Table 2: Statistical Quality Control Analysis of the Rotary Shouldered Connections for 2019

Unit Produced	Defectives	Fraction Defective (P)	Upp2er Control Limit (UCL)	Lower Control (LCL)
13	6	0.46154	0.87633	0.046746
17	10	0.58824	0.94633	0.23014 -
25	4	0.16	0.37996	0.059964
20	11	0.55	0.88373	0.21627 -
26	4	0.15385	0.36612	0.058431
22	10	0.45455	0.77302	0.13607 -
19	5	0.26316	0.56623	0.03991
26	10	0.38462	0.67085	0.098381
24	7	0.29167	0.57001	0.013325
33	5	0.15152	0.33876	-0.035732
41	11	0.26829	0.47588	0.060705
37	9	0.24324	0.45484	0.031642
303	**92**	**0.30363**	**0.38288**	**0.22438**

From Equation (1), the fraction defective is calculated as:

$$F = \frac{92}{303}$$

$$F = 0.30363$$

The standard deviation as calculated using Equation (2) is;

$$\Sigma = \sqrt{\frac{\mathbf{0.30363}(1-\mathbf{0.30363})}{303}}$$

$$\sigma = 0.026416$$

The upper control limit as determined by Equation (3) is

$$UCL_P = 0.30363 + 3(0.30363)$$

$$UCL_P = 0.38288$$

Furthermore, the lower control limit as determined by Equation (4) is

$$LCL_P = 0.30363 - 3(0.026416)$$

$$LCL_P = 0.22438$$

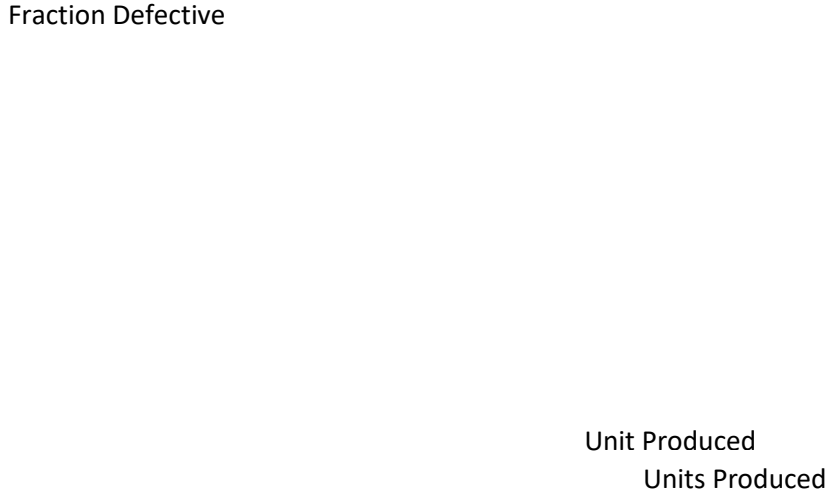

Figure 3: P-chart of the Rotary shouldered connections for 2019

From Figure 3, out of 12 data points, it is observed that 7 falls outside the control limits, this implies that the result did not display statistical control. This was due to defects that were inherent in the rotary shouldered connections which were discovered during final inspection using Liquid penetrant test and Non-destructive test.

2.3 Statistical Quality Control Results for 2020

The result obtained from the control chart analysis carried out on the defects on the rotary shouldered connections during machining from quality control records of the Manufacturing company are shown in Table 3.

Table 3: Statistical Quality Control Analysis of the Rotary Shouldered Connections for 2020

Unit Produced	Defectives	Fraction Defective (P)	Upper Control Limit (UCL)	Lower Control Limit (LCL)
17	7	0.41176	0.76986	0.053671 -
19	5	0.26316	0.56623	0.03991
33	5	0.15152	0.33876	0.035732

26	8	0.30769	0.57924	0.036147
37	11	0.2973	0.52272	0.071873 -
23	4	0.17391	0.41102	0.06319
31	13	0.41935	0.68524	0.15347
25	7	0.28	0.5494	0.010601
42	8	0.19048	0.37225	0.0087022
253	**68**	**0.26877**	**0.37245**	**0.22279**

From Equation (1), the fraction defective is calculated as:

$$F = \frac{68}{253}$$

$$F = 0.26877$$

The standard deviation as calculated using Equation (2) is;

$$\sigma = \sqrt{\frac{\mathbf{0.26877}(1-\mathbf{0.26877})}{253}}$$

$$\sigma = 0.024943$$

The upper control limit as determined by Equation (3) is

$$UCL_P = 0.26877 + 3(0.024943)$$

$$UCL_P = 0.37245$$

Furthermore, the lower control limit as determined by Equation (4) is

$$LCL_P = 0.26877 - 3(0.024943)$$

$$LCL_P = 0.22279$$

Figure 4: P-chart of the Rotary Shouldered Connections for 2020

From Figure 4, out of 9 data points, it is observed that 5 falls outside the control limits, this implies that the result did not display statistical control. This was due to defects that were inherent in the rotary shouldered connections which were discovered during final inspection using Liquid penetrant test and Non-destructive test.

4.4 Fishbone Diagram

The variables identified during brainstorming are summarized using the fishbone diagram. The diagram visually outlines which variables affects which phase of the process. In determining the possible causes, several main factors like materials, operator, measurements, and machine were considered as shown in Figure 5.

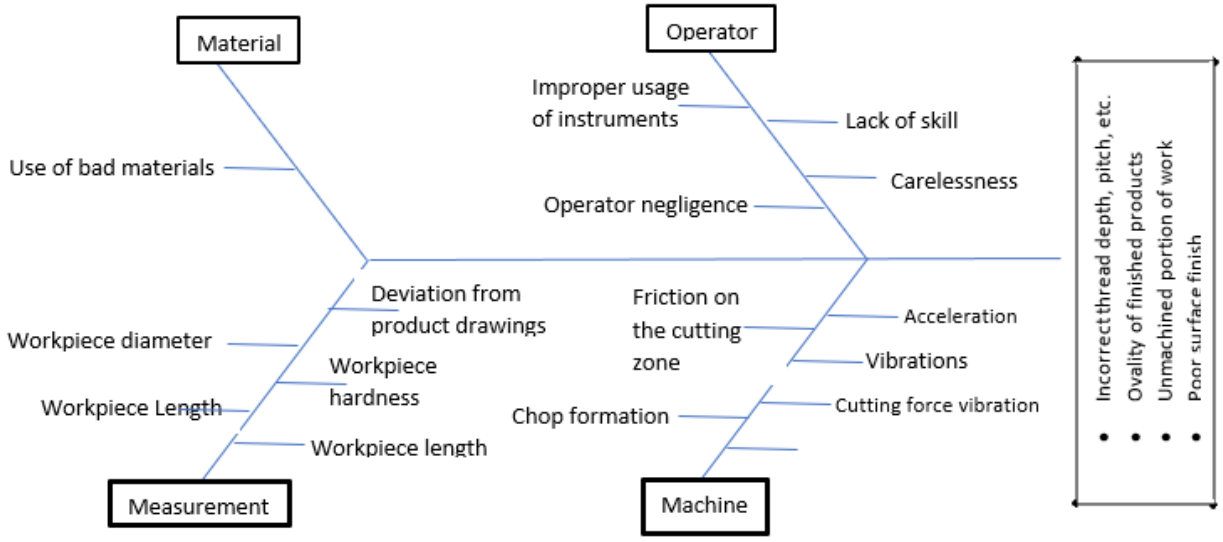

Figure 5: Fishbone Diagram of the Rotary Shouldered Connection

4. CONCLUSION

From the statistical quality control analysis of results using p-chart carried out on the defects of the rotary shouldered connections in the machine shop within a period of five years, the following conclusions were drawn.

i. That machining process was out of statistical control due to the high extent of nonconformance of the rotary shouldered connections to customer specifications and standard requirement with fraction defective of 0,30508, 0.30363, and 0.26877 for years 2018, 2019, and 2020 respectively.
ii. That results of statistical analysis of product data carried out show that more sample values are above the UCL and below LCL respectively (8 in 2018, 7 in 2019, and 5 in 2020) which is abnormal and shows that the production process was not properly controlled.

Furthermore, from the Fishbone diagram, the following conclusion were drawn;

i. Unskilled personnel errors such as lack of skill, operator negligence, improper usage of instruments, and carelessness led to poor quality of products produced like ovality of the product
ii. Also friction on the cutting zone, chip formation, acceleration, and vibration, caused breakdowns of machines thereby leading to long manufacturing process
iii. Use of incorrect stock dimension and inherently bad material led to defects of the manufactured products
iv. That condition of materials used for rotary shouldered connections were not inspected at the incoming stage until the final inspection before spotlighting the causes of the product defects.

From the detailed analysis, the following recommendations were made

i. Materials should be inspected on arrival to identify signs of deterioration. Before machining, tests such as liquid penetrant test and non-destructive test should be carried out on products to ascertain whether there are hidden cracks which will grow and make the end product fail.
ii. Carrying out in-process inspection is a better-quality control measure to ensure that the process is under control at every machining stage.
iii. Also, analysis of both conforming and nonconforming products should be carried out and plotted in the P-chart which is constructed and studied to know that the process was under statistical control or not based on the control limits,
iv. Strictly follow product drawings and machining processes sheet for quality assurance and realization of product quality as per specified control limits. With the implementation of these

correction and corrective actions on subsequent rework and production processes are in line with ISO 9001 etc. a better quality is sure,

v. Adequate training and retraining of personnel to be more careful,
vi. Use correct tools, feed and speeds.
vii. Adopt preventive maintenance on machines and equipment.

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