The Effects of Six Sigma on the Performance of Pipe Manufacturing In Hi-Tech Industries

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Abstract: The ability to identify the significant factors that affect productivity is very critical to estimate accurate productivity for fabrication process. A case study of Hi-Tech pipe manufacturing industry at Kotri site area, Sindh, Pakistan has been carried out to implement the Six Sigma DMAIC (Define Measure Analyze Improve and control) methodology to improve the quality of the product. The data reveals from the two cluster of pipes. The Non-Destructive Tests (NDTs) show that from a cluster of 100 pipes 19 were found defective and for another cluster of 100 pipes,14 pipes found defective and the nature of defects were burn through and incomplete fusion, pin holes, porosity, lack of penetration, undercut (U/C) and slag. To avoid from such loss in form of defects, Six Sigma has been implanted in the manufacturing environment to improve product quality. The study concentrates on the effect of Six Sigma on the manufacturing of pipe and after its implementation the quality of the welding has improved relatively. It is because the major welding defects i.e. Burn through, incomplete fusion and Porosity were not developed and only two undercuts found from each cluster of 100 pipes.

Keywords: *Six sigma, non-destructive testing, DMAIC, statistical process control, defect analysis.*

1. Introduction

Pipe manufacturing industry Hi-Tech was established in 2004 at Kotri site area, Sindh, Pakistan. The company started manufacturing of pipes and its accessories to meet the requirement of the local market. The pipes produced have outside diameter ranging from 8.628 inches (219 mm) to 54 inches (1626 mm). These are used for oil, gas, sewage and water. The type of welding being used is submerged Arc Welding (SMAW) process followed by approved welding procedure specification (WPS). In fabrication process, some welding defects are usually developed. A new innovative technique such as Six Sigma is a set of practices that improve the quality of the product and make the product almost defect free.

Motorola developed the set of practice i.e. Six Sigma .This technique removes the welding defects by improving the process and declare the defects as non-conformity or non-serviceable to its specifications. The significant approach of Six Sigma refers to a highly capable methodology that can serve as the perfect solution to enhance productivity. It can develop products as per specifications with minimum defect rate i.e. 3 to 4 per million opportunities. Therefore Six Sigma focuses on the improvement of all significant processes used in manufacturing operation and considers quality. Six Sigma brings rational cases of welding process into required Six Sigma limits that uses statistical analysis. [1]

DMAIC (Define Measure Analyze Improve and control) methodology provides a possible guidelines in manufacturing process that help to identify, quantify and remove in question causes in an working process to enhance the operation variables. Besides this, it also provides guidelines to design and develop a system. The basic factor of Six Sigma is DMAIC methodology to improve in a better way the working process eliminating the rate of defects in the final product. It has been studied that the DMAIC methodology implementation does not required expensive belt-based training of Six Sigma. The DMAIC approach utilized Six Sigma within the lean methodology to reduce welding defects in a turnaround industry, where the welding repair rate was reduced by more than 25%, because the welding process was improved. The Six sigma use the methodology of implementing TQM (Total Quality Management) has five phases i.e. Define, Measure, Analyze, Improve and Control. It has an innovative approach process for continuous improvement and is the prime component of TQM. Six Sigma DMAIC methodology implementing is a steering wheel in manufacturing plant to reduce weld defects, decreased rework from 16 to 5 percent and ensured the welding process within desired Six Sigma limit. The core idea of TQM was introduced in the mid of 1980 is known as system methodology that aid some value in design and improving organizational processes continuously that ultimately benefit to the customer. TQM has developed very fast owing to its strategic methodology in the last two decades to face the challenges of world competitive business almost in all manufacturing and service organizations. TQM process develop awareness to the end customer in quality/service in each phase of production and provides a new vision for management leader ship. The customer's role is pivotal in this system towards the product quality and customer satisfaction. All the researchers agreed that if TQM is fully integrated with a planning into business would be a useful philosophy for management that would help organization to deliver its goal, target and policies.[2-3]

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Six sigma is problem-solving tool and a set of techniques to discover enhancements with remarkable impacts on the bottom line results. For optimization of the SAW process Six Sigma DMAIC methodology was used where the Scrap cost was reduced to 100 %. [4] In case to get the benefit of Six Sigma throughout the entire company then it is necessary to establish the Six Sigma organizational support that would be the one of the essential factor and approach required to implement six Sigma. It is internationally believed that till today there is no theoretical approach has been developed to cope Six Sigma with its challenging effectively. TQM methodology is an innovative approach for quality improvement that possess the prime ingredients of Six Sigma and covers almost all of its elements of the business system of the company. The cost is saved by reducing variability in processes that is new emerging approach and has proved decrease in defects and increase in customer's satisfaction therefore Six Sigma is more attractive to industry and practitioners [5]. The Statistical Process Control (SPC) software is the supports approach to help organizations to get for their improvement. The Statistical Process Control is the most successful SPC software that use to record data and observe the uneven diameter during fit-up, e.g., a very high or low to be detected when occurs. Now when Six Sigma applied in the Hi-Tech pipe manufacturing, the quality of the pipes has improved and defects has been reduced to considered level and such improvement has been reported by Hi- Tech. [6-7].

2. Related Work

Six Sigma has positively impacts on the performance of the organization and mostly enhance the efficiency with defects free welding joints and there is no evidence that Six Sigma have a negatively impacts corporate performance that is why Six Sigma is called organized problem solving methodologies.[2-6].The productivity of the pipe spool and focused on the fabrication shop for effective scheduling. He developed genetic algorithm (GA) to enhance solution, used coding suitably represent a schedule for the fabrication shop. The designed algorithm was able to collect data that contain operation processing time taken from an industrial fabrication shop and in the result pipe spool productivity was increased by 88 percent in friction taper plug welding (FTPW) process In his investigation, he explored the use of improper welding parameter developing lack of connection and imperfect filling defects within the weld and identified the various [8]. Worked on automotive exhaust system welding assembly process and pointed out that when the improper parameters are used then numerous welding defects will occur that seriously affect the quality of product. After the experimental work, he observed that improper parameters influencing the welding process and concluded that touching the cutting edge significantly is due to the angle of torch and the key factors were welding speed and argon flow parameters., when implemented to control the welding assembly process of automobile exhaust system, the Six Sigma DMAIC methodology, and results indicate that big improvement found in biting edge defects per million opportunities (DPMO) became less and controlled which is much better as raised from 3.55σ to 4.52σ about the level of product quality and the effectiveness of the enterprise had enhanced due to the efficient DMAIC methodology of the Six Sigma.[9] One study established that Six sigma technique that eliminates problems to measure and identify the nonconformance through destructive testing, improves the process yield performance of the critical operational process and when compare to DMAIC methodology of Six Sigma observed that DMAIC methodology, identifies the root causes of failure for a welding process, decreases variations maintains consistent quality of the process output at a manufacturing plant and leading to better utilization of resources.[10] One of the case study about the quality productivity in a manufacturing enterprise and used Six Sigma DMAIC methodologies specially optimize the operation variables to improve the quality performance. Six sigma is a unique driven methodology that closely fulfill the requirement of the customer needs, It is found that diligent attention managing to improve and reinventing business processes. Many factors that affect the process of pipe spool fabrication and develop a simulation model capable to examine the factors affecting the fabrication process and productivity and based on the result incorporated various methods and measured the diameter of the each spool. The combined method that can be implemented separately for better estimation of the productivity. The effects of lean production and Six Sigma for competitive sustainable advantage (SCA). The welding was carried out on 3 mm thick 304 stainless steel welding with arc travel speed 700-1230 mm/min. The HAZ zone more hardness found in the weldment and that may be due to grain refinement. It was further observed that higher tensile strength found by using a non-pulsed current weldments. The construction equipment by using (DFSS) design for Six Sigma assessing the quality. The advanced joining methods and techniques of welding in the manufacturing process found economically useful and sustainable remain highly imperative as in the metal industry welding is one of the most common joining methods used. During fabrication of pipes some welding defects develop such as porosity, lack of penetration, lack fusion, burn through, pin hole and under cuts etc, identified through Non Destructive Test (NDT).The research aim is to rectify the welding defects in Hi-Tech Pipe industry through six sigma technology to achieve the aim for that following objectives have been set. [11-15]

3. Methodology

Hi tech industry is manufacturing a steel pipes with wide range of pipe diameters. These pipes are long, hollow and use for a variety of purposes. It is then made into a pipe by stretching the steel out into by forcing to bring their edges together and sealing them with a weld. The bevel angles and the root gap are very important base on the material thickness and depend upon the processes used to make the joint as shown in Fig. 2.1.

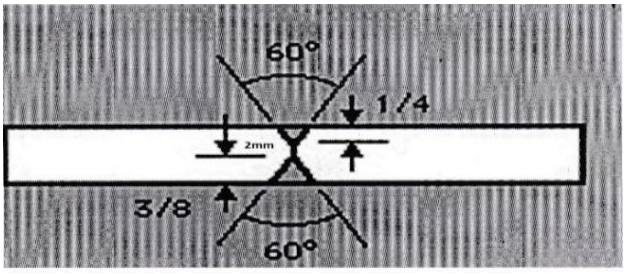

Figure 3.1 Double V-groove section

A risk of welding defects increases if a bevel angle is narrow because less weld metal deposit that is more economical but downside to this is the narrower angle having very less access therefor difficult to weld therefore the risk of welding defects as mentioned would develop and incase of bevel angle too wide root gap because of a loss of control of the weld pool melt and weld defects would develop. So the pipe circumference and bevel design is very important. Pipe Specifications data collected from pipes I to 100 for both ends .i.e. lower circumference (LCL) and upper circumference (UCL) The Table 4.1 and Table 4.2 shows the data of pipes from 1 to 100 of pipe end circumference. The pipe circumferences varies from 1014 mm to 1021 before the alignment whereas the actual nominal circumference is shall be 1017 mm. It is observed that misalignment make the centerline offset therefore in the results weld joints become offset of spherical shell and cylindrical shells. Therefore spiral pipe welding begins with precision welding heads is cost effective ways. Weld setup is required for the accuracy of the joint to be welded, so Hi Tech spiral pipe welding maintained the bevel angle 60° included 1mm to 2 mm root gap.

The Statistical Process Control (SPC) software has been used for process variation to check low and random joints hundred percent. This software using the data collected before the welding. It provides quality control applying data trending, tolerance and sequential analysis. This system collects the data of the parameter of the sample and calculates the mean, standard deviation, and range. The changes are displayed by using the charts that shows the weld record for single weld, weld number i.e. multiple welds. The SPC tools also provides tolerance chart plotted against the record number of welds and that comprises of the upper control limit (UCL), lower control limit (LCL) and nominal value of the pipe diameter during the fit-up and displayed with tolerance on chart.

After metal prepared ready for welding the time begins to weld. SMAW welding machine was turned on and the controller automatically controlled the mechanism of rate of an electrode feed and where as an AC servomotor adjusting the current for the molting part of the electrode against the unwanted current fluctuation of the arc length during welding operation this would reduce the lack of fusion defect. The figure 2.1 depicts causes of defects in weld joint.

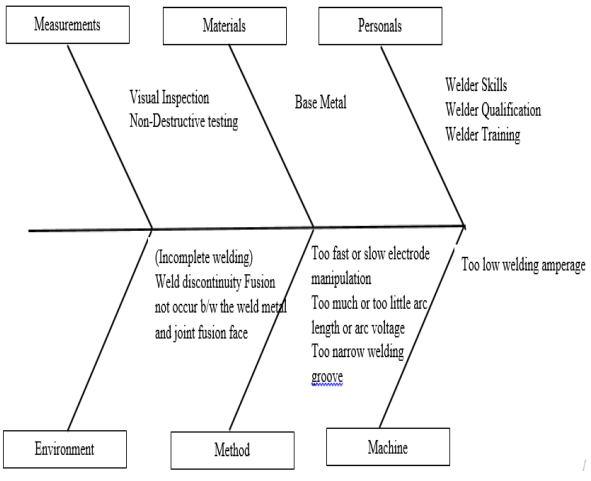

Figure 3.2 causes of weld defects

4. Results and Discussion

The research work was carried out with modern quality improvement methodology to improve the pipe manufacturing quality by using the SIX Sigma DMAIC methodology. The implementation has been made right from the fit-up to the welding and testing that has been discussed as under.

After using the Six Sigma DMAIC methodology the major welding defects like Porosity, Lack of penetration,

Burn through and Pinhole were completely eliminated to zero level only in 02 pipes having a undercut that is within the limit of standard API 5L B grades as shown in Fig. 6.1 and Table 6.2

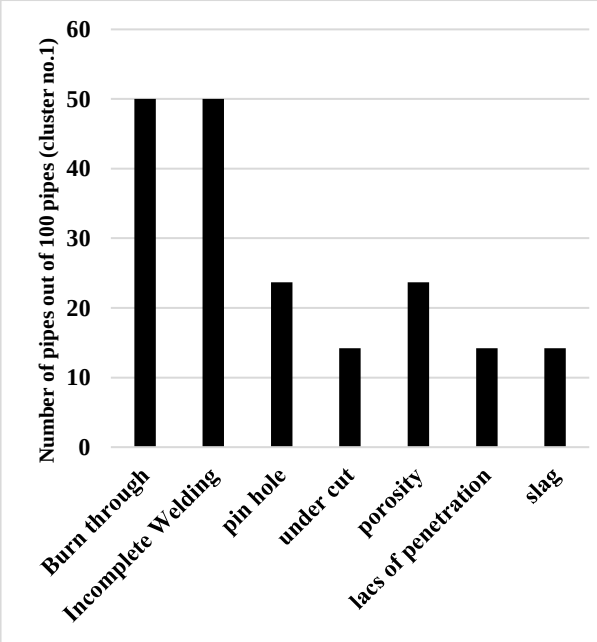

Figure 4.1 Welding defects before -application of Six Sigma

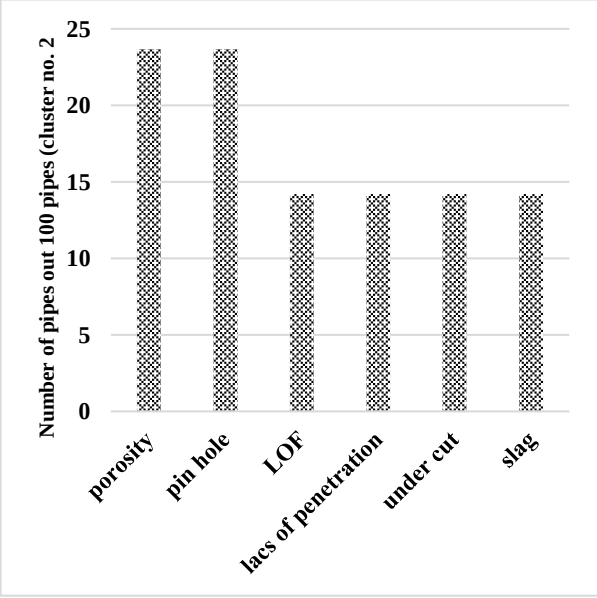

Figure 4.2 Welding defects before application of Six Sigma

This welding defect was developed on the surface of the weld of the base metal but away from the weld zone. The root cause of the defect was the arc length/ arc voltage were fluctuated that must be within the range i.e.at 450 to 500 amps; 28 to 32volts in DC mode.

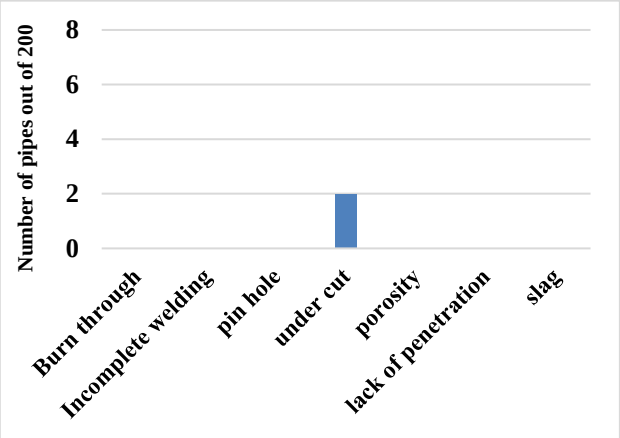

Fig. 4.3: Welding defects of after using Six Sigma DMAIC Methodology

5. Conclusion

The basic issue identified was the joint preparation mismatched i.e. low and high in pipe circumference, that issue has been resolved by using Statistical Process Control (SPC) software. The welding defects has reduced to a considerable level that would ultimately reduce the repair cost and to eliminate the scrap cost, so to implement Six Sigma system will pay back for a long run. Implementing Six Sigma, DMAIC methodology the Hi-tech pipe manufacturing industry has acknowledged the improvement in quality, enhanced the confidence of the customer's fulfilment, adherence to delivery schedules. For further research work there is a possibility in the organization to compromise in achieving the breakthrough in their process.

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