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A DMAIC based Six Sigma approaches to reduce defects in Steel Tube Welding

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Abstract: Today manufacturing industries are highly impacted by the fast changing economic conditions. In this scenario manufacturing industries are facing global competition due to globalization. The major problems those are being faced by these industries are declining profit margin, customer demand for high quality product and product variety. There is a high pressure today on every manufacturing industry of reduced lead–time.In this paper we use surveys as well as observation to provide clear concept of a steel tube welding by using DMAIC (Define, Measure, Analysis, Improve and Control) technology under Six-Sigma in order to reduce leakage problem in steel tube welding. By taking various tube welding parameters in a machining process the tube welding strength (yield stress and tensile stress) increased. By taking into consideration and analyzing the drawbacks in the previous researches in context with constraints like finishing, quality, mechanical properties, time taken for welding and selection of material, we implemented our own welding method which has the ability to withstand the all these features and can easily rectify the leakage problems arising in the machining operations.

Keywords: *Six* Sigma, DMAIC, tube welding, yield stress.

I. INTRODUCTION

The Six Sigma Methodology is a customer focused continuous improvement strategy that minimizes defects and variation towards an achievement of 3.4 defects per million opportunities in product design, production, and administrative process. Gutierrez et al. (2004) state that Six Sigma is a strategy of continuous improvement of the organization to find and eliminate the causes of the errors, defects and delays in business organization processes. Six sigma is a problem solving methodology that reduces cost and improvement customer satisfaction and greatly Reduce waste in all the process involved creation and delivery of the product and service. Six-Sigma process involves collection of data, measurement and statistics to find out the different types of factors and parameter. Six-Sigma has been a powerful and successful tool in manufacturing industries to reduce rate of rejects and to enhance productivity. The service industries are diversified and the features are different from manufacturing industries. Thus, the use of Six-Sigma in service industries and its benefits are limited to some specific types of services like health care and banks. Quality management has been an important management strategy for achieving competitive advantages and improvements. Traditional quality concepts like Statistical Quality Control, Statistical Process Control, Zero Defects and Total Quality Management, have been key players for many years; while six-Sigma is a more recent initiative quality improvement to gain popularity and acceptance in many Industries across the world .The basic elements of Six-Sigma like, Statistical Process Control, Failure Mode Effect Analysis, Gage Repeatability and Reproducibility and other tools that have been on reduction of rejects and enhancing the quality. Six-Sigma provides a framework in which all these tools can be performed with management support.Related work Apply the Six-Sigma technique on the steel tube welding process for the solved leakage problem in steel tube used by electric resistance welding low voltage, high current process. Electric Resistance Welding **(ERW)** Tube manufactured by continuous roll forming and hot coil material into a tube shape butt welding the weld seam after heating/melting the coil edge using the heat generate by passing a high frequency current through the edge at the seam of the electric resistance welding butt welding and welding beads on the tube inside and outside surface are removed. Full length grinding follow by seam heat treatment to improve the weld microstructure after electric resistance welding line tubes are cut to the specified length and tubes are passed for quality assurance process and check the quality and leakage defect and tube strength, tubes dimension through the tube testing process. Through this manufacturing process to changes the parameter of tubes and reduced the tubes leakage problem. It can be shown in fig.

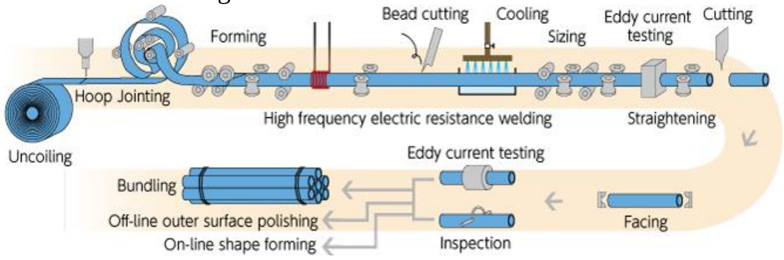

Fig. 1 Welded Tubing Manufacturing Process

produce the required financial reports. The Six-Sigma DMAIC Methodology was used to streamline the 'Continuing Account Reconciliation Enhancement' process. The team followed the five phases of DMAIC in this project and the result was a significant reduction in errors, cycle times, and costs associated with preparing financial reports. The potential impact of cycle time reduction on both internal and external customer satisfaction was not measured in this study but could be incorporated into future. Bagaitkar has explained the results of Six Sigma movement at Tata Honeywell Ltd. The project undertaken was to reduce the travel costs per kilo meter per month of the company. By the successful implementation of the Six Sigma methodology are makeable improvement, month after month, had been noticed without a decrease in the total travelling Kilo meters per month. The process metric improvement had been reflected in gains in the business result metric. Oguz et al. has implemented Six-Sigma in the construction industry. Using a case study, a company is developing the Phase II of Jubail Industrial City in Saudi Arabia. The combination of Lean tools and Six-Sigma methodology is used on projects to improve the process by eliminating the variations and creating workflow in a process. Despite its relatively new introduction to the construction industry, it has been popularized by several organizations and adopted as the primary improvement process. The complexity of the construction project has its own unique and uncertain environments, which made the use of Lean Six Sigma methodology somehow different from the other industries, especially manufacturing. However, as seen on the case study, major Lean Six Sigma tools have been successfully applied to improve the process. The methodology of Lean Six sigma was effective in reducing variability of daily panel production rate. However, taking into account inherited uncertainty in construction processes, the value of Cp can be applied flexibly to construction processes Rasis et al. have dealt with Paper Organizers International (POI) which offered a full range of filing, organizing and paper shuffling services. The purchasing department had noticed an increase in complaints from employees in the paper shuffling department about metallic securing devices breaking and failing to keep paper together. Define and measure phases of the Six Sigma methodology were used to define the problem using voice of the customer, Gauge R&R study and to calculate the DPMO level of the process. Henderson and Evan have reviewed the basic concepts of Six Sigma, its benefits, and successful approaches for implementation. They have concluded that keys for successful implementation include upper management support and involvement, organizational infrastructure, training, tools, and links to human resource based actions.

II. METHODOLOGY

The Methodology is then classified mainly into five phases effective for all target elements. Which are define phase, measure phase, analyze phase, improve phase and control phase. These are to be executed while implementing any of the classified elements. The paper has chosen to concentrate upon six sigma (DMAIC) methodology:

Define Phase: In order to implement the Six Sigma Methodology and Management System it is crucial to define:
The Customer – who is the customer, what do they want and what are their expectations? This will involve looking at quality control issues and core business processes

- The project boundaries – Where does the process begin and end?
- The process to be improved

Tools used in the phase are as follows:

- Project charter
- Project Schedule
- CTQ(Critical to Quality)

Measure phase: In order to apply the Six Sigma Methodology and Management System it is essential that you measure the performance of Core Business Processes. You will need to –

- Develop a plan for the collection of data for the process
- Gather data to identify types of defects and metrics
- Compare evidence to customer survey results

Tools used in the phase are as follows:

- Data Collection
- Gage R&R(Gage Repeatability and reproducibility)
- SIPOC

Analyze Phase: The next step in the DMAIC model is to analyze the data and process map to establish causes of defects and where you can improve:

- Current performance and goal performance are compared to identify gaps
- Opportunities for improvements are prioritized
- Sources of variation are identified

Tools used in the phase are as follows:

- Pareto Chart

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- Fishbone diagram
- Regression Analysis
- FMEA(Failure Mode and Effect Analysis)

Improve Phase: Using the data from the implementation of the above it is now possible to improve the process by designing creative solutions to fix and prevent problems. This is achieved by

- Using discipline and technology to develop innovative solutions
- Develop and implement a plan

Tools used in the phase are as follows:

- Brainstorming
- Design Changes
- DOE(Design of Experiment)

Control Phase: Control and sustain improvements over time by –

- Preventing the instinct to return to the old ways of doing things
- Developing, documenting and implementing an ongoing monitoring plan
- Integrating the improvements throughout the company through the use of training, staffing and incentives.

Tools used in the phase are as follows:

- Control Charts
- Process Capability Six pack
- Hypothesis Testing
- Process Sigma Calculation

III. RESULTS

This present work deals with the manufacturing process in which welding is done on the steel. The electrical resistance welding is used in manufacturing process. In this work with consideration of various parameters we will find out the reasons responsible for leakage problem in the tube.
Welding type: Electric Resistance Welding at low voltage high current
Cooling medium water
For corrosion reduction: Nitrogen gas used
Electrode angle: 90 degree
By the variations in different parameter in tube welding process the yield stress and tensile stress are increased
When we are change the thickness (variable) then improve the welded tube strength show below in table and graph.

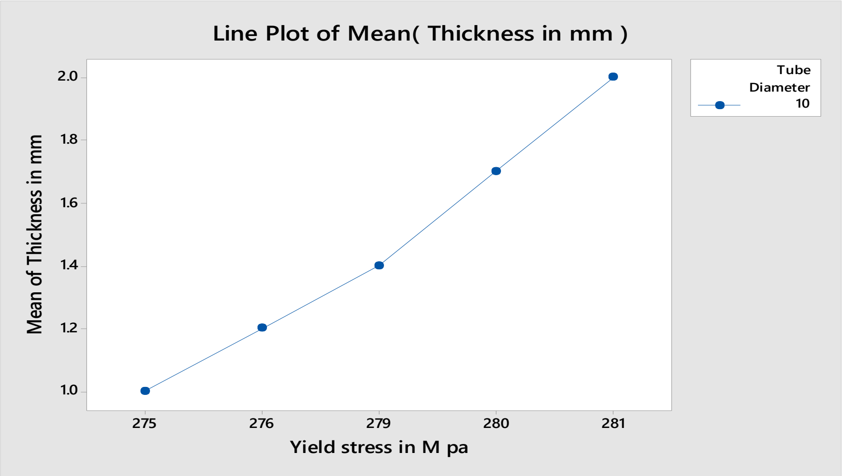

Fig. 2: Thickness v/s yield stress

In this graph we are changes the thickness (vary) then variable slowly yield stress increase and strength of weld tube are increase so solve the leackage problem. In previous time steel tube strip thickness 1-2 mm thickness used in **Gandhi Special Tube Ltd Halol (Gujrat) India.** And maximum received strength (yield stress=275 Mpa, tensile stress=315 Mpa) but in my research work thickness increased to maximum strength (yield stress=350 Mpa, tensile stress=417 Mpa).

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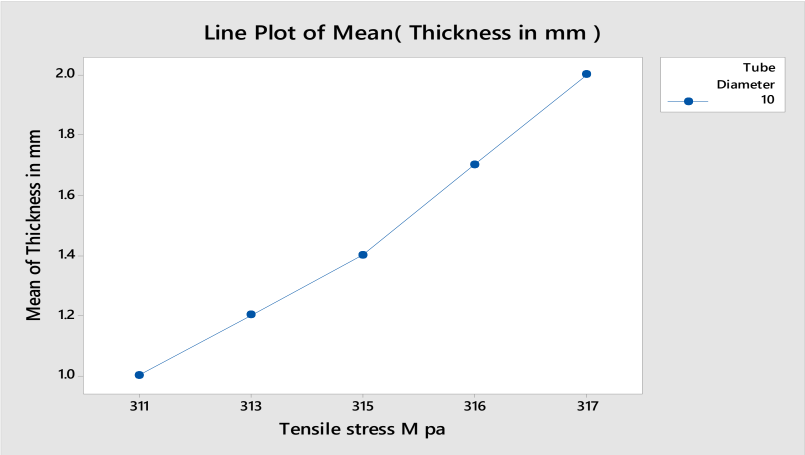

Fig. 3: Thickness v/s Tensile Stress

In this graph thickness vary to increased tensile stress and increased welded tube strength then reduced leackage problem through the Six –Sigma technique in my research work.

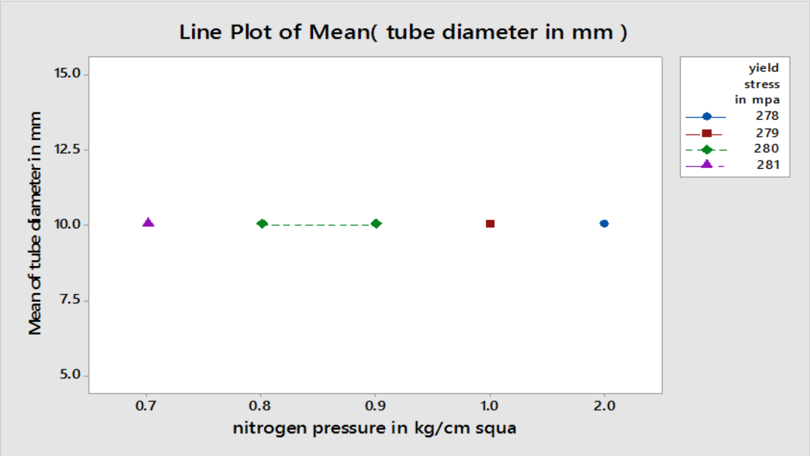

Fig. 4: Nitrogen gas pressure v/s Yield stress

Nitrogen gas used for reduced corrosion in the steel tube through electric resistance welding process low voltage high current but nitrogen gas pressure effected on the steel tube strength then changes the increased nitrogen pressure and reduced yield stress show in fig: 4

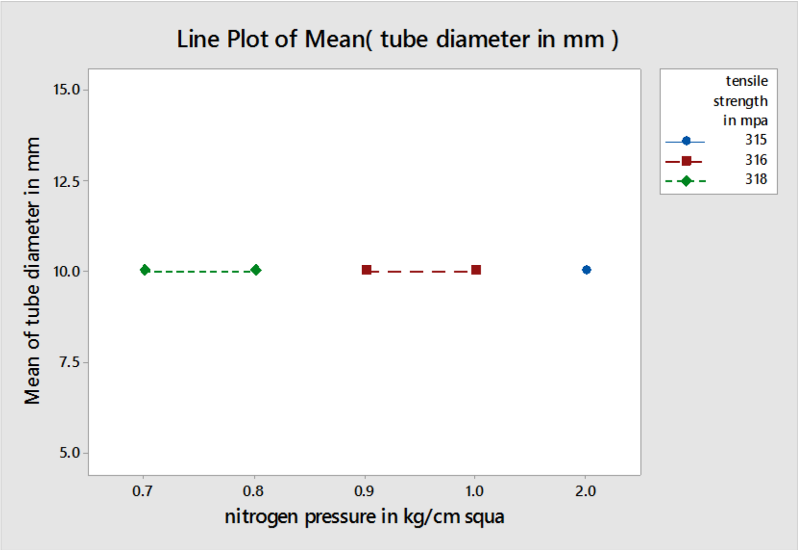

Fig. 5: Nitrogen pressure v/s Tensile Stress

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In this graph show the nitrogen gas pressure reduced then increased tensile stress so these improvement to automatically reduced leakage problem in steel tube welding at the flow of fluid in tube.

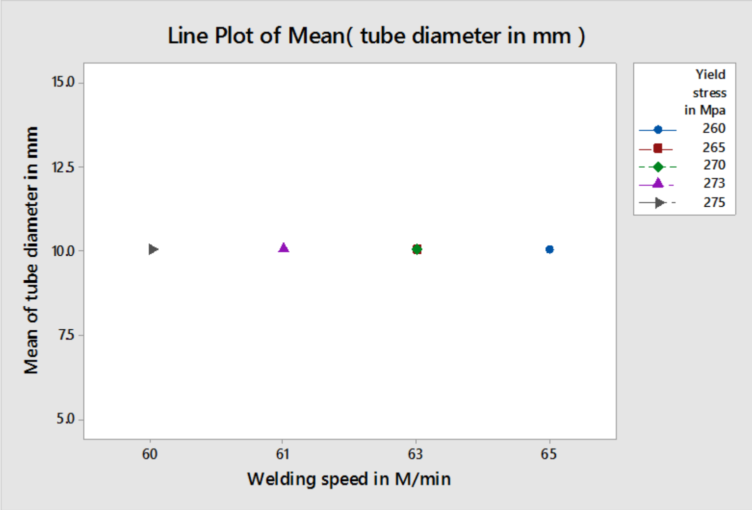

Fig. 6: Welding Speed v/s Yield Stress

In this graph changes the yield stress with welding speed, in electric resistance welding used low voltage high current. In ERW high speed strip converted into the tube so create defect because strip material shape perfectly no change in tube shape so at the testing time tube create leackage problem because material porosity problem from the high welding speed and reduced yield stress of welded tube, And reduced welding speed increased yield stress. Show the graph, welding speed reduced then increased tensile stress and not created porosity at the ERW process, low voltage high current (2.4V, 15000 Amp.) strip converted in to the tube shape so automatically reduced leackage problem in welded tube.

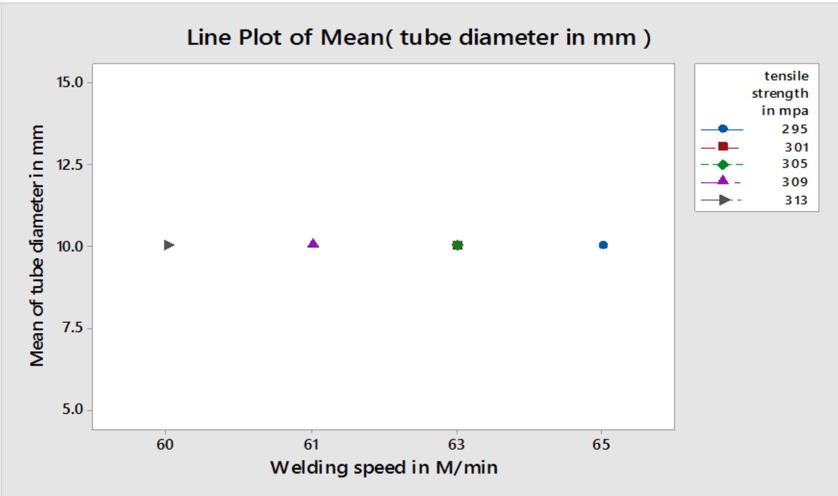

Fig. 7: Welding Speed v/s Tensile Stress

IV. CONCLUSION

In this work with consideration of various parameters we found the various reasons responsible for leakage problem in the tube. The various parameters such as use of nitrogen gas, change in welding pressure, increase in strip thickness and reduction in welding speed were taken under consideration in order to find the better results are taken as nitrogen gas pressure V/S yield stress and tensile stress (yield stress=285 Mpa and tensile stress=320Mpa) to find the welding leakage problem. The tensile strength increases with increase in welding speed. As the diameter increases, tensile strength increases. Tensile strength increase with increase in base current, peak current and pulse frequency. By implementing six sigma DMAIC technique the tube leakage problem is minimized and strength of tube welding is improved. By the implementing of six sigma quality level is increased which reduces the rework cost process capability value are increased and also increases the value of upper specification limit and lower specification limit as a result of which the value of standard deviation is increased. Due to variation in diameter and thickness of the tube and by the change of parameters in the tubes we meet the required standard therefore improvement in the selection of diameter and thickness of tubes was required.

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