Scientific Journal of University of Benghazi

SJUOB (2024) 37 (2) Applied Sciences: 115 – 120

Abdelwanis et al.

http://journals.uob.edu.ly/sjuob

Implementation of Statistical Control Processes in Benghazi's Food Industry

Naji Abdelwanis [1] - Asma Alkshir [1]- Eman Al-Amami [1]- Sondos AlWarfali [1,*] - Abdelaziz Badi [1]

1 Industrial and Manufacturing Systems Engineering, Faculty of Engineering, University of Benghazi, Benghazi, Libya.

Received: 21 / 09 / 2024; Accepted: 27 / 11 / 2024

ABSTRACT

Quality control is a crucial aspect of any organization aiming to reach a high-quality level by providing products or services that satisfy customer needs. Control charts are among the most effective tools used to detect the occurrence of defects in the manufacturing process so they can be fixed before being delivered to the customers. This paper aims to assess the filling machine's performance in the Al-WAHA factory. In this investigation, a control chart and process capacity were implemented. Comprehensive details on the control chart and process capacity are discussed, along with an overview of the literature on related subjects. 33 samples of 800-gram jars' worth of data were examined. The metrics for performance were computed. Through the control charts S and X, it was found that there were ten out-of-control samples in the mean chart (3, 4, 6, 7, 8, 10, 21, 23, 32, 33) and one observation in the variance chart (30) due to assignable reasons. After excluding the samples that caused the variance in the mean chart, the control charts. Both the S and X charts are within the control limits. Filling process capacity = 0.59, the process is unable to meet the specifications, and about 23.48% of the fillings are above 810 grams and 1.51% are below 790 grams. The CPK value describes the process as decentralized.

KEYWORDS: Quality Control, Statistical Process Control, Food Industry.

1. INTRODUCTION

In the fields of manufacturing, distribution, transportation, finance, health, and public services, control and improvement are among the most crucial business strategies. A company can gain a competitive edge by improving quality and control, which will enable it to satisfy customers and remain competitive [1]. Achieving company business objectives requires maintaining high levels of quality. Company products and services should continue to be characterized by quality, which serves as a competitive advantage. High quality is not merely an extra benefit but rather a fundamental necessity. Quality is not only related to the final products and services provided by the company but also to the way the company's employees perform their work and the work methods aimed at producing the results. or services. Work processes must be efficient and continuously improved. Every employee in all organizational units is responsible for ensuring excellence and continuous improvement in their area of responsibility. Quality control (QC) is the most important requirement for sustainable quality. QC, essential to maintaining quality and updating expectations, can be broadly defined as a system that maintains the desired level of quality through feedback on product/service characteristics of the specified standard [2].

*Correspondence: Sondos AlWarfali

sondosalohish704@gmail.com

Statistical process control, or SPC, is a monitoring and control approach that makes use of statistical methods to make sure a process works as efficiently as possible in order to provide a product that complies with specifications. A process that operates consistently and yields the most compliant output with the least amount of waste is referred to as SPC. Design experiments, control charts, and continuous improvement are important SPC techniques [3]. It is possible to identify and correct process variations that could compromise the final product's quality, cutting down on waste and the possibility of customer issues. SPC provides a clear benefit over other quality processes, like inspection, which depend on resources to find and fix issues after they have occurred [4]. This is because SPC places an emphasis on early problem identification and prevention. Process quality encompasses the whole approach that companies use to implement their quality system. The aim of process quality is to ensure that every process is designed with the quality philosophy in mind, which is ensured by putting such measures into place [5]. Walter A. Shewhart introduced control charts, a technically intricate instrument for quality management, to Bell Telephone Laboratories in the 1920s. They distinguish between statistically controlled scenarios (both inside and outside of UCL and LCL) and out-of-control scenarios (beyond UCL or below LCL) by demonstrating how a process develops over time. Control charts are crucial for monitoring processes and identifying the underlying causes of quality issues in order to reduce variability and prevent mistakes [6]. Numerous quality metrics have been suggested to assess

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

the performance of processes. In recent years, one of the most well-liked and often applied metrics for evaluating process performance has been process capability indices, or PCIs. A process's ability to produce conforming goods under engineering specification limitations (SLs) is assessed using PCIs [7]. Process capacity, as established by the system of common causes, is the range within which the process's natural variation takes place. People, equipment, processes, materials, and measurements all work together to create products that reliably fulfill design requirements. If the process is in a statistically controlled condition and all exceptional reasons have been ruled out, then the process capacity may be quantified. For production engineers as well as product designers, process competency is crucial. A process capacity study enables one to make quantitative predictions about how well a process will function under particular operating circumstances in order to produce detailed information about the process's performance [8].

In this study, machine changes in jam production were measured using statistical control. Food manufacturing and processing facilities are increasingly utilizing affordable automation technologies in place of more conventional techniques in order to boost production capacity. There might not be many modifications to the automobile because of this engine. In one of the UUM restaurants, the study by Lai Jian Wei et al. looks at statistical control (SPC) as an improvement method. The SPC tool is being used in this study to determine how long students must wait to place food orders at the SME Cafe. The three goals of this study are to ascertain how long students wait for meals, compute the upper and lower control limits, and estimate the processing capacity of Inasis SME Cafe. The total number of students in the student body who have lunch at the SME Cafe, UUM, yields 500 data points for this study. The x and R chart is the data analysis technique employed in this investigation. Results pertaining to the study's declared research goals are given. The outcome of the students' meal wait time at the SMB café is displayed. The period of cooking as determined by the control law design will be displayed in the study's findings [9]. The purpose of this study is to propose a systematic review program by Sarina Abdul Halim et al. to investigate frequent issues that arise from the application of statistical process control (SPC) in the food sector. From four databases, a total of 41 journal papers were carefully chosen and examined. When using SPC in the food business, advantages are the most frequently discussed subjects; incentive, prevention, and key success factors (CSF) are the remaining issues. This evaluation demonstrated the effectiveness of the SPC implementation suggestions for the food business, however, the absence of information and instructions about this implementation has resulted in a decrease in withdrawal. Additionally, a critical evaluation of the current SPC frameworks is provided in this research. In order to systematically manage SPC distribution in the food business, this systematic study indicated that more research is necessary in the SPC distribution sector. One solution to that issue has been suggested: the creation of useful and efficient guidelines to support food manufacturers in using SPC [10]. Control charts and process capacity ratios—two statistical control (SPC) tools—are used in this work by Omar Batina et al. for quality control and improvement. R and Cumulative Sum (CUSUM) control charts are often utilized. The so-called process capacity index (PCI) is the process capacity ratio that is employed. The statistical application Minitab is used to implement these techniques. The effectiveness of gelatin capsules has been examined in this study with regard to the caliber of capsules produced and supplied by various pharmaceutical businesses. The number of faulty capsules was predicted to decrease by 29% as a result of the use of SPC tools in comparison to the previous period of implementation [11]. Madanhire et al. (2016) conducted research on statistical control tools in production systems with the overall objective of modernizing them to increase quality and save costs. This is an effort to rectify the documentation's shortcomings regarding the SPC implementation. SPC has been proven to be highly advantageous to quality procedures like final product inspection because of its emphasis on issue prevention and early identification. It is important to inspect gauges and machinery to ascertain whether they require maintenance or replacement, as malfunctioning equipment is unable to generate high-quality output. It is necessary to write new papers, train managers, and complete activities that will benefit the future. Financial resources should not come before a mechanism for tracking progress and performance results [12]. The following study explains quality control and the role that plays in the food sector, applying statistical control process techniques into practice, determining the reasons behind variance and the origins of subpar performance, and offering various remedies for the existing situation in order to enhance the factory's overall process and evaluate how the process behaves right now. The present study data and results are limited to the EL-WAHA food company. The factory was selected because it's one of the largest factories with thousands of customers every year it has become one of the leading factories in food with different products and production lines; therefore, the process in the factory should be evaluated for suggesting improvements.

2. METHODOLOGY

The jam production process is carried out in the Al-WAHA Factory for Food Industries in different sizes

 ISSN:Online 2790-1637, Print 2790-1629; National Library of Libya, Legal number : 154/2018

250,350 and 800 grams and different fruits such as (strawberries, oranges, and figs) in the Al-WAHA Factory in the Kweifieh Benghazi, Libya, in several steps:

1. How to prepare fruit?
2. Mash the fruit, remove the seeds, and peel it.
3. The fruit pieces turn into juice after the mashing process.
4. The process of heating the juice and combining the sugar and pectin.
5. How to transfer the jam container to the filling machine (12 pistons)?

The SPC chart for problem-solving methodology is the main framework for executing the implementation of SPC tools; thirty-three observations (each consisting of a total of twelve samples measuring weight in grams) at the EL-WAHA factory. The SPC chart consists of the mean chart (upper and lower control level) and the standard deviation chart (upper and lower control level), offering a well-defined and structured approach for implementation. A variety of tools and techniques have been employed in conjunction with the framework, effectively supplementing the work of identifying problem areas in the earlier phases and the proposal of improvement measures in the concluding phases.

3. RESULTS

Before performing any data analysis and performing the control scheme, it must be ensured that the data follows a normal distribution by performing a normality test using the Minitab 17 Statistical Software. After performing the test, notice that the p-value is 0.096, which means that the data follow a normal distribution. Figure 1 presents normal probability plot of jam filling process.

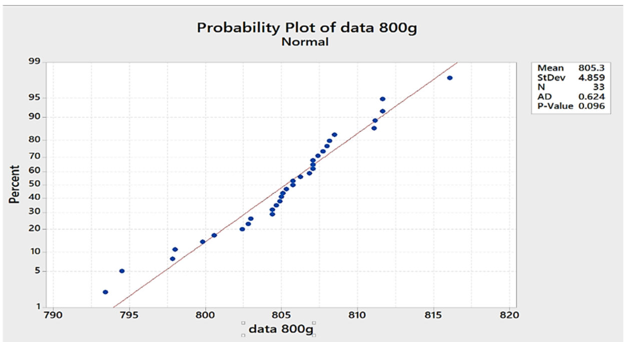

Figure 1. Normal Probability Plot of Jam Filling Process.

3.1 X-chart for Jam Container Weight

This type of control chart is used for characteristics in this study, which are weights that can be measured on a continuous scale. The chart is essential since it helps to monitor the average or mean of the filling process and how it changes over time. It is also used to evaluate whether the filling process is under control or not. Figure 2 shows the X-bar chart for the 33 observations. The control charts show that there are about 10 observations that are out of control (3, 4, 6, 7, 8, 10, 21, 23, 32, 33) due to assignable causes. delete the samples that are out of control and recalculate the S-bar and X-bar control charts.

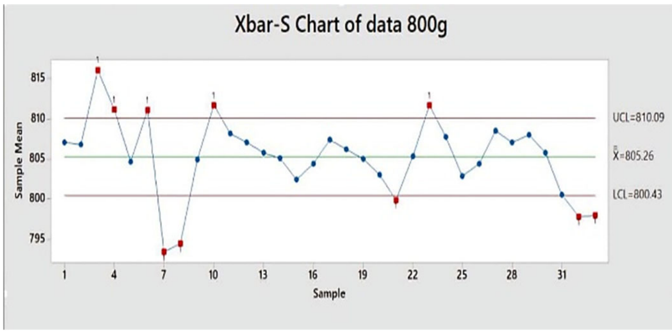

Figure 2. X-bar chart for Jam Filling Process.

The following equations present average or mean of the filling process,

$$CL = \bar{\bar{X}} = \sum_{i=1,k} \bar{x}/k \quad (1)$$

$\bar{\bar{X}}$ = 805.26

$$\text{UCL}=\bar{\bar{X}}+A_3 \times \bar{S} \quad (2)$$

UCL=805.26+0.886×5.454=810.092

$$\text{LCL}=\bar{\bar{X}} - A_3 \times \bar{S} \quad (3)$$

LCL = 805.26−0.886×5.454=800.428

Where,

CL is the center line.

$\bar{\bar{X}}$ is the grand mean of all the individual subgroup averages.

$\bar{X}$ is average for each subgroup.

K is the number of subgroups.

UCL is the upper control limit.

LCL is a lower control limit.

A_3 is a coefficient that is determined from tables of statistical constants based on the sample size.

$\bar{S}$ is the standard deviation.

3.2 $\bar{S}$ Chart for Jam Container Weight

The s-chart is used to monitor the variation of the packing process based on samples taken from the factory and Figure 3 shows the S-bar chart that there is a sample outside the control limits.

The following equations present standards deviation of the filling process,

$\bar{S} = \frac{\sum_{i=1}^{k} s_i}{k}$=5.454 4)

UCL=$B_4 \times \bar{S}$ (5)

UCL = 1.646 × 5.454 = 8.980

LCL=$B_3 \times \bar{S}$ (6)

LCL = 0.354 × 5.454 = 1.928

where:

$\bar{S}$ is (center line) mean standard deviations of all samples.

S is the standard deviation of the subgroup.

K is the number of subgroups.

UCL, LCL The lower and upper control limits for the s chart.

B_4, B_3 coefficients that are determined from tables of statistical constants based on the sample size.

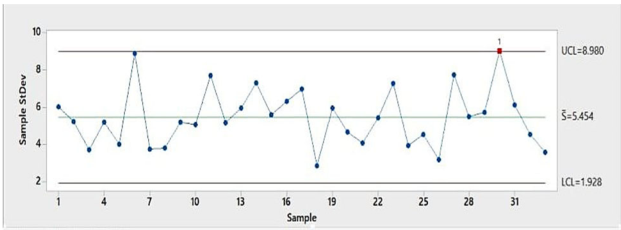

Figure 3. S-bar Chart for Jam Container Weight.

3.3 X-bar Chart for Removed Control Observations

Figure 5.4 shows the X-bar plot after removing the out-of-control sample. This leaves twenty-three observations with twelve samples. On the X-bar chart, there is no indication of a trend, shift, or run observed. Hence, it concludes that the process is under statistical control and operates under the influence of sole causes of variation. That is, the process is stable over time.

CL=$\bar{\bar{X}}$=$\sum_{i=1,k} {}^{x}/_{k}$=18528.33/23=805.58 (7)

UCL=$\bar{\bar{X}}$+$A_3 \times \bar{S}$ (8)

UCL = 805.58 + 0.886 × 5.659 = 810.59

LCL=$\bar{\bar{X}} - A_3 \times \bar{S}$ (9)

LCL = 805.58 − 0.886 × 5. 659 = 800.57

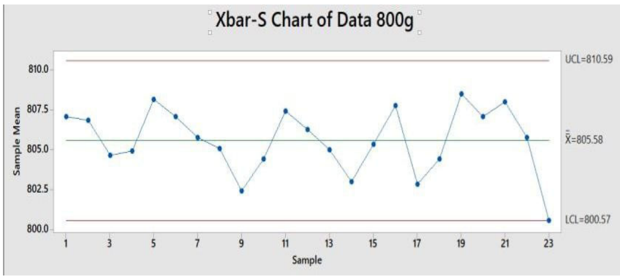

Figure 4. X-Bar Chart for Jam Filling Process.

3.4 $\bar{S}$ Chart for Removed Control Observations

Figure 5.5 shows the standard deviations for each subgroup, as well as, the corresponding centerline and limits. The S chart seems to indicate the variation is in control, as presented in Equation (1.10).

$\bar{S}$= $\frac{\sum_{i=1}^{k} s_i}{K}$=5.659 (10)

UCL=$B_4 \times \bar{S}$ (11)

UCL = 1.646 × 5.659 = 9.318

LCL=$B_3 \times \bar{S}$ (12)

LCL = 0.354 × 5.659 =2.001

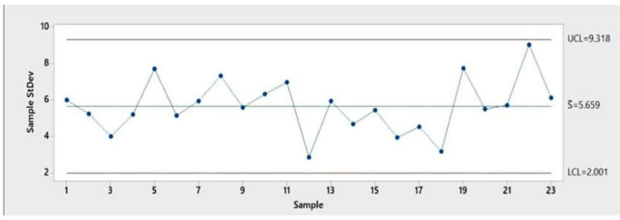

Figure 5. $\bar{S}$ Chart for Jam Container Weight.

3.5 Process Capability

After collecting and analyzing the data using the X-Bar S-chart control, it is now necessary to find out whether the filling process complies with the practical specifications. Therefore, it is necessary to understand the current capability of the system.

CP= (USL-LSL) /6σ (13)

CP = (810 -790) /6*5.67379 = 0.59

CPL= ($\bar{\bar{X}}$–LSL) /3σ (14)

CPL = (805.26 – 790) / 3*5.67379 = 0.8965

CPU= $(USL - \bar{\bar{X}})$ /3σ (15)

CPU = (810 – 805.26) / 3*5.67379 = 0.2784

CPK=Min. of (CPU, CPL) (16)

CPK = Min. of (0.2784, 0.8965) = 0.2784

The process is not centralized

$$\text{CPM} = \frac{cp}{\sqrt{1+(\frac{\bar{\bar{X}}-T}{\sigma})^2}}$$
(17)

$\bar{\bar{X}}$=T=805.26
(18)

$$\text{CPM} = \frac{0.5874}{\sqrt{1+(\frac{805.26-805.26}{5.67379})^2}} = 0.5874$$

CP is the process capability index.

USL, LSL The lower and upper specifications limits.

σ is the standard deviation.

$\bar{\bar{X}}$ is mean of the process.

CPL, CPU the lower and upper capability process.

CPK is the process capability index for centering.

CPM is a capability process for the mean target.

CP and CPK are generally referred to as process capability indicators, and they are used to determine the ability of a product to meet specifications.

The current capacity of the filling process is assessed and it can be seen that CP = 0.5874, which indicates that the process is not capable of specification limits. The CPK value describes the process as not centralized. Figure 6 shows the process capacity analysis for the filling process.

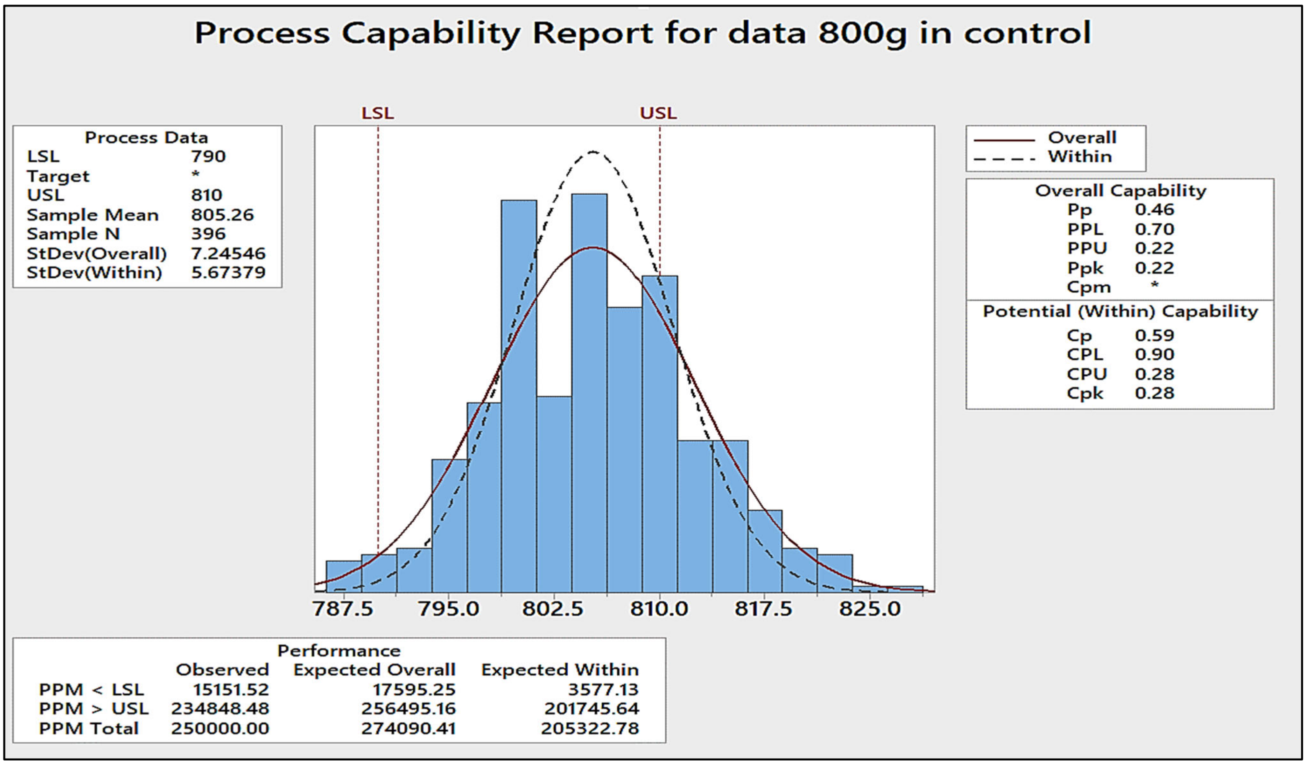

Figure 6. Process Capability Analysis of Filling Process.

To determine the root of the problem a gauge capability analysis should be conducted but due to the limitation of the data difficult to conduct it. The use of gauge capability analysis is to determine if the cause of variation is from operators or machines.

4. CONCLUSION

The objective of this study was to investigate to evaluate the current performance of the jam-filling machine in EL-WAHA. Shewhart control chart methodology was implemented and several recommendations were suggested to improve the efficiency of the production line. Through data collection for 33 random Observations of 800 grams, the calculations relevant to the performance measures, and the analysis of capability methodology, the following conclusions are reached:

Using Shewhart control charts for standard deviation charts indicated the following:

- Initially the process was out of the mean control limits with a mean average of 805.26g.
- Observation numbers 3, 4, 6, 10, and 23 were above the upper limit of 810.9g.
- Observations 7, 8, 21, 32, and 33 outside the lower limit of 800.43g.

Results from the capability analyses show the following:

- The process wasn't capable of meeting specifications limits that indicate that approximately about 23.48% of the fills are above 810g and 1.51% less than 790g.

REFERENCES

1. Godina R, Matias JCO, Azevedo SG. Quality improvement with statistical process control in the automotive industry. Int J Ind Eng Manag. 2016;7(1):1-8.
2. Demirkaya F. The quality control tools used for sustainability of quality. Archiwum Wiedzy Inżynierskiej. 2022;7.
3. Madanhire I, Mbohwa C. Application of statistical process control (SPC) in manufacturing industry in a developing country. Procedia CIRP. 2016;40:580-583.
4. Qiu P. Introduction to Statistical Process Control. Chapman and Hall/CRC Texts in Statistical Sciences; 2013. ISBN-13:978-1439847992, ISBN-10:1439847991.
5. Alzoubi A. The impact of process quality and quality control on organizational competitiveness at 5-star hotels in Dubai. Int J Technol Innov Manag (IJTIM). 2021;1(1):54-68.
6. Neyestani B. Seven basic tools of quality control: An appropriate tool for solving quality problems in the organization. 2017 Mar.
7. Adibi S, Noorossana R. Process capability analysis for simple linear profiles in multistage processes. Pak J Stat Oper Res. 2020;16(2):139-155.
8. Oberoi EH, Singh H, et al. SPC (statistical process control): A quality control technique for confirmation to ability of process. Int Res J Eng Technol (IRJET). 2016;3(6):666-672.
9. Lai JW, Taib CA. Application of statistical process control at food joint: A case study of Inasis SME Café. In: Symposium on Technology Management and Logistics (STML Go Green) 2019. Universiti Utara Malaysia; 2019.
10. Lim SAH, Antony J. The implementation of statistical process control in the food industry: A systematic review. In: Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management; 2014.
11. Bataineh O, Al-Dwairi A. Application of statistical process control tools to improve product quality in manufacturing processes. Appl Mech Mater. 2012;110:4023-4027.
12. Madanhire I, Mbohwa C. Application of statistical process control (SPC) in manufacturing industry in a developing country. Procedia CIRP. 2016;40:580-583.