Journal of Management Science (JMAS)
Volume 8, No. 3, July 2025, pp 544-553
ISSN 2684-9747 (Online)
www.exsys.iocspublisher.org/index.php/JMAS
Published by: Institute of Computer Science (IOCScience)

Evaluating liquid soap product quality using process capability indicators and statistical control charts / case study

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ARTICLE INFO

Article history:

Received May 18, 2025
Revised Jul 8, 2025
Accepted Jul 25, 2025

Keywords:

Capability;
LCL;
Process;
Quality;
UCL.

ABSTRACT

Maintaining product quality and identifying deviations in the event of their occurrence is one of the most important topics in industry, as it forms the basis for the success and continuity of an industrial project. This study aims to measure and analyze the production capacity of the process and monitor the quality of the processes through its indicators. It also aims to identify and diagnose the causes of deviations in production capacity through the quality control process and address the causes of these deviations. The study followed a descriptive-analytical approach as a scientific method to arrive at its findings. Researchers selected a detergent manufacturing company as a sample for the study, given the product's importance in daily life and its constant demand. Data were collected through field observations, a review of production records, and interviews with production managers. The researchers used statistical control charts and graphical results to determine the extent of process deviation. The study found that the Cp value was 3.03, while the Cpk index was 2.99, indicating that the process mean was far from the target, leading to process variation. The study recommended that tolerance limits should be reduced, as setting large tolerance limits for the manufactured product (±15) affects process quality.

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1. Introduction

The concept of controlling product quality and process efficiency is an important concept in production processes because of its impact on controlling product specifications. Statistical control charts are important tools used to ensure process efficiency and product quality. They are also used to identify process variances for the purpose of improving them. The current study aims to evaluate process quality, identify and diagnose deviations and their causes, if any, and determine ways to address them with the aim of reducing them. The study's problem revolves around answering a question about the extent to which the study sample product deviates from the specified specifications and whether the tolerance limits approved by the company are appropriate. The importance of the study stems from the importance of monitoring product quality, measuring process efficiency, and analyzing results to detect deviations in the production process and determine their causes using statistical methods. The researchers selected a detergent manufacturing company as a sample for the study. Data and information about the production process were collected, and quality improvement tools were used, represented by mean, range, and standard deviation charts and (Cp, Cpk) calculations, to determine whether the processes were under statistical control or not. The topic of process efficiency has become a common denominator for various administrative, economic and industrial entities in developed and developing countries, as it is receiving increasing attention. Many researchers have addressed process evaluation, and researchers have used different charts. Therefore, (Ottenstreuer et al.,

2021) used the normal CUSUM chart, which shows the best overall performance, While the performance of other schemes depends largely on the out-of-control scenario and the level of autocorrelation, respectively, which is what the current study adopted. (Alordiah & Oji, 2024) emphasized the importance of taking into account sample characteristics and statistical assumptions, a view the current study agreed with. The current study also agrees with (Wang et al., 2024), who emphasized the importance of estimating sample data when examining product quality. Therefore, sampling error and measurement uncertainty lead to miscalculations in evaluating product performance. This study also agrees with(Zwetsloot et al., 2024), who developed a four-stage framework for developing, implementing, using, and maintaining control charts. Numerous studies have led to the development of process and quality capability indicators and monitoring methods. These methods reduce costs and increase and improve product quality, which leads to customer satisfaction and maintaining market share

Today, the customer has an important role in the design and development of products. Therefore, the need has increased to understand and control processes to be more clear and specific to meet his requirements. As a result of the increased complexity occurring in production systems in industrial organizations, The need arose to apply quality management tools to assess the ability of production processes to meet pre-defined specification requirements. Process capacity is defined as the normal or true behavior when the process is stable and in a state of statistical control (Mahapatra et al., 2020). Process capability also refers to the ability to continue producing a specific product or service that meets the customer's needs according to specified specifications or parameters. The ability of the process is expressed by comparing the percentage of variation within the process to the limits of the specifications (allowances) specified for the product or service. The most commonly used indicators for comparing process variation with design specifications are the Cp index and the Cpk index. It is usually measured by graphing or by counting which parts are produced to meet specifications (Dogan & Areta Hiziroglu, 2024). Process capability is also defined as a measure of the changes that accompany production processes and is known mathematically as (s6), where (s) refers to the standard deviation of the statistically controlled production process, that is, when the variables in the production processes are the result of chance causes only.

Regarding the factors affecting the capacity of production operations, (Dimitrova et al., 2021) identify a number of these factors: effective planning and management of production capacity, the use of modern technological methods and automation of production, the degree of efficiency of use of production equipment, planning and implementation of maintenance and upkeep of production equipment, and the rational use of various resources, capabilities and qualifications of the workforce, analysis of the results of administrative decisions, risks, benefits and feedback, flexibility and timely response in the event of a problem.

A change in one or all of these factors leads to a change in the capacity of production operations. Therefore, the capacity of production operations must be determined by the consistency of the points mentioned above. The conditions for production operations are subject to two conditions: a) The data should have a normal distribution; b) Production processes are subject to statistical control (statistical control).

The ability of production processes is an important part of achieving quality, so its importance can be determined through the following points(Zacharias, 2022): a) By relying on the best designs, the process capability helps prevent defects during the production cycle; b) Determine the variation in the production process and determine the necessary methods to reduce it; c) Know the limitations of the process and know the factors that cannot be controlled; d) Benefiting from the results of process capability can be achieved in inspection, design of new technologies, and evaluation of used technologies; e) Comparison of tolerance limits with specifications.

On the other hand, Measuring and analyzing the capacity of production processes is an important part of evaluating the success or failure of the production process. In order to measure the capacity of the production process, two conditions must be met, namely that the data be normally distributed and that the process be statistically controlled. Accordingly, there are several tools used to indicate the extent of discipline in the process, which are (Benková et al., 2024): a) Examine whether the process conforms to specifications by drawing a diagram; b) Study the process capacity and stability through control panels.

The Cp index generally takes the extent of the spread of the studied process and is not affected by a change in the average of the process. In order to be able to overcome this problem, we try to find new formulas to calculate the production capacity to address this deficit. Among these formulas are:(Mahapatra et al., 2020): a) Capacity index based on the two specifications Cpk; b) Capacity indicator based on the specifications and setting the Cpm target value; c) Capacity index based on the maximum CPU specifications; d) Capacity index based on the minimum specifications Cpl.

Through the use of these indicators, the ability of the production process can be judged according to the indicator values that are calculated from the process data and specification limits. In general, if the indicator is greater than or equal to 1, then the process capability is considered good, while various studies confirm that the value of 1.33 can be used as a value for the minimum acceptable value of Cp. However, if the indicator is less than 1, this means that there is a large number of units that do not conform to the specifications (Ostadi et al., 2021). There are many steps that are followed to analyze the ability of the process to produce products within tolerance limits, including: Determine the critical parameters for the selected process. These parameters may have been determined from drawings, inspections, or contracts, as well as work instructions (Benková et al., 2024), and Conduct data collection, where at least 60 data values are collected for each critical parameter,and Calculate process capability indicators, as well as estimate the process average and standard deviations obtained from the collected data (Qader et al., 2025), Conducting an analysis of the causes of variation, which in turn involves identifying the factors affecting the normal distribution of the process and thus it is possible to improve the process's ability.

On the other hand, the term quality control was used for the first time in the 1920s. Quality control is defined as a system of control to ensure that the correct standards are maintained in the production of products, and the products are usually inspected periodically (Kwilinski & Kardas, 2023).Quality is the ability of the product to meet consumer expectations. Quality is the sum of the features and characteristics of a product or service that affect its ability to meet the needs and requirements of the customer. Performance is affected by the quality of the product. The higher the quality of the product, the higher the level of performance, which leads to customer satisfaction(Adesanya & Adesanya, 2024). Product quality has eight dimensions: performance, features, compatibility, reliability, durability, serviceability, aesthetics, and quality perceived by the consumer (Alsabbagh, 2023). An increase or increase in one of them does not mean an increase in the other dimensions. Quality is one of the main reasons for an organization's survival and success, distinguishing itself from competitors, and obtaining the largest market share(Hoe & Mansori, 2018). The dimensions of quality are defined as follows: Performance: It is one of the basic dimensions of quality, and it expresses what is required of the product and what the customer expects from the product. Performance expresses the quality of the product and the characteristics expected in the product, through which the customer judges the quality of the product (Setiono & Hidayat, 2022), Features: These are the additional characteristics that enhance the attractiveness of the product or service to the user (Lone & Bhat, 2023), and sometimes they are the basic characteristics that exceed the requirements and expectations of customers and are verified as features with their potential to change the perception of the product(Puja Whardana et al., 2024), and Reliability: It refers to the product's ability to work with the same efficiency since its first use and for the period specified in its specifications without being exposed to malfunction or failure and this dimension is a key factor in determining the quality of the product for customers (Rasib et al., 2023) and Compatibility: It expresses the conformity of the product to the established standards, and that the product matches the specified characteristics, and Durability: It expresses the period of time during which the product is supposed to be usable before it becomes unusable, which requires its replacement (Chituru et al., 2024). and Service: It expresses the quality and speed of providing after-sales services, which include repair, maintenance, or installation of the product in response to the customer's request (Tirtayasa, 2022), and Aesthetics: It refers to some specifications in the external appearance of the product, and the evaluation of the extent of the product's aesthetics varies from one person to another depending on the culture and preferences of the customer, and it is one of the methods of attraction that prompts him to buy the product, and Tangible quality: Brand reputation is one of the main factors influencing the purchase decision when the customer does not have clear details about the product's characteristics (Nguyễn Văn Nhân & Nguyễn Văn Lực, 2023). Therefore, tangible quality is directly linked to the brand (Puja Whardana et al., 2024).

Quality control: Industrial growth in the early years of the twentieth century led to the need to recognize that quality is the responsibility of management. Quality managers must be independent in their decision-making role. The term (quality control) was first used in the 1920s. Quality control is defined as a system of control to ensure that the correct standards are maintained in the production of products, and the products are usually inspected periodically. Quality control tools are considered one of the basic elements of product quality management, and can be considered a system used to maintain the required level of product quality. Among these tools are the following: Process flow maps: It is a diagram through which the flow of the process is described and the steps that the product goes through or the procedures that the service goes through. Through this map, the current processes and their sequence can be described, and this leads to clarifying the main processes required to produce products or provide services. Through this tool, amendments and improvements in service activities and production processes are suggested (Santos et al., 2023), Pareto chart: It is a graphical representation of the problems present in the process, through which the problems are arranged descending from the most occurring to the least occurring, that is, according to their importance and frequency of occurrence, and Cause and effect diagram: Or what is called the Ishikawa diagram, named after the Japanese scientist Karo Ishikawa, who developed this technique in 1943. This technique was used by quality improvement teams in organizations, the aim of which is to identify problems or goals to be achieved, and Scatter diagram: It is a chart or drawing that helps to know the relationship between two quantitative variables and present and display this relationship, as it helps to make the process outputs of high quality as well as make sound decisions based on knowledge of the relationship between the two variables, and Monitoring maps: Monitoring maps are the backbone of statistical monitoring of operations, through which continuous statistical analysis of changes in the process is conducted with the aim of monitoring and controlling the quality of products or services and improving the performance of operations, Histogram: It is a graphical representation that provides a simple explanation and analyzes the data collected from the production or service process with the aim of studying the quality of its outputs and discovering defects and the extent of deviation from the average, and Monitoring maps: It is a graph that shows the deviations and changes that are likely to occur in quality characteristics over time. Through these maps, it is possible to distinguish between natural changes that are due to general underlying causes and changes that are due to specific causes. Monitoring maps are It is a graph that shows the changes that occur in the characteristics of the product over time, and is used to display data on a specific phenomenon sequentially during a specific period of time. By looking at the graph, the quality officer or production manager can know the stability of the readings for certain characteristics or the extent of fluctuation occurring in them, and thus identify the problems that affect the quality of the product in a timely manner, which helps him make decisions that address the error and solve the problem, leading to improved performance. It is also possible, through quality maps, to determine whether the deviations are due to natural changes or due to abnormal changes and are due to special reasons, as well as knowing whether the process is proceeding under statistical control.

2. Research Method

The methodology represents the path and work plan of the study to reach its purpose, as it represents the definition of the problem of the study, its importance, and its objectives, as well as defining the study's methodology, the tools for collecting data, the methods used to analyze it, and the spatial and temporal boundaries of the study.

First: the problem of the study, the production process has a vital and important role in achieving design specifications and meeting customer requirements. Therefore, the inability to achieve a percentage of conformity between the specified specifications and the specifications achieved for the products will ultimately lead to an increase in the amount of defects in the outputs, leading to a negative impact on costs, delivery, quality and reputation. Organization, therefore, process capability analysis is an important technique for improving product quality and reducing defects. The problem of the study can be determined through the following questions: a) The extent to which the production process of the General Company for Food Products deviates from the planned process; b) Are the allowances specified by the company consistent with the actual reality of the production process?

Second: Objectives of the study, the study seeks to implement a set of objectives, the most prominent of which are the following: a) Measure and analyze the process capability and quality control of the studied processes through their indicators; b) Identify and diagnose the causes of high deviation in process capacity, quality control, and address the causes; c) Introducing workers in the field of production and operations to process capacity and quality control, their measurement indicators, and how they are measured.

Third: Description of the study community and sample: The study population comprised companies that produce cleaning materials. The researchers chose the General Company for Food Products as the study site, as it is one of the largest Iraqi companies that produces a variety of cleaning products. The study sample was the Zahi 2-liter dishwashing liquid production line, which was selected due to its large production volume and the continuous demand for the product.

Fourth: The researchers relied on more than one aspect in collecting data: physical observations through presence in the company's factories, direct meetings with production officials, reviewing the company's documents and examining daily production records and the results of examining product samples, in addition to the results of the statistical control maps conducted during the field study.

Fifth: Observation period: The process of being present in the company for the purpose of preparation and then collecting data took more than two and a half months during which the most appropriate method for taking samples was determined. The researchers found that the most appropriate method was to take five random samples daily at different times during one work meal for a working month (25 days). The researchers worked to ensure that there was no bias in taking samples in order to guarantee accuracy.

Sixth: Steps of systematic analysis: In order to answer the questions raised in the study problem, the researchers first worked on drawing samples and then calculating the arithmetic averages of the samples drawn for each day and then calculating the quantitative arithmetic average. Also, regarding the range, the range values for the subsets were calculated by calculating the difference between the highest and lowest values. After that, the upper and lower limits were extracted and statistical control charts were drawn to determine whether the process was within the permissible limits or not. (Cp) and (Cpk) were also extracted to determine the efficiency of the process and whether it needed improvement or modification.

3. Result and Discussion

Data were collected from the General Company for Food Products as a site for the study, as it is one of the companies affiliated with the Iraqi Ministry of Industry and Minerals, which contributes to supporting the national economy through its various products (solid fats, liquid oils, liquid soap, laurel, and various cleaning powders). The company's performance clearly stands out compared to other public companies operating in the same sector, particularly after its implementation of the ISO 9001:2015 quality standard and its distinguished position in the local market. The study was conducted, and data was collected on the detergents division and the product (liquid detergent) as a sample for the study. The department has benefited from significant development and rehabilitation, with new storage and production spaces added. The department's current production consists of a liquid detergent, a glossy type, in 2-liter and 1-liter packages.

Due to the effectiveness of production process capacity indicators, they have been adopted by a number of American and Japanese organizations, such as: General Motors and Toyota, and these indicators are summarized as follows: Process capacity ratio, For the process to be able to produce according to specified specifications, the process capacity value must be within (±3 standard deviations from the process mean), because this set of values is 6 standard deviations.

As for the process capability index, it measures the extent of variation that the process faces in relation to the limits of its specifications. It also helps us compare different processes regarding what is optimal or whether they meet our expectations. The most common process capability index is given by Cp, which is an estimate of what the process could produce if the average process were centered between specification limits, assuming that the process outputs were approximately normally distributed. We can say that it indicates how many times the tolerance zone is larger than the contrast value 6σ. (Kiran et al., 2017).These indicators are easy to apply and easy to understand, and express the process performance and a summary of what is happening in production with a numerical value.XXXX Many researchers have been interested in developing several measures called process capability indicators (PCIs) and (CP), and Cp (Wang et al., 2024).The first indicator developed by (Juran; 1974) who defined it as comparing the quantity of the process deployed within the specifications limits according to the following formula

$$Cp = USL - LSL / 6S$$

whereas:
USL: Upper limit of standard specifications.
LSL: minimum standard specification.

The use of the multiplier 6 mentioned in the above equation goes back to the same idea that led Shewart to use three standard deviations to calculate the limits of control in control panels, as he noticed when applying limits (σ3±) to the data that it gives a good result in terms of application and achieving effective limits. When Cp=1, the expected percentage of units that do not conform to specifications is 0.27%.

When Cp<1, there are a large number of units that do not meet the specifications. As for the relationship between the quality status of the process and the value of the process capability, it can be explained in the following table

Table 1. The relationship between the quality status of the process and the value of the process capability

Seq	Quality condition	CP Rate
1	When the direct ratio to is greater than or equal to 2, this indicates that the quality is excellent.	$Cp \geq 2$
2	When the direct to direct ratio is less than 2 and greater than or equal to 1.67, this indicates that the good quality is excellent.	$1.67 \leq Cp < 2$
3	When the direct to direct ratio is smaller than 1.67 and greater than or equal to 1.33, this indicates that the production quality is satisfactory.	$1.33 \leq Cp < 1.67$
4	When the direct direct ratio is less than 1.33 and greater than or equal to 1, this indicates that the quality of behavior is ineffective.	$1 \leq Cp < 1.33$
5	When the direct ratio is less than 1 and greater than or equal to 0.67, this indicates that the quality of the production process is poor.	$0.67 \leq Cp < 1$
6	When the ratio is less than 0.67, this indicates that the quality of production performance is poor	$Cp < 0.67$

Source:(Alwan & Jasim, 2023). Measuring and Analyzing the Process Capability of Productivity–An Applied Study in the Al-Tahady Factory for the Production of Filters. Iraqi Journal of Industrial Research, 10(3), 33-40.

The production process energy is calculated when the process is controlled statistically, as this is known by drawing the qualitative control panel of the mean and range, or the qualitative control panel of the mean and standard deviation, and when it is confirmed that the production process is under the influence of chance changes only, the capacity of the production process is calculated (6s) According to the following cases :

• When using the average and range panel:

6s = 6R` \ d2 ………………………. (1)

• When using the mean and standard deviation panel:

6s = 6σ`\c2 ………………………..(2)

Where it indicates:

S : Standard deviations of operations.

σ`: the average standard deviation of the samples.

R`: the average of the sample ranges.

d2, C2: Constants whose values depend on the sample size.

There are many tools used to measure and monitor the ability of the production process, which are as follows (Power et al., 2021):Using quality control panels to measure process capability, we extract the boundaries of the map ($\bar{x}$)from the following equations:

$$ULC\ \bar{x} = \bar{\bar{X}} + A_2\bar{R}\ \ And\ \ ULC\ \bar{x} = \bar{\bar{X}} - A_2\bar{R}$$

Where ($\bar{\bar{X}}$) refers to the center line of the chart, which can be either the average of the previous sample means or a target value specified for this process.

A2 = Constant to provide three-sigma and six-sigma limits for the sample mean.

R¯= the average of several past R values and the center line of the control chart

OR

$$UCLR = D4\bar{R}$$

$$LCLR = D3\bar{R}$$

D3, D4 = constants that provide three standard deviation limits (three sigma) for a given sample size.

- Using histograms to monitor process capability:

This is done according to the following steps (Kuo & Chuang, 2023): a) Collect data on the property to be studied; b) Extract data range and category length; c) Distributing the data into categories and according to the position of each category; d) Draw a histogram; e) Draw a graph according to the coordinates; f) Determine the capacity of the process; g), i.e. production outside the tolerance limits, is calculated.

To prepare the arithmetic mean map, the arithmetic means and range values for the subsets are first calculated. The quantitative arithmetic mean and mid-range values are then calculated, as shown in the following table of monthly liquid detergent quality characteristics

Table 2. shows the values of the arithmetic means and range for liquid detergent samples

Seq	X1	X2	X3	X4	X5	R	X
1	2004	2000	1999	2004	2000	5	2001.4
2	2000	2000	1998	2003	2000	5	2000.2
3	2001	2004	1999	1999	1999	5	2000.4
4	2003	2000	1998	1999	1998	5	1999.6

5	2000	2000	2000	1999	2000	1	1999.8
6	2004	2000	2004	2000	2000	4	2001.6
7	2003	2000	2003	2000	2001	2	2001.4
8	1999	1999	1999	1999	2003	4	1999.8
9	1999	1998	1999	1998	2000	2	1998.8
10	1999	2000	1999	2000	1999	1	1999.4
11	1999	2000	1999	2000	2000	1	1999.6
12	2000	1999	2000	1999	2004	5	2000.4
13	2004	2003	2001	2003	2000	4	2002.2
14	2000	2000	1998	2000	2000	2	1999.6
15	2000	2004	1999	1999	2000	5	2000.4
16	1998	2003	1998	2000	1998	5	1999.4
17	2004	2003	1999	1999	1999	5	2000.8
18	1999	2000	2004	2000	2000	5	2000.6
19	2000	2004	2003	2000	2000	4	2001.4
20	1999	1999	2000	2004	2000	5	2000.4
21	2000	2000	2003	2003	1999	4	2001
22	2004	1999	2000	2000	2003	5	2001.2
23	2000	2000	2000	2004	2003	4	2001.4
24	2003	1999	1999	1999	1999	4	1999.8
25	2000	1998	2003	2000	2000	5	2000.2
						3.88	2000.432

The table was prepared by the researcher

To calculate the observation limits for the arithmetic mean map, the following equations were used to extract the upper and lower limits of the observation limits, as follows:

$\bar{\bar{X}} = 2000.432 = CI$

$UCL\bar{X} = \bar{\bar{X}} + A2\bar{R} = 2000.432 + 0.577 * 3.88 = 2002.670$

$LCL\bar{X} = \bar{\bar{X}} - A2\bar{R} = 2000.432 - 0.577 * 3.88 = 1998.194$

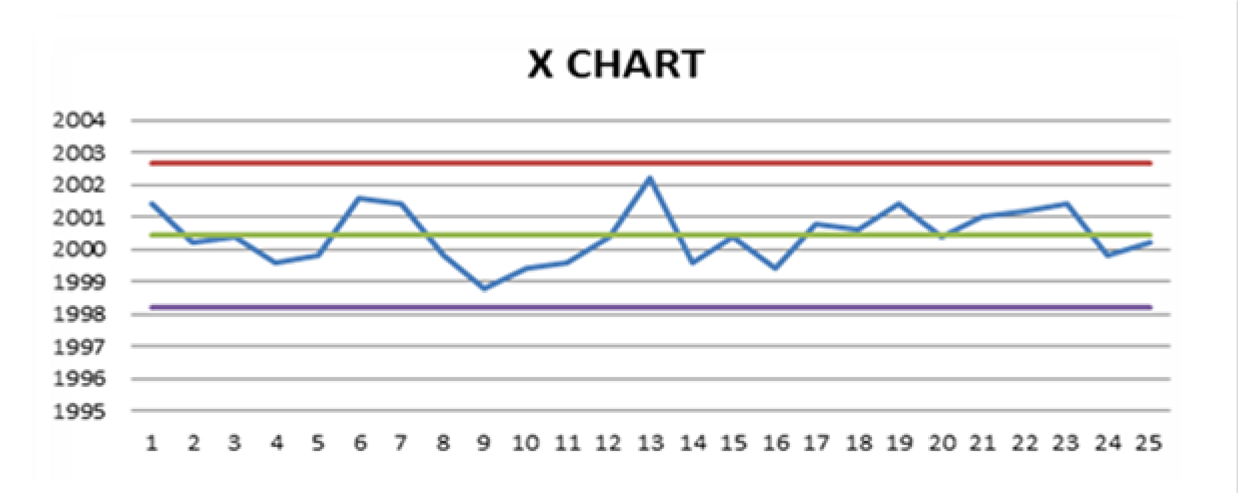


Figure (1) Average panel chart for the month

Range chart:

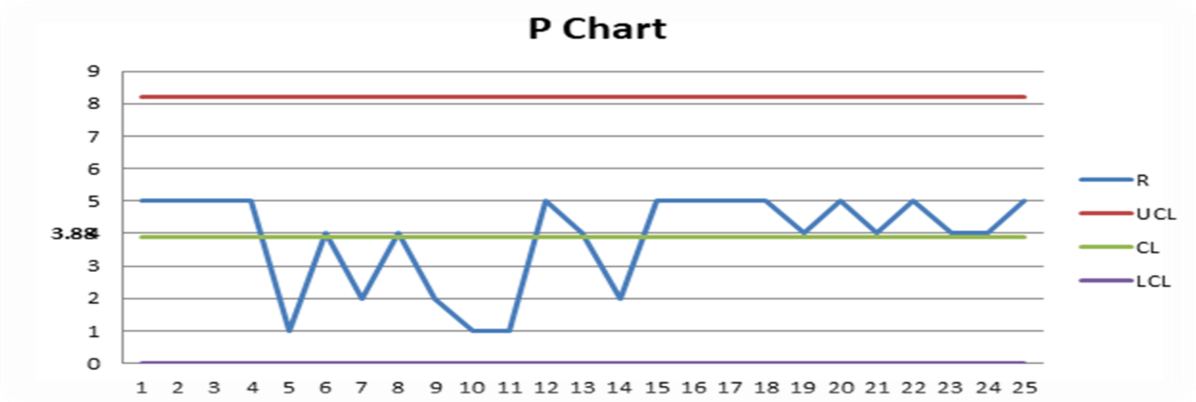
A range map was prepared, R was calculated for all subsets, and R was then calculated

The observation limits of the range map using equations to extract the upper and lower limits of the observation limits as follows:

$\bar{R} = 3.88$

$UCL = D4\bar{R} = 2.114 * 3.88 = 8.202$

$LCL = D3\bar{R} = 0 * 3.88 = 0$



2. Measuring process capability
CI=2000
UCL=2015
LCL=1985
We calculate th ... ons:

Figure (2) Range panel chart for month

d_2 = 2. 326
n= 5

$$\delta = \frac{\overline{R}}{d2} = \frac{3.88}{2.326} \approx 1.651$$

$$Cp = \frac{USL-LSL}{6\delta} = \frac{2015-1985}{6*1.651} = \frac{30}{9.906} \approx 3.03$$

$$Cpk = \min\left(\frac{USL-\overline{X}}{3\delta}, \frac{\overline{X}-LSL}{3\delta}\right) = \min\left(\frac{2015-2000.2}{3x1.651}, \frac{2000.2-1985}{3x1.651}\right)$$

$$= \min\left(\frac{14.792}{4.953}, \frac{15.208}{4.953}\right) = \min(2.99, 3.07) = 2.99$$

Cp=3.03
Cpk=2.99

This means that the condition of the product is very good and close to being excellent
From the analysis of the test results, we can conclude the following facts about the process based on the results of the panels used, the information extracted, the process estimation results, and the process deviation:
1.The X-means panel indicates that all units are within the control limits. Furthermore, there are no abnormal patterns, indicating that the sample averages are statistically stable.
2.Regarding the control chart (R range), all values are also within the control limits, and there is no significant dispersion of values around (R).
3. Process capacity calculations indicate that the value of (Cp) is (3.03), which is greater than the correct value (2), indicating excellent process quality. The value of (Cpk≈Cp) also indicates that the process has little dispersion and is centered between the upper and lower limits.

4. Conclusion

One of the most important reasons for the success of industrial organizations is the adoption of a management philosophy that places a much greater emphasis on controlling product quality than on profit. Therefore, measuring process efficiency is a systematic approach that relies on collecting highly accurate data and analyzing it statistically to accurately identify sources of errors and use appropriate methods to eliminate defects and deviations. Implementing a process capability measure also contributes to faster, more accurate, and more efficient product development in manufacturing processes. Conducting statistical testing ensures that a company's product is under control. The results of the statistical tests of the study sample show that the process is under statistical control and is highly efficient and does not require immediate modification or improvement. The quality indicators (Cp=3.03) and (Cpk=2.99) indicate that the performance is excellent, but it is necessary to continue monitoring the performance using control charts (X-Chart) and (R-Chart) regularly in order to address any possible defect that may occur. Achieving good results does not mean that there is no need for continuous improvement, as continuous improvement is one of the foundations of quality. These results are a result of the company's application of ISO 9001 quality specifications. It is concluded that the product tolerance limits ($\mp$15) are considered large, as the values fluctuate within a wide range. Therefore, the company is called upon to reduce the tolerance limits. Continued testing to determine whether the process remains under control will lead to increased quality. Furthermore, management's focus on an effective information system that ensures the flow of information to and from various company departments reduces deviations by identifying and quickly addressing them. Researchers recommend conducting further studies and utilizing quality tools to improve operational efficiency.

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