ST. MARY'S UNIVERSITY

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INSTITUE OF QUALITY & PRODUCTIVITY MANAGEMENT

EVALUATING STATISTICAL PROCESS CONTROL TOOLS: THE CASE OF BELAYAB CABLE MANUFACTURING PLC

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May, 2025

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Evaluating Statistical Process Control Tools: the Case of Belayab Cable Manufacturing Plc

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Acronyms/Abbreviations

PLC	Private Limited Company
SPC	Statistical Process Control
SPSS	Statistical Package for Social Sciences
BAC	Belayab Cable
PCA	Process Capability Analysis

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Abstract

This study aims to evaluate the application and effectiveness of Statistical Process Control (SPC) tools in enhancing quality and operational efficiency at Belayab Cable Manufacturing PLC, a key player in Ethiopia's cable production industry. As global competition and customer expectations continue to rise, manufacturers are increasingly turning to SPC as a data-driven approach to monitor, control, and improve production processes. Using a descriptive research design, this study employed both quantitative and qualitative data collection methods, including structured questionnaires and interviews with quality control personnel, supervisors, and production staff. The research focused on identifying which SPC tools are currently in use—such as control charts, histograms, Pareto diagrams, and cause-and-effect diagrams—and assessing their impact on reducing process variability and improving product quality.

Findings reveal that while awareness of SPC concepts is moderately high among employees, the practical application of these tools is inconsistent and often limited to basic control charts. Factors such as inadequate training, lack of management commitment, and insufficient data infrastructure were found to hinder full-scale implementation. Nonetheless, statistical analysis indicates a positive correlation between the use of SPC tools and improvements in defect rates, process stability, and customer satisfaction. The study recommends enhancing employee training programs, integrating SPC into daily production monitoring, and adopting a more strategic approach to quality management. These steps are expected to maximize the benefits of SPC and drive continuous improvement in the manufacturing process.

Key words: Statistical Process Control Tools and Manufacturing Industries

CHAPTER ONE

INTRODUCTION

In today's competitive manufacturing environment, maintaining consistent product quality is essential for organizational success and customer satisfaction. One of the most effective methods for quality improvement and control in manufacturing is the application of **Statistical Process Control (SPC)** tools. SPC enables manufacturers to monitor, control, and improve production processes by using statistical methods to detect and reduce variability.

In the context of **Belayab Cable Manufacturing PLC**, ensuring the reliability and quality of cable products is crucial, both for customer trust and compliance with industrial standards. However, the implementation and effective use of SPC tools in manufacturing processes remain a challenge for many companies in Ethiopia, including those in the cable industry.

Despite the recognized importance of SPC, there is limited research specifically focusing on its practical application, challenges, and outcomes within the Ethiopian cable manufacturing sector. This study seeks to address this gap by examining how SPC tools are applied at Belayab Cable Manufacturing PLC and evaluating their impact on production quality.

The chapter begins by outlining the background and context of the study, followed by a clear statement of the problem, research questions, objectives, scope, and significance of the study. The findings of this research are expected to contribute valuable insights for quality improvement strategies in similar manufacturing environments.

1.1. Background of the Study

In today's competitive manufacturing environment, achieving high levels of quality and efficiency is crucial. **Statistical Process Control (SPC)** tools provide essential methods for monitoring and improving production processes by identifying and controlling variations. Techniques such as **control charts**, **process capability analysis**, and **design of experiments** enable real-time monitoring, reduce defects, and support continuous improvement (Montgomery, 2013; Seymour et al., 2007; Ishikawa, 1985).

SPC enhances product quality, minimizes waste, and improves process performance by empowering employees, promoting data-driven decision-making, and aligning with lean manufacturing principles (Deming, 1986; Womack, 2003). The shift from end-product inspection to proactive process control has become central to modern quality management (Taylor, 2011; Montgomery, 2009).

This study investigates the application and effectiveness of SPC tools at **Belayab Cable Manufacturing PLC**, in line with Ethiopia's industrial policy goals of improving quality, reducing waste, and boosting operational efficiency.

1.2. Background of the Organization: Belayab Cable Manufacturing PLC

Belayab Cable Manufacturing PLC is a key player in the Ethiopian cable manufacturing sector. As a locally established manufacturer, the company is committed to producing high-quality electrical cables and wires to meet the growing demands of infrastructure development and industrial expansion in Ethiopia and beyond.

Belayab is known for integrating modern production technologies with quality-driven manufacturing systems. The company focuses on delivering reliable and standardized cable products for domestic and international markets. With a dedication to quality assurance, Belayab has begun adopting Statistical Process Control (SPC) tools as part of its strategic initiatives to enhance operational efficiency, minimize waste, and maintain product consistency.

Belayab's commitment to quality is aligned with national and international standards, and the organization aims to contribute to Ethiopia's broader industrial development goals. By incorporating SPC methodologies, Belayab seeks to foster a culture of continuous improvement and innovation, empowering employees at all levels to participate in quality enhancement efforts.

The case of Belayab Cable Manufacturing PLC provides a practical and relevant context for examining the real-world application of SPC tools in a manufacturing environment, particularly within a developing country setting.

1.3. Statement of the Problem

In the highly competitive landscape of manufacturing, maintaining product quality while optimizing operational efficiency is a significant challenge faced by companies worldwide. This challenge is particularly pronounced in the cable manufacturing sector, where the demand for high-quality products is coupled with stringent regulatory standards and customer expectations (Del Castillo, 2010). Belayab Cable Manufacturing PLC, a prominent company in the industry, has acknowledged the importance of adopting robust quality management practices to improve its production efficiency and respond effectively to market requirements.

Preliminary observations and reports indicate that many cable manufacturers in Ethiopia rely heavily on traditional inspection methods rather than preventive, data-driven approaches like SPC. This reactive quality control strategy often results in increased scrap rates, rework, production downtime, and customer complaints—leading to higher operational costs and reduced competitiveness in both local and export markets.

Despite the potential benefits of Statistical Process Control (SPC) tools in monitoring and improving manufacturing processes, Belayab Cable Manufacturing PLC has encountered difficulties in fully integrating these methodologies into its operations. Initial assessments reveal inconsistencies in product quality, elevated levels of waste, and inefficiencies in production processes, which not only affect customer satisfaction but also threaten the company's competitive position in the market. This study begins with an initial assessment carried out by the author to examine the current use of SPC tools."

According to Montgomery (2013), organizations lacking structured quality control systems often resort to reactive measures, addressing quality problems only after they occur rather than preventing them proactively. As a consequence, variations in production processes often go unnoticed until they result in defective products or increased operational costs. Moreover, insufficient employee training and limited involvement in SPC practices hinder the successful application of these tools. Therefore, the central problem addressed in this study is: How can the applications of SPC tools usage at Belayab Cable Manufactur PLC improves product quality, reduce waste, and enhance overall operational efficiency? This research aims to identify specific areas within the manufacturing processes where SPC tools can be effectively applied and to develop a framework for their implementation that fosters a culture of continuous improvement and data-driven decision-making within the organization.

While previous studies have explored the application of SPC in various manufacturing sectors in Ethiopia, there is a notable gap in research specifically focusing on the cable manufacturing industry. The proposed study aims to fill this gap by: Investigating the unique challenges and opportunities in applying SPC within the cable manufacturing industry, which may differ from other sectors due to specific production processes and quality requirements. Conducting a comprehensive assessment of how SPC tools are currently being utilized in cable manufacturing, identifying barriers to effective implementation, and proposing tailored strategies to overcome these challenges. Comparing the effectiveness of SPC implementation in cable manufacturing with other sectors to draw sector-specific conclusions and recommendations.

1.4. Research Questions

Given the challenges identified in the statement of the problem such as inconsistent product quality, excessive production waste, and inefficiencies in the manufacturing process this study seeks to address these gaps by investigating the extent to which the implementation of SPC tools can improve quality, reduce waste, and enhance overall operational efficiency at Belayab, as outlined in the research questions.

1. How consistency is statistical process control tools implemented in Belayab Cable Manufacturing PLC to monitor and improve production quality?
2. What changes do statistical process control tools have on reducing production variability and defects in the manufacturing processes at Belayab Cable Manufacturing PLC?
3. How does employee training in statistical process control methods influence the overall operational efficiency and quality outcomes at Belayab Cable Manufacturing PLC?

1.5. Research Objectives

1.5.1. General Objective

To asses Application of Statistical Process Control Tools in Manufacturing Industries:
The Case of Belayab Cable Manufacturing Plc

1.5.2. Specific Objectives

1) To assess the effectiveness of the implementation of Statistical Process Control (SPC) tools at Belayab Cable Manufacturing PLC in monitoring and improving production quality.
2) To evaluate the impact of Statistical Process Control tools on reducing production variability and defects in the manufacturing processes at Belayab Cable Manufacturing PLC.
3) To examine how employee training in Statistical Process Control methods influences overall operational efficiency and quality outcomes at Belayab Cable Manufacturing PLC

1.6. Significance of the Study

The findings of the study will help the organization policy makers to identify areas of potential problems related with Application of Statistical Process Control Tools in Manufacturing Industries: mainly training & development policies, performance management system, and selection procedure which will have a direct or indirect impact on the organization‘s effectiveness. The recommendations which described based on the conclusions of the research findings will help the organization either maintain, improve or totally change the existing Application of Statistical Process Control Tools implementation approach. Besides, the study adds value for the researcher gaining more knowledge regarding the topic and then getting the opportunity to work on strategy formulation, analysis and implementation of the organization and to conduct research with similar titles in different manufacturing sectors. The study will also help other governmental or nongovernmental organizations as a tool to customize the suggested models in to organizational context to improve their Application of Statistical Process Control Tools related strategic problems. Finally, the study will help other researchers working in similar/related topics as a reference.

1.7. Scope of the Study

The research has conducted in Ethiopia Belayab cable manufacturing factory. In this share company there are five process sub stations and the research has studied only one substation, in order to accomplish the research objective. Specifically, it closely focused on insulation process and solutions. Thematically it focuses on knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control as well as production efficacy.

1.8. Limitations of the Study

This study has several limitations that may affect the scope and generalizability of its findings. It focuses solely on Belayab Cable Manufacturing PLC, which limits the applicability of results to other companies or industries. The sample size was relatively small, and time constraints restricted more in-depth analysis and long-term observation. Limited access to certain internal data also posed challenges in fully assessing SPC performance. Additionally, the reliance on self-reported data through questionnaires and interviews may have introduced response bias, and the primarily quantitative approach limited exploration of contextual and cultural factors influencing SPC implementation.

1.9. Definition of Basic Terms

Statistical process controls: is defined as the application of statistical and engineering methods in measuring, monitoring, controlling, and improving quality. Montgomery, D.C. (2013). *Introduction to Statistical Quality Control* (7th ed.). Wiley.

Variations: is the degree of variation, more than its presence, which varies. Deming, W. E. (1986). *Out of the Crisis*. MIT Press. *(Deming emphasized that understanding and reducing variation is central to quality improvement.)*

Control charts: a run chart with statistically determined upper and lower control limits. hewhart, W. A. (1931). *Economic Control of Quality of Manufactured Product*. D. Van Nostrand Company.

Process capability: is capable of producing products which conforms to specifications.

Pyzdek, T., & Keller, P. (2014). *The Six Sigma Handbook* (4th ed.). McGraw-Hill.

Montgomery, D. C. (2013). *Introduction to Statistical Quality Control*.

Quality Improvement: the reduction of variability in processes and products. Ishikawa, K. (1985). *What Is Total Quality Control? The Japanese Way*. Prentice-Hall.

1.10 Organization of the Study

This study is organized into five chapters. Chapter one present the introduction part that includes background of the study, statement of the problem, research questions, objectives of the study, significance of the study, and scope of the study. Chapter two present an extensive literature review which contains the relevant literature compiled as related to the study. The third chapter presents the research design and methodology and chapter four data presentation and analysis. Finally, there is conclusion and recommendation of the research.

CHAPTER TWO

Review of the Related Literature

This chapter presents a comprehensive review of literature relevant to the application of **Statistical Process Control (SPC)** in manufacturing, with a particular focus on its use in improving product quality and process efficiency. The review aims to provide both a theoretical foundation and empirical background for the study conducted at **Belayab Cable Manufacturing PLC**.

The chapter begins by introducing the concepts and principles of SPC, followed by an overview of commonly used SPC tools such as control charts, process capability analysis, and cause-and-effect diagrams. It also explores the historical development and evolution of quality control systems in manufacturing industries, with emphasis on their adoption in developing countries like Ethiopia.

Additionally, this chapter examines previous studies related to SPC implementation, its impact on manufacturing performance, challenges encountered during application, and the role of employee involvement and training. The review highlights both international and local studies to draw comparisons and identify gaps in the current body of knowledge—especially in the context of cable manufacturing.

2.1 Theoretical review

Statistical Process Control (SPC) is a vital methodology employed in manufacturing industries to monitor and control processes through the use of statistical tools. The primary objective of SPC is to ensure that the manufacturing process operates at its full potential, producing conforming products with minimal waste. According to Hawkins (2013), SPC involves the use of control charts, process capability analysis, and other statistical techniques to detect and reduce variability in production processes. The application of these tools has been shown to lead to improved product quality, reduced operational costs, and enhanced customer satisfaction.

The implementation of SPC tools has been extensively documented in various manufacturing sectors. For instance, a study by Lowry (2017) highlights the successful application of control charts in the automotive industry, where they were used to monitor critical dimensions of components during production. The authors found that the use of control charts not only helped in identifying trends and shifts in the process but also facilitated timely interventions that significantly reduced defects. This case exemplifies how SPC can lead to substantial improvements in quality control and operational efficiency.

Moreover, the integration of SPC with other quality management frameworks has gained traction in recent years. For example, Chen et al. (2020) explored the synergy between SPC and Lean Manufacturing principles. Their research indicated that combining SPC tools with Lean methodologies enhances waste reduction efforts by providing a data-driven approach to identify non-value-added activities. This integrated approach allows manufacturers to achieve higher levels of efficiency and quality, thereby fostering a culture of continuous improvement.

In addition to traditional manufacturing applications, the advent of Industry 4.0 has opened new avenues for SPC implementation. As highlighted by Kumar et al.(2021), the integration of SPC with advanced technologies such as IoT (Internet of Things) and big data analytics enables real- time monitoring and predictive analysis of manufacturing processes. This technological advancement allows for proactive decision-making, where potential issues can be identified and addressed before they escalate into significant problems. The authors argue that this shift towards data-driven decision-making is crucial for maintaining competitiveness in today's fast-paced manufacturing environment.

As the whole, the application of Statistical Process Control tools in manufacturing industries has proven to be a cornerstone for enhancing quality and operational efficiency. Through various case studies and research findings, it is evident that SPC not only aids in identifying process variations but also fosters a culture of continuous improvement when integrated with other methodologies. As manufacturing continues to evolve with technological advancements, the role of SPC will likely expand, providing further opportunities for innovation and excellence in production processes.

2.1.1 Control Charts:

Control charts are a fundamental tool in Statistical Process Control (SPC) that enables manufacturers to monitor process performance over time. Developed by Walter A. Shewhart in the 1920s, control charts serve as visual representations of process data, helping to distinguish between common cause variation, which is inherent to the process, and special cause variation, which indicates potential issues that require investigation (Box, 2013). By plotting data points in relation to predetermined control limits, practitioners can quickly identify trends, shifts, or any out-of-control conditions that may arise during production. This proactive approach to quality management allows for timely interventions that can prevent defects and reduce waste.

The application of control charts spans various manufacturing sectors, demonstrating their versatility and effectiveness. For instance, a study by Butler (2017) illustrated the successful implementation of control charts in the automotive industry, where they were utilized to monitor critical dimensions of components. The authors found that the use of control charts led to a significant reduction in defects by enabling operators to detect variations early and take corrective actions before the production of non-conforming products. This case highlights how control charts not only improve quality but also enhance overall operational efficiency by minimizing rework and scrap rates.

Moreover, advancements in technology have further augmented the capabilities of control charts. With the integration of real-time data collection through IoT devices and data analytics, manufacturers can now employ control charts in a more dynamic and responsive manner (Kumar et al., 2021). This modern approach allows for continuous monitoring of processes, facilitating immediate feedback and enabling predictive maintenance strategies. As a result, organizations can achieve higher levels of process stability and product quality, ultimately leading to increased customer satisfaction and competitive advantage in the marketplace.

2.1.2 Process Capability Analysis:

Process Capability Analysis (PCA) is a statistical method used to evaluate the ability of a manufacturing process to produce products that meet specified requirements or specifications. It quantifies how much a process can vary while still producing output that falls within acceptable limits. PCA is essential for quality management as it helps organizations understand the inherent variability in their processes and identify areas for improvement (Alwan, 1988). By assessing process capability, manufacturers can ensure that they consistently meet customer expectations and regulatory requirements.

One of the key metrics used in PCA is the Process Capability Index (CpI), which measures how well a process is centered within its specification limits. A higher Cpk value indicates that a process is more capable of producing products within specifications. Typically, a Cpk value of 1.33 or higher is considered acceptable in many industries, suggesting that the process can reliably produce products that meet quality standards (Besterfield et al., 2011). This metric not only helps in evaluating current performance but also serves as a baseline for future improvements.

Another important aspect of PCA is the assessment of process stability through control charts. Before conducting a capability analysis, it is crucial to ensure that the process is stable and free from special cause variation. Control charts help in identifying variations in the process over time, allowing practitioners to differentiate between common cause and special cause variations (Pignatiello 2001). Once stability is established, PCA can be performed with greater confidence, leading to more accurate assessments of process capability.

The application of PCA extends beyond manufacturing; it is also relevant in-service industries where processes must meet specific performance criteria. For instance, a study by Pande et al. (2000) illustrated how PCA was utilized in a healthcare setting to evaluate the capability of patient appointment scheduling processes. By analyzing the data, the organization identified bottlenecks and implemented changes that improved patient satisfaction and reduced wait times.

As the whole Process Capability Analysis is a vital tool for organizations seeking to enhance their quality management practices. By quantifying process performance and identifying areas for improvement, PCA enables manufacturers and service providers alike to deliver products and services that consistently meet customer expectations. As industries continue to evolve, the importance of PCA will only grow, making it an essential component of any comprehensive quality management strategy.

2.1.3 Integration with Engineering Controls: An Overview

Integration with engineering controls is a critical aspect of workplace safety and health management systems. Engineering controls are physical modifications to the workplace that help minimize or eliminate exposure to hazards. By implementing these controls, organizations can effectively reduce the risk of accidents and health issues associated with hazardous materials, equipment, and processes (Bergman, 2017). Integrating engineering controls into safety protocols not only enhances worker protection but also promotes a culture of safety within the organization.

One of the primary benefits of integrating engineering controls is the reduction of reliance on personal protective equipment (PPE). While PPE is essential for protecting workers, it should be considered the last line of defense against hazards. By focusing on engineering controls such as ventilation systems, machine guards, and automated processes, organizations can create safer work environments that minimize the need for extensive PPE (Geller, 2001). This shift not only improves worker comfort and compliance but also addresses hazards at their source.

Effective integration of engineering controls requires a thorough understanding of the specific risks present in the workplace. Conducting comprehensive risk assessments is crucial to identifying potential hazards and determining the most appropriate engineering solutions. For instance, a manufacturing facility may identify noise exposure as a significant hazard and subsequently implement sound-dampening materials and enclosures around noisy machinery (Harris et al., 2018). This targeted approach ensures that engineering controls are tailored to the unique needs of each workplace.

Training and education are vital components of successfully integrating engineering controls into safety management systems. Workers must be informed about the purpose and function of the engineering controls in place, as well as how to use them effectively. Providing ongoing training ensures that employees understand how to operate machinery safely and recognize when engineering controls may require maintenance or adjustment (Zohar, 2000). This proactive approach fosters a sense of ownership among workers regarding their safety and encourages them to actively participate in maintaining a safe work environment.

Moreover, integrating engineering controls into organizational processes can lead to improved operational efficiency. By reducing hazards through design modifications, companies can decrease downtime related to accidents and injuries. This not only enhances productivity but also contributes to overall cost savings (Bergman, 2017). Additionally, organizations that prioritize safety through engineering controls often experience improved employee morale and retention, as workers feel valued and protected in their work environment.

In conclusion, the integration of engineering controls is essential for effective workplace safety management. By focusing on eliminating hazards at their source, organizations can create safer work environments while reducing reliance on PPE. Through risk assessments, training, and ongoing evaluation, companies can ensure that engineering controls are effectively implemented and maintained. Ultimately, this integration not only protects workers but also enhances operational efficiency and contributes to a positive organizational culture.

2.1.4 Emerging Applications of Technology in Various Fields

Emerging technologies are reshaping numerous industries, providing innovative solutions and enhancing operational efficiency. One of the most significant applications is in the field of healthcare, where telemedicine and remote patient monitoring are gaining traction. These technologies enable healthcare providers to offer services to patients regardless of their geographical location, improving access to care and patient outcomes (Koonin et al., 2020). The COVID-19 pandemic has accelerated the adoption of telehealth solutions, demonstrating their effectiveness in maintaining continuity of care while minimizing the risk of infection.

In the realm of education, technology is transforming traditional learning environments through the integration of online learning platforms and virtual classrooms. Tools such as Learning Management Systems (LMS) and Massive Open Online Courses (MOOCs) are making education more accessible and personalized. Research indicates that blended learning approaches, which combine online and face-to-face instruction, can enhance student engagement and achievement (Garrison, 2004). As educational institutions continue to embrace these technologies, they are fostering a more inclusive and flexible learning experience for students around the globe.

The manufacturing sector is also experiencing significant advancements through the implementation of Industry 4.0 technologies, including the Internet of Things (IoT), artificial intelligence (AI), and robotics. These technologies enable smart manufacturing processes that optimize production efficiency, reduce waste, and enhance product quality. For instance, IoT devices can monitor equipment performance in real-time, allowing for predictive maintenance and minimizing downtime (Brettel et al., 2014). As manufacturers adopt these emerging technologies, they position themselves to remain competitive in an increasingly globalized market.

In the realm of finance, blockchain technology is revolutionizing transactions and data security. By providing a decentralized and transparent ledger system, blockchain enhances trust among parties involved in financial transactions. Its applications extend beyond cryptocurrencies; for example, it can streamline supply chain management by ensuring traceability and authenticity of products (Kouhizadeh, 2018). As financial institutions explore blockchain's potential, they are discovering new ways to improve efficiency and reduce fraud.

Environmental sustainability is another area where emerging technologies are making a significant impact. Innovations such as renewable energy sources, smart grids, and energy-efficient systems are essential in combating climate change. For example, solar panels and wind turbines are becoming increasingly cost-effective alternatives to fossil fuels, contributing to a reduction in greenhouse gas emissions (IRENA, 2020). Additionally, smart grid technology allows for better energy management and distribution, enabling consumers to make informed decisions about their energy usage.

Finally, the integration of augmented reality (AR) and virtual reality (VR) is transforming sectors such as real estate, retail, and entertainment. These immersive technologies provide unique experiences that enhance customer engagement and satisfaction. In real estate, for instance, virtual tours allow potential buyers to explore properties remotely, streamlining the purchasing process (Tussyadiah et al., 2018). As AR and VR technologies continue to evolve, they will undoubtedly play an increasingly vital role in shaping consumer experiences across various industries.

2.1.5 Benefits of Statistical Process Control (SPC) in Manufacturing

Statistical Process Control (SPC) is a quality control method that employs statistical techniques to monitor and control manufacturing processes. The primary objective of SPC is to ensure that the process operates efficiently, producing more specification-conforming products with less waste. One of the most significant benefits of SPC is its ability to identify variations in processes before they result in defects. By utilizing control charts and other statistical tools, manufacturers can detect deviations from the norm, allowing for timely interventions that prevent quality issues (Pignatiello, 2013).

Another key benefit of SPC is improved product quality. By continuously monitoring processes, manufacturers can ensure that their products meet or exceed quality standards. This proactive approach reduces the likelihood of defects and enhances customer satisfaction. Research indicates that companies implementing SPC have reported significant reductions in defect rates, ultimately leading to higher customer retention and loyalty (Snee, 2003). A focus on quality not only improves the bottom line but also strengthens a company's reputation in the marketplace.

SPC also contributes to reduced production costs. By identifying and eliminating sources of variation, manufacturers can minimize waste and rework, which are significant contributors to production expenses. Studies have shown that organizations employing SPC techniques can achieve cost savings ranging from 15% to 30% due to enhanced efficiency and reduced scrap rates (Besterfield et al., 2016). These cost reductions can be reinvested into the business, further driving growth and innovation.

Additionally, SPC fosters a culture of continuous improvement within organizations. By involving employees in the monitoring process and encouraging them to identify areas for improvement, companies can create a more engaged workforce. This participative approach not only enhances employee morale but also leads to innovative solutions that drive efficiency (Deming, 1986). When employees feel empowered to contribute to process improvements, the organization benefits from diverse perspectives and ideas.

Furthermore, SPC aids in compliance with industry regulations and standards. Many industries are subject to strict quality control requirements, and implementing SPC can help organizations demonstrate their commitment to quality management. For instance, industries such as pharmaceuticals and aerospace rely heavily on SPC to meet regulatory compliance (ISO 9001:2015). By adhering to these standards, manufacturers can avoid costly penalties and maintain their market position.

The implementation of SPC also enhances decision-making capabilities within organizations. By providing real-time data on process performance, SPC allows managers to make informed decisions based on empirical evidence rather than intuition. This data-driven approach reduces the risk of errors in judgment and enables organizations to respond swiftly to emerging issues (Keller et al., 2015). The ability to analyze trends and patterns further supports strategic planning and resource allocation.

Moreover, SPC facilitates better supplier relationships. By establishing clear quality expectations and monitoring incoming materials, manufacturers can ensure that they receive high-quality inputs. This not only reduces variability in the production process but also strengthens partnerships with suppliers who consistently meet quality standards (Flynn et al., 2015). As a result, organizations can build a reliable supply chain that contributes to overall operational success. In addition to these benefits, SPC can enhance workplace safety. By monitoring processes for deviations that could lead to unsafe conditions, organizations can proactively address potential hazards. This focus on safety not only protects employees but also minimizes the risk of costly accidents and downtime (Zohar, 2000). A safe work environment contributes to employee satisfaction and retention, further supporting organizational performance.

Finally, SPC supports sustainable manufacturing practices. By reducing waste and improving efficiency, organizations can minimize their environmental impact. Implementing SPC techniques helps manufacturers optimize resource utilization, which aligns with the growing emphasis on sustainability in the industry (González, 2005). As consumers increasingly demand environmentally friendly practices, companies that adopt SPC can enhance their market appeal while contributing positively to the planet. So the benefits of Statistical Process Control in manufacturing are manifold, ranging from improved product quality and reduced costs to enhanced decision-making and sustainability. As organizations strive for excellence in an increasingly competitive landscape, implementing SPC will be crucial for achieving operational efficiency and maintaining customer satisfaction.

2.2 Empirical Review on the Application of Statistical Process Control Tools in Manufacturing Industries

Statistical Process Control (SPC) is a vital methodology in manufacturing that employs statistical techniques to monitor and control production processes. The primary objective of SPC is to ensure that processes operate efficiently, producing more specification-conforming products with less waste. In recent years, numerous studies have highlighted the effectiveness of SPC tools in enhancing quality, reducing variability, and improving overall operational performance in various manufacturing settings (Shewhart, 2011).

2.2.1 Historical Context

The origins of SPC can be traced back to the early 20th century, with significant contributions from pioneers such as Walter A. Shewhart and W. Edwards Deming. Shewhart introduced control charts as a means to monitor process variability, while Deming emphasized the importance of quality management principles (Montgomery, 2013). These foundational concepts have evolved into a comprehensive suite of tools that are widely adopted in modern manufacturing environments.

The practical application of SPC gained significant momentum during World War II. The U.S. military, recognizing the critical importance of quality in defense production, adopted Shewhart's methods to enhance manufacturing reliability and consistency. Training programs such as Training within Industry (TWI**)** were implemented to instruct workers and engineers in statistical quality control techniques (Deming, 1986). This period marked the transition of SPC from an academic innovation to a standardized industrial practice.

In the post-war period, the dissemination of SPC saw a pivotal expansion, particularly in Japan. W. Edwards Deming, a statistician and advocate of Shewhart's principles, played a central role in transferring SPC knowledge to Japanese industry. Invited by the Union of Japanese Scientists and Engineers (JUSE) in 1950, Deming introduced SPC and broader statistical quality management concepts to industrial leaders (Deming, 1986).

The adoption of these principles catalyzed the transformation of Japanese manufacturing, giving rise to what became known as the Japanese Quality Revolution**.** Companies such as Toyota integrated SPC into their production systems, combining it with lean manufacturing and continuous improvement (kaizen) strategies (Ishikawa, 1985). This led to substantial improvements in product quality, reliability, and global competitiveness.

2.2.2 Implementation of Control Charts

D. Montgomery described the control chart as is an on-line process-monitoring technique widely used for this purpose. Control charts may also be used to estimate the parameters of a production process, and, through this information, to determine process capability. The control chart may also provide information useful in improving the process. The eventual goal of statistical process control is the elimination of variability in the process. It may not be possible to completely eliminate variability, but the control chart is an effective tool in reducing variability as much as possible. The details of above method may refer to Montgomery fifth edition. A control chart has three significant parts:

Halima Elfaghihe (2016) illustrated that the components of this three items of control chart as Let *M* be a sample statistic which is a measure of quality. Suppose that M has a normal distribution with mean μM and the standard deviation σM. The mean of M is equal to the target value $\mu M=\mu 0$, when the process is in control. Then the central line is $CL=\mu M$, the upper control limit is $UCL=\mu M+\sigma M$, and the lower control limit is $LSL=\mu M-\sigma M$. Shewarts control chart is shown in Figure (1.1). The quantity $k\sigma M$ represents the distance of the control limits from the central line. Parameters of the control chart are the following: the sample size n and the control limit width k. It should be noticed that Shewarts control charts actually represent tests corresponding to hypothesis testing. Null hypothesis $H0(\mu M=\mu 0)$ corresponds let M is (Based on the inspection or measurement of quality characteristics from the obtained sample,to the situation when the production process is in control, while the alternative hypothesis $H1(\mu M\neq\mu 0)$ corresponds to the situation when the production process is out of control.

For each sample she notes that i, i=1, 2, m we calculate the value of sample statistic M and we denote it by Mi. If the point Mi is within limits UCL and LCL, then the process is in-control state and this leads to the acceptance of the hypothesis($H0{:}\mu M=\mu 0$). But if the point Mi is out of the interval (UCL, LCL), this means that the process is out of control, and we reject the hypothesis ($H0{:}\mu M \neq\mu 0$). The result is an acceptance of the alternative hypothesis and it becomes necessary to discover the causes that led to this out-of-control state, and to correct them.

Control charts have two broad classifications: when the quality nature can be quantified, then we use the

1. Variable control chart: we use when the quality nature can be quantified, then we use the
2. Attribute control charts: we use when the quality characteristic is qualitative in nature

Variable control chart

X- Bar R control chart is the most widely used control chart especially in manufacturing industries. D. Montgomery stated about process variability, can be monitored with either a control chart for the standard deviation, called the s control chart, or a control chart for the range, and called an R control chart. The R chart is more widely used. Usually, separate and R charts are maintained for each quality characteristic of interest.

To calculate the UCL and the LCL of the mean is we use the formula:

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R} \qquad LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$$

To calculate the range, we use the formula:

$$UCL_{R} = D_4\bar{R} \qquad LCL_{\bar{R}} = D_3\bar{R}$$

Reinhart (1960) elaborates E. Shewhart's X-bar R control chart as, core consideration in the using of X and R charts, the type of data needs to be variable and should be analyzed. This variable must be something that can be measured and expressed in numbers, such as a dimension, hardness number, or compressive strength. It is important that the variable chosen depict a pertinent characteristic of the product's quality.

The X-bar chart is used for monitoring the process mean. On this chart, we plot the sample mean. For monitoring the process variability, we use S-chart and R-chart. If we have a sample (x1, x2, xn) of the size n, then on S-chart we represent the sample standard deviation.

To calculate X- bar S chart we use the formula:

$$S = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}}.$$

X-bar S chart is used when the sample size is small (n<10).

Attribute charts

The most frequently used attribute charts are: np-chart, c-chart, u-chart and p-chart.

We use np-chart to plot the number of defectives (per batch, per day, per machine). The control limits in this chart are calculated from binominal distribution. On the c-chart, the number of defects (per batch, per day, per machine, per 100 feet of pipe, etc.) is plotted. It is presumed that the quality defects are not frequent and the control limits are computed using Poisson distribution. A defect per unit chart (u-chart) is used to plot the rate of defects. We divide the number of defects by the number of inspected units (the n; e.g., feet of pipe, number of batches). The differences between u-chart and c-chart is that u-chart does not need a constant number of units, and we can use it, for example, when the batches (samples) are not of the same size. We use proportion defective chart (p-chart) in order to plot the fraction of defectives (per any unit of measure, per day, per machine, etc.) just like in the u-chart. The control limits are based on binominal distribution of proportions. To construct the control limits, we need an estimate of the standard deviation σ. We may estimate σ from either the standard deviations or the ranges of the m samples.

P chart: We use this chart when:

- ✓ only when variable data cannot be obtained;
- ✓ charting fraction rejected as nonconforming from a varying sample size;
- ✓ screening multiple characteristics for potential monitoring on variable control charts and
- ✓ tracking the quality level of a process before any rework is performed

To calculate the UCL and LCL of this chart are we use:

$$UCL = P_0 + \frac{3\sqrt{P_0(1-P_0)}}{\sqrt{n_i}} \qquad LCL = P_0 - \frac{3\sqrt{P_0(1-P_0)}}{\sqrt{n_i}}$$

np chart: we use it when: -

- used when subgroup size is constant (n)
- the actual number of defects is represented by pn (or np)

To calculate the UCL and LCL of this chart are we use:

$$UCL_{np} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$UCL_{np} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

C chart: used to monitor the number of nonconformities on a unit of a process based on units taken from the process at given times (hours, shifts, days, weeks, months, etc.)

The lower and upper control limits for the C chart are calculated using the formulas:

$$LCL = \bar{c} - m\sqrt{\bar{c}} \quad UCL = \bar{c} + m\sqrt{\bar{c}}$$

2.2.3 Process Capability Analysis

Russell and Tailor (7^{th} edition) described about process capability as, refers to the natural variation of a process relative to the variation allowed by the design specifications. In other words, how capable is the process of producing acceptable units according to the design specifications? Process control charts are used for process capability to determine if an existing process is capable of meeting design specifications. They point out three main elements related with process capability such as: Process variability (the natural range of variation of the process), Process center (mean) and Design specifications.

Measure of process capability

According to the book of Russell and Tailor, one measure of the capability of a process to meet design specifications is the process capability ratio (Cp). It is defined as the ratio of the range of the design specifications (the tolerance range) to the range of the process variation, which for most firms is typically:

$$C_p = \frac{\text{tolerance range}}{\text{process range}} = \frac{\text{upper specification limit} - \text{lower specification limit}}{6\sigma}$$

They notify the second measurement as process capability index (Cpk). The Cpk differs from the Cp in that it indicates if the process mean has shifted away from the design target, and in which direction it has shifted—that is, if it is off center.

$$C_{pk} = \text{minimum}\left[\frac{\bar{\bar{x}} - \text{lower specification}}{3\sigma}, \frac{\text{upper specification} - \bar{\bar{x}}}{3\sigma}\right]$$

2.2.4 Pareto Analysis

The concept of Pareto Analysis is rooted in the work of Vilfredo Pareto, an Italian economist who observed that 80% of Italy's land was owned by 20% of the population. Pareto's principle was later generalized to a broader context, particularly in the quality management and problem-solving fields.

In quality management, the Pareto Principle indicates that a small proportion of problems are responsible for the majority of the defects. This principle forms the basis of Pareto Analysis, which aims to identify and address the "vital few" causes that lead to the majority of problems, rather than focusing on the trivial many.

Pareto analysis, often referred to as the 80/20 rule, is an essential tool for prioritizing issues based on their impact on quality. A study by Juran and Godfrey (1999) highlighted the application of Pareto charts in a textile manufacturing facility, where they were used to identify the most common defects contributing to product rejections. By focusing on the critical few issues, management was able to allocate resources effectively and implement corrective actions that led to substantial reductions in defect rates.

2.2.5 Root Cause Analysis

Root Cause Analysis traces its origins back to quality control practices in manufacturing, particularly in the post-World War II era, as industries began adopting statistical methods to improve quality and reduce defects. The idea is to avoid quick fixes that only address symptoms and focus on the true cause of a problem.

Kaoru Ishikawa, a Japanese organizational theorist, is often credited with developing the Fishbone Diagram (or Ishikawa Diagram) in the 1960s, which visually categorizes potential causes of issues, making it easier to understand and address underlying problems in processes.

In the 1980s, RCA gained prominence with Quality Circles and the increasing adoption of Six Sigma and Total Quality Management (TQM) practices, both of which emphasized continuous process improvement through systematic analysis of defects and errors.

Root cause analysis (RCA) is integral to SPC, as it helps identify underlying causes of process variations or failures. A case study by Besterfield et al. (2011) illustrated how RCA techniques, including fishbone diagrams and the 5 Whys method, were employed in an automotive manufacturing plant. The findings revealed that addressing root causes rather than just symptoms led to sustainable improvements in process performance and a significant decrease in warranty claims.

2.2.6 Six Sigma Integration

The integration of SPC with Six Sigma methodologies has become increasingly popular in manufacturing industries seeking to enhance quality and reduce defects. As noted by Antony et al. (2012), organizations that adopt Six Sigma principles alongside SPC tools experience improved process control and higher customer satisfaction levels. Their research indicated that companies implementing this integrated approach achieved substantial cost savings and competitive advantages in their respective markets.

The benefits of implementing SPC tools extend beyond immediate quality improvements. According to a comprehensive review by Kume (2008), organizations employing SPC reported enhanced employee engagement, better supplier relationships, and a culture of continuous improvement. The study emphasized that when employees are actively involved in monitoring processes and identifying issues, it fosters a sense of ownership and accountability, leading to improved organizational performance.

2.2.7 Challenges in Implementation

Despite the clear advantages of SPC, several challenges hinder its widespread adoption in manufacturing industries. A study by Goh et al. (2015) identified resistance to change, lack of training, and insufficient management support as significant barriers. The authors recommended that organizations invest in training programs and foster a supportive culture to overcome these challenges and fully realize the benefits of SPC. In general, the application of Statistical Process Control tools in manufacturing industries has proven to be an effective strategy for enhancing quality and operational efficiency. Empirical evidence supports the assertion that SPC tools, such as control charts, process capability analysis, Pareto analysis, and root cause analysis, significantly contribute to reducing defects and improving overall process performance. While challenges remain in implementation, organizations that commit to SPC can achieve substantial benefits, leading to increased competitiveness and customer satisfaction. This empirical review synthesizes findings from various studies and highlights the significance of SPC tools in enhancing manufacturing processes while addressing both benefits and challenges associated with their implementation.

2.3 Conceptual framework

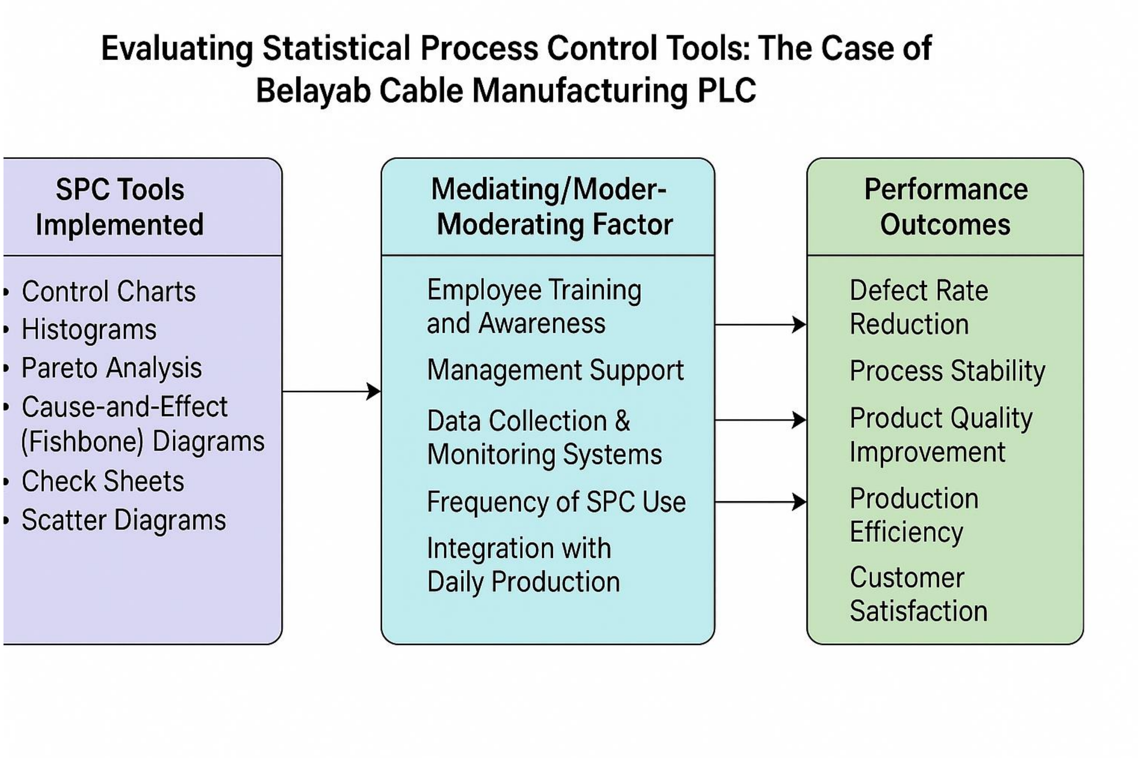

Figure 1 Framework the study

Source: developed by researcher

Fundamental Idea in SPC is the framework's core idea and the basis for all ensuing advantages and results. Key Benefits for Every benefit is linked to SPC, demonstrating how applying SPC improves manufacturing processes in a number of ways. Outcomes: Each benefit further branches out to its respective outcomes, illustrating the positive effects that arise from improved practices due to SPC this structured framework provides a clear overview of how SPC contributes to various benefits in manufacturing, ultimately leading to significant positive outcomes for organizations. By visualizing these relationships, it becomes easier to understand the comprehensive impact of SPC on manufacturing efficiency and quality.

CHAPTER THREE

RESEARCH DESIGN AND METHOD

This chapter presents the research methodology employed in investigating the application of **SPC** tools at **Belayab Cable Manufacturing PLC**. The purpose of this chapter is to explain the research design, methods of data collection, data analysis techniques, and the procedures followed to ensure the validity and reliability of the findings.

The study adopts a **descriptive research design**, which is appropriate for gathering detailed information about current practices, perceptions, and challenges related to SPC implementation in the company. The research primarily uses **quantitative methods**, supported by qualitative insights where necessary, to analyze data collected from employees and management personnel involved in the production process.

The methodology is carefully selected to align with the study's objectives, which include assessing the types of SPC tools used, evaluating employee awareness and training, and identifying the impact of SPC on product quality. Data was gathered through structured questionnaires and interviews, and analyzed using both **descriptive statistical techniques**.

The chapter is organized into several sections: research design, population and sampling techniques, data sources and instruments, data collection procedures, methods of data analysis, and ethical considerations.

3.1. Research Design

This study adopts an explanatory, cross-sectional research design to examine the relationship between the implementation of statistical control charts and operational performance in manufacturing organizations. The explanatory design enables the identification of causal links between SPC tools and defect rates, while the cross-sectional approach provides a snapshot of current practices across a diverse sample of firms at a specific point in time.

3.2. Research Approach

A researcher used mixed method research approach. Combining both quantitative and qualitative research methods has proven to be more powerful than a single approach (Mack *et al.,* 2005). Triangulation is a process of using more than one form of research method (Denscombe *et al.,* 2007). The main aim of using the triangulation method is to improve the reliability and validity of the research outcomes. The researcher uses to collect, generate and analyze relevant data on the application of statistical process control tools in manufacturing industries: the case of Belayab cable manufacturing plc condition in the study area and on factors that impede the provision of safe and adequate service delivery and its implication on the customer’s using mixed research approach.

3.3. Data Types and Resources

In this study, both primary and secondary sources of data were used to gather adequate information about the application of statistical process control tools in manufacturing industries of Belayab **C**able Manufacturing PLC. The Primary data was collected through questionnaires and interviews distributed to 138 employees in Belayab **C**able Manufacturing PLC. Moreover, Belayab **C**able Manufacturing PLC performance statistics, documents, and reports were the secondary data source for the study. In addition to these, secondary sources of data were also obtained from government and non-government publications, annual and inventory reports, previous studies, and books. On the other hand, the primary data were collected from sample respondents through questioner, observation and key informants Population.

As November 2023/4, Belayab **C**able Manufacturing PLC human resource directorate report shows the total numbers of employees are **235.** Therefore, the target population of the study is both employees and administrative staff working at all department office. The population of this study does not include all employees due to limitations of resources such as time, money, and specific purposes of the study.

3.4. Sample size

According to **Triola, M. F. (2018). Elementary Statistics (13th ed.). Pearson Education**. Isreal (1999) for any sample, given the estimated population proportion of 0.5 and 95% confidence level, the sample size is given by

$$n = \frac{z^2 P(1-P)}{\alpha^2}$$

Where n = Actual sample size

Z= standard normal deviation (1.96)

P= proportion of the target population estimated to have at a particular study (10%)

□$\alpha = .05$

$$\boldsymbol{n} = \frac{(\mathbf{1.96})^{\mathbf{2}}\,\mathbf{.10(1-.10)}}{\mathbf{.05^2}} = 138$$

Based on this formula it was desirable to have a sample size that is representative of the population as much as possible. Therefore, by considering limitations in time and costs, selected 138 respondents were selected from Belayab **C**able Manufacturing PLC employees' and managers from the total population. From the total respondents 22 are administrative staff the remaining number which is 116 are employees. Simple random sampling technique was applied to select the sample employees to get representative informants whereas purposive sampling technique was used to select the Administrative staff of Belayab **C**able Manufacturing PLC. I use both simple random and purposive sampling techinique in order balance obectivitiy and relevance in data collection. To carry out this study the researcher-grouped the study area into 2 group, and make proportion to extract sample size of 138 respondents. Assume the total population N and the population of each stratum to be N1, N2, N3.the sample (n) drawn from each stratum calculated as n¡= (N¡/N) *138

Table 1 Sample size of the population

Stratified by administration and employees	Number of populations in each Strata (Ni)	Proportion total	The sample selected from each stratum
1	37	15.7	**22**
2	198	84.3	**116**
Total(N)	**235**	**100**	**138**

3.5. Sampling Techniques

The simple random and purposive sampling technique would be used to get information from different departments and administrative staff in 2 groups as shown in the above table. From 138 samples 13 key informants selected purposively from department and managers.

The researcher used simple random sampling because of simple random sampling technique was used to assist in minimizing bias when dealing with the population. With this technique, the sampling frame organized into relatively heterogeneous groups (strata) before selecting elements for the sample. According to Janet (2006), this step increases the probability that the final sample is representative in terms of the stratified groups. The strata are departments and support staff. Dawson (2009), the correct sample size in a study is dependent on the nature of the population and the purpose of the study.

3.6. Methods of Data Collection

Both qualitative and quantitative data are collected to counter balance the limitation of the one by the other. The data were generated through Questionnaires, Key Informant Interview, and Personal observation to supplement, complement, validate and triangulate data obtained from the report

Interview

Interviews are the most widely used and valuable tool in all steps of this study. During the interview concerned bodies such as quality assurance and quality control team, technicians, supervisors and managers of the case company are conducted. The interview has made in two forms: Initially it was made face to face with individuals and in group. Individuals from all substations such as quality checkers, supervisors are interviewed. Individuals from quality assurance team also responded significant data. Technician from selected sub process stations interviewed in group and delivered the expected information. Later, telephone call is used up to the end of the research.

The questionnaire was pre-tested with a small group of employees to ensure **clarity, reliability, and relevance**, and minor revisions were made based on the feedback received. Copies of the questionnaire were then distributed to selected employees and supervisors in key production and quality departments. Participation was voluntary, and respondents were assured of confidentiality and anonymity to encourage honest and unbiased responses.

Secondary sources of data

As a secondary data, a monthly and weakly product performance report are involved as an initial study to identify the most likely defects. It was obtained through documentation such as weekly, monthly and quarterly reports of quality assurance team of BAC.

3.7. Methods of Data Analysis

To analyze the data collected a combination of quantitative and qualitative analysis methods would be employed. Descriptive analysis: – It sets out to describe and interpret the existing situation OKAMI study Guide Chapter 11

Quantitative data which is generated from household survey were analyzed using simple descriptive statistical tools like data tables frequency, mean, standard deviation and percentages, graphs and charts would be the means of data presentation and they were operated with Statistical Package for Social Studies (SPSS) and Micro Soft Excel version 10.0 could be means of data processing for descriptive statistical analyses to be used. The qualitative data collected using Key Informants Interview and personal observation is also analyzed through description, narrating and interpreting the situation contextually so that the city's water supply situation has been properly revealed. Qualitative data is presented using diagrams, maps, photos and narration and the data were analyzed using researcher's judgmental analysis and in light of current scientific knowledge in the subject.

3.8. Validity and Reliability

3.8.1. Validity

Validity concerns the degree to which a question measures what it was intended to measure. To ensure content validity and ethicality of the items incorporated in the instrument have examine the instrument. The researcher reviews mainly the ethicality of the items and the professionals appraised the content of the questionnaire in each variable. Moreover, the instrument is given to my research advisor for final comment. Accordingly, based on comments, subsequent corrections were made to the survey questionnaire and finally distributed to the sample population. In addition, all reference materials are acknowledged with proper citation and confidentiality of data is maintained throughout the process.

3.8.2. Reliability

As per Khotari (2004) reliability refers to consistency, where internal consistency involves correlating the responses to each question in the questionnaire with those other questions in the questionnaire. The researcher used Cronbach ‘s alpha to calculate the internal consistency of the instrument. So, item reliability of the questioners was examined by pilot test of 30 respondents and analyzed by Cronbach ‘s alpha.

The reliability test was done using Cronbach Alpha (α) which is an internal consistency test that measures the degree to which the items or measurements consistently measures the underlying construct. The reliability of the questionnaire calculates to be knowledge of SPC tools, 0.983, implementation of SPC tools, .988, effectiveness of SPC tools, .982, training and education, .986, management support, .975, impact on quality control.987, and production efficiency 0.95, respectively by using alpha value. All those results above the 0.7 as result it acceptable and excellent internal consistence do the questioner have been occurred.

3.8.3 Reliability test

No.	**Items**	**Cronbach's Alpha**
	Independent Variables	
1	Knowledge of SPC Tools	.983
2	Implementation of SPC Tools	.988
3	Effectiveness of SPC Tools	.982
4	Training and Education	.986
5	Management Support	.975
6	Impact on Quality Control	.987
	Dependent variables	
9	Production Efficiency	.965

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

This chapter presents, analyzes, and interprets the data collected from respondents to answer the research questions posed in this study. The findings are based on the application of the research tools and methods discussed in the previous chapter. The main goal of this chapter is to examine the collected data in light of the study objectives and provide meaningful insights into the research problem.

The data is organized and presented in two major sections. The first section covers the **demographic characteristics** of the respondents, including gender, age, education level, and years of experience. The second section presents the **analysis and interpretation** of the core research variables, such as the SPC tools, employee training, quality outcomes, and challenges faced during SPC implementation at Belayab Cable Manufacturing PLC.

4.1. Response Rate …………..

A total of 152 questionnaires were distributed to employees at Belayab Cable Manufacturing PLC, including an additional 10% contingency to ensure a sufficient sample size. From these, 138 were returned, providing a high response rate of 90.7%. Among the 138 responses, five respondents only filled in the demographic section. This strong response rate indicates high engagement from the staff, which contributes to the reliability of the study results.

4.2. Profile of Respondents

The study analyzed the demographic characteristics of the respondents involved in the study. In this section, the respondent's profile is presented. It includes gender, age, level of education, and length of service in the current position. Analyzing these variables was meant to provide any evidence of the association between these variables and the various responses.

Tables 4-1 demographic characteristics of respondents

No		Item	Frequency	Percent
1	Sex	Female	55	39.9
		Male	83	60.1
		Total	138	100
2	Age	20-30	61	44.2
		31-40	66	47.8
		41-50	11	8
		Total	138	100
3	Educational Level	Bachelor Degree	105	76.1
		Masters	33	23.9
		Total	138	100
4	Experience	<5 year	50	36.2
		6-10 year	16	11.6
		11-15 year	66	47.8
		>16	6	4.3
5	Current position	Manager	778	55.8
		Officer	33	23.9
		Chief Officer	22	15.9
		Other	4.3	4.3
		Total	138	100

Source: Own SPSS output, 2025

Table 4.1 depicts that those who completed the survey, 60.1% were male and 39.9% female. Gender status was important as it is a variable that shows the extent of an individual's social commitment in relation when it comes to interaction with others and it was also analyzed to check whether both sexes were given chances to participate in the study.

- **Gender:** Out of 138 respondents, 83 (60.1%) were male and 55 (39.9%) were female. This shows a moderately balanced gender representation in the workforce.
- **Age:** The largest group of respondents (47.8%) was between 31 and 40 years old, followed by 44.2% aged 20 to 30 and only 8% were aged 41 to 50. The mean age score was 1.64 on a 3-point scale, indicating that the majority of the workforce is in the younger to middle-age categories, typically associated with high productivity.
- **Educational Level:** A significant majority of respondents (76.1%) hold a Bachelor's Degree, while 23.9% hold a Master's Degree. The mean education level was 1.76, suggesting a relatively well-educated workforce capable of understanding and applying SPC concepts.
- **Work Experience:** 47.8% of the respondents have 11-15 years of experience, 36.2% have less than 5 years, 11.6% have 6-10 years, and 4.3% have over 16 years. The mean value of 2.2 indicates that many employees have been with the company long enough to gain solid insights into SPC practices.
- **Current Position:** The roles were distributed as follows: 55.8% managers, 23.9% officers, 15.9% chief officers, and 4.3% in other positions.

These characteristics indicate a qualified, experienced workforce capable of providing valuable insight into SPC implementation.

4.3. Level of application of statistical process control tools in Belayab Cable Manufacturing Industries

Tables 4-2 Collected Date

Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	SPC Level
1. Knowledge of SPC Tools	50	55	15	10	5	135	High
2. Implementation	30	45	25	20	15	135	Moderate
3. Effectiveness	25	40	30	25	15	135	Moderate
4. Training and Education	15	25	20	40	35	135	Low
5. Management Support	45	50	20	15	5	135	High
6. Impact on Quality Control	35	40	30	20	10	135	Moderate

The researcher tries to examine the level of application of statistical process control tools in Belayab Cable Manufacturing Industries using descriptive statistics.

From the below table data, it is possible to observe that the mean value of knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, and impact on quality control were 3.4044, 3.2790,2.8601, 3.1173, 2.7718 and 2.5547 respectively. This suggests a moderate level of SPC integration within the company.

From the descriptive statistics output above it is possible to conclude the level of each knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control and production efficiency were medium since its mean value were lies between 2.5-3.4 from Likert scale measurement it shows medium value which is around 3 and above.

Tables 4-3 Level of application of statistical process control tools in Belayab manufacturing industries

Statistics

		Knowlede of SPC Tools	Implementation of SPC Tools	Effectiveness of SPC Tools	Training and Education	Management Support	Impact on Quality Control
N	Valid	133	133	133	133	133	133
	Missing	0	0	0	0	4	4
Mean		3.4044	3.2790	2.8601	3.1173	2.7718	2.5547
Std. Deviation		1.04361	1.16260	1.03436	1.09595	1.12974	1.09030
Minimum		1.00	1.00	1.00	1.00	1.00	1.00
Maximum		5.00	5.00	5.00	5.00	5.00	5.00

Source: Own SPSS output, 2025 and the rating is: 5= strongly agrees 4= agrees 3= undecided 2= disagree 1= strongly disagree

4.4. Level of production efficiency Belayab manufacturing industries

Here the researcher tries to examine the level of production efficiency Belayab manufacturing industries using descriptive statistics. From the below data it is possible to observe that, the mean value production efficiency is 2.8622. Thus, it is possible to conclude that, production efficiency parameters practiced medium lower level in Belayab manufacturing industries.

Table 4-4 Level of production efficiency

Statistics

Production Efficiency

N	Valid	133
	Missing	5
Mean		2.8622
Std. Deviation		1.09108
Minimum		1.00
Maximum		5.00

Source: Own SPSS output, 2025 and the rating is: 5= strongly agrees 4= agrees 3= undecided 2= disagree 1= strongly disagree

4.5. The Role of application of statistical process control tools in Belayab cable manufacturing industries

In this section, the study showed the application of statistical process control tools in Belayab cable manufacturing industries based on knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control and production efficiency. Furthermore, the goodness of fitness of the model was checked based on the key assumptions of for regression. The model summary that shows the effect of independent variable on the dependent variable is shown in table 2: From the below table based on the result of adjusted R-square it is possible to observe that 99.2 % of the variation on production efficiency is explained by implementation of SPC tools, effectiveness of SPC tools in the case organizations in the study area.

From the table below it is possible to observe that R, R Square, Adjusted R Square and Std. Error of the Estimate were; .996, .992, .992 and .09928 respectively. Thus, it is possible to conclude that the predictive power of application of statistical process control tools on production efficiency is 0.992 or 99.2%.

Table 4-5 Predictive power of application of statistical process control tools on production efficiency

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.996[a]	.992	.992	.09928	.992	1977.189	8	124	.000

A. Predictors: (Constant), knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality

B. Dependent Variable: control and production efficiency.

Source: Own SPSS output, 2025

4.6. The contribution application of statistical process control tools on production efficiency

The contribution of each of the application of statistical process control tools aspects were shown in Table 4.4. Based on the beta coefficient of the variables the significance levels the following factors i.e. knowledge of SPC Tools (b= -.037), implementation of SPC tools, (b=.149), effectiveness of SPC tools, (b=-.077), training and education, (b=.285), management support, (b= .049), and impact on quality control, (b= -.103).

In the below tables data, it is possible to conclude that the predict power of application of statistical process control tools on production efficiency 99.2%. The average knowledge of SPC Tools (b= - 0.037) is not a significant impact (p=0.474) which is greater than 0.05 and the coefficient is negative which would indicate the more emphasis on knowledge of SPC Tools is related to higher production efficiency. The average implementation of SPC tools (b=0.149) is not a significant impact (p=0.001) which is less than 0.05 and the coefficient is Positive which would indicate the emphasis on implementation of SPC tools is related to increase production efficiency. Similarly, the average effectiveness of SPC tools (b=-0.077 is not significant impact (p=0.226) which is greater than 0.05 and the coefficient is negative which would indicate that more emphasis on effectiveness of SPC tools decrease production efficiency. Training and development (b= .049), (p= .363) Impact on Quality Control, (b= -.103) is a not significant impact (p=. 017) which is greater than 0.05 and the coefficient is negative which would indicate that more emphasis on Effectiveness of SPC Tools decrease production efficiency.

From the finding the negative coefficient of Knowledge of SPC Tools, Effectiveness of SPC Tools and Impact on Quality Control indicates that when an increasing on these independent variables declines production efficiency. These shows respondents on the study area are not aligned with Knowledge of SPC Tools, Effectiveness of SPC Tools and there is no SPC impact control system in accordance with their production efficacy even if the effectiveness of the company being higher.

Results from the SPC are a critical at Belayab Cable Manufacturing PLC to monitor and control manufacturing processes through statistical techniques. By measuring and analyzing variations, SPC helps to identify and address potential issues before they lead to defects, thereby enhancing product quality, reducing waste, and increasing efficiency. The company has implemented various SPC tools, including control charts to monitor process stability, Pareto charts for identifying significant defect sources, fishbone diagrams for root cause analysis, and process capability analysis to assess how well processes meet specifications. To ensure all employees are proficient in these tools, Belayab has established a structured training program featuring workshops led by SPC experts, hands-on practice sessions, continuous support, and regular refresher courses. A notable instance of SPC effectiveness involved the use of control charts that detected an upward trend in defect rates for a specific cable product, leading to the discovery of a malfunctioning machine and subsequent maintenance that improved quality. Initially, challenges such as employee resistance and unfamiliarity with statistical methods were addressed through comprehensive change management strategies, engaging employees in the process, and providing clear examples of SPC benefits. The implementation of control charts has significantly enhanced real-time monitoring of production processes, enabling quick identification of trends and timely corrective actions. Additionally, process capability analysis revealed that certain production processes were not consistently meeting specifications; adjustments were made that resulted in improved capability indices and higher product quality. Data collection is vital to the effectiveness of SPC, with systematic gathering of measurements related to dimensions, weights, and defect rates managed through a centralized database for easy access and analysis. The success of SPC initiatives is evaluated through key performance indicators (KPIs) such as defect rates and customer satisfaction scores, with regular reviews ensuring continuous improvement.

Looking ahead, Belayab plans to enhance its SPC tools by integrating advanced data analytics and machine learning for predictive quality control, expanding automated data collection systems, implementing sophisticated software solutions for real-time monitoring, and exploring additional advanced statistical training for employees

Table 4-7 Beta coefficients of Unstandardized and Standardized Coefficients

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	-.059	.042		-1.381	.170	-.143	.025
Knowledge of SPC Tools	-.037	.051	-.035	-.718	.474	-.139	.065
Implementation of SPC Tools	.149	.045	.155	3.301	.001	.060	.239
Effectiveness of SPC Tools	-.077	.063	-.070	-1.218	.226	-.201	.048
Training and Education	.285	.090	.280	3.154	.002	.106	.463
Management Support	.049	.053	.050	.913	.363	-.057	.155
Impact on Quality Control	-.103	.043	-.101	-2.411	.017	-.187	-.018

a. Dependent Variable: production efficiency

Source: Own SPSS output, 2025

4.7. Production efficiency and management

Table 4-8 Residual statistics table

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.9438	4.7094	2.8622	1.08683	133
Residual	-.29634	.30142	.00000	.09623	133
Std. Predicted Value	-1.765	1.700	.000	1.000	133
Std. Residual	-2.985	3.036	.000	.969	133

a. Dependent Variable: production efficiency

Source: Own SPSS output, 2025

From the above data it is possible to observe that, the mean value production Efficacy 2.8622. Thus, it is possible to conclude that; product efficacy practiced medium level in Belayab cable manufacturing plc.

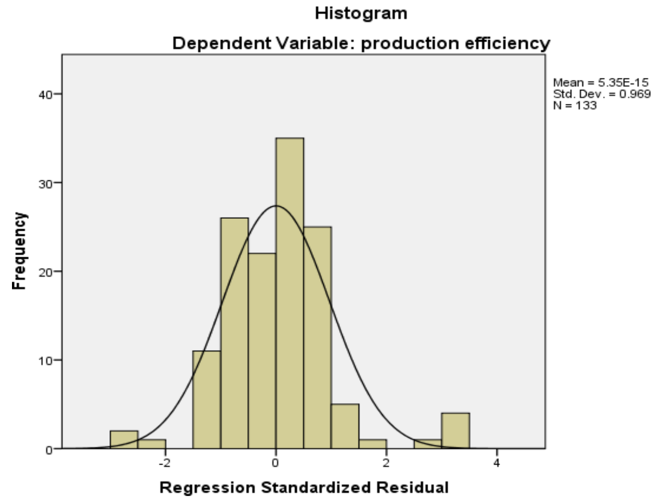

Figure 3 distribution figures

Source: Own SPSS output, 2025

As shown in the above figures the distribution is normal distribution as a result those indicates most of the knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control and production efficiency.

4.8. The Relationship between application of statistical process control tools and production efficiency

In this part the study relationship between application of statistical process control tools and production efficiency based on variables like knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control and production efficiency.

The data show positive and significant relationship between production efficiency between differing aspects of application of statistical process control tools practices considered for the present study i.e Implementation of SPC Tools, Effectiveness of SPC Tools, Training and Education, Management Support Impact on Quality Control, From the data it is possible to observe that there is a positive and significant correlation between each application of statistical process control tools practice with production efficiency because the P-value for the correlation is less than 0.05. Similarly, it is also possible to deduce that there is a positive significant correlation between each practice with production efficiency on customer satisfaction because the P-value for the correlation is less than 0.05.

In my conclusion that there is a positive significant correlation between each application of statistical process control tools practice with effectiveness on learning and development in Belayab cable manufacturing plc because the P-value for the correlation is less than 0.05. Similarly, it is possible to conclude that there is a positive significant correlation between each application of statistical process control tools practice with effectiveness on internal processing in Belayab cable manufacturing PLC because the P-value for the correlation is less than 0.05.

Correlations

		1	2	3	4	5	6	7
1. Knowledge of SPC Tools	Pearson Correlation	1	.932**	.967**	.973**	.979**	.971**	.952**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
	N		133	133	133	133	133	133
2. Implementation of SPC Tools	Pearson Correlation		1	.960**	.913**	.979**	.900**	.931**
	Sig. (2-tailed)			.000	.000	.000	.000	.000
	N			133	133	133	133	133
3. Effectiveness of SPC Tools	Pearson Correlation			1	.955**	.984**	.947**	.960**
	Sig. (2-tailed)				.000	.000	.000	.000
	N				133	133	133	133
4. Training and Education	Pearson Correlation				1	.958**	.986**	.968**
	Sig. (2-tailed)					.000	.000	.000
	N					133	133	133
5. Management Support	Pearson Correlation					1	.952**	.960**
	Sig. (2-tailed)						.000	.000
	N						133	133
6. Impact on Quality Control	Pearson Correlation						1	.966**
	Sig. (2-tailed)							.000
	N							133
7. production efficiency	Pearson Correlation							1
	Sig. (2-tailed)							.992**
	N							.000

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Own SPSS output, 2025

Tables 4-9 Table Pearson Correlation Matrix

The above data shows the correlation between application of statistical process control tools and production efficiency practices .932, .967, .973, .979, .971, .952, .972 and .992 with knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control and production efficiency respectively with P-value 0.00 for all independent variable. From the data it is possible to conclude there is a positive significance correlation between each application of statistical process control tools and production efficiency practices practice in Belayab cable manufacturing plc because the P-value for the correlation is less than 0.05. The disparity between the employee and the job can slow down performance levels, whereas a sophisticated selection system can ensure a better fit between the person ‘s abilities and the organization ‘s requirement. Also, the selection has been found to be positively related to firm performance (Oladipo and Abdulkadir, 2011).

A well-planned career development system along with internal advancement opportunities based on merit, results in high motivation among employees, which has an impact on firm performance (Milkovich and Boudreau, 1998). Studies have also shown that application of statistical process control tools and production efficiency practices of an employee and then to the organization (Verma, 1995).

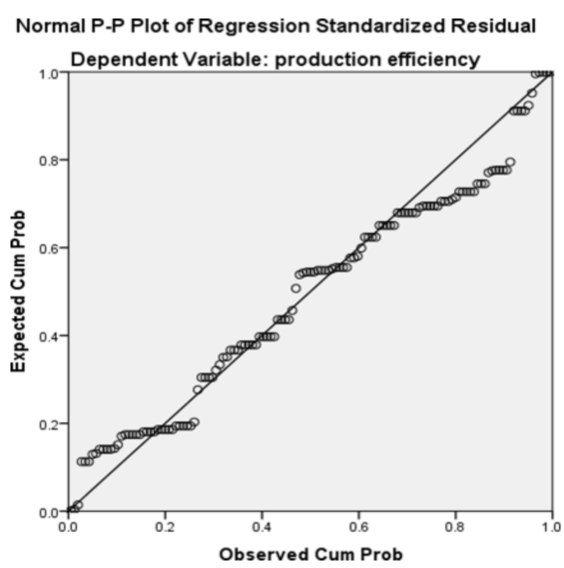

Figure 4- Linear regression p-plot

Source: Own SPSS output, 2025

The above figure shows that the relationship between dependent variables (production efficiency) and independent variables (knowledge of SPC tools, implementation of SPC tools, effectiveness of SPC tools, training and education, management support, impact on quality control) are aligned or closely related each other as a result when improve these dependent variables it also improves the production effectiveness.

CHAPTER FIVE

SUMMARY CONCLUSIONS AND RECOMMENDATION

This chapter presents the final section of the research study on the application of **SPC** tools in the manufacturing process at **Belayab Cable Manufacturing PLC**. It provides a comprehensive summary of the key findings obtained from the data analysis in Chapter Four, followed by conclusions drawn based on these findings. The purpose of this chapter is to interpret the research results in the context of the study objectives and to offer actionable recommendations for improving SPC practices within the company.

The first section offers a **summary** of the main findings, highlighting the extent to which SPC tools are being implemented, the level of employee involvement, and the impact on product quality and process efficiency. The second section provides **conclusions** that address the research questions, while the final section presents **recommendations** aimed at enhancing the effectiveness of SPC application at Belayab Cable Manufacturing PLC and similar manufacturing industries in Ethiopia.

Overall, this chapter seeks to consolidate the study's contributions and suggest pathways for both practical improvements and future academic research.

5.1. Summary

In this presents a comprehensive examination of data collected from respondents at Belayab Cable Manufacturing PLC, focusing on both demographic characteristics and the application of Statistical Process Control (SPC) tools. The findings are systematically structured into two main sections: the demographic profile of respondents and the evaluation of SPC tools. A total of 152 questionnaires were distributed, with a notable 90.7% response rate achieved, resulting in 138 completed surveys.

The analysis of SPC tools employed descriptive statistics to assess their level of application within the organization. The findings indicated a medium level of application across various aspects of SPC. Specifically, the mean values for knowledge of SPC tools was 3.4044, the implementation of SPC tools was 3.2790, and the effectiveness of these tools was rated at 2.8601. These results suggest that while there is a reasonable understanding and implementation of SPC tools, there remains room for improvement in their effectiveness. Production efficiency was also a critical focus, with a mean value of 2.8622 indicating a medium lower level of efficiency within the manufacturing processes. This finding raises questions about the operational practices and highlights potential areas for enhancement. Further, regression analysis provided insights into the predictive power of SPC tools on production efficiency, revealing an impressive Adjusted R^2 value of 99.2%. This indicates that a significant portion of variability in production efficiency can be explained by the application of SPC tools, underscoring the importance of these tools in driving operational improvements. The analysis identified significant relationships among various factors, emphasizing the need for a structured approach to SPC implementation.

Interviews conducted with key stakeholders reinforced the critical role of SPC tools in monitoring and controlling manufacturing processes. Successful implementations were noted, including the effective use of control charts for maintaining process stability and the establishment of training programs aimed at enhancing employee proficiency in SPC practices. These initiatives were crucial in addressing initial resistance to SPC adoption, fostering a culture of engagement and continuous improvement. The chapter advocates for the adoption of continuous improvement strategies, emphasizing the need for advanced data analytics, enhanced training programs, and a commitment to fostering a culture of quality and efficiency. This holistic approach is essential for maximizing the potential of SPC practices and achieving sustained operational excellence within the organization.

5.2. Conclusion

The findings of this study highlight that Belayab Cable Manufacturing PLC is supported by a predominantly young, educated, and experienced workforce, which serves as a strong foundation for quality improvement initiatives. The results indicate a moderate level of knowledge and implementation of SPC tools, suggesting that while the company has adopted these practices to some extent, there remains considerable room for improvement.

Despite the medium-level application, the regression analysis confirmed a strong positive relationship between SPC tool usage and production efficiency, underscoring the significant impact these tools have on operational performance. This finding reinforces the idea that enhanced application of SPC can directly contribute to reduced process variability, minimized defects, and overall improved productivity.

Additionally, qualitative data from interviews provided valuable context, revealing that employees and supervisors recognize the potential of SPC tools in improving process monitoring, early problem detection, and maintaining consistent quality standards. However, they also emphasized challenges such as insufficient training, lack of continuous support, and limited engagement in SPC practices.

In summary, the study concludes that while SPC tools are being used to some degree at Belayab, increasing employee training, awareness, and systematic integration of SPC into daily operations could unlock greater efficiencies and quality improvements, aligning well with the company's and national industrial development goals.

5.3. Recommendations

- Enhance Training Programs: To improve the effectiveness of SPC tools, it is recommended that the organization invests in comprehensive training programs for employees. These programs should focus on not only the technical aspects of SPC but also on fostering a culture of quality and continuous improvement.
- Enhance Leadership Support: Management should actively support the application of SPC tools by providing the necessary resources and encouragement. This includes creating an environment where employees feel empowered to suggest improvements and participate in SPC initiatives.
- Regular Monitoring and Feedback: Implement a system for regular monitoring of SPC tool application and production efficiency. This could involve periodic reviews and feedback sessions to assess progress and make necessary adjustments to strategies.
- Promote Data-Driven Decision Making: Encourage the use of data analytics to inform decision-making processes. By leveraging data insights, the organization can identify trends, areas for improvement, and measure the impact of SPC tools on production efficiency.
- Foster a Culture of Collaboration: Promote collaboration among different departments to ensure a holistic approach to process improvements. Cross-functional teams can facilitate knowledge sharing and ensure that SPC practices are integrated throughout the organization.
- Invest in Advanced SPC Tools: Consider investing in advanced SPC tools and technologies that can automate and enhance data collection and analysis. This will not only improve accuracy but also enable quicker responses to any deviations in production processes. By implementing these recommendations, Belayab Cable Manufacturing PLC can maximize the potential of SPC tools, leading to improved production efficiency and overall operational excellence.

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Appendix

INSTRUCTION:

Research questions structured around six variables related to the application of Statistical Process Control (SPC) tools in manufacturing industries, specifically for Belayab Cable Manufacturing PLC. Each question is designed for a Likert scale response. Please make a „√" mark on your response to each statement according to the five-point scale labeled at each statement 1 = Strongly Disagree 2 = Disagree3 = Neutral 4 = Agree 5 = Strongly Agree

Please place a tick (√) or a mark (x) in the box (cell) that represents your appropriate level of agreement.

Variable	Research Question	1	2	3	4	5
Knowledge of SPC Tools	1. Employees are well-informed about SPC tools used in the manufacturing process.					
	2. There is a clear understanding of how SPC tools contribute to quality control.					
	3. Knowledge of SPC tools is regularly updated in the organization.					
	4. Employees can identify the different types of SPC tools available.					
	5. The importance of SPC tools is emphasized in company communications.					
Implementation of SPC Tools	6. SPC tools are consistently applied in daily manufacturing operations.					
	7. There are documented procedures for implementing SPC tools.					
	8. The organization invests resources in implementing SPC tools.					
	9. SPC tools are integrated into the production workflow.					
	10. There are regular audits to assess the implementation of SPC tools.					
Effectiveness of SPC Tools	11. The use of SPC tools has led to improved product quality.					
	12. SPC tools help in reducing production costs.					
	13. SPC tools have decreased the number of defects in produced items.					

	14. The effectiveness of SPC tools is regularly evaluated.					
	15. SPC tools contribute to faster decision-making processes.					
Training and Education	16. Employees receive adequate training on SPC tools.					
	17. Training sessions on SPC tools are conducted regularly.					
	18. The training provided is practical and applicable to daily tasks.					
	19. Employees feel confident in using SPC tools after training.					
	20. Continuous education on SPC tools is encouraged by management.					
Management Support	21. Management actively supports the use of SPC tools.					
	22. There is a clear communication channel for discussing SPC-related issues with management.					
	23. Management allocates budget for SPC-related initiatives.					
	24. Leadership encourages a culture of quality through SPC tools.					
	25. Management recognizes and rewards effective use of SPC tools.					
Impact on Quality Control	26. The application of SPC tools has positively impacted overall product quality.					
	27. Customers have noticed an improvement in product quality due to SPC.					
	28. SPC tools help in identifying quality issues before they escalate.					
	29. The company uses data from SPC tools to drive quality improvements.					
	30. SPC tools have increased customer satisfaction levels.					
Additional Questions	31. Employees believe that SPC tools are essential for their roles.					
	32. There is a collaborative approach to using SPC tools across departments.					
	33. Feedback from employees is considered in the selection of SPC tools.					
	34. SPC tools are adapted based on specific manufacturing processes.					

	35. The organization benchmarks its SPC practices against industry standards.					
	36. There is a clear understanding of the metrics used in SPC tools.					
	37. The organization utilizes software for SPC data analysis.					
	38. Employees feel that SPC tools simplify their work processes.					
	39. There is a culture of continuous improvement related to SPC usage.					
	40. Employees are encouraged to suggest improvements to SPC practices.					
	41. SPC tools help in maintaining compliance with industry regulations.					
	42. The organization conducts regular reviews of SPC tool performance.					
	43. Employees are actively involved in SPC-related decision-making.					
	44. The application of SPC tools has led to a reduction in waste.					
	45. SPC tools assist in forecasting production needs.					
	46. There is a noticeable reduction in rework due to SPC tool usage.					
	47. Employees understand the relationship between SPC tools and operational efficiency.					
	48. The organization has a dedicated team for SPC tool management.					
	49. Regular workshops on SPC tools are held for knowledge sharing.					
	50. The long-term benefits of using SPC tools are recognized by the organization.					

Product Quality: Measurements of defects or non-conformities in the manufactured cables.

Process Variability: Changes in process performance metrics such as cycle time, yield, and scrap rates

Customer Satisfaction: Feedback and return rates from clients based on product quality. Efficiency Metrics: Overall equipment effectiveness (OEE) and production efficiency.

Interview Questions

1) Can you explain what Statistical Process Control (SPC) is and why it is important in manufacturing?
2) What SPC tools have been implemented at Belayab Cable Manufacturing PLC, and what are their specific purposes?
3) How did you ensure that all employees were trained effectively on the use of SPC tools?
4) Can you describe a specific instance where SPC identified a significant quality issue in the production process?
5) What challenges did Belayab face during the initial implementation of SPC, and how were these challenges addressed?
6) How has the use of control charts impacted the monitoring of production processes at Belayab?
7) Can you provide an example of how process capability analysis has been used to improve product quality?
8) What role does data collection play in the effectiveness of SPC at Belayab, and how is this data managed?
9) How do you evaluate the success of SPC initiatives over time at Belayab Cable Manufacturing PLC?
10) What future improvements or expansions of SPC tools do you envision for Belayab Cable Manufacturing PLC?