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Reduction in Welding Defects by Implementing Six Sigma Techniques

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ABSTRACT:

The paper presents the detailed discussion of the reduction of welding defects in fabrication industry by using six sigma methodology which can be result into increase in six sigma level of overall component. The study also represents the types of welding defects which were observed while doing experimental trial, the DMAIC methodology which reduces the welding defects and time require to complete the welding of auxiliary piping. Additionally, the difference observed in sigma level of pipes before and after the Six Sigma implementation has also been described.

Keywords: DMAIC methodology, Six Sigma Rule

Introduction:

Implementation of quality initiatives in any business leads to improvements in the performance of the organization through the generation of high-quality products and services, and improved efficiency and competitiveness. The DMAIC (define-measure-analyze-improve-control) approach has been followed here to solve a problem of reducing rework time and the associated high defect rate. The Greek letter σ or „sigma" is a notation of variation in the sense of standard deviation. For a stable process parameter should be within suitable limits. Six Sigma, a statistically-based quality improvement program, helps to improve business processes by reducing the waste and costs related to poor quality, and by improving the efficiency and effectiveness of processes.
The Auxiliary piping that are currently being manufactured and it contain three segments in it which are welded to make pipe which are Upper pipe, Middle pipe and lower pipe. Auxiliary piping is generally used with a secondary piping system include such as tertiary services such as instrument piping, flush piping, drain piping etc. The welding joint n it should be defect free. The pipe quantity used were 50 nos. of pipe of each type.

2.Methodology

2.1 Define Phase:

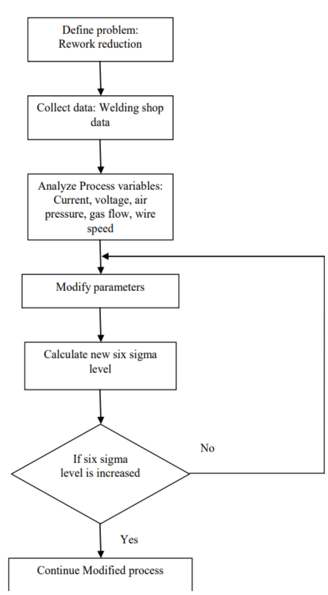

Fig 1 Research Methodology

In this phase we must define the methodology that how the welding defects can be minimized, and which can result into increase in production with best quality output. By using DMAIC methodology, define phase is described in below. SIPOC diagram is one of the statistical methods used give brief information about flow of process.

SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
ADOR	Welding Electrode	SMAW	Good Quality Electrode	Sulzer India Pvt. Ltd
fabrication shop	Welder & Machines	Welding	Defect Free Weld	NDT
QC & NDT	Operators & Machines	NDT Techniques	Evaluation (no. of defects)	Fabrication Shop
Shop floor	Plan & Welder	Repair Welding	Repair Cleared Weld	Machine Shop

Fig 2 SIPOC Diagram

The below check list i.e Table no.1 contains data to determine the defects and to prepare plans to minimize these defects. And From the table No.2, it has been observed that incomplete welding defect and Undercut defecthas been totally minimized and other defects has been moderately minimized.

Table no.1 Check sheet data of three pipes

Sr no.	Defects	Quantity		
		Upper Pipe	Middle Pipe	Lower Pipe
1	Spatter	26	20	23
2	Weld Burn	22	16	19
3	Welding Incomplete	9	7	6
4	Welding Undercut	5	2	3
5	Blow Holes	3	2	1

Table no.2 Check sheet of no. of defects after six sigma implementations

Sr no.	Defects	Quantity		
		Upper Pipe	Middle Pipe	Lower Pipe
1	Spatter	9	10	7
2	Weld Burn	10	9	8
3	Welding Incomplete	0	0	0
4	Welding Undercut	0	0	0
5	Blow Holes	2	1	3

2.2 Measure Phase

Defects per million opportunities (DPMO) is the average number of defects per unit observed during an average production run divided by the number of opportunities to make a defect on the product under study during that run normalized to one million. Standard sigma performance level is shown in table 3.3.

Defects per Million Opportunities (DPMO) = *Total no. of samples found in sample* / Total no. of defects opportunities in a sample *x 1000*

The below table 3.4 shows the six-sigma level for each component as well as level of overall component.

Sigma performance levels – One to Six Sigma	
Sigma Level	**DMPO**
1	690000
2	308537
3	66807
4	6210
5	233
6	3.4

Table no.3 Standard sigma performance level

Sr. No.	Component	DPMO	Sigma Level
1	Upper Pipe	260000	2.127
2	Main Pipe	188000	2.315
3	Lower Pipe	208000	2.263
4	Overall	218667	2.371

Table no.4 Six sigma level for each component

2.3 Analyze Phase

This phase involves detailed examination to identify causes behind the defects. Table no.3.5 gives the process parameters that affect the occurrence of defects with their observed values. These values have been observed while analyzing the numbers of the defects in each component mentioned in the report. The paraments like Current, Voltage, Gas flow, Wire speed, Air pressure is observed while collecting the data for further process. Table No.5 Specifications of variable parameter.

Parameters	Specifications
Current	210 A
Voltage	30 V
Gas flow	8 lpm
Wire Speed	20 m/min
Air Pressure	4-5 kg/m2

Table no. 5 Specifications of variable parameters

Based on process observations cause and effect diagrams can be plotted as shown below. Cause and effect diagram are shown by Fishbone diagram for all types of the defects. This is the method that is used to address a problem or nonconformance, in order to get the root cause of the problem. It is used so we can correct or eliminate the cause and prevent from recurring. It isa separate process to incident management and immediate corrective action.

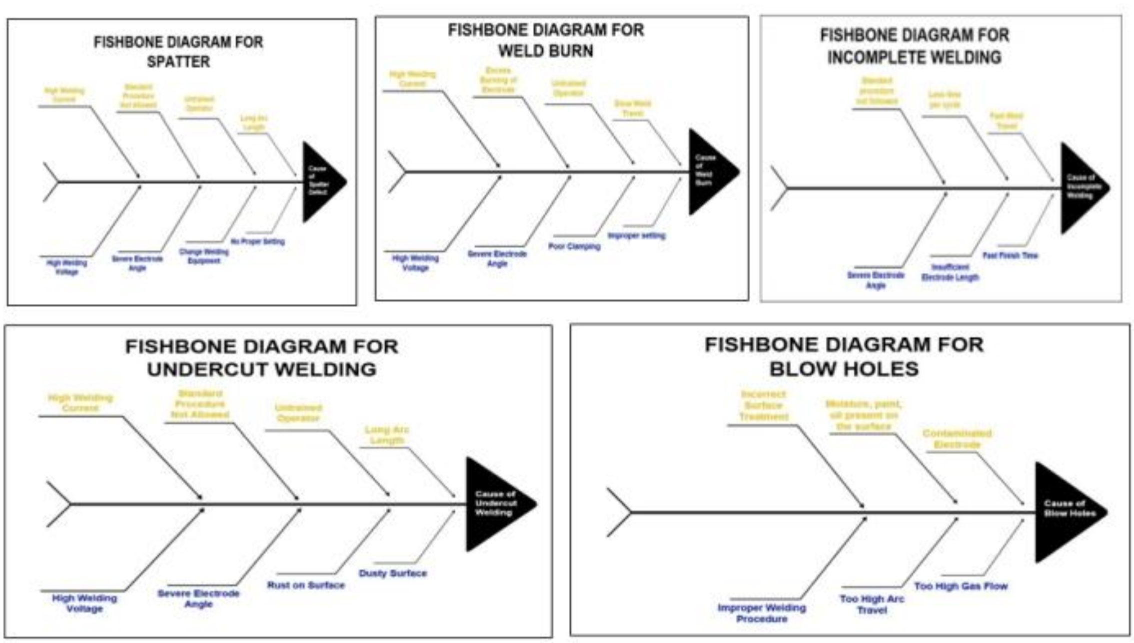

Fig No. 3 Fishbone Diagram for all defects

2.4 Improve Phase

The goal of this phase is to select problem solution, recognize the risk and implement selected solution. This phase focuses on fully understanding the top causes identified in the analyze phase, with the intent of either controlling those causes to achieve breakthrough performance. The observed values of process parameters were found to be improper for the manufacturing process. Further studies about defects revealed that the defects occurring during manufacturing can be minimized by changing the process parameters to some extents. Table no.6 gives the improved values of process parameters.

Parameters	Specifications
Current	165-185 A
Voltage	18-20 V
Gas flow	10-15 lpm
Wire Speed	8-15 m/min
Air Pressure	4-5 kg/m2

Table no. 6 Improved Range of processed parameters

2.5 Control Phase

The last phase of DMAIC rule is control phase, in which we ensure that the process continue to work well, produce desired output result and maintain quality levels. Controls are required to ensure that the improvements are maintained over time. This phase includes implementation andperiodic revaluation of changes made in process or process parameters. After changing the process parameters, the quantity of defects was reduced considerably as shown in Table no. 7

Sr no.	Defects	Quantity					
		Upper pipe		Middle Pipe		Lower Pipe	
		Before	After	Before	After	Before	After
1	Spatter	26	9	20	10	23	7
2	Weld Burn	22	10	16	9	19	8
3	Welding Incomplete	9	0	7	0	6	0
4	Welding Undercut	5	0	2	0	3	0
5	Blow Holes	3	2	2	1	1	1

Table no. 7 Quantity of defects before and after implementation of six sigma

3. Calculations and Result

Sigma levels for all components are found out using Table no. 3 by interpolation. Table no.8 gives previous and later values of DPMO and sigma level after application of six sigma tools.

Defects per Million Opportunities (DPMO)= $\dfrac{\textit{Total no. of samples found in sample}}{\text{Total no. of defects opportunities in a sample}}$ *x 1000*

3.1 DPMO of upper pipe:

DPMO(OBS) = (65*5/50) x 10000

DPMO(OBS) = 260000

3.2 Sigma level of Upper pipe:

$$\text{Sigma level} = SL2 - \frac{DPMO(2) - DPMO(OBS)}{DPMO(2) - DPMO(1)} \times (SL2 - SL1)$$

$$\text{Sigma Level} = 2 - \frac{308537 - 260000}{308537 - 6807} \times (2-3)$$

Sigma level = 2.1

Similarly, calculations are obtained for other components.

Sr. No.	Component	DPMO		Sigma Level	
		Before	After	Before	After
1	Upper Pipe	260000	84000	2.16	2.92
2	Main Pipe	188000	80000	2.32	2.95
3	Lower Pipe	208000	64000	2.26	3.04
4	Overall	218667	76000	2.37	2.96

Table no. 8 Result Table

Conclusion

From above report by changing process parameters the occurrence of defects in inspectedcomponents are minimized.

Operating parameters considered are:

- Welding current
- Voltage
- Welding speed
- Gas pressure

Thus, the overall sigma level of product was 2.37 which was increased to 2.97 due toimplementation of six sigma.

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