wants;
3. Process Capability: What your process can deliver;
4. Variation: What the customer sees and feels;
5. Stable operations: Ensuring consistent, predictable processes to improve what the customer sees and feels;
6. Design for six sigma: Designing to meet customer needs and process capability.

1.2 DMAIC methodology

It is a process for continued improvement. It is systematic, scientific and fact based. This closed loop process eliminates unproductive steps, often focuses on new measurements, and applies technology for improvement. It is in the six sigma methodology being used as the standard routine for planning and implementation in the gas industry.DMAIC forms the five major phases of any six sigma project:

1.2.1 Phase I: Define

The purpose of this phase is to clarify the goals and value of a project.

1.2.2 Phase II: Measure

The purpose of this phase is to gather data on the problem

1.2.3 Phase III: Analyze

The purpose of this phase is to examine the data and process maps to characterize the nature and extent of the defect.

1.2.4 Phase IV: Improve

The purpose of this phase is to eliminate defects in both quality and process velocity.

1.2.5 Phase V: Control

The purpose of this phase is to lock in the benefits achieved by doing the previous phases.

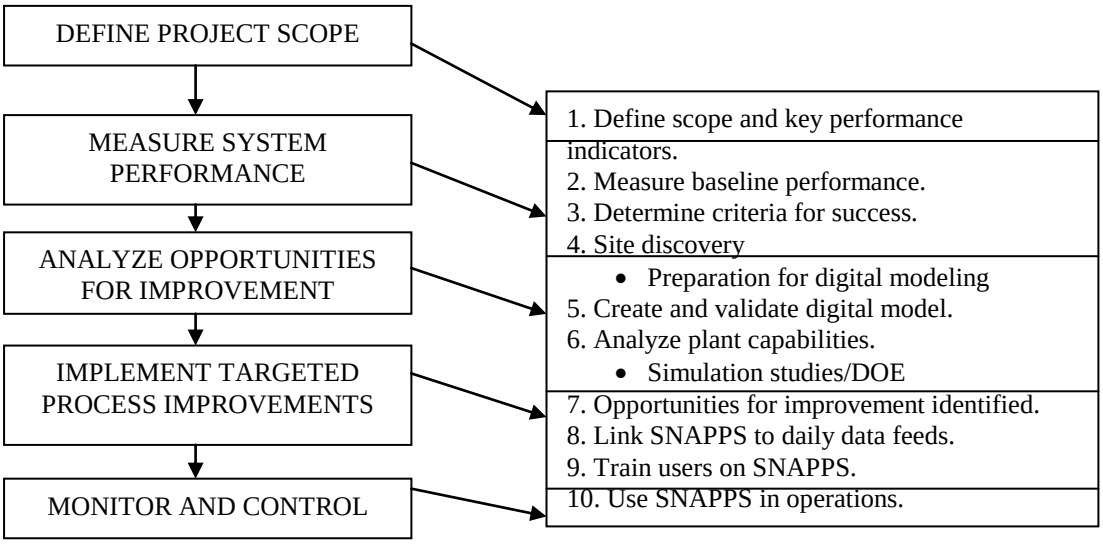

Fig 1: The abetment for Six Sigma projects

II. IMPLEMENTING DMAIC IN GAS INDUSTRY

2.1 Define

The gas cylinder plant is one of the most unique plant in country where both high pressure and low pressure cylinders are manufactured. These are used for both domestic as well as industrial purposes. The cylinders manufactured in gas cylinder plant are seamless gas cylinder, welded gas cylinder, liquefied petroleum gas cylinder and porous mass plant.

2.1.1 Seamless gas cylinder
These are made by two methods: closing the pipe end on CNC hot roller spinning machine and piercing billet to from shell and close the end on hot spinning machine.

2.1.2 Processes involved in manufacturing of seamless gas cylinder
2.1.2.1 Cutting of pipe
The pipes are first cut to required dimensions using gas cutting machines.

2.1.2.2 Dooming
After the cutting of the pipe to suitable length, it is loaded on the hot spinning CNC machines. End part of the pipe is heated in induction furnace at same time it is rolled and dome is formed.

2.1.2.3 Bottom forming
After dooming of cylinder end, it is loaded on tile HMT-press machine. HMT press is used to make bottom by pressing it with dies. It is done according to requirement, sometime footing is also provided.

2.1.2.4 Necking
It is the operation of making neck at the cylinder. This operation is done on the hot spinning CNC machine with roller. Some part of neck is cut after necking completion because at end material becomes oxidized.

2.1.3 Heat treatment of cylinders
The stresses are developed during dooming, bottom forming and necking. To remove these stresses two heat treatment operations are performed on cylinders.

2.1.3.1 Hardening
It is the process in which steel is heated above its critical temperature. It is then held at this temperature for a considerable time and then allowed to cool by quenching in water, oil or brine solution.
Temperature : 860^0C
Quenching media: Oil
Time required : 22 minutes for temperature rise and 23 minutes for soaking

2.1.3.2 Tempering
Steel after hardening becomes brittle, develops non visible micro cracks and is strained due to residual stresses. This undesired stresses are removed by tempering. Steel is heated below lower critical temperature followed by slow cooling.
Temperature : 560^0C
Time required : 45 minutes for temperature rise and 45 minutes for soaking

2.1.4 Machining operations
These operations are carried out for giving final shape to the gas cylinders:
1. Turning and facing
2. Neck ring jamming by cold press
3. Drilling in neck by straight drill
4. Hob milling (14 TPI and 1:8 taper in thread)
5. Rimming
6. Hob threading

2.1.5 Cleaning
Wire brushing is done for removal of scales that are formed during heat treatment processes. Steam cleaning is also preferred.

2.1.6 Testing
2.1.6.1 Hydro-stress Test
After cleaning the cylinders it is loaded for hydro-test to check their capability. Cylinder filled with water and put in the water jacket which is already filled with water. Jacket is connected with burette when cylinder is put in it extra water is filled in burette. After closing the jacket hydraulic press fills the water in it. Pressure inside the cylinder normally it is about 1.5 times of the working pressure. In case of CNG cylinder it is about 469 Kg/cm^2.

2.1.6.2 Pneumatic test

This is performed at working pressure. In case of CNG cylinder these are manufactured at a pressure of 205 Kg/cm^2.

2.1.7 Shot blasting

For painting and stamping on the outer surface a finished surface is achieved. This is done by using a mixture of short and small abrasive particles to blast on cylinder in shot blasting machines.

2.1.8 Colour coding

After finishing the surface vacuum cleaning is done. Colour coding is done to recognize the cylinder which gas is filled in it without testing.

2.1.9 Stamping

After colour coding, stamping is the final step that is done to write working pressure, testing pressure, batch number and gas filled etc. At end these cylinders are tested by ISI members. They confirm their quality and safety measures.

2.2 Measure

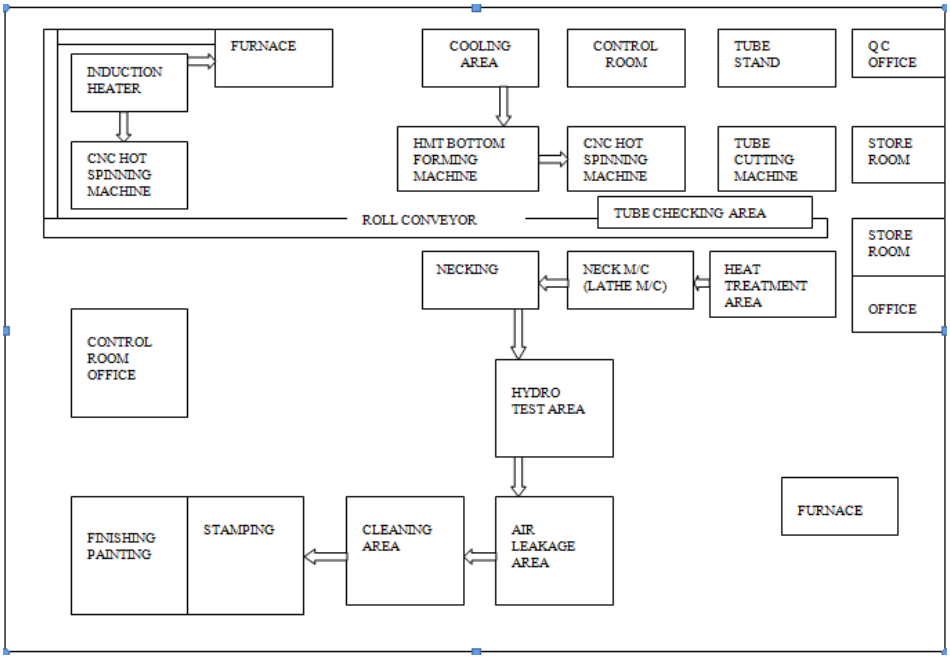

Fig 2: Gas Cylinder Manufacturing layout

2.3 Analyze

The cylinders that were manufactured had defects due to the irresponsibility of the worker and operator. The tube cutting process is not very good in industry because operator cuts the taper by hand which takes very much time in the process. According to tube cutting process, workers are few. The supply of material is not in proper condition so much time is lost during this period. Due to improper heat treatment process, the operator or worker makes mistakes and failure is obtained. Many of the work is done by the manual operation which is not suitable for production. This decreases the production rate and cost of the cylinder increases. All the machines are not working properly due to which production per capita is less. The plant layout even does not facilitate fast production due to improve arrangement of working stations. Due to unavailability of studied and experienced workers, defects are increasing as a result much scrap and waste are being obtained. Proper maintenance and repair of machines are being lacked due to which much machines are in overhaul condition.

2.4 Improve

The processing of the cylinders and for improving the production rate should be based upon the modern technology because it is impossible to increase the production rate by manual operation on the machine. Better technique is to be adopted such as modern CNC lathe machines for taper tube cutting and automatic belt

conveyors for moving cylinders inside the manufacturing workshop. The production rate will be enhanced by taking these steps. The operator and worker must take great responsibility and care while performing the jobs. The stamping and finishing of the manufacturing product must not be done manually instead it should be replaced by automatic presses and punches to do work faster and economically.

2.5 Control

The following steps are to be implemented for enhancing the production rate and improving quality of the gas cylinders thereby reducing the cost of manufacturing:

1. The plant layout should be revised.
2. The work floor space should be used economically.
3. Skilled workers are to be employed for doing work.
4. Automatic lathe machines and chain conveyor belts should be adopted.
5. Time saving must be the prime factor.
6. Faster production rate and economic irresponsibility of the products must be considered.
7. Machines should be repaired and maintained as soon as it fails to perform operation.
8. Accuracy and dimensional tolerances of the machine should be checked.

III. REMEDIES AND DISCUSSION

The graph shows the production rate of gas cylinder in the plant. In this graph we can see that production rate of gas cylinder by using lathe machine is less than by using CNC machine. The production rate of gas cylinder by using lathe machine is 1.08 lakhs/year while the production rate of gas cylinder by using CNC machine nearly 2.5 lakh/year. The preference to use CNC machine should be optimum for good production rate. CNC machines can be used continuously 24 hours a day, 365 days a year and only need to be switched off for occasional maintenance. CNC machines are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same. One person can supervise CNC machines as once they are programmed they can usually left to work unlike lathe machines which needs trained technicians for handling. A skilled technician on lathe machine can make the same component many times. However, if each component is carefully studied, each one will have minute defects unlike CNC machines which will manufacture each component exactly.

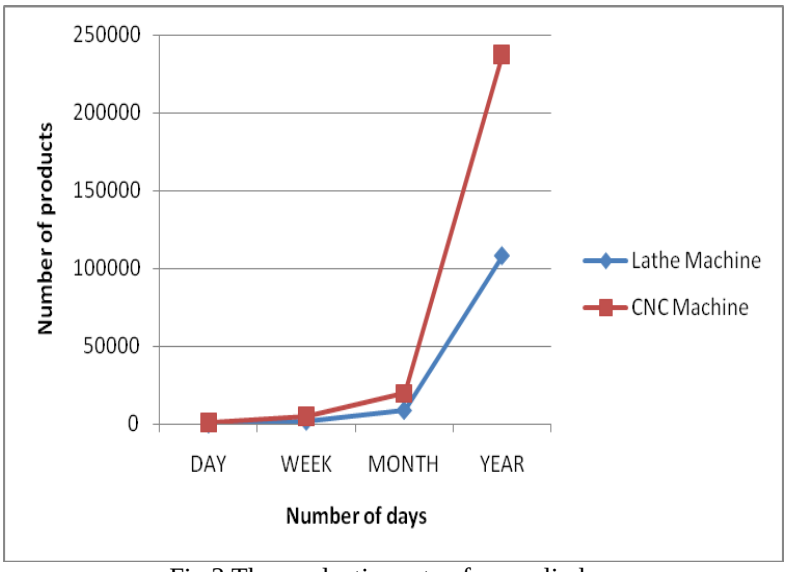

Fig 3 The production rate of gas cylinders

IV. CONCLUSION

The maturity of a manufacturing process can be described by a sigma rating indicating its yield, or the percentage of defect free products it creates. A Six sigma process is one in which 99.99966% of the products manufactured are statistically expected to be free of defects. As can be seen from the study that Six Sigma can be very successfully implemented in any manufacturing unit. It also shows the importance of strong supplier base with Six sigma product quality. The breakthrough improvement using Six sigma can be achieved, however, to sustain this, the organization will have to continue with rigorous implementation and sustainance of the same.

Six Sigma DMAIC projects ideally should concentrate on a specific area of interest. Larger projects, or projects targeting more than one area of concentration and taking more than three to six months, should be divided into separate projects with the spin-offs to be completed later or worked on in parallel as separate projects. As Six sigma project experience increases, person will become better at using the right tools to develop project scopes that meet the description of a Six Sigma project while simultaneously producing quantifiable benefits.

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