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Research Article

Assessment of Machining and Assembly Activities Performance in a Local Subsea Production System

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Abstract

The cost of running operations and executing project in developing country is high partly due to wastes that could be eliminated through effective implementation of quality tools. There are layers of wastes that increases time required to execute tasks from tender stage to contract acquisition. The study covered specific improvement initiatives implemented in a local Oil and Gas Project. It covered activities in fabrication and assembly plants in one of the under developed country. There were visits and interactions with staff of the organizations in the area where operational and project data was collected and also review their existing method in use. A data collection plan was developed in conjunction with checklist to guide the process. Both documents were designed so that the personnel responding to questions were able to identify specific issues encountered in their operations, the type of quality intervention applied and the results of the intervention. Quality review processes were initiated to resolve the problems identified. Root Cause Analysis (RCA) was performed by utilizing the "5 Why Analysis" Root Cause Method. The findings revealed that, there is significant relationship between quality intervention and project execution leading to an overall reduction in waste and thus improving compliance products and services, customer satisfaction and profitability. The involvement and commitment of top management is essential for the intervention to be successful. Hence, the study further reveals that the tools of Quality can be adapted to the Local environment and implemented. Finally, the study demonstrated that quality intervention can be used to solve the problems highlighted.

Keywords: *Quality, Waste, Fabrication, Assembly, Maintenance, Manufacturing.*

1. Introduction

In production operations, quality plays a significant role in achieving the overall objective of the enterprise. Quality is not just a requirement to fulfil contractual and statutory obligations; it is a means of reducing waste and eliminating the huge cost associated with nonconforming process and outputs (Ahire and O'Shaughnessy, 1998), (Godfrey, 1993). In Nigeria, the rigorous application of quality tools is more pronounced in the oil and gas industry. Quality management has emerged as a management paradigm for enhancing organizational effectiveness and competitiveness. Several empirical studies suggest that firms achieve higher levels of profitability and organizational performance through successful implementation of quality management (Powell, 1995), (ABD.Hakim, 1997). A misconception exists in project management in that quality is only applicable during the manufacture and installation of hardware. This is incorrect since comprehensive quality management in projects includes the entire development process and is inclusive of all disciplines during the project study and execution phases (Rao, *et al*, 1999) , (Jan, *et al* 2015).
Quality management in projects spans the entire project management function, the manufacturing and execution processes and includes quality assurance, quality control and quality costing. Effective quality in projects can only be achieved by addressing all these elements. Due to the significant differences in terms of construct development and research methodology, research in quality management has produced mixed results. For example, process management programs appear to improve profitability in the auto industry while they deteriorate profitability in the computer industry (Ittner and Larcker, 1997), (Hackman and Wageman, 1995).

Furthermore, operationalizing quality management as single or multiple constructs, measuring performance in one level or multiple levels, and differences in data analysis techniques have contributed to producing mixed results in the relationship between quality management and firm performance (Kaynak, 2003), (Punter and Gangneux, 1998).However, there are other factors that have had a great impact on producing mixed results. Researchers

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have utilized different theoretical frameworks for understanding the effect of quality management on firm performance. It is what to know that, some have focused on the viewpoint of the pioneers of quality management and have framed their model on the perspective of founders of quality management (Rungtusanatham, *et al*, 2005), most recent studies have employed the Baldrige criteria as the reference model for quality management (Lee, *et al*, 2006), (Bou-Llusar, *et al*, 2009). In addition, there is not much consistency in the selection of industries as the research context. While some have focused on manufacturing firms (Lascelles and Dale, 1989), there are some studies where firms in different industries have been mixed (Flynn, *et al*, 1994). It has been shown that contextual variables such as the industry structure and competition affect the strategic planning of quality of firms (Zhao, *et al*, 2004). Differences in theoretical framework and industry selection as well as differences in construct development have resulted in mixed and somewhat confusing results in the effect of quality management on firm performance. It has been suggested that more industry-specific and cross-cultural research in quality management is needed to validate the effect of quality management on firm performance. Industry-specific studies help us to better understand the determinants of performance (Garvin, 1988). Quality assurance ensures that the quality of the product or service meets and exceeds the customer's requirements, whereas quality control is a methodology for ensuring that the quality requirements of the project, including testing and other verification systems, have been implemented and are effective. Effective quality management in projects requires that all quality prerequisites and controls are included in the project, from concept to execution, commissioning close out and that quality is customized to meet the project requirements. An essential component of good operations management and project execution is the usage of quality intervention to identify, assess and mitigate risks associated with poor or weak quality system. A robust quality system consists of quality assurance and control. Quality assurance defines the level of quality required for project implementation, and the process to be followed to achieve it. A good quality assurance plan will also define the method to measure compliance with the project's quality requirements. Mistakes are bound to occur occasionally; a good quality assurance systemwill filter out mistakes to ensure an accurate output (Asian Development Bank, 2012).

2. Methodology

2.1 Materials and Methods

There were visits and interactions with staff of the organizations in the Local area in developing country where operational and project data was collected and to also review their existing method in use. As the entire organization operational and project process could not be reviewed for the reason of time and resources under this study, area of concentration was identified by scoping which resulted into focusing data collection in the area of Machining and Assembly activities. The location covered was Subsea Equipment Assembly Plant located in the Oil and Gas area of the country. A data collection plan as shown in Table 1 was developed in conjunction with checklist in Table 2 to guide the process. Both documents were formulated so that the personnel responding to questions were able to identify specific issues encountered in their operations, the type of quality intervention applied and the results of the intervention. The reliability of the information provided was verified during interview by reviewing the data directly from the organization Enterprise Resource Planning tool (ERP). Pareto and Run Charts were employed to analyse the data. Quality review processes were initiated to resolve the problems identified. Root Cause Analysis (RCA) was performed to review and analyse available data in other to understand and advice on the true cause of any issue that occurred. "5 Why Analysis" root cause method was employed. The 5 Whys is a technique used in the Analyse phase of the Six Sigma DMAIC (Define, Measure, Analyse, Improve, Control) methodology. By repeatedly asking the question "Why" (five is a good rule of thumb), the layers of symptoms were peeled away leading to revelation of the root cause of the problems (Zu, *et al*, 2008).

Table 1 Data Collection Plan Sample

DATA COLLECTION PLAN

Process Name: Machining and Assembly activities

	A. Identify	
1	What variable will be measured? (Output or Inputs) ?	The Outputs.
2	Which requirement(s) will be compared against performance standards ?	All of them.
3	Why were these requirements chosen?	All of them have the same level of importance to keep the process working well.
	B. Count	
4	Who will be responsible for data collection?	Process Operator -
5	How will the data be collected?	Every first week of the month from SAP system.
6	Who should be responsible for taking action based on the	All as assigned by the manager or supervisor
	C. Communicate	
7	What kind of chart will be used and how will it be labeled?	The process operator will generate an excel chart with all datas necessaries.
8	Who will be responsible for recording	The process operator.
9	Who routinely needs to be aware of the data?	(internal and external customers) and the process owner
10	How will the information be communicated to those identified above?	Every first week of the month the operator inform all customers about the new update of capacity chart avilable on the net.
	D. Conclude	
11	What new information is gathered from the Run and Pareto Charts?	The actions had been taken and the problems had been controlled.
12	What are the next steps?	Keep the process under control

Table 2 Checklist Sample

Measurement Checksheet

Process Name: Machining and Assembly activities

	Requirements	Nonconformances					Required Actions to Address Nonconformances
		Period 1	Period 2	Period 3	Period 4	Period 5	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
	Total Nonconformances						
	Total sample						
	Nonconformance Rate						

2.2. Machining and Assembly Activities

2.2.1 Machining Activities and Problems

Machining activities of the organization and its subcontractors includes machining of actuator valve component,Machining of Christmas Trees (XT) frames and various componentsMachining of Well-Head preparation for Welding. The tools used in these machining activities include; horizontal boring machine and Computer Numerical Controlled Lathe machines. The reviews were carried out on the entire machining process which focused on the following sections: Receiving material Traceability process and Quality Control Check Communication during work stage. Numerous problems are associated with any form of manufacturing process, as moving equipment operated by humans is prone to known and unknown failures.

The following machining related problems were observed in the workshop over a period of five months.

- Different formats and lack equipment information were noticed in the reviewed inspection reports.
- Faulty tools were used in welding repair due to over machining of some of the receiving materials.
- A Poor inspection plan which did not indicate which stages of production quality control check would be performed was in use in the workshop resulting in numerous machining errors.
- The quality control personnel were not familiar with the inspection requirements.
- It was observed that there were no proper records of inspection/observation reports during audit.
- Poor communication between production team/engineers/machinist resulted in the many machining errors especially - thread error, false cut and outside diameter error.

The summary of the overall resultant effect of the major issues identified above during the study resulted in the various defects manifested as captured in the Table 3 and Figure 1 respectfully.

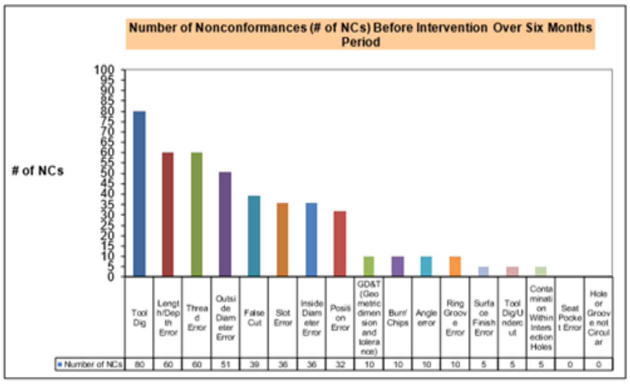

Fig.1 Machining activities Frequency failure chart before intervention

Table 3 Machining activities Non-conformance before Intervention

Measurement Checksheet

Process Name:		Machining and Assembly activities				
Requirements		Nonconformances Before Intervention				
		Period 1	Period 2	Period 3	Period 4	Period 5
1	Tool Dig	15	14	12	20	15
2	Length/Depth Error	15	11	12	14	10
3	Thread Error	15	11	12	14	10
4	Outside Diameter Error	11	9	8	12	11
5	False Cut	8	7	9	7	8
6	Slot Error	7	7	6	8	8
7	Inside Diameter Error	8	6	8	7	7
8	Position Error	6	7	9	5	5
9	GD&T (Geometric dimension and tolerance)	2	2	2	2	2
10	Burr/Chips	2	2	2	2	2
11	Angle error	2	2	2	2	2
12	Ring Groove Error	2	2	2	2	2
13	Surface Finish Error	1	1	1	1	1
14	Tool Dig/Undercut	1	1	1	1	1
15	Contamination Within Intersection Holes	1	1	1	1	1
16	Seat Pocket Error	0	0	0	0	0
17	Hole or Groove not Circular	0	0	0	0	0
	Total Nonconformances	96	83	87	98	85
	Total sample	600	600	600	600	600
	Nonconformance Rate	16%	14%	15%	16%	14%
Notes:						

2.3 Assembly Activities and Problems.

The preparation for the start of Modular Christmas Tree (XT) assembly process in the Workshop area was originally planned to mirror the processes in a develop country for the assembling and testing. The inspection and test plan (ITP) that was used in the develop country plant and all intervention points were to be mirrored in the case studied area. A review of the welders' performance was carried out in relation to the requirements of the Inspection and Test Plan that requires creation of Quality Notice (QN) and approval by the customer (CPY) for every defecting small bore tubing weld before repairs could commence. Creation of quality notification (QN) and client approval was required based on the agreed inspection and test plan (ITP) for every nonconforming small bore tubing weld before repairs could commence. The administrative process of QN creation and approval became a bottle neck that caused major delays. As shown in Figure 3 on welders performance chart, this was causing a major challenge to the uptime of the production line as some of the welders were having significant rate of rejection in the welding of small bore pipes leading to a minimum down time of one day for each weld failure encountered. A one day down time has significant cost and schedule impact.An analysis of each welder's performance over a period was performed. A threshold of rejection rates was established and agreed between both parties. Welders Weld repairs captured by QNs were stopped and replaced with welders repair rate that did not require approval process from CPY. Welder 4 was then selected based on the performance shown in figure 2

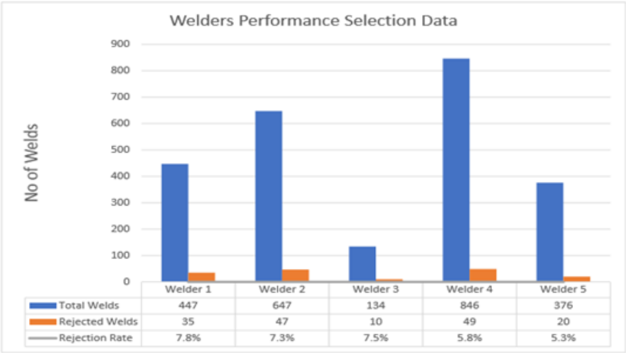

Fig. 2 Welders Performance Chart

The outcome of the root cause analysis carried out were used to develop improvement plans which were implemented in the areas of focus of this study. Data collection on the effect of the implementation was carried out over a period of time and analyzed. There was general improvement in the output of the process unlike what was happening before the quality intervention shown in Tables 3 and Figures 1 and 2 where the rate of rejection over each period was consistently high. In the run chat of Figure 3 the reduced rate of rejection within the periods monitored is consistence and sustained. The rate of rejection dropped from average of 15% to less than 1% after the quality intervention.

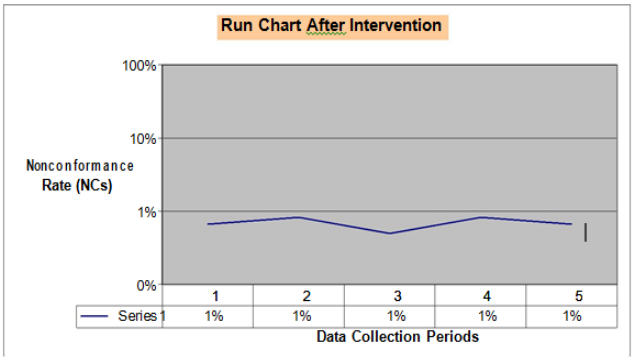

Fig. 3 Outcome of Quality Intervention on Machining

The systemic failure and breakdown of the quality process linked to weak traceability, poor inspection plan and breakdown in communication between production team was adequately addressed by the improvement plan implemented as captured in Table 4. Communication improved between Engineering, Production team and the Machinist. Inspection checks at various stages also improved. Personnel are now consistently inspecting and approving each stage of work. Inspection reports are regularly updated with the necessary information and all QC personnel were familiar with its contents. The issue of defective tool was addressed by replacing machine tools/bits. The post intervention analyses showed that the performance of the welder that was selected based on the improvement plan led to reduce down time in the shop floor. This new system allows focus on tracking the welder performance and that led to a consistent high production rate and low rate of rejection as shown in Figure 5.

Table 4 Post intervention rejection rate on Machining and Assembly Activities

		Measurement Checksheet				
	Process Name:	Machining and Assembly activities				
	Requirements	After Intervention				
		1/0 Period 1	1/0 Period 2	1/0 Period 3	1/0 Period 4	1/0 Period 5
1	Tool Dig	2	1	1	1	2
2	Length/Depth Error	0	1	0	1	0
3	Thread Error	1	1	1	1	0
4	Outside Diameter Error	0	1	1	1	1
5	False Cut	1	1	0	1	1
6	Slot Error	0	0	0	0	0
7	Inside Diameter Error	0	0	0	0	0
8	Position Error	0	0	0	0	0
9	GD&T (Geometric dimension and tolerance)	0	0	0	0	0
10	Burr/Chips	0	0	0	0	0
11	Angle error	0	0	0	0	0
12	Ring Groove Error	0	0	0	0	0
13	Surface Finish Error	0	0	0	0	0
14	Tool Dig/Undercut	0	0	0	0	0
15	Contamination Within Intersection Holes	0	0	0	0	0
16	Seat Pocket Error	0	0	0	0	0
17	Hole or Groove not Circular	0	0	0	0	0
	Total Conformances	4	5	3	5	4
	Total sample	600	600	600	600	600
	Conformance Rate	1%	1%	1%	1%	1%

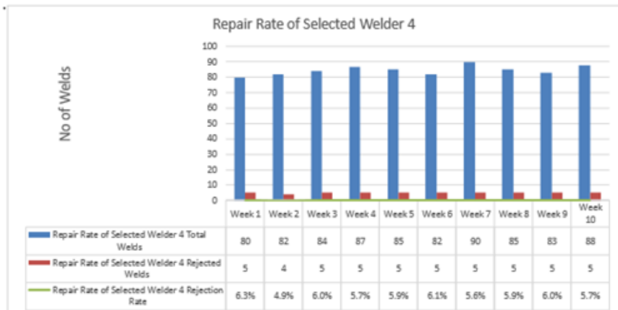

Fig. 5 Repair rate for Selected Welder 4

Conclusions

The outcome of the analysis carried out confirmed that there is significant relationship between quality intervention and project execution leading to an overall reduction in waste and thus improving compliance products and services, customer satisfaction and profitability. The study reveals that the tools of Quality can be adapted to the Nigerian environment and implemented. The involvement and commitment of top management is essential for the intervention to be successful. Also, the notion that it costs a lot of money to implement good quality measures can be seen not to be true using the simple tools applied in the study.

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