The Use and Implementation of Pareto and Ishikawa Diagram for defect minimization in manufacturing firms

Dereje Geleta Oljira[1]& **Misgana Lamessa Dinsa**[2]

[1]Department of Industrial Engineering, Faculty of Technology, Wollega University Shambu Campus, Ethiopia
[2]Department of Water Resources & Irrigation Engineering, Faculty of Technology, Wollega University Shambu Campus, Ethiopia

Abstract

Many unavoidable challenges in the rejection of a large percentage of finished garment products after shipment owing to quality control failures in garment manufacturing motivated this article. Global competition, diminishing profit margins, customer need for products, product variety, and shorter lead times, among other factors, have a significant impact on the garment manufacturing industry. The need for higher quality products at a lower price is growing, and clothing manufacturers must enhance their operations by manufacturing right the first time. This paper examines how to enhance garment manufacturing quality and productivity by reducing the number of reworks that occur during the manufacturing process. Using Pareto analysis and the Ishikawa diagram effectively, this study enhances the process performance of a major operational process, resulting in higher resource utilization, less variances, and consistent quality of the process output. According to the Pareto principal of 80/20 of 80/20 rule, the up and down sections are rated top in the sewing process area, followed by broken stitch 27.20 percent, uneven stitch 9.44 percent, twisting 6.94 percent, and slip stitch 5.28 percent of defects. After identifying and ranking the primary causes based on the 80/20 principle, viable solutions were presented on how to tackle these issues and reduce the rejection rate to a minimum, as well as minimize costs and increase internal throughput time. This study provides a general summary of the development, stating that by decreasing faults, an industry can earn higher production and profitability.

Keywords: 1.Sewing, 2.Pareto, 3.Defects, 4.Productivity, 5.Ishikawa

1. Introduction

Global economic conditions vary frequently, and profit margins, customer demand for high-quality products, and increased efficiency are often prioritized in a sector. After shipment, there are always a few rejected garments in the garment manufacturing industry. Most manufacturers consider clothing to be soft commodities, with non-repairable faults occurring as a result of low-quality raw materials, poor methods, or casual employee behavior.

Factory checkpoints, on the other hand, are required to address this issue. There is no ready-made remedy that can minimize the percentage of rejections in a single day. Each order is distinct. However, the research presented in this paper reveals how to deal with such issues and keep the rejection rate to a bare minimum through high-quality production. Most organizations label these clothing rejected since they cannot be mended in any way, as we observe in many rejected garments after shipment.

Reworks are a typical occurrence in the garment business, and they impede smooth production rates by focusing on low-quality items, which have an impact on the entire factory economy. Rework must be minimized to improve quality and productivity. Rework is a critical issue for low-value-added operations, such

as those that clients are unwilling to pay for. Nonproductive behaviors show that the customer does not believe the product can be improved.

The corporation can invest less money and save more costs by reacting faster in the minimizing of reworks to develop a product that meets customer demand with expected quality.

As a result, a study was conducted in the sewing sector of the Gullele Garment Share Company, which is located in Gullele (Asko), Addis Ababa, Ethiopia, to discover reworks and eradicate them to save time, money, and enhance product quality. The Gullele Garment Share Company, founded in 1983 in Addis Ababa's Gulele Sub-city, is one of Ethiopia's garment factories. It manufactures a variety of garments for export and domestic use, including T-shirts, athletic wear, and military uniforms.

The industry is divided into three sections: cutting, sewing, and finishing. This research focuses on the sewing area of the garment to raise firm efficiency, production, reduce time, and increase profit, all of which have a significant impact on the country's economy.

2. Problem Statement

Establish and maintain clear, complete, and current written records of inspection and test methods for each operation to be effective in defect and rejection reduction. These records were utilized to determine the acceptance/rejection criterion. Fabric is the most important raw material in the garment manufacturing industry, followed by various forms of trimming and accessories. Top surface rework, printed label rework, stitching flaws, pinhole rework, fabric defects, inappropriate fly shape, and other reworks are examples of operational wastage in the garment manufacturing process (at Gullele Garment S.C.). It is required to produce a document and maintain a system capable of guaranteeing that goods comply with standard requirements to meet the ultimate goal of minimizing faults and rejecting finished items. This is essential at all phases of the manufacturing process. These standards must be met by all records. These flaws and faults cause industries to fail or go out of business.

3. Literature Review

The current worldwide market's increasing competition necessitates a significant demand for the industry's continued evolution. As a result of the increasing demands of customer needs and expectations, global firms are constantly seeking a competitive advantage. Quality is more efficient and effective in the global market, resulting in increased production, customer loyalty, and market share. Quality is an ephemeral term whose meaning shifts with time. Quality used to be defined as "conformance to valid client requirements." That is, an output was regarded conforming, good, or acceptable if it fell within accepted limitations, known as specification limits, around a desired value, known as the nominal value or target value. This is what we call the "goalpost" definition of quality (Deming, 1950).

Quality is one of the most important choice variables in purchasing products and services, according to (Montgomery, 2005). As a result, quality promotes corporate success, growth, increased competitiveness, and better working conditions. It also involves employees helping the company achieve its objectives and provides a significant return on investment. Understanding, meeting, exceeding, and beyond client demands and expectations must be the goal of quality research and analysis (Kolarik, 1995).

Statistical tools allow the measurement and evaluation of the performance of a process to improve its quality. These tools are frequently used to support decision making. Montgomery (2005) additionally states that statistical tools can be helpful in developing activities prior to manufacturing, in measuring process variability, in analyzing this variability relative to product requirements or specifications, and in eliminating or greatly reducing variability in the process. These tools allow the interpretation of the process by detecting when the

variables change and experimentation by knowing how the variables can change according to the experimental design (Ott et al., 2000).

Among the many quality tools available for problem solving, the Pareto Diagram and Fishbone Diagram are the most important as they discover the root causes and eliminate them, enabling continuous improvement of any process. Dr. Juran suggested the use of Pareto principle,also known as the 80/20 rule of quality control for separating the "vitalproblems from the "trivial now called the "useful (Varsha and Vilas, 2014) stated that the results of a Pareto analysis are typically represented through a histogram sorted from the highest to the lowest frequency.

It is also considered one of the seven statistical quality tools in the food industry that is frequently applied to break a problem into several parts and identify which parts directly affect the issue and which parts don't. The cause-and-effect diagram is a schematic tool that resembles a fishbone that lists causes and sub causes as they relate to a concern, also known as the Fishbone diagram or Ishikawa diagram (Hagemeyer, et al., 2006). "Root Cause Analysis is a structural investigation that aims to identify the true cause of a problem, and the actions necessary to eliminate it". According to (Anderson and Fagerhaug, 2006), if root cause analysis is used in a reactive mode, it provides an objective identification of organizational faults. In the proactive mode, the root cause analysis identifies and prevents future mistakes. (Wilson et al., 1993) described various techniques used in a Root Cause Analysis (RCA) are; Why-Why Analysis (WWA), Brainstorming Sessions (Kalantri and Saurabh, 2012) as well as Corrective and Preventive Action (CAPA) plan. WWA is a methodology to inquire about the root cause behind the surface causes of a problem by asking —whymany times in succession. Corrective action is taken to eliminate the cause of a detected problem, which prevents it from recurring, whereas preventive action is defined as the action taken to eliminate the cause of a potential problem from occurring (Ketola and Roberts, 2003). After identifying the root causes,the CAPA plan is an essential quality tool that can be used to record the actions needed to successfully carry out the implementation to avoid repetition of problems.

(Wilson et al., 1993) defined Root Cause Analysis as an analytical tool that can be used to perform corrective and comprehensive system-based reviews of critical defects. This includes the identification of the root and contributory factors, determination of defect reduction strategies, and development of action plans along with measurement strategies to evaluate the effectiveness of the plans. The Canadian Root Cause Analysis Framework (2005) states that root-cause analysis is an important component of the understanding of defects.

(Mohiuddin Ahmed and Nafis Ahmad, 2011) minimized defects in the lamp production process by applying Pareto analysis and a cause-and-effect diagram. They worked for zero waste and zero-defect objectives. They studied the lamp production process by using production data. They also work for data collection in all steps involved inlamp production with month-wise rejection in the group production system. The author applied Pareto analysis to all defects and found the major and minor contributors. Finally, the author applies cause-and-effect diagrams to each defect and determines the main factor. Therefore, they suggest that the cause-and-effect diagram is very useful in indicating the appearance of abnormalities of process in the form of excessive variations of process parameters.

(Mazedul et al., 2013) suggested ways to handle these issues and reduce the rejection rate to a minimum in the sewing section of the apparel industry. Based on their findings, the sewing percent defects were reduced byapproximately to 80%. Reworking increased the cost of the different work categories from 2% to 15%.

The Pareto chart that helps us to prioritize our efforts and focus attention on the most pressing problem or symptoms it is the cause-and-effect diagram that helps to lead us to the root cause of the problem (Devor*et al.*, 2007).

4. Design and Methodology

This chapter comprises all strategies used by Gullele Company to improve the garment industry's quality based on the reported imperfect items for two consecutive months. It also covers how to prevent inappropriate flaws to reduce rework, manage time, boost productivity, and support the company's global market development.

It is also required to nominate a management representative who is responsible for managing the complete control system and inspection at each manufacturing stage, preferably independent of other functions. The designated individual should have the authority to carry out any action necessary to meet the desired product requirements. A planned periodic assessment by top management is required to guarantee that the system's effectiveness is maintained.

The general methodology followed to minimize the defects rate is given in the following steps.

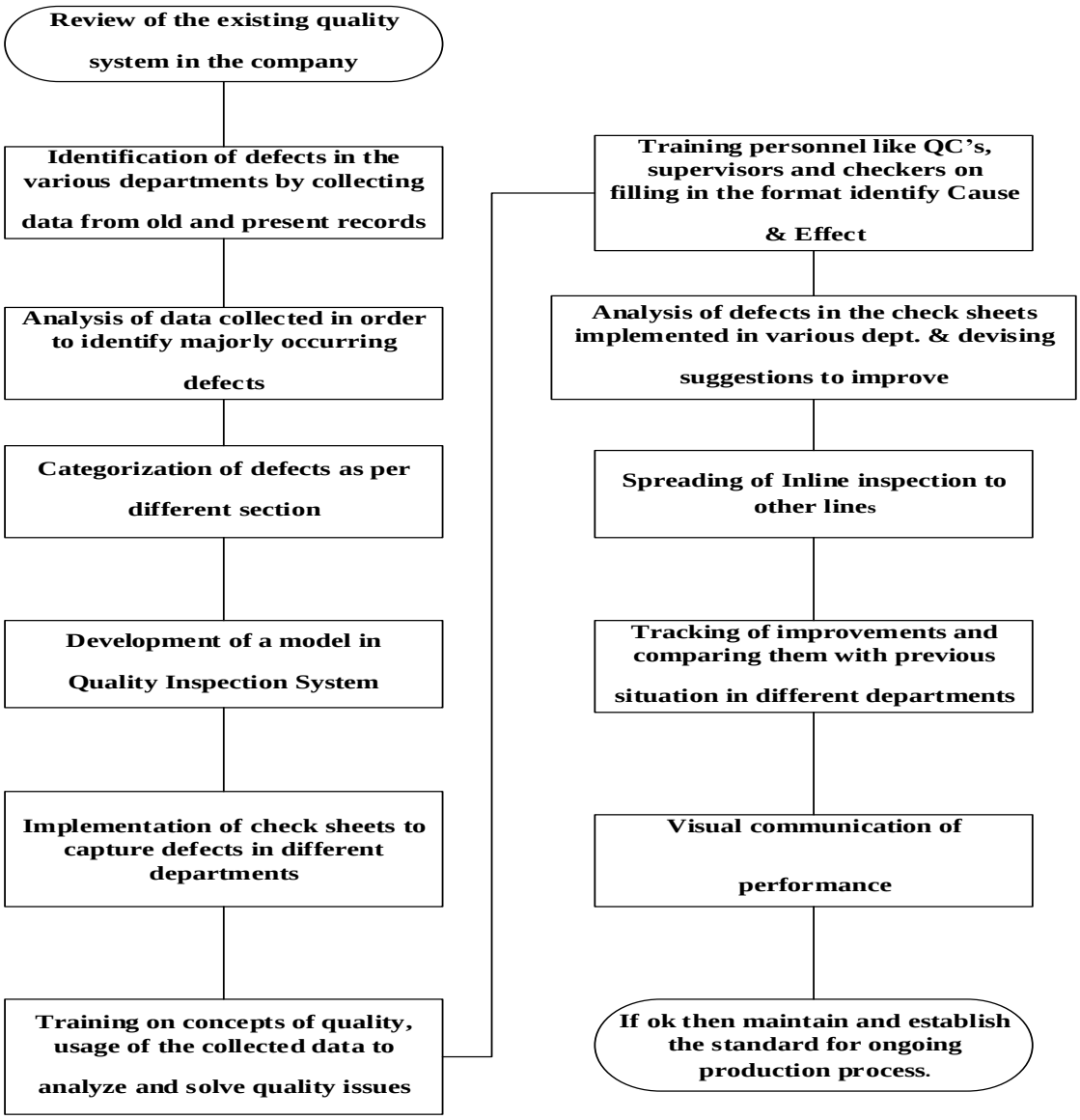

Fig 1. The general methodology followed to minimize the defects rate

(Source: The author)

Sewing Room Repair Standard Operation Procedures (SOP)

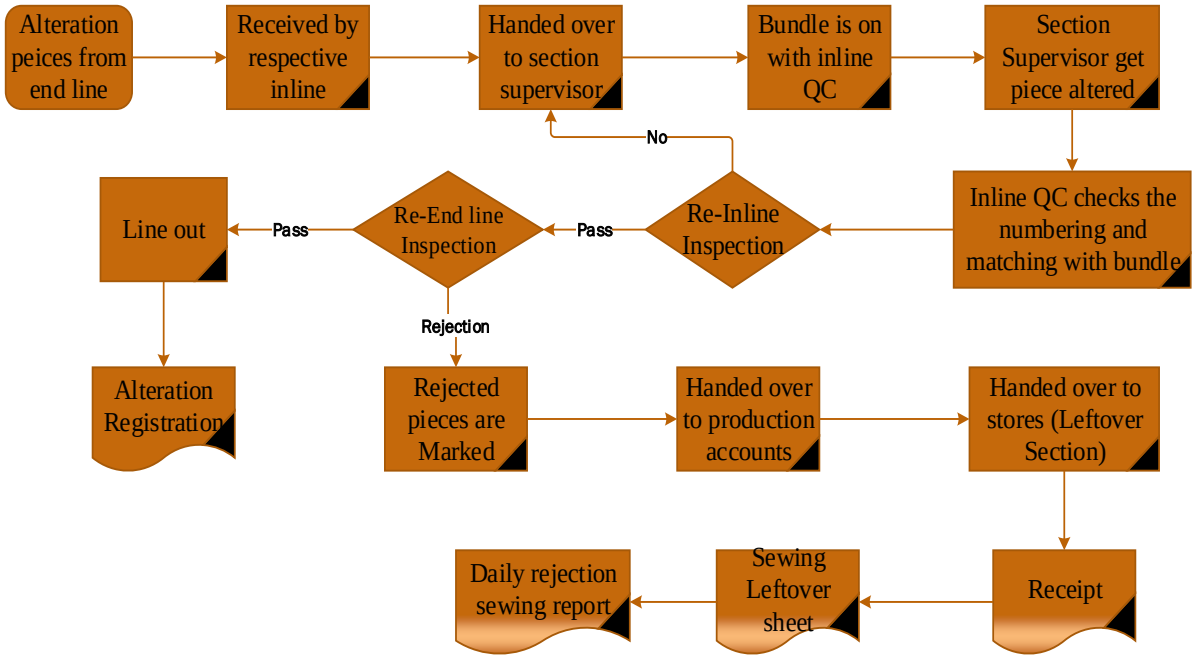

Fig 2. Sewing Room Repair SOP ***(Source: The Company)***

4.1. Sewing Section

Sewing is the process of joining two fabric portions together with needle and thread stitches. Sewing is one of the most fundamental tasks in the garment-making process. In the ready-made garment industry, the sewing department is the most important. In the sewing sector, many forms of faults or defects occur, which must be reduced to maintain the required garment quality. This article has shown all flaws made in the sewing sector of a garment manufacturing factory because of its importance.

Cutting, stitching, and finishing are all part of the Gullele clothing industry. We concentrated on the sewing section in this project because it is crucial to the industry's defect production.

Maintaining a high level of quality in any industry or business is critical to increase sales and build a better reputation among customers and competitors. Quality control is practiced in the garment industry from the beginning of the sourcing of raw materials to the end of the finished garment. Product quality is measured in terms of fiber, yarn, fabric construction, color fastness, surface design, and final finished garment items in the textile and apparel sector. Quality expectations for exports, on the other hand, are linked to client categories and retail locations. The garment industry's quality fitness is determined by a number of variables, including performance, reliability, durability, and the visual and perceived quality of the garment.

Quality has to be defined in terms of a budget. National regulatory quality certification and international quality programs like the ISO 9000 series establish broad quality requirements by which enterprises in the textile and apparel sector maintain export quality. Here are some of the most important fabric qualities to consider when making garments for export: -

The garment's overall appearance.

- The garment should be properly formed.
- The garment's feel and fall.

Physical characteristics

- The garment's colorfastness

Finishing characteristics

- Presentation of the finished product

Certain quality-related issues in garment manufacturing should not be overlooked.
Sewing faults include things like open seams, incorrect stitching techniques, the same color garment with different color threads, missing stitches in between, creasing of the garment, erroneous thread tension, and raw edges.
Color flaws: non-color faults that could arise include changes in the color of the final created garment compared to the sample displayed, incorrect color combinations for accessories, and dye mismatching between components.
Sizing flaws include: - Incorrect size gradation, differences in measurement across garment parts, such as sleeves that are 'XL' size but the body is 'L' size. It is also necessary to see if such flaws exist.

Faulty zippers, irregular hemming, loose buttons, raw edges, wrong button holes, uneven portions, inappropriate trimming, and fabric color differences are all examples of garment flaws that can arise throughout the manufacturing process.

Sewing defects

Sewing Section Defects: - In the sewing part, the following defects should be recognized and fixed: -
DefectsInSewing: -

1. Needle damage, such as a thread being pulled from the fabric or a large hole in the fabric.

2. A stitch that has been skipped

3. Drawn-off thread

4. Puffiness in the seams

5. Incorrect stitch density

6. Stitching that is uneven

7. Stitches that are staggered

8. A Faulty stitch

9. A smear or a patch of oil

Seaming Defects: -

1. Uneven width
2. Uneven seam line
3. Not secured by back stitch
4. Twisting
5. No matching of checks stripe
6. No matching of seam
7. Unexpected materials are attached to the sewing
8. Not sewn by matching face side or back side of fabrics
9. Use of wrong stitch type
10. Wrong shade matching of sewing thread

Assembly Defects: -

1. Defected finished components by size (e.g., poor size and shape of finished components)
2. Imperfect garment size
3. Misuse of a ticket
4. Any missing parts or a garment with a set design
5. Improper component alignment (i.e., buttons and hook)
6. Wrong interlining placement or creasing
7. Interlining stiffness or looseness
8. Folding of any clothing pieces that have a poor appearance.

Table-1: Defect category wise and percentage defectives in the sewing department

Types of Defects	Sewing cumulative Defects	Percentage defects (%)
Broken Stitch	98	27.22
Skip Stitch	19	5.28
Puckering	11	3.06
Uneven stitch	34	9.44
Hole/damage	16	4.44
Hook & Bar/Button	5	1.39
Raw edge	3	0.83
Up and Down parts	114	31.70
Shape out	10	2.78
Wrong size	17	4.72
Twisting	25	6.94
Shading	8	2.22
Total	**360**	**100%**

5. Pareto Analysis and Ishikawa Diagram (CED)

Pareto chart

Losses appear as a result of quality issues (defective items and their costs). The distribution pattern of this loss must be clarified as soon as possible. The majority of the damage is caused by a small number of faults, which may be traced back to a limited number of sources. Thus, if the causes of these critical errors are identified, we may remove practically all losses by focusing on these specific causes and temporarily ignoring the other numerous defects. We can address this type of problem quickly by using the Pareto diagram. The Pareto chart is a type of bar chart in which the values are plotted in ascending order from the largest to smallest. The most common defects, the most common causes of defects, and the most common causes of customer complaints are all highlighted using a Pareto chart.

Juran was also the first to recognize that the Pareto Principle can be applied to quality improvement. The foundation is to separate the critical vital few from the insignificant many.

Data from two months had been collected for this project to identify the key problems that cause frequent faults in the sewing process of Gullele garments (October and November, 2019).

The actual rejections (Tables 1 and 2) were divided into categories based on the flaws they contained.

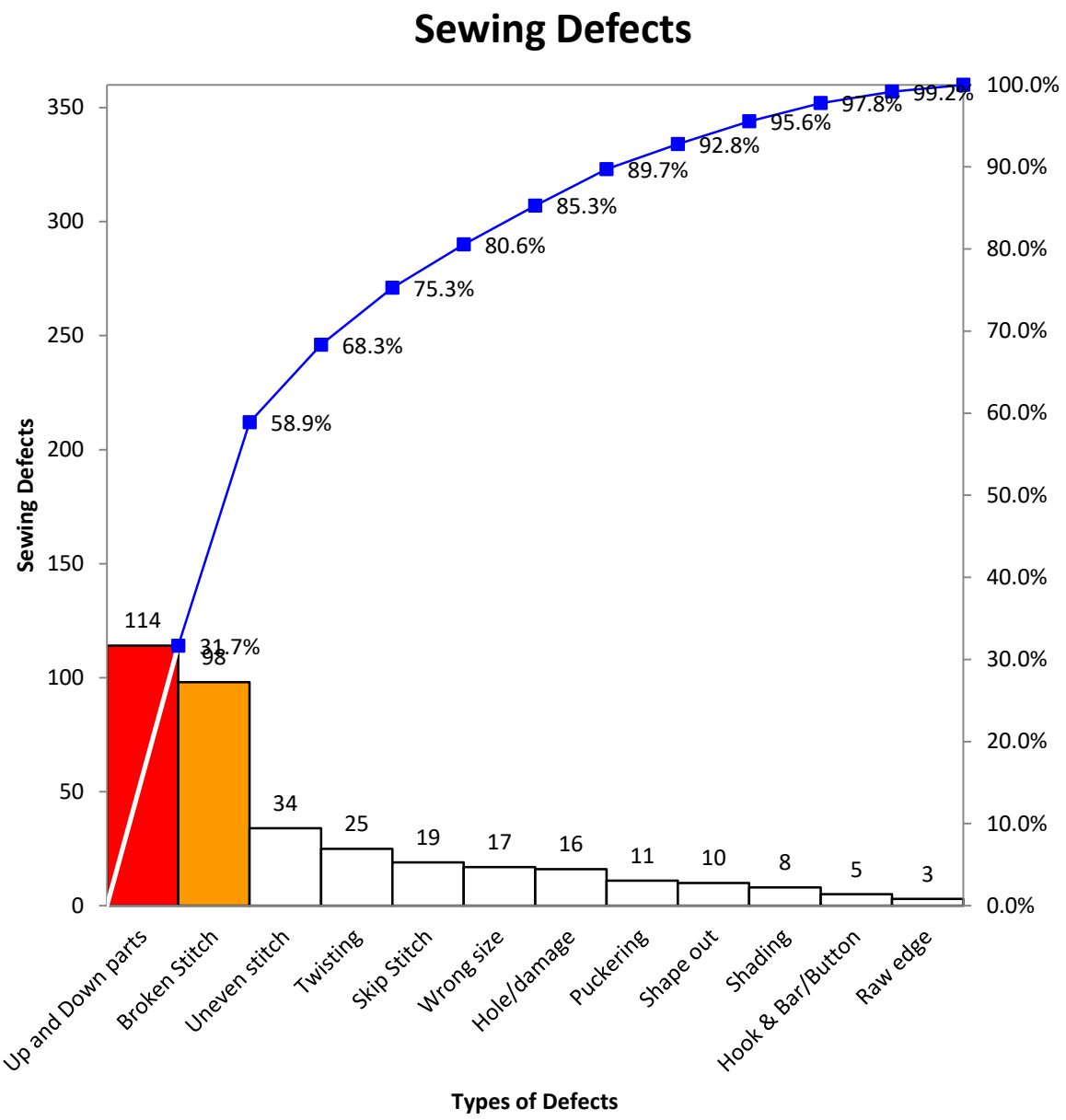

Fig 3. Pareto diagram analysis

A crucial view of the Gullele Garment was identified using the Pareto diagram above. This company's quality production is mostly influenced by up and down parts, which account for 31.7 percent of all problems. As a result, the second most common problem in the results is broken stitches, which account for 27.2 percent. On the basis of the cause-and-effect diagram, these two essential issues are explained below.

According to the preceding Pareto diagram, the most common flaws are the upand down components, which account for up to 31.70 percent of the total as shown in Figure 4. Broken stitches account for 27.20 percent of all defects, uneven stitch accounts for 9.44 percent, twisting flaws account for 6.94 percent, and skip stitch accounts for 5.28 percent. These five flaws are the "critical elements that account for 80.6 percent of the overall rejection in Gullele Garment's sewing process. Other flaws include incorrect size, holes/damage, puckering,

shading, form, raw edges, hook & bar/button, and joint stitches, among others. With a line of cumulative percent, Table 2 displays the percentage of each type of factor for failures in the process.
The data analyzed by the cause-and-effect diagram usually comes from a brainstorming session.
The quality team was organized bythe company and was composed of production managers, quality control,and line supervisors. Brainstorming rules were taught to these team members at the companyso to establish the cause-and-effect diagram.

The information used to create the cause-and-effect diagram is typically derived from a brainstorming session. The company's quality team was made up of production managers, quality control specialists, and line supervisors. These team members were taught brainstorming rules at work to create a cause-and-effect diagram.

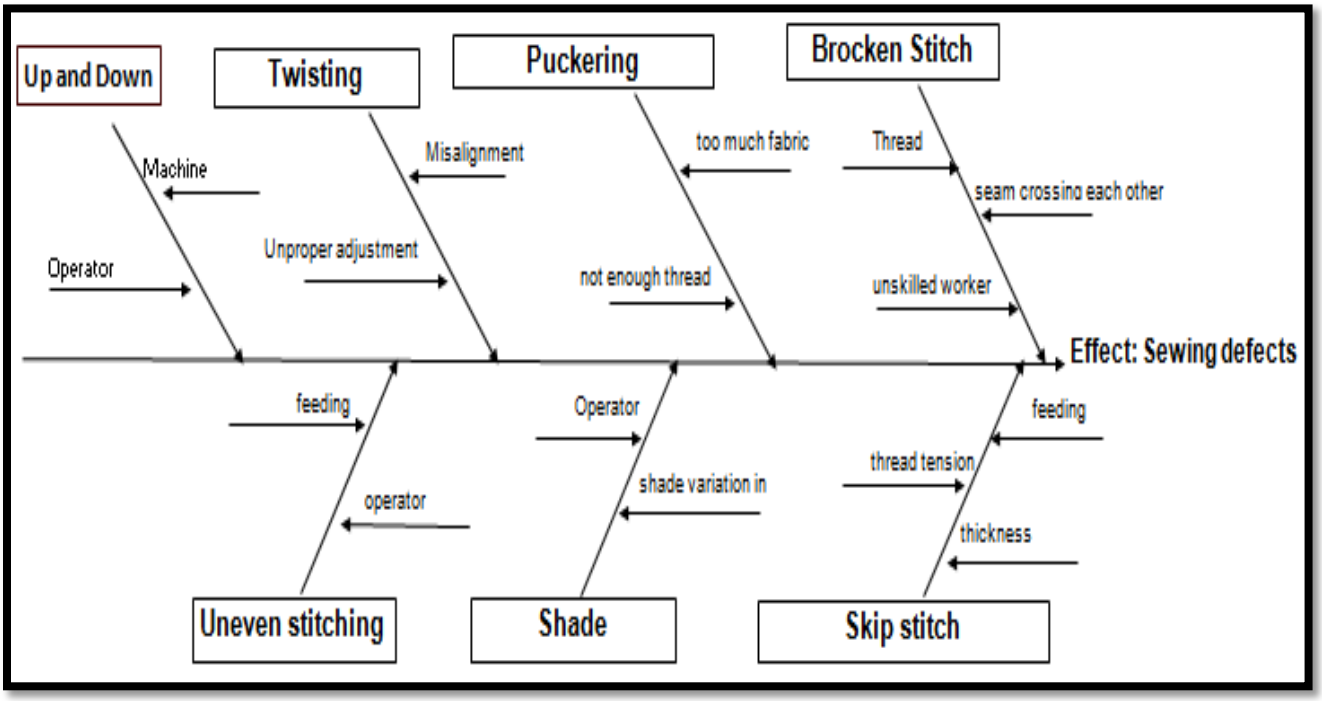

Fig 4. Cause and Effect (Fishbone Diagram) of defects in Sewing section

6. Results and Discussion

Based on the Pareto principal of 80/20 of 80/20 rule, in the sewingprocess department,it is found that up and down parts are the rank first defects as 31.70 %, then broken stitch is in rank second as 27.20 % of defects, then uneven stitch as ranked third as 9.44 % of defects then twisting type defect is ranked fourth as 6.94 % of defects and skip stitch 5.28% of defects.

The CED approach was utilized to discover the root causes in different processing steps of the production garment after learning about the top priority defect type.
The use of CED in the garment manufacturing industry opens up new possibilities for improving product quality (both final and intermediate) and increasing production efficiency. This can be performed by extracting and visualizing the knowledge that has been hidden in previously collected data.
Making the workplace clean – from the fabric store to cutting to sewing to washing and finishing – was advised as one of the finest methods to control defect generation within the production. Place the quality control system in the appropriate location. This refers to having a sufficient number of checkers, that they are trained,

that they make reports while checking, that they analyze the reports, and that they take action based on the quality check reports.
Conduct a training program for checkers on how to properly check pieces to catch defective ones. Employees should be taught how to make garment inspection reports. Organize a quality awareness program for your staff. Each employee must understand the quality standard, and everyone must work together to achieve the quality goal. The concerned department should not accept any work of poor quality. Operators on a sewing line are not permitted to leave the bundles open, and each bundle must be completed before moving on to the next. It will assist you in locating the lost pieces. When operators make a mistake or receive defective (incomplete) clothing from a previous operator, it is a commonpractice for them to dump pieces beneath tables. Nobody kept track of these missing pieces until you discovered a clothing shortfall in the finishing department.

Establish standard operating procedures (SOP) for each task that your workers complete. SOP for each department's quality control system. Set up an audit team to go over your quality system on a regular basis. These suggestions were made to each department separately. The percentage of defective items fell once the suggestions were implemented, as seen below.

The following solutions were proposed after a careful examination of the actual root causes of the defects: -

Table 2: Recommendations for Correcting Sewing Defects

Types of Defects	Rank	Root causes	Corrective Measures
Up and Down Parts	1	• Operator inattention • Machine's bottom and top parts are not properly attached	➢ Increasing the size of the bottom or top stop ➢ Paying close attention to the operation at hand
Broken Stitch	2	• Broken threads • Incorrect thread tension • Abrasive handling of pieces	➢ Thread trimming should not be done aggressively; ➢ Thread feed and tension should be managed; and ➢ Workers should be trained to handle the garment properly.
Uneven Stitch	3	• Feeding • Operator • Pressure	➢ Speed control ➢ Use proper pressure with skilled human labor
Twisting	4	• Misalignment • Trimming • Inadequate adjustment • Poor operator	➢ The front and back should be appropriately matched so that they are the same length. ➢ To ensure perfect alignment, notches may be employed. ➢ Ensure that the operator does not use scissors to cut the front or rear to make them the same length. ➢ Make sure the sewing machine is set up properly to feed the top and bottom plies evenly.
Skip stitch	5	• Thread tension is correct. • Use of needles that are bent	➢ Use needles that are strengthened. ➢ To ensure needle clearance, we use the needle guard. ➢ Maintain proper thread tension.

7. Conclusion

Ethiopia's textile sector is extremely important to the country's economy. The rapid expansion of the country's industry has not been matched by the expansion of backward connection facilities. As a result, producing a high-quality product is essential to being competitive in today's global market. Customer happiness is the ultimate criterion for quality. Good quality raises a product's value, establishes a brand name, and establishes a good reputation for the garment exporter, resulting in consumer happiness, increased sales, and foreign exchange for the country. The suggested tools established in this study play an important role in eliminating faults and reworks in the apparel industry's sewing section by ensuring excellent production. A manufacturer's product quality satisfies his clients at the price they are willing to pay, and he stays in business. As a result, failing to maintain a sufficient quality level might be disastrous. One of the methods for scientifically identifying and analyzing key issues that develop in processes is Pareto analysis. The perceived quality of a garment is the consequence of a variety of factors that work together to provide the buyer with the appropriate level of satisfaction. However, we must keep in mind that a 1% defective product for an organization is a 100% defective product for the client who purchases it. Clothing with a high level of comfort and the highest quality completed product is preferred in the long run. Examine the appearance and compare it to the sketch or photo. Check for any fabric flaws, sewing thread, seaming flaws, and other technical issues. All problems discovered during the final inspection should be recorded for quick rectification and to identify the requirement for Preventive maintenance at a given stage of production.

Finally, every connected worker in and reworks is required to work together to add value, improve quality, and give higher levels of service to consumers through "Right first time, right-on time, right every time."

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