ST. MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT

ASSESSING THE APPLICATION OF STATISITICAL PROCESS CONTROL FOR QUALITY IMPROVEMENT THE CASE OF TEKRON DETERGENT AND COSEMTICS COMPANY

By

EKRAM AWOL

ID NO: SGS/0536/2012A

July 8, 2021

Addis Ababa, Ethiopia

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A THESIS SUBMITTED TO ST. MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES, INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN QUALITY AND PRODUCTIVITY MANAGEMENT

Advisor:

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July 8, 2021

Addis Ababa, Ethiopia

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DECLARATION

I declare that this work entitled “Assessing the Application of Statistical Process Control for Quality Improvement: The Case of Tekron Detergents and Cosmetics Company” is outcome of my own effort and that all sources of materials used for the study have been accordingly acknowledged. I have produced it independently except for the guidance and suggestion of my Research Advisor. Moreover, this study has not been submitted for any degree in this University or any other University.

Ekram Awol

Signature _____

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate studies for examination with my approval as a University Advisor.

Advisor: Ass. Prof Asrat Bulbula

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July 8, 2021

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ACRONYM

ASQ - American Society for Quality

DMAIC - Define, Measure, Analyze, Improve, Control

ISO - International Organization for Standardization

LCL - Lower Control Limit

QC - Quality Control

SPC - Statistical Process Control

SPSS - Statistical Package for Social Science

SQC - Statistical Quality Control

TQM - Total Quality Management

UCL - Upper Control Limit

ABSTRACT

In order to survive in a competitive market, improving quality and productivity of product or process is a must for any company. The purpose of this study is to assesses the application of statistical process control for quality improvement. The study adopted descriptive research method. In the course of analyzing the problems, both qualitative and quantitative research methods were introduced. The main tools of data collection were questionnaires, interviews, observation and focus group discussion. Purposive sampling technique was applied to select respondents. The quantitative data collected through questionnaire was analyzed by making use of descriptive statistics using SPSS version 20 software. The study tried to identify the quality related problems and root causes for the defects. The study used the statistical process control tools to identify the variation and figure out the root causes for the variation. Four statistical process control tools were used. The check sheet to record different types of defects occurred in the company. Control chart was used to analyze the weight and PH parameter for the liquid hand soap. Pareto chart constructed to prioritize the vital few defects which were damaged bottle, labeling error, overweight and caps on open mode. Cause and defect diagram was constructed using brainstorming technique for each vital defects. It has been found that the root causes for quality related problems and defects were lack of top management, unskilled operator, lack of awareness about quality and quality improvement, old/outdated machine, raw material quality, lack of employee motivation and lack of effort for quality improvement.

Keywords: *Statistical Process Control(SPC), Quality Improvement, Cause and Effect Diagram, Control Chart, Pareto Chart, Check Sheet*

CHAPTER ONE

INTRODUCTION

This Chapter presents an overview of the entire study. It includes the Background of the study, Statement of the problem, Research questions and Objectives of the study, Significance of the study, Scope of the study, Limitation of the study, Definition of terms and Organization of the study.

1.1 Background of the Study

In today's tough world market environment, the need to be better is more demanding, and the need to be more competitive is a necessity to survive. A company cannot rest on the success of the past performance and expect to continue to remain successful. The key to being competitive lies in the ability to exceed customers' needs and expectations as well as providing, in the manner required by the customer, a quality product at low cost, on time, every time (Ignatio and Charles, 2016).

Statistical Process Control (SPC) is the application of statistical methods to monitoring and control of a process to ensure that it operates at its full potential to produce a conforming product. Under SPC, a process behaves predictably to produce as much conforming product as possible with least possible waste (Kanji, 2002).

Statistical process control (SPC) has become one of the most popular and widespread organizational interventions in the name of quality improvement. Continuous quality improvement process assumes, and even demands that team of experts in field as well as company leadership actively use quality tools in their improvement activities and decision making process. Quality tools can be used in all phases of production process, from the beginning of product development up to product marketing and customer support (Avinaw and Priyan, 2017).

In a manufacturing environment, the SPC tool is used for continuous improvement of the production volume as well as quality which leads to achieve manufacturing excellence. The bottom line of any company is to make profit by achieving the customers' satisfaction. By this

tool, the production manager can easily identify the causes responsible for poor product quality, machine breakdowns and also huge wastage (Faranza, Nahid and Abdulahil, 2009).

The 7 Quality Control (QC) tools are simple statistical tools used for problem solving. These are the most useful tools. 7 QC tools are called Basic because they are suitable for people with little formal training in statistics and they can be used to solve the vast majority of quality-related issues. Kaoru Ishikawa has stated that these 7 tools can be used to solve 95 percent of all problems. These tools have been the foundation of Japan's astonishing industrial resurgence after the second world war (Varsha and Vilas, 2014).

For solving quality problems seven QC tools used are Pareto Diagram, Cause & Effect Diagram, Histogram, Control Charts, Scatter Diagrams, Graphs and Check Sheets. All this tools are important tools used widely at manufacturing field to monitor the overall operation and continuous process improvement. This tools are used to find out root causes and eliminates them, thus the manufacturing process can be improved. The modes of defects on production line are investigated through direct observation on the production line and statistical tools (Varsha and Vilas, 2014).

The study will analyze the quality related issues in the company. The study will assess the quality related issues using statistical process control tools in identifying those problems and propose quality improvement method that will improve overall performance of the company.

1.2 Statement of the Problem

Reducing or eliminating defects from process to produce and deliver quality products to customers is critical for manufacturing industries. The pivotal quality principles in production are to prevent, improve and control (Bergman, 2003). According Beshah and Kitaw, (2014), quality management practices in Ethiopia was found to be low in all the tenets including leadership, policy and strategy, resources management, process management, customer satisfaction, business performance and impact on society. So improving quality management practices needs critical concern to improve quality in the organization and to meet the growing competition in the local market demand of detergent and cosmetics.

In the company there are many quality related problems such as damaged bottle, finished product wastage, damaged carton, returns from customers, and other quality related problems. It’s a must

to analyze the variations and asses root causes of this variations. 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. Using statistical process control the study will find out the root causes for the variation and defects. The study will assess the vital few causes of the defects and in return will able to reduce defects, reduce cost, increase customer satisfaction and maximize the profit.

The research worked in our country tried to analyze on companies started applying statistical process control for quality and productivity improvement. However, the case company did not use SPC tools for quality improvement practice so this study will assess the application of statistical process control for quality improvement. The study attempts to add a new information on application of SPC in our country context and detergent and cosmetics industry.

1.3 Basic Research Questions

The following are research questions to be answered

1) What are the main quality problems need to be solved in Tekron Detergent and Cosmetics Company?

2) What are the root causes of quality related problems in the company?

3) How can quality related problems of Tekron Detergent and Cosmetics Company be identified?

1.4 Objective of the Study

1.4.1 General Objective

The General objectives of the study is to assess the application of statistical process control for quality improvement.

1.4.2 Specific Objective

The Specific objectives of the study are

- To identify the main causes and effects of quality problems in the company.
- To assess the quality related problems in the company and suggest the appropriate solutions.

1.5 Significance of the Study

The significance of the study is to figure out how statistical process control take part in identification of quality related problems and interpret loss the company faces due to defects. The study identifies the quality related problems based on collected data using statistical process control tools. The research finds out the causes for quality related products so that the company can address the causes of the defects for quality improvement. The company can be more productive by minimizing defective products which in turn minimize wastes, time, cost and defective products that will reach customers. The research would create awareness about the usefulness of the Statistical Process Control implementation to enhance the Quality Improvement for those manufacturing companies which did not apply Statistical process control. This study can be used as an input for further study for similar future researchers on application of statistical process control for quality improvement in detergent and cosmetics industry and to forward suggestions, conclusions, and recommendations based on the findings.

1.6 Scope of the Study

The scope of this study was limited to Tekron detergent and cosmetics company which excludes others companies in the detergent industry due to time and convenience constraints. The study was conducted on the production line, packaging and PET bottle blowing line in the company. The Plastic Jerrycan (1liter and 5-liter size) production line was excluded because the machine was under maintenance.

1.7 Limitation of the Study

The challenges faced during the study was shortage of time. Moreover, the unavailability of data form the company was another constraint for the study.

1.8 Operational Definition of Basic Terms

Statistical Process Control: - is method of identifying the variation in the process and product using statistical methods.

Quality Improvement: - is a continuous improvement process by reducing quality related problems to improve the process and product quality.

Control Chart: - is graphical display of a quality characteristic that has been measured or computed from a sample versus the sample number or time.

Pareto Diagram: - is simply a graph that show the items in the X axis in decreasing order and their frequency in Y axis.

Cause and Effect Diagram (Fishbone Diagram): - is diagram shows root causes of a certain problem(effect).

Histogram: - is graph used to show frequency distributions in convenient class intervals an arranged in order of magnitude.

Check Sheet: - is used to collect data about an activity in a way that is easy to use and analyze.

Scatter Diagram: - is used to determine the correlation (relationship between two variables).

1.9 Organization of the Study

This research paper consists of Five Chapters. The content of each chapter is summarized as follows:

Chapter One: Introduction

This chapter contains background of the study, statement of the problem, basic research questions, research objective, significance of the study, scope of the study, limitation of the study, operational definition of terms, and organization of the study.

Chapter Two: Review of Related Literature

This chapter contains the concept of quality, background of statistical control, statistical process control tools, benefits of applying statistical process control for quality improvement, factors impeding product quality improvement and conceptual framework of the study.

Chapter Three: Research Design and Methodology

This chapter composed of the research methodology that is used, the research design and approach, target population and sampling technique, data types and data sources, data collection instrument and method of data analysis.

Chapter Four: Data Presentation, Analysis and Discussion

This chapter is about finding of analysis and interpretation of the study which includes demographic presentation, descriptive analysis of questionnaire questions, and data through measurement their interpretation and results found form control chart, pareto chart and cause and effect diagram.

Chapter Five: Summary of Major findings, Conclusions, and Recommendations

This chapter is about the summary of major findings, conclusions, and recommendations

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter represents the concept of quality, background of statistical control, statistical process control tools, benefits of applying statistical process control for quality improvement, factors impeding product quality improvement and conceptual framework of the study.

2.1 The Concept of Quality

Quality is defined in different ways by a number of scholars. According to Joseph Juran Quality means "fitness for use" (Juran, 1988). According to Philip Crosby, (1984), it means "conformance to requirements". According to Feingenbaum, (1961), quality does not mean "best" but "best for the customer use and selling price" people have a conceptual understanding of quality as relating to one or more desirable characteristics that a product or service should possess. 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". 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.

Quality has become a tool of providing a continuous feedback to the organizational production and business systems with the objective of producing products with high quality and minimum cost, and thus increasing the organization's performance (Aly and Elshennawy, 2003). Quality refers not only to the quality of finished products, but also to the quality of the processes that go into those products. (Robert, 2000) found evidence that quality improvement practices do what they set out to do raise product quality.

The phenomenon is widespread, regardless of whether the consumer is an individual, an industrial organization, a retail store, a bank or financial institution, or a military defense program. Consequently, understanding and improving quality are key factors leading to business success, growth, and enhanced competitiveness. There is a substantial return on investment from improved quality and from successfully employing quality as an integral part of overall business strategy.

2.1.1 Quality Control and Quality Assurance

Quality Control (QC) is a process by which entities review the quality of all factors involved in production. ISO 9000 defines quality control as "A part of quality management focused on fulfilling quality requirements". Inspection is a major component of quality control, where physical product is examined visually (or the end results of a service are analyzed). Product inspectors will be provided with lists and descriptions of unacceptable product defects (Aft, 1997).

Quality control encapsulates all the operational techniques and activities utilized by a company to ensure a conforming final product (Pyzdek & Keller, 2010). This involves the process of examination of products or material with the aim of identifying defective material prior to client delivery (Yunus et al., 2016).

Quality control is about adherence to requirements. Quality assurance is generic and does not concern the specific requirements of the product being developed. Quality control is used to verify that deliverables are of acceptable quality and that they are complete and correct.

Montgomery, 2009 defines quality assurance as a series of actions proactively undertaken by a company to ensure a standardized quality of products and services. Quality assurance systems enhance customer confidence as they provide credibility that the processes are capable and suitable to manufacture according to the requirement (Yunus et al., 2016).

Quality assurance, the process or set of processes used to measure and assure the quality of a product, and quality control, the process of ensuring products and services meet consumer expectations. Quality assurance is process oriented and focuses on defect prevention, while quality control is product oriented and focuses on defect identification.

2.2 Statistical Process Control

Statistical Process Control(SPC) was pioneered by W. A. Shewhart in the early 1920s. In 1939, he created the basis for the control chart and the concept of a state of statistical control, through carefully design experiments (Shewhart, 1939). He discovered that some process variation in manufacturing data is natural to the process, while others display uncontrolled variation that is not present in the process causal system.

W. E. Deming later applied SPC methods in the US during the World War II, thereby, successfully improving the quality in the manufacturing of munitions and other strategically important products. Deming also introduced SPC methods to Japanese industries after the war. The methods were practiced by many manufacturing and service organizations.

Statistical process control (SPC**)** is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability. SPC is one of the greatest technological developments of the twentieth century because it is based on sound underlying principles, is easy to use, has significant impact, and can be applied to any process (Montgomery, 2009).

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.

The philosophy behind SPC concept is the output of a process can be brought into a state of statistical control by means of management and engineering intervention The desire to implement SPC is driven by proactiveness as the reactiveness of an inspection-based quality control system is unreliable, costly and time-consuming (Mason & Antony, 2000).

The SPC initiative is commonly avoided due to the lack of awareness of the potential benefits (Mason & Antony, 2000).

Ishikawa, 1985 points out that SPC's strength lies in its ability to monitor both process center and its variation about that center. It can be done by collecting data from samples at various points within the process; variations in the process that may affect the quality of end product can be detected and corrected. Thus, SPC will be able to reduce the probability of passing problems to the customers.

SPC has a distinct advantage over other quality control techniques, such as final inspection, which utilize human resources for detecting and correcting problems at the end of the production cycle. SPC emphasize on early detection and prevention of problems. In other words, SPC is aimed at continuously improving the process to manufacture quality product for achieving high customer satisfaction (Karuppusami and Gandhinathan, 2006).

2.3 Statistical Process Control Tools

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).

Once the basic problem-solving or quality improvement process is understood, the addition of quality tools can make the process proceed more quickly and systematically. The concept behind the seven basic tools came from Kaoru Ishikawa, a renowned quality expert from Japan. The seven quality tools are check sheet, Pareto chart, histogram, scatter diagram, process flow chart, cause-and-effect diagram or fish bone diagram, and control charts (Besterfield, 2003; Ishikawa, 1985).

According to Ishikawa, 95% of quality-related problems can be resolved with these basic tools. The key to successful problem resolution is the ability to identify the problem, use the appropriate tools based on the nature of the problem, and communicate the solution quickly to others (Ishikawa, 1985).

A general perception exists that SPC is the deployment of control charts on the manufacturing line; however, the control chart is a method used to statistically differentiate between assignable cause and common cause variation and it is necessary to employ additional tools to identify the origin of the adverse change in the process (Antony & Taner, 2003). This skewed perception contributed to the failure of the initial SPC deployment in the case study environment.

A successful SPC program incorporates all seven SPC problem-solving initiatives and is well integrated into the problem solving routines of an organization which strives for an environment conducive to continuous improvement (Antony & Taner, 2003 and Montgomery, 2009).

The seven major tools are Histogram, Check sheet, Pareto chart, Cause-and-effect diagram, Process flow chart, and Scatter diagram. Although these tools, often called “the magnificent seven,” are an important part of SPC, they comprise only its technical aspects. The proper deployment of SPC helps create an environment in which all individuals in an organization seek

continuous improvement in quality and productivity. This environment is best developed when management becomes involved in the process.

Once this environment is established, routine application of the magnificent seven becomes part of the usual manner of doing business, and the organization is well on its way to achieving its quality improvement objectives. Of the seven tools, the Shewhart control chart is probably the most technically sophisticated. It was developed in the 1920s by Walter A. Shewhart of the Bell Telephone Laboratories (Montgomery, 2009).

The seven major SPC problem-solving tools should be widely taught throughout the organization and used routinely to identify improvement opportunities and to assist in reducing variability and eliminating waste. The tools are discussed as follows.

2.3.1 Check Sheets

In the early stages of process improvement, it will often become necessary to collect either historical or current operating data about the process under investigation. The main purpose of Check Sheets is to insure that the data collected is carefully and accurately by operating personnel. Data should be collected in such manner that it can be quickly and easily used and analyzed. The form of the check sheet is individualized for each situation and is designed by the project team (Besterfield, 2003).

They are designed specific to the type of data to be collected. Check sheets aid in systematic collection of data. Some examples of check sheets are daily maintenance check sheets, attendance records, production log books, etc. Data collected using check sheets needs to be meaningfully classified. Such classification helps gaining a preliminary understanding of relevance and dispersion of the data so that further analysis can be planned to obtain a meaningful output (Varsha and Vilas, 2014).

2.3.2 Pareto Chart

The Pareto diagram named after the Italian economist Alfredo Pareto. Dr. Joseph Juran recognized this concept as a universal that could be applied to many fields. He coined the phrases Vital Few and Useful Many in quality problems (Besterfield, 2003).

The Pareto (pah-ray-toe) chart is a very useful tool whenever one needs to separate the important from trivial (Goetsch, 2006). It is a special type of bar charts in which the categories of responses are listed on the X-axis, the frequencies of responses (listed from largest to smallest frequency) are shown on the left side Y-axis, and the cumulative percentages of responses are shown on the right side of Y-axis (Montgomery, 2009).

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 (trivia 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.

2.3.3 Control Chart

Control charts was developed by Dr. Walter A. Shewhart during 1920's while he was with Bell Telephone Laboratories. The control chart is a graphical display of a quality characteristic that has been measured or computed from a sample versus the sample number or time. The chart contains a center line that represents the average value of the quality characteristic corresponding to the in-control state (That is, only chance causes are present). Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL), are also shown on the chart.

The control limits are chosen so that if the process is in control, nearly all of the sample points will fall between them. As long as the points plot within the control limits, the process is assumed to be in control, and no action is necessary. However, a point that plots outside of the control limits is interpreted as evidence that the process is out of control, and investigation and corrective action are required to find and eliminate the assignable cause or causes responsible for this behavior. It is customary to connect the sample points on the control chart with straight-line segments, so that it is easier to visualize how the sequence of points has evolved over time (Montgomery, 2009).

These charts separate out assignable causes. Control chart makes possible the diagnosis and correction of many production troubles and brings substantial improvements in the quality of the

products and reduction of spoilage and rework. It tells us when to leave a process alone as well as when to take action to correct trouble (Varsha and Vilas, 2014).

The type of control chart varies with different data type. The two types of data are variable and attribute. The Variable data is data that is measurable and is expressed on numerical scale(quantitatively). The Attribute data is that cannot be measured or expressed on a numerical scale (expressed qualitatively).

Control Charts for Variables are I-MR chart, X bar- R chart and X bar- S chart. I-MR chart used for sample size of 1. X bar- R charts are used for variable data when the sample size of the subgroup is 2-10. Mean(X) is the average of a sub-group. Range(R) is the difference between the minimum and maximum in a sub-group. When the subgroup size is greater than 10, S Charts are used instead of R charts where S is the standard deviation of the subgroup (Mamta, Harpreet, Rahul and Er. Harpreet, 2016).

CL X bar = X bar/ N UCL X bar = X bar + A2 * R bar LCL X bar = X bar - A2 * R bar

CL R = R bar/ N UCL R = D3 * R bar LCL R = D4 * R bar

Where, R bar = Mean of ranges X bar = Mean of means of individuals

UCL X bar = Upper control limit for means LCL X bar = Lower control limit for means UCL r = Upper control limit for ranges LCL r = Lower control limit for ranges D4, D3, A2, d2 =Values of constants CL X= center line for X bar and CL R= center line for R bar. (Mamta et.al, 2016)

The control charts for attributes are p-chart, np-chart, c-chart and u-chart. Control charts for defectives are p and np charts. P charts are used when the sample size is constant and np charts are used when the sample size is variable. In the case where the number of defects is the data available for plotting, c and u charts are used. If the sample size is constant, c charts are used and u charts are used for variable sample sizes (Varsha and Vilas, 2014).

The principle of sampling states that the variation between subgroups should be solely attributable to the common causes in the system rather than the sampling method. Subgroups or samples should be selected so that if assignable causes are present, the chance for differences between subgroups will be maximized, while the chance for differences due to these assignable causes within a subgroup will be minimized (Rational subgrouping) (Mulat, Subhalakshmi, Yan H and Linzi, 2018).

2.3.4 Scatter Diagram

The scatter diagram is the simplest of the seven tools and one of the most useful. The scatter diagram is used to determine the correlation (relationship between two characteristics/variables) (Goetsch, 2006). If a relationship exists, it may be positive or negative, it may be strong or weak and may be simple or complex. Scatter diagram consists of plotting a series of points representing several observations on a graph in which one variable is on X-axis and the other variable in on Y-axis. If more than one set of values are identical, requiring more points at the same spot, a small circle is drawn around the original dot to indicate second point with the same values. The way the points lie scattered in the quadrant gives a good indication of the relationship between the two variables (Varsha and Vilas, 2014).

2.3.5 Histogram

Histogram is a special bar chart for measurement data. Histograms are used to chart frequency of occurrences (Goetsch, 2006). Histograms or frequency distribution Diagrams are the most commonly used graphs to show frequency distributions in convenient class intervals an 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 (Rami and Adnan, 2010).

2.3.6 Flow Chart

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.

2.3.7 Cause and Effect Diagram

It is a tool used to organize the possible factors that could be negatively impact the stability, center, spread, and shape of a critical to quality (CTQ) characteristics measure. A team typically used a Cause-and-Effect (C&E) diagrams to identify and isolate causes of a problem. The late Dr. Kauro Ishikawa, a noted Japanese quality expert, developed the technique, so some times the diagram is called an Ishikawa diagram. It is also called a Fishbone Diagram because that is what it looks like (Goetsch, 2006).

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 (Rami H, and Adnan M, 2010)

2.4 Benefits of Applying Statistical Process Control for Quality Improvement Program

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.

The correct implementation and use of the SPC can lead to decisions based on facts, to a growing perception about quality at all levels, to a systematic methodology concerning problem resolution, to a gathering of experience and to all kind of improvement, even in communication. Predominantly in manufacturing and concerning quality, SPC is the most widely used technique and once appropriately applied, can improve operational and financial benefits (M. Rungtusanatham, 2001).

The primary benefit of SPC is the establishment of the ability to identify and remove assignable cause variation, assuring the consistent manufacturing of compliant products (Besseris, 2013). The tool also allows for better understanding of a process as a better understanding is required of the inputs and outputs of a process to ensure effective implementation of SPC.

The statistical nature of the tool allows for the collection of vast amounts of data. Historic data can be beneficial by establishing performance benchmarks which allow for improvement (Toledo et al., 2017). Statistical process control requires a specific and logical thought process for effective implementation. Antony & Taner, (2003) argue that employing the incorrect methodology when implementing an SPC program contributes largely to the lack of SPC success in companies. Therefore, it is essential to employ the correct methods when implementing SPC. This increases the potential value which could be gained by implementing SPC.

Most of the production and quality cost that SPC aims to minimize such as rework, loss 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 categories 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.

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.

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 (Montgomery, 2009).

2.5 Factors Impeding Product Quality Improvement

According to Gebremeskel, P.H.Osanna and N.M.Durakbasa, 2007 their work on quality awareness and development on Ethiopian medium and large scale manufacturing industries they have found factors impeding product quality improvement. They uncover nine factors which are affecting the product quality of Ethiopian medium and large scale manufacturing industries.

These are old and/or outdated machines, poor quality of raw material, unskilled manpower, lack of quality awareness by employees, lack and/or inefficient measuring and testing equipment, lack of commitment by top management, lack of employee motivation, lack of standards and lack of effort for improvement.

2.5.1 Old and/or Outdated Machines

Many companies surveyed firmly believe that major barrier for their product quality competitiveness is the frequent failure and process incapability of them production machines. This is understandable considering the year of establishment of plants. This complaint was mainly limited to the establishments of 1980s and before since most companies never had major replacement program till date.

Obviously, recent generation machineries are more efficient and sophisticated. Even though, it is difficult to find the exact correlation, age structure of companies has an influence on quality competitiveness of the firms. Service life of machines varies from country to country, especially on the age of information technology. However, based on general experience, depreciation of plants, particularly in developing countries, lasts for about 10 to 15 years, even though hard wares may not remain efficient enough throughout the whole period (EEA, 2004:192).

The same problem cannot be ruled out for the establishments of 1990s and after, as in some cases the firms installed secondhand machines intentionally or cheated by suppliers. In some cases, it is common to see old machines painted to look a new one. It is also common to see some companies uses machines which are outdated compared with the current level of technology used by their competitors.

Advanced technologies and methodologies have helped to improve the quality of goods and services (Wadsworth *et al.*, 2002). Some machines are still manual while supposed to be semi-automatic or fully automated. Moreover, their productivity was reduced due to lack of proper maintenance techniques.

2.5.2 Poor Quality of Raw Material

Poor quality of raw material was found another major hindrance for many companies both who use local raw material as well as imported one. Although, the complaints of those companies who use raw materials from the local market are understandable, it is very difficult to justify the

problems related with imported raw materials. This is an alarm for Ethiopian companies to work in cooperation with domestic suppliers, to enhance their supplier's capacity or invest on the area to maintain the quality of raw materials. As to the imported raw material, the problem is much more complex and needs company's commitment to investigate their system**.**

2.5.3 Lack of Trained Manpower

It goes to the overall composition of both the line and functional staffs of the companies. Although, no research was conducted to assess the gap between company's requirement and the present staffing, it is easy to understand from our direct observation that companies should do a lot in this aspect. There was a time that we found only one engineer in one metal industry. The problem is not only on quantity, but also on the quality of the professionals, particularly, in those public industries. New western management techniques of lay off and early retirement incentives may give a new imputes to this serious problem. There is a strong correlation between product quality and skill of manpower in the company.

2.5.4 Lack of Quality Awareness by Employees

Although, the awareness by top management is getting momentum, there is a lack of awareness by the main actors such as operators and supervisors at shop floor, this, added with lack of trained manpower will remain as a major hindrance in an effort to promote quality in the present situation of Ethiopian industries.

Deming noted that everyone in the organization, from top to bottom, from office to technical services, from headquarters to local sites, must be involved. He further suggested that people are the source of ideas and innovation; therefore, their expertise, experience, knowledge and sense of duty have to be harnessed to the benefit of the organizations (Deming, 1986:15). Thus, employees are expected to have the right knowledge about factors that affect their product quality and what have to be done to achieve a better quality product.

2.5.5 Lack and/or Inefficient Measuring and Testing Equipment

If we can't measure correctly, it is not possible to know our system efficiency and the quality of our products as the saying goes if you can't measure it, you can't improve it. In the absence of proper measuring and testing instruments, it is impossible to measure deviations of form and dimensions. For that matter, any type of deviation from the requirement be it in weight,

composition or dyeing, so this is a crucial component in which industries has to pay due attention to maintain their product quality.

2.5.6 Lack of Commitment by Top Management

Although, there is no exaggerated problem on quality awareness by top management as most of the respondents claimed to have quality training. There seems to be a lack of commitment to work towards quality improvement. It is not common to share their knowledge and skills to the employees either in the form of seminars, short term training or through practicing the principles of quality. One problem for the lack of commitment can be attributed to lack of in-depth knowledge on the subject.

Moreover, the top management thinks that quality is the responsibility of the quality department and tries to disassociate themselves from activities related to quality promotion and improvement. They fail to introduce new tools, techniques and initiatives to achieve continuous improvement of product quality.

2.5.7 Lack of Employee Motivation

Though, it is not a significant inhibitor, some companies indicated that lack of employee's motivation is contributing to hindrances of firm's product quality improvement. This can be a result of lack of job satisfaction or low earnings from the company. Our interview with some employees revealed that their lack of motivation is directly correlated with lack of job satisfaction. This problem was severe among the public than private industries.

2.5.8 Lack of Standards

In the absence of standard working procedures as well as standards for some products, it is obvious that firms will face difficulty in evaluating their product quality as well as efforts towards system or product quality improvement.

2.5.9 Lack of Effort for Improvement

This is a shared problem among the Ethiopian industries; an industry that was producing a nail fifty years ago produces the same nail with no improvement in size, material or production system which proves the lack of strong researchp and development department. In general, Ethiopian industries lack dynamism and found to be static.

2.6 Conceptual Framework for Quality Improvement

The conceptual framework was developed by the researcher based on the literature review conducted. The proposed conceptual framework which served as foundation of this study describes the dependent variable and independent variables. Quality improvement is the Dependent variable and Top management commitment, Skilled manpower, Employee motivation, Effort for Quality improvement, Raw material quality, Quality awareness and Age of machine are the Independent variables.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

This chapter presents the type of research conducted, how the research work was designed, the type of data used, and the methods employed in carrying out the research work. This included sources of data, data collection tools/instruments, participants of the study, target population and sampling technique used, procedure of data collection, and methods of data analysis.

3.1 Research Design

The method in this research was descriptive in which it describes the characteristics of the population and phenomena under study to assess the application of SPC tools for quality improvement in the company in identifying the quality related problems. The researcher used mixed approach both qualitative and quantitative approaches because it provides strengths that offset the weakness of both qualitative and quantitative research. It also can give a better understanding of the problem and yield more complete evidence the investigator gains both depth and breadth. Creswell and Tashakkori, (2007:108) notes that a mixed approach can provide a fuller description and more complete explanation of the phenomenon being studied by providing more than one perspective on it.

3.2 Data Types and Sources

Both qualitative and quantitative data type were used and primary and secondary sources of data were also employed. The major source of data was primary data collected by the researcher. The primary data is any original data the researcher collect for the purpose of answering the research questions. The primary sources of data were the employees working in the company through self-administered close ended questionnaire, semi structured interview, and focus group discussion.

A direct observation of the production and related environment which was helpful for the study. Moreover, the data and measurements collected by the researcher for the purpose of the study were employed as a primary source of data gathering tools. The secondary sources of data were company recorded data, websites, written documents, books and other related literatures.

3.3 Target Population and Sampling Techniques

The target population of this study was a total of 76 professional and non-professional employees working in the production, packaging, and blowing line of the company.

The sampling technique employed to select respondents was non probability sampling. From Non probability sampling, Purposive sampling method was used to select the interviewee's and respondents of the questionnaire. Purposive sampling technique, also called judgment sampling, is simply put, the researcher decides what needs to be known and sets out to find people who were willing to provide information by knowledge or experience.

The respondents were 40 non-professionals and 17 professional employees. They were selected purposely to assess SPC application and identify the quality related problems in the company because they have a better understanding and knowledge about the case under study. This includes Production department, Quality department, Technical department, Marketing department and Production supervisor. They were included in the questionnaires and interview.

3.4 Instruments of Data Collection

In order to gather the data from relevant sources the following methods were applied. To explore what employees think about quality improvement and the quality related problems occur in the company. This research employed direct observation, questionnaire, interview and focused group discussion as data collection instrument.

3.4.1 Direct Observation

Direct observation was used when the information required is sought after by way of investigator's own direct observation without asking from the respondents. Direct observation is most simple and involves 'seeing' things such as objects, processes, relationships, events and formally recording the information. During observation the required data and measurements were conducted. This was done by the researcher in the daily basis.

3.4.2 Questionnaire

The researcher designed self-administered questionnaires to get data from both professional and non-professional employees of the company. The number of questionnaire prepared for non-

professional employees were 40. Accordingly, 35 were returned and 5 were not properly filled. So 30 were ready for analysis.

The questionnaire prepared for non-professional had four parts and translated to Amharic language. The first section assessed the demographic characteristics of the respondents. The second one about their quality awareness, the third part about employee motivation and the last about effort for quality improvement. The respondents had three choices yes, no and do not know this chosen on purpose in order not to bother them with 5 point Likert scale.

The questionnaire prepared for the professional employees had three parts. The first section assessed the demographic characteristics of the respondents. The second part addressed about employee's quality awareness, employee motivation, effort for quality improvement, age of the machine, raw material quality, skill of operator, and top management commitment using closed ended questions. In the close ended questions, the researcher enquired the respondents to give a score by using a 5-point Likert Scale ranging from Strongly Agree (1), Agree (2), Neutral (3), Disagree (4) and Strongly Disagree (5), this allowed the researcher to draw conclusions based on comparisons made from the responses. Finally, the last part assessed the quality related problems, the possible causes and types of defects using multiple choice. Then questionnaires were distributed to selected respondents and filled questionnaires were collected.

3.4.3 Interview

Interview was conducted with the 5 selected respondents form Production department, Quality department, Technical department, Marketing department and Production supervisor departments. The interview was semi structured and held by the researcher of the study. The interview questions have been prepared on the basis of the objectives of the study itself. Some of these questions are similar to the questions of the questionnaire. And this has been used for crosschecking the responses given by the respondents on both methods of assessment and to get more detail information.

3.4.4 Focus Group Discussion

Focus group discussion was held with 6 professional employees from production department, quality department and technical department to get an in depth data. Brainstorming technique

was used to elicit a large number of ideas from a team using its collective power. The root causes of the quality related problems were deeply assessed in the discussion session.

Brainstorming is a technique used to elicit a large number of ideas from a team using its collective power. It normally takes place in a structured session involving between three to twelve people, with five to six people being the optimal group size. The team leader keeps the team member focused, prevents distractions, keeps ideas flowing, and records the outputs (or make sure that team members record their own outputs. The brainstorming session should be a closed-door meeting to prevent distractions.

3.5 Procedure of Data Collection

Before the data collection started the researcher contacted with General manager to get permission to collect the data and necessary information to conduct the research. After getting the permission, the researcher discussed with selected respondents to participate in assessment. All were willing to take the necessary actions whether filling the questionnaire, conduct the interview and the group discussion. Then the questionnaires were distributed to respondents. The interview was conducted considering the convenient time of the interviewee. The focus group discussion was held in closed door meeting to avoid distraction. Finally, the filled questionnaires were collected.

3.6 Methods of Data Analysis

The study used both primary and secondary data. The primary data was collected through observation, semi structured interviews, close ended questionnaires and focused group discussion. The secondary data was collected from the website written documents, and books.

Both qualitative and quantitative methods of data analysis were deployed. For quantitative analysis, check sheets were used to identify the frequent problems and prioritized by Pareto diagram. Then, the prioritized defect causes filtered by cause and defect diagram. Control Chart was used constructed using the sample data collected, the chart was constructed using Minitab software after entering the collected data. The pareto chart was constructed by entering the type of defects and number of defects using Minitab software. The cause and effect diagram was constructed using Minitab software.

The quantitative data collected form questionnaire was analyzed using descriptive statistics with the help of SPSS software. The descriptive statistics was presented using tables to see the descriptive statistical values mean and standard deviation for the five-point Likert scale data. The qualitative data analysis, content analysis was used. For the presentation of the data collected control charts, pareto chart, cause and effect diagram, tables and diagrams were used.

3.7 Reliability and Validity Test

Validity and reliability of the measures need to be assessed before using the instrument of data collection (Hair et al., 2003). Validity concerns whether an instrument can accurately measure, while reliability pertains to the consistency in measurement.

Validity of the measuring instrument was checked by first distributing the questionnaires to a selected 3 employees to evaluate the accuracy. Accordingly, what the questions meant in the questionnaires were accurately captured by the respondents. The normal range of Cronbach's coefficient alpha value ranges between 0- 1 and the higher values reflects a higher degree of internal consistency.

Different authors accept different values of this test in order to achieve internal reliability, but the most commonly accepted value is 0.70 as it should be equal to or higher than to reach internal reliability (Hair et al., 2003). The researcher has tested the reliability using Cronbach's Alpha (α) which is an internal consistency test that measures the degree to which the items or measurements consistently measures the underlying construct.

Table 3.1 The Cronbach's Alpha (α) result

Variable	Cronbach's Alpha (α)	No of items
Quality Awareness in the Organization	0.819	4
Employee motivation	0.96	6
Top management commitment	0.83	5
Raw material quality	0.87	3
Skill of operator	0.81	3
Old and/or outdated Machines	0.73	4

3.8 Ethical Consideration

The researcher informed and make sure to 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. Their names were not mentioned here for protection of their right and wellbeing.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

This chapter presents the background about the company, demographic characteristics of professional and non-professional employees, descriptive analysis of questionnaire, interview analysis, construction of control chart, check sheet, pareto chart and cause and effect diagram and discussion of the results.

4.1 Background of the Company

Tekron Detergent and Cosmetics was established in 2008 G.C as Share Company of Tekron group in Turkey. The joint venture arrangement lasted followed by a full takeover after settling the share previously held by the Tekron group. It has been producing liquid cleaning detergents and cosmetic products.

The company produces personal and home care products which includes liquid hand soap, liquid dishwashing detergent, multipurpose detergent, window cleaner, laundry detergent, antiseptic disinfectant, shower jel, shampoo and conditioner.

The company has PET bottle blowing line in which the bottle preforms were blown to different types of bottles using semi-automatic machine and also jeerycan production line. The company can be considered as medium scale manufacturing company. The company was pioneer to introduces liquid hand soap in our country. The company did not apply SPC tools to identify variation and causes for defects.

4.1.1 Production Process

For this study from the different products produced in the company liquid hand soap was chosen for the consistency and there was daily production of liquid hand soap due to the demand of the product was increased due to COVID 19. For constructing control chart rational sub grouping was considered. The selected samples consist of products that are produced in the same lines, coming from same batches, produced by same operators.

The liquid hand soap production process involves the following steps.

1. Mixing - involves weighing and combining various raw materials for the production of product in the mixing tank.

2. Filling - is the process of filling the product from temporary storage tank in to bottles using manual pneumatic machine.

3. Capping - involves manually capping the filled and weighted product bottles.

4. Labeling - involves manual labeling of front and back side labels.

5. Codding - is the process of codding the production date, expiry date and batch number on the final product.

6.Packaging - involves entering 12 pieces of final product in to the carton. Then transferred to final product store.

4.2 General Information of Respondents

4.2.1 Demographic Analysis of Professional Employees

The general information of the respondents includes the gender, work experience and academic qualification of respondents.

From the data collected form the questionnaire about the gender, academic qualification and work experience it was found that 64.7% are males and 35.29% of the respondents are females.

Besides, 11.7% of them have a Master's degree, 70.58% of the respondents have Bachler degree and 17.04% have diploma. This indicates that most of respondents are degree holders and all the respondents can understand the questions and respond properly.

On the other hand, 17.64% of the respondents have a work experience of less than 2years and 52.94% of the respondents have an experience of 3 to 5 years whereas 29.41% of the respondents have an experience of more than 5 years. From this we can assume that respondents aware of the company.

4.2.2 Demographic Analysis of Non-professional Employees

The general information of the respondents includes the gender, work experience and educational level of respondents.

From the data collected form the questionnaire about the gender, educational level and work experience it was found that, 43.33% are males and 56.66% of the respondents are females.

Besides, 36.66% were from grade 9^{th} -12^{th}, 40% were from grade 1-8^{th} and 23.33% reading and writing. This indicates that most of respondents were from grade 1-8^{th} and the educational level of employees affects the quality improvement and defects analysis using SPC tools.

On the other hand, 53.33% of the respondents have a work experience of less than 2years and 30% of the respondents have an experience of 3 to 5 years whereas 16.66% of the respondents have an experience of more than 5 years.

4.3 Questionnaire Data Analysis and Interpretation

4.3.1 Frequency Analysis of Variables

Questionnaire Gathered from Non-professional Employees

Part 1. Quality Awareness in the Organization

From the data most of the respondents agree that quality leads to a decrease in reject rate however they do not agree that quality related problems will lead the organization to loss its customers and quality is the responsibility of everyone in the organization. This indicates the lack of awareness of employees about quality.

Table 4.1 Quality Awareness in the Organization

Quality Awareness of Employees	**Frequency %**		
	Yes	**No**	**Do not know**
Quality lead to a decrease in rejects rate	28 (93.33%)		2 (6.67%)
If a product gets rejected due to poor quality the managers are to blame	20 (66.66%)	6 (20%)	4 (13.33%)
Quality is the responsibility of everyone in the organization	10 (33.33%)	15 (50%)	5 (16.67%)
Quality related problems will lead the organization to loss its customers	2 (6.67%)	18 (60%)	10 (33.33%)

Part 2. Employee Motivation

From the analyzed data, most of the respondents (greater than 80% of them) agree that they are not comfortable with their working environment, the company did not motivate employees, no effective communication with their supervisor, they will absent from work without valid reason.

This indicates the employees are not comfortable with their work which can lead to carelessness, negligence and not concerned about the company loss due to quality related problems.

Table 4.2 Employee Motivation

Employee Motivation	**Frequency**		
	Yes	**No**	**Do not Know**
Are you willing to take additional responsibility?	1 (3.33%)	27 (90%)	2 (6.67%)
Are you satisfied with your current job?	4 (13.33%)	26 (86.67%)	
Do you absent from work without visible or valid reason?	27 (90%)	3 (10%)	
Are you comfortable with working environment?	5 (16.67%)	22 (73.33%)	3 (10%)
Dose the company motivate employees?	3 (10%)	26 (86.67%)	2 (6.67%)
It there an effective communication between operator and their supervisor?	3 (10%)	25 (83.33%)	2 (6.67%)

Part 3. Effort for Quality Improvement

From the analyzed data, almost all agree that they did not take training about quality and did not know about quality improvement. This indicates that the company did not take an effort for quality improvement.

Table 4.3 Effort for Quality Improvement

Effort for Quality Improvement	**Frequency**		
	Yes	**No**	**Do not know**
Company provides you formal training about your position before you started this job?	4 (13.33%)	26 (86.67%)	
Company provides you quality related training after you started this job?		30 (100%)	
Do you have awareness about quality improvement?		28 (93.33%)	2 (6.67%)

4.3.2 Descriptive Analysis of Variables

Questionnaire Gathered from Professional Employees

Part 1. Quality Awareness in the Organization

Table 4.4 Quality Awareness in the Organization

Quality Awareness in the Organization	N	Mean	SD
Quality lead to a decrease in rejects rate	17	4.05	0.43
If a product gets rejected due to poor quality the managers are to blame	17	1.82	0.72
Quality is the responsibility of everyone in the organization	17	3.82	0.72
Quality related problems will lead the organization to loss its customers	17	4.47	0.51

From the above data, Quality related problems will lead the organization to loss its customers got highest mean 4.47 and 0.51 SD and If a product gets rejected due to poor quality the managers are to blame was got lowest mean 1.82 and 0.72 SD. This indicates professional have better understanding about quality awareness.

Part 2. Employee Motivation

Table 4.5 Employee motivation

Employee Motivation	N	Mean	SD
Are you willing to take additional responsibility?	17	1.94	0.899
Are you satisfied with your current job?	17	3.05	1.29
Do you absent from work without visible or valid reason?	17	3.0	1.0
Are you comfortable with working environment?	17	2.47	1.37
Does the company motivate employees?	17	1.74	1.19
It there an effective communication between employee and their supervisor?	17	3.47	1.01

There an effective communication between employees and their supervisor has got highest mean 3.47 and 1.01. The company motivates employees got lowest mean 1.74 and 1.19 SD. The company did not motivate employees that will affect the employees negatively.

Part 3. Old and/or Outdated Machines

Table 4.6 Old and/or Outdated machines

Old and/or Outdated Machines	N	Mean	SD
Is there frequent failure of machines?	17	4.41	0.73
Are the machines old?	17	4.41	0.51
Is there a regular machine maintenance schedule?	17	4.17	0.62
Unplanned downtime can happen due to machine failure?	17	3.7	0.47

The machines are old and there is frequent failure of machines got highest mean 4.41. Unplanned downtime can happen due to machine failure got lowest mean 3.7 and 0.47 SD. This indicates that machines were old and due to that frequent machine failure causes defect.

Part 4. Raw Material Quality

Table 4.7 Raw Material Quality

Raw Material Quality	N	Mean	SD
Imported raw material quality is assessed before use?	17	3.76	0.66
Local purchased raw material quality is assessed before use?	17	3.70	0.77
Defective raw materials delivered from suppliers?	17	3.58	0.71

Imported raw material quality is assessed before use and Local purchased raw material quality is assessed before use has got 3.76 and 3.7 mean respectively. This indicates the raw materials were assessed.

Part 5. Skills of Manpower

Table 4.8 Skill of Manpower

Skills of Manpower	N	Mean	SD
Company provides training to develop the skill of operator?	17	3.03	1.04
Operators did not notice the working principles of the machine?	17	3.21	0.95
Operator did not try to detect the causes of defects?	17	3.46	0.88

Operators did not try to detect the causes of defects got highest mean 3.46 and 0.88 SD. Company provides training to develop the skill of operator got lowest mean 3.03 and 1.04 SD. This indicates there is lack of skill of operators and the operators did not got training on detection of defects before their occurrence.

Part 6. Top Management Commitment

Table 4.9 Top Management Commitment

Top Management Commitment	N	Mean	SD
Is the top management committed to the for quality improvement?	17	2.17	0.95
Management is committed to the idea that quality is at least as important as quantity/ volume of production	17	4.05	1.41
Does the management listen to employees	17	2.35	1.53
Does the management encourage ideas and suggestions?	17	2.23	1.09
Management has resistance to change that slows down company improvement?	17	2.58	0.65

Management is committed to the idea that quality is at least as important as quantity/ volume of production got 4.05 mean and 1.41 SD. The management encourage ideas and suggestions got lowest mean 2.23 and 1.09 SD. This indicates that management have basic understanding of the quality but did not take action for the improvement.

Part 2 Obstacles for Quality Improvement

Table 4.10 Obstacles for Quality Improvement

Obstacles for Quality Improvement	Frequency	Percentage
a. The top management commitment	16	26.22%
b. Lack of awareness about quality improvement	13	21.31%
c. Lack of employee motivation	10	16.39%
d. Lack of resources and time	3	4.91%
e. Lack of employee engagement and communication	9	14.75%
f. Lack of quality equipment	7	11.47%
g. Non-compatibility with company policies	2	3.27%
h. Organizational structure	1	1.64%

For the obstacle for quality improvement top management commitment, Lack of awareness about quality improvement, and Lack of employee motivation have got percentage of 26.22%, 21.31% and 16.39% respectively were chosen as the obstacles for quality improvement.

Part 2. The Possible Causes for Quality Related Problems

Table 4.11 The Possible Causes for Quality Related Problems

The Possible Causes for Quality Related Problems	Frequency	Percentage
a. Poor quality of raw materials	**7**	**6.6%**
b. Inadequate skilled operators	**14**	**13.2%**
c. Poor Machine maintenance schedule	**16**	**15.09%**
d. Low awareness of workers about quality	**13**	**12.26%**
e. Age of Machinery	**12**	**11.32%**
f. Poor raw material handling	**10**	**9.43%**
g. Poor measurement	**8**	**7.54%**
h. No calibration of testing instruments as scheduled	**4**	**3.77%**
i. Poor final product handling	**10**	**9.43%**
j. Discipline of workers	**12**	**11.3%**

From the above data of frequency and percentage causes for quality related problems were Poor Machine maintenance schedule 15.09%, Inadequate skilled operators 13.2%, Low awareness of workers about quality 12.26%, Age of Machinery 11.32% and discipline of workers 11.3%

4.4 Interview Question Analysis

Interview was conducted with the 5 selected respondents form production department, quality department, technical department, marketing department and production supervisor. The interview was semi structured and held by the researcher of the study. The interview questions have been prepared on the basis of the objectives of the study itself. Some of these questions are similar to the questions of the questionnaire.

Question for the obstacles of quality improvement top management commitment, lack of awareness about quality improvement, and employee motivation was highly mentioned.

The types of defects mentioned was labeling, capping, underweight, overweight and coding. The causes for quality related problems listed was skill of operator, lack of quality awareness, age of machines, lack of employee motivation, no regular maintenance of machine, no training and education program for the employees as a whole and no incentive for employee that show good performance.

The question for the SPC tool to be used in the company were answered were check sheet, pareto diagram, control chart and cause and effect diagram

4.5 Data Collected through Measurement

4.5.1 Application of Control Chart Using Weight

The volume or weight in the production of liquid hand soap is one of the quality parameters. The average weight or volume of liquid hand soap bottle should be 500gm. The X-bar (x) and R-chart graphics in Table are created from the weight or volume of 26 samples of 5 runs. The control limits drawn in both plots were obtained by using equations given in the literature and chart was constructed using Minitab software.

Table 4.12 Sample Data of Weight Collected for X double bar –R chart

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Mean	Range
540.2	542.3	540.1	539.1	541.3	540.6	3.2
543.9	542.1	541.8	541.6	545.4	542.96	3.8
540.1	541.7	540.2	543.6	543.8	541.88	3.7
540.1	544.3	535.8	541.6	542.3	540.82	8.5
539.1	538.3	537.8	540.2	542.3	539.54	4.5
535.9	543.8	540.1	542.5	544.4	541.34	8.5
542.8	547.7	540.9	547.2	548.9	545.5	8
540.2	540.7	543.6	540.1	541.3	541.18	3.5
548.1	540.7	543.6	540.1	541.3	542.76	8
548.1	542.7	538.9	539.1	540.8	541.92	9.2
535.1	539.1	533.9	534.6	535.0	535.54	5.2
545.1	549.2	540.8	544.9	539.0	543.8	10.2
548.1	549.2	543.6	536.2	549.9	545.4	13.7
539.9	538.6	540.8	540.1	545.7	541.02	7.1
546.6	547.7	548.0	539.0	539.7	544.2	9
539.8	548.7	540.7	548.6	535.9	542.74	12.8
549.5	549.9	548.5	546.1	547.4	548.28	3.8
539.8	540.9	546.5	540.1	543.2	542.1	6.7
548.0	539.1	536.9	539.9	540.8	540.94	11.1
539.1	540.8	543.1	542.9	540.0	541.18	4
547.0	536.9	539.1	548.0	537.0	541.6	11.1
536.0	545.9	549.0	540.9	543.8	543.12	13
543.1	548.9	536.8	536.0	543.1	541.58	12.9
541.9	544.2	546.2	542.2	538.5	542.6	7.7
543.1	548.2	546.7	547.2	542.7	545.58	5.5
547.0	536.9	536.0	545.9	547.0	542.56	11

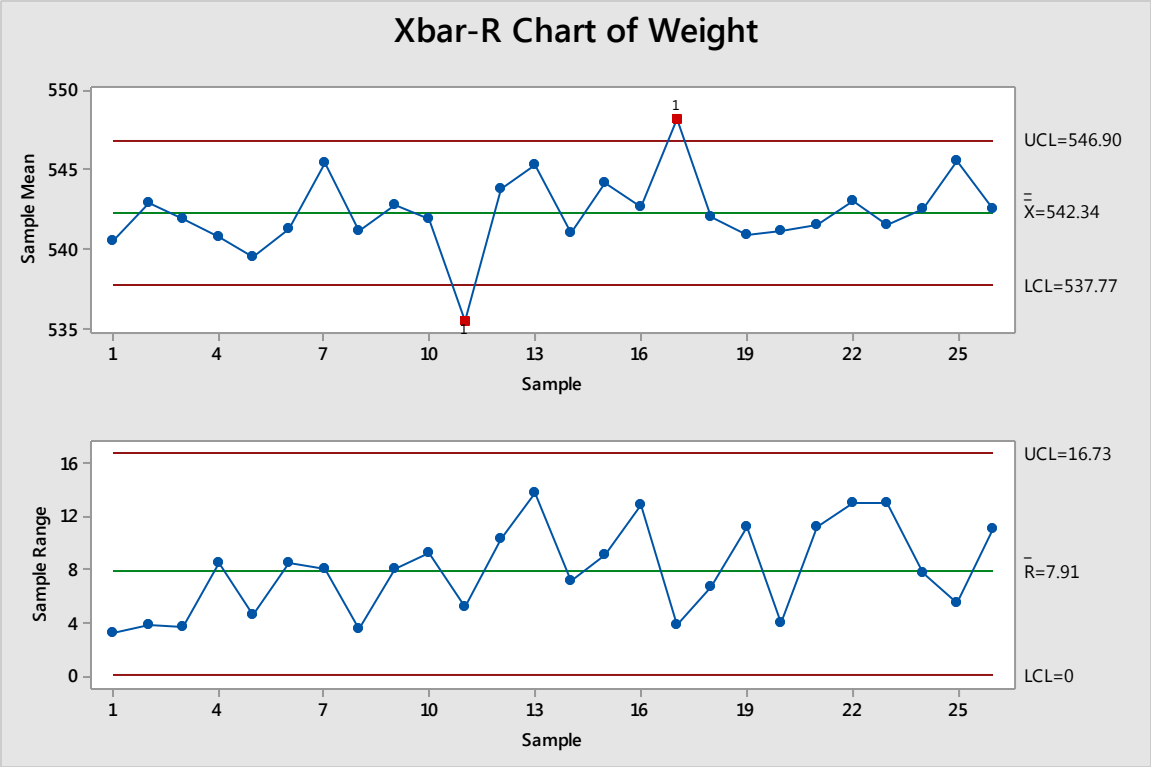

Figure 4.1 Control Chart (X bar R chart) of Weight

The volume or weight in the production of liquid hand soap is one of the quality parameters. The average weight or volume of liquid hand soap bottle should be 500gm. The X-bar (x) and R-chart graphics in Table are created from the weight or volume of 26 samples of 5 runs. The result shows 2 samples out of statistical control. One point below lower specification limit and the other above the upper specification limit.

4.5.2 Application of Control Chart for PH

The PH in the production of liquid hand soap is one of the quality parameters. The PH of liquid hand soap bottle should be around 5.5 - 6. The X-bar (x) and R-chart graphics in Table are created from the PH of 26 samples of 4 runs. The control limits drawn in both plots were obtained by using equations given in the literature.

Table 4.13 Sample Data of PH Collected for X double bar –R chart

Sample 1	Sample 2	Sample 3	Sample 4	Mean	Range
5.5	5.6	5.9	6	5.75	0.5
6	6	5.9	6	5.97	0.1
5.8	5.9	5.8	5.5	5.75	0.4
6	5.7	5.5	6	5.8	0.5
5.5	6	5.8	5.8	5.77	0.5
5.9	5.7	5.6	6	5.8	0.4
6	5.8	5.5	5.6	5.72	0.5
5.8	5.5	5.7	5.7	5.67	0.3
6	5.7	5.6	5.5	5.7	0.5
5.7	6	6	5.9	5.9	0.3
5.9	5.8	5.9	5.9	5.87	0.1
6	5.7	6	5.6	5.8	0.4
5.8	5.6	5.6	5.9	5.7	0.3
6	5.6	5.7	6	5.8	0.4
5.9	5.8	5.6	5.9	5.8	0.3
5.5	5.5	5.7	5.7	5.6	0.2
6	5.9	5.7	5.8	5.85	0.3
5.5	5.7	5.6	5.5	5.57	0.2
6	5.8	5.7	5.9	5.8	0.3
5.9	5.6	5.5	6	5.75	0.5
5.7	5..8	5.7	5.9	5.76	0.2
5.5	5.6	5.7	6	5.7	0.5
5.9	5.8	6	5.5	5.8	0.5
5.8	5.7	5.9	6	5.85	0.3
5.9	5.8	5.5	5.6	5.7	0.4
6	5.9	5.9	5.5	5.8	0.5

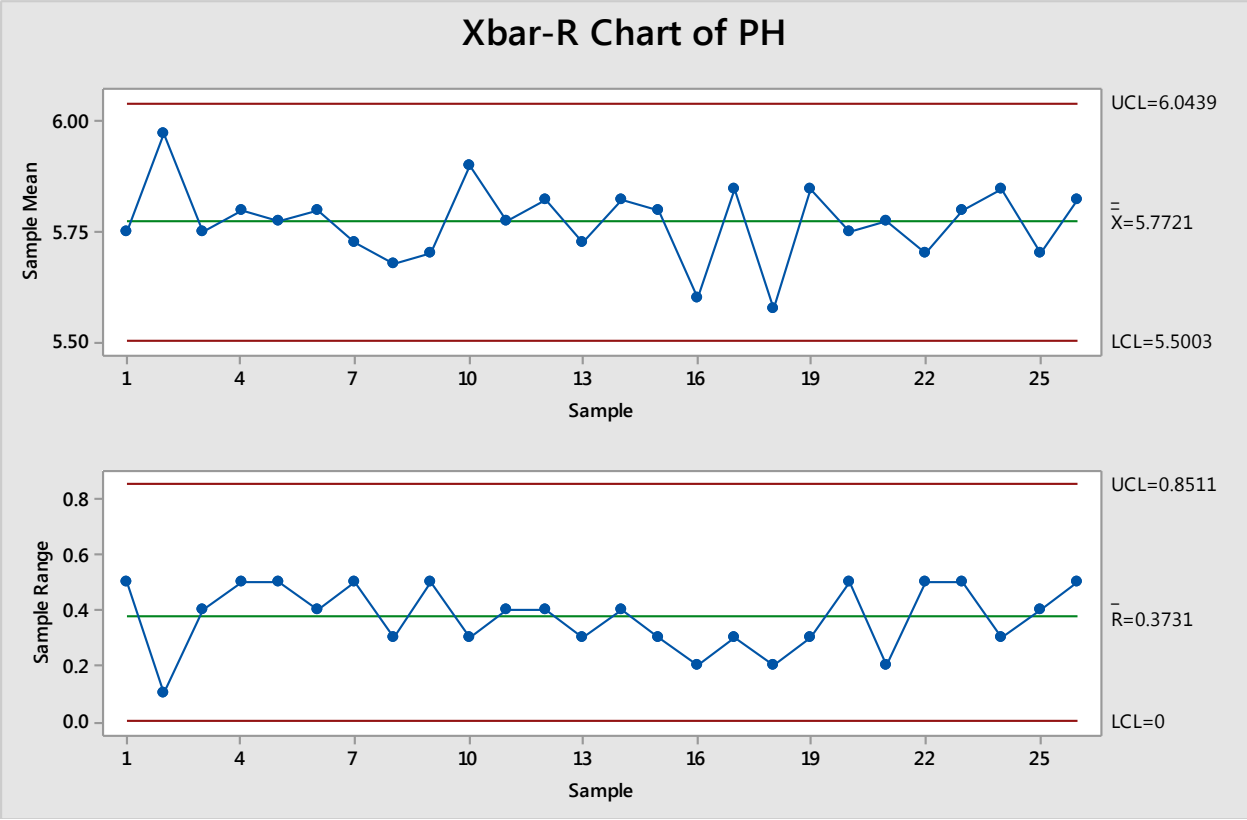

Figure 4.2 Control chart (X bar R chart) of PH

The PH is one of quality parameters. PH should be around 5.5 – 6. The x-bar(X) and R- chart graphics are created from the PH of 26 samples of 4 runs. The control limits drawn in both plots were obtained by using Minitab based on review literature of study. From the above x-R bar chart of the graph, The PH parameter is under statistical control.

4.5.3 Application of Check Sheet

Check sheet was used to gather the data of defects occurred. All the necessary details were listed in the check sheet. The date, the name of the data collector, and the types of defects. The following table was constructed from the data collected using check sheet.

Table 4.14 Number of Defect

Types of defects	**No of defects**
Damaged bottle	469
Overweight	294
Labeling error	260
Cap on open mode	177
Underweight	101
Return	69
Un coded	65
Improper capping	49
Blurred coded	33
Total	1517

4.5.4 Application of Pareto Diagram

To identify the main problems which cause frequent defects of production, a one-month data had been collected (March 2021). Since there were no data collected in the company the researcher tried to gather the defects with the help of quality controller. Defects were collected for 26 days (excluding Sundays and one holiday) on March. From this analysis the Vital few areas where maximum defects occur can be identified. The Pareto principle states that it is possible for much performance measure, such as damaged bottle, overweight, labeling error and cap on open mode to separate the vital few causes resulting in unacceptable performance from the trivial many causes.

Table 4.15 Number of Defects with Cumulative Percentage.

Types of Defect	No of Defect	Cumulative Count	Cumulative Percentage
Damaged bottle	469	469	30.91 %
Overweight	294	763	50.29 %
Labeling error	260	1023	67.43 %
Cap on the open mode	177	1200	79.1 %
Underweight	101	1301	85.75 %
Return	69	1370	90.3 %
Un coded	65	1435	94.5 %
Improper capping	49	1484	97.82 %
Blurred coded	33	1517	100 %
Total	1517	1517	100 %

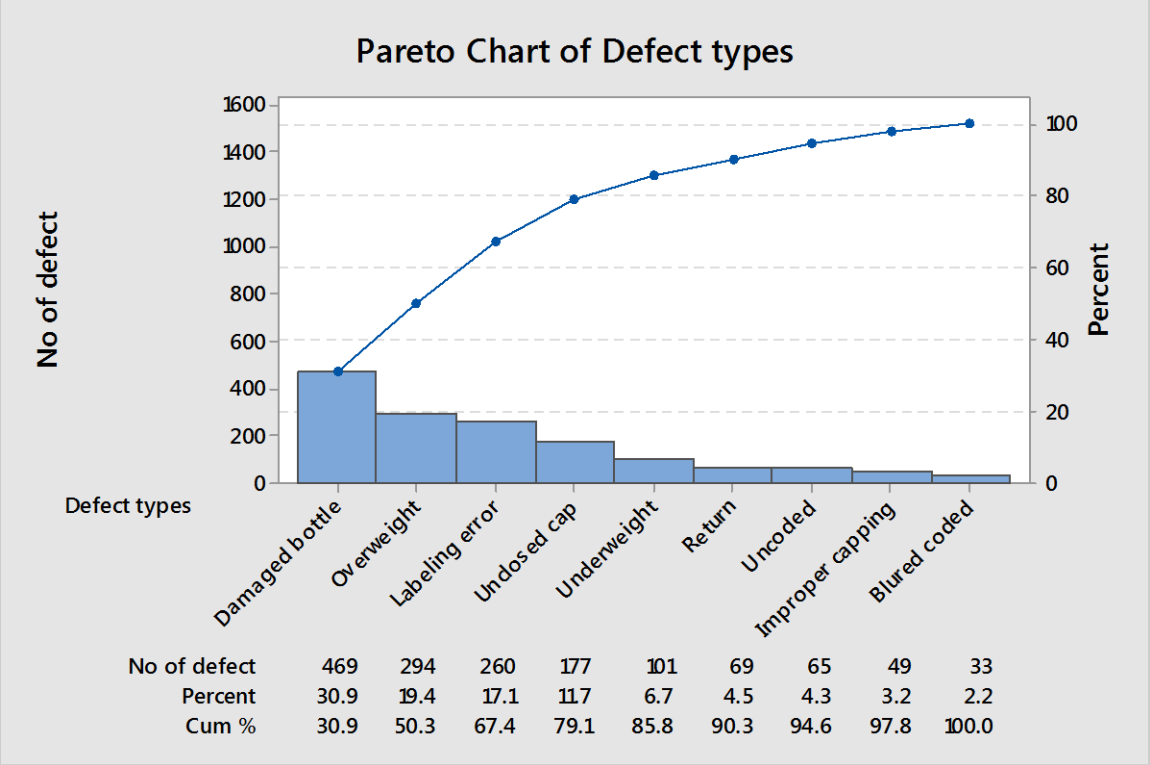

Figure 4.3 Pareto Chart for defects

4.5.5 Application of Cause and Effect Diagram

From Pareto Analysis percentage of defect was identified and by further analyzing it was also identified top four defect types that contribute to 79.1%. Those defect types are damaged bottle, overweight, labeling error and cap on open mode.

Focused group discussion with brainstorming technique was held to identify the root cause of defects. In analyzing the product defect or quality problem, we elected to lay out the major categories of products defects as man, machine, material, methods, and measurement. The team identify the root causes of quality defects by asking or raising and discussing brainstorming questions. Then the following diagram was constructed for each vital few defect types.

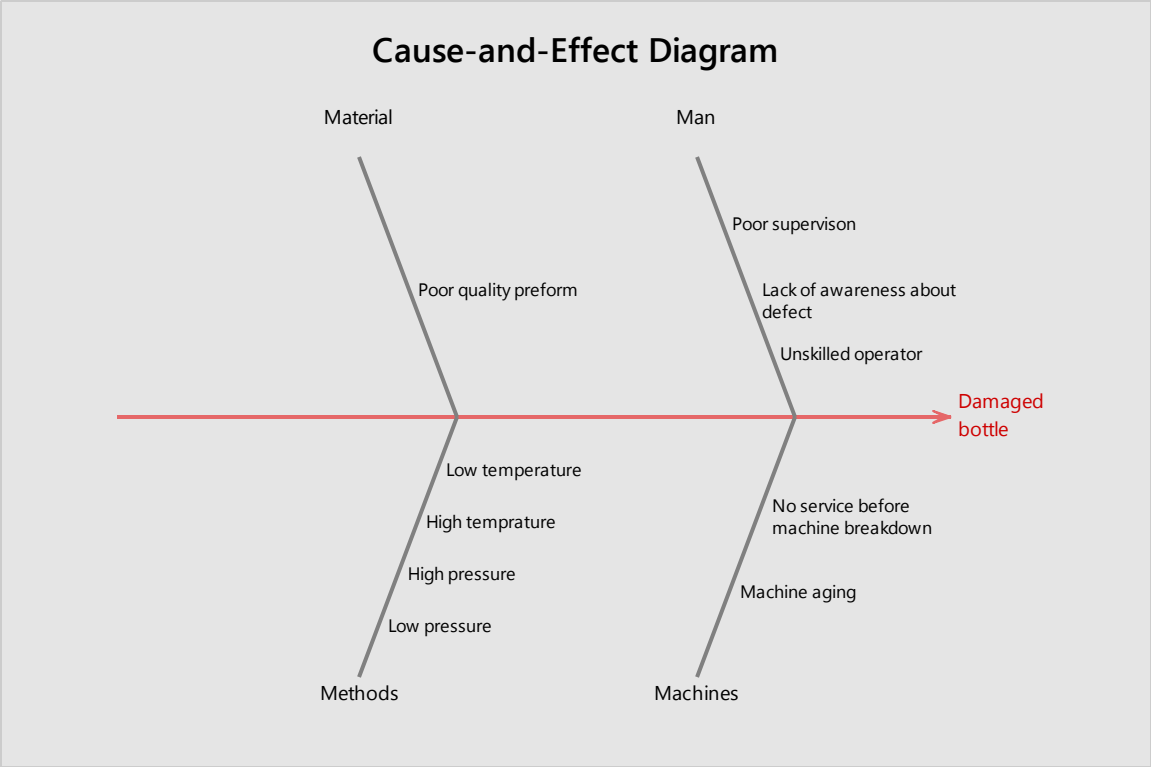

Figure 4.4 Cause and Effect Diagram for Damaged bottle.

The root causes for damaged bottle were indicated in the above diagram. The causes poor supervision, lack of awareness about defect, and unskilled operator in the Man category, no regular service and machine aging in Machine category, poor quality preform in the Material category, operating with high/low pressure and high/low temperature was cause in the Method category.

The root causes for overweight were indicated in the diagram below. The causes poor supervision, lack of awareness about defect, and discipline of workers (carelessness and negligence of the workers) in the Man category, un calibrated balance in Machine category, poor quality preforms in the Material category, measuring error was cause in the Method category.

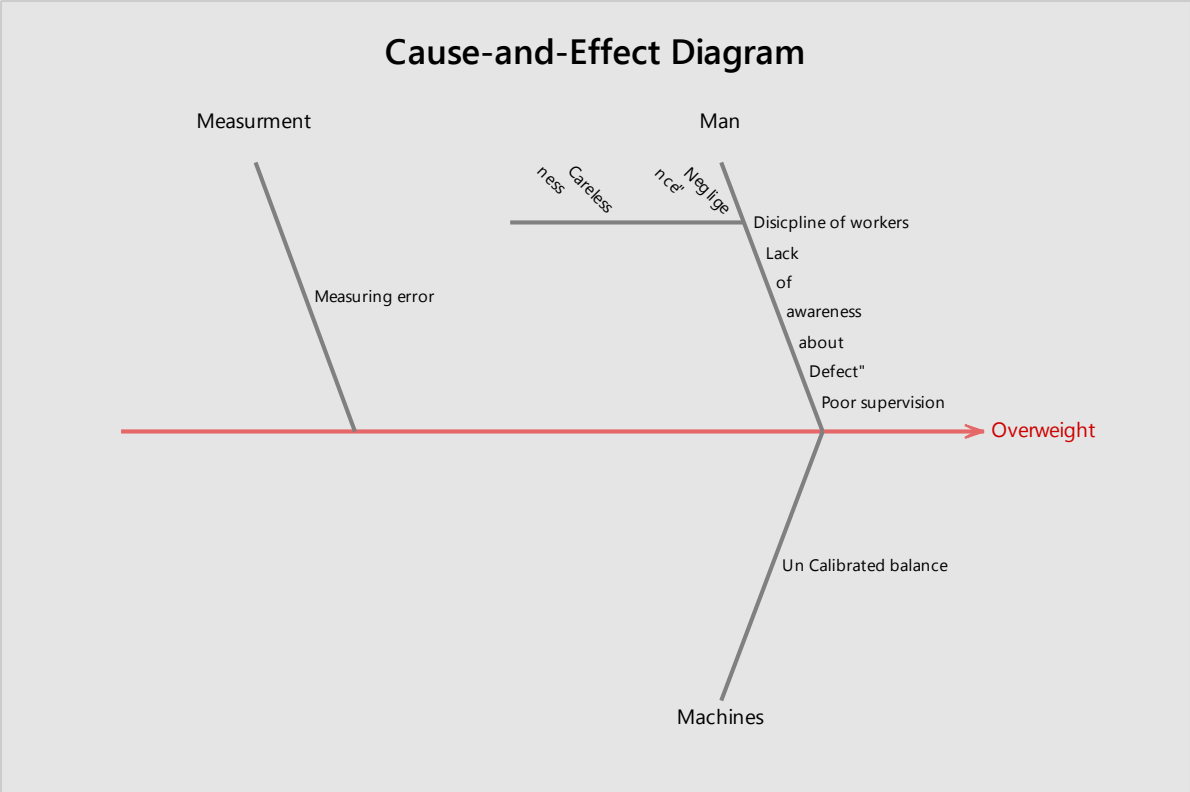

Figure 4.5 Cause and Effect Diagram for Overweight

The root causes for labeling error were indicated in the diagram below. The causes poor supervision, carelessness and negligence of the workers in the Man category, working method in the Method category.

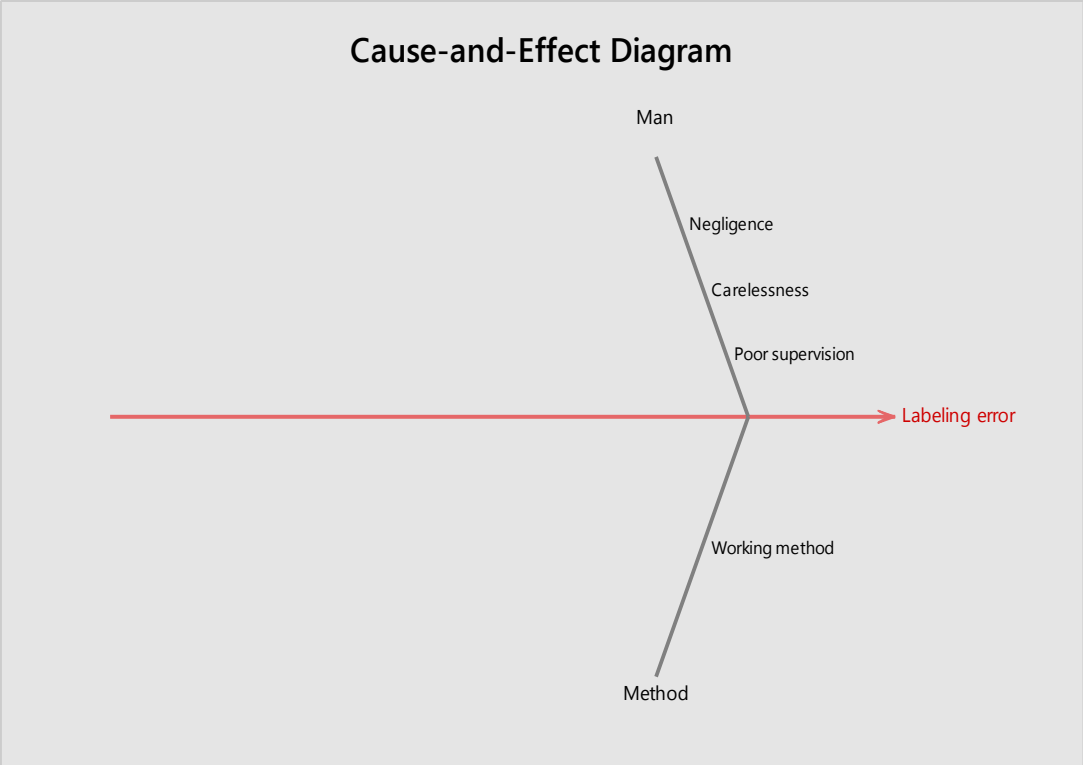

Figure 4.6 Cause and Effect Diagram for Labeling Error

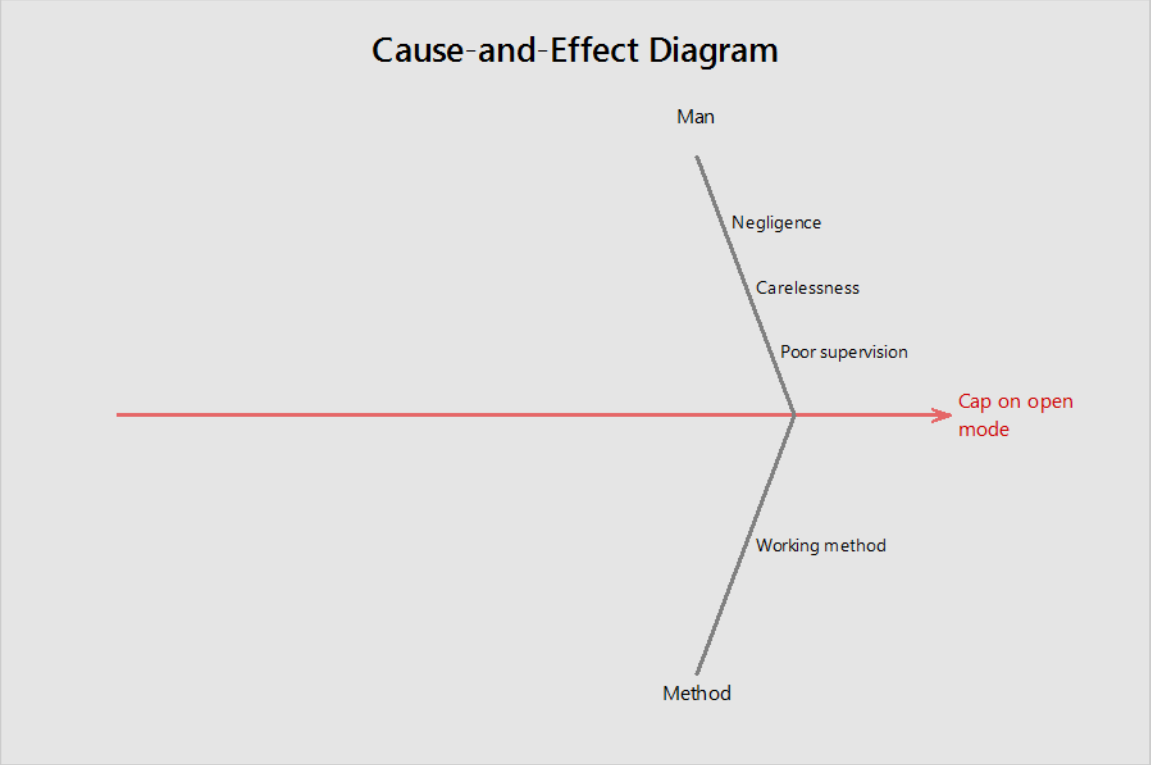

Figure 4.7 Cause and Effect Diagram for Cap on Open Mode

The root causes for Cap on open mode were indicated in the above diagram. The causes poor supervision, carelessness and negligence of the workers in the Man category, working method in the Method category.

4.6 Summary of Result Findings

From the questionnaire responses of non-professional employees, it was found that there is lack of awareness about quality and quality improvement, lack of employee motivation and they did not got training from the company. Form respondents of professional employees it was found that there is lack of top management commitment, lack of skill of operator, lack of awareness about the quality and quality improvement, old/ outdated machine, employee motivation were cause for quality related problems in the company. Also form interview similar comments were raised.

Form the statistical process tools it was found that the vital few defects were damaged bottle, overweight, labeling error and cap on open mode. The roots causes found were can be generalized to is lack of top management commitment, lack of skill of operator, lack of awareness about the quality and quality improvement, old and/or outdated machine, employee motivation.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, CONCLUSION AND RECOMMENDATION

This Chapter presents the summary of the findings, conclusions and recommendations.

5.1 SUMMARY OF THE FINIDINGS

This part of the section tries to summarize the key findings of the study. The objectives of the study were to assess the application of statistical process control for quality improvement. In order to meet the objectives, the researcher collected primary data using questionnaire, semi structured interview, observation and focus group discussion. Purposive sampling was used to select respondents. 17 from a professional employees and 30 from non-professional employees were selected as respondent. Descriptive analysis was conducted using SPSS software.

Four types of SPC tools were used to identify the variation and root causes of quality related problems. Four vital few types of defects were identified which were damaged bottle, overweight, labeling error and cap open mode and the root causes for the defects were lack of awareness about quality and quality improvement, lack of top management commitment, Inadequate skill of operator, lack of employee motivation, age of machine and lack of training and education.

5.2 CONCLUSIONS

The questionnaire survey, interview, direct observation, control charts, Pareto chart, and Fish bone diagrams analysis have provided useful information in identifying causes of quality problems products, quality defects such as damaged bottle, overweight, labeling error and cap on open mode were vital few causes of defect.

The survey has indicated that quality related problems are a serious for the competitiveness of company. The main goal of this study is identify the quality related problems and suggest a better solution to improve the production line performance of company.

Since the company did not apply any of the tools it is helpful to assess the tools.

Quality tools i.e. check sheet was used to collect the different defect types on daily bases, control chart was used to identify the variation of weight and PH parameters of liquid hand soap. Pareto

chart used to identify vital few defects and Cause and effect diagram was constructed for each individual vital few defects.

The study reveals that lack of top management, lack of awareness about quality and quality improvement, unskilled operator, lack of effort for quality improvement, poor raw material quality, lack of employee motivation and age machine was the cause for quality related problems in the company.

In this paper it has found that the SPC tools can be applied to different products to identify quality related problems. Although SPC seems to be collection of statistically based problem solving tools, there is more to the successful use of SPC than learning and using these tools, SPC is the most effective when it is integrated into an overall, companywide quality improvement program.

Minimizing defect is very important for ensuring the quality of products. The perceived quality is one of the quality dimension. The company was pioneer in liquid hand soap production but when such types of defects reached to customers lowers reputation of the company. The perceived quality of company is the result of a number of aspects, which together help achieve the desired level of satisfaction for customers. However, we should bear in mind that 1% defective product for an organization is 100% defective for the customer who buys that defective product. So manufacturing the quality product is mandatory to sustain in this global competitive market the company need to address the root causes for quality improvement.

5.3 RECOMMENDATIONS

Following some remedial issues are suggested for minimization of loss of quality related problems

1. Seriously measure weight of the products because under estimating weight is one of the major loses for customers and also overweight estimation is the major loses of profitability of the company.
2. In the meantime to minimize the defects due to un proper working procedure of labeling and capping follow up the working procedure and improve the procedure to decrease the error. For the long run Use automatic labeling and capping machine and also filling machine.

3. Provide training for all employees working in the company to avoid improper consistency of defective products in production line. Operators must have skill in identifying causes of defects before it occurs or provide training to develop the skill of operator.

4. Operators must have attention and good attitude towards quality. Be able to identify defects quickly and accurately and how to remedy them /must have been provided.

5. For the meantime, the company can reduce defects due to old machine by arranging regular maintenance schedule and ensure machines are in good conditions. For long term plan, substitute the manual working system to automated production system.

6. It will be helpful if management provide incentives or rewards to motivate employees.

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APPENDIX

Questionnaire

Dear Respondents,

Thank you for participating in this study.

The purpose of this survey is to assess the application of statistical process for quality improvement in your company. Your response will help to understand the quality related problems in the company.

Dear Participants, this study is purely for academic purpose and for partial fulfillment of the requirements for the Degree of Master of Science (MSc) in St. Mary University. All responses will be kept confidential and will not be traceable to individual respondent.

Questionnaire Prepared for Professional Employees

Part 1: Profile of respondent (not necessary to write your Name!)

This section of questionnaire refers to general information about the respondent. The information will allow me to compare groups of respondent.

1. Gender: Male ☐ Female ☐

2. Academic Qualification: Diploma ☐ Degree ☐ Masters ☐

3. Work Experience: less than 2 years ☐ 3-5 year ☐ more than 5years ☐

Part 2: Please rate your responses to the following questions on the scale 1 to 5.

Please tick ‘X’ mark in the corresponding cell that you most agree with.

1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree

Quality Awareness in the Organization	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Quality lead to a decrease in rejects rate					
If a product gets rejected due to poor quality the managers are to blame					
Quality is the responsibility of everyone in the organization					
Quality related problems will lead the organization to loss its customers					

Top Management Commitment	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Is the top management committed to the for quality improvement?					
Management is committed to the idea that quality is at least as important as quantity/ volume of production					
Does the management listen to employees					
Does the management encourage ideas and suggestions?					
Management has resistance to change that slows down company improvement?					

Skills of Manpower	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Company provides training to develop the skill of operator?					
Operators did not notice the working principles of the machine?					
Operator did not try to detect the causes of defects?					

Raw Material Quality	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Imported raw material quality is assessed before use?					
Local purchased raw material quality is assessed before use?					
Defective raw materials delivered from suppliers?					

Old and/or Outdated Machines	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Is there frequent failure of machines?					
Are the machines old?					
Is there a regular machine maintenance schedule?					
Unplanned downtime can happen due to machine failure?					

Employee Motivation	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Are you willing to take additional responsibility?					
Are you satisfied with your current job?					
Do you absent from work without visible or valid reason?					
Are you comfortable with working environment?					
Does the company motivate employees?					
It there an effective communication between employee and their supervisor?					

Part 3: Mark all that are applicable

1. What are the obstacles for quality improvement in the company?

a. The top management commitment ☐ b. Lack of knowledge about quality improvement ☐

c. Insufficient employee motivation ☐ d. Lack of resources and time ☐

e. Lack of employee engagement and communication ☐f. Lack of quality equipment ☐

g. Non-compatibility with company policies ☐ h. Organizational structure ☐

2. What are the possible causes for quality related problems in the company?

a. Poor quality of raw materials ☐ b. Inadequate skilled operators ☐

c. Poor Machine maintenance schedule ☐ d. Low awareness of workers about quality ☐

e. Age of Machinery ☐ f. Poor raw material handling ☐

g. Poor measurement ☐ h. No calibration of testing instruments as scheduled ☐

i. Poor final product handling ☐ j. Discipline of workers ☐

Questionnaire Prepared for Non-professional Employees

Part 1: Profile of respondent (not necessary to write your Name!)

This section of questionnaire refers to general information about the respondent. The information will allow me to compare groups of respondent.

1. Gender: -Male ☐ Female ☐

2. Education level: Grade 1-8th ☐ Grade 9th -12th ☐ Reading and writing ☐

3. Work Experience: less than 2 years ☐ 3-5 year ☐ more than 5 years ☐

Quality Awareness in the Organization	**Yes**	**No**	**Do not know**
Quality lead to a decrease in rejects rate የጥራት መሞር በጥራት ጉድለት ምክንያት የሚወገዱ ምርቶችን ብዛት ይቀንሳል			
If a product gets rejected due to poor quality the managers are to blame የጥራት ጉድለት ምክንያት ምርት ቢወገድ ስራ አስኪያጅ ተጠያቂ ይሆናሉ			
Quality is the responsibility of everyone in the organization ጥራትን መጠበቅ የሁሉም ሰራተኛ ሀላፊነት ነዉ			
Quality related problems will lead the organization to loss its customers በጥራት ጉድለት ምክንያት ድርጅቱ ደንበኞቹን ያጣል			

Employee Motivation	**Yes**	**No**	**Do not Know**
Are you willing to take additional responsibility? ተጨማሪ ሀላፊነት ለመቀበል ዝግጁ ነህ			
Are you satisfied with your current job? በስራ ደስተኛ ነህ			
Do you absent from work without visible or valid reason? ከስራህ ገበታ ላይ ያለአሳማኝ ምክንያት ትቀራለህ			
Are you comfortable with working environment? በምትሰራበት ቦታ ላይ ደስተኛ ነህ			
Dose the company motivate employees? ድርጅቱ ሰራተኞችን ያበረታታል			
It there an effective communication between operator and their supervisor? ድርጅቱ መደበኛ ስራ ከመጀመርህ በፊት ስለስራ ድርሻ ስልጠና ተሰጥቶሀል			

Effort for Quality Improvement	**Yes**	**No**	**Do not know**
Company provides you formal training about your position before you started this job? ድርጅቱ ስለ ስራህ ስልጠና ሰጥቶሀል			
Company provides you quality related training after you started this job? ድርጅቱ ስለ ጥራትና የጥራት ችግሮች ስልጠና ተሰጥቶሀል			
Do you have awareness about quality improvement? ስለ ጥራት መሻሻል ግንዛቤው አለህ			

Interview Questions

1. What are the obstacles for quality improvement?

2. What are types of defect that occur in the company?

3. Which type of SPC tool will you recommend to assess the quality related problems in the company?

4. What are the causes for quality related problems?