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STATISTICAL PROCESS CONTROL – EFFECTIVE TOOL OF QUALITY CONTROL

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Abstract
Exponential growth is observed in quality development since a century. World has become very narrow in terms of business and market. Total Quality Management (TQM) Technique is introduced to help the organizations to grow in world market. It is a continuous development process to meet expectations of customers and satisfy their demands. One of the TQM methods is Statistical Process Control to improve quality and decrease variation. It helps to eliminate the process randomness, to develop an effective technique to analyze and a systematic way of thinking and problem solving. This paper discusses different terminology, procedure and method of SPC. Salient features of the present volume of research work is discussion on process capability and step by step procedure to draw control charts.

Keywords: Statistics, Statistical Control, Statistical Process Control (SPC), process capability, control charts.

I. Introduction

Statistical Process Control is made up of three words. Statistics, Statistical Control and 3. Statistical Process Control.

1. Statistics: A value calculated from or based upon sample data (e.g., a subgroup average or range) used to make inferences about the process that the produced the output from which the sample comes.
2. Statistical Control: The condition describing a process from which all special causes of variation have been eliminated and only common causes remain.
3. Statistical Process Control (SPC): The use of Statistical techniques such as control chart to analysis a process or its output so as to take appropriate actions to achieve and maintain a state of statistical control and to improve the process capability.

II. Literature

Quality of the product or service can be determined by the process employed to develop a method plays a crucial role. Every organization should develop a standard, organized procedure for best quality. Statistical Process Control is the best tool to develop better quality products, to control & improve the process, to identify the reasons for quality problems and reduce variability in product output, in making delivery, in maintenance, in equipment use etc. [1]

H. G. Wells has mentioned the goals of SPC as collection of data, finding out variations, analyzing through brainstorming, finding out the causes and effects, continuous improvement [2]. Dr. Kaoru Ishikawa first introduced and mentioned benefits of these quality control techniques to the workers in Japan in 1968.

The concepts, need, steps, use and advantages of the seven basic quality control tools - pareto diagram, process flow chart, cause and effect diagram, check sheet, histogram, scatter diagram and control chart were illuminated by A. Mystica & J. Mary Suganthi Bai [3].

Studying the statistical process control tool in manufacturing systems with the broad aim of upgrading them to improve on quality and cost effectiveness was focused by Ignatio Madanhire & Charles Mbohwa [4].

The basic techniques of multivariate statistical process control (MSPC) under the dimensionality criteria, such as Multiway Principal Component Analysis, Multiway Partial Squares, Structuration à Trois Indices de la Statistique, Tucker3, Parallel Factors, Multiway Independent Component Analysis, Multiset Canonical Correlation Analysis, Slow Features Analysis, and Parallel Coordinates were highlighted by Miriom Ramos et al. [5].

The objective of research work presented by Laura Nabero Horácio et al. is to analyze and raise the problems reported by various sectors of the company in the manufacture of rollers and foam blocks. Factors such as problems related to quality, variation in size and quality of the equipment were observed, using the tools CEP (statistical process control) and control charts [6].

Sarah Isniah and Humiras Hardi Purba reviewed the 2016-2020 research papers that consistently apply the SPC method and have been published [7]. Published and relevant literature meta-analyses to provide some evidence of the effect of the existence of the implementation of the SPC method with several classifications were reviewed, which includes the growth of research publications in the manufacturing sector and other sectors. The results of research literature that have been published from 2015 - 2020 is this research is useful as a basis for developing knowledge, gaps in views, providing evidence of effects, and if done well, has the capacity to be applied as further research ideas. Elimination of waste as reduce defect and increasing quality and improving process can be achieved through SPC. As the SPC method implements must be carried out continuously, high process commitment is required for subjective application of the SPC method.

III. Statistical Quality Control

3.1 Tools for process control

1. Detection: A past oriented strategy that aims to identify unacceptable output after it has been produced and then separates it from the good output.
2. Prevention: A future oriented strategy that improves quality and productivity by directing analysis and action toward correcting the process itself so that unacceptable parts will not be produce.

3.2 Why is SPC required?

Effectiveness of any activity in an organization is measured with respect to time and cost involved in it.

Let us compare Mistake Proofing, 100 % Inspection and Statistical Process Control.

1. Mistake Proofing: In this technique, 100% process control is achieved by sealing all types of failures by using modern techniques to get defect free product. Here causes are prevented from making the defect. In this method, modern techniques are used which require substantial investment during its installment and maintenance. However, time required in this technique is very less.
2. 100 % Inspection: In this technique, 100% checking of all the parameters of all products are done to get defect free product. Here only defects are detected. As it is detection type of technique, it can't avoid failure but reject defective products which increase waste and also payment of inspection staff is involved. As all parameters of 100% components are to be checked, it requires more time.
3. Statistical Process Control: In this method, statistical techniques such as control chart, histogram etc. are used so as to analyze the process, achieve & maintain state of statistical control to get defect free product. Causes are detected and prompting corrective actions before defect occurs. For this technique, investment is very less and process is controlled on each work station. Therefore, defective components are not forwarded to next operation. Process is controlled at each instant, which avoids further waste.

Mistake proofing takes less time, but involves more cost. 100 % Inspection consumes more time and efforts. SPC offers blend of advantages. Above comparison shows that SPC is more effective with respect to cost and time compared to Mistake Proofing and 100% inspection.

3.3 Statistical Process Control - Terminology

- Variation: The inevitable differences among individual output of a process the source of variation can be grouped into two in two major classes: Common Causes and Special Causes.
- Common Causes: A source of variation that affect all the individual values of the process output and inherent in the process itself and cannot be eliminated totally.
- Special Causes: A source of variation that is intermittent, unpredictable, and unstable. These causes can be identifiable and can be eliminate permanently.
- Types Of Variation

Random Variation: Characteristics are: Only common causes are present, Process can be statistically control, Process is predictable, Management is responsible to remove it.

Non-Random Variation: Characteristics are: Both common and special causes are present, Process cannot be statistically control, Process is predictable, Operator is responsible to remove it.

- Process Control: A process is said to be operating in state of statistical control when the only source of variation is common causes.
- Process Stability: The process is said to be stable when the process is in control and variation is constant with respect time.
- Process Capability: The measure of inherent variation of the process when it is stable condition is called as process capability.
- Over Adjustment: It the practice of adjusting each deviation from the target as if it was due to a special cause of variation in the process. If stable process is adjusted on the basis of each measurement made, then adjustment comes an additional source of variation.
- Predictable Process: Process free from assignable cause.
- Capability: Measure of inherent variation.
- Capable Process: C_p & C_{pk} > 1.33) Cp and Cpk measure your consistency compared to your average performance. The ‘k’ stands for ‘centralizing factor.’)
- Measurement System Analysis (MSA):

Measurement System Analysis measures the contamination of variation due to measurement system in the total variation of characteristic. In this technique both variable and attribute data measurement systems are verified.

Following types of variations are observed in M.S.A.

1. Equipment Variation: Variation of measuring instrument.
2. Appraiser Variation: Variation between measuring persons.
3. Combine Variation: Variation of both instrument and person.
4. Part to Part Variation: Variation comes when measuring two different parts.
5. Within Part Variation: Variation comes when measuring same part at different places.

3.4 Statistical Process Control – Procedure & Methods

- Definitions:

1. Sample: It is item or group of items which represent the whole process to provide the purpose of estimation of process at that time when sample is taken.
2. Subgroup: Group of one or more samples or measurement used on analysis the performance of process is called subgroup.

- Guidelines for plotting X_{bar} & R Chart.

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- Subgroup should be chosen so that opportunities for variation among the units within a subgroup are small and pieces within each subgroup would all be produced under very similar production condition over a very short time interval.
- Subgroup frequency should be such major source of variation have had an opportunity to appear.
- Set the scale spacing for the range chart to be double that of average chart.
- The R chart is analyzed first as subgroup ranges or subgroup averages depends on the place-to-place variability.

• Procedure :

I. Fix the sample size and subgroup frequency.
II. Fill up the reading in the subgroup according to their numbers.
III. Plot the readings in the control chart as follows.

• R CHART: Range chart is used to the process variation.

1. Range is different between maximum and minimum reading in the subgroup.
   Range = R = X_{max}-X_{min}.
2. R_{bar}= Average of range = (R_{bar1} + R_{bar2} +……+ R_{barm}) / m

where, R_{bar1} = Range of first subgroup
R_{bar2} = Range of second subgroup
R_{barm} = Range of m^{th} subgroup
m = Number of subgroups

3. Control Limits for R Chart

I. Upper Control Limits = UCL = D_4 * R_{bar}
II. Lower Control Limits = LCL = D_3 * R_{bar}

where, R_{bar} = Average of all ranges
D3, D4 = Constant depend upon the sample size.

• X_{bar} CHART: This chart is used to study location of distribution.

1. Average is the sum of values divided by the number of values designated by a bar symbol for the values being averaged.

Average = X_{bar} = (X_{bar1} + X_{bar2} + X_{bar3} +……+ X_{barm}) / m

2. X_{bar} = Average of average = (X_{bar1} + X_{bar2} + ... + X_{barm}) / m

where, X_{bar1} = Average of first subgroup
X_{bar2} = Average of second subgroup
X_{barm} = Average of m th subgroup
m = Number of subgroups

3. Control Limits for X Chart

I. Upper Control Limits = UCL = X_{bar} + A_2*R_{bar}
II. Lower Control Limits = LCL = X_{bar} – A_2*R_{bar}

where, X_{bar} = Average of all average
A_2 = Constant depend upon sample size.

• How to calculate capability?

Standard Deviation (δ)

Standard Deviation is a measure of the spread of the process output or the special of a sampling of a stamping statistics from the process. (e.g., of sub-group averages). It is denoted by Greek letter δ (Sigma) = R_{bar} / D_2

Capability Index for Bilateral Specification (Cp)

In the case of bilateral specification, we also define C_{pk} that takes into account the centering (or decentering) of the process which the coefficient Cp cannot do.

➢ Case of a maximum limit or a decentering towards the upper side of the characteristics.

C_{pk} = (USL - X_0) / 3δ

➢ Case of a minimum limit or a decentering towards the lower side of the characteristics.

$C_{pk} = (X_0 - LSL) / 3\delta$

Note: In the case of bilateral specification, calculate both the values and take minimum of two as C_{pk}.

Interpretation of C_p values		**Interpretation of C_{pk} values When $C_p = 1.33$**	
$C_p < 1$	Not capable	$C_{pk} = 0.66$	Reject
$C_p = 1$	Merely capable	$C_{pk} = 1$	Risky
$C_p = 1.33$	Acceptable	$C_{pk} = 1.33$	Centered
$C_p = 1.66$	Performing	*C_{pk} should not be	Greater than Cp

Table 1: Interpretation for process capability

IV. Conclusion

Statistical Process Control techniques are very useful to monitor and improve quality in manufacturing and service sectors. With proper use of all method of SPC, application can be widened to modern day requirements like healthcare, computer industries etc. This is very effective tool in hands of manufacturer, process control managers and quality control managers to satisfy present age high demands of quality at comparatively lower cost. Cost cannot be reduced at the cost of quality. Cost can be reduced by eliminating waste, reducing defects and decreasing rejections. Here is the role of SPC, implement it, get better quality and high economic advantage.

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