Optimization of Submerged Arc Welding Process Using Six Sigma Tools

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Abstract: *Many researchers and project managers have attempted to improve project performance by applying new philosophies such as lean principle, just-in-time, pull scheduling, and last planner. However, very little research has been conducted on setting definite quantitative goals for performance improvement while considering the defect rate involved in the submerged arc Welding operations. This research explores practical solutions for welding operations performance improvement by applying the six sigma principle. This principle provides the metrics required to establish performance improvement goals and a methodology for measuring and evaluating improvement. The proposed approach is expected to achieve more reliable workflows by reducing process variability to fit in a desirable range—thereby improving the overall performance through the evaluation of the quality level in current welding operations. To verify the suggested methodology, this case study has been presented and process analyses are performed to observe the performance changes based on the six sigma principle. Critical total quality control, as the sigma level rises, is also discussed.*

Index Terms: - *Total quality management, Six Sigma, DMAIC tool, SPC, Critical total quality.*

I. Introduction

In today's global competition and economic liberalization, quality has become one of the important factors for achieving competitive advantage. A good quality product or service enables an organization to add and retain customers. Poor quality leads to discontented customers, so the costs of poor quality are not just those of immediate waste or rectification but also the loss of future sales. Technological innovations have diffused geographical boundaries resulting in more informed customers. The business environment has become increasingly complex and the marketplace has changed from local to global. Constant pressure is applied on the management to improve competitiveness by lowering operating cost and improving logistic. Customers are becoming increasingly aware of rising standards, having access to wide range of products and services to choose from. There is an ever-increasing demand for quality product and/or services and this global revolution had forced organizations to invest substantial resources in adopting and implementing total quality management strategies. [1]

Total Quality management

TQM is a systems approach to management that aims to enhance value to customer by designing and continually improving organizational processes and systems. It provides a new vision for management leadership. It places customers as principal focal point and redefines quality as customer satisfaction. TQM relies on fact-based decision-making. TQM is a broad-based approach used by world class companies to achieve organizational excellence, the highest weighted category of all the quality and excellence awards. Most of the researchers agree that TQM is a useful philosophy for management if properly planned and. It has been proposed that if TQM is used properly and fully integrated into the business, this approach will help any organization deliver its goals, targets and strategy. [2]

TQM implementation is based on three core elements:

- The TQM philosophy that comprises a set of TQM principles;
- The organizational culture – the present and desired state of culture that will be reached when the TQM philosophy is realized; and
- The implementation strategy – the approach to realizing the philosophy that will specifically include the activities to identify and offset TQM implementation barriers. [2]

Six sigma

Six Sigma is considered as a methodology of implementing TQM. Six Sigma is an innovative approach to continuous process improvement and a TQM methodology. Since quality improvement is the prime ingredient of TQM, adding a Six Sigma program to the company's current business system covers almost all the elements of TQM. Six Sigma has become a much broader umbrella compared to TQM [3].

Six Sigma is new, emerging, approach to quality assurance and quality management with emphasis on continuous quality improvements. The main goal of this approach is reaching level of quality and reliability that will satisfy and even exceed demands and expectations of today's demanding customer [4].

A term Sigma Quality Level is used as an indicator of a process goodness. Lower Sigma quality level means greater possibility of defective products, while, higher Sigma quality level means smaller possibility of defective products within process. Achieving Six Sigma quality level involves leadership, infrastructure, appropriate tools and methods, while quality have to become a part of corporate business plan [4].

The main objective of Six Sigma initiative is to aggressively attack costs of a quality. Overall costs of quality are, usually, divided in tangible and intangible part. The tangible or visible part
of costs of quality, e.g. inspection and warranty costs, scrap, rework and reject, can be approximated with only 10–15 % of overall costs of quality. Remaining 85-90 % of quality costs is usually intangible and, therefore, overlooked and neglected in companies' quality costs analyses.

Tools and methodology within Six Sigma deal with overall costs of quality, both tangible and intangible parts, trying to minimize it, while, in the same time, increasing overall quality level contribute to company business success and profitability [4].

Submerged Arc Welding process

- The Submerged arc welding process (which may be done manually or automatically) creates an arc column between a base metallic electrode and the workpiece.
- The arc, the end of the electrode, and molten weld pool are submerged in a finely divided granulated power that contains appropriate deoxidizers, cleansers and any other fluxing elements.
- The fluxing power is fed from a hopper that is carried on the welding head. The tube from the hopper spreads the power in continue mount in the electrode along the line of weld.
- This flux mound is sufficient depths to submerge completely that are column so that there is no splatter or smoke, and the weld is shielded from all effects at atmospheric gases. As a result of this unique protection, the weld beads are exceptionally smooth.
- The flux adjacent to the arc column melts and floats to the surface of the molten pool; then it solidified to from a slag on the top of the welded metal. The rest of the flux is simply an insulator that can be reclaimed easily.
- The slag that is formed by the molten flux solidifies; the slag will crack off by itself as it cools.
- The unused flux is removed and placed back into the original hopper for use for the next time.
- Granulated flux is a complex, metallic for silicate that can be used over a wide range of metals.

Welds made by the submerged arc welding process have high strength and ductility with low hydrogen or nitrogen content [5].

II. Problem Definition & Methodology

The contact /jaw welding are a continuous production process and during normal production the operators of the welding equipment faced problems with the problems with welded component. The operators experienced lots of scrap page due to variability in the welding strength and requested an immediate attention from the management, initiating the quality study.

This research paper identifies the root causes of failure for a welding process at a manufacturing plants, and purpose to use Operational six sigma methodology to eliminate the problem. In contrast to other methods which measure and identify the non-conformance through destructive testing, a technique is proposed to use a mathematical model, which is later charted using SPC technique. The control chart for mathematical model will identify the failure of the process in real time and will reduced/ eliminate the testing process. The proposed Six Sigma methodology can be applied to eliminate non-conformance in other similar processes.

Operational Six Sigma methodology which is widely used in industries to eradicate these types of problem. Operational Six Sigma was successfully implemented in both the manufacturing and services industries. Many companies in both industries have deployed the process in various activities throughout their organizations. Six sigma is a term used to describe a measure of quality control that is higher than what is provided to be normal. Sigma is a statistical metric that measure variation from an expected outcome. Essentially, the Six means that the process has no more than 3.4 defects per million opportunities.

Six Sigma is a methodology that is intended to reduce process variation to within some specified limit. State that sigma refers to the ability of a process to perform defect-free work. The increase in numerical value that accompanies six sigma suggests that the process is performing better and thus defects are less probable to occur. Consequently, six sigma strives to be a near measure of quality in a process.

Six Sigma aims to reduce variability in a process. Operational Six Sigma follows the DMAIC principle which is the acronym for Define. Measure, Analyze, Improve and Control. The following subsections describe the tasks performed at each step of the welding improvement process, under study.

III. Six Sigma Dmaic Methodology

Dmaic is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applied technology for continuous improvement. Implementation of DMAIC Methodology took place in five phases as outlined earlier and established at Motorola. Problem identification and definition takes place in define phase. After identifying main processes, their performance is calculated in measure phase with the help of data collection. Root causes of the problem are found out in analysis phase. Solutions to solve problem and implementing them are in improve phase. Improvement is maintained in control phase.

ROADMAP TO SIX SIGMA

- ***DEFINE****- Set project goals and objectives.*
- ***MEASURE -*** *Measure the defects where they occur.*
- ***ANALYZE -*** *Evaluate data/information for trends, pattern and root causes.*
- ***IMPROVE -*** *Develop, implement and evaluate solution targeted at identified root causes.*
- ***CONTROL -*** *Make sure that almost the problems have cleared, and method is improving.*

I. Section ;Define Phase:-

This phase determines the objectives & the scope of the project, collect information on the process and the customers, and specify the deliverables to customers (internal & external).

Project Title	Optimization of SAW welding process.
Project Start	April to May 2012
Project Location	A large scale manufacturing unit, Surat, Gujarat, India.
Business Case	• Quality control. • Production cost increases. • Reduce the profit margin.
Team Member	Project student- ***Shashank Soni*** & Company employees.
Expert	G. Manager & Sr. Manager. Quality & Industrial Engg. Deptt.

Table (1):- Project Team Charter

Project Plan

- ***Define Phase:-*** 01 April to 10 April-2012
- ***Measure Phase: -*** 11 April to 20 April-2012.
- ***Analyze Phase: -*** 21 April to 30 April-2012.
- ***Improve Phase: -*** 01 May to 10 May-2012.
- ***Control Phase: -*** 11 May to 20 May-2012.

In this phase, the equipment that performs welding also performs several other manufacturing processes. Figure 1 shows the sequences of the manufacturing processes that are performed on welding equipment. A continuous coated strip is stamped, formed; the contacts are welded and trimmed to make the component. The contacts are made of brass. The above sequences of processes are carried out using two sets of assembly; one is located at the front of the equipment and other at the back. Therefore, the corresponding welds are called front and back weld, respectively. The objective of the Six Sigma study is to control and reduce the variability in the welding strength,

Define	*What problem needs to be solved?*
Measure	*What is the capability of the process?*
Analyze	*When and where defects do occurs?*
Improve	*How can process capability be Six Sigma?* *What are the vital factors?*
Control	*What control can be put in place to sustain the again?*

Table (2):- DMAIC Process

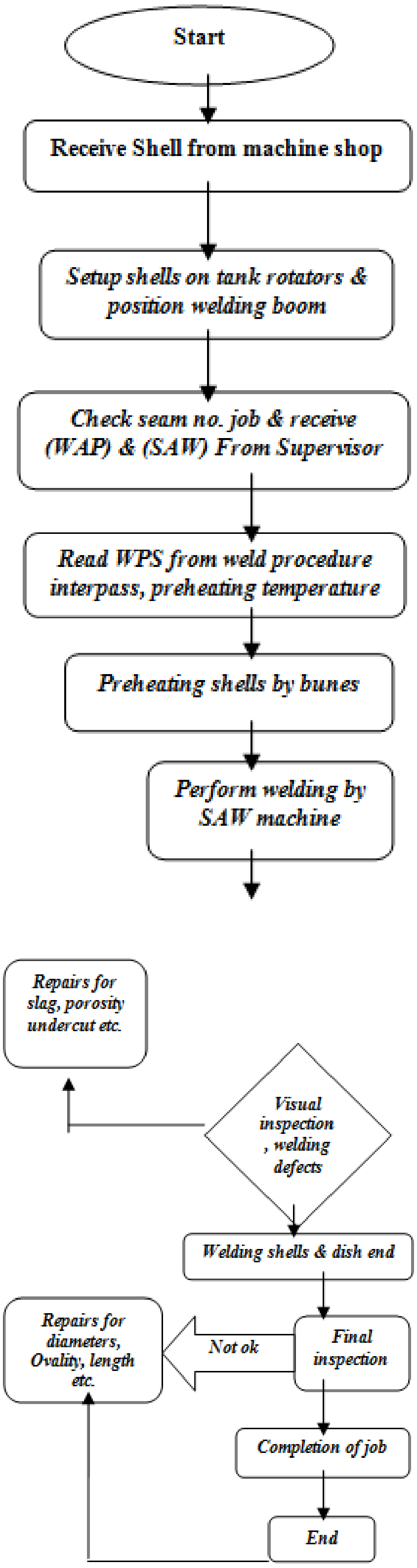


Figure (1):- Sequences of SAW welding process

II. *Section; Measure Phase*

This phase presents the detailed process mapping, operational definition, data collection chart, evaluation of the existing system, assessment of the current level of process performance etc.

The measure phase actually welding strength is measured in terms of the resistance the joints provide against the shear force. The existing SPC process recommends picking 10 out of 5000 random components that are tested using shear tester. The parts are destroyed using shear force and the destroyed sing shear force and the destruction- point values are plotted on a control chart. Figure 2 illustrates the existing inspection system.

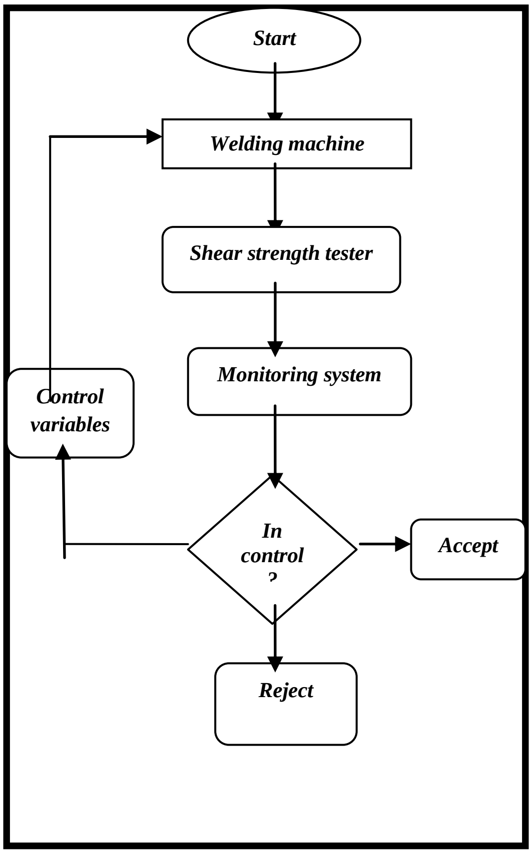


Figure (2):- Exiting testing & inspection system

III. Section (3) Analysis phase:-

The analyze phase is the third step in the DMAIC improvement cycle. The data collected are analyzed and X-bar charts are plotted. The front and back weld are controlled by separate processors; therefore the control charts were plotted separately for the two welds. From the control charts figure 3 & 4, it can be clearly seen that few data points were out of the control limits and the process is out of control.

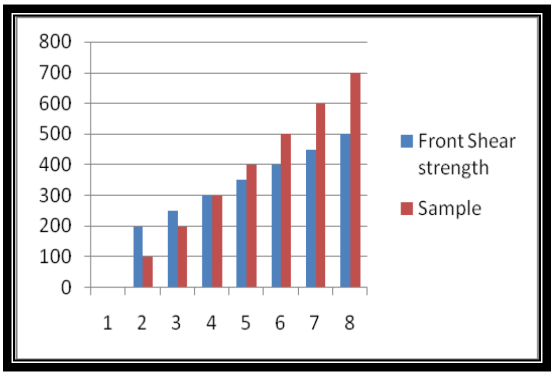


Figure (3):- Front weld X-bar chart

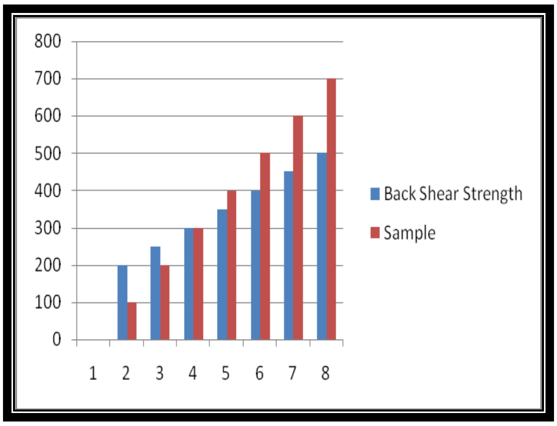


Figure (4):- Back weld X-bar chart

IV. *Section: Improve Phase:-*

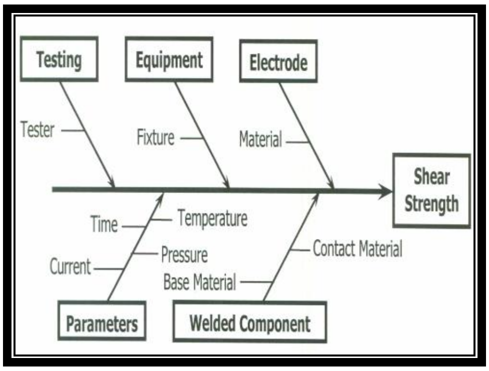
The Improve phase is the fourth step in DMAIC improvement cycle and its aim is to find and implement measures that would solve the problem.

In the improving stage, a new SPC system was proposed to improve the existing system. The disadvantages of the existing system were:

- The occurrence of a defective part lead to scraping the whole batch.
- There was no standard procedure to rectify the problem when it occurs.
- The sample testing procedure is destructive in nature and tested components cannot be used further.

The purpose SPC system uses a real time regression chart instead of an X-bar chart that will resolve the above problem in the existing system. To develop the regression chart a mathematical relationship needs to be established between the welding strength and the parameters influencing it.

As a first step the parameters that influence the welding strength that are shown in the fishbone diagram as shown in figure no.5.



Figure(5) fishbone diagram

In the above fishbone diagram most of the parameters can be assumed to be constant because they experience variation only due to the change causes. Therefore heating time, current and pressure are the only variables that have effect on the shear strength. These three variables with three levels each are in a statistically designed experiment. Table no 3 shows the treatment variables and their levels.

The experiment run will include a full factorial design that is all possible combination of the factors with 4 replicates each.

Table(3) :-variables and levels

	Heating time (Cycles)	Current (k. Amps)	Pressure (PSI)
Low	*120*	*9.6*	*2500*
Mid	*140*	*10.6*	*3000*
High	*160*	*11.0*	*3500*

V. *Section: Control Phase:-*

The last phase of DMAIC is control, which is the phase in which we ensure that the processes continue to work well, produce desired output results, and maintain quality levels.

The regression function obtained from the experiment runs will yield an equation as follows:

(SS)=A+B*+C*+D*

Where: SS- Shear strength of the welds, A+B*-Heating Time, C*-Current, D*-pressure.

Where A, B, C and D are fitted constants. Using an online data collection system real time monitoring run charts will be plotted for heating time, current, & pressure, individually to monitor the variation in the values. A regression chart will be plotted using the developed mathematical relationship and the shear strength of the welded components can be tweak the controllers with the help of the mathematical relationship during the occurrence of a defective component.

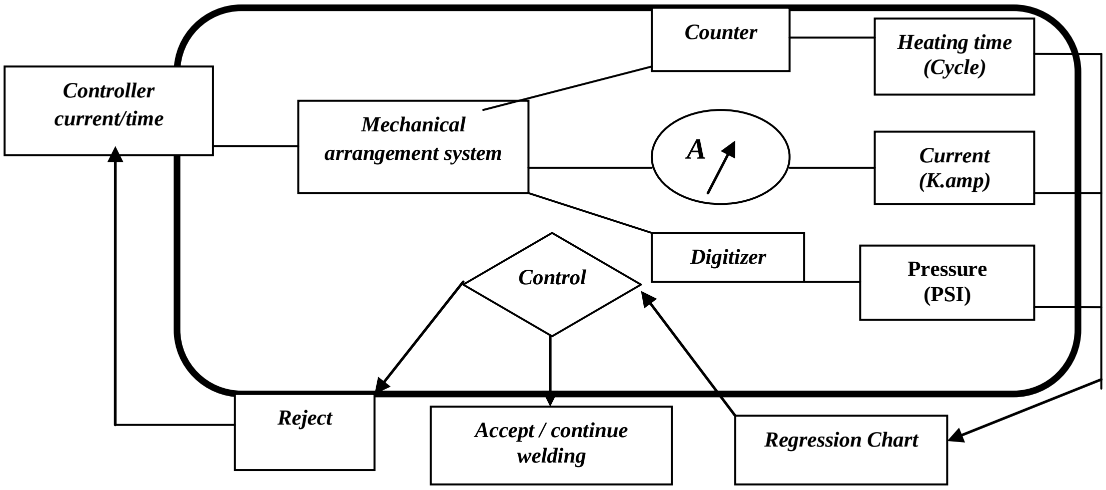


Figure (6):- Real time monitoring system

IV. Result & Conclusion

Operational Six Sigma methodology was selected to solve the variation problem in welding process; the study purposed a real time monitoring system by which the shear strength of the weld can be estimated without destructive testing. Due to 100% inspection, errors made by the selective sampling can be eliminated, reducing the scrapped cost. The implementation of this system will pay for itself in a long run.

Six Sigma was found to be the greatest motivator behind moving everyone in the organization and bringing radical transformation. People in the workplace have developed the required statistical thinking with their involvement in this particular study. Benefits of implementation have been found to be enormous in this case study. However further research is possible in the direction of what the people and organization has to sacrifice for getting this breakthrough in their process. As no gains possible without companying improvement in work habit Six Sigma is continues improvement process involving all operations in the work place and more such opportunities are potentially available in the workplace.

Refrences

[1] Vidhu Shekhar Jha & Himanshu Joshi. “Relevance of Total Quality Management (TQM) or Business Excellence Strategy Implementation for Enterprise Resource Planning (ERP) – A Conceptual Study,” international Journal of manufacturing & Industrial Management (2003)1301-1310.

[2] Rallabandi Srinivasu G. Satyanarayana Reddy. “The Contributions of TQM and Six SIGMA in the Organizations to Achieve the Success in Terms of Quality,” International Journal of Computer Applications (0975 – 8887) Volume 8– No.4, October 2010.

[3] Anup A.Junankar & P.N Shende(2011). Minimization Of Rework In Belt Industry Using Dmaic; International Journal of Applied Research in Mechanical Engineering, Volume-1, Issue-1, 2011.

[4] M. Soković , D. Pavletić & E. Krulcc.(2006). Six Sigma process improvements in automotive parts production; Journal of Achievements in Materials and Manufacturing Engineering, Vol.19 Issue 1 November2006.

[5] R.K Rajput. “A text book of Manufacturing Technology,” Laxmi Publication (p) Ltd, First Edition: 2007, India.

[6] H. Wang, “A Review of Six Sigma Approach: Methodology, Implementation and Future Research”, Zhejiang Normal University, Jinhua City, China, pp.1-4

[7] M. Hekmatpanah, M. Sadroddin, S. Shahbaz, “Six Sigma Process and its Impact on the Organizational Productivity”, World Academy of Science, Engineering and Technology-43, pp. 365-369, 2008.

[8] Sung H. Park, “Six Sigma for Quality and Productivity Promotion”, Published by The Asian Productivity Organization, Hirakawacho, Tokyo, Japan.

[9] M.S. Raisinghani, H. Ette, R. Pierce, G.Cannon, P. Daripaly, “Six Sigma : Concept, Tools and Applications”, Industrial Management & Data Systems, Vol. 105, No.4, pp.491-505, 2005

[10] P. Tanuska and T. Skripcak, “Data Driven Scenario Test Generation for Information Systems,” International Journal of Computer Theory and Engineering, vol. 3, No. 4, pp. 565-570.

[11] R. Halenar, “Loading data into data warehouse and their testing,” Journal of Information Technologies, vol. 2, pp. 7-14, 1999.

[12] Ropp, T. D., Dubikovsky, S., Johnson, M. E., “Using Peer And Team Performance Assessments As Learning Tools On Collaborative Student Projects,” *Journal of Aviation/Aerospace Education and Research*, in press.