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Enhancement of Quality Performance of Machine and Efficiency by Six Sigma Quality Tool through DMAIC Approach in ASQ Standards

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Abstract:- Now a days, industries need to increase the quality of machine performance in order to meet the market demand and voice of customer, otherwise the industry will lose the customers which in turn results in losing their business. This can be achieved by reducing the variations in the process by reducing the variations in the machine defects will be minimized. This paper deals with the reduction of variations in the machine with the application of six sigma tool that manufacturing of a bush(455530) component fixing between two possible moving parts which is used in vehicle suspension, to connect the various moving arms& pivot points to the chassis. DMAIC methodology is used in the industry to reach the goal. In define phase according to voice of customer the CTQ parameter has been identified and data regarding critical to quality being collected and visualized statistically in the measure phase through capability charts in Minitab software, Prior to the data collection, a measurement system analysis &GR&R study is done to ensure that variations are due to the process but not due to person or instrument while recording the data, the cause of variations in the process like tool length over hanging ,proper inserting of component and some more are identified by ishikawa diagram in the analyze phase and the proposed changes are made which can be shown in Improve phase . By following the DMAIC approach, the capability indexes of Cp, Cpk values of outer diameter& inner diameter of bush(455550) are increased from different interval 0.39,0.14 to 1.28,0.41 0.56,0.43 to1.68,0.47 0.43,0.38 to 0.88,0.64 and 0.44,0.33 to 0.83,0.50 respectively after the implementation of outer diameter and also for inner dimeter 0.51,0.39 to1.57,0.38 0.57,0.57 to 1.03,0.49 0.56,0.25 to 1.16,0.28 and 0.57,0.53 to1.22,0.49 after implementation. The increase in the capability index values suggests that process variations are reduced and there by resulting in the improvement of machine quality and efficiency.

***Keywords**:- BUSH(455530), Bush(455550),CTQ, Measurement System Analysis, GR&R Study Cp, Cpk, DMAIC, Ishikawa Diagram, Capability Index Control Charts.*

I. INTRODUCTION

This paper represents the results that focused on Round components that are manufactured on cnc machine by using turning operations for 4 parameters which gives you a running performance of machine and efficiency by using statically tool called six sigma in which approach called DMAIC through which improving the sigma level previous level of company and present level of company through necessary improvements of a machine. Since last two decades, the companies have witnessed an increased pressure from customers and competitors for greater value from their purchase whether based on quality, faster delivery or lower cost in both manufacturing and service sector. This has encouraged many industries to adopt either six sigma as their process improvement and problem solving. Often high quality is referred to as fewer defects, fewer failures, fewer errors, lesser process variations. **“Six sigma is a well structured fact-based, data-driven philosophy of improvement that values defect prevention over defect detection. It carries customer satisfaction and bottom line results by reducing variation and waste thereby promoting a competitive advantage. It applies anywhere variation and waste exist, and every employee should be involved”**.(T.M.Kubaik Donald W.Benbow, 2009 pp:7). Six sigma is a quality tool for process improvement program in any organization. It aims to reduce defects up to 3.4 parts per million opportunities. If the processes were improved so that the degree of variation for this particular variable halved, the specifications would now be Six Sigma from the centre line. The specifications remain unchanged, as does the distance between the centre line and the specifications. However, because the degree of variation in the data has been halved, so too has the standard deviation. Six Sigma’s aim is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting based on there by increasing the productivity it can reduce the other defects like Improving process, Lowering Defects, Reducing process variability Reducing Costs &Increased Profits.

A wide range of companies have found that when the six sigma philosophy is fully embraced, the enterprise thrives. What is the Six Sigma philosophy? Several definitions have been proposed , with the following:

Use of teams that are assigned well defined projects that have direct impact on the organization's bottom line.

Training in statically thinking at all levels and providing key people with extensive training in advanced statistics and project management these key people are designated "Black Belts".

Emphasis on the DMAIC approach to problem solving :define, measure, analyze, improve, and control. A management environment that supports these initiatives as a business strategy.

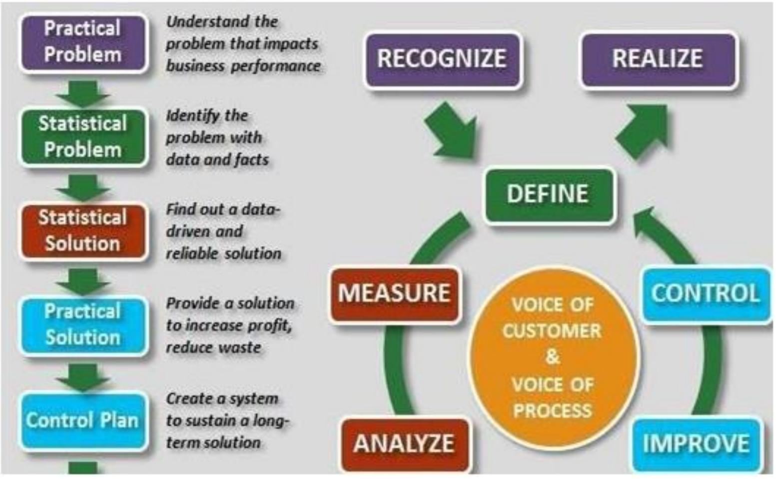
Six sigma is likely to remain as one of the major initiatives to improve the management process than just being remembered as one of the trend. The primary focus should be on improving overall management performance , not just pinpointing and counting the defects. Most of the researchers and practitioners are trying to integrate six sigma with other existing innovative management practices that have been around to make six sigma method even more attractive to different organizations that might have not started or fully implemented the six sigma method. Integrating and comparing principles and characteristics of six sigma with T.Q.M, Human resource functions, ISO9000, ISO9001, And the capability model are all part of quality community's effort to maximize the positive effect of six sigma method.

II. LITERATURE REVIEW

Six Sigma is a concept that has objectives to improve quality, reduce Processing time and reduce production cost. Six Sigma, on the Other hand, offers fewer standard solutions but provides a general analytic framework for problem solving and an organizational infrastructure. Today six sigma is the most important technology for quality aspects. Most of the people apply six sigma on two perspectives that are statistical view point and business view point. In statistical point of view, it is defined as 3.4 defects per million opportunities or a success rate of 99.997% where it represents the variation in the process average(Antony and Banuelas,2002). Whereas for the business point of view it is defined as the 'business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customers needs and expectations(Antony and Banuelas,2001). The six sigma approach was first applied in manufacturing operations and rapidly expanded to different functional areas such as marketing, engineering, purchasing, servicing, and administrative support, once organization realized the benefits. Six sigma have been applied in other organizations like General Electric, Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instrument, Sony and Motorola etc. The first company who applied six sigma concept by the Motorola organization in 1980s to enhance the quality improvement, as a part of quality performance and improvement of program. In any business, Customers are the main important factor that measures the success of business. Retention and loyalty towards the customers is the thing that shows the level of customer's satisfaction. In many businesses, Customers are dissatisfied towards the quality issues and employee attitude. The Company may not know that they have a dissatisfied customer. By implementing Six Sigma in the business, the chance of having dissatisfied customers is very less. As the Six Sigma process looks over the quality issues and considers the voice of customer. Implementing six sigma results in an efficient business helps the employees to manage their time effectively and makes the employees more productive. The main important things required for time management are learning, performing and fulfillment. In the area of learning, the main question is how often the interruptions deviate the worker from the task and how many interruption require his attention. In the area of performance, as the workers perform the task, they will come to know how the practices they were using are being helpful to them in reaching their professional goals and they can create an action plan. The result of this will be efficient and the employees are happier in themselves having better work life balance. By following the learning and performance tasks employee will be able to achieve the desired, promised and predicted results. In most of the times in many companies we observe that they extend their deadlines often because of the changes in project scope or shift in management policy. By implementing Six Sigma in any business a team of well experienced employees from all levels of the organization and from every functional department are developed. These teams work on identifying the factors that leads the project to long cycles. The same team is asked to find solutions to these problems. This method allows the business to reduce the cycle time and create a shorter cycle times. All the employees working follow the fixed schedule given by the task members after finding the problem and solving it. For working on Six Sigma the main aim of it is to have a defect rate less than 3.4 million and the supplies should have influence on whether the target is met or not. One of the best ways to reduce the defect rate is to implement Six Sigma to decrease the number of supplies your business have. The original task of six sigma's DMAIC methodology is process variation reduction. It has also been used for quality improvement, efficiency improvement, cost reduction, bottom line results, N.V.A and other fields in operations.

III. METHODOLOGY

This section explain the methodology adopted from the six sigma tool which the approach taken is DMAIC in which it explains about the details so called define, measure, analyze, improve and control based on the phases the investigation will be conducted. In the define the problem was identified from data it was statically collected and created the project charter then problem was explained in this gr&r study was conducted for equipment variation, appraisal variation, part variation and total variation then process capability was checked for Cp and CPK levels. In the analyze from the root cause we identified what are critical to the variation and needs to the improvement conducted after that paired t-test was conducted for hypothesis testing was done is there significance difference. In the improve from the root cause analysis necessary improvements were done then conducted again process capability whether the variation has changed based on the necessary improvements for CP and Cpk and then control trough the control charts whether the machine process variation is stability then we can see that sigma level before implementation of six sigma after implementation of six sigma differ the level of sigma.



DMAIC DIAGRAM

IV. EXPEREMENTATION AND RESULTS

Define – The present study focus on the process performance of the Jobber elite J300 LM machine based on the collection of data and there is a process variation in machine this tell you the effectiveness and efficiency of the machine through machining of component of bush (455530) component fixing between two possible moving parts which is used in vehicle suspension, to connect the various moving arms& pivot points to the chassis and moreover the Cp and Cpk is low.

Project title	**Enhancement of quality through DMAIC for precise machines**
Define of project	**Based on the spcification the tolerance is specified but Cp& Cpk is low due to the process variation in machining**
Critical to quality	**Process variation in the machine for bush(455530) in outer diameter& inner diameter**
Project scope	**Process variation and machining variation**
Team member	**Planning manager, maintenance engineer, senior engineer, machine operator.**
Expected customer benefits	**Quality & delivery**

Table1: project charter

Supplier	**UNIPARTS, Manufacturing shops , own parts**
Input	**Pins, Bushes, Shafts, Hitch plates, P.L.T Plates, pin keyed**
Process	**Band saw machine, CNC lathe machine, vertical milling machine, Stamping, oiling,**
	cleaning, &Packaging
Output	**Finished products pins, bushes, shafts, &bushes64**
Customer	**Inspection& testing, vendors, external customer, internal customer**

Table2: SIPOC Table

- **MEASURE:**

The most suitable tool which is measured in the measure phase is data collection and prior to measurement system analysis is conducted which is nothing to prove the data collected is accurate and can be reliable. In this phase we collected the data of bush for 10 samples at regular interval, 5interval, 10interval,and 15interval for four parameters like inner diameter, outer diameter, length, &chamfer length for the bush(455530) on CNC machine which is measured with micrometer and Vernier calipers.

- **MEASUREMENT SYSTEM ANALYSIS**:

In this we performed GR&R Study with ANOVA method and checked the equipment variation, operator variation, part to part variation, Total GR&R and total variation for four parameters for Bush(455530).

- *GR&R STUDY:*

The objective of gage R&R(GRR) study is to regulate (determine) whether measurement system is as per the requirement of the product as per the customer need. In a GRR study, a gage is used to obtain repeated measurements on selected parts by several operators to understand the system variability in terms of repeatability and reproducibility. Repeatability measures the variability when the gage is used to measure the same part by the same operator and reproducibility measures variability from different operators measuring the same part. The variability in the measurement system arises mainly due to (i) the components (ii) the operators taking the measurements and (iii) the devise used to take measurement. A measurement system is often treated as good if the entire variation presents only in the products. In the measurement system if the variation is present due to component or operators other than products, the system is invalid. The goal of GRR study is to capture the sources of variation and to examine and achievement of the measurement system fulfilment as per the requirements. The drawback of GRR study is it does not give the level of accuracy.

- *GRR Study methods:*

1 .Crossed gage R&R study:

In this each part is measured by each operator and each part is measured repeatedly by a specific number of times by each operator. It is used to study the amount of process variation is caused by measurement system variation.

Nested gage R&R study: In this each part is measured by single operator as the part is destroyed while doing the test. It is known as nested as another factor nest one or more factors and concluding not being crossed with the other factors.

3. Expanded gage R&R study: In this one or more factors will be considered, namely appraisals, number of instruments, and product. As the number of factors/ conditions in the measurement can be varied is called as expanded GRR study.

The sources of variation in the GR&R study: The variation in the gauge R&R study arises due to the following sources:

1. Repeatability & Reproducibility Error (R&R): The R&R error is the combined result of repeatability reproducibility error.
2. Reproducibility Error: Reproducibility error is caused when the reading of a part is not reproduced across operators or under different environmental conditions.
3. Part Variation Error (PV): It is the error coming from product chosen for measurement.
4. Total Variation (TV): it is the resultant of repeatability and reproducibility error (R&R) and part variation error (PV).
5. Equipment Variation (EV) Or Repeatability Error: When instrument is not having repeated reading of the product when same operators measure number of times in the same conditions of environment. It is also called Instrument error. In this study, GRR study is carried out using crossed method. Apart from other methods two-way ANOVA is used to understand sources of variation in measurement of the product attribute such as length, outer diameter, inner diameter etc The general statistical hypothesis under two-way AOVA with interaction and without interaction of each parameter in terms of products (items)and operators are as follows:

Ho : There is no significant difference in the average value of the parameter in terms of products (items)

H1 : There is a significant difference in the average value of the parameters in terms of products (items)
Ho : There is no significant difference in the average value of the parameter in terms measurement of operators.
H1 : There is a significant difference in the average value of the parameters in terms of measurement of operators.
Ho : There is no significant difference in the average value of the parameter due to the interaction of products and operators.
H1 : There is a significant difference in the average value of the parameters in due to the interaction of products and operators.

- *GR&R STUDY FOR OUTERDIA AT REGULAR INTERVAL:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). The output is given in following graphs and tables:

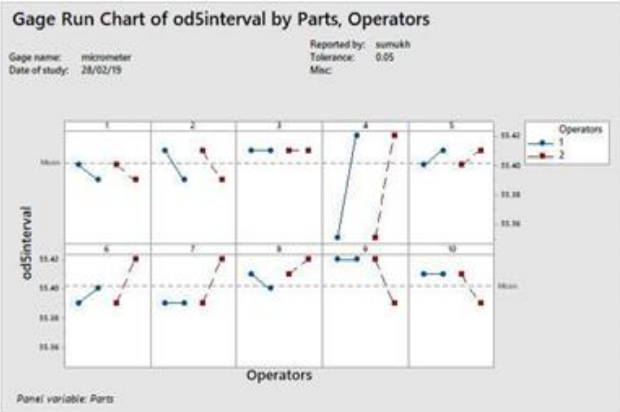


Figure1: Gage Run Chart for outer dia at regular interval by parts and operators

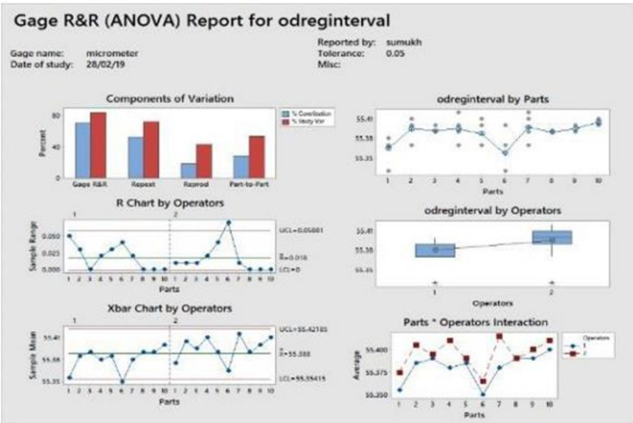


Figure2: Gage R&R (ANOVA) report for outer dia at regular interval

- *GR&R STUDY FOR OUTERDIA FOR INTERVAL of 5:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every fifth part in the production process is taken for measurement. The output is given in following graphs and tables.

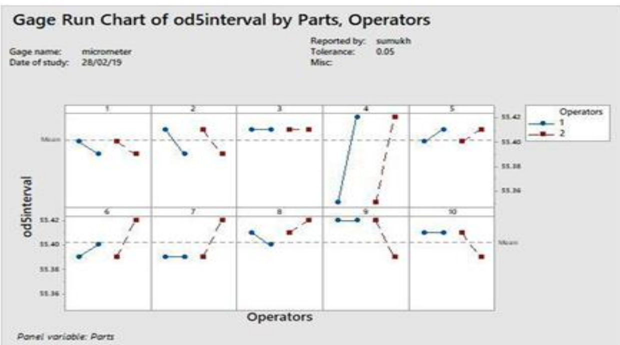


Figure 3: Gage Run Chart for outer dia at interval of 5 by parts and operators

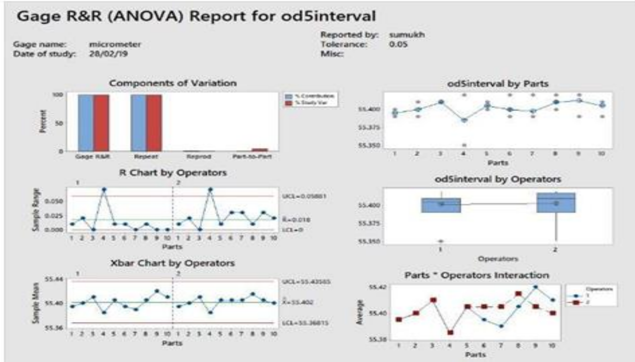


Figure4: Gage R&R (ANOVA) report for outer dia at interval of 5

- *GR&R STUDY FOR OUTER DIA AT INTERVAL of 10:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every tenth part in the production process is taken for measurement. The output is given in following graphs and tables:

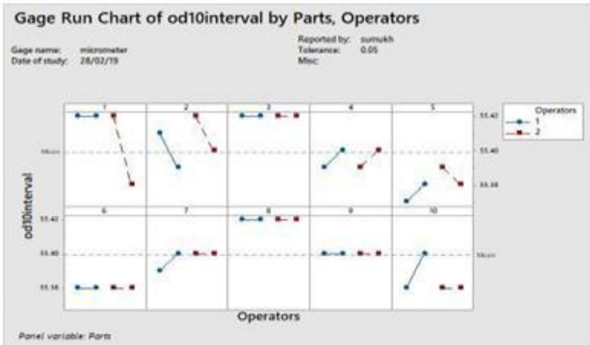


Figure5: Gage Run Chart for outer dia at interval of 10 by parts and operators

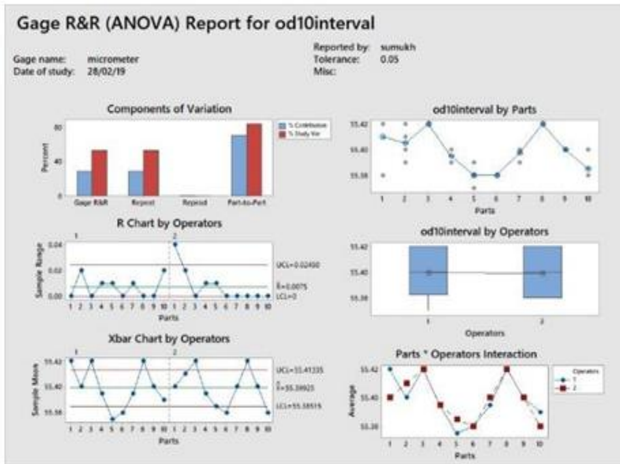


Figure 6: Gage R&R (ANOVA) report for outer dia at 10 interval

- *GR&R STUDY FOR OUTER DIA AT INTERVAL of 15:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every

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fifteenth part in the production process is taken for measurement. The output is given in following graphs and tables.

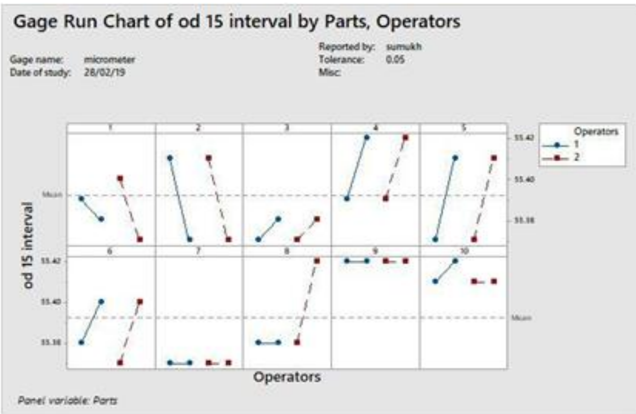

Figure7: Gage Run Chart for outer dia at interval of 15 by parts and operators

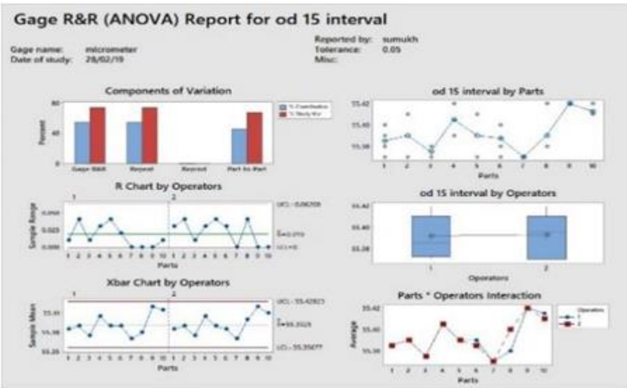

Figure8: Gage R&R (ANOVA) report for outer dia at interval of 15

➢ *GR&R STUDY FOR LENGTH AT REGULAR INTERVAL:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). The output is given in following graphs and tables:

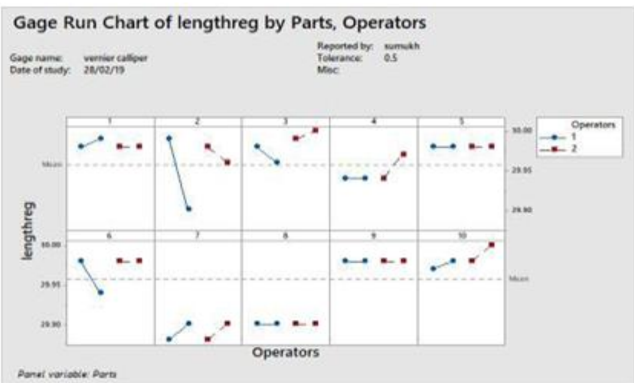

Figure9: Gage Run Chart for length at regular interval by parts and operators

➢ *GR&R STUDY FOR LENGTH AT INTERVAL of 5:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush

(455530). Every fifth part in the production process is taken for measurement. The output is given in following graphs and tables

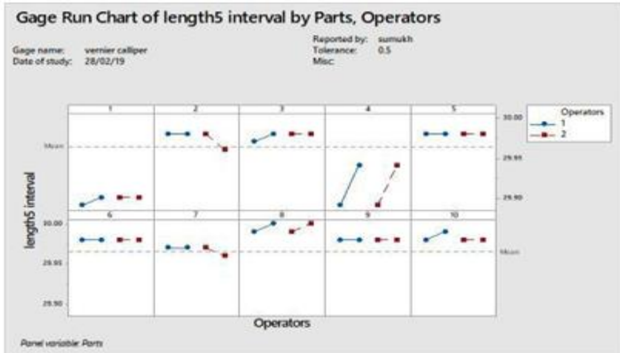

Figure 10: Gage R&R (ANOVA) report for length at regular interval

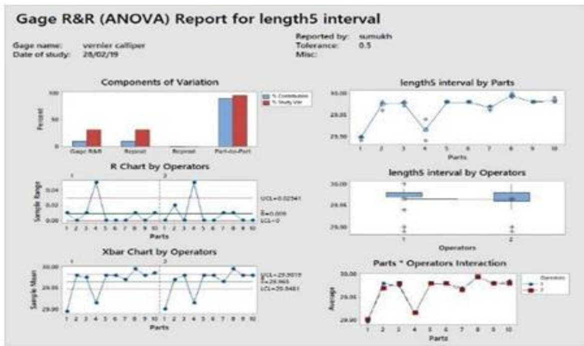

Figure11: Gage Run Chart for length at interval of 5 by parts and operator.

➢ *GR&R STUDY FOR LENGTH AT INTERVAL of 10:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every tenth part in the production process is taken for measurement. The output is given in following graphs and tables:

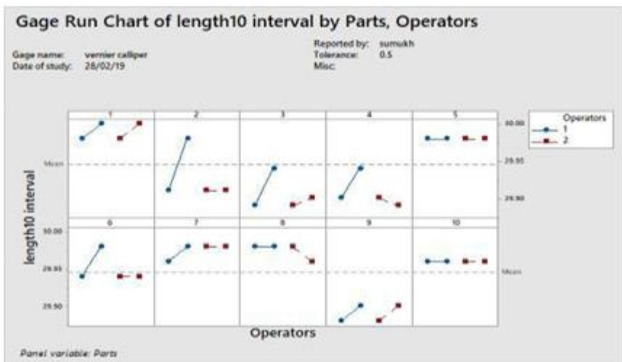

Figure 12: Gage R&R (ANOVA) report for length at interval of 5

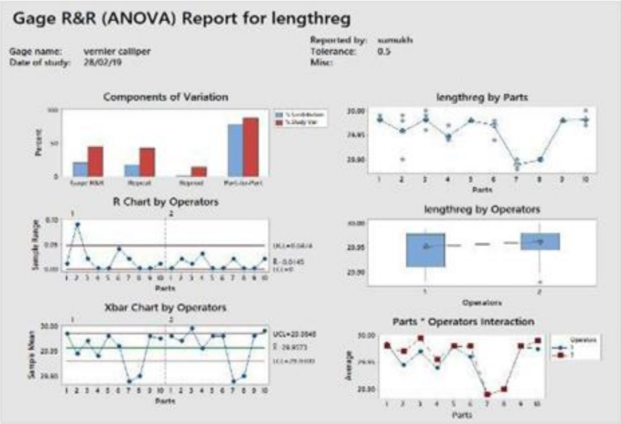

Figure 13: Gage Run Chart for length at interval of 10 by parts and operators

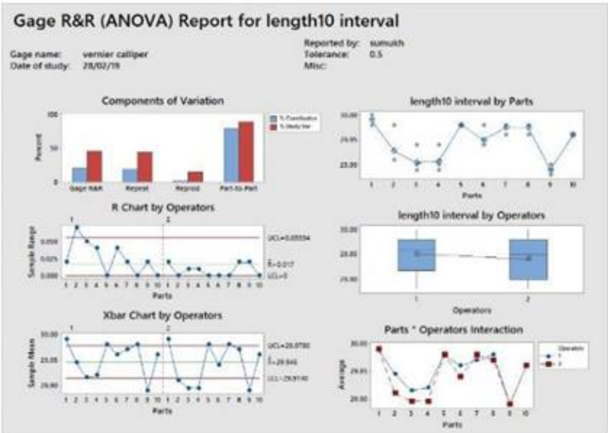

Figure 14: Gage R&R (ANOVA) report for length at interval of 10

➢ *GR&R STUDY FOR LENGTH AT INTERVAL of 15:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every fifteenth part in the production process is taken for measurement. The output is given in following graphs and tables:

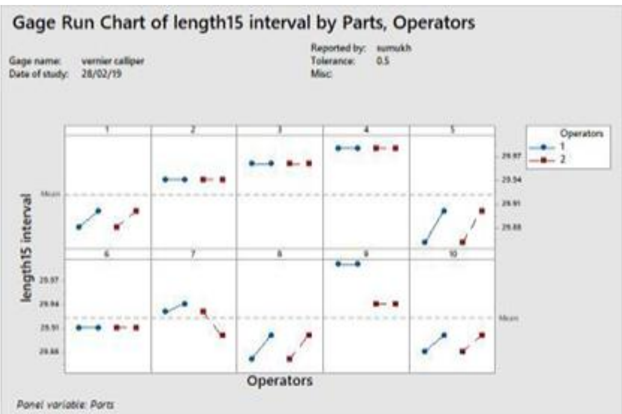

Figure 15: Gage Run Chart for length at interval of 15 by parts and operators

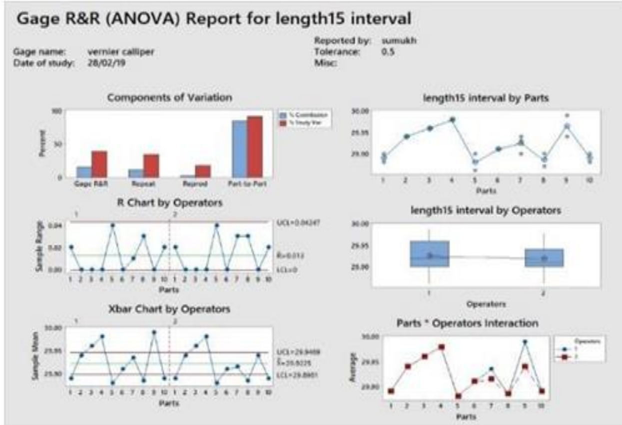

Figure 16: Gage R&R (ANOVA) report for length at interval of 15

➢ *GR&R STUDY FOR INNER DIA AT REGULAR INTERVAL:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). The output is given in following graphs and tables:

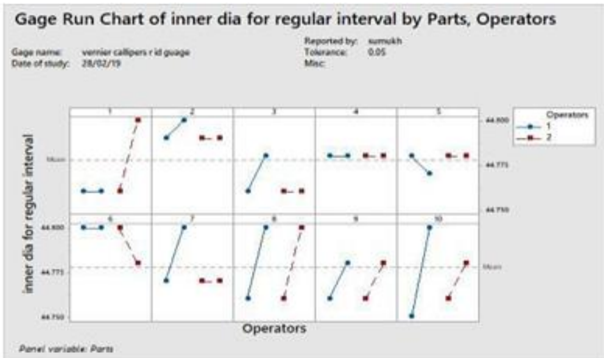

Figure 17: Gage Run Chart for inner dia at regular interval by parts and operators

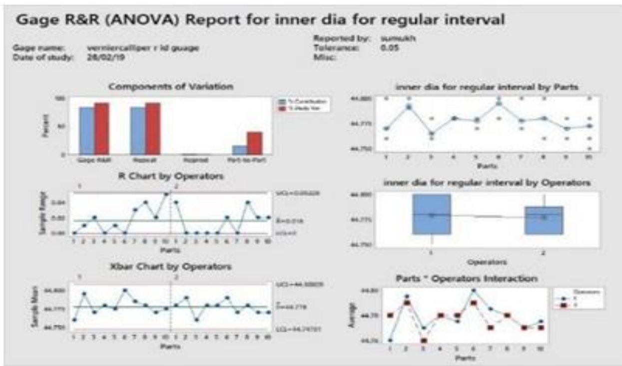

Figure 18: Gage R&R (ANOVA) report for inner dia at regular interval

➢ *GR&R STUDY FOR INNER DIA AT INTERVAL of 5:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every fifth part in the production process is taken for measurement. The output is given in following graphs and table

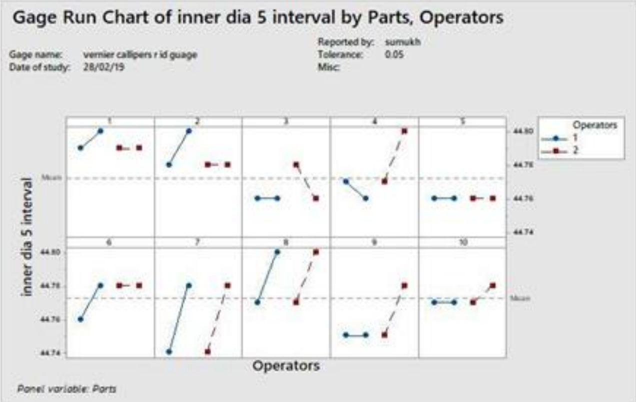

Figure 19 : Gage Run Chart for inner dia at regular interval by parts and operators

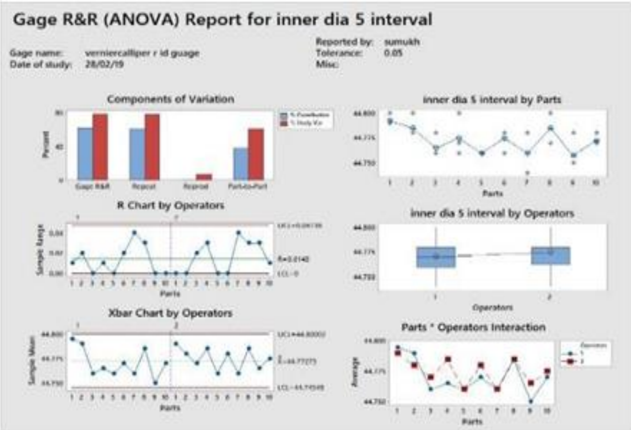

Figure20: Gage R&R (ANOVA) report for inner dia at interval of 5

➢ *GR&R STUDY FOR INNER DIA AT INTERVAL of 10:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every tenth part in the production process is taken for measurement. The output is given in following graphs and tables:

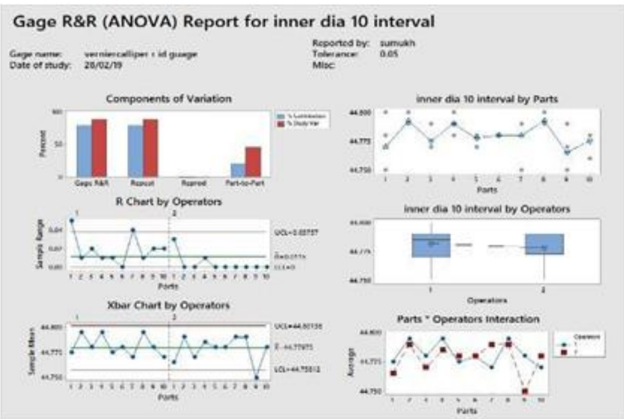

Figure 21: Gage Run Chart for inner dia at 10interval of parts and operators

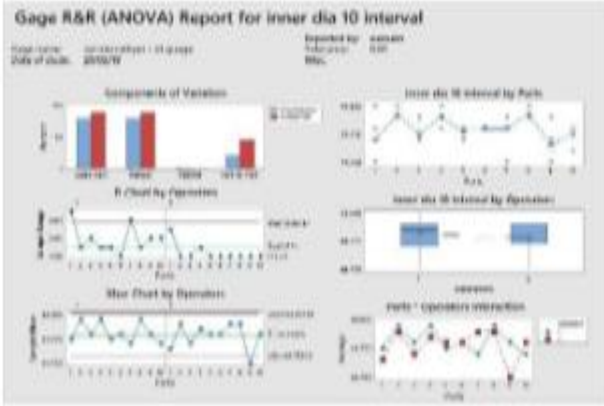

Figure 22: Gage R&R (ANOVA) report for inner dia at 10 interval

➢ *GR&R STUDY FOR INNER DIA AT INTERVAL of 15:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every fifteenth part in the production process is taken for measurement. The output is given in following graphs and tables

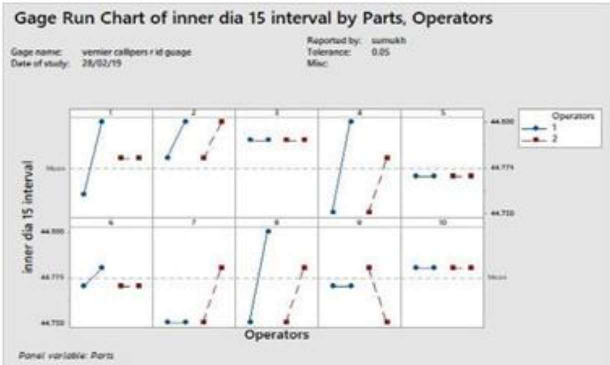

Figure 23: Gage Run Chart for inner dia at interval of 15 by parts and operator

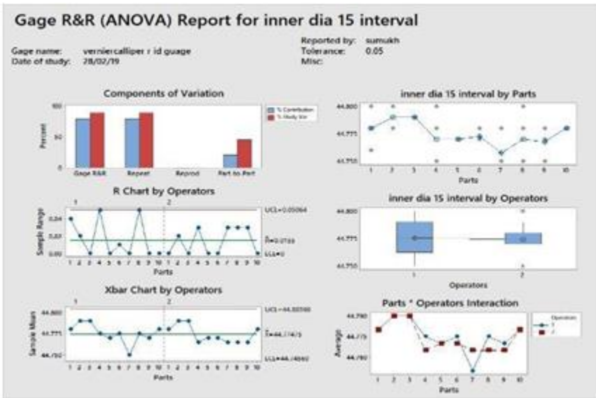

Figure 24: Gage R&R (ANOVA) report for inner dia at interval of 15

(455530). Every part is collected at regular interval in the production process is taken for measurement. The output is given in following graphs and tables

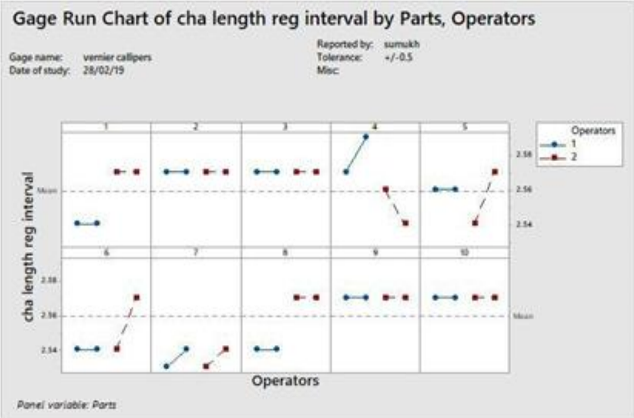

Figure 25: Gage Run Chart for chamfer length at regular interval by parts and operators

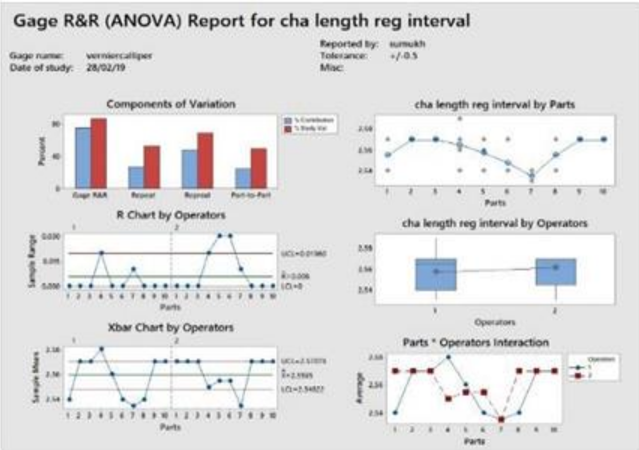

Figure 26: Gage R&R (ANOVA) report for chamfer length at regular interval

➢ *GR&R STUDY FOR CHAMFER LENGTH AT INTERVAL of 5:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush (455530). Every fifth part in the production process is taken for measurement. The output is given in following graphs and tables:

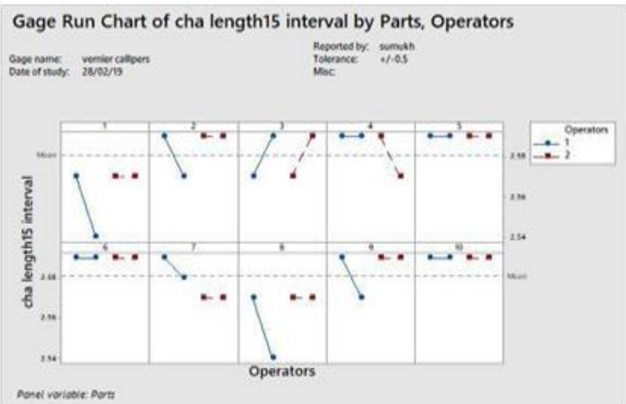

Figure27 : Gage Run Chart for chamfer length at interval of 5 by parts and operation

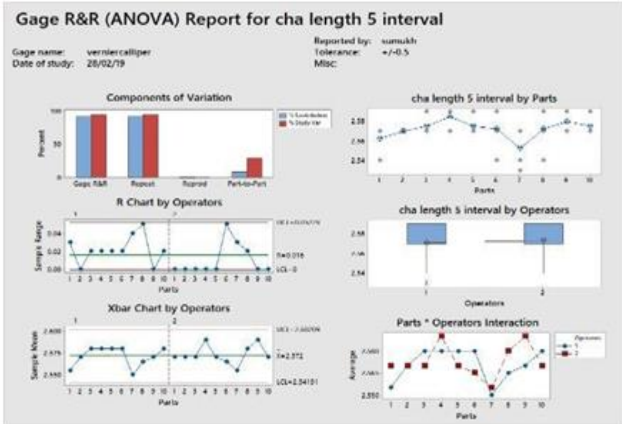

Figure 28: Gage R&R (ANOVA) report for chamfer length at 5 interval

➢ *GR&R STUDY FOR CHAMFER LENGTH AT REGULAR INTERVAL:*

The data is collected for 10 parts (observations) with 2 replicates, 2 operators and measured with 2 different instrument for the component of Bush After conducting the GR&R study the measurement system for inner diameter, outer diameter, chamfer length, length for four parameters at four interval we have confirmed that equipment variation, part to part variation, appraisal variation, total variation which all produced from crossed gauge r&r study (anova) there is no significance difference. If the GRR% is less than 10% which is acceptable M.S.A“As per the AIAG is that if T.V is less than 10% the measurement system is usually deemed acceptable for ANOVA method” form this study a confirmatory test is done

➢ *Process capability for regular interval:*

S.No	outerdia
1	55.38
2	55.4
3	55.39
4	55.37
5	55.37
6	55.33
7	55.37
8	55.39
9	55.39
10	55.4

Table3: Bush(455530) outer diameter data for regular interval

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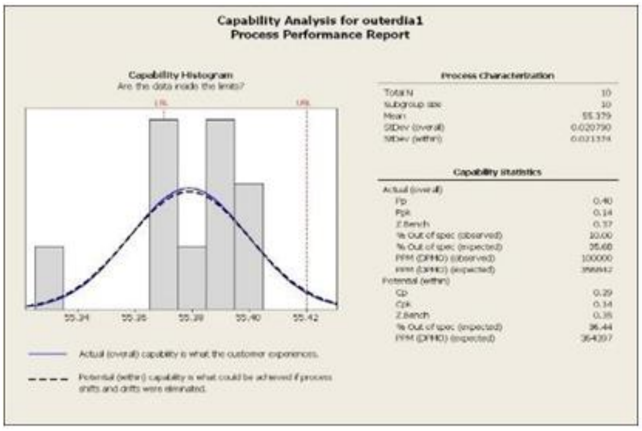

Figure 29: process capability of outer diameter for regular interval

For regular interval at 1st shift the data is measured with micrometer with a accuracy of 0.01mm, from the observations it is noticed that out of 10parts in which 1part was rejected based on the CTQ parameter of outer diameter of bush(455530) with limit of 55.37mm-55.42mm and the Cp& Cpk values are 0.39 and 0.14 respectively, the sigma level of order of 1.85 and from the DPMO table it is noted that is 63%yield and of defect range of 3 ,64,397 defects per million

➢ *Process capability 5interval:*

slno	outerdia
1	55.4
2	55.41
3	55.41
4	55.37
5	55.4
6	55.39
7	55.39
8	55.41
9	55.42
10	55.41

Table4: Bush outer diameter for 5interval

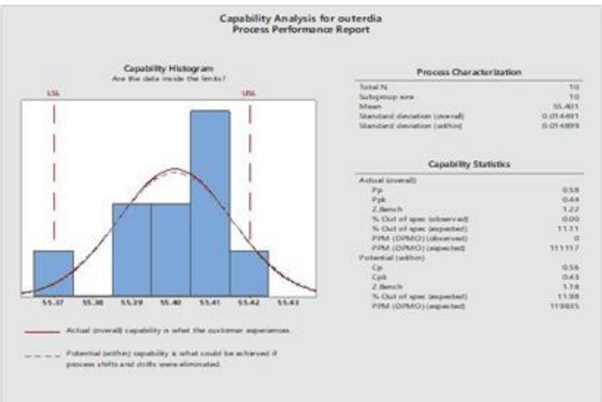

Figure 30: process capability for 5 interval

For the 5 interval in the 1st shift data is measured with micrometer with an accuracy of 0.01mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 55.37mm-55.42mm and the Cp& Cpk values are 0.56 and 0.43 respectively, the sigma level of order of 2.68 and from the DPMO table it is noted that is 87.6%yield and of defect range of 1,19,835 defects per million

➢ *Process capability 10 interval:*

S.No	outerdia
1	55.42
2	55.41
3	55.42
4	55.39
5	55.37
6	55.38
7	55.39
8	55.42
9	55.4
10	55.38

Table5: outer diameter for 10 interval of bush

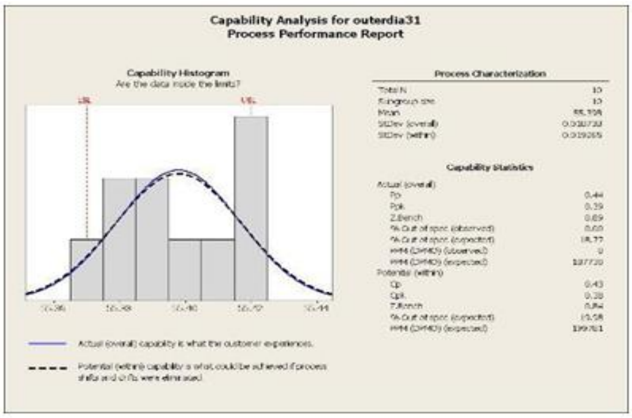

Figure 31: process capability for outerdia for 10 interval

For the 10 interval in the 1st shift data is measured with micrometer with an accuracy of 0.01mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 55.37mm-55.42mm and the Cp& Cpk values are 0.43 and 0.38 respectively, the sigma level of order of 2.35 and from the DPMO table it is noted that is 79.8%yield and of defect range of 1,99,781 defects per million.

➢ *Process capability15 interval:*

S.No	outerdia
1	55.39
2	55.41
3	55.37
4	55.39
5	55.37
6	55.38
7	55.37
8	55.38
9	55.42
10	55.41

Table6: for outer diameter at 15 interval of bush

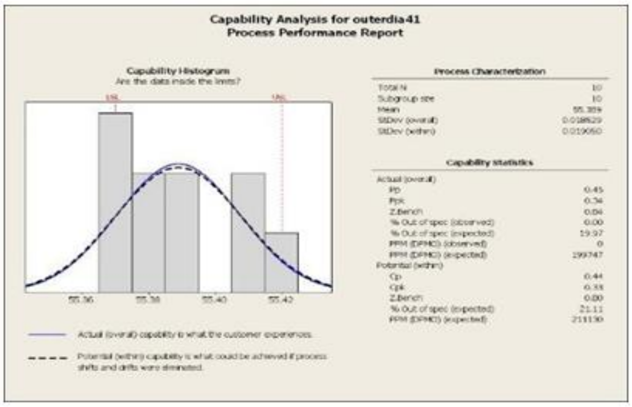

Figure 32 : process capability for outer diameter for 15 interval

For the 15 interval in the 1st shift data is measured with micrometer with an accuracy of 0.01mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 55.37mm-55.42mm and the Cp& Cpk values are 0.44 and 0.33 respectively, the sigma level of order of 2.35 and from the DPMO table it is noted that is79 %yield and of defect range of 2,11,130 defects per million.

➢ *PROCESS CAPABILITY LENGTH FOR REGULAR INTERVAL:*

S.No	Length
1	29.98
2	29.99
3	29.98
4	29.94
5	29.98
6	29.98
7	29.88
8	29.9
9	29.98
10	29.97

Table 7: length for regular interval of bush

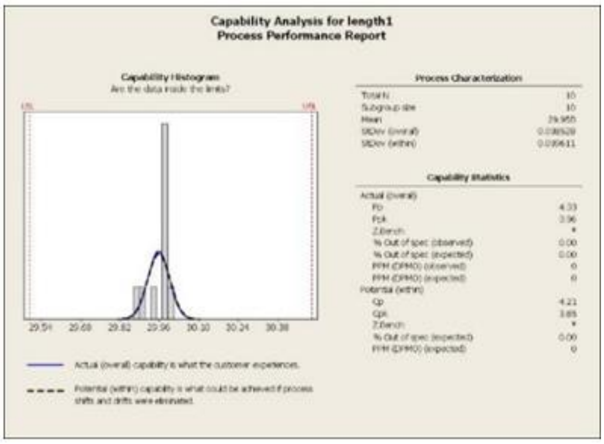

Figure33: process capability for length at regular interval

For the regular interval in the 1st shift data is measured with digital Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 30.5mm-29.5mm and the Cp& Cpk values are 4.21 and 3.95 respectively , the sigma level of order of and from the DPMO table it is noted that is 79%yield and of defect range of 0 defects per million opportunities

➢ *Process capability 5 interval:*

S.No	Length
1	29.89
2	29.98
3	29.97
4	29.89
5	29.98
6	29.98
7	29.97
8	29.99
9	29.98
10	29.98

Table8: length for 5 interval of bush

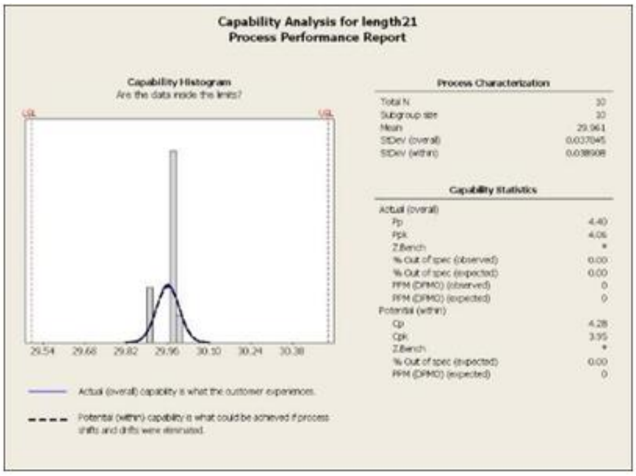

figure34: process capability for length at 5 interval

For the 5interval in the 1st shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 30.5mm-29.5mm and the Cp& Cpk values are 4.28 and 3.95 respectively , the sigma level of order of 6 and from the DPMO table it is noted that is79 %yield and of defect range of 0 defects per million opportunities

Process capability Regular interval:

S.No	Inner dia
1	44.76
2	44.79
3	44.76
4	44.78
5	44.78
6	44.80
7	44.77
8	44.76
9	44.76
10	44.75

Table10 : for inner diameter at regular interval of bush

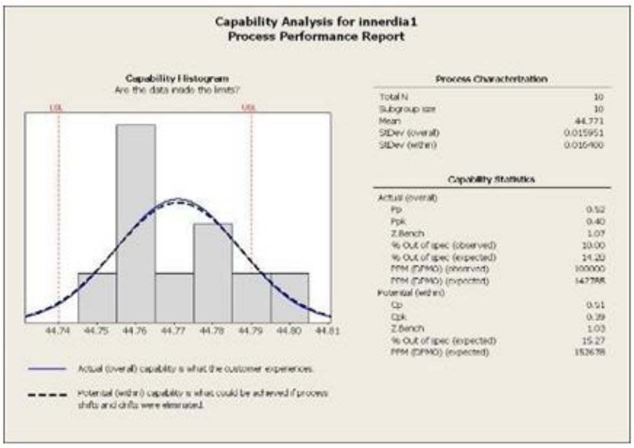

Figure35: process capability at regular interval for inner diameter

For the regular interval in the 2nd shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 0.51 and 0.39 respectively , the sigma level of order of 2.52 and from the DPMO table it is noted that is84 %yield and of defect range of 1,52,678 defects per million opportunities

➢ *Process capability 5 interval:*

S.No	Inner dia
1	44.79
2	44.78
3	44.76
4	44.77
5	44.76
6	44.76
7	44.74
8	44.77
9	44.75
10	44.77

Table 11: for inner diameter at 5 interval of bush

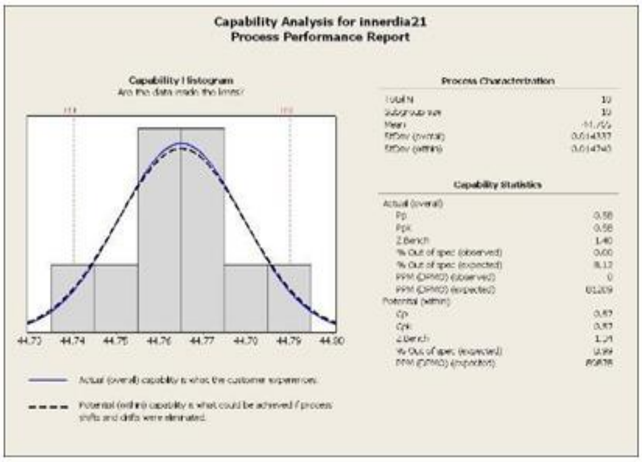

Figure 36: process capability for inner diameter at 5 interval

For the 5interval in the 1st shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 0.57 and 0.57 respectively , the sigma level of order of 2.85 and from the DPMO table it is noted that is90.9 %yield and of defect range of 89,878 defects per million opportunities.

➢ *Process capability 10 interval:*

S.No	Inner dia
1	44.75
2	44.79
3	44.77
4	44.79
5	44.78
6	44.78
7	44.79
8	44.79
9	44.79
10	44.76

Table12: for inner diameter at 10 interval of bush

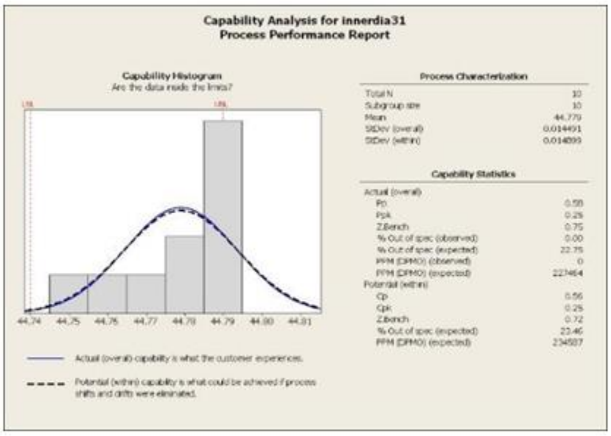

Figure 37: process capability for inner diameter at 10 interval

For the 10 interval in the 2nd shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 0.56 and 0.25 respectively , the sigma level of order of 2.25 and from the DPMO table it is noted that is76.2%yield and of defect range of 2,34,587 defects per million opportunities.

➢ *Process capability15 interval:*

S. No	Inner dia
1	44.76
2	44.78
3	44.79
4	44.75
5	44.77
6	44.77
7	44.75
8	44.75
9	44.77
10	44.78

Table 13: for inner diameter at 15 interval of bush

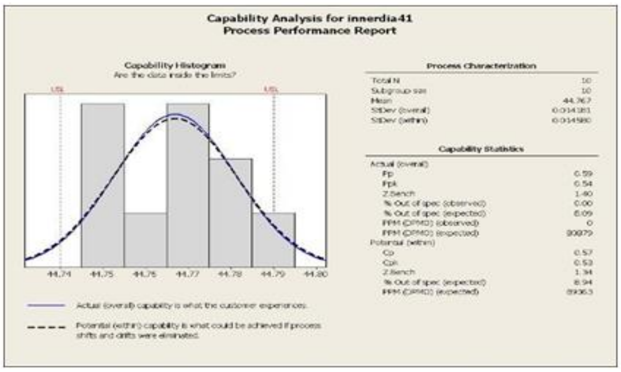

Figure 38: process capability for inner diameter at 15 interval

For the 15 interval in the 2nd shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 0.57 and 0.53 respectively , the sigma level of order of 2.83 and from the DPMO table it is noted that is90.6%yield and of defect range of 89,363 defects per million opportunities.

➢ *Process capability Regular interval:*

S.No	Chamfer length
1	2.54
2	2.57
3	2.57
4	2.57
5	2.56
6	2.54
7	2.53
8	2.54
9	2.57
10	2.57

Table14: for chamfer length at regular interval of bush

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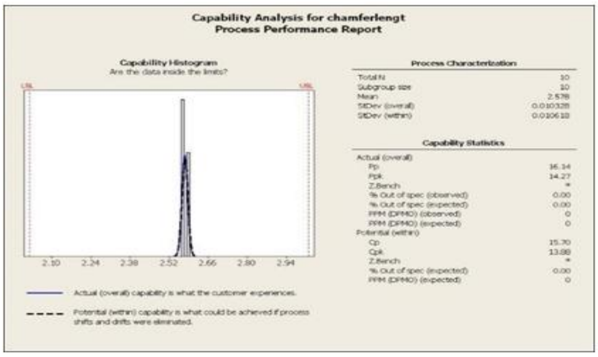

Figure39: process capability for chamfer length at regular interval

For the regular interval in the 1st shift data is measured with Vernier caliper with an accuracy of 0.03mm, from the observations of the data 0f 10 parts based on the CTQ parameter of outer diameter of bush(455530) with a limit of 3.02mm-2.02mm and the Cp& Cpk values are 0.57 and 0.53 respectively , the sigma level of order of 6 and from the DPMO table it is noted that is99.97yield and of defect range of 0 defects per million opportunities.

➢ *ANALYZE: CAUSE AND EFFECT DIAGRAM:*

A fish bone diagram is an important tool in the analyze phase that can help you perform a cause and effect analysis for a problem you are trying to solve. This type of analysis enables you to discover the root cause of a problem

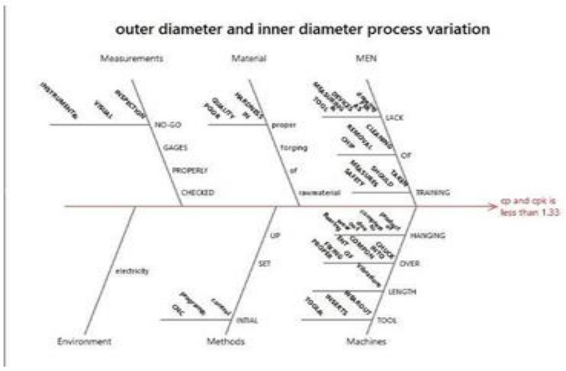

Figure45:ISHIKAWA DIAGRAM

In the fish bone diagram, various cause for the variations in the process are labeled so that it becomes easier to figure out the root cause and thereby focusing only on the root cause and how to eliminate it. The root cause is:

- Tool length over hanging
- Tool & inserts wear out
- Co-axiality between chuck and tool
- Proper cleaning of chip removal
- Tools and measuring devices as per drawing
- No-go gages properly checked
- Inspection should be done with measuring instruments Safety measures should be taken thoroughly

Fixtures should be tighten up the operator while loading the product

PROBLEM	CAUSE	EFFECT
TOOL	Tool length over hanging	Which effect the cutting parameters in the product leads to process variation
Tool inserts wear out	Usage more than span life	Which effect dimensional un stability
Co-axiality between chuck and tool	Concentricity problems	Which effects on I.D/O.D and cutting parameters changes leads to process variation
Maintenance	Chip removal cleaning	Which reduces the inserts& tool life and effect the cutting parameters leads to process variation
Tool& instrument supply as per drawing	non value activities	Cycle time will increases if pre tool kit is not available
Workers	Lack of training	As per standard not followed which effect on variation
No-go gauges ,visual inspection & instrument frequently checked	Measurement system frequently checked	Some time accepted product get rejected, rejected product get accepted

Table15:cause and effect process variation

➢ *Hypothesis testing:*

Paired t-test:

The paired t-test is used to test is there a significant difference the average measurement of the product namely, outer dia, length, inner dia, chamfer length between operators who measured these variables on the same part/ product units. The general null and alternative hypotheses are:

Ho: There is no significant difference in the average value of the variable measured by two operators
H1: There is a significant difference in the average of the variable measured by two operators.

➢ *PAIRED T-TEST FOR OUTER DIAMETER*

FOR MEAN DIFFERENCE

Interval	Mean difference	SE of mean	t-statistic	p-value	95% confidence Interval
Regular	-0.120	0.00573	-2.09	0.066	(-0.02497, 0.00097)
Interval of 5	0.000	-	-	-	(0.0000,0.000)
Interval of 10	0.004	0.00221	-1.81	0.104	(-0.00900, 0.00100)
Interval of 15	0.00000	0.00149	0.00	1.000	(-0.00337, 0.00337)

Table16: Results of paired t-test for outer dia measured at various intervals

From the table is found that there is no difference in the average value of the outer dia measured by two operators at various intervals of regular, interval of 10 and interval of 15 as the p-values are more than 5% level of significance. In case of interval 5, it can't be concluded as the difference of sample means is zero.

➢ *PAIRED T-TEST FOR LENGTH FOR MEAN DIFFERENCE*

Interval	Mean difference	SE of mean	t-statistic	p-value	95% confidence
Regular	-0.00100	0.00180	-0.56	0.591	(-0.00506, 0.00306)
Interval of 5	-0.00200	0.00133	-1.50	0.168	(-0.00502, 0.00102)
Interval of 10	-0.00200	0.00200	-1.50	0.168	(-0.00652, 0.00252)
Interval of 15	0.00500	0.00500	1.00	0.343	(-0.00631, 0.01631)

Table 17: Results of paired t-test for length measured at various intervals

From the table is found that there is no difference in the average value of the length measured by two operators at various intervals of regular, interval of 5, interval of 10 and interval of 15 as the p-values are more than 5% level of significance.

➢ *PAIRED T-TEST FOR CHAMFER LENGTH FOR MEAN DIFFRENNCE:*

Interval	Mean difference	SE of mean	t-statistic	p-value	95% confidence Interval
Regular	-0.00100	0.00100	-1.00	0.343	(-0.00326, 0.00126)
Interval of 5	-0.00400	0.00267	-1.50	0.168	(-0.01003, 0.00203)
Interval of 10	0.00200	0.00467	0.43	0.678	(-0.00856, 0.01256)
Interval of 15	-0.00300	0.00213	-1.41	0.193	(-0.00783, 0.00183)

Table 18: Results of paired t-test for chamfer length measured at various intervals.

From the table is found that there is no difference in the average value of chamfer length measured by two operators at various intervals of regular, interval of 5 and interval of 15 as the p-values are more than 5% level of significance In case of interval 10, it can't be concluded as the difference of sample means is zero.

➢ *PAIRED T-TEST FOR INNER DIAMETER FOR* **MEAN DIFFRENNCE:**

Interval	Mean difference	SE of mean	t-statistic	p-value	95% confidence Interval
Regular	-0.00300	0.00496	-0.61	0.560	(-0.01421, 0.00821)
Interval of 5	0.00000	0.00422	0.00	1.000	(-0.00954, 0.00954)
Interval of 10	0.000000	0.000000	-	-	(0.000000, 0.000000)
Interval of 15	0.00200	0.00200	1.00	0.343	(-0.00252, 0.00652)

Table19: Results of paired t-test for inner diameter measured at various intervals

From the table is found that there is no difference in the average value of inner dia measured by two operators at various intervals of regular, interval of 5, interval 10 and interval of 15 as the p-values are more than 5% level of significance.

➢ *IMPROVE:*

In the improve phase for the implementation of analysis is taken from the Ishikawa diagram the various solutions that can be obtained from men, material, machine, method. It came to the conclusion that it might effect. how fast and efficient CNC machines is they are incapable of making mistakes. They develop problems and need maintenance just like any other type of machine or tool and there are certain things you can do that without intention damage to these machines. While there are certainly any number of problems that leads to issues and errors. These are the problems are also ones that are easy to overlook and easy to misdiagnose. And some of the problems these are identified during the operations.

Following suggestions are done:

For specifying a product we have to consider all factors for the quality in this we consider the inner diameter, outer diameter, chamfer length, length in this if we take individually two components have attained sigma level but outer diameter, inner diameter these are below the 3σ level for four interval. So the factors that effect inner diameter, outer diameter which are taken from the root cause analysis.

For the outer diameter at regular interval the level of sigma is 1.85 which effects process variation and reduces the Cp and Cpk values. The reasons we have identified

Proper loading material into the chuck by locking the fixtures

Frequent inspection should be done by the operator. If any flaw seen by the customer rework, and manhours will be produced and increased the lead times and moreover we can identify by regular inspection that how accurate the measurement system is.

Poor maintenance near the work floor.

- Sudden shortage of power drop that leads to the product and cause breakdown it may effect the tool or tool inserts due to sudden vibrations.

For the outer diameter at 5 interval the level of sigma is 2.68 which effects the process variation and reduces the Cp and Cpk values. The reasons we have identified.

During the operations the work offset were changing due to inconsistent of process variations and lack of proper programming by the worker For the outer diameter at 10&15 interval the level of sigma is 2.35 which effects the process variation and reduces the Cp and Cpk values. The reasons we have identified.

Chip removal were not frequently done which leads to breakdown of tool and reduce the tool life and efficiency of machine.

Tool length overhanging should be checked before run an operation which leads to vibrations or chatter and cause the process variations and leads to breakdown of machine

Concentric problem should be maintain according to the product which leads to process variations

Coolant due the over usage may change the cutting parameters and leads to process variation For the inner diameter at regular interval the level of sigma is 2.52 which effects the process variation and reduces the Cp and Cpk values. The reasons we have identified.

- Proper lubrication should be done to the the material as well to the tools cutting parameters may not effect and leads to the process variation

- Proper loading of material into chuck by the operator is checked before running of operation. For the inner diameter at 5 interval the level of sigma is 2.85 which is near to the 3 sigma which effects the process variation and reduces the Cp and Cpk . the reasons we have identified

- Due to the over time work by the manhours that lead to fatigue problems that effect the ergonomic conditions while measuring system may vary

- Due to the improper setting of tool by manpower and the tool work at the wrong speed before running of operation is checked.

For the inner diameter at 10 interval the level sigma is 2.25 which effects the process variation we have identified.

- Due to the over sharpening of tip inserts in which usage more than the life which does not produces surface roughness due to the over speed and feed rate

- After the process the workers are not at the work place they are moving in search of tools.

For the inner diameter at 15 interval the level sigma is 2.83 which is near to the 3 sigma which effect process variation and reduces the Cp and Cpk the reasons we have identified

- Due to the damping vibrations are suddenly created during the operations which leads to the tools movement.

- Training was given to the operator to take safety precautions and also to get aware of work and job to perform in a better manner.

- During the operation the material handling was carried the workers are not presented near the work place due this lead time increase and idle time increase

These are the suggested implementations performed in industry in order to reduce the variations. After the implementation the data regarding to the bush inner diameter, outer diameter was collected and it was analysed in the Minitab software. The readings of bush inner diameter and outer diameter have collected 40 bushes at different interval. This data was undergone the capability analysis for comparison of various parameter like mean, standard deviation, process capability etc. The process capability was drawn out for 40 readings for both inner diameter and outer diameter and the Cp and Cpk values has been tremendously increased with small amount of variation in the process and the process capability chart is depicted out these values are depicted from six sigma table whether the sigma level Is based on which level.

➢ *Data Collection after Improvement:*

After necessary changes and suggestion to the supervisor we have collected the bush(455550) with same turning operations , with different material on same machine for 4 interval of 40 samples of both outer diameter and inner diameter and conducted the process capability performance how close to performance it is meeting

➢ *Process capability for regular interval:*

S no	Outerdia
1	55.37
2	55.37
3	55.36
4	55.37
5	55.38
6	55.36
7	55.37
8	55.37
9	55.37
10	55.36

Table20: for outer diameter at regular interval after improvement

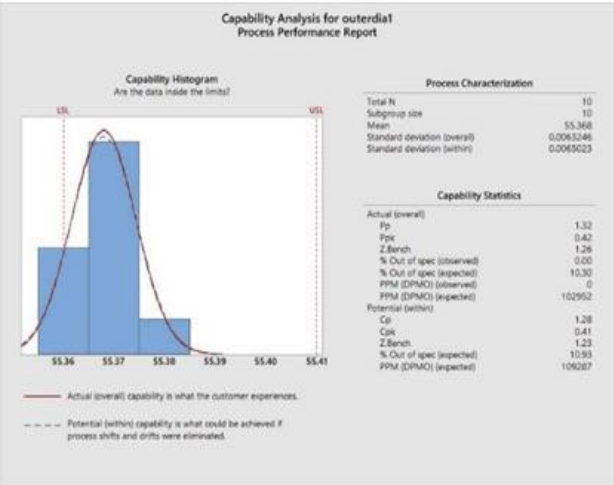

Figure40 :process capability for bush at regular interval after improvement

For the parameter of outer diameter of bush with a limit of 55.36mm-55.41mm and the Cp& Cpk values are 1.28 and 0.41 respectively, the sigma level of order of 2.72 and from the DPMO table it is noted that is 89 %yield and of defect range of 1,09,287 defects per million.

➢ *Process capability for 5 interval:*

Slno	Outerdia
1	55.37
2	55.37
3	55.36
4	55.37
5	55.36
6	55.37
7	55.37
8	55.37
9	55.37
10	55.36

Table21**:** for outer diameter at 5 interval after imp

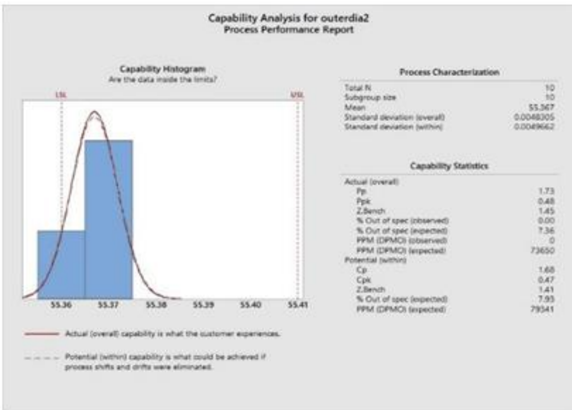

Figure41:process capability for bush at 5 interval after improvement

For the parameter of outer diameter of bush with a limit of 55.36mm-55.41mm and the Cp& Cpk values are 1.68 and 0.47 respectively, the sigma level of order of 2.93 and from the DPMO table it is noted that is 92%yield and of defect range of 79341 defects per million.

➢ *Process capability for 10 interval:*

sno	Outer dia
1	55.37
2	55.37
3	55.37
4	55.38
5	55.38
6	55.38
7	55.37
8	55.39
9	55.39
10	55.39

Table22**:** for outer diameter at 10 interval after improvement

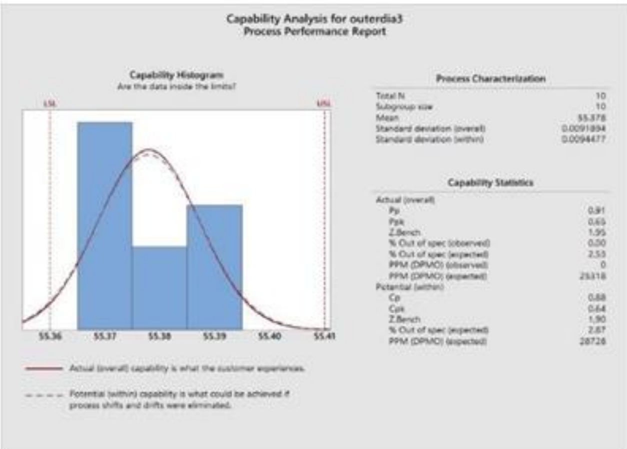

Figure 42:process capability for bush at 10 interval after improvement

For the parameter of outer diameter of bush with a limit of 55.36mm-55.41mm and the Cp& Cpk values are 0.88 and 0.64 respectively, the sigma level of order of 3.39 and from the DPMO table it is noted that is 97%yield and of defect range of 28,728 defects per million

➢ *Process capability for 15 interval:*

sno	Outer dia
1	55.37
2	55.37
3	55.37
4	55.38
5	55.38
6	55.40
7	55.37
8	55.37
9	55.37
10	55.37

Table23**:** for outer diameter at 15 interval after improvement

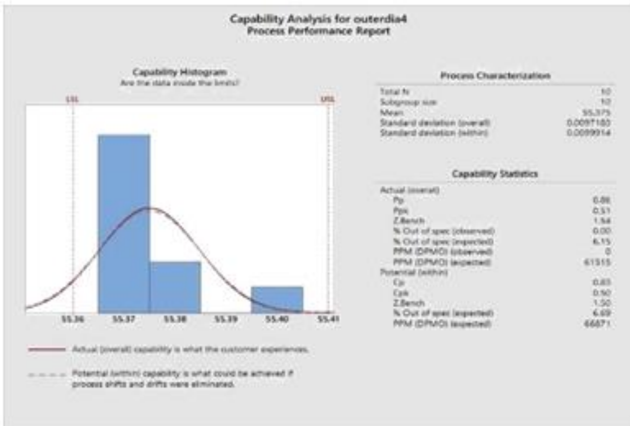

Figure 43:process capability for bush at 15 interval after improvement

For the parameter of outer diameter of bush with a limit of 55.36mm-55.41mm and the Cp& Cpk values are 0.83 and 0.50 respectively, the sigma level of order of 2.88 and from the DPMO table it is noted that is 91%yield and of defect range of 66,871 defects per million..

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➢ *Process capability for regular interval:*

sno	Inner dia
1	44.79
2	44.78
3	44.78
4	44.78
5	44.79
6	44.79
7	44.78
8	44.78
9	44.79
10	44.79

Table24**:** for inner diameter at regular interval after improvement

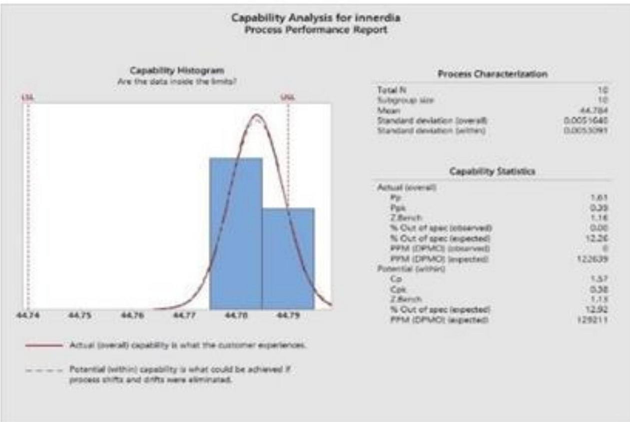

Figure44:process capability for bush at regular interval after improvement

For the parameter of outer diameter of bush with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 1.57 and 0.38 respectively , the sigma level of order of 2.67 and from the DPMO table it is noted that is86 %yield and of defect range of 1,29,211 defects per million opportunities.

➢ *Process capability for 5 interval:*

sno	**Inner dia**
1	44.79
2	44.79
3	44.78
4	44.77
5	44.78
6	44.77
7	44.77
8	44.78
9	44.78
10	44.77

Table25**:** for inner diameter at 5 interval after improvement

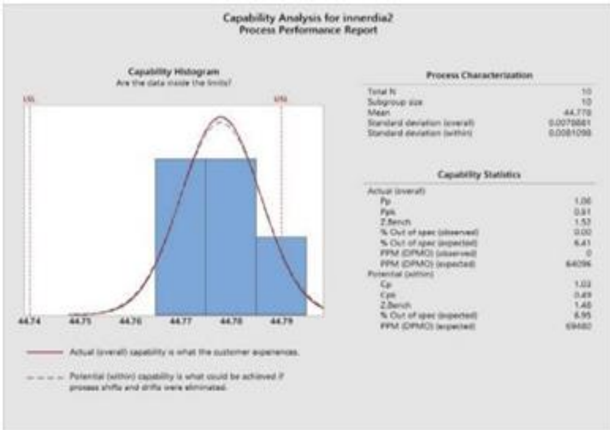

Figure45 :process capability for bush at 5 interval after improvement

For the parameter of outer diameter of bush with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 1.03 and 0.49 respectively , the sigma level of order of 2.96 and from the DPMO table it is noted that is93 %yield and of defect range of 69,480 defects per million opportunities.

➢ *Process capability for 10 interval:*

sno	Inner dia
1	44.79
2	44.79
3	44.78
4	44.77
5	44.79
6	44.78
7	44.79
8	44.78
9	44.78
10	44.78

Table26**:**inner diameter at 10 interval after improvement

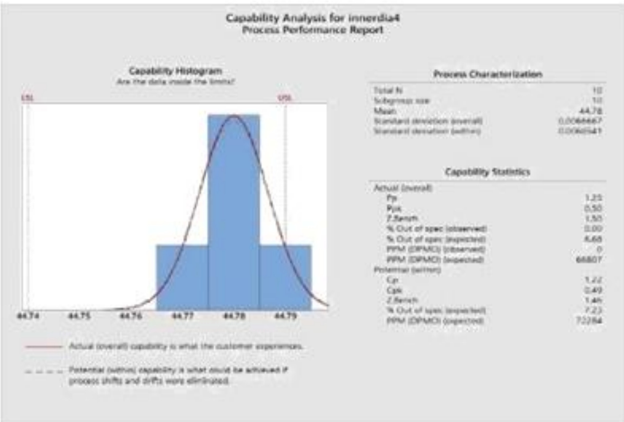

Figure46:process capability for bush at 10 interval after improvement

For the parameter of outer diameter of bush with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 1.16 and 0.28 respectively , the sigma level of order of 2.35 and from the DPMO table it is noted that is79.4%yield and of defect range of 2,01,956 defects per million opportunities.

➢ *Process capability for 15 interval:*

sno	Inner dia
1	44.78
2	44.78
3	44.78
4	44.77
5	44.77
6	44.79
7	44.79
8	44.78
9	44.78
10	44.78

Table27**:** for inner diameter at 15 interval after improvement

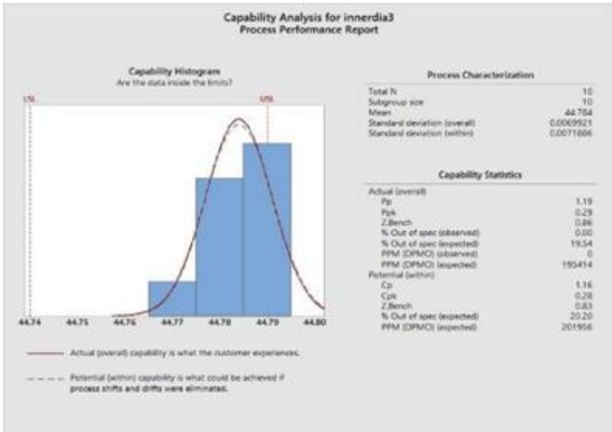

Figure48:process capability for bush at 15 interval after improvement

For the parameter of outer diameter of bush(455530) with a limit of 44.79mm-44.74mm and the Cp& Cpk values are 1.22 and 0.49 respectively , the sigma level of order of 2. and from the DPMO table it is noted that is90.6%yield and of defect range of 72,284 defects per million opportunities.

➢ *CONTROL PHASE:*

Since the necessary process variations has improved and data has been seen through the process capability in the control whether the machine variation is stability are not is seen by charts through individual -moving range charts. By the collection of data of inner diameter and outer diameter for different interval for 40 components.

The data collected is undergone Minitab analysis and the following results are

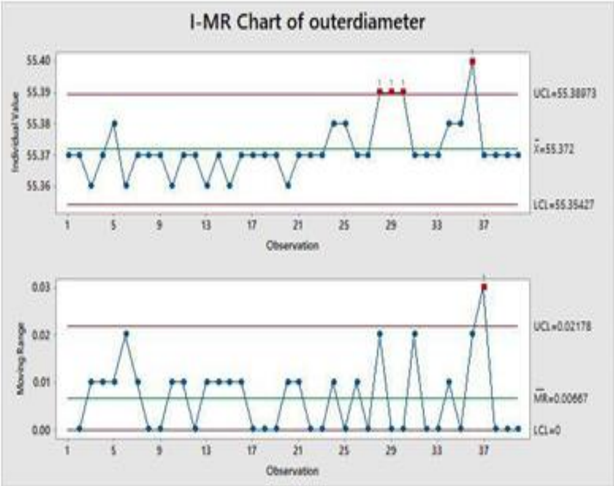

Figure49:I-MR Chart for outer diameter

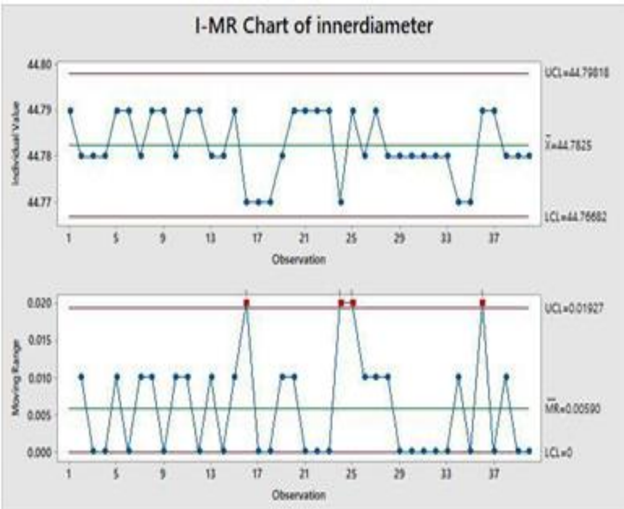

Figure50: :I-MR Chart for inner diameter

For the above I-MR chart it is clearly observed for both inner diameter and outer diameter maximum data collected lies on with in the control limits for both inner diameter and outer diameter point at outer diameter for individual mean chart 27,28,29&36 which are out of limits and moving range chart only one point lies out of limit at 37. And for the inner diameter the individual mean chart the data point lies on the control limits but when coming to the moving range chart the data point lies out of limits are 16,24,25and 36 which it is clear that process is under control and improvement and process maintained or carried throughout the end of process have less fluctuations.

V. CONCLUSION

After collection of data the problem was defined that there is no defect in the product within the tolerance limit but there is process variation in the machine. Then GR&R study was performed for comparing the measurement system analysis that is for equipment variation & appraisal variation through ANOVA method. our measurement system which is confirmed that GR&R% which is less than 10% which is accepted for the 4 parameters like inner diameter, outer diameter, length, &chamfer length for regular interval, 5 interval, 10 interval,15 interval Then conducted the process capability for 4 parameters their cp and cpk is below the 1.33 and there is a process variation in it. for outer diameter& inner diameter is which is below the 1.33 which produces the more defect rate in it. Then we analyzed through ishikawa diagram which effects the process variation which should eliminate through the root cause by improving through suggestions like

- Tool length overhanging should be checked during the operation it may cause to the breakdown of machine which leads to tool life and cause unplanned downtime and their by increase the lead times and moreover it cause to efficiency of the machine
- While observing the company majority of the operators are aware of work that has to be done and but there are not capable for quality training. By giving awareness of the programs to the operator it get benefit to the company
- Calibration should be done frequently it helps the reject criteria and rework
- Maintenances should be done frequently breakdown problem occurs if scrap removal of chips should not be removed and moreover lubrication should be properly done if parts is stickily or not moving as smooth as they should this leads to errors and also air blockage and overheating which also cause problems like material movement during the process
- Process variation may occur due to the concentricity problem due co-axiality between chuck and the tool
- Inspection the operators by the supervisor and conduct the meeting on weak operator so that aware of doing work.
- Usage more than tool inserts wear out will reduce the tool life
- Process variations also effect due to the two different components with two different material and also with same turning operations will reduce the tool life and tool inserts and also reduces efficiency of machine.
- Due to this sudden breakdown in machine it leads to increase in lead times, rework and also man-hours increase.
- Speed ,feed rate with two different speed and feed rate this effects the tool life and inserts wear out which causes breakdown during the operations and leads to manhours and productivity.

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