STATISTICAL PROCESS CONTROL

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Abstract

The deployment of statistical process control (SPC) in manufacturing environments is a prominent global phenomenon. Statistical Process Control is largely used in industries for monitoring the process parameters. It is a standard method for visualizing and controlling processes on the basis of measurements of randomly selected samples. The decisions about what needs to be improved, the possible methods to improve it, and the steps to take after getting results from the charts are all made by humans and based on wisdom and experience. The statistical process control described in this paper gives the details about the SPC, its advantages and limitation, applications and information regarding the control charts.

Keywords: *Statistical Process Control, Control chart, 5M's, Capability Indices.*

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1. INTRODUCTION:

Statistical Process Control (SPC) is a procedure for open or closed loop control of manufacturing processes based on statistical methods. This procedure helps in monitoring the process behavior. It is a standard method for visualizing and controlling processes on the basis of measurements of randomly selected samples.

The main objective of SPC is to ensure that the planned process output is achieved and the related customer requirements are fulfilled. In this process control, randomly some parts are taken from the manufacturing process and then their characteristics are measured and shown on the control charts. Statistical indicators are determined from the measurements and used to evaluate the current status of the process. If required, the process is rectified with some appropriate actions.

2. TERMS USED FOR SPC:

2.1 Process

A process is a series of activities which transforms the raw materials or pre-machined parts or components into a finished product.

The definition is as follows: "Set of interrelated or interacting activities which transforms inputs into outputs."

2.2 Stable Process

Process which is in a state of statistics control. In this type, the location and variation of the process characteristics are stable over the time.

2.3 Quality-Capable Process

A process having capability to completely fulfill the specified requirements.

2.4 Shewhart quality control chart

It is used for monitoring a parameter of the probability distribution of characteristics, in order to determine whether the parameter varies from a specified value.

2.5 Capability and Performance Indices

Quantitative measures for evaluating capability include the machine and process capability or process performance indices. These must achieve or surpass the specified minimum values. The minimum requirements for process capability or performance may exist for special characteristics, or may be specified internally on a product-by-product basis.

2.6 Machine Capability Study

The machine capability study is a short-term study with the sole aim of discovering the machine-specific effects on the production process.

2.7 Process Capability Study

The process capability study is a longer-term study. In addition to variation arising from the machine, all other external factors that influence the production process over a longer operating time must be taken into account.

2.8 Capability Indices Cmk, Cpk and Performance Index Ppk

In accordance with the QS-9000 reference documents, the term Cpk must only be used for a stable process. A process is stable if the following synonymous statements apply to it:

- Mean and variance are constant.
- No systematic variations of the mean such as trend, batch-to-batch variation, etc., occur.
- There is no significant difference between sample variation and total variation.
- Every sample represents the location and variation of the total process.

2.9 Machine Capability Study:

A machine capability study concentrates exclusively the characteristics of the machine, i.e. to the extent possible, the influence or effects of variables external to the machine (noise factors) are minimized. Some examples of variation sources are:

Man:

- Personnel
- Shift changes

Machine:

- Speed
- Feed rate
- Tools
- Cycle times
- Coolant flow rate and temperature
- Pressures
- Current (in the case of welding equipment)
- Power (in the case of laser welding)
- Change status (in the case of optimization measures)

Material:

- Semi-finished products, rough parts or blanks from different lots or Manufacturers

Method:

- Run-in (warm-up) time of the machining facility before sampling
- Differing pre-machining or production flow

Milieu (Environment):

- Room temperature (temperature changes during production of the sample).
- Relative humidity, atmospheric pressure
- Vibration acting upon the machining facility
- Location of the machining facility in the building (storey)
- Unusual events

It is expected that only the machine's inherent sources of variation will affect the product and its characteristics if these possible influences are kept constant. In cases where this is not possible, the changes in the external influencing factors should be documented in the record of test results. This information can be used as the basis for optimization measures if the capability specifications are not met.

3. TOOLS FOR SPC:

Seven basic tools for quality improvement are used for statistical process control as given below.

- Check sheet
- Run chart
- Histogram
- Pareto chart
- Scatter diagram/chart
- Cause and effect or fishbone diagram
- Control chart

4. CONTROL CHART:

Control chart is the most successful statistical process control tool, developed by Walter Andrew Shewhart in early 1920s. Control charts may be used to monitor a process to determine whether or not the process is in statistical control, to evaluate a process and determine normal statistical control parameters and to identify area of improvement in process.

Control charts attempt to differentiate between the types of process variation:
Common cause variation: It is intrinsic to the process and will always be presents. It is also known as Chance cause variation.
Special cause variation: Special cause variation stems from external source and shows that the process is out of statistical control. It is also known as assignable cause variation or Out of Statistical Control.

Other Process monitoring tools are:

1. **Cumulative Sum (CUSUM) charts:** In these charts, the ordinate of each plotted point represents the algebraic sum of the previous ordinate and the most recent deviation from the target.
2. **Exponentially Weighted Moving Average (EWMA) charts:** In these charts, each point on chart represent the weighted average of current and all previous subgroup values, giving more weight to recent process history and decreasing weight for older data.

In order to correctly explain the results, one have to know which mathematical model to use, where its limits are and to what extent it can be used for practical reasons, even if it differs from the actual situation.

Control charts can be employed for both discrete (countable) and continuous (measurable) characteristics. Continuous variables are those which can be calculated over a continuous range, such as averages, dimensions (length, width, and height), weight and temperature. Discrete characteristics are those which can be counted, such as number of product manufactured of number of parts.

5. 5M's of SPC:

The 5M's of SPC i.e. man, machine, material, method and milieu are the primary groups of input. Each "M" can be subdivided, e.g. milieu (environment) in temperature, vibration, humidity, contamination, lighting, etc.

1. **The Man** does not set the machine consistently or thereafter works without concentration; causes fluctuations, in readings.
2. **The Machine** is subjected to temperature fluctuations, clearance in guides and bearings and also to joints and vibrations-all of this can lead to deviation in dimension more or less.
3. **The Material** can have non-homogeneous composition, inconsistent hardness, internal stresses etc.
4. **The Method** for the components that are being manufactured can be wrong. In this case, it would be judicious, that components are manufactured with another method.
5. **The Milieu** (Environment) may differ from time to time and place to place.

In spite of careful process control, some uncontrolled random effects of several input cause the deviation of actual characteristics value from their target values.

The random effects of several inputs ideally result in a normal distribution for the characteristics. A normal distribution can be characterized by two parameters i.e. the mean (μ) and the standard deviation (Sn). The graphic representation of the density function of a normal distribution show a typical bell shaped curve, whose inflection point lie at $\mu-\sigma$ and $\mu+\sigma$.

Within SPC, the parameters μ and σ of the distribution of the characteristic are determined from the random sample values and the results obtained are used to assess the current status of the process.

6. ADVANTAGE OF SPC IMPLEMENTATION:

- It could improve process performance by reducing product variability
- Improves production efficiency by decreasing scrap and rework
- Leads to higher quality product by reducing: variability and defects
- Improving their overall business competitiveness
- Minimize rework
- Minimize lost of sales
- Maintain a desired degree of conformance to design
- Eliminate any unnecessary quality checks
- Reduce the percentage of defective parts purchased from vendors
- Reduce returns from customers

7. DISADVANTAGE OF SPC IMPLEMENTATION

SPC can take time to apply rigorously but applications do show that there are few, if any, disadvantages to SPC. Its application must remain relevant and useful, rather than becoming a system 'for its own sake'. Problems can occur in introducing it to avowed innumerate.

8. APPLICATIONS OF SPC:

The application of SPC involves three main sets of activities:
1. The first is understanding the process. This is achieved by business process mapping.
2. The second is measuring the sources of variation assisted by the use of control charts.
3. The third is eliminating assignable (special) sources of variation.
It can be used in various industries for improving the quality of the product and helps in lowering the product costs as it provides a better product and/or service.

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