International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 7; Issue 2(H); February 2018; Page No. 10108-10113
DOI: http://dx.doi.org/10.24327/ijcar.2018.10113.1699

Research Article

IMPROVEMENTS IN THE PROCESS PERFORMANCE BY OPTIMIZING PROCESS CAPABILITY INDICES FOR LUG HOLE CENTER DISTANCE OPERATION IN MODERN AUTOMOTIVES

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ARTICLE INFO

Article History:
Received 12th November, 2017
Received in revised form 13th December, 2017
Accepted 3rd January, 2018
Published online 28th February, 2018

Key words:

Process Capability, Products, Production, Production Process, Statistical Process Control, etc.

ABSTRACT

The relation between Statistical Process control (SPC) and Production is the need of today's organization. Since any Production Industry has almost one of the most important objective that to minimize the cost associated with their product and services. This can be achieved by improving and developing new strategy among these departments. So, it is necessary to study the various parameters of the Statistical Process Control and Production Department. For this purpose, a commercial component Y9T caliper has been selected to understand the relations between the parameters related to Production process. In the Present approach, study has been done to analyze the component Parameters as per requirement of customer of ABC Manufacturing Pvt. Ltd. Total three trials have been taken on Lug Hole Center Distance of Y9T caliper. The SPC analysis and Investigations of Process Capability has been understood and Studied by self-Investigation for Process Capability Analysis by varying production parameters that Spindle Speed, Feed and Depth of Cut. The observations are taken based on sampling data taken by Process Sheet. The result shows that, there is very close agreement between the SPC parameters and Production parameters. This Prove that optimization of Process Capability index improves the process performance and Rate of productivity.

INTRODUCTION

Quality has turned out to be a standout amongst the most customer choice factors in the selection of product and processes. The phenomenon is across the board, paying little mind to whether the customer is an individual, a mechanical association, a retail location, a bank or monetary foundation, or a military guard program. Thusly, understanding and enhancing quality are key components prompting business achievement, development, and improved aggressiveness. There is a significant degree of profitability from enhanced quality and from effectively utilizing quality as an indispensable piece of general business methodology.

There are two general parts of fitness for utilize: quality of design and quality of conformance. All products and processes are created in different evaluations or levels of quality. These varieties in evaluations or levels of quality are deliberate, and, thusly, the fitting specialized term is quality of design. For instance, all cars have as their fundamental goal giving safe transportation to the purchaser. In any case, autos vary as for estimate, arrangements, appearance, and execution.

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These distinctions are the aftereffect of purposeful outline contrasts among the kinds of vehicles. These outline contrasts incorporate the kinds of materials utilized as a part of development, determinations on the segments, unwavering quality acquired through designing advancement of motors, drive trains, producing forms and different embellishments or equipment. Fig. 1 decides two organizations X and Y delivering same items inside certain specification limits, LSL (Lower Specification Limit) and USL (Upper Specification Limit). The organization X creating items inside Specifications yet their procedure is focused close LSL, while Company Y delivers a few items out of specification limits. It portrays the generation of organization X is great however contrast and friends Y where the items are focused and some item are out of specs.

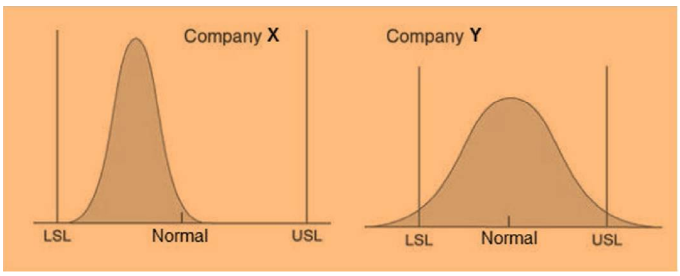

Fig 1 distributions of products from two companies x and y

LITERATURE REVIEW

As fast developments in the production system, customers need their products be good quality with very low defectives. Historical methods for determining defectives become inapplicable for those good quality processes because any manufacturing sample of specific size likely contains no defective products. An alternative modern approach based on Process Capability Indices for determining quality of manufacturing process, especially for complex product requiring very defectives (Measured in PPM, parts per million). The manufacturing engineers can use the presented approach to evaluate quality testing and measure whether their processes are capable for reproducing products satisfying customers. (Pearn & Wu, 2005)

A continuous pattern to work reconciliation, scaling down and densification opens new open doors in industry. To make small scale products, machine tools, raw materials and recent technologies have to be scaled down from the large to minimum domain. (Sancho, Pastor, Martinez, & Garcia, 2013) A downscaling of typical processes results in non-applicable process behavior. New challenge arises for process quality inspection based on the dimension of the small products which needs microscopic determinations for effective quality control. A model containing characteristics of quality testing and general process variables allows the quantification of the process performance. The quality control strategy considerably to the properties of the manufacturing process and the properties of the quality testing using SPC allows good results than just looking at them in general. To avoid the limits of a unidirectional measurement system a combination of different SPC will further improve the overall quality. (Weimer, Rippel, Hildebrandt, Lutjen, & Scholzreiter, 2014)

Target values for the capture factor are in the scope of 96 - 99% for average working conditions. These values must be come to if suitable quality details are satisfied. Specification values are recommended and their suggestions on catch factors are examined in view of the well-demonstrated Statistical calculation model. An assortment of measurement techniques which can be connected for estimation and control of the geometry parameters. It permits the identification of geometrical deficiencies, and countermeasures to enhance the product quality and performance can be actualized. The prescribed quality confirmation approach is proposed for execution in manufacturing industry, construction projects, prompting enhanced yield and better financial process performance. (Kandananond, 2014)

The preferred quality assurance approach is suggested by (Pottler, Ulmer, Lupfert, Landmann, Roger, & Prahl, 2014) for application in production industry, construction projects, leading to improved output and better economic process performance.

There has been a way to think that Statistical Process Control and Statistical Quality Control are the similar, while the fact is that Statistical Process Control is a study of process capability and Statistical Quality Control clears the quality of item being manufactured. Statistical Process Control is a part of a successful SQC application. SPC considers that less quality is due to the process performance. Statistical Process Control is the total of all technical and administrational efforts to tackle the production process for developing quality. Statistical Process Control tools have described that it is possible to develop both quality and rate of productivity continuously. Statistical Process Control may not be covered to control charts only; it is the tool which forms the changes going on. The Statistical Process Control can help a significant payback to that production process that can successfully apply them. Despite the fact that SPC is by all accounts an accumulation of factually based critical thinking apparatuses, there is a whole other world to the effective utilization of SPC than learning and utilizing these instruments. SPC is best when it is incorporated into a by and large, made item quality change program. The essential SPC critical thinking instruments must turn out to be generally known and broadly utilized all through the association. Quality change that is centered on diminishment of inconstancy must turn out to be a piece of the way of life of the association.

By the application of SPC program the firm realizes a means of identifying error at measurement. The SPC results to a uniform quality of manufacturing and develops the relationship with the customer. Also by implementing SPC tools, reduces the defectives and saving in the manufacturing cost. With the SPC, the final products are in some prescribed control limits. The SPC is helpful to study the production process for fewer skills and signifies the understanding and appreciation of quality control. It helps a means for obtaining the capability of the production process.

MATERIALS AND METHODS

A company has taken the trial on Statistical Process Analysis for Lug Hole Center Distance Operation. The trial 1 has taken based on changes in production parameters. The Spindle Speed, Feed and depth of cut for trial 1 are 2000 RPM, 300 mm/min and 19 mm. The sampling data taken from production department for inspecting the Lug Hole Center Distance Diameter of produced components. The Process Capability indices are evaluated and considering them as reference the excess trials have taken to optimize the process capability indices. The table 1 shows the changes in process performance parameters for successive trials.

Y9T Caliper is product of ABC Company. This Caliper is used in Maruti Suzuki Pick up Van as Brake Caliper in Braking System which is used in Abroad. In process there are critical parameters. Critical Process Parameters (CPP) in pharmaceutical manufacturing is key variables affecting the production process. CPPs are attributes that are monitored to detect deviations in standardized production operations and product output quality or changes in Critical Quality Attributes. There are two kinds of Critical Parameter; First kind parameter is Fitment parameter which is important because it helps to attach component to the vehicle. And Second kind parameter is Safety Parameter which is related to safety of component or vehicle. Fig. 2, Actual Y9T Caliper machined in MCV 650 – F48 with Parameters. If both kinds of parameters failed to work then it leads to major accident.

Table 1 Process Performance Parameters for Successive Trials

Sr. No.	Trial	Operations in Process	Process Performance Parameters		
			Spindle Speed (RPM)	Feed Rate (mm/min)	Depth of Cut (mm)
1	Trial 1	Lug Hole	2000	300	19
2	Trial 2	Center	2500	500	20
3	Trial 3	Distance	3000	700	22

Fig 2 Actual Y9T Caliper machined in MCV 650 – F48 with Parameters

Sampling Calculations

The table 2 shows the inspected readings of 120 samples. The sub groups of each 30 samples are created and their Average, min, max and Cp and Cpk are evaluated. The trial 2 has taken by improving production parameters to Speed 2500 RPM, Feed 500 mm/min and Depth of cut 20 mm. Again performing the SPC analysis to the sample data of trial 2. The trial 3 has also taken for further improvements and the data of trial 3 is shown in table 2.

For trial 1,

Formula for Standard Deviation is

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where μ = mean of all given N sample

x = value of variables

N = number of sample considered (120 Sample)

$$\mu = \frac{x_1 + x_2 + x_3 + \cdots + x_N}{N} = \frac{16079.766}{120} = 133.998$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (x_1 - \mu)^2 + (x_2 - \mu)^2 + (x_3 - \mu)^2 + \ldots\ldots\ldots\ldots + (x_N - \mu)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (134.034 - 133.998)^2 + (134.020 - 133.998)^2 + (133.984 - 133.998)^2 + \ldots\ldots\ldots\ldots + (134.005 - 133.998)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = 0.093824572$$

$$\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2 = \frac{0.093824572}{120} = 0.0007819$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} = \sqrt{0.0007819} = 0.0285$$

$$6\sigma = 6\ X\ 0.0285 = 0.171$$

$$Cp = \frac{(USL - LSL)}{6\sigma}$$

Table 2 Sample Readings for Successive Trials

	Trial 1				Trial 2				Trial 3			
Production Parameters:	**Spindle Speed 2000 RPM, Feed 300 mm/min, Cutting Depth 19 mm**				**Spindle Speed 2500 RPM, Feed 500 mm/min, Cutting Depth 20 mm**				**Spindle Speed 3000 RPM, Feed 700 mm/min, Cutting Depth 22 mm**			
Sr. No	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**	**Sub 1**	**Sub 2**	**Sub 3**	**Sub 4**
1	134.034	133.997	133.984	134.011	134.011	133.995	133.974	134.002	134.034	134.001	133.994	133.989
2	134.020	134.023	133.984	134.034	134.058	133.994	133.994	133.983	134.017	133.967	133.994	133.952
3	133.984	133.983	134.012	133.970	134.020	134.011	133.986	133.987	133.993	133.988	133.995	133.972
4	134.015	134.038	134.036	133.923	133.990	134.035	133.984	134.016	134.020	133.994	133.999	134.016
5	133.970	134.015	133.966	134.036	133.991	133.986	133.978	134.010	134.016	134.020	134.032	134.045
6	133.993	133.993	134.014	134.050	133.988	133.992	134.001	134.032	134.014	133.988	134.011	134.026
7	133.983	134.004	133.971	134.041	133.998	133.970	133.999	133.981	134.035	134.003	133.995	133.992
8	133.978	133.993	134.052	133.981	134.012	134.028	133.948	133.993	133.996	134.013	134.014	133.976
9	133.968	134.077	133.968	133.997	133.977	134.001	134.003	134.007	133.975	133.990	133.996	133.998
10	133.985	133.984	134.003	133.976	134.016	134.026	133.970	133.974	134.017	133.985	133.997	134.005
11	133.985	133.988	134.020	133.962	134.009	134.035	133.996	133.971	133.993	134.035	134.008	134.017
12	133.995	133.999	133.992	134.023	134.003	133.982	133.975	133.981	133.998	134.024	133.985	134.014
13	134.010	133.969	134.002	133.980	133.995	133.986	133.985	134.009	133.978	134.013	133.975	133.983
14	133.980	133.970	134.007	133.988	133.986	134.018	133.954	134.038	134.022	134.031	133.998	133.978
15	134.043	134.028	134.017	133.940	133.978	134.049	134.013	134.008	133.954	134.018	133.962	133.966
16	133.970	134.024	133.973	133.959	133.958	134.004	134.021	133.951	134.033	134.040	133.990	134.011
17	134.014	133.962	133.999	133.989	133.996	134.030	134.001	133.998	134.014	134.038	133.983	134.028
18	133.948	133.948	133.986	133.997	133.974	133.992	134.006	133.994	134.022	134.002	133.959	133.969
19	133.956	133.996	134.019	134.006	133.981	133.993	134.054	134.012	134.004	134.021	134.018	133.966
20	134.021	133.947	134.010	133.999	134.012	134.010	133.991	133.961	134.009	134.001	134.009	133.999
21	134.013	134.011	134.056	134.023	134.002	134.000	133.989	133.971	133.982	133.971	134.026	133.988
22	133.977	134.024	134.031	133.980	134.026	133.944	133.969	134.026	133.973	133.977	134.006	133.963
23	133.989	133.967	133.935	133.989	133.977	133.999	134.016	134.006	133.959	133.994	134.002	133.980
24	134.038	134.003	134.009	134.035	133.979	134.011	134.024	134.013	133.998	133.996	134.043	134.011
25	133.987	134.007	133.970	133.961	133.981	134.014	133.971	133.993	134.000	134.016	133.999	134.024
26	133.958	134.014	134.012	134.026	133.971	134.017	134.012	134.022	133.957	133.983	134.007	133.980
27	134.059	134.017	133.970	134.006	134.028	134.006	134.013	133.992	134.052	134.021	133.990	133.975
28	134.003	133.992	134.009	134.012	133.996	133.986	133.971	133.979	134.004	133.995	133.973	134.041
29	134.039	133.985	134.017	133.996	134.005	133.980	133.995	133.990	134.005	134.006	134.030	134.006
30	133.966	134.011	133.995	134.005	133.959	134.017	134.026	133.973	134.058	134.020	133.988	133.997
Min	133.923				133.944				133.952			
Max	134.077				134.058				134.058			
Range	0.155				0.114				0.106			
Average	133.998				133.997				134.0011			
Cp	1.17				1.41				1.58			
Cpk	1.15				1.38				1.56			

Where USL = Upper Specification Limit & LSL = Lower Specification Limit

$$Cp = \frac{(134.1 - 133.9)}{0.171} = \frac{0.2}{0.171} = 1.17$$

$$\boldsymbol{Cp = 1.17}$$

$$CpU = \frac{(USL - \bar{x})}{3\sigma} = \frac{(134.1 - 133.998)}{3 X 0.0285} = \frac{0.102}{0.0855} = 1.19$$

$$CpL = \frac{(\bar{x} - LSL)}{3\sigma} = \frac{(133.998 - 133.9)}{3 X 0.0285} = \frac{0.098}{0.0855} = 1.15$$

$$\boldsymbol{Cpk = Minimum(CpU, CpL) = 1.15}$$

For Trial 2

Formula for Standard Deviation is

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where µ = mean of all given N sample
x = value of variables
N = number of sample considered (120 Sample)

$$\mu = \frac{x_1 + x_2 + x_3 + \cdots + x_N}{N} = \frac{16079.675}{120} = 133.997$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (x_1 - \mu)^2 + (x_2 - \mu)^2 + (x_3 - \mu)^2 + \ldots\ldots\ldots + (x_N - \mu)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (134.034 - 133.997)^2 + (134.020 - 133.997)^2 + (133.984 - 133.997)^2 + \ldots\ldots\ldots + (134.005 - 133.997)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = 0.06671065$$

$$\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2 = \frac{0.06671065}{120} = 0.000555922$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} = \sqrt{0.000555922} = 0.023578$$

$$6\sigma = 6 X 0.023578 = 0.141468$$

$$Cp = \frac{(USL - LSL)}{6\sigma}$$

Where USL = Upper Specification Limit & LSL = Lower Specification Limit

$$Cp = \frac{(134.1 - 133.9)}{0.1415} = \frac{0.2}{0.1415} = 1.41$$

$$\boldsymbol{Cp = 1.41}$$

$$CpU = \frac{(USL - \bar{x})}{3\sigma} = \frac{(134.1 - 133.997)}{3 X 0.02358} = \frac{0.103}{0.07074} = 1.45$$

$$CpL = \frac{(\bar{x} - LSL)}{3\sigma} = \frac{(133.997 - 133.9)}{3 X 0.02358} = \frac{0.097}{0.07074} = 1.38$$

$$\boldsymbol{Cpk = Minimum(CpU, CpL) = 1.38}$$

For Trial 3

Formula for Standard Deviation is

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where μ = mean of all given N sample
x = value of variables
N = number of sample considered (120 Sample)

$$\mu = \frac{x_1 + x_2 + x_3 + \cdots + x_N}{N} = \frac{16080.129}{120} = 134.001$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (x_1 - \mu)^2 + (x_2 - \mu)^2 + (x_3 - \mu)^2 + \ldots\ldots\ldots + (x_N - \mu)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = (134.034 - 134.001)^2 + (134.017 - 134.001)^2 + (133.993 - 134.001)^2 + \ldots\ldots\ldots + (133.997 - 134.001)^2$$

$$\sum_{i=1}^{N}(x_i - \mu)^2 = 0.0591645$$

$$\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2 = \frac{0.0591645}{120} = 0.000493037$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} = \sqrt{0.000493037} = 0.0211$$

$$6\sigma = 6 X 0.0211 = 0.1266$$

$$Cp = \frac{(USL - LSL)}{6\sigma}$$

Where USL = Upper Specification Limit & LSL = Lower Specification Limit

$$Cp = \frac{(134.1 - 133.9)}{0.1266} = \frac{0.2}{0.1266} = 1.58$$

$$\boldsymbol{Cp = 1.58}$$

$$CpU = \frac{(USL - \bar{x})}{3\sigma} = \frac{(134.1 - 134.001)}{3 X 0.0211} = \frac{0.099}{0.0633} = 1.56$$

$$CpL = \frac{(\bar{x} - LSL)}{3\sigma} = \frac{(134.001 - 133.9)}{3 X 0.0211} = \frac{0.101}{0.0633} = 1.60$$

$$\boldsymbol{Cpk = Minimum(CpU, CpL) = 1.56}$$

CONCLUSION

It is concluded that as the manufacturing process parameters changes, the SPC parameters also changing. For this review, operation is selected namely Lug Hole Center Distance. The operation is critical from the company point of view, since failure of the dimensions of the operation will result in failure of functioning of the system.

The three trials have taken for SPC analysis. In Trial 1, a specific value of three manufacturing parameters Spindle Speed, Feed Rate and Cutting Depth are selected. The manufacturing process is observed for a day. The capacity of parts producing is 180 parts. The samples of 120 parts have taken in 4 subgroups for inspection. The statistical process control analysis has been performed on these 120 parts. The SPC found out the values of X-bar, Range, Cp, Cpk, etc. based on that data the manufacturing cost have been calculated.

The Trial 2 also performed by selecting another values of production parameters. Same analysis has performed as stated in Trial 1, to inspect change in Process Capability. As there are changes in production parameters, there is improvement in SPC parameters.
To validate the methodology, Trial 3 also taken and results are close to the agreements. Thus it is concluded that there is some relation between the production parameters and SPC parameters. As the production parameters changes the SPC parameters also improved.

Thus, it is concluded that, the process performance has been improved and the process capability indices are optimum.

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How to cite this article:

Sachin B. Patil *et al* (2018) 'Improvements in the Process Performance By Optimizing Process Capability Indices For Lug Hole Center Distance Operation In Modern Automotives', *International Journal of Current Advanced Research*, 07(2), pp. 10108-10113. DOI: http://dx.doi.org/10.24327/ijcar.2018.10113.1699

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