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Process Quality Analysis Using Statistical Process Control Tool: A Case Study

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A B S T R A C T

Ensuring that product/service meets customer's expectation and desired specification is important for any business growth and sustainability. In the light of this, continuous review of performance whether it corresponds with actual goals is pertinent, quality control and improvement is a relevant measure for achieving this. In this research, the statistical process control (SPC) tool-control chart was used to evaluate the performance of gas lift valves (GLV) in production wells to determine the nature of variability in the process. Data of the test rack opening pressure (TRO) of five different wells specified as A-E were collected and analysed using the mean control chart. Wells A-D was out of statistical control, only Well E was observed to be in a state of statistical control. The wide spread in the variation of the points in the plot for Wells A-E is an indication of special and common cause variation in the process which can be addressed by monitoring closely the valve calibration operation. That is, regular inspection of the machine against aging and wrong calibration and also proper orientation of operators on calibration procedures and techniques.

Keywords: Quality, Quality control, Statistical Process Control, Control Charts, Mean of mean

1. Introduction

Owing to the recent outbreak in technology and industrialization, leading to a competitive market, every industry needs to introduce quality standards and imbibe the culture; device ways for evaluating actual performance relative to set goals and regularly upgrade and improve the quality of their product or service. This will enable them survive and be among the best of the best in the market and maintain desired level of quality. Quality is the extent to which a particular product or service satisfies the expectation of the customers [3]. It also measures the degree of excellence when applied to manufactured product [2].

In order to achieve the desired level of quality in product and service delivery, one has to systematically control the factors that affect the quality of the product or service such as materials, tools, machine, type of labour, working condition etc. The regulatory process through which actual performance is measured and compared with set standards is called quality control (QC). QC aims at prevention of defect from the source and relies on effective feedback system and corrective actions. According to ANSI/ASQ standards (1778) it is an operational techniques and activities that sustains the quality of the product that will satisfy given needs. It works hand in hand with Quality Improvement (QI) which methodologically attacks all waste and non-value adding operations in the process. QC and QI can be achieved through the use of statistical process control (SPC) tools. They are used to compare the output of the process or a service with the standard and taking remedial actions in case of discrepancy between them. This research aims to evaluate the process quality of an industry's service delivery to verify whether the outcome meets the desired specifications and understudy the level of variability in the process. The variability study was conducted using the mean statistical process control (SPC) tool. Several works have been conducted regarding the use of SPC in quality control, [1] applied statistical tools to improve quality in a service sector and discovered that quality control and improvement should be understood as an all-encompassing deliberate application of the statistical tools, simple or more complex with the goal of achieving product and process quality. [4] applied quality tool in improving product quality, the SPC was performed at pre-production stage in a mass production process on only one of the component that presented higher percentage of non-conformity over time. The result showed that the process was no longer capable requiring process improvement activities, [5] used seven basic quality control tools to significantly improve the monthly defect of local plastic injection molding company from 13.49% to 7.4%, Cost effective problem solving tool was recommended for the company.

2. Research Design

2.1 Description of Study Area

The study was conducted in the Artificial Lift Segment of an oil servicing company in Trans- Amadi Industrial area of Rivers State, Port Harcourt, Artificial Lift solution employs down-hole lift mechanisms such as the gas lift in monitoring a well to optimize production performance additional equipment are installed in the well to lift the fluid to the surface other than the natural drive. During this process, energy is transferred down hole to provide the well with sufficient pressure to lift the reservoir fluid to the surface. The gas lift mechanism entails the continuous injection of high pressure gas to supplement the reservoir energy (continuous flow) or by ejecting gas beneath accumulated liquid slug for a short time to move the slug to the surface The injected gas moves the fluid to the surface by: reducing the fluid pressure on formation because of decrease fluid density; expansion of the injected gas and displacing the fluid as the case may be.. The major equipment for this operation is the retrievable gas lift mandrels, valves and pop joints which come in different sizes and types. The mandrels sizes are: $3\frac{1}{2}''$ KPMG, $4\frac{1}{2}''$ KPMG, $5\frac{1}{2}''$ KPMG, $3\frac{1}{2}''$ KPMM, $4\frac{1}{2}''$ KPMM, $5\frac{1}{2}''$ KPMM while the valves are of two major types: Live and Orifice valves and their size depends on the seat and stem. They are: $\frac{\,}{4}''$, $\frac{1}{8}''$, $\frac{5}{16}''$, $\frac{13}{16}''$ etc. The equipment is prepared in the blue base based on design requirements. Some of the equipment preparations are: flushing of the mandrel, loading of the valve, pre-test, buckling, final test, valve calibration and redress and QA/QC. If any of these processes is not properly carried out there will be bottle neck due to backtracking of materials and discontinuous flow.

2.2 Research Methodology

Data of five different wells were collected to examine the Test Rack Opening (TRO) pressure of the valves at the wells. The data were used to analyses the variation of the Pressure at the wells in order to determine the valve consistency and mandrel performance during production. The Pressure readings were analyzed using the Statistical process control chart: Mean (X) chart. The chart has a line down on the centre representing the average, upper control limit (UCL) and the lower control limit (LCL). If all data values fall within the UCL and LCL the system is said to be in a state of statistical control. Equations 1-3 give the formula for the mean, mean of mean, UCL and LCL.

The examination was conducted for 30 days and the sample size of 4 was used for the analysis. The range for Well A was gotten as 5.13 while the UCL and LCL approximately 1519.15 and 1511.66 respectively, the corresponding mean of mean for that well was 1515.4. For well B, the range was 3.9, while the UCL and LCL were 1557.72 and 1554.88 respectively. The corresponding mean of mean was 1554.88. The range computed for the sample analysis of well C was 6.27. The UCL and LCL were gotten as 1539.25 and 1530.12 respectively while the mean of mean was 1534.68. Well D recorded a range value of approximately 11.56, an UCL and LCL of about 1488.60 and 1481.22 respectively with a mean of mean of 1484.90. The last well E, when observed gave a range reading of about 5.0, an UCL and LCL of 1558.61 and 1551.31 respectively and a mean of mean of 1554.96. The value for A_2 was read from the control chart table shown in table 1

Fig1: X-chart for well A

$$\bar{R} = \frac{\sum_{i=1}^{m} R}{m} \quad (1)$$

$$\bar{\bar{X}} = \frac{\sum_{i=1}^{m} \bar{X}}{m} \quad (2)$$

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} \quad (3)$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R} \quad (4)$$

$\bar{R}$= Range

$\bar{X}$ = Mean value

$UCL_{\bar{X}}$ = Upper control limit

$LCL_{\bar{X}}$ = Lower control limit

A_2 is the control chart factor

The data analysis of the valve performance for a period of approximately one month is shown in Fig 1 – Fig 5. The calculation for the UCL and LCL for well A is given below:

$\bar{R} = \frac{154}{30}$=5.133

$\bar{\bar{X}} = \frac{45642.25}{30} = 1515.41$

$UCL_{\bar{X}} = 1515.40 + 0.729(5.133) = 1519.15$

$LCL_{\bar{X}} = 1515.40 - 0.729(5.133) = 1511.66$

For Well B the calculations are given below:

$\bar{R} = \frac{177}{30}$=3.9

$\bar{\bar{X}} = \frac{46648.25}{30} = 1554.88$

$UCL_{\bar{X}} = 1554.88 + 0.729(3.9) = 1555.72$

$LCL_{\bar{X}} = 1554.88 - 0.729(3.9) = 1552.03$

For well C the calculations are given below:

$\bar{R} = \frac{188}{30}$=6.26

$\bar{\bar{X}} = \frac{46040.5}{30} = 1534.68$

$UCL_{\bar{X}} = 1534.68 + 0.729(6.26) = 1539.25$

$LCL_{\bar{X}} = 1534.68 - 0.729(6.26) = 1530.12$

For well D the calculations are given below:

$\bar{R} = \frac{152}{30}$=5.07

$\bar{\bar{X}} = \frac{44547.25}{30} = 1484.90$

$UCL_{\bar{X}} = 1484.90 + 0.729(5.07) = 1488.60$

$LCL_{\bar{X}} = 1484.90 - 0.729(5.07) = 1481.21$

For Well E the calculations are given below:

$\bar{R} = \frac{150}{30}$=5.0

$\bar{\bar{X}} = \frac{46648.75}{30} = 1554.96$

$UCL_{\bar{X}} = 1554.96 + 0.729(5.07) = 1558.61$

$LCL_{\bar{X}} = 1554.96 - 0.729(5.07) = 1551.31$

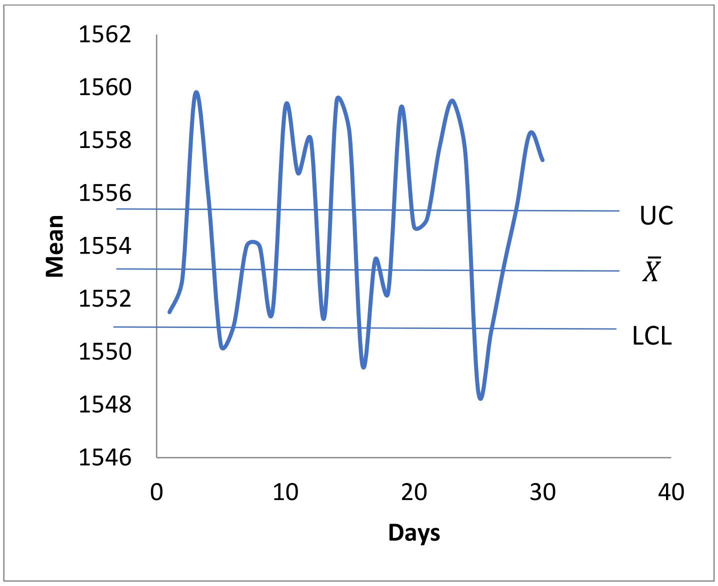

Fig 2: X-chart for well B

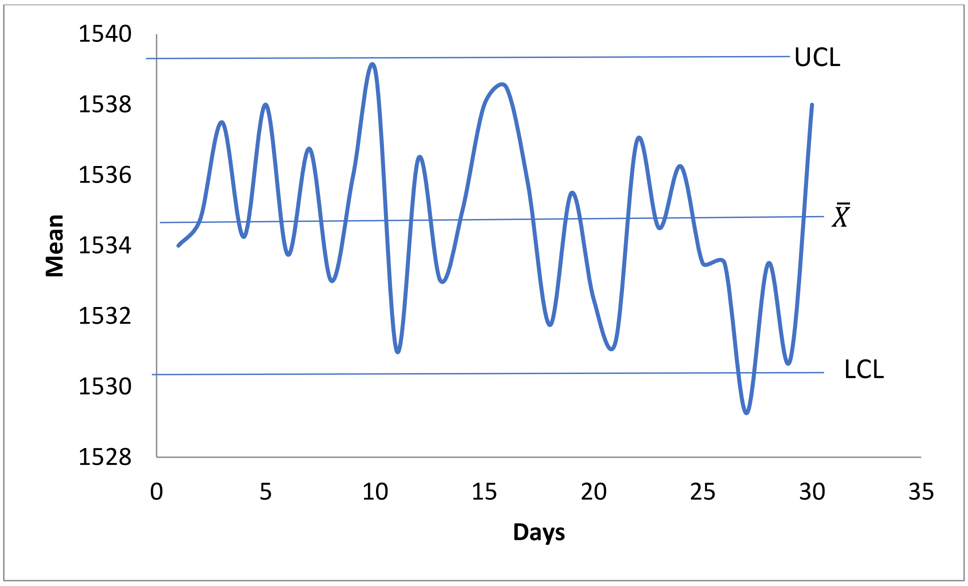

Fig 3: X-chart for well C

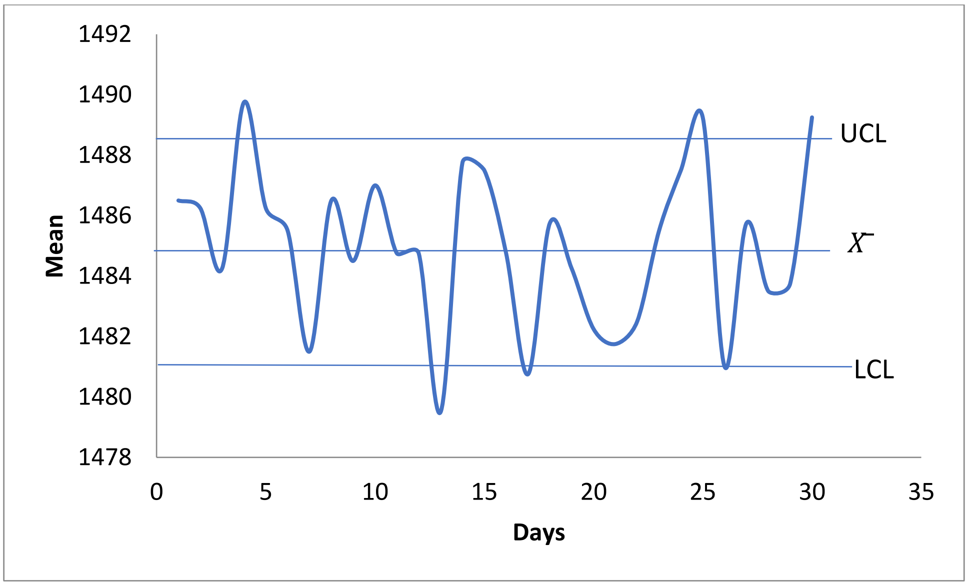

Fig 4: X-chart for well D

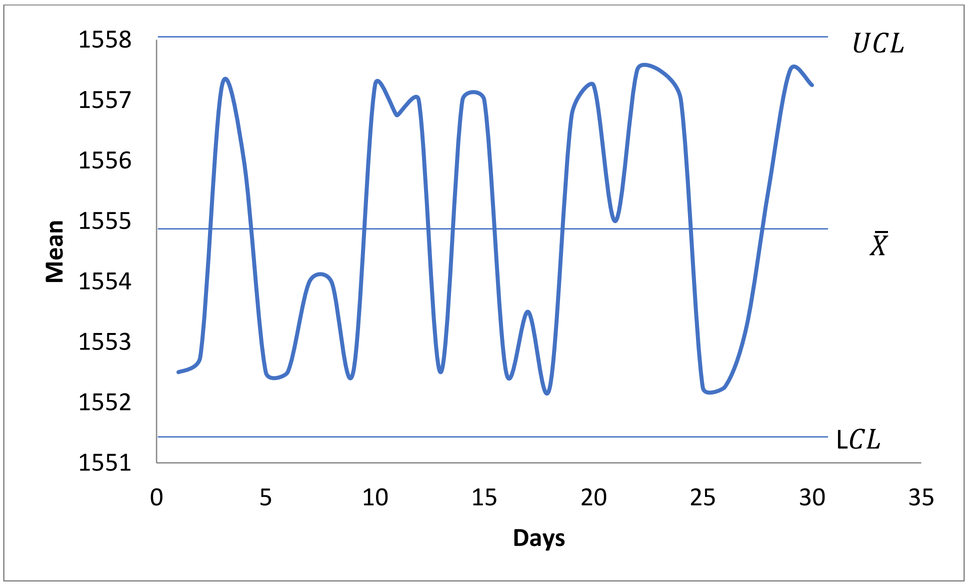

Fig 5: X-chart for well E

3. Results and Discussion

The plot of Fig 1 shows that a point fell below the LCL which is an indication that the system is out of statistical control. For the second well reading, about 5 points are within the control limit; the remaining points are outside the control limits implying an out of control system.

The result from the plot from well C shows that only a point fell below the LCL. In the case of well D, three points fell below the upper control limit as well as the lower control limit. Well E, had a peculiar case in which all points are within the upper and lower control limit indicating a case of statistical process control.

4. Conclusion

The result of the five plots shows that four out of the five Wells observed are out of statistical control only one is in control. Causes of the variability of the process can further be analyzed using the cause an effect diagram. Close examination of the overall process such as equipment, materials and operators involved in the process would be helpful in detecting and tackling the areas of bottleneck in the operations and aid in reduction/elimination of variability in the process thereby increasing service quality delivery.

] Table 1: Control chart Factors

Subgroup Size (n)	LCL_R Factor (D_3)	UCL_R Factor (D_4)	CL_X Factor (A_2)	R: σ Ratio (d_2)
2	0	3.326	1.88	1.128
3	0	2.575	1.023	1.683
4	0	2.282	0.729	2.059
5	0	2.115	0.577	2.326
6	0	2.004	0.483	2.534
7	0.076	1.924	0.419	2.704
8	0.136	1.864	0.373	2.847
9	0.184	1.816	0.337	2.97
10	0.232	1.177	0.308	3.078
11	0.256	1.744	0.285	3.173
12	0.284	1.716	0.266	3.258
13	0.308	1.692	0.246	3.336
14	0.326	1.671	0.235	3.407
15	0.348	1.652	0.223	3.472
16	0.364	1.636	0.212	3.532

References

1. Orgragenrek, I (2002): " Applying statistical tools to improve in the service sector " Anuska Feligoj and Andrej mrvan. Fdv
2. Sanders, R and others (2011):" Operations management". An integrated approach. 4th Edition. John Wiley and Sons, Incorporated.
3. Slack, N. (2010): Operations management". Pitman Publishing Inpront. 8th edition.
4. Seigio S.. Nuno R,. usebio N., (2017): "Application of SPC and quality tools for process improvement", 27th international conference on flexibility, automation and intelligent manufacturing ; 27-310 June . motem Italy.
5. Jofi M., Roho C. K., (2001): "Improving quality with basic Statistical Process control Tool: A case Study" Journal Technology 5(A) 21-34. Universiti Teknologi, Malaysia.

6. [Abdul T. B., Daiyanni D., (2010) “Time motion study in determination of time standard for manpower process” 3rd Engineering Conference on advancement in Mechanical and manufacturing for sustainable environment.Kuching Sarawak. Vol 14

7. Kowalik K., Klimecka-Tatar D. Brozova S. (2018) “Service quality model based on the 4Q‟s model and the system approach to service quality‟‟‟, in Proceedings of the 2nd International Conference: Contemporary Issues in Theory and Practice of Management, pp. 236-243.

8. Dorota K., Kamila K., (2020): “Analysis and Evaluation of service quality, quality improvement-A case study‟ Research gate, 2(9) pp 92-102.

9. Pedro H. A., Jose S. (2018) “Time and motion study applied to a production line of organic lenses in Manuas Industral Hub”

10. Pedro H. A and Jose S. (2018) Time and motion study applied to a production line of organic lenses in Manus Industria Hub” Gest Prod,Sao Carlos,25(2) pp 901-915.

11. Nishanth A.S.,Rao R.P.,Rajyalakshmi G.(2016)” Productivity Improvement Using Time Study Analysis in Small Scale Solar Appliances Industry-A Case Study.ARPN Journal of Engineering and Applied Science, Vol 11, pp 1.

12. Cengiz D.,Ayse C.,Yunus E.A.,(2018): „ Productiviy Improvement by wrk and time study techniques for earth energy-glass manufacturing company‟.4th World Conference on Business, Economics and Management, WCBEM.

13. Keshavarz Y., Jamshidi D., (2018) “Service quality evaluation and the mediating role of perceived value and customer satisfaction in customer loyalty‟‟‟ International Journal of Tourism Cities, vol. 4(2) pp. 220-244.

14. Solimun, Fernandes A., (2018) ,“The mediation effect of customer satisfaction in the relationship between service quality, service orientation, and marketing mix strategy to customer loyalty‟‟‟ Journal of Management Development, vol. 37(1), pp. 76-8

15. Kowalik K., Klimecka-Tatar D. Brozova S., (2018), “Service quality model based on the 4Q‟s model and the system approach to service quality‟‟‟, in Proceedings of the 2nd International Conference: Contemporary Issues in Theory and Practice of Management, pp. 236-243.

16. Cavallone M., Magno F., Zucchi A., (2017),“Improving service quality in healthcare organizations through geomarketing statistical tools‟‟‟ The TQM Journal, vol. 29, no 5, pp. 690-704, Jun. 2017.

17. Rocha J., Pinto A., Batista M., Simpson J., Ambrosano G., (2017),“The importance of the evaluation of expectations and perceptions to improve the dental service quality” International Journal of Health Care Quality Assurance, vol. 30, no. 6, pp. 567576.

18. Pakdil F., Kurtulmusoglu F. (2018), “Quality improvement initiatives based on customer and service provider perspectives in shopping malls” International Journal of Quality and Service Sciences, vol. 10(2) pp.176-195.

19. Kowalik K., Klimecka-Tatar D.,(2017), “Identification of main areas of customer service process improving in the cinema” Archiwum Wiedzy Inżynierskiej, vol. 2(1) pp. 42-44.

20. Izadi A., Jahani Y., Rafiei S., Masoud A., Vali L., (2017)“Evaluating health service quality: using importance performance analysis” International Journal of Health Care Quality Assurance, vol. 30(7), pp. 656-663.

21. Arbore A., Bussaca B.,(2011) “Rejuvenating importanceperformance analysis” Journal of Service Management, vol. 22(3) pp. 409-429.

22. Ingaldi M.(2018) “Overview of the main methods of service quality analysis” Production Engineering Archives, vol. 18, pp. 54-59.

23. Nakhai B., Neves J.,(2009) “The challenges of Six Sigma in improving service quality” International Journal of Quality&Reliability Management, vol. 26, no. 7, pp. 663-683. [19] Hensley R..L., Dobbie K., (2005),“Assesing Readiness for six sigma in service setting” Managing Service Quality, vol. 15(1) pp. 82