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# STATISTICAL PROCESS CONTROL TOOLS FOR QC

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## ABSTRACT

This work presents a case study on the application of quality tools to improve product quality. One component was selected as object study because it presented higher percentage of nonconformities and was increasing over time. Before mass production, in pre-production, Statistical Process Control (SPC). It was performed, and it was concluded that the process was capable. No further SPC was done during production. After defective units were detected at increasing levels, it was apparent that process variability had increased and the process was no longer capable. The study ends with the development process improvement activities. In order to endure in an aggressive market, getting better quality and production of product or process is a must for any industry. SPC is an efficient controlling methodology for analysing, monitoring, managing, and recuperating process performance.The biggest benefits for implementing SPC in industries are enhanced Quality and Condensed Process Variation.

**KEYWORDS:** Statistical Process Control, QC tools, Process Variability, Development process, Better quality.

## INTRODUCTION

Statistical process control, one of the major quality techniques being emphasized as part of the resurgent focus on quality in this country, has gained wide acceptance among quality control experts. The long-term benefits of this technique are increased communications among all departments, better insight into cost reduction, continuous quality improvement, and effective design and fabrication interface. The "total quality process is a never-ending endeavor to add new value to a product or service. This total quality approach presents a sharp constant to the detection/inspection mode of quality control prevalent in industry over the last four decades, a mode that is costly and does not enhance either product or service.[1] In the emerging total quality environment, a fundamental understanding of all process is essential for continuous improvement. The objective of Total Quality Management (TQM) is to broaden the focus of quality to embrace the concept of a continuous improvement process as a means by which an organization creates and sustains a positive and dynamic working environment, fosters teamwork, applies quantitative methods and analytical techniques and taps the creativity and integrity of all its people. As defined by the Department of Defence, Total Quality Management (TQM) is both a philosophy and a set of guiding principles that represents the foundation of a continuously improving organisation TQM is the application of quantitative methods and human resource to improve the material and services supplied to an organisation all the process within an organisation, and the degree to which the needs of the customer are met, now and in the future. TQM integrates fundamental management techniques, existing improvements efforts, and technical tools under a disciplined approach focused on continuous improvement.[2] The term quality is widely used by practitioners and academics, although there is no generally accepted definition as different definitions of quality are appropriate under different circumstances. While not a universally accepted definition, quality can be defined by this definition, written by the world’s largest international standard developer and publisher (ISO 9000, 2005) by keeping in mind the ever-changing standards: Quality is a situation when a set of inherent characteristics consistently fulfil the continuously changing requirements of the organization’s customers and other stakeholders.[3] Quality and quality control are inseparable puzzle pieces. When quality control is carried out by conditions and requirements and the right quality control instruments are used, it makes a great contribution to the process of maintaining and improving quality. In this research, quality control methods and quality control processes will be examined and the importance of quality control tools on the sustainability of quality will be investigated. In today’s competitive environment, manufacturers have created needs such as lower production costs, more production in less time, high quality production process. There are different quality control tools applied to improve product quality according to expectations. In this article, these quality control tools and process will be examined. In addition, the use of different quality control tools to improve production quality are determined. There are too many defects in the production process, which adversely affect the profitability, productivity and production quality of companies. This research aims to examine the research work done by the researchers, to produce technical solutions to various defects and make improvements in the production process.[4] The basic issue in a qualityoriented organization is to what level we can satisfy customers expectations. One of the key techniques used to guarantee a specific standard of quality in a good or service in accordance with consumer expectations is quality control.[5] A product should be produced in a suitable process in order to have an acceptable level of variation in the specified quality index relative to their stated specifications[6] Statistical process control (SPC) is a statistical method that is frequently employed to make sure the process meets the standards. Statistical process control (SPC) is commonly used in manufacturing process to monitor standards, take measurements, and corrective action.[7] The SPC can be helpful not only for examining a single sample but also to monitor consistency over time. This is accomplished by using control charts to determine whether the process is considered to be performing appropriately or whether it is out of control.[8] The SPC involves collecting samples and determining if the mean, range, or standard deviation are all included with in the confidence interval indicated by limits on a control graph, also termed as a control chart.[9] A good business event if in manufacturing or service cannot be separated from the consumer and the product. Along the advances information and technology today, the company is required to face consumers who are increasingly sensitive to the quality of goods or services that they wish to consume. To face this condition the company must pay attention to the quality of its products and intensified to produce quality of the goods and services, so that the product can accepted by consumers and competence in the market with the other products. The company's quality control is necessary needed, by producing the customers needs the company will attract consumers to buy the company's products in fulfilling their needs. So that from the consumer buying company can increase profits. Many methods can be used to control the quality with each characteristic. The control chart is one commonly used tool in the measure and control phase. Control charts can also act as a means of organizational learning.[10]

## METHODOLOGY

The quality control process consists of some basic steps. First, the production process to be controlled is selected, and then the targeted quality standards for the products are determined. The performance after production is measured and the quality standards of the targeted and final product are interpreted, if there is a difference between the two, R&D studies are carried out, and the product is put into production again to reach the targeted quality measure. There are 7 quality tools that are very effective in solving quality problems at the Quality Control stage. These are as follows:

1) Flow Chart
2) Cause and Effect Diagram (Fishbone or Ishikawa Diagram)
3) Check Sheet
4) Pareto Chart
5) Scatter Diagram
6) Histogram
7) Control Chart

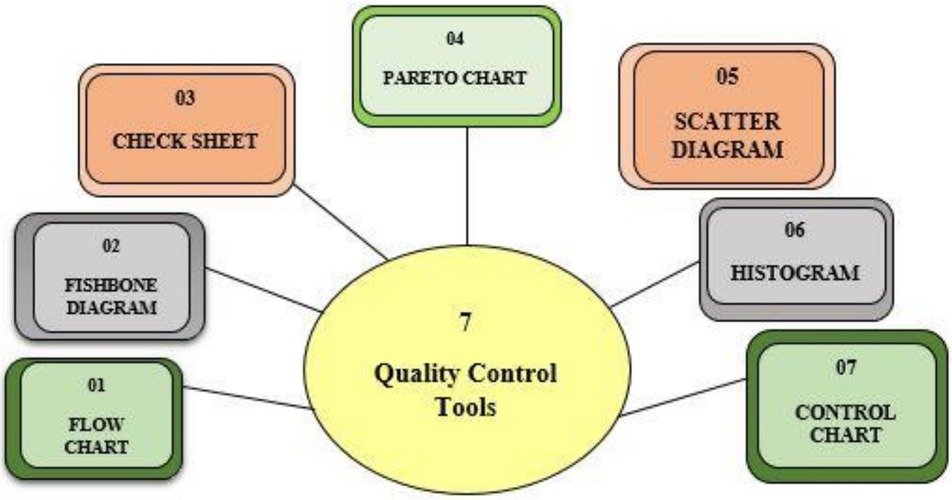


**Figure 1: Quality Control Tools**

The Fishbone Diagram which is called "The Cause and Effect Diagram" is based on the logic of "All the cause that create the problem are caused by some sources" through the cause-effect relationship; it is created to show, visualize and analyse the cause that produce the results. Causes are divided into main categories in order to identify the sources causing the error and sub-reasons such as people, methods, materials, measurements, environment, etc. are added to these categories. The main purpose is to prevent quality errors that may occur. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories. When identifying possible causes for a problem and a team's thinking tends to fall into ruts it's a useful method.[11,12]

**1) Flow Chart:**

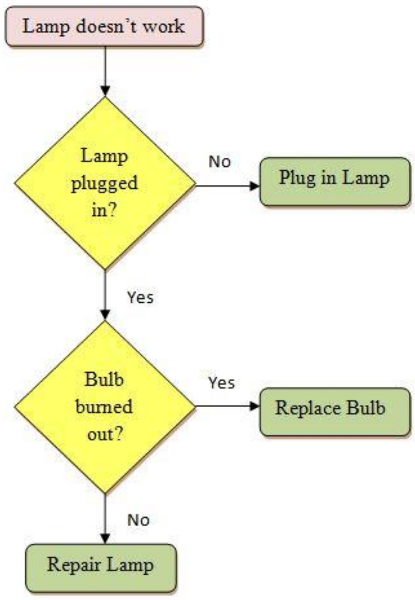


**Figure 2: Flow Chart**

A type of diagram that represents a workflow or process. A flowchart can also be defined as a diagrammatic representation of an algorithm, a step-by-step approach to solving a task\. The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. This diagrammatic representation illustrates ab solution model to a given problem. Flowcharts are used in analysing, designing, documenting or managing a process or program in various fields.[13] Flowcharts are used to design and document simple processes or programs. Like other types of diagrams, they help visualise the process. Two of the many benefits are that flaws and bottlenecks may become apparent. Flowcharts typically use the following main symbols:

- ❖ A type of diagram that represents a workflow or process, A flowchart can also be defined as a process step, usually called an activity, is denoted by a rectangular box.
- ❖ A decision is usually denoted by a diamond.

A flowchart is described as "cross-functional" when the chart is divided into different vertical or horizontal parts, to describe the control of different organisational units. A symbol appearing in a particular part is within the control of that organisational unit. A cross-functional flowchart allows the author to correctly locate the responsibility for performing an action or making a decision, and to show the responsibility of each organisational unit for different parts of a single process.

**2) Cause and Effect Diagram (Fishbone or Ishikawa diagram)**

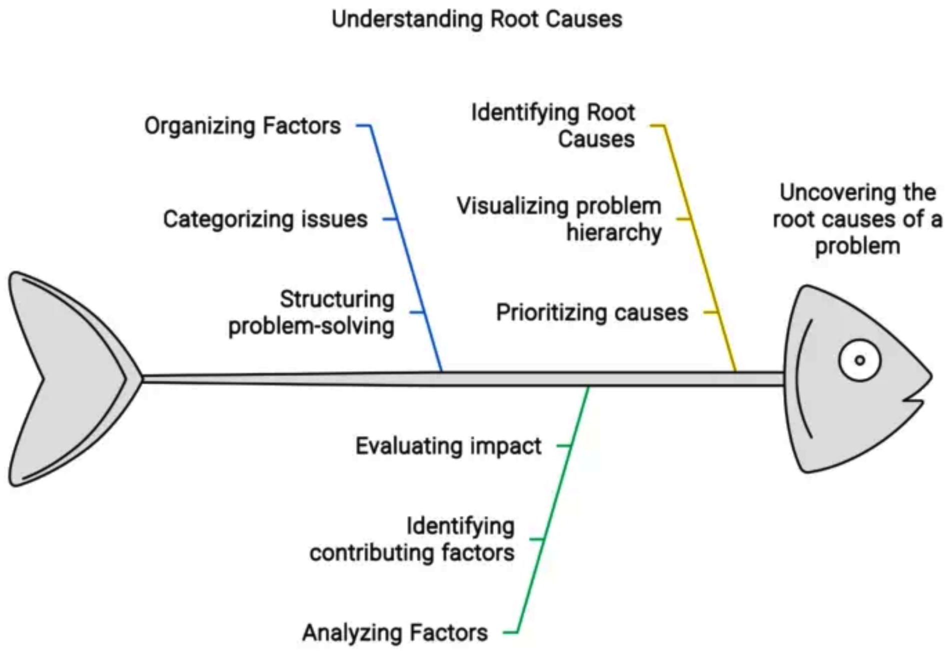


**Figure 3: Cause and Effect Diagram (Fishbone or Ishikawa Diagram).**

Ishikawa diagram (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagram) are casual diagrams created by Kaoru Ishikawa that show the potential cause of a specific event [14]. Common uses of the Ishikawa diagram are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. The defect, or the problem to be solved, is shown as the fish's head, facing to the right, with the causes extending to the left as fishbone: the ribs branch off the backbone for major causes, with sub-branches for root-causes, to as many levels as required.[15] Ishikawa diagrams were popularized in the 1960s by Kaoru Ishikawa. Who pioneered quality management processes in the Kawasaki shipyards,and in the process became one of the founding fathers of modern management. The basic concept was first used in the 1920s, and is considered one of the seven basic tools of quality control.[16] It is known as a fishbone diagram because of its shape, similar to the side view of a fish skeleton. Mazda Motors famously used an Ishikawa diagram in the development of the Miata (MX5) sports car. The Ishikawa diagram has been widely adopted across various industries as an effective tool for root cause analysis and service contexts. In the manufacturing industry, particularly in the automotive and electronics sectors, the diagram is frequently used in continuous improvement initiatives such as Six Sigma and Lean Manufacturing.

### 3) Check Sheet:

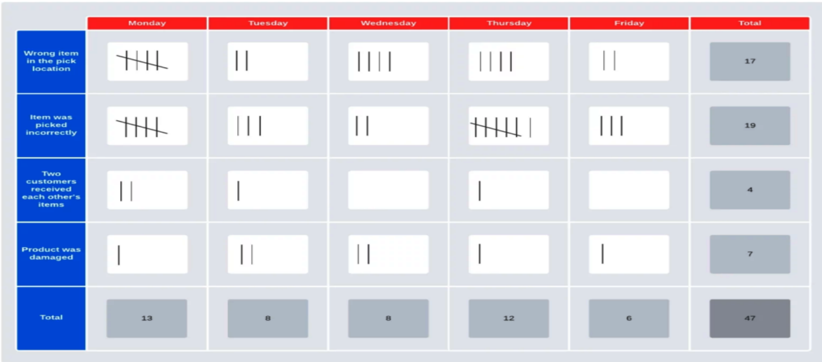


**Figure 4: Check Sheet**

A check sheet is a form used to collect data in real time at the location where the data is generated. The data it captures can be quantitative or qualitative.When the information is quantitative, the check sheet is sometimes called a tally sheet [17]. The defining characteristics of a check sheet is that data are recorded by making marks ("checks") on it. A typical check sheet is divided into regions, and made in different regions have different significance. Data are read by observing the location and number of marks on the sheet.

Check sheets typically employ a heading that answers the Five ways:

- Who filled out the check sheet
- What was collected (what each check represents, an identifying batch or lot number)
- Where the collection tool place (facility, room, apparatus)
- When the collection tool place (hour, shift, day of the week)
- Why the data were collected.

**Function:**

Kaoru Ishikawa identified five uses for check sheets in quality control:

- To check the shape of the probability distribution of a process
- To quantify the defects by type
- To quantify defects by location
- To quantify defects by cause (machine, workers)

**4) Pareto Chart:**

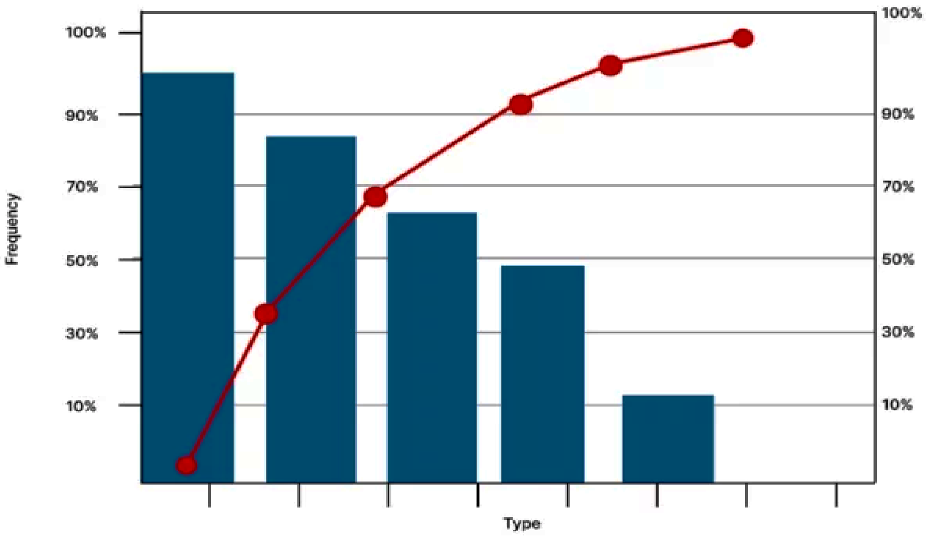


**Figure 4: Pareto Chart.**

A pareto chart is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The chart is named for the pareto principle, which in turn, derives its name from Vilfredo Pareto, a noted Italian economist. The left vertical axis is the frequency of occurrence, but it can alternatively represent cost or another important unit of measure. The right vertical axis is the cumulative percentage of the total number of occurrences, total cost, or total of the particular unit of measure.

Because the values are in decreasing order, the cumulative function is a concave function. To take the example below, in order to lower the amount of late arrivals by78% it is sufficient to solve the first three issues. The Pareto Chart demonstrates a power law relationship between the rank of a quality issue and that issues contribution to cost. This means one can find a linear relationship on a log-log plot. The purpose of the Pareto Chart is to highlight the most important among a (typically large) set of factors. In quality control, Pareto Charts are useful to find the defects to prioritize in order to observe the greatest overall improvement. It often represents the most common sources of defects, the highest occurring type of defect, or the most frequent reasons for customer complaints, and so on. Wilkinson (2006) devised an algorithm for producing statistically based acceptance limits (similar to confidence intervals) for each bar in the Pareto Chart.[18]

**5) Scatter diagram:**

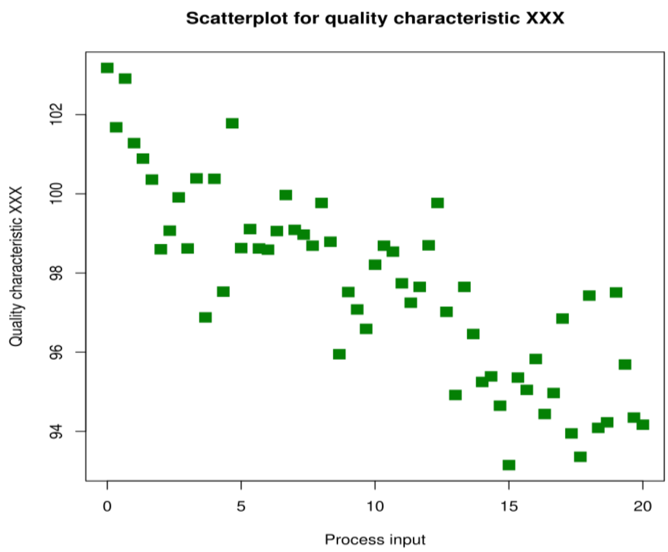


**Figure 5: Scatter Diagram.**

A scatter plot, also called a scatterplot, scatter graph, scatter chart, scattergram, or scatter diagram, is a type of plot or mathematical diagram using Cartesian co-ordinates to display values for typically two variables for a set of data. If the points are coded (colour/shape/size), one additional variable can be displayed. The data are displayed as a collection of points, each having the value of one variable determining the position on the vertical axis.[19] A scatter plot can be used either when one continuous variable is under the control of the experiment and the other depends on it or when both continuous variable are independent. If a parameter or independent variable and is customarily plotted along the horizontal axis. The measured or dependent variable is customarily plotted along the vertical axis. If no dependent variable exists, either type of variable can be plotted on either axis and a scatter plot will illustrate only the degrees of correlation (not causation) between two variables. A scatter plot can suggest various kinds of correlations between variables with a certain confidence interval. For example, weight and height would be on the y-axis, and height would be on the x-axis. Correlations may be positive (rising), negative (falling), or null (uncorrelated). If the dots pattern slopes from lower left to upper right, it indicates a positive correlation between the variables being studied. If the patterns of dots slope from upper left to lower right, it indicates a negative correlation. A line of best fit (alternatively called"trendline") can be drawn to study the relationship between the variables. An equation for the correlation between the variables can be determined by established best-fit procedure.

**6)Histogram**

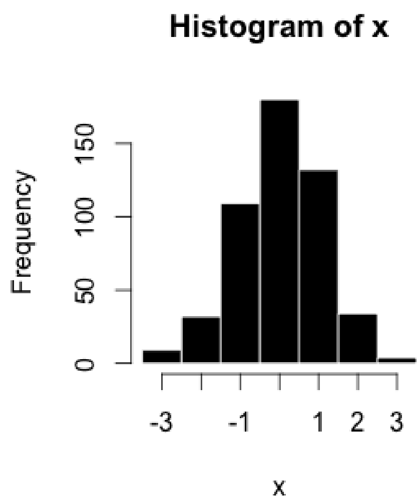


**Figure 6: Histogram**

A histogram is a visual representation of the distribution of quantitative data. To construct a histogram, the first step is to “bin” (or “bucket”) the range of values-divide the entire range of values into a series of intervals- and then count how many values fall into each interval. The bins are usually specified as consecutive, non-overlapping intervals of a variable. The bins (intervals) are adjacent and are typically (but not required to be) of equal size.[20]

Histogram gives a rough sense of the density of the underlying distribution of the data, and often for density estimation: estimating the probability density function of the underlying variable. The total area of a histogram used for probability density is always normalized to 1. If the length of the intervals on the x-axis are all 1, then a histogram is identical to a relative frequency plot. Histograms are sometimes confused with bar charts. In a histogram, each bin is for a different category of observations (e.g., each bar might be for a different population), so altogether the bar chart can be used to compare different categories. Some authors recommended that bar charts always have gaps between the bars to clarify that they are not histograms.[21] [22]

The data used to construct a histogram are generated via a function that counts the number of observations that fall into each of the disjoint categories (known as bins). Thus if we let n be the total number of observations and k be the total number of bins, the histogram data mi meet the following conditions:

$$n = \sum_{i=1}^{k} m_i .$$

### 7) Control Chart

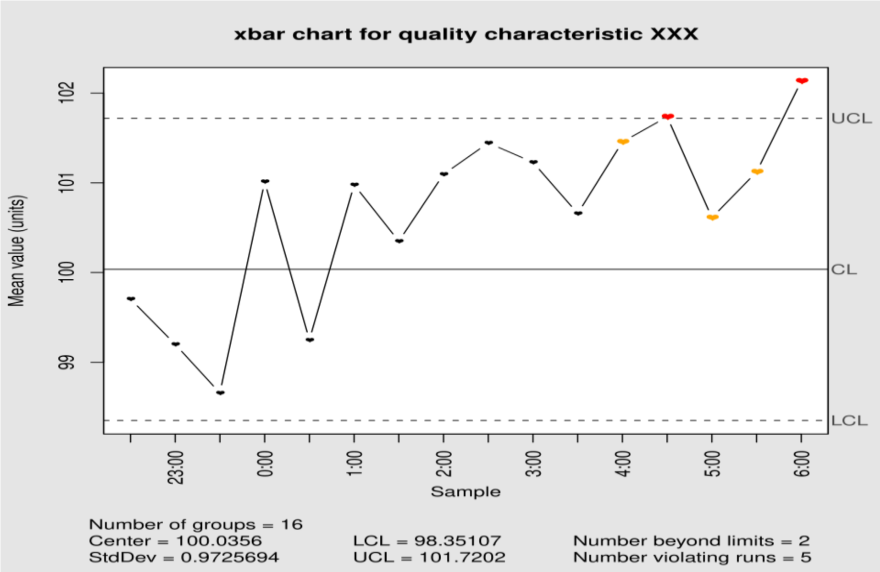


**Figure 7: Control Chart.**

Control charts are graphically plots used in production control to determine whether quality and manufacturing processes are being controlled under stable conditions. (ISO 7870-1). The hourly status is arranged on the graph, and the occurrence of abnormalities is judged based on the presence of data that differs from the conventional trend or deviates from the control limit line. Control charts are classified are classified into Shewhartindividuals control charts (ISO 7870-2).[23] And CUSUM (CUSUM) (or cumulative sum control charts) (ISO 7870-4).[24] control charts, also known as Shewhart charts (after Walter a. Shewhart) or process-behaviour charts, are a statistical process control tool used to determine if a manufacturing or business process is in a state of control. It is more appropriate to say that the control charts are the graphical device for statistical process monitoring (SPM). Traditional control charts are mostly designed to monitor process parameters when the underlying form of the process distributions are known. However, more advanced techniques are available in the 21st century where incoming data streaming can-be monitored even without any knowledge of the underlying process distributions. Distribution-free control charts are becoming increasingly popular. The control chart is one of the seven basic tools of quality control. Typically control charts are used for time-series data, also known as continuous data or variable data. Although there can also be used for data that has logical comparability (i.e. you want to compare samples that were taken all at the same time, or the performance of different individuals); however the type of chart used to do this requires consideration.[25]

## CONCLUSION

In conclusion the company should endeavour for the execution of SPC tools for productivity development. SPC implementation is significant as it could improve process performance by plummeting product variability and improves production efficacy by lessening scrap and rework. It is concluded that SPC helps the organisation to observe the process activities. As a result, quality control and quality control methods are indispensable for the sustainability of quality. Which quality control tools should be used in which process should be determined appropriately and carried out in accordance with the standards. Although the results obtained by eliminate visible errors with one-to-one controls of people, and to detect defective products by sampling. This study found that the implementation of all seven QC tools, as well as the pre-production, in-line and final inspection stages, are crucial for organizations to troubleshoot production processes. Undoubtedly, all of the above-mentioned quality tools should be considered and used by management to identify and resolve quality issues during the production of products and services.

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