ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT

PRACTICES AND CHALLENGES OF IMPLIMENTING STATISTICAL PROCESS CONTROL FOR IMPROVING QUALITY: THE CASE OF MOHA SOFT DRINKS INDUSTRY

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A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT FOR

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JUNE, 2019

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DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Dr.Ing Amare Matebu. All sources of material used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institutions for the purpose of earning any degree.

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ENDORSEMENT

This Thesis has been submitted to St. Mary's University School of Graduate Studies for examination with my approval as University advisor.

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LIST OF ACRONYMS AND ABREVIATIONS

ASQ - American Society for Quality

CO_2 - Carbon Di Oxide

DMAIC- Define, Measure, Analyze, Improve and Control

ISO - International Organization for Standards

LCL - Lower control limits

OCPA - Out of Control Action plan

QA - Quality Assurance

QC - Quality Control

SPC - Statistical process control

SQC- Statistical Quality Control

UCL- Upper control limits

Abstract

In order to survive in a competitive market, improving quality and productivity of product or process is a must for any company. The principal aim of this study is about identifying the practices and challenges of a company in applying statistical process control (SPC) tools in the production processing line and on final product in order to improve the quality of the product and suggesting appropriate solution for the challenges. The approach used in this study is direct observation, thorough examination of production process lines, and information has been collected from managements, quality department and from company's workers working in the area of production process through interview and questionnaire. Pareto chart/analysis and control chart was constructed in order to prioritize the major defects occurred and to suggest a suitable control limits for some variables. From the analysis of the data, it has been found that the company has many practices like usage of control charts, Usage of computerized technology for data recording, usage of calibrated measuring devices, Planning for quality improvement, Presence of in house technical staff experts and setting definition for quality are in use in the organization etc. and challenges specifically like there is lack of higher management support, lack of team working, lack training etc. If a statistical process control practices are employed effectively, it could improve the quality of the product and overall organizational performance by knowing the customer requirement and meeting them. Even if the company has many constraints to implement all suggestion for improvement within short period of time, but it is important to give training for employs and management commitment is important and the company recognized that the suggestion will provide significant productivity improvement in the long run.

Key words:- Statistical process control, quality improvement, control charts and control limits.

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CHAPTER ONE

INTRODUCTION

This chapter consists of background of the study, statement of the problem, research questions, general and specific objective of the study, limitation of the study, scope of the study, organization of the study and company background.

1.1 Background of the Study

In today's complex and dynamic business world, organizations are expected to perform well in their line of business in order to stay competent and be profitable. This study shows that how statistical process control can help an organization to improve the quality of their product(s). Quality is a concept whose definition has changed overtime. In the past, quality meant "conformance to valid customer requirements". That is, as long as an output fell within acceptable limits, called specification limits, around a desired value, called the nominal value, or target value, it was deemed conforming, good, or acceptable. We refer to this as the "goalpost" definition of quality (Deming, 1950). According to Montgomery (2005), quality is one of the most important decision factors in the selection of products and services. Therefore, quality leads to business success, growth, and increases competitiveness, as well as improves the work environment. Additionally, it involves the employee in achieving the corporate goals and brings a substantial return of investment. The study and the analysis of quality must be aimed at understanding, meeting, exceed and surpassing customer needs and expectations (Kolarik, 1995). Statistical tools allow measurement and evaluation of the performance in a process to improve its quality. The tools frequently used to support decision making. According to Montgomery (2005), statistical tools can be helpful in developing activities previous to manufacturing, in measuring process variability, in analyzing this variability relative to product requirements or specifications, and in eliminating or greatly reducing variability in process. These tools allow the interpretation of the process by detecting when the variables change and experimentation by knowing how the variables can change by experimental designs (Ott et al., 2000)

This paper is concerned with practices and challenges of using statistical process control method for quality improvement in MOHA soft drinks industry S.C, identification and analysis of existing quality problems, and to propose a better quality improvement method that will improve overall performance of the factory.

1.2 Statement of the Problem

Quality improvement is the key factor for the success and growth of any business Organization. Thus it is important to focus on the process; how it proceeds, how to control and how to improve the process. Even if, the company uses SPC as a good practice for quality improvement, in doing this the company faces challenges like lack of management commitment, lack of knowledge in statistical process control (SPC) implementation, including the data collection system for further investigation of the problem, and even in interpretation of the data for quality improvement . To answer all of these, decisions must be made on facts, not just opinions; consequently, data must be gathered and analyzed in order to help the decision making process and as such statistical process control (SPC) technique would help in analyzing the process quality. Due to these and other reasons the company has still many defective products. So as to monitor the variability's such as; volume dispersion in the filling process, the amount of sugar, the amount of carbon dioxide (CO_2), and related substances of the product occurs in MOHA soft drinks industry S.C, and the sampling technique specifically for one of the product of a company having high market share with a brand name called Mirinda orange. Implementing a proper SPC technique can resolve all the practical challenges that the company faces and reduces all the variations that affect the product quality.

1.3 Research questions

- What are the challenges possibly faced in the implementation of quality improvement methods like statistical process control?
- Does the management committed in the implementation of statistical process control tools?
- Are the resources available like trained man power, finance, materials etc used for the implementation of statistical process control?

- How much statistical process control helps the process to improve the quality of the product?
- What are the possible approaches used to solve the quality related problems in using statistical process control?
- What are the benefits gained after starting to implement statistical process control?
- Does the current data used to improve the quality of machines processes?
- Does both bottles and pets of the products properly filled as calibrated by the machines?
- Dose all the ingredients used for the production of Mirinda orange properly maintained as per the requirements?
- How often does the company verify the product?

1.4 Research Objectives

The study addresses the following general and specific objectives.

1.4.1 General Objective

- To investigate the practices and challenges of implementing statistical process control and Recommend quality improvement approach.

1.4.2 Specific Objectives

The specific objectives are:

- To identify the most common techniques used, the scope of usage, and source of information used in setting up the systems.
- To assess the existing quality related problems of the company.
- To have through understanding of the basics of statistical process control and its effective application in the company.
- To identify constrains for applying quality tools such as SPC.
- To recommend a possible solution for the identified causes of variation for achieving quality improvement.

1.5. Significance of the Study

This study; practices and challenges of implementing SPC for improving quality has different significances when it is applied in practice. Some of the significances are:

1. Helps to find out the good practices and challenges present in the implementation of SPC for quality improvement in MOHA soft drinks industry.
2. Enables in showing business organizations on the importance, if any, of implementing SPC for improving the quality of their product and by so doing getting a competitive advantage.
3. Important for making corrective actions for organizations that do not well implement SPC tools.
4. It can also serve as a reference document for further studies on practice and challenges of implementing SPC in the soft drink industries.

1.6 Scope of the Study

The scope of this project report covers only the packaging processing line of the company i.e. its processes in bottle and pet section due to lack of time to address all the process. However, the technique could be extended and applied to other process lines and other divisions of the organization where it is necessary.

1.7. Limitation of the Study

The major constraint in the course of the study was time and company's rules and regulation which prevented the researcher from undertaking in depth study and analysis. There are also resource constraints, in terms of utilization of SPC tools, lack of cooperation of employs to respond on questionnaires and interviews.

1.8. Definition of Basic Terms

Statistical Process Control:- is a scientific, data- driven methodology for quality analysis and improvement.

Quality: - The totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs (ISO 9000)

Quality Improvement: - is a continuous improvement process and a proactive approach to improve processes and systems. Or it can be defined as the reduction of variability in processes and products.

A control chart: - is a "Trend Chart" with the addition of statistically calculated upper and lower control limits drawn above and below the process average line.

1.9. Organization of the Study

This research paper consists of five chapters; the first chapter discusses the introductory part. It reflects what this research is all about through describing background of the study, statement of the problem, basic research questions, objective, significance of the study, scope of the study, limitation of the paper sand definitions of basic terms,. Chapter two states the review of the literatures and relevant pass research studies that act as a basis for the purposed study. This followed by chapter three which describes the methodology of the study, describe how the research has been conducted. The fourth chapter will provide data analysis and interpretations of data collected through questionnaires interview and documentation review. Finally, the fifth chapter will draw recommendation and conclusion based on the findings.

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CHAPTER TWO

REVIEW OF THE RELATED LITRATURE

This chapter provides an overview of literature that is related to the research problem presented in the previous chapter. Definition of quality, inspection based quality control vs. prevention based quality control, quality control for defect prevention and defect identification, definition and history of statistical process control, the seven quality control tools, types and cause of variation in statistical process control, aim of statistical process control, statistical process control implementation, implementing SPC as a quality improvement program, problems and difficulties in the implementation of SPC in the organizations and process capabilities are briefly discussed.

2.1 Quality

2.1.1 Definition of Quality

Quality is defined in different ways by a number of people. But, from the definitions given by most quality can be seen as meeting customer requirements effectively. It includes providing right quality goods and services at the affordable prices and at the committed time.

Some definitions of Quality that are defined by different groups/people:-

According to the definition of ISO 9000 quality is defined as 'The totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs'. Armand Feigenbaum explains Quality as "A customer determination based upon a customer's actual experience with a product or service, measured against his or her requirements – stated or unstated, conscious or merely sensed, technically operational or entirely subjective and always representing a moving target in a competitive market". American Society for Quality (ASQ) opines that quality denotes an excellence in goods and services, especially to the degree they conform to requirements and satisfy the customers. Optical measurements for soft drink, quality control defines quality as the taste and appearance of soft drinks must be of consistently high quality. In response to the question "What is quality? ", the American dictionary defines quality as "Degree or level of excellence''. All the definitions of quality stated above implies that quality can be defined in many ways depending on who is defining if and what product or service it is related to.

Quality is important because a successful business means when the organization can produce a higher quality product or service than its competitors. Therefore, when quality is the main important factor for the company's success, statistical quality control allow organizations to improve the quality of the product levels, meet the consumer's requirement for quality and to remove defects of the product.

2.1.2 Quality Control, Quality Assurance and Quality Improvement

The terms Quality Control (QC) and Quality Assurance (QA) are often used interchangeably. But, according to International Standard of Organization (ISO) for Quality Management often referred to as IS0 9000:2005 distinguished the subjects as follows: "QC is a part of quality management focused on fulfilling quality requirements" while "QA is a part of quality management focused on providing confidence that quality requirements will be fulfilled". The standard further reiterated that QA involved all the planned and systematic activities implemented within the quality system that can be demonstrated to provide confidence that a product or service will fulfill requirement for quality. Conversely, QC was seen as operational techniques and activities used to fulfill requirements for quality. In other hands, QA is concerned with defects prevention while QC is concerned with defects identification and quality improvement is a continuous improvement process and a proactive approach to improve processes and systems.

2.1.3 Inspection-Based Quality Control vs. Prevention-Based Quality Control

The traditional approach to manufacturing is to rely on production to make the product and on quality control to inspect the final product and screen out items not meeting specifications. This involves a strategy of "detection" or "inspection". Inspection is an activity which is often expensive, unreliable and provides very little information as to why the defects or errors occurred and how they can be corrected. The following figure shows the generalized process diagram for a process operating on an inspection-based quality control.

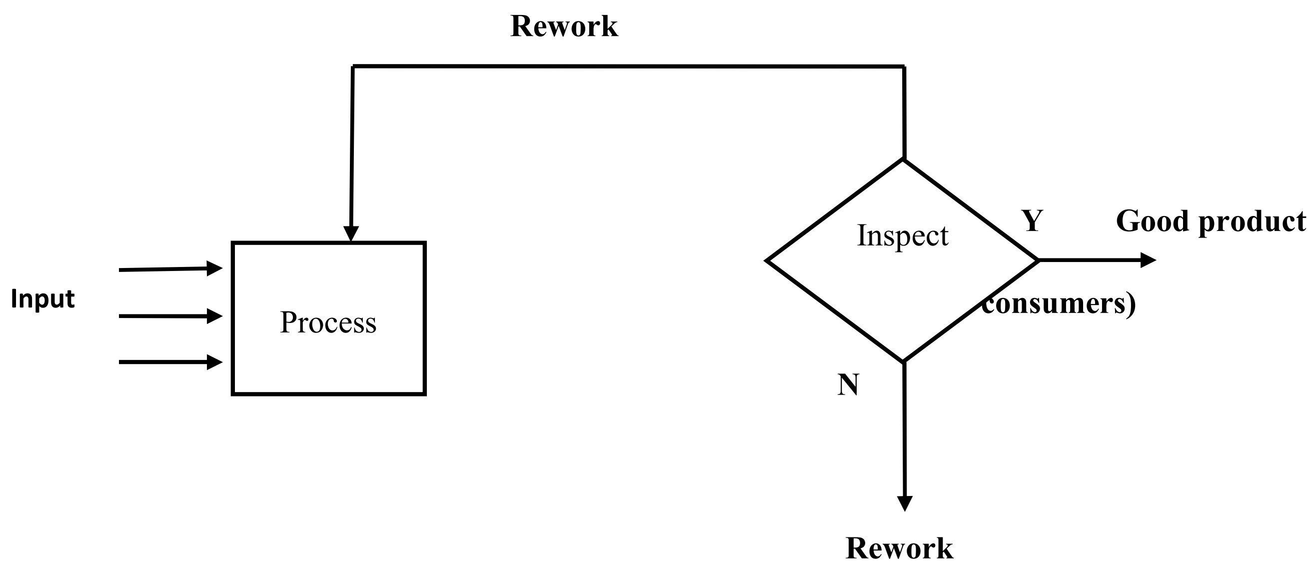

Figure 1– Inspection based quality control

2.1.4. Quality Control for Defect Prevention and Defects Identification

Typically, product quality measurements are performed both in the laboratory and process environment, their focus is however shifting. While quality assurance is process oriented and focuses on defect prevention, quality control is product oriented and focuses on defect identification. In this light, laboratory measurements are now viewed more as a verification measurement to ensure the inline measurement is correct. The laboratory sampling frequency is reduced, thus saving time and allowing operators to perform other tasks.

As a result of this development, the need for real-time process monitoring for continuous quality control and assurance has significantly increased. While the laboratory measurements remain the reference for process instrumentation the continuous measurement of key parameters directly in-line provides means for detecting quality deviations or problems immediately and enables appropriate actions to be made. Additionally, production parameters are continuously tracked and stored for reporting and statistical process control. In other words, the importance of data connectivity between inline, at-line and laboratory beverage analyzers is more important than ever and a complete solution is needed

2.1.5. Operational Demands to Comply with Quality Standards

Beverage manufacturers now face a complex range of operational demands, from the need to comply with exacting quality standards, the ability to measure new and different components, meeting rigorous production schedules, all while satisfying consumers' ever-evolving tastes and preferences. The only solution to manage all these criteria is to initiate a comprehensive quality assurance and control program, a key component of which is the measurement of the critical quality parameters °Brix, Sugar Inversion, % Diet, CO_2, and many others. Manufacturing products within the specified limits of these parameters is essential for consistent product quality and taste.

2.2 Statistical Process Control

Definition and history

Statistical Process Control is a scientific, data-driven methodology for quality analysis and improvement. As a result, statistical methods and their application in quality improvement have had a long history. Statistical Process Control (SPC) is a statistical approach for assisting operators, supervisors and managers to manage quality and to eliminate special causes of variability in a process. The initial role of SPC is to prevent rather than identify product or process deterioration, but Xie and Goh (1999) suggest for its new role to actively identifying opportunities for process improvement. The main tools in SPC are control charts. The basic idea of control charts is to test the hypothesis that there are only common causes of variability versus the alternative that there are special causes. By continuously monitoring the process, the manufacturing organization could prevent defect items to be processed in the next stage and to take immediate corrective action once a process is found to be out of control.

Walter Shewhart, at the Bell Telephone Laboratories, introduced the control chart in the1920s to distinguish between inherent or normal variability, known as common cause variation, and variation due to a special cause which was popularized worldwide by Dr W Edwards Deming, Shewhart charts are typically used to distinguish between variations due to special causes from variations due to common causes. Special causes are changes in the pattern of data that can be assigned to a specific cause. They are referred to unnatural variation due to events, changes, or circumstances that have not previously been typical or inherent in the regular process. Common causes are problems inherent in the manufacturing system as a whole which are natural and expected. Processes that exhibit only common cause variation are said to be stable, predictable, and in statistical control. The process is said to be in statistical control when the special causes have been identified and eliminated. Shewhart charts can be used to monitor the process for the occurrence of special causes and to measure and reduce the effects of common causes. These techniques include control charts, histogram distribution, Pareto analysis and correlation methods. Six-sigma is the latest development in the SPC effort. It incorporates many of the innovations in quality and efficiency improvement of the 20th century.

If a product is to meet or exceed customer expectations, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with little variability around the target or nominal dimensions of the product's quality characteristics. Statistical process control methods extend the use of descriptive statistics to monitor the quality of the product and process. Using statistical process control we want to determine the amount of variation that is common or normal. Then we monitor the production process to make sure production stays within this normal range. That is, we want to make sure the process is in a state of control. The most commonly used tool for monitoring the production process is a control chart. Different types of control charts are used to monitor different aspects of the production process. A control chart (also called process chart or quality control chart) is a graph that shows whether a sample of data falls within the common or normal range of variation. A control chart has upper and lower control limits that separate common from assignable causes of variation. We say that a process is out of control when a plot of data reveals that one or more samples fall outside the control limits.

2.2.1 Statistical Process Control (SPC) versus Statistical Quality Control (SQC)

Statistical quality control is defined as the application of the 14 statistical and analytical tools (7-QC and 7-SUPP) to monitor process outputs (dependent variables). Statistical process control is the application of the same 14 tools to control the process inputs (independent variables). Although both terms are often used interchangeably, statistical quality control includes acceptance sampling where statistical process control does not.

2.2.2. The Seven Quality Control Tools

In 1974 Dr. Kaoru Ishikawa brought together a collection of process improvement tools in his text guide to quality control. Known around the seven quality control tools, they are:

***Check sheet*:**

A check sheet is a form specially prepared to enable data to be collected simply by making check marks. It is used for tallying the occurrences of the defects or causes being addressed by graphing or charting them directly. Check sheet is a powerful data recording tool.

Pareto Charts:

First developed in 1906, by Italian economist, Vilfredo Pareto, then Joseph M. Juran applied it in classifying problems of quality. The Pareto Principle also known as the 80/20 rule states that only a "vital few" 20% causes are responsible for producing most of the 80% problems (trivial many). It is used to detected problems by classifying them, showing their frequency in the process and set their priority. Pareto Charts allows the user to focus attention on a few important problems in a process and makes it easy to see which of many problems have the most serious effect on quality, productivity, cost, safety, morale, delivery time, surrounding etc. together with their relative proportions process and set their priority.

Cause and effect diagram:-

It is sometimes called Ishikawa Diagram because it was invented by Dr. Karou Ishikawa in the 1943. It is also called fish-bone diagram because it looks like fish bone. Cause and effect diagram is a tool that identifies, sort and display possible cause of a specific problem or effect.

Its main use is to pick up and arrange all possible causes without any omissions. And it allows many factors to be seen at the same time, and can be used by everyone from beginners to experienced workers. Picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes and Effect (characteristics that need improvement) on the right and causes on the left.

Histograms:-

Histograms or frequency distribution Diagrams are the most commonly used graphs to show frequency distributions in convenient class intervals and arranged in order of magnitude. They are useful in studying patterns of distribution or shape of a distribution and comparing it with specifications or standard values. It organizes bulk data in an easy manner to understand the population or data. Histograms Can Be Used to determine distribution of sales and Say for instance a company wanted to measure the revenues of other companies and wanted to compare numbers.

Flow Charts:-

It is a diagram showing the development of something through different stages or processes. Flow chart is a pictorial representation showing all of the steps of a process.

Control charts:-

The control chart is a graph used to study how a process changes over time. It is used to analyze a process and to determine whether a process will process a product or service with consistent measurable properties. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether a process is in control or is unpredictable (out of control, affected by special causes of variation).

If your process is in control, then

- 99.73% of all the data points will be inside those lines or no sample points outside limits
- most points near process average
- about equal number of points above and below center line points appear randomly distributed

Scatter Diagrams:-

A scatter diagram shows the correlation between two variables in a process. Also called scatter plot, X–Y graph. Its purpose is to find if there is correlation between paired sets of data to identify the correlations that might exist between a quality characteristic and a factor that might be affecting it. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.

2.2.3 The Seven Supplemental Tools

In addition to the seven basic quality tools, there are also some additional statistical process control tools known as the seven supplemental tools. These are: data stratification, Defect map, Events log Process flow charts/maps, Progress centers Randomization and Sample size determination

2.2.4 Types and Causes of Variation in SPC

When looking at bottles of a soft drink in a store carefully, it will be notice that no two bottles are filled to exactly the same level. Some are filled slightly higher and some slightly lower. This type of difference is completely normal. Wiley et al (2007), says no two products are exactly alike because of slight differences in materials, workers, machines, tools, and other factors". These are called common, or random, causes of variation (Wiley et al, 2007). Wiley further say that common cause of variation are based on random causes that cannot be identify. These types of variation are unavoidable and are due to slight differences in processing.

An important task in quality control is to find out the range of natural random variation in a process when all the data falls within the predetermined range of control, i.e. Lower Control Limit (LCL) and Upper Control Limit (UCL) it is regarded as random or normal causes of variation. This normal or random cause of variation cannot be identified because the data falls within the preset limits.

Wiley et al (2007) further says, the other type of variation that can be observed involves variations where the causes can be precisely identified and eliminated. These are called assignable causes of variation. Examples of this type of variation are poor quality in raw materials, an employee who needs more training, or a machine in need of repair. In each of these examples the problem can be identified and corrected. Also, if the problem is allowed to persist, it will continue to create a problem in the quality of the product where data falls above and below the preset control limits (LCL and UCL) indicating that a variation due to assignable causes has been developed and can be identified and also be corrected.

2.2.5 Aim of Statistical Process Control

The seven quality control tools are simple statistical tools used for: - problem solving, collecting data, analyzing data, identifying root causes and measuring the results. The primary main function of statistical quality control tools is to effectively collect quality data like various product quality including defect data, retry rate of machines, operating rate. Compute the fraction defective based on data collected to create a chart with plotting such fraction defective in time sequence, so that the chart may be used as a poster in the office space. Further, it is important for them to confirm that product quality is remaining within a manageable range. If the quality would be out of the range, every worker should discuss about any possible counter measures. These data should be analyzed by certain method to examine counter measure. For example: stratify defect cause to find the defection fracture by each phenomenon, take countermeasure toward defect caused by a group with high defection fracture in order to decrease it below the manageable range. If the fraction defective improved to that level, narrow down the manageable range to repeat the procedure (Hansen B.I and Gahere P.M 1987).

2.2.6. SPC Implementation

According to Ignatio Madanhire in SPC application, it is important to understand and identify key product characteristics which are critical to customers or key process variation as shown in the key steps for implementing SPC are:

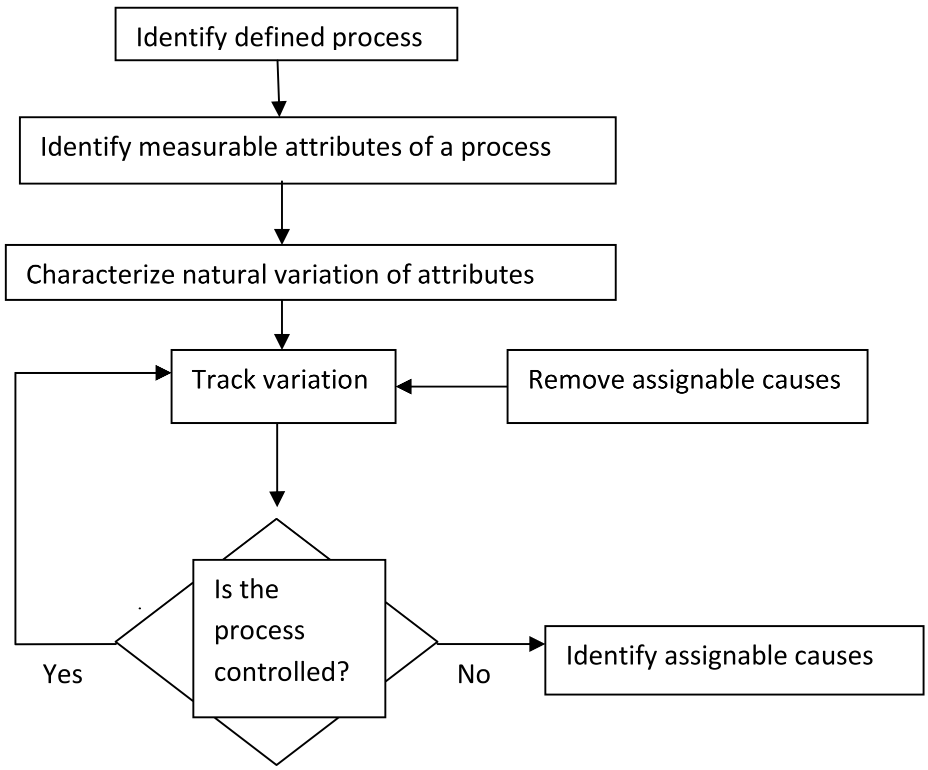

Figure 2 Steps in SPC implementation (source gold practice)

2.2.7 Statistical Process Control Charts

Statistical process control (SPC) is a statistical procedure using control charts to check a production process to see if any part of it is in some way not functioning properly, which could lead to poor quality. A control chart is a graphical method for displaying control results and evaluating whether a measurement procedure is in control or out of control. Control results are plotted versus time or sequential run number; lines are generally drawn from point to point to accent any trends, systematic shifts, and random excursions. The chart contains a center line that represents the average value of the quality characteristic corresponding to the in control state. Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL) are also drawn.

2.2.7.1 Types of Control Charts

Control charts are important statistical tool for quality control. They display the results of inspecting a continuous process and separate random variations due to real assignable causes from normal variations due to chance causes. Such a running commentary as to what is happening in the process provides a convenient and rapid feedback suggesting when adjustments, corrections or overhauls may be needed. Control charts are basically of two types. These are:-

A) Control charts by variables

Those capable of being measured and the product can be classified well or bad, acceptable or non-acceptable based on quantitative measurements of their properties. Typical examples of variables are diameter, volume, length, thickness, weight, temperature, humidity, voltage, hardness, viscosity etc.…Control charts for variables are the following:-

i. The average chart (X-chart), which measures the central tendency of the process.
   To calculate control limit of X chart

Center line: $CL = \bar{X} = \frac{\sum X}{N}$

Upper control limit $UCL = \bar{X} + A_2 \bar{R}$

Lower control limit $LCL = \bar{X} - A_2 \bar{R}$

ii. The range chart (R-chart), which measures the spread of the process.
   To calculate control limit of R chart

Center line CL= R

Upper control limit $UCL = D_4 R$

Lower control limit $LCL = D_3 R$ (Unnecessary） because $D_3 = 0$

Since average chart and range charts are usually used together, they are commonly known as

X_{bar} - R charts

B) Control charts by attributes

- Properties which are difficult to measure quantitatively.

- These properties are usually measured by comparison and any sample taken is classified good or bad, ok or defective by quality characteristics.
- Typical examples of attributes are surface appearance, color, texture, cracks, imperfections, burns etc.
- Control charts for attributes are basically the following:-

i. The fraction defective chart (P-chart) which records the proportion of defective items in a sample.

$\bar{P}$ = total no. of reject items divided by total no. of inspected items

To calculate the control limit ;

Control limit = $\bar{P}$

Upper control limit UCL = $\bar{P} + 3 \text{ x } \sqrt{\frac{P(1-P)}{n}}$

Lower control limit LCL = $P - 3 \text{ x } \sqrt{\frac{P(1-P)}{n}}$

ii. The number defective chart (nP - chart) which records the number of defective items in a sample.

The control limit CL = Average of rejected No. = No. of reject divided by Size of group

Upper control limit UCL = nP + 3x $\sqrt{np(1-p)}$

Lower control limit LCL = nP – 3x $\sqrt{np(1-p)}$

iii. The defects chart(C-chart) which records the number of defects in a component/product

The control limit CL = Average of defects No. = C

Upper control limit UCL = C + 3 x $\sqrt{C}$

Lower control limit LCL = C – 3x $\sqrt{C}$

iv. Control chart for defects per unit (U - chart)

Control limit = the average number of defects per unit = U

Upper control limit UCL = U + 3x $\sqrt{\frac{U}{n}}$

Lower control limit UCL = U - 3x $\sqrt{\frac{U}{n}}$

2.2.8 Advantages of SPC Implementation

SPC implementation is important as it could improve process performance by reducing product variability and improves production efficiency by decreasing scarp and rework.

According to Attaran (2000), in their attempts to remain competitive, US business had embarked on TQM techniques such as SPC that leads to higher quality product by reducing-variability and defects; rework, failure, scrap, warranty claims and product recall costs, thus improving their overall business competitiveness (Booker, 2003). Most of the production and quality cost that SPC aims to minimize such as rework, lost of sales and litigation are measurable. The success and failure in SPC implementation does not depend on company size or resources, but it relies on appropriate planning and immediate actions taken by workers with regards to problem solving.

According to Benton (1991) and Talbot (2003), the advantages of implementing SPC could be Categorize into the following categories; maintain a desired degree of conformance to design, increase product quality, eliminate any unnecessary quality checks, reduce the percentage of defective parts purchased from vendors, reduce returns from customers, reduce scrap and rework rates, provide evidence of quality, enable trends to be spotted, ability to reduce costs and lead times. In other words, SPC implementation can also help to accomplish and attain a consistency of products that meet customer's specifications and thus fulfill their expectations. In general, SPC can be used to monitor the natural variation of a process and minimize the deviation from a target value and thus play a major role in process improvement.

2.2.9 Implementing SPC in a Quality Improvement Program

The methods of statistical process control can provide significant payback to those companies that can successfully implement them. Although SPC seems to be a collection of statistically based problem-solving tools, there is more to the successful use of SPC than learning and using these tools. SPC is most effective when it is integrated into an overall, companywide quality improvement program. It can be implemented using the DMAIC approach. Indeed, the basic SPC tools are an integral part of DMAIC. Management involvement and commitment to the quality improvement process are the most vital components of SPC's potential success. Management is a role model, and others in the organization look to management for guidance and as an example. A team approach is also important, as it is usually difficult for one person alone to introduce process improvements. Many of the magnificent seven are helpful in building an improvement team, including cause and-effect diagrams, Pareto charts, and defect concentration diagrams. This team approach also fits well with DMAIC. The basic SPC problem-solving tools must become widely known and widely used throughout the organization. Ongoing education of personnel about SPC and other methods for reducing variability are necessary to achieve this widespread knowledge of the tools. The objective of an SPC-based variability reduction program is continuous improvement on a weekly, quarterly, and annual basis. SPC is not a one-time program to be applied when the business is in trouble and later abandoned. Quality improvement that is focused on reduction of variability must become part of the culture of the organization.

The control chart is an important tool for process improvement. Processes do not naturally operate in an in-control state, and the use of control charts is an important step that must be taken early in an SPC program to eliminate assignable causes, reduce process variability, and stabilize process performance. To improve quality and productivity, we must begin to manage with facts and data, and not simply rely on judgment. Control charts are an important part of this change in management approach.(Douglas C. Montogomery, 1997)

According to different researches and books, in implementing a companywide effort to reduce variability and improve quality, several elements are usually present in all successful efforts. These elements are as follows:

Elements of a successful implementation program

1. Management leadership program
2. A team approach, focusing on project-oriented applications
3. Education of employees at all levels
4. Emphasis on reducing variability
5. Measuring success in quantitative (economic) terms
6. A mechanism for communicating successful results throughout the organization

2.2.9.1 Problems and Difficulties in the Implementation of SPC in Organization

The following points seem to inhibit the successful application of SPC in organizations: .

- ✓ **Lack of commitment and involvement of top managem**ent. One of the most common reasons for the failure of SPC implementation in many organizations is due to lack of commitment and involvement of top management (Mason and Antony, 2000). It is always important to remember
- ✓ that change within the organization cannot occur until there is a "change agent" present. In this case, the change agent would usually be top or senior management representatives. Management must understand that variability-reduction techniques such as SPC are their responsibility and therefore they should be the first recipients of SPC training. They should believe in SPC as a powerful problem-solving tool and understand the requirements or key ingredients for a successful SPC system within the organization. .
- ✓ **Lack of training and education in SPC.** Lack of training and education in SPC creates problems company-wide, from the operators to the senior management, because there is a general lack of understanding and awareness of why SPC is being implemented. The purpose of this training and education is to establish a culture in which SPC is welcomed as a powerful quality management technique to understand, manage and reduce variation due to special causes and to support the goal of continuous improvement (Gaafar and Keats, 1992). .
- ✓ **Failure to interpret control charts and take any necessary actions.** The purpose of a control chart is not only just to hunt for special causes of variation but also to bring a process into a state of statistical control by taking appropriate remedial actions on the process. The emphasis must be placed on the selection of and interpretation of control charts and not on the construction of control charts. Many existing training programmers' have given an awful lot of importance on the construction of control charts and not on when, where and why a particular control chart must be chosen for a certain process. **.**
- ✓ **Lack of knowledge of which product characteristics or process parameters to measure and monitor within a process.** Many SPC initiatives in organizations get kicked-off without having a good understanding of the process and the product characteristics or parameters related to core processes. It is best to identify the key process parameters and its relationship to process output using experimental design methods. Experimental design is a powerful

technique to discover a set of process variables which are most important to the process and determine at what levels these variables should be kept to optimize the process output (Montgomery, 1991). The critical product characteristics may be identified from a quality function deployment exercise by working closely with customers (Chen, 1995).

- ✓ **Invalid and incapable measurement system at workplace**. Measurement is a process, and varies, just like all processes vary. Many organizations often ignore the variation associated with the measurement system that is certainly an important feature for the successful implementation of SPC in organizations. There is uncertainty in every measurement that is taken and this can be attributed to a number of key inputs such as gauges, operators, parts, methods or the interaction between these inputs. If the measurement system is not capable, the SPC study must be deferred (Bird and Dale, 1994). . SPC should be implemented not as a customer requirement rather it must be used to make customers happy with your stability and capability of processes. SPC should not be used as a requirement from your customers. It should be used to improve the stability and capability of processes that are most critical to your customers and thereby a distinct competitive edge and increased market share can be generated.

2.3. Process Capabilities

So far we have discussed ways of monitoring the production process to ensure that it is in a state of control and that there are no assignable causes of variation. A critical aspect of statistical quality control is evaluating the ability of a production process to meet or exceed preset specifications. This is called process capability. To understand exactly what this means, let's look more closely at the term specification. Product specifications, often called tolerances, are preset ranges of acceptable quality characteristics, such as product dimensions. For a product to be considered acceptable, its characteristics must fall within this preset range. Otherwise, the product is not acceptable. Product specifications, or tolerance limits, are usually established by design engineers or product design specialists. For example, the specifications for the width of a machine part may be specified as 15 inches ± .3. This means that the width of the part should be 15 inches, though it is acceptable if it falls within the limits of 14.7 inches and 15.3 inches. Similarly, for Mirinda, the average bottle fill may be 300 ml with tolerances of ±3% Although the bottles should be filled with 300ml of liquid, the amount can be as low as 291 or as high as

309ml. Specifications for a product are preset on the basis of how the product is going to be used or what customer expectations are. As we have learned, any production process has a certain amount of natural variation associated with it. To be capable of producing an acceptable product, the process variation cannot exceed the preset specifications. Process capability thus involves evaluating process variability relative to preset product specifications in order to determine whether the process is capable of producing an acceptable product. In this section we will learn how to measure process capability.

2.3.1 Measuring Process Capability

Simply setting up control charts to monitor whether a process is in control does not guarantee process capability. To produce an acceptable product, the process must be capable and in control before production begins. Let's look at three examples of process variation relative to design specifications for the MOHA soft drink company. Let's say that the specification for the acceptable volume of liquid is preset at 300 ±3%, which is 291 and 309ml. Process capability is measured by the process capability index, Cp, which is computed as the ratio of the specification width to the width of the process variability

$$C_P = \frac{Specification\ width}{process\ width} = \frac{USL - LSL}{6\delta}$$

The process width is computed as 6 standard deviations (6δ) of the process being monitored. The reason we use 6δ is that most of the process measurement (99.74 percent) falls within ±3 standard deviations, which is a total of 6 standard deviations. There are three possible ranges of values for Cp that also helps us interpret its value.

Cp =1: A value of Cp equal to 1 means that the process variability just meets specifications. We would then say that the process is minimally capable.

Cp ≤ 1: A value of Cp below 1 means that the process variability is outside the range of specification. This means that the process is not capable of producing within specification and the process must be improved.

Cp ≥1: A value of Cp above 1 means that the process variability is tighter than specifications and the process exceeds minimal capability.

A Cp value of 1 means that 99.74 percent of the products produced will fall within the specification limits. This also means that .26 percent (100% - 99.74%) of the products will not be acceptable. Although this percentage sounds very small, when we think of it in terms of parts per million (ppm) we can see that it can still result in a lot of defects. The number .26 percent corresponds to 2600 parts per million (ppm) defective (0.0026 X 1,000,000). This number can seem very high if we think of it in terms of 2600 defective products out of a million. You can see that this number of defects is still high. The way to reduce the ppm defective is to increase process capability. Cp is valuable in measuring process capability. However, it has one shortcoming: it assumes that process variability is centered on the specification range. Unfortunately, this is not always the case Because of this, another measure for process capability is used more frequently.

$$\mathbf{C_{PK} = min\left(\frac{USL-\mu}{3\delta}, \frac{\mu-LSL}{3\delta}\right)}$$

Where μ = the mean of the process

δ = the standard deviation of the process

This measure of process capability helps us to address a possible lack of centering of the process over the specification range. To use this measure, the process capability of each half of the normal distribution is computed and the minimum of the two is used.

CHAPTER THREEE

RESEARCH DESIGN AND METHODOLOGY

In this study, data related to the process of the product and the main reason that makes the defects would be collected. The research is descriptive by its nature since different defect can be counted and recorded for further analysis.

3.1 Research Design

The design of the research is descriptive since it allows the collection of data through questionnaires on the bases of sample, which helps to find out the view of the population. The researcher used a mixed methods approach both quantitative and qualitative in order to achieve the main objective of this research. According to Mark et al. (2009:101) mixing qualitative and quantitative approaches gives the potential to cover each method's weaknesses with strengths from the other method. It helps to collect data that could not be obtained by adopting a single method. Therefore, survey with questionnaires and semi-structured interview was employed so as to address the SPC implementation practices and challenges in respect to quality improvement. The semi structured interview was used to gather some information about the views of the quality managers and managing directors of the company.

3.2 Data source

To acquire data on the nature and extent of quality control tools usage such as SPC in MOHA soft drinks S.C the researcher used both primary and secondary data sources. Self administered close ended questionnaire, semi structured interview, focus group discussion was held to technical managers, quality department, production managers, supervisors and with the others who are working in the area of production process, and a direct observation were employed as a primary source of data gathering tools. Whereas the different work pieces such as; a company previous recorded data related to the proposed research title and other relevant literatures were considered as a secondary source of data and were reviewed.

3.3 Sample Size and Sampling Technique

Employing convenient sampling technique, all the production staffs were chosen as respondents. So as per the information obtained from MOHA soft drinks a total of 40 employees are working mainly in the area of the production process. Therefore the researcher employed purpesive convenient sampling method and all the production staffs were taken for the research.

3.4 Data Collection Methods and Procedures

So as to collect the reliable and relevant data this research used open (oral) semi structured interview, self administered close ended questionnaires, direct observation of the industry, documentation review of previously recorded data and reviewing related literatures. These data collecting tools are chosen intentionally on the basis of their applicability to this research and considering their advantages and limitations as well. Therefore, reasons that the research intended to employ the above mentioned tools discussed clearly as follows.

Direct Observation

This method is used for collecting the required data and information from the selected industry. During direct observation, the researcher observed how the process was preceded and took the actual data directly from the observation. This was a means to evaluate the use of appropriate quality.

Oral (open) Interviews

As of the interview, even though could take much time, was costly and was hard to analyze and compare, the researcher choose it to obtain full range and depth of information. Besides, the researcher could get the opportunity to develop relationship with clients and could be flexible with them as well. More over the researcher fully understood employee impressions or experiences, or learned more about their answers to questionnaires.

It was employed to technical managers, quality department, production managers, to the operators, supervisors and with the others who were working in the area of production to evaluate the existing quality considerations and the practices and challenges faced in the implementation of quality improvement tools. And also the interview helped to determine the overall perception about the application of statistical process control.

Questionnaire

The questionnaires helped the researcher to gather the required data enabling the respondents to complete anonymously. In addition to this questionnaire was inexpensive to administer to many people, easy to compare and analyze and the researcher could get lots of data.

The Questionnaire addressed the level of awareness, usage and experience of the selected manufacturing industry on quality control tools such as SPC methods as well as constraints/challenges of industry for introducing quality improvement tools**.**

Accordingly the questionnaire was distributed for 40 sample respondents but only 35 of them were returned.

3.5 Validity and Reliability of Data

In any research, the concern of an investigator is how to minimize possible errors and bias by maximizing the validity and reliability of data. This then requires that the tool for the collection of data is valid and reliable. Validity is concerned with the extent to which scale accurately represents the contracts of interest (Marshal, 2006). With this regard, as mentioned earlier, the questionnaire were distributed to a total of 40 participants, but 5 of them, not returned; were not included as participants in the study in order to increase the content validity of the questionnaire. In addition to this, internal consistency of this study was checked by Cronbach's alpha. The data obtained were analyzed by using Minitab version 18 to say the reliability and scales of tools and patterns and it indicates an alpha value greater than 7 so the data is reliable.

items/questions/components	78
sum of the item variances	76.13795
variance of total scores	392.5029
Cronbach's α	0.816487

3.6. Data Analysis Methods

As long as the quantitative and qualitative data were required to be gathered, presented, analyzed and interpreted, different ways of presenting data were used. For the presentation of the quantitative data control charts, tables and/ or diagrams were used. Whereas for presenting qualitative data the researchers summarize comments or responses in to X number of people commented that.

In order to make the analysis and interpretation, the researcher explored key themes – what answers does it give to the research question? And identified what is surprising about the information, are there any 'unplanned' issues! Then discussed the interpretation of the findings and linked it back to the terms of reference, the project objectives and the literature review.

3.7. Ethical Consideration

In order to have permission for the study, and to avoid unnecessary reluctance, suspicion and dishonesty the researcher was ethical and informed the participants about the objective and purpose of the study that it is only for academic purpose and confidentiality of their response will be strictly maintained.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

In order to achieve the main objective of the research the researcher prepared and distributed a total of 40 questionnaires to the employees of the MOHA soft drinks working in the area of the manufacturing process. Out of the 40 questionnaires, 35 responses were valid with complete answers. Therefore, the researcher used 35 questionnaires for further analysis. On the other hand, in order to have some idea on how the production staffs view on quality related issues and SPC the researcher prepared an interview for the production management staffs and used all the responses for analysis.

4.1. About the company

MOHA soft drinks industry S.C was formed and registered under the commercial code of Ethiopia on the 15th of May 1996. The brand produces Pepsi cola, Mirinda orange, 7-up, Mirinda apple, Mirinda tonic, pine apple, and pepsi diet and kool water. The maximum production capacity of the plant is 24000 bottles per hour for RGB and 14400 bottles per hour for PET line. To execute the plant's production, sales and other activities, the plant has 515 permanent employees in seven different departments.

Process description

Sugar tanks will be cleaned and sanitized. Following washing and sanitizing, sugar will be dumped to the sugar dissolving tank to treat sugar at 85^{o}c for 30 minutes. After it is treated, it will be filtered and transferred to washed and sanitized finished tanks. And water will be treated through coagulation/membrane system and released for filling, cleaning and sanitation purpose for various areas. Carbon dioxide will be produced through gasoil burning by using absorption, stripping purification, drying and re-boiling systems. The solid and liquid ingredients are inspected during staging, and solid ingredients are dissolved in the required order and transferred to finished tank/s, and liquid ingredients are also added to the finished tank without future processing. Finished syrup and water will be filled in RGB bottles that are soaked and cleaned in 2% caustic solution for a minimum of 6-minutes at 65^{o}c, and in PET bottles which are blown in the facility. After it is filled, it will be crowned/capped, coded, inspected, cased and palletized and stored in full product storage. Through this process, wastes s are segregated and removed into a designated area so as to control cross contamination the warehouse personnel will dispatch the product by keeping first in first out practice. Product is loaded onto a covered vehicle or it should be covered before the vehicle leaves the facility, and it is delivered to customers.

4.2. Results

Under this section the existing SPC are presented using descriptive statistics. The descriptive statistics tool implemented to explain the findings including frequencies, measure of relative position (percentages), and measure of central tendency (mean) of the SPC related issues.

The questioner contains two parts with five response scales with similar questions under 12 categories. Accordingly the demographic characteristics of the respondents are addressed in the first part. The other SPC related questions are addressed in the second part with mixed part questions like a scale from 1 to 5 were used to measure the respondents' perception on SPC implementation practices.

4.2.1. Demographic characteristics of the respondents

This section provides respondents background in terms of gender, work position and work experience. The following tables present the personal data of the respondents in detail.

Table 4.1. Demographic characteristics of the respondents

Variables	Groups	Frequency	Percent
Gender of respondents	Female	10	28.57%
	Male	25	71.43%
	Total	35	100%
Work position	Chemist	20	57.14%
	Quality head manager	5	14.28%
	Line worker	10	28.57%
Work experience	Below 2years	7	20%
	From 3 to 5 years	15	42.85%
	More than 5 years	13	37.14%
Educational back ground	MSC graduates	12	34.29%
	Under graduates	22	62.85%
	Diploma	1	2.85%
Total		35	100%

Table 4.1.above Presents gender, work position and work experience of the respondents who are working in the company. As it indicates, 28.57% of the respondents are females and 71.43% are males.

Besides, 57.14% of the respondents are chemists whereas, 14.28% and 28.57% of the respondents are quality head managers and line workers respectively. This implies the participants in this research work are well aware of the SPC implementation. On the other hand, 20% of the respondents have a work experience of less than 2years and 42.85 % of the respondents have an experience of 3 to 5 years whereas 37.14% of the respondents have an experience of more than 5 years. It is plausible to assume that most of the respondents can exactly know the implementation of statistical process control to improve quality of the product. In addition, 34.29% of them have a master's degree and 62.85% of the respondents have degree only 2.85% or one respondent has a diploma. This indicates all the respondents can understand all the questionnaire questions and respond properly.

Perception of the respondents on SPC generally

The major components of SPC are assessed under this part of the question. This part also has a total of 12 groups namely, managerial actions and polices to support the implementation program, identification of critical measurement characteristics, technological sophistication and soundness of measurement devices, operator responsibility for process control via control charts, major quality related problems/obstacles in the company, usage of control chart information for continuous improvement, training in statistical and cognitive methods for process control and improvement, technical support for SPC implementation and practice, quality improvement team support of SPC practice, absence of final inspection as a primary quality control strategy, update of knowledge of processes and audit and review of SPC practice and performance. Each group has detail parameters that contribute for the major group and also for SPC as a whole.

4.2.2. Managerial actions to support the implementation Program.

Table 4.2. Standard deviation and mean score of respondents on managerial actions to support the implementation program.

Statement	N	No of responses					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
Higher Mgt provides visible support for the implementation program	35	4	6	9	12	4	3.17	1.183	34.26% moderate
Financial resources have been allocated to support the activities involved in using SPC tools	35	1	1	4	22	7	3.94	0.8261	62.86% moderate
Higher Mgt uses control chart information in planning	35	0	3	13	9	10	3.74	0.9663	37.14% some what
Higher management permits sharing of control chart information with either suppliers or customers	35	0	4	11	14	6	3.63	0.8972	40% moderate
Higher Mgt regularly spearheads quality improvement effort identification	35	0	1	5	18	11	4.11	0.7472	51.43% moderate
The Mgt is willing to accept any suggestions, comments and complaints from employee	35	0	8	8	10	9	3.57	1.1029	28.57 %m moderate

Based on the above table, 34.2% of respondents said that the higher Mgt gave visible support for implementation of the program where as noticeable number of respondents, 54.28 % said there was not enough support. Thus, the data revealed that the organization was not experiencing the required amount of support.

The other managerial action to support the implementation program is allocation of financial resources. On this respect 62.86% of the respondents insured that there was a moderate support from the Mgt. It implies that the organization has a good practice up on the issues discussed.

On the other managerial action usage of control charts for planning 37.14% of the respondents ticked under somewhat the Mgt uses control chart information for planning. However, the remaining 54.29% of the respondents said that there was moderate usage of control charts for planning. On the other managerial action 51.43% of the respondents were saying that there was a moderate regular quality improvement identification effort.

According to the data presented in the above table, 22.86% of the respondents agreed by saying low, 22.86% said somewhat whereas, 28.57% and 25.71% of the respondents respectively agreed there is a moderate and very extreme management willingness to accept any suggestions, comments and complaints from employees.

Regarding higher management support, 11.43% of the respondents very extremely agree there is a higher management support in using control charts and 34.28% of the respondents moderately agree, 25.71% have a neutral response, 17.14% of the respondents have a low response and 11.43% of the respondents have a not at all response on the support of higher management in using control charts throughout the organization. Although visible support of higher management for the use of control charts throughout the organization had a lowest level, it doesn't mean that there was no support from higher management at all.

4.2.3. Identification of critical measurement practices

Table 4.3 Mean and Standard deviation score of respondents on identification of critical measurement characteristics.

Statement	N	No of respondents					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
The quality characteristic (s) associated with this process has been documented by an operator	35	0	0	8	9	18	4.286	0.8134	51.43% always
The impact the manufacturing process on key quality characteristics of final product is well-known	35	0	0	0	17	18	4.514	0.499	51.43% always
Customers have been surveyed to identify those quality characteristics associated with this process	35	6	3	1	20	5	3.429	1.3155	57.14%often
Quality characteristics associated with manufacturing process is being monitored via control charts	35	0	3	2	20	10	4.057	0.8261	57.14% often
No one has bothered to identify and define how or why this process affects the quality of the final product delivered to our customers	35	6	3	5	11	10	3.457	1.4211	31.43%often
Our customers have been asked to identify quality problems of final product	35	4	0	7	17	6	3.657	1.1449	48.57% often
Quality problems with final product have been related back to particular parameters of this process	35	0	0	12	17	6	3.8285	0.693	48.57% often
Process parameters affecting the quality of the final product delivered to our customers have been documented for the process operator	35	0	0	6	14	15	4.2571	0.73066	42.86% always
Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools	35	2	0	5	23	5	3.8286	0.8778	65.71% often

As shown in the above table the identification of critical measurement characteristics has been evaluated with different variables. Based on the result with an average mean value of 3.92 most of the critical measurement characteristics are identified often. According to the above data compared to other variables customers have been surveyed to identify those quality characteristics associated with this process have the least mean value which is 3.45.

Regarding documentation by the operators, 51.43 % of respondents witnessed that the quality characteristic associated with the process were always documented.

In addition to this, the impact of the key quality characteristics up on final products was known by the manufacturing process. This was revealed by 51.43 of respondents as cited above.

Associated with customers surveying, 17.14% of the respondents showed that customers have never been surveyed to identify those quality characteristics associated with the process while 8.5% and 2.86% the respondents respectively said that the company have been rarely surveyed and sometimes surveyed. To the contrary, the remaining 57.14% and 14.28% of the respondents said that customers have been surveyed to identify those quality characteristics associated with process often and always respectively as shown in the graph below.

Customers have been surveyed to identify those quality characteristics

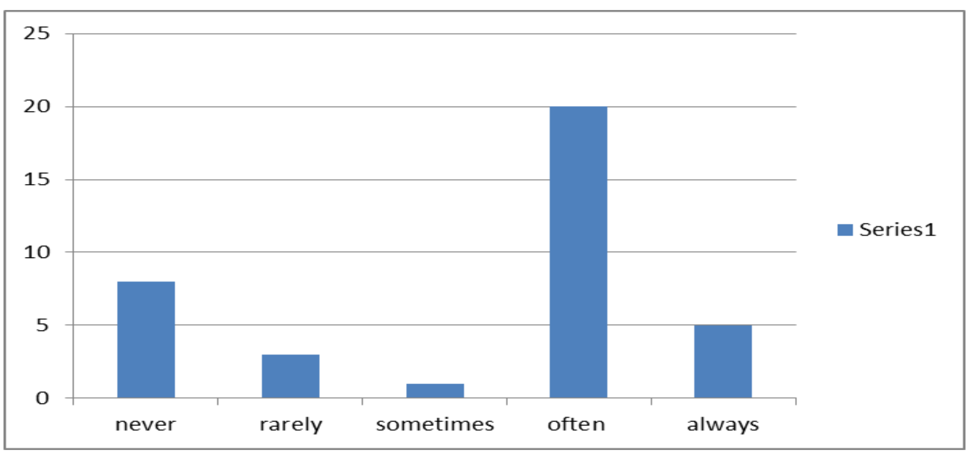

Figure 3 Graph for Analysis for customers has been surveyed to identify quality characteristics.

4.2.4. Technological sophistication and soundness of measurement devices

Table 4.4 Mean and Standard deviation score of the respondents on technological sophistication and soundness of measurement devices.

Statement	N	No of responses					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
Measurements of critical process/product characteristics are automated	35	0	2	1	23	9	4.114	0.7079	65.71%moderate
Computer controlled devices are employed to measure critical process/ product characteristics	35	0	0	0	29	6	4.17	0.376	82.85%moderate
Data in the form of measurements of critical process are collected by computerized sensors	35	0	3	0	21	11	4.143	0.797	60% moderate
Measurement data are entered electronically into a data base	35	0	0	0	20	15	4.428	0.4948	57.14% moderate
Only calibrated measuring devices are being used to take measurements on critical process/product characteristics	35	0	0	0	26	9	4.257	0.437	74.28% moderate
Measuring devices are calibrated in real time via computer control	35	3	0	3	23	6	3.828	0.999	65.71 moderate

As shown from the above table technological sophistication and soundness of measurement device has evaluated with different variables. Based on the result most of the respondents replied that the organization used technology for measuring different parameters of the product via computer in a moderate amount. It implies that the organization had a good practice.

4.2.5. Operator responsibility for process control via control charts

Table 4.5.Mean and Standard deviation scores of operators responsibility for process via control charts.

Statement	N	No of respondents					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
Data are collected on critical process/product characteristics , either manually or via computer	35	0	0	0	25	10	4.286	0.4517	71.43% somewhat true of me
observations of process/product characteristics on this manufacturing process are plotted on control charts by me, a process operator, either manually or via computer control	35	0	0	10	20	5	3.857	0.6388	57.14% somewhat true of me
Process operator look for out of control points on the control charts or verify out of control points identified via computer control	35	0	0	8	22	4	3.8	0.748	62.86% somewhat true of me
One of my key responsibilities as a process operator on this manufacturing process is to ensure that control charts are being correctly evaluated for out of control situations	35	1	0	4	24	6	3.97	0.736	68.57% somewhat true of me
How would you describe your role as a process operator in the application of control charts on this process?	35	0	0	0	31	4	4.114	0..318	88.57% somewhat true of me

Based on the data presented above in table 4.5, very noticeable amount of respondents which weighs more than 50% witnessed that the operator’s responsibility for process via control charts was to some extent. This data implies that there is a need for responsible operators so as to accomplish the tasks discussed under the above table.

4.2.6. Major quality related problems/obstacles

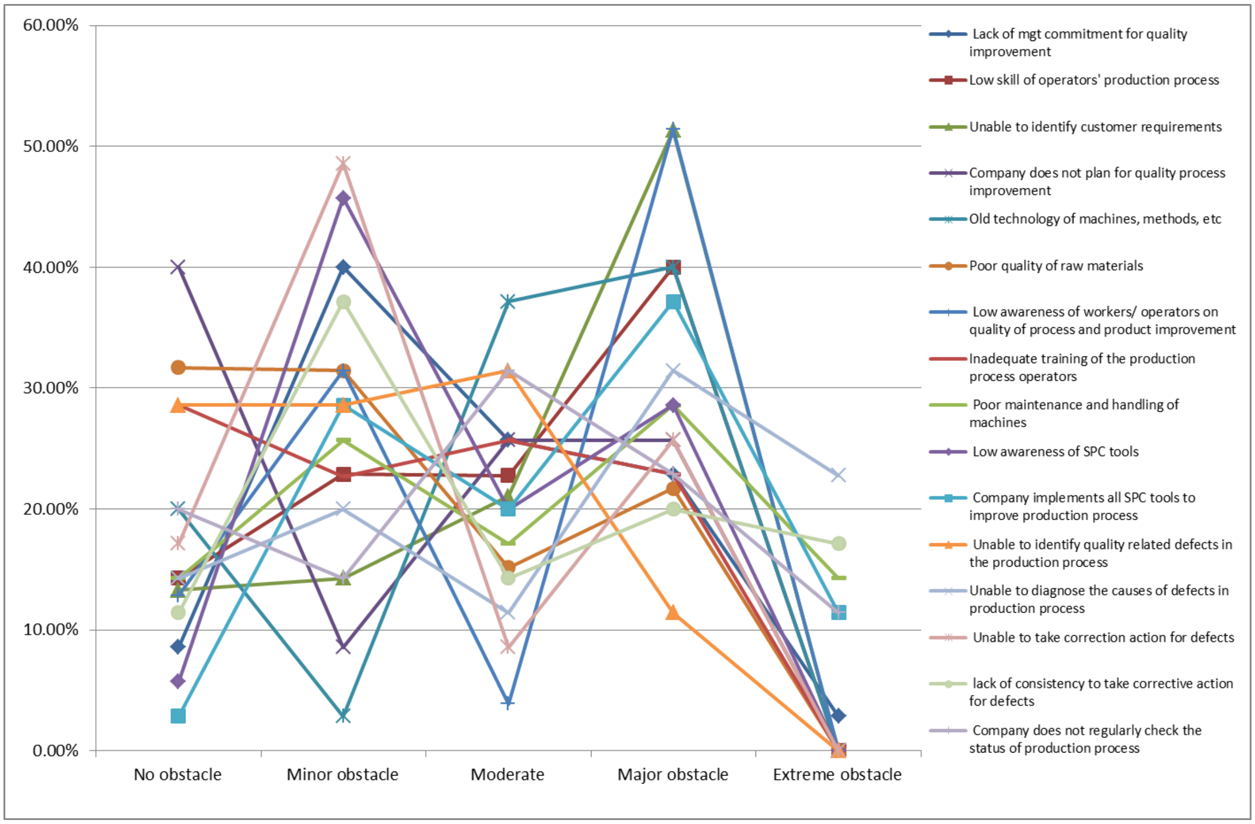

Figure 4 Graph of major quality related problems

Based on the above graph, lack of management commitment for quality improvement is figured out as 8.57% said that it was not an obstacle, 40% said that it was a minor obstacle, 25.71% said that it was a moderate obstacle while, the remaining 22.86% and 2.86% of the respondents said that it was a major and very sever obstacle for the company. This figure revealed that it was one of the moderate obstacles for the company.

Regarding operators skill, the data showed us low skill of machine operators for production process was not an obstacle as it was ticked by 14.29% of respondents. Besides, 22.86% of respondents said that it was a minor obstacle, although 22.76% and 40 % of respondents respectively addressed that it was moderate and major obstacle.

Associated with identification of customers' requirement, 51.33% of the respondents indicated that being unable to identify customers' requirements was a major obstacle for the company as cited in the above table.

For the question “Does not the company plan for quality and process improvement?”, 40% of the respondents said that it was not an obstacle, 8.57% of them said that it was a minor obstacle. Nevertheless, 51.42 % of respondents said that it was moderate and major obstacle sharing equal percent each.

Regarding technologies of machine, methods and so forth, the data gathered insured that the company should considered as it had mentionable obstacle on these issues. This was figured out by 77.14 % of respondents indicating that old technology and methods were moderate and major obstacles taking 37.1 % and 40 % share respectively.

Regarding poor quality of raw materials, 31.71 % and 31.43 % of respondents said that it was not obstacle and it was minor obstacle as well. However, 36.85 % of respondents considered it as an obstacle. Thus, poor quality of materials might not be considered as an obstacle for the company.

Related to awareness of workers to the quality of process and product improvement, very noticeable number of respondents, 55.29%, revealed that it was major obstacle. Although 12.86 % and 31.43% of respondents respectively said that it was not an obstacle and minor obstacle.

Regarding trainings, the data presented above in table 4.6 indicated that 28.57 % of respondents said that inadequate training was not an obstacle. Besides, 22.68 % of respondents said that it was a minor obstacle. To the contrary, 48.57 of respondents said that inadequate training was reasonable obstacle to the company.

More over the data gathered through the questionnaire, the interview witnessed that inadequate training was a major obstacle to the company.

Regarding poor maintenance and handling of machines, almost 60% of respondents ensured that poor maintenance and handling of machines were basically obstacles to the company. Even though, 14.29% of respondents said that these were not an obstacle where as the remaining 27.1% of respondents leveled it as minor obstacle.

Related to awareness of operators and supervisors to SPC tools, 5.71% of respondents said that it was not obstacle where as 94.28 % of respondents including 45.71 % saying minor obstacle, reveal that awareness of operators and supervisors to SPC tools was noticeably an obstacle to the company. Besides, the interview investigated that it was really an obstacle to the company.

On the subject of implementation of all SPC tools to control and improve production process; product, 2.86% of the respondents said that it was not an obstacle. Besides, 28.57% of the respondents said that it was minor obstacle. Very large number of respondents, 68.57% said that it was very noticeable obstacle to the organization.

Related to identification of quality related defects in the production process, 57.14 % of respondents said that it was not an obstacle and was a minor obstacle taking equal amount. However, 42.86% of respondents mentioned that it was an obstacle. Thus, the data ensured that the organization should give emphasis on to the issue.

Beside identification of defects, diagnosing the cause of quality defects in the production process was labeled as it was considerably an obstacle by 65.62% of respondents.

In turn, corrective actions up on defects were not as such an obstacle to the company as said by huge number of respondents, 65.71 %. Besides, it is simple to understand that when there is no identification and diagnosis of defects of quality in production process, taking corrective action won’t be consider as an obstacle.

Related to consistency of taking corrective action, the data gathered through the questionnaire showed contradiction to the above issues discussed. Thus, 51.43% of respondents said that lack of consistency of corrective actions was an obstacle by which it opposed the fact that there was almost no corrective action taken because the organization didn’t conduct identifications and diagnosis of defects on the product process. In general, it was impossible to even think of consistency on the absence of corrective actions implemented.

Related to regular check up on the status of production process capability, 65.29 % of respondents labeled moderate, major and very sever obstacle. Whereas 34.29 % of respondents said no obstacle and minor obstacle it was.

Lack of management commitment for quality improvement

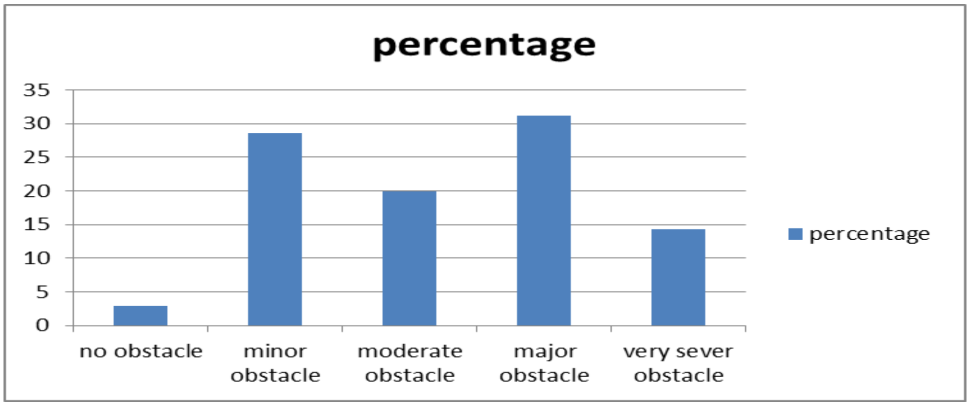

Figure 5 Graph for Lack of management commitment for quality improvement

Unable to diagnose the causes of quality defects in the production process

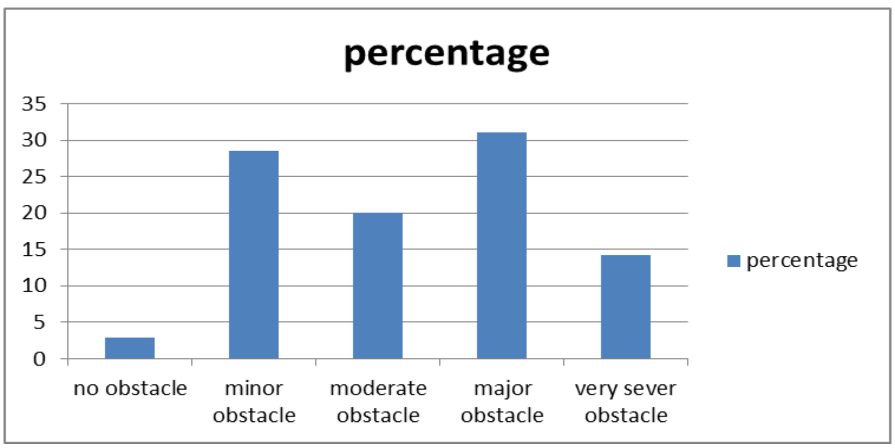

Figure 6. Graph for Unable to diagnose the causes of quality defects in the production process

As indicated in the above graph, 'unable to diagnose the causes of quality defects in the production process' is mostly a major obstacle for the company for improving quality of the product. This implies that the company needs to give special emphasis to come up with solution.

Company implements all SPC tools to control and improve production process

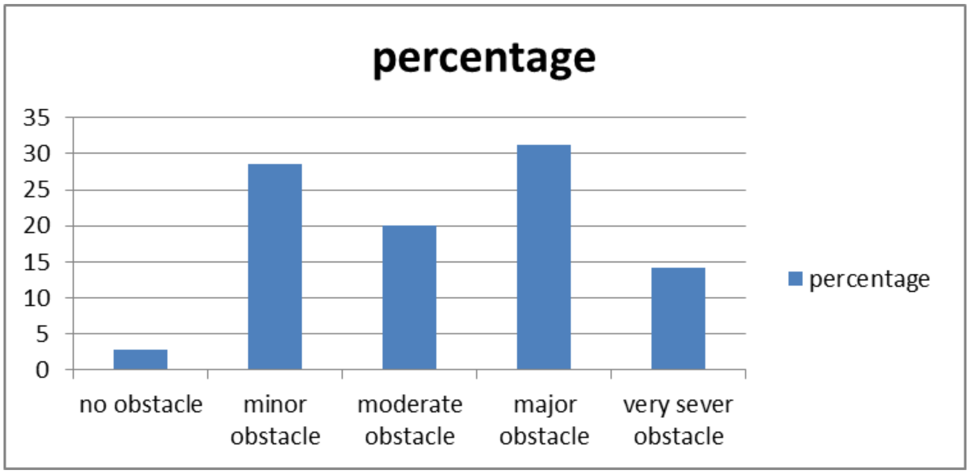

Figure 7 Graph for Company's implementation on SPC tools to control and improve production process

The above graph showed that 2.86% of the respondents said that it was not an obstacle, 28.57% of the respondents indicated that it was a minor obstacle, while 20%, 31.14%, and14.25% of them were saying it was a moderate, major and very sever obstacle respectively. From this implementation of all SPC tools to control and improve the product the company requires special emphasis.

Beside the questionnaire the interview also revealed that it was the very significant obstacle to the company. Not only the implementation related problem was exhibited but also there was knowledge gaps among the workers on the SPC tools as it was cited in the table above. In other word, almost equal number of respondents said that it was minor obstacle while others said that it was a major obstacle to the same issue, the SPC tool.

4.2.7. Usage of control chart information for continuous improvement

Table 4.6. Mean frequency and standard deviation score of respondents for usage of control chart information for continuous improvement.

Statement	N	Response no					Mean	Standard deviation	%of the maximum frequency scale
		1	2	3	4	5			
Decision rules are in place to allow the detection of out-of-control situations	35	2	8	9	14	2	3.161	0.9536	40% almost every time
Whenever a manufacturing process goes out of control, special causes of variation are identified and removed	35	0	4	3	20	8	3.914	0.874	57.14% almost every time
various off-line tools (e.g., Pareto charts, histograms, etc.) are used to identify special causes of variation when a manufacturing process goes out of control	35	1	9	1	23	1	3.4	0.9913	65.71% almost every time
various off-line tools are employed to reduce common causes of variation when a manufacturing process is already in a state of statistical control	35	2	8	5	15	5	3.4	1.1759	42.86%almost every time
A stable manufacturing process is frequently checked to see if it is capable of meeting product specifications	35	2	5	0	21	7	3.742	1.10435	60%almost every time
Control charts are not being used to monitor this process	35	1	7	15	10	2	3.142	0.8989	42.86% sometimes
Control charts are displayed simply to satisfy customer demands	35	1	3	8	17	6	3.685	0.9493	48.57% almost every time
Control charts are used only to identify out-of-control situations ; no corrective actions are taken to bring the process back into control	35	4	3	9	11	8	3.457	1.2499	31.14%almost every time
Control charts are used not only to identify out-of-control situations for corrective action but also to identify opportunities for reducing common cause variation affecting the process	35	2	1	9	23	0	3.571	0.8378	65.71%

As shown in the above table, 40% of the respondents said that decisions were in place almost every time while, the remaining 25.71%, 22.86% and 5.71% of the respondents respectively said that decisions were in place sometimes, almost never and never. This implies, decision rules were not properly placed to allow the detection of out of control situations.

For the second statement given under usage of control charts, 57.14% of the respondents said that whenever a manufacturing process goes out of control, special causes of variations were identified and removed almost every time.

65.71% of the respondents labeled almost every time for the usage of various off line tools (Pareto charts, histograms, etc) to identify special causes of variation when a manufacturing process goes out of control. However, the researcher investigated the fact that the company only used X-bar R-chart control charts to identify causes of variation through the interview conducted.

Based on the data cited in the table, 60% of the respondents said that the manufacturing process was checked frequently almost every time to see whether the process is capable of meeting product specifications. However, the researcher observed the checking system of the company is not frequent enough. Not only the intervals of checking but also the samples taken for consideration are few in numbers so it is difficult to say the sampling is convenient to identify the variations.

Regarding usage of control charts for monitoring product process as well as satisfying customer demand, more than 50% of respondents said that the control chart was both used and displayed for the sake of monitoring the product process and satisfying customer demand.

Besides, significant number of respondent, 65.71% of revealed that the control charts were not only used to identify out-of-control situations but also to identify opportunities for reducing common causes of variation almost every time.

Generally according to the responses gathered from the questioner, interview and observation, the overall performance of the company in usage of control chart information for continuous improvement was somehow good.

4..2.8 .Training in statistical and cognitive methods for process control and improvement

Table 4.7. Mean, frequency and standard deviation scores of respondent's on training in statistical and cognitive methods for process control and improvement.

Statement	N	Response no					Mean	Standard deviation	% of the maximum frequency scale
		1	**2**	**3**	**4**	**5**			
Almost everyone in this organization has received training in the construction of control charts	35	0	8	15	12	0	3.114	0.7472	42.85% sometimes
Almost everyone in this organization can describe what a control chart is saying about the performance of a critical process/product characteristics	35	3	9	8	15	0	3	1.0142	42.85%almost every time
Almost everyone in this organization has received training in applying various off-line tools to quality improvement	35	1	13	5	16	0	3.028	0.9706	45.71%almost every time
There are on-going refresher classes in the application of control charts and/or various off-line tools	35	2	7	8	18	0	3.2	0.9502	51.43almost every time
Periodic refresher training is mandated for everyone in the organization	35	14	3	1	12	5	2.7428	1.592	40% never

From the table above under training in statistical and cognitive methods for process control and improvement, 42.85% (the maximum frequency scale) of the respondents labeled sometimes to "almost everyone in the organization has received training in the construction of control charts". While 34.29% of the respondents said almost every time the training has been given to everyone. On the contrary 22.85% of the respondents revealed almost everyone in the organization almost never received training in the construction of control chart. Thus, the presented data from the questionnaire coincided with the observation revealed that the control chart was applied align with the production process. However, it was not simple to ensure whether the training was frequently given to them.

As cited above in the table, 42.85% of the respondents approved that almost everyone in the organization can describe what a control chart is by labeling almost every time. While the remaining 57.15% of the respondents labeled almost never, never and sometimes so as to say most of them were not capable to describe the control chart properly.

51.43% of the respondents agreed that there were ongoing training classes given almost every time on the application of control charts but, the researcher investigated through the interview that there was remarkable problem in respect to training either in control chart usage or in any other various off-line tools.

Although periodic refreshing training classes is mandated for everyone in the organization had a lowest mean value from the other variables, it doesn't mean that training was never given for everyone. In this regard, 40% of the respondents agreed that there was not any periodic refreshing training given for anyone in the organization. 8.57% of the respondents responded saying that the training was almost never given, while 34.26% and 14.29% of the respondents agreed that the periodic refreshing training was given for everyone in the organization saying almost every time and every time respectively as shown below.

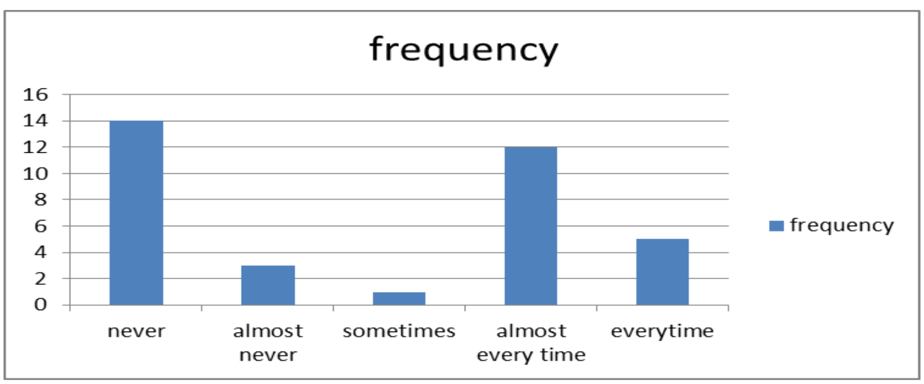

Figure 8.Graph Periodic refreshing training

The data discussed above and presented in the above graph showed that the company still needed to give special consideration for periodic refreshing training for employees.

4.2.9. Technical support for SPC implementation and practice

Table 4.8. Mean and standard deviation scores of respondents on technical support for SPC implementation and practices.

Statement	N	No of respondents					Mean	Standard deviation	% of the maximum frequency scale
		1	2	3	4	5			
Technical staff experts are able to answer technical questions arising from the use of control charts.	35	1	2	8	19	5	3.7143	0.8806	54.28% very good
When a problem arises from the application of control charts that I, as a process operator, am unable to resolve, technical staff personnel comes to my aid.	35	2	8	4	21	0	3.2571	0.9955	60% very good
Technical support for the implementation and use of control charts is obtainable in-house.	35	1	1	20	13	0	3.2857	0.6578	57.14% good
Availability and accessibility of in house technical staff experts	35	2	5	5	23	0	3.4	0.93197	65.71%very good

From the above table, technical support for SPC implementation & practices; 54.28% of the respondents said that technical experts are very good at answering technical questions that were raised from the use of control charts. In addition to this, half above the frequency percentage most of the respondents labeled very good to technical staff regarding team work, obtainable in house use of support and access of knowledgeable technical staff experts.

All in all, having some of the limitations that the company had in mind, it had also a good technical support for SPC implementation and practices with an average mean value of 3.4142.

4.2.10. Quality improvement team support of SPC practices

Table 4.9. Mean, frequency and standard deviation scores of respondents on quality improvement team support of SPC practices.

Statement	N	No. of respondent					Mean	Standard deviation	% of max frequency scale
		1	2	3	4	5			
Quality improvement teams, consisting of at least one process operator, meet opportunities regularly to discuss for improvement.	35	5	1	4	25	0	3.4	0.74377	71.43% usually true
Quality improvement teams, consisting of at least one process operators, submit a large number of recommendations for improvement to higher management.	35	0	5	9	21	0	3.457	0.7307	60% usually true
As a process operator, I often work with a team of other process operators, staff engineers, and/or management to resolve out-of-control situations on my process.	35	1	5	10	19	0	3.342	0.8261	54.29% usually true
Quality improvement teams, consisting of at least one process operator, implement recommendations for improvements that have been approved.	35	0	0	5	26	4	3.971	0.5063	74.29% usually true

Based on table 4.10, from the four different variables listed under quality improvement team support of SPC practices, 71.43% of the respondents labeled usually true to the quality improvement teams, consisting of at least one process operator, meet opportunities regularly to discuss for improvement.

Quality improvement team consisting of at least one process operator, submit a large number of recommendations for improvement to higher management was labeled usually true with a maximum frequency percentage score of 60.

Besides, 54.29% of the respondents indicated there was a usual team work in between process operators and managers to resolve out of control situations**.** However, the fact revealed through observation and interview was quite opposite to this. Thus, the researcher is highly compelled to say that the company experienced less team work and management support in SPC practice at large.

4.2.11. Absence of final inspection as a primary quality control strategy

Table 4.10. Mean and standard deviation scores of respondents on absence of final inspection as a primary quality control strategy.

Statement	N	No of responses					Mean	Standard deviation	% of max frequency scale
		1	2	3	4	5			
Final product inspection is kept to be minimal	35	9	7	2	16	1	2.8	1.3267	45.71%moderately concerned
The organization no longer uses final inspection as a primary quality control strategy	35	6	6	1	18	4	3.257	1.3595	51.43%moderately concerned
Quality of final product is maintained through SPC rather than through final inspection	35	5	4	8	10	8	3.34	1.3297	28.57% moderately concerned
This organization does not believe in inspecting "quality" into the final product as the primary quality control strategy	35	3	2	7	17	6	3.6	1.1006	48.57% moderately concerned

As indicated on the above table, absence of final inspection as a primary quality control strategy, 45.71% of the respondents labeled moderately concerned that final inspection is kept to be minimal, And 20% are said there a slight concern. While 25.71% of the respondents said inspection of the final product was not a concern at all.

As cited above in the table, 51.43% of the respondents approved that the inspection of the final product was a moderate concern for the organization for a quality control strategy. 28.57% of the max frequency respondents were said quality of the final product is maintained through SPC rather than through final inspection is a moderate concern for the company.

Besides, 22.85% of the respondents revealed that maintain the process through SPC than in a final inspection was an extreme concern for the company.

Regarding inspecting the quality of the final product as a primary strategy 48.57% of the max frequency percentage scale the respondents approved the organization does not believe in inspecting quality in the final stage is a moderate concern as a primary quality control strategy.

4.2.12. Update of knowledge of a processes

Table 4.11 Mean, Frequency and Standard deviation scores of respondents for update of knowledge of a process.

Statement	N	No of respondents					Mean	Standard deviation	% of the max frequency scale
		1	2	3	4	5			
The capability of this manufacturing process, to which I am assigned, is continually documented	35	0	5	5	10	15	4	1.069	42.86% all of the time
understanding of a manufacturing process by the operator	35	0	8	7	17	3	3.428	0.9346	48.57% often
Updating of control chart limits as the process is changed	35	4	0	4	15	12	3.886	1.2135	42.86%often
In the manufacturing process changes, information descriptive of the process is updated	35	0	0	12	8	15	4.086	0.8741	42.86% often
Knowledge of this manufacturing process, to which I am assigned, is easily retrievable	35	0	4	3	24	4	3.8	0.7855	68.57% often
It is easy to update information about this manufacturing process, to which I am assigned	35	0	5	3	20	7	3.8286	0.9098	57.14% often

As indicated on the above table, for update of knowledge of processes, 42.86% of the respondents approved the capability of the manufacturing process continually documented all of the time. While 28.57% of the respondents agreed the process is continually documented often.

And 14.29% of the respondents labeled sometimes the capability of the production process is continually documented. On the contrary, 14.29% of the respondents revealed that the capability of the process was rarely documented continuously.

As cited above in the table, 42.86% of the respondents said that control chart limits for parameters associated with the manufacturing process are updated very often. Whereas, 34.29% of the respondents agreed the parameters are updated almost every time. However, the researcher identified through observation of the process control limits was cited as 300 ± 3% which means the UCL =309 and the LCL =291 used as a control limits unchanged.

Besides, 68.57% of the respondents revealed that knowledge of the manufacturing process was easily retrieved often.

On the other hand for the issue mentioned on the above table, 57.14% with the maximum frequency scale of the respondents revealed that the information about a manufacturing process was easily updated often. However, the researcher investigated the fact that the company had still limitations on updating knowledge of the process through the interview conducted.

4.2.13. Audit and review of SPC practice and performance

Table 4.12. Mean and standard deviation scores of respondents on audit and review of SPC practices and performance

Statement	N	No of response/scale					Mean	Standard deviation	% of max frequency scale
		1	2	3	4	5			
.The SPC intervention is periodically audited to identify opportunities for improvement	35	0	1	12	22	0	3.6	0.545	62.86% almost every time
An audit of SPC activities is regularly conducted	35	0	0	12	14	9	3.914	0.7698	40% almost every time
The organization continually monitors SPC activities	35	0	10	5	15	5	3.428	1.0497	42.86% almost every time
All aspects of the SPC intervention undergo frequent "checkups" to ensure that all is going well	35	0	5	4	14	12	3.942	1.01257	40% almost every time

From the table above under audit and review of SPC practice and performance, 62.86% (the maximum frequency scale) of the respondents ladled almost every time to “the SPC intervention is periodically audited to identify opportunities for improvement”.

As cited above in the table, 40% of the respondents approved that almost every time an audit of SPC activities was conducted regularly. While 25.71% of the respondents agreed the SPC activities were every time conducted regularly. On the other hand, the remaining 34.29% of the respondents revealed that sometimes the audit of SPC conducted regularly.

Besides, the organization continual monitoring of SPC activities, 42.86% of the respondents approved almost every time this process is conducted in the organization. On the contrary, 28.57% of the respondents revealed this activity is conducted in the organization rarely.

Regarding all aspects of the SPC intervention undergo frequent checkups to ensure that all is going on, 74.28% of the respondents labeled every time and almost every time the SPC intervention undergo frequent checkups.

4.3. Data gathered through document review

This part is dedicated to present and discuss the data that was gathered from the case factory which is MOHA soft drinks S.C with respect to the objectives of the thesis.

After using the methodologies like questioner, interviewing, visiting and personal contact, the following 1 month report real data has been identified from the quality and assurance department of the company starting from April 1 till April 30 has been recorded.

Table 4.3.1 Sample size with varied number of defective product for the month of April

Sample no	Sample size	Number of defects		Sample no	Sample size	Number of defects	
1	10000	24	0.0024	14	10000	33	0.0033
2	10000	51	0.0051	15	10000	55	0.0055
3	10000	64	0.0064	16	10000	28	0.0028
4	10000	46	0.0046	17	10000	24	0.0024
5	10000	38	0.0038	18	10000	15	0.0015
6	10000	52	0.0052	19	10000	65	0.0065
7	10000	40	0.004	20	10000	26	0.0026
8	10000	35	0.0035	21	10000	21	0.0021
9	10000	31	0.0031	22	10000	22	0.0022
10	10000	39	0.0039	23	10000	32	0.0032
11	10000	34	0.0034	Total	**230000**	**796**	
12	10000	34	0.0034				
13	10000	19	0.0019				

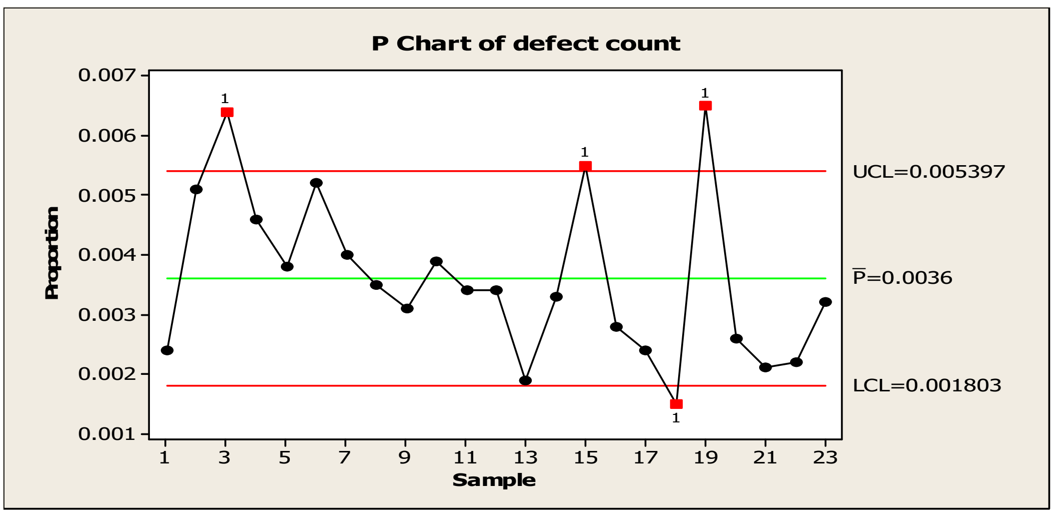

Figure 9. P- chart of defect count

The control chart with center line at p = 0.0036 and the above upper and lower control limits are shown in .The sample fraction nonconforming from each preliminary sample is plotted on this chart. Note that four points, those from samples 3, 15, and 19 plots above the upper control limit and sample 18 plots below the lower control limit so the process is not in control. These points must be investigated to see whether an assignable cause can be determined.

Analysis of the data at sample 3, 15 and 19 indicates that there was a seal problem and some of the filling valves were not working properly. Consequently the causes of the problem for sample 3,15 and 19 are eliminated by using maintenances system. Therefore, the new center line and control limits are calculated as follows.

UCL = 0.005034

LCL= 0.001587

CL_P = 0.003311

Prioritization of defects

To prioritize the defects/non conformities and determine the vital problems in each cause from Table 4.3.1, using a Pareto diagram, the data are analyzed in table 4.3.2 below. Based on Table 4.3.2, the Pareto diagram in Fig 10 elaborates the problems that affect quality significantly

Table 4.3.2. Defect rate analysis based on cause of defects for the month of April

No	Cause of defect	Number of defects	Cumulative total	Percentage	Cumulative percentage
1	Over fill	7134	7134	41.24	41.24
2	Uncrown	5171	12305	29.89	71.13
3	Under fill	2613	14918	15.10	86.23
4	contaminated	2381	17299	13.76	99.99
Total		17299		100	

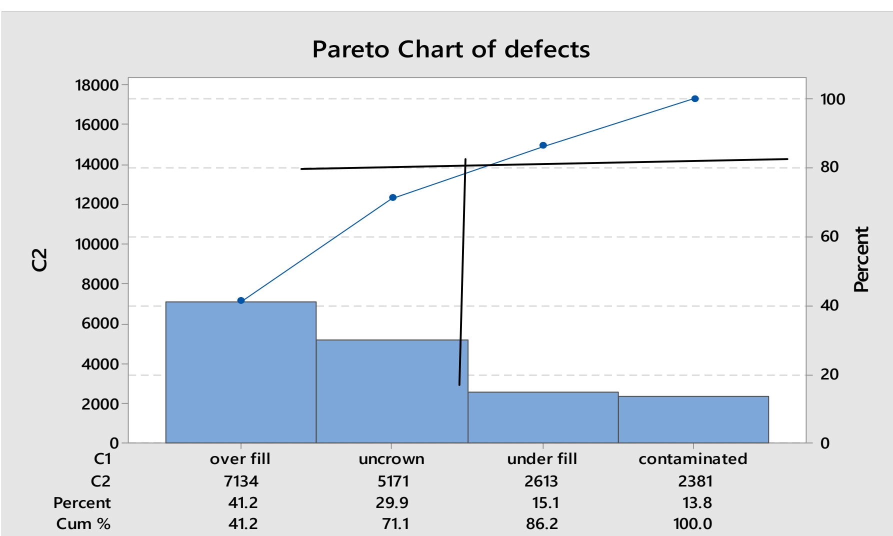

Figure 10. Graph for Pareto chart for defects

As the above Pareto chart indicates, improvement efforts should be focused on the categories to the left line, which are called the "vital few". In this case, the vital few are: over fill and uncrown.

Data taken for volume

Table.4.3.4, below, shows data collected for 18 sample days with 4 shifts taken by the quality control department of the company with four observations, each of the volume of a glass bottle filled in milliliters.

The Mean and Range of the sample size

Due to a large number of data, the excel software was used to compute the mean and range for time consumption. Table below shows the computed mean and range using data from table

Table. 4.3.3. Mean and Range for the sample of net volume

Sample number	Shift 1	Shift 2	Shift 3	Shift 4	X- bar	R-bar
1	299.08	302.06	301.7	306.835	302.4188	7.755
2	300.58	302.92	298.99	298.8	300.3225	4.12
3	299.655	296.625	302.22	297.57	299.0175	5.595
4	297.85	299.345	296.395	296.25	297.46	3.095
5	295.57	301.64	296.53	297.065	297.7013	6.07
6	300.58	302.915	298.985	298.8	300.32	4.115
7	295.385	298.16	299.1	295.935	297.145	3.715
8	295.085	300.39	296.63	297.95	297.5138	5.305
9	299.435	297.06	300.93	300.105	299.3825	3.87
10	307.255	299.905	306.875	301.135	303.7925	7.35
11	299.895	298.865	298.975	296.915	298.6625	2.98
12	298.8	297.965	297.345	295.92	297.5075	2.88
13	310.2	313.9	311	311.3	311.6	3.7
14	299.415	299.68	297.655	299.25	299	2.025
15	306.395	304.64	301.265	296.825	302.2813	9.57
16	305.27	297.65	300.62	298.8	300.585	7.62
17	303.545	294.885	299.095	305.27	300.6988	10.385
18	301.44	298.27	301.47	306.06	301.81	7.79
19	306.685	306.17	308.74	306.18	306.9438	2.57
					ΣX-bar=5714.163	ΣR-bar= 100.51
					S X-double bar=300.75	R-double bar=5.29

Establishing control limits

From table 4.3.3. The average of the mean, X=300.75

The average of the range, R=5.29

By using the above result from table 4.9, we can compute UCL, CL and LCL for each X-bar and R-chart

a) For X-bar chart, the UCL & LCL can be determined as;

$UCL= X_{GA} + A_4R_A$

$=300.75 + (0.729* 5.29) = 304.61$

Center line (CL) = X-double bar = 300.75

$LCL= X_{GA-} -A_4R_A$

$= 300.75-(0.729*5.29)= 296.89$

b) For R-chart, the UCL & LCL can be computed as;

$UCL= D_4R_A$

$= 2.574*5.29=13.62$

Center line = R-bar = 5.29

$LCL= D_3R_{A,}$ since D_3 is 0, LCL=0

Construction of control charts

X-bar charts are plotted as means against the sample no while, the R-bar chart is plotted as a range against sample days.

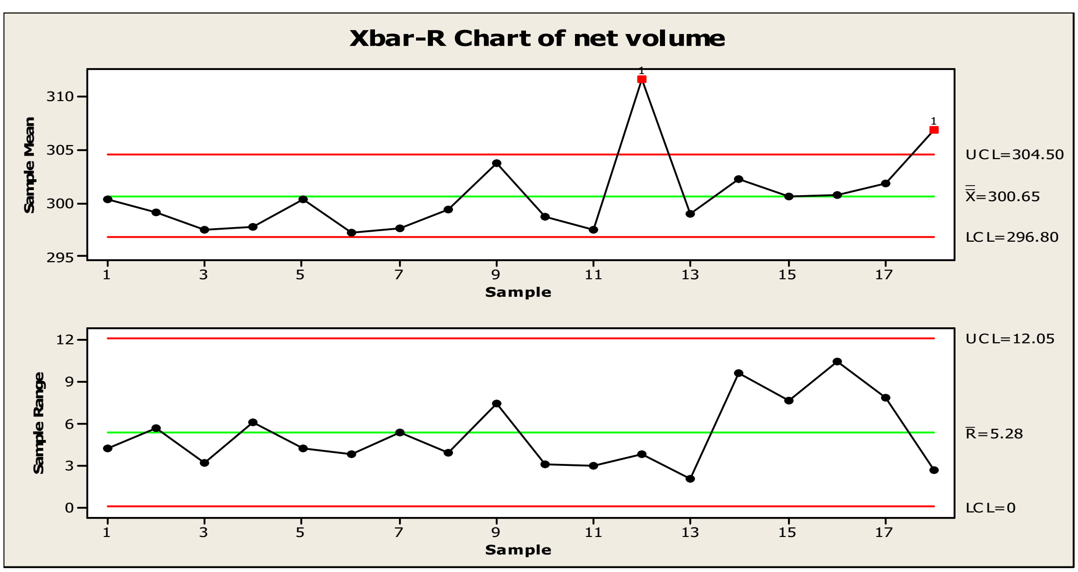

Figure 11 Graph for X bar-R chart of net volume

From the above graph ,4 points are almost on the central line, 9 points are just below the central line, 2 points are above the central line on the other hand, two points are out of the upper limit. Excluding the points that are out of the control limit, recalculating the new control limits, resulted process is under control. As shown in the graph below. This pattern might be indicative of a sudden increase in the process variation due to seal problem or filler valve.

Figure 12 Graph -for the revised net volume

As shown in the above graph, the revised control values are CL= 299.74, UCL= 303.81 & LCL= 295.68. Therefore; so as to monitor the process properly and to increase the process capability, these control limits are advisable to take as a specification limits.

Data taken for CO_2

The following data is taken from the company documented report for the month of April for one of the major quality affecting raw material, CO_2.

Table 4.3.4. Samples taken for CO2 analysis with mean and range values

Sample no	Observation					
	X_1	X_2	X_3	X_4	X-bar	Range
1	1.2575	1.234	1.2075	1.2095	1.227125	0.05
2	1.222	1.234	1.219	1.225	1.225	0.015
3	1.2105	1.2515	1.24	1.231	1.23325	0.041
4	1.243	1.24	1.231	1.231	1.23625	0.009
5	1.0498	1.0498	1.0498	1.0498	1.0498	0
6	1.278	1.243	1.219	1.261	1.25025	0.059
7	1.29	1.249	1.219	1.208	1.2415	0.082
8	1.196	1.208	1.243	1.255	1.2255	0.059
9	1.202	1.278	1.255	1.237	1.243	0.076
					X-double bar 1.215	R-bar=0.045

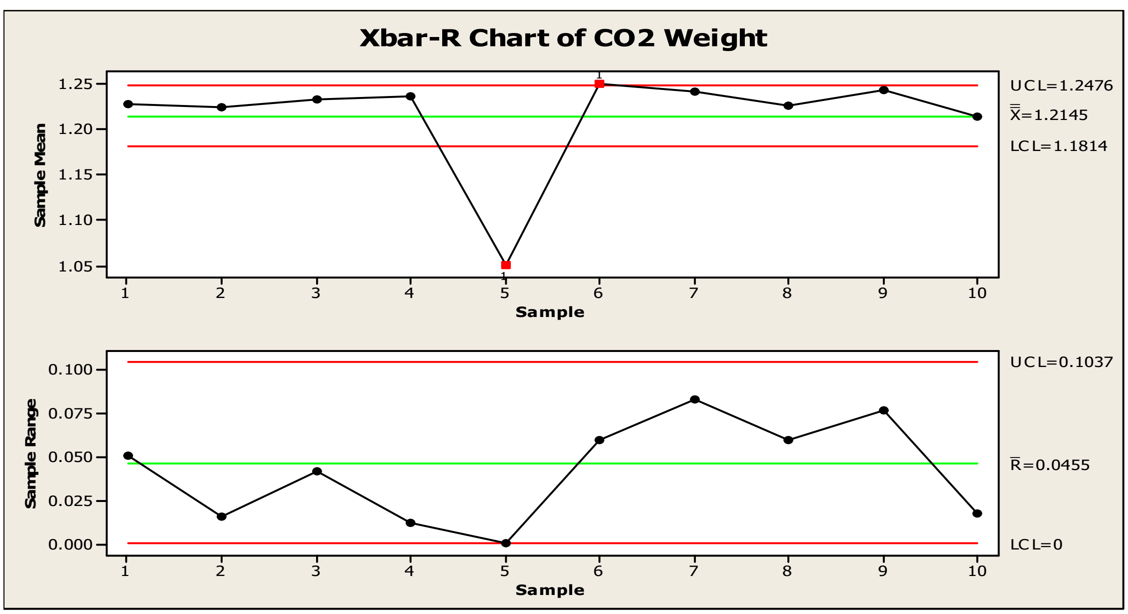

Figure 13 Graph for X-bar R chart of CO_2 Weight

From the above graph, 8 points are above the central line while the other two points are above and below the center line sharing equal values. For the CO_2 weight level, the mean chart shows that two points are out of control, whereas no point was out of control on the range chart. However the process is not fully in control until all the out-of-control points are eliminated. Such kind of variation still occurred due to the variation in volume that are occurred from the 84 filling valves.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMENDATION

5.1 Summary of Findings

This part of the section tries to summarize the key findings of the study. The objectives of the study were to identify the practices and challenges of implementing statistical process control for improving quality in the case of MOHA soft drinks industry S.C. In order to meet the objectives of the study the researcher collected primary data by the use of Questionnaire and Semi-structured interview and observation. Thus, from a population of 40 employees; however, 35 questionnaires were retrieved from the respondents and analyzed. Accordingly, the findings of the study are summarized as follows.

Regarding background of the respondents, the finding showed that the respondents had significantly well work experience labeled 3-5 years with 42.85% and more than 5 years with 37.14%. In addition to the work experience, 34.28% of the respondents have a masters' degree, 62.85% of them have degree only one of the respondent was a diploma holder.

This indicated that a large number of respondents could reply the application of statistical process control tools for improving quality of the process. In addition to the work experience almost all they were working in the area of the production.

From the different dimensions shown, findings revealed that the practices and challenges of the company on SPC for improving quality were identified. Even if; the responses from the questionnaire showed that the company had a good practice in every aspect, there were still certain limitations investigated. These are: - lack of management commitment in the implementation of SPC, unable to identify customer requirements, old technology of machines, low awareness of workers /operators, poor maintenance and handling of machines, low awareness of SPC tools usage by process operators and supervisors, low level of implementation of all SPC tools, lack of consistency to take corrective actions, lack of regular checking on the status of the production process, lack of periodic refreshing trainings, lack of team working and poor sampling.

On the other hand, even if the company has many limitations but due to the good practices implemented and identified from the data gathered through documentation review, from semi-structured interview as well as from the questionnaire revealed that the company was benefited after the implementation of the SPC as the findings exhibited. These benefits are mention as; reduced non conforming products, guaranteed food safety, Control microbiological contamination level, minimize the risk of product recalls, improved process visibility and understandability and reduced product giveaway or under fills.

5.2 Conclusion

Based on the findings of the study, the following conclusions are drawn by the researcher. Practices like documentation of the quality characteristics by operators, identification of the impact of the manufacturing process on key quality characteristics, usage of control charts, usage of computerized technology for data recording and usage of calibrated measuring devices are some of the good practices of the company so as in the implementation process of SPC all these are very basic to improve the process and the quality of the product. The other good practice of the company was planning for quality improvement so planning is very important to use all the appropriate tools for quality improvement. Therefore, they should keep on doing this practices and also improving them more so that all the quality characteristics associated with the process can be improved.

Lack of higher management support, law awareness of SPC tools by the operators and supervisors, lack of team working over SPC, lack of a periodic refreshing training, lack of consistency to take corrective actions and unable to diagnose the cause of quality defects in the production process were also observed as weaknesses or challenges for the company. As a result, it is very difficult to think effective implementation of SPC for quality improvement without all the required parameters mentioned above. Therefore; a company should take corrective actions for the successful implementation of SPC.

Based on the findings of the study, the company has been benefited from implementation of SPC in terms of minimizing the risk of product recalls, non conforming products, product giveaways or under fills or over fills. This implies SPC has a power to improve the quality of the product

Besides, the organization improved process visibility and understandability, brought guarantee food safety. So as to increase the benefits or maintain the company should work more on the implementation of SPC.

Moreover, the organization could bring improvement on product quality characteristics, rework and could reduce customer compliance. It also exhibited waste product minimization.

Finally, it can be concluded that if a statistical process control Practices are employed effectively, it could improve the quality of the product and overall organizational performance by knowing the customer requirement and meeting them.

5.3. Recommendation

Based on the above findings and conclusions for sustainable quality improvement the following recommendations are suggested.

The most challenging in SPC implementation is in answering how and where to get started the implementation. If the implementation is planned at the organizational level, the support of organizational scale must be prepared as well.

1. Educating employees to aware on the values for SPC implementation in the company and guarantee top level management commitment.
2. Top level management be supposed to be convinced that SPC has the ability to improve the company‘s bottom-line. To enable the top level management to be familiar with the fundamentals of SPC, points should be briefed as;
    - SPC requires changes of management style with respect to the delegation of tasks and employee empowerment.
    - SPC is a technique used to establish process capabilities.
    - SPC is a technique to recognize, quantify, reduce and control variation.
    - Top level management should be the first recipients of the session.

If the top level managers are willing to accept all the points mentioned above the challenges of the company associated with implementation of SPC could be solved.

3. SPC Training: As cited above the company is highly in need of consistent training provision. Thus, some of the recommended suggestions are indicated as follows :-

- Training of SPC in the company should be more than just once, as SPC involved both technical aspect and managerial aspect where the training is highly suggested to be delivered in level-by level within the organization's hierarchy.
- The training should consist of underlying philosophy of SPC, theoretical and management aspect of SPC, OCAP and other quality tools and technique.
- The training materials should focus on statistical tools, leadership, and change of culture, which wider attendance of participants should be encouraged at this point of training sessions.
- Continuous training session and workshops focusing on awareness creating could help the company to achieve such objectives.
- Providing trainings for technical personnel who are required to collect and analyze data is highly suggested to be appropriate with the level of employees understanding.

4. The other challenge which was cited under the conclusion was lack of team working. So as to come up with the solution the researcher recommended the following points.

SPC team establishment

- The company should establish SPC team. SPC team may consist of top level management team, middle level management team, steering team, and process action team. It also consists of one problem solving team. Type of employee‘s position is not the only factor necessary for the implementation, but also individual roles. Thus, the responsible body which will organize the team should take this under consideration.
- Creating a multi-disciplinary team able to increase the effectiveness of the teamwork in SPC. Therefore, the body should ensure that the team is whether multi-disciplinary or not.
- SPC steering team should be responsible to continuously monitor the performance of key processes.

5. Plan for the SPC implementation

- The company/ the management should ensure that the SPC implementation is planned according to vision and mission.

- Such planning should cover several aspects such as people, time, tools, training, activities and resources.

6. Poor maintenance and handling of machine. This was identified as an obstacle for the implementation of SPC and quality improvement. Thus, the researcher recommended recalibrating the equipment/machine, preventive maintenance, updating the latest model of manufactured machines to get improved.
7. As constant learning leads to continual change and learning facilitates response to change**,** the company should be a learning organization.
8. Benchmarking and learning from best-practice of internal and external competitors will continuously keep the company in the momentum for change. Therefore, the company should give a value to.

9**.** Reward system

- One of the causes of failure in deploying and sustaining SPC implementation is that the management's ignorance to the fact that the deployment of SPC can lead to unintentional improvements in intrinsic reward. Thus, the management should provide rewards and give recognition for successful project.

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APPENDIX- A

ST MARY'S UNIVERSITY

School of Graduate Studies

Institute of Quality and Productivity Management

Survey on practices and challenges of implementing statistical process control for improving quality

QUESTIONNAIRE

This questionnaire is prepared to collect data regarding the practices of the company in using statistical process control for quality improvement and also to identify the main challenges faced in the implementation process. Thank you for your cooperation and willingness to be a part of this research.

Part one : Personal Information

1. Gender of the respondent Male ☐ Female
2. Work position ____________________ (like manager, quality control head, foreman, line worker , etc)
3. Work Experience; ≤ 2years 3-5 years More than 5years
4. Educational back ground ☐ MSC/MA ☐ degree ☐ diploma ☐ PhD

Part Two: Rate the following questions and put "X" in the respected area.

1-Not at all 2-Low 3- Somehow 4- Moderate 5- Very extremely

1. Managerial actions to support the implementation program

	1	2	3	4	5
1. Higher management provides visible support for the use of control charts throughout organization.					
2. Financial resources have been allocated to support the activities involved in using SPC tools					
3. Higher management uses control chart information in planning					
4. Higher management permits sharing of control chart information with either suppliers or customers					
5. Higher management regularly spearheads quality improvement effort identification					
6. The management is willing to accept any suggestions, comments and complaints from employee					

1-Never 2- Rarely 3-sometimes 4-often 5- always

2. Identification of critical measurement characteristics

	1	2	3	4	5
1. The quality characteristic (s) associated with this process has been documented by an operator					
2. The impact the manufacturing process on key quality characteristics of final product is well-known					
3. Customers have been surveyed to identify those quality characteristics associated with this process					
4. Quality characteristics associated with manufacturing process is being monitored via control charts					
5. No one has bothered to identify and define how or why this process affects the quality of the final product delivered to our customers					
6. Our customers have been asked to identify quality problems of final product					
7. Quality problems with final product have been related back to particular parameters of this process					
8. Process parameters affecting the quality of the final product delivered to our customers have been documented for the process operator					
9. Process parameters affecting quality of final product delivered to customers are being controlled using SPC tools					

1-Never 2- Rarely 3-Occasionally 4- a Moderate amount 5- A great deal

3. Technological sophistication and soundness of measurement devices

	1	2	3	4	5
1. Measurements of critical process/product characteristics are automated					
2. Computer controlled devices are employed to measure critical process/ product characteristics					
3. Data in the form of measurements of critical process are collected by computerized sensors					
4. Measurement data are entered electronically into a data base					
5. Only calibrated measuring devices are being used to take measurements on critical process/product characteristics					
6. measuring devices are calibrated in real time via computer control					

1-Untrue of me 2-Somewhat untrue of me 3-Neutral 4-Somewhat true of me 5-True of me

4. Operator responsibility for process control via control charts

	1	2	3	4	5
1. Data are collected on critical process/product characteristics , either manually or via computer					
2. observations of process/product characteristics on this manufacturing process are plotted on control charts by me, a process operator, either manually or via computer control					
3. Process operator look for out of control points on the control charts or verify out of control points identified via computer control					
4. One of my key responsibilities as a process operator on this manufacturing process is to ensure that control charts are being correctly evaluated for out of control situations					
5. How would you describe your role as a process operator in the application of control charts on this process?					

1-No obstacle2-Minor obstacle3-Moderate obstacle4-Major obstacle 5-Very severe obstacle

5. Major quality related problems/obstacles in the company

	1	**2**	**3**	**4**	**5**
1. Lack of management commitment for quality improvement					
2.Low skill of operators of machine production process					
3. Unable to identify customer requirements					
4. Company does not plan for quality and process improvement					
5.Old technology of machines, methods, etc					
6.Poor quality of raw materials					
7. Low awareness of workers/ operators on quality of process and product improvement					
8. Inadequate training of the production process operators					

9. Poor maintenance and handling of machines					
10. Low awareness of SPC tools by the operators and supervisors					
11. Company implements all SPC tools to control and improve production process/products					
12. Unable to identify quality related defects in the production process					
13. Unable to diagnose the causes of quality defects in the production process					
14. Unable to take correction action for defects in the production process					
15. lack of consistency to take corrective action for defects					
16. Company does not regularly check the status of production process capability					

1-Never2-Almost never 3-Occasionally/Sometimes 4-Almost every time 5-Everytime

6. Usage of control chart information for continuous improvement

	1	2	3	4	5
1. Decision rules are in place to allow the detection of out-of-control situations					
2. Whenever a manufacturing process goes out of control, special causes of variation are identified and removed					
3. various off-line tools (e.g., Pareto charts, histograms, etc.) are used to identify special causes of variation when a manufacturing process goes out of control					
4. various off-line tools(e.g., design of experiments, Taguchi methods, etc.) are employed to reduce common causes of variation when a manufacturing process is already in a state of statistical control					
5. A stable manufacturing process is frequently checked to see if it is capable of meeting product specifications					
6. Control charts are not being used to monitor this process					
7. Control charts are displayed simply to satisfy customer demands					
8. Control charts are used only to identify out-of-control situations ; no corrective actions are taken to bring the process back into control					
9. Control charts are used not only to identify out-of-control situations for corrective action but also to identify opportunities for reducing common cause variation affecting the process					

1-Never 2- Almost never 3-Sometimes 4-Almost every time 5-Everytime

7. Training in statistical and cognitive methods for process control and improvement

	1	2	3	4	5
1. Almost everyone in this organization has received training in the construction of control charts					
2. Almost everyone in this organization can describe what a control chart is saying about the performance of a critical process/product characteristics					
3. Almost everyone in this organization has received training in applying various off-line tools to quality improvement					
4. There are on-going refresher classes in the application of control charts and/or various off-line tools					
5. Periodic refresher training is mandated for everyone in the organization					

1-Poor 2-Fair 3-Good 4-Very good 5-Excellent

8. Technical support for SPC implementation and practice

	1	2	3	4	5
1. Technical staff experts are able to answer technical questions arising from the use of control charts.					
2. When a problem arises from the application of control charts that I, as a process operator, am unable to resolve, technical staff personnel comes to my aid.					
3. Technical support for the implementation and use of control charts is obtainable in-house.					
4. How available and accessible are in-house knowledgeable technical staff experts to you, a process operator, when a problem arises from the implementation and use of control charts?					

1-Never true 2-Rarely true 3-Neutral 4-Usually true 5 -Always true

9. Quality improvement team support of SPC practice

	1	2	3	4	5
1. Quality improvement teams, consisting of it least one process operator, meet regularly to discuss opportunities for improvement.					
2. Quality improvement teams, consisting of at least one process operators, submit a large number of recommendations for improvement to higher management.					
3. As a process operator, I often work with a team of other process operators, staff engineers, and/or management to resolve out-of-control situations on my process.					
4. Quality improvement teams, consisting of at least one process operator, implement recommendations for improvements that have been approved.					

1**-Not at all concerned 2-Slightly concerned 3-Somewhat concerned 4-Moderately concerned 5-Extremly concerned**

10. Absence of final inspection as a primary quality control strategy

	1	2	3	4	5
1. Final product inspection is kept to be minimal					
2. The organization no longer uses final inspection as a primary quality control strategy					
3. Quality of final product is maintained through SPC rather than through final inspection					
4. This organization does not believe in inspecting "quality" into the final product as the primary quality control strategy					

1-Never 2-Rarely 3-Sometimes 4-Often 5-All of the time

11. Update of knowledge of processes

	1	2	3	4	5
1. The capability of this manufacturing process, to which I am assigned, is continually documented					
2. The nuances of this manufacturing process are well understood by me, an operator on this process					
3. Control chart limits for parameters associated with this manufacturing process are updated as the process is changed					
4. In the manufacturing process changes, information descriptive of the process is updated					
5. Knowledge of this manufacturing process, to which I am assigned, is easily retrievable					
6. It is easy to update information about this manufacturing process, to which I am assigned					

1-Never 2-Almost never 3-Sometimes 4-Almost every time 5-Everytime

12 .Audit and review of SPC practice and performance

	1	2	3	4	5
1.The SPC intervention is periodically audited to identify opportunities for improvement					
2.An audit of SPC activities is regularly conducted					
3.The organization continually monitors SPC activities					
4.All aspects of the SPC intervention undergo frequent "checkups" to ensure that all is going well					

Thank you very much to respond questions in the Questionnaire.

INTERVIEW QUESTIONS

1. How your company defines quality?
2. Does the company identify the customer requirements for its products? How often the company communicate with its customers? Are objectives of the company linked to customer needs and expectations?
3. Does the company focused on the production process improvement to satisfy its customers? Does the company recognize and solve the quality related problems?
4. Does the company implement the SPC tools? When is the company implementing SPC? Is that implemented throughout the company
5. Which statistical process control (SPC) are applied and used in the company to monitor, inspect, and control the process:

A. Histogram
B. Pareto analysis
C. Control charts
D. Scatter diagram
E. Check sheet
F. Cause and effect diagram
G. Flow chart

6. Does the company have procedures for continuous improvement and preventive action?
7. What are the major benefits gained after the implementation of SPC?
8. What major challenges faced in the implementation of SPC to improve quality?
9. How the company does evaluate the effectiveness of SPC implementation?
10. What are the major defects observed in the production of Mirinda orange in bottle and pet section