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Enhancement in Process Capability to Improve the Quality of the Boring Process as Smart Manufacturing by Theoretical Approach

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***Abstract:*— Quality has become one of the most important consumer decision factors in the selection among competing products and processes. The quality of conformance is how well the product conforms to the specifications required by the design. The quality can be measured in terms of Process Capability defined as the index of which the process is capable of producing mass products with certain specifications. However, for every product there is certain limits for design, manufacturing and aesthetics. The limit of manufacturing for producing accurate dimensional products may called as specification limits. These limits denote the end criteria for the batch production.**

The approach presented here is to define the meaning of quality and the influence of process capability on batch production. The literature provided for the quality and process capability are useful to study the behavior of the processes under batch production. Certain charts have discussed here to understand the Boring Process.

***Keywords:*----- Boring Process, Process Capability, Quality, Specification Limits, etc.**

I. INTRODUCTION

A. Quality of product

The quality of conformance is how well the product conforms to the specifications required by the design. Quality of conformance is influenced by a number of factors, including the choice of manufacturing processes, the training and supervision of the workforce, the types of process controls, tests, and inspection activities that are employed, the extent to which these procedures are followed, and the motivation of the workforce to achieve quality. Unfortunately, this definition has become associated more with the conformance aspect of quality than with design. This is in part due to the lack of formal education most designers and engineers receive in quality engineering methodology. This also leads to much less focus on the customer and more of a "conformance-to-specifications" approach to quality, regardless of whether the product, even when produced to standards, was actually "fit-for use" by the customer. Also, there is still a widespread belief that quality is a problem that can be dealt with solely in manufacturing, or that the only way quality can be improved is by improving manufacturing processes of the product.

In organizations Quality has more meaning and changes from person to person. The overall description about quality is that ability which superior from something. It is also defined as degree of fitness for some purpose. For example, production workers might see quality as conformance to specifications. If the size of the hole they produce is within their tolerance, it is a good hole. If not, it's bad. Marketing people might think of quality as something that sells well and causes little trouble for the customer. Supervisors see quality when production is higher than normal and there are few reworks. Customers see quality if the product does what they expect it to do without any breakdowns.

B. Statistical Quality Control

Statistical quality control really came into its own during World War II. The need for mass-produced war-related items, such as bomb sights, accurate radar, and other electronic equipment, at the lowest possible cost hastened the use of statistical sampling and quality control charts. Since World War II these statistical techniques have been refined and sharpened. The use of computers in the last decade has also widened the use of these techniques.

Quality and its management played a crucial role in human history. Managing quality was important even for ancient civilizations. Standardization was recognized as the first step towards quality. In ancient Rome, a uniform measurement system was introduced for manufacturing bricks and pipes; and building regulations were in force. Water clocks and sundials were used in ancient Egypt and Babylon (15th century BC) even though they were not terribly accurate. The Chinese Song Dynasty (10th century) even mandated the control of shape, size, length, and other quality factors of products in handicrafts using measurement tools, such as carpenter's squares.

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A number of statistical and analytical tools are useful in analyzing quality problems and improving the performance of processes. The role of some of these tools is illustrated in Fig. 1, which presents a process as a system with a set of inputs and an output. In the case of a manufacturing process, the controllable input factors x1, x2, . . . , xp are process variable such as temperatures, pressures, feed rates, and other process variables. The inputs z1, z2, . . . , zq are uncontrollable (or difficult to control) inputs, such as environmental factors or properties of raw materials provided by an external supplier. The production process transforms the input raw materials, component parts, and subassemblies into a finished product that has several quality characteristics. The output variable y is a quality characteristic, that is, a measure of process and product quality.

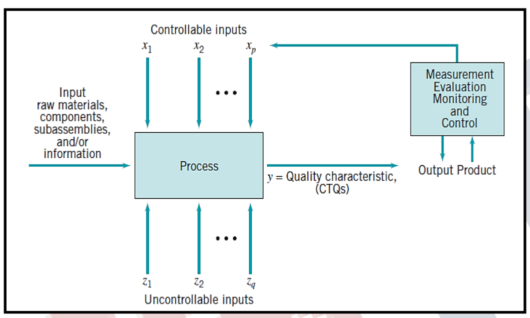

Fig. 1 Inputs and Outputs for Manufacturing Process

There has been a tendency to think that Statistical Process Control and Statistical Quality Control are the same, while the fact is that Statistical Process Control is a measure of process capability and Statistical Quality Control ensures the quality of product being produced. Statistical Process Control is an important part of a successful Statistical Quality Control implementation. Statistical Process Control assumes that poor quality is due to the process. So it is the process that must be monitored to ensure product quality.

Statistical Process Control is the sum total of all technical and managerial efforts to control the manufacturing process for improving and maintaining quality. Statistical Process Control techniques have demonstrated that it is possible to improve both quality and productivity simultaneously. Statistical Process Control should not be limited to control charts only, it is also a diagnostic tool where it tells us, where the problem exists and provides hints on probable causes.

II. LITERATURE REVIEW

As rapid advancement of the manufacturing technology, suppliers require their products be high quality with very low fraction of nonconformities. Traditional methods for measuring fraction of nonconformities become inapplicable for those high quality processes since any manufacturing sample of reasonable size likely contains no defective product items. [1] Classic techniques such as Statistical Process Control (SPC) and Process Capability Analysis (PCA) that form the Statistical Quality Control can be used to identify outliers or special causes of variability. In the event that the distribution is unknown novel tools such as Functional Data Analysis (FDA), have been used successfully in this communication to study these phenomena in situations where the classic quality control cannot. Control charts and the concept of rational subgroups can be used successfully in the search and elimination of outliers. When data do not follow a normal distribution, Functional Data Analysis can be used effectively in the detection of outliers, also contributing major advantages in the detection of specific variability compared to traditional techniques such as Statistical Control Process. [2] Tuning the quality control strategy appropriately to the characteristics of the manufacturing process and the characteristics of the quality inspection using discrete event simulation allows more accurate results than just looking at them in isolation. It combines material transport, production, abrasive tool wear, sorting, bulk handling and quality inspection processes. To overcome the limits of a single measurement system a combination of different metrologies will further improve the overall quality inspection reliability. [3]

The implementation of statistical control charts under auto correlated situations is a critical issue since it has a significant impact on the monitoring capability of manufacturing processes and performance of control charts under different scenarios and to optimize the design of control charts to best deal with auto correlated processes. Statistical process control (SPC) is a methodology used for monitoring and reducing the variation in manufacturing processes and the main tools of SPC are control charts. Normally, SPC works under the assumption that observed data is independent. [4] Statistical process control (SPC) is a powerful technique which organizations can use in pursuit of continuous improvement of both product and service quality. It can be argued that it is not just control charts which makes SPC initiative successful in organizations, rather the emphasis should be on the critical factors which are essential for the success of SPC program and also issues such as "how to get started" and "where to get started". [5] SPC and process capability analysis present powerful means for the analysis of current and previous process behavior and they provide information that serve as a basis for the process improvement. Correct implementation of SPC assures possibility to detect special causes of process variation on time, in order to eliminate them before generating defective products. Process capability analysis entails comparing the performance of a process against its specifications, thus enabling analysis of previous and current process performance, as well as benchmarking. This is of special importance when comparing previous or current process performance with the process performance after improvement. [6] Statistics is the art of making decisions about a process based on an analysis of an information obtained from a process. The SPC tool is used to see when a process is working correctly or not. The approach is the improving quality of product through SPC technique. The achievements in the product quality leads to scope of product in the market. [7] Statistical process control is a well-established and respected method which provides a general purpose, and consistent framework for monitoring and improving the quality of a process. It is routinely used in many industries where the quality of final products is critical. Statistical process control is a powerful tool for investigating and improving proteomics research work-flows. The process of characterizing measurement systems and defining control rules forces the exploration of key questions that can lead to significant improvements in performance. Statistical process control is a very versatile QC technique that utilizes simple but powerful charts and rules. [8]

The capability indices CP, CPU, CPL, k and Cpk are presented and related to process parameters. These indices are shown to form a complementary system of measures of process performance and can be used with bilateral and unilateral tolerances, with or without target values. Capability indices can be used to effectively summarize process information in a succinct manner. The indices Cp, CPU, CPL, k and Cpk form a group of complementary measures that comprise a convenient unitless system. These measures collectively determines whether a process has sufficiently low variability to meet the process specification or whether process location is a problem. They can be used with one sided or two sided specification limits and can be generalized to use with target dimensions. Perhaps the greatest value of these indices is that their use encourages efforts to prevent production of nonconforming products and they provide a method to monitor continuous improvement on a broad scale. [9]

A capability indices, containing Cp, Cpk, Cpm, and Cpmk, is defined by varying the parameters of the studied class, indices with different properties can be found. Two estimators of the indices are considered and, assuming that the studied characteristic of the process is normally distributed and that the target value is equal to the mid-point of a two-sided specification interval, their expected values, variances, and mean square errors are derived. By studying the properties of the class of indices alone, without taking the properties of its estimators into account, might be misleading. [10]

III. METHODOLOGY

The boring process is one of the important manufacturing processes. The boring is affected by various manufacturing parameters like speed of spindle, feed and cutting length. Here the entry caliper of an automotive brake system is considered for analysis purpose. The dimension which is to be measured is lug distance between two holes. The base dimension for lug distance is 128 mm and the tolerance allowed is ± 0.1 mm. Total 60 numbers of samples in four sub groups are tested and inspected by using dial snap air gauge having Least Count of 0.001 mm. the data can be formulated in excel and converted in array form as shown in Table 1. The data analysis i.e. formation of averages and range for each subgroups has been tabulated as shown in Table 2.

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Table 1 Data Collection of Lug Distance as Measured Parameter

Samples	Sub Group 1	Sub Group 2	Sub Group 3	Sub Group 4
1	128.029	128.033	128.042	128.024
2	128.047	128.046	128.025	128.034
3	128.050	128.010	128.021	128.019
4	128.050	128.008	128.049	128.015
5	128.028	128.020	128.057	128.014
6	128.046	128.006	128.032	128.028
7	128.063	128.004	128.046	127.979
8	128.062	128.027	128.038	128.008
9	128.032	128.055	128.042	128.034
10	128.048	128.002	128.054	128.022
11	128.064	128.032	128.048	127.996
12	128.045	128.022	127.997	127.997
13	128.060	128.006	127.997	127.997
14	128.031	128.035	127.997	127.997
15	128.088	128.024	127.997	127.997

Control Chart

The control charts has evolved by Sir Walter Shewhart around 1920s. The basic purpose of the control charts are to determine whether the manufacturing process is in specified limits or out of specified limits. Two main charts are more helpful to inspect the manufacturing process are X-bar chart and R-chart.

The X-bar chart determines the no of parts produced within specification limits. The specification limits are moreover the upper and lower bounds for manufacturing process and required because of variation in process parameters, labor errors for inspection and properties of materials.

Table 2 Data Formulation for Averages and Range

Samples	$\bar{X}$	Range
1	128.0320	0.018
2	128.0380	0.022
3	128.0250	0.040
4	128.0305	0.042
5	128.0297	0.043
6	128.0280	0.040
7	128.0230	0.084
8	128.0337	0.054
9	128.0407	0.023
10	128.0295	0.052
11	128.0350	0.068
12	128.0152	0.048
13	128.0150	0.063
14	128.0150	0.038
15	128.0265	0.091
Average	128.0278	0.0484

These bounds are often called as tolerances. The tolerances are of two types i.e. Upper specification limit (USL) and Lower specification limit (LSL). The dimensions of lug distance should be in between these USL and LSL in order to have proper control on manufacturing process. The fig. 2 shows the X-bar chart for data collected from table 1.

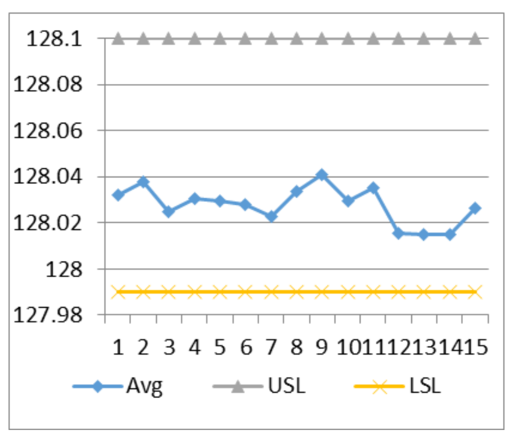

Fig. 2 X-bar chart for Collected Data

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The fig. 3 shows the R-chart for the collected data. The R-chart determines the range between maximum and minimum of measuring distance. It defines the variation in the measurement with respect to the control limit (CL). The control is the limit of average of all the ranges of samples. The R-chart denotes that, how much shifting of distances will be for each sample.

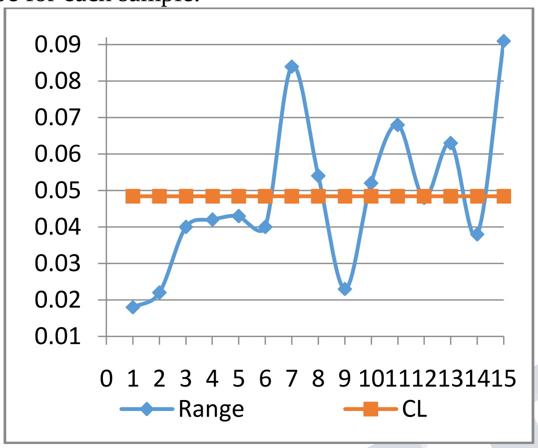

Fig. 3 R-chart for Collected Data

Histogram

A histogram is a graphical representation of the conveyance of numerical information. It is a gauge of the likelihood conveyance of a continuous variable and was initially presented by Karl Pearson. To develop a histogram, the initial step is to "bin" the scope of qualities—that is, divide the range of qualities into a certainty of intervals—and after that number what number of qualities fall into every interval. On the off chance that the bins are of equivalent size, a rectangle is raised over the container with tallness corresponding to the recurrence — the quantity of cases in each receptacle. A histogram may likewise be standardized to show "relative" frequencies.

The histogram for the data is shown in fig. 4. It is obtained by use of frequency of distribution. The collected data is divided into seven intervals known as bins. Each bin has certain limits equal to range of the sampling. The samples are counted for each interval in which they falls. The histogram is constructed by using these intervals and the possible units obtained by frequency distribution. The histogram is more helpful to analyze data and finds distribution of samples in intervals.

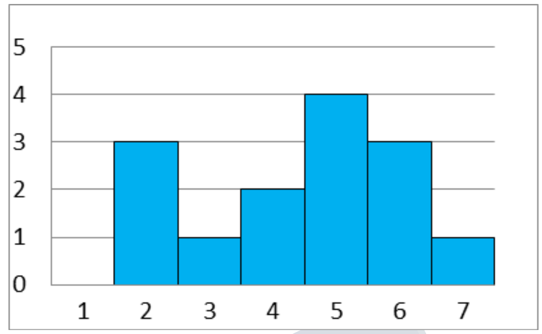

Fig. 4 Histogram for Collected Data

CONCLUSION

From this study it is concluded that, boring process affected by various parameters like spindle speed, feed and length of cut. The lug distance is measured by dial gauge. The 15 samples of each four sub groups are inspected and used for the statistical process control application.

The tool of SPC is more effective and provides better solution to process control. The X-bar chart shows the boring process is in control and R-chart determines the variation of a sample with mean. The maximum variation leads to the process is out of control. However from R-chart it is concluded that the process has better performance. The SPC tools could be successfully applied to non-normal data distribution and it could have better results.
Thus, it is concluded that the SPC tools could provide an idea for understanding the manufacturing process.

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