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Research Article

Improving Quality, Productivity, and Cost Aspects of a Sewing Line of Apparel Industry Using TQM Approach

Raihan Ahmed Joy, Md Solaiman Hawlader, Md Saifur Rahman, Md. Rafayat Hossain, Shariful Islam Shamim, and Hosen Mahmud

Department of Industrial and Production Engineering, National Institute of Textile Engineering and Research (NITER), Dhaka, Bangladesh

Correspondence should be addressed to Raihan Ahmed Joy; raihanahmed221@gmail.com

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Total quality management (TQM) is a methodical strategy to minimize defects through six processes including choosing the manufacturer, gathering information, identifying the issues, analyzing the current situation, and coming up with solutions, putting the plan into action, data collection, and result analysis. The study investigates how quality, productivity, and cost aspects of a sewing line can be improved by implementing (TQM) approach in an apparel manufacturing industry in Bangladesh. This research concentrates on reducing four primary types of faults in the sewing department of DMC Apparels Ltd., such as uncut thread, up-down, broken stitch, and joint stitch. Proper information on several stitching errors was provided by the operators and helpers and those are used to assess the study in the next step. Performing the Pareto analysis and histograms to identify the primary concerns are part of the analyzing process. Moreover, using the 10 TQM pillars, the implementation step entails establishing the TQM mindset in the sewing line of the apparel industry. Several data-gathering methods are utilized to analyze primary data throughout the study's final phase. To analyze the acquired data, Microsoft Excel was employed. The percentage of defect per hundred unit was decreased by 1.51% after optimization, as the recommended solutions' impact on the defect level in the section was found to be quite significant. Significant parameters such as efficiency, quality, and cost aspect were analyzed and showed positive changes after implementing the TQM approach. The new technical layout also allows for the saving of five employees and a 3,000-min labor expense reduction. Finally, the research was completed by analyzing the basic pitch time graph and calculating the overall equipment effectiveness.

1. Introduction

The manufacturing sector of Bangladesh has been growing dramatically in recent decades because of the rising public demand, government initiatives, and increased interest of investors in the business. Unfortunately, there is still a lot of anxiety about the quality of locally produced goods. Only a small number of businesses offer excellent products that are well-liked by the clients. A small number of companies have advanced to the point where they can successfully implement the current quality concepts and practices, even though many of them have quality certificates. According to studies on product quality improvement, the use of modern quality philosophies and principles, such as total quality management (TQM), can result in higher customer satisfaction, increased profitability, and minimal losses. The measurement of a product's or service's level of acceptance is referred to as "quality."

The expense of producing a defective garment is completely squandered if a defect is found during the final inspection because the item cannot be shipped. Sometimes the flawed products can be modified to make them exportable, but doing so is more expensive and uses more resources to create the same goods. Defects at DMC Apparels Ltd. typically originate in the sewing department. The stitching section is the most crucial and challenging one to use. In this situation, sewing section flaws such as stains, broken stitches, skip stitch slip-outs, wavy stitches, etc., affect the factory's overall quality. Based on the company's daily rework rate, these faults cause the rework rate to exceed 7%. This rework rate is brought on by a variety of factors, including

poor thread quality, fabric flagging, needle deflection, and others. As a result, the needed quality standards will not satisfy the volatile organic compounds (VOCs). To reduce the rate of rework, it is essential to prioritize the faults over other issues. Several effective tactics are suggested by various authors, and PDCA (plan–do–check–act) is one of them. The reason PDCA was chosen is that it is a structured tool in the defining phase, making it simple to define the problem in the measurement phase. During the analysis phase, the causes of problems and the company's current performance can be evaluated by using it. Then the root cause removal procedure is improved during the improvement phase, and the benefits are maintained during the control phase, which comes after.

A company's quality plan should include TQM which must be applied to implement an organization's quality concept. To achieve customer satisfaction and organizational success, this concept refers to a management system that focuses on maintaining the highest level of quality at all levels of the organization, continuous improvement, high-product quality, teamwork, and collaboration among all stakeholders. As a result of globalization, Bangladeshi enterprises are getting access to foreign markets nowadays and many companies are looking for a more stable operating environment as a result. They are measuring how well their own company is doing by comparing it to that of the other companies. It has been emphasized how important TQM is to accomplish its goals. The TQM idea is currently being used by numerous companies across a wide range of industries to try and achieve their goals. On the other hand, many industrial enterprises in Bangladesh lack the necessary knowledge and expertise in the TQM practices.

In this study, an industry was selected and data were collected from the sewing operation of that industry at first. The main objective of this study was to improve the quality, productivity, and cost aspects of a sewing line by implementing the TQM approach. This study tried to find out the problems first. Cause-and-effect diagram or fishbone diagram, a quality tool was used to analyze each phase to find out the problems related to defects. After analyzing different problems, defects were identified in the sewing process. Corrective and preventive actions were also discussed to reduce the defects per hundred units (DHU) found in the processes for 12 days of investigation. By implementing the TQM approach and cellular manufacturing system (CMS) methodology, the total operations of the sewing line were broken down. After that, the total number of operators, the manpower, standard allowed minutes (SAM) was reduced and the efficiency was improved. Then the defects were analyzed graphically to show the rate of reduction after the implementation of TQM compared to before. Moreover, the basic pitch time (BPT) was shown graphically to show the real improvement in the process. The cost of a day was also minimized to $180 a day. Lastly, the productivity and overall equipment effectiveness (OEE) were calculated and improvements were shown there.

2. Related Research Work

The most basic definition of quality is that it meets the requirements of the client. To increase consumer happiness, many businesses, including Samsung in South Korea and Toyota in Japan, have prioritized quality and cost-cutting. In addition, several quality experts have defined the term "quality." The various levels of craftsmanship needed for various jobs are referred to as "quality" in this context. As a result, each business or activity has its unique definition of excellence. For example, "quality in sales" refers to the way customers are treated, "quality in manufacturing" to the way products are made, and "quality in garment manufacturing" to both the services and the products themselves [1].

According to the research, TQM implementation can improve an organization's capacity for competition and the development of strategic market advantages, and TQM policies can help an organization compete globally. Therefore, implementing a TQM system can result in a 90% improvement in laborers, operating procedures, employee happiness, and capital structure. Even though Saudi Arabia's manufacturing sector has grown significantly over the past 10 years, the bulk of goods' quality has not increased at the same rate. Poor user satisfaction (less dependable service at an increased cost) and business loss are the results, mostly at the international and national levels [2].

Attar et al. [1] wanted to survey current quality control practices within the manufacturing industries in the Western region of the Kingdom of Saudi Arabia. This research presented an evaluation of current quality control activities within the manufacturing industries in a specific region of Saudi Arabia to show the advantages of implementing the TQM technique. This study also tried to improve product quality and customer satisfaction [1].

Capon et al. [3] tried to find the role of measurements in a TQM program and the improvement of the rate of success after using the measures. Measuring and displaying the existing TQM results improves the rate of success in a TQM program [3, 4].

Chapman and Al-Khawaldeh [5] investigated the relationship between TQM and labor productivity. TQM was found as positively correlated with labor productivity [5].

Chan [6] tried to formulate both quantitative and qualitative performance measurements for easy and better understanding. Performance measurement details were listed to define five other performance measurements with the common aspects of cost and quality, and suggestions and guidelines were given. The analytic hierarchy process (AHP) was used to make decisions based on the priority of performance measures. This paper outlined the application and made the pairwise comparison to identify the importance of performance measurements [6].

Hendricks and Singhal [7] showed the impact of TQM on financial aspects, where practicing TQM can improve the financial performance.

Hlaing and Lwin [8] focused on how overall quality management affects financial issues. utilizing the tools of TQM to increase the quality of the product (check sheet, Histogram, Pareto chart, cause-and-effect diagram). When the authors' suggested methodology was used, the percentages of defects per hundred units (DHU) were compared between the original and final states. It was found that there had been a 66.762% drop in DHUs [8].

Lagrosen and Lagrosen [9] examined how different quality management approaches and technologies affect a company. It was discovered that good quality management and the adoption of TQM principles were statistically correlated [9].

Mann and Kehoe [2] elaborated the work on the main effects of TQM and other quality actions on the performance of a business. Implementing TQM has a beneficial impact on the performance of a business [2].

Quazi and Padibjo [10] conducted a pilot study that was carried out among a sample of local SMEs were evaluated, and the findings were compared to a similar study that was also conducted in Singapore. This paper also examined the results of follow-up interviews with some local SMEs and talked about the advantages and disadvantages of ISO 9,000 [10].

Rahman and Attar [11] attempted to look at the effects of TQM implementation in the industrial sector. TQM increases market share overall, customer satisfaction, and product quality [11].

El Shenawy et al. [12] synthesized the results of empirical research on the impact of TQM on competitive advantage. The components employed therefore provide a significant advantage [12].

Sjarifudin et al. [13] wanted to apply the six sigma methodology to men's formal jacket items in the apparel sector. Determining 5W + 1H by a focus group discussion (FGD) with five expert opinions was a novel method. The garment industry's production of formal men's coats grew and defects decreased when the six sigma method was applied to the DMAIC methodology [13].

Hlaing and Lwin [14] tried to improve product quality by reducing the defect rate using the DMAIC methodology of six sigma. The cause-and-effect diagrams were drawn to analyze the cause of the defects. The defect percentage has decreased from 21.484 to 4.952 and the sigma level has increased from 2.28 to 3.16 [14].

Syduzzaman et al. [15] studied the impact of implementing TQM principles in the manufacturing industry. Implementing TQM reduces alters in the production line [15].

Syduzzaman et al. [16] wanted to improve productivity, the quality of products, and quality of the garment industries of Bangladesh by implementing the TQM approach. Performing the study taking the help of the tools of TQM to analyze data which were collected through observation method. To see the significant number of changes or minimization of defects by applying this method [16].

Sun [17] clarified the elements of TQM and how they affect performance. Many TQM practices can contribute to the increase in customer satisfaction and the performance of a business [17].

Tannock et al. [18] evaluated the progress of four Thai SMEs that were implementing TQM over 2 years. They were assisted by a facilitator and a "model company". The efforts, causes of problems, difficulties, and lastly progress of the selected companies were described. It was found that the relative success of the companies was related closely to management and information issues [18].

Yusof and Aspinwall [19] wanted to fill the gap between large businesses and small businesses in terms of adopting many advanced management techniques including TQM. Building a framework for TQM implementation in SMEs is necessary to improve continuously [19].

Jadhav et al. [20] wanted to determine the average time needed to finish each step in the garment manufacturing process, compare the actual and basic times for each step, and provide suggestions for increasing the production rate based on the study. The article examined the production process of shirts and leggings over time. It details how long each stage of the clothing production process takes. One of the study's key conclusions is that increasing the industry's efficiency [20].

Shao et al. [21] tried the use of smart technology in the management of the sewing process, standard time in the process was predicted and computed, a machine learning prediction model was created, and model parameters were adjusted. Six factors such as sewing length, stitch density, bending stiffness, fabric weight, production amount, drape coefficient, and length of service were identified by correlation analysis. Next, a novel forecasting approach is put up to estimate the sewing process's standard time. By analyzing the performance using the mean-square error (MSE) and squared correlation coefficient, the suggested forecasting model is validated [21].

Peralta et al. [22] wanted to set time limits to reduce wasted time and unnecessary actions, such as talking on the phone excessively, taking tools and components from far away, and so on, thus reducing operating costs. Inefficient worker production and a lack of time standards caused delays for the workers which were found in this study when making square pant clothing. Recommended improvements include tightening up corporate policies, reorganizing the manufacturing floor, offering incentives and prizes, training employees, and establishing new time standardizations [22].

Hasan [23] wanted to gain a better understanding of the entire process flow of the clothing manufacturer, with a focus on cutting, finishing, and a single sewing production line, to picture value stream mapping, and to evaluate production lead time, processing time, retention time, process technique study, and production line architecture as a component of value stream mapping. Using VSM as a lean tool to boost productivity at a particular clothing company is the subject of a single case observation. Value stream concepts are used to explain cutting section and sewing line state mapping for both the present and the future. This was examined alongside the standard minute value (SMV) computation of the process lead time, which represented productive and nonproductive time [23].

Fahad Halim and Hawlader [24] demonstrated how to properly use work aids to reduce operation cycle durations in comparison to the present, which can improve SMV, production, and product quality while also lowering manufacturing costs. The phases involved in making pants and jackets, the kinds of machinery used in each step, the number of workers on a sewing line, SMV, and the daily output of those associated clothes were recorded. Data were gathered both when the clothing was made on the sewing line with sewing work aids and when it was produced without them. This experiment showed that, with the right use of work aids,

operation cycle times can be shortened compared to current times, which can have a positive impact on SMV, production, and product quality as well as lower manufacturing costs [24].

Several types of research are conducted based on the implementation of TQM. Productivity improvement and reduction in defects are shown in those works. Our research is also focused on these two things, additionally, we tried to show the causes and effects of those defects, BPT or basic pitch time analysis for comparison, machine utilization alongside production summary, and OEE calculation considering six different factors. So, we tried to show the details of activities related to a sewing line in the apparel industry to measure the output more precisely.

3. Experimental Procedure/Methodology

Analysis of previous research papers and works linked to TQM paved the way for more development. Over the last several years, quality management research has become increasingly popular. Furthermore, researchers are interested in exploring the topic due to ever-changing client demand and a tough worldwide market. They investigate the correlation of TQM with the productivity aspects of manufacturing industries. This thesis work was initiated to maintain a long-term TQM framework to produce high-quality results. In this case, it was important to generate concepts and identify the objectives of this important study. At the time of application, the concept and framework are needed to be designed and implemented. The study demonstrates how systemic framework development and data collection can be accomplished.

3.1. Flowchart of Methodology. Sequential research diagrams can be utilized in a variety of ways to ensure the effectiveness of the study. To perform and finish the entire process, this study will adhere to a clearly defined sequence of steps shown in Figure 1.

3.2. TQM Pillars and Their Application. Although, the definition of TQM appears straightforward, its practical application necessitates the establishment of a corporate culture and climate. According to some experts, it can take up to 10 years to fully appreciate the benefits of quality management implementation as an organization must go through several procedures before switching to quality management. TQM places a strong emphasis on customer-defined quality, strategic planning as the main focus, top-level management leadership, employee responsibility at all organizational levels, continuous quality improvement as a means of achieving strategic goals, management and employee collaboration, the application of statistical process control (SPC), and ongoing improvement via workforce education and training. We have acquired in-depth knowledge about the basis of TQM from the literature. For a successful adoption of TQM, some authors suggest four pillars, while others suggest nine pillars. However, we have chosen 10 pillars, which are shown in Figure 2.

3.3. Defects Identification and Measure Action. Various sewing defects are found in the industry which is related to DHU in decreasing the quality of the product. The three categories of defects are considered based on frequency and effects of the quality of the product. Based on the defects category the four defects are considered for applying the corrective and preventive action to reduce the DHU. Table 1 shows the actions needed to improve the quality by using various continuous improvement techniques.

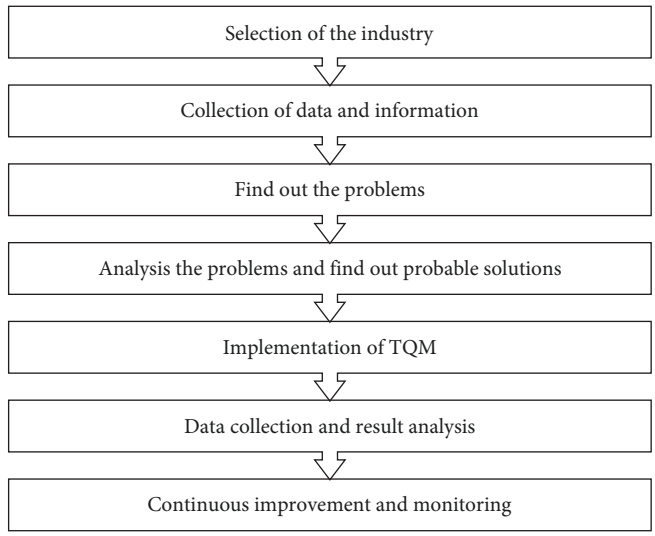

Figure 1: Steps involved in research work.

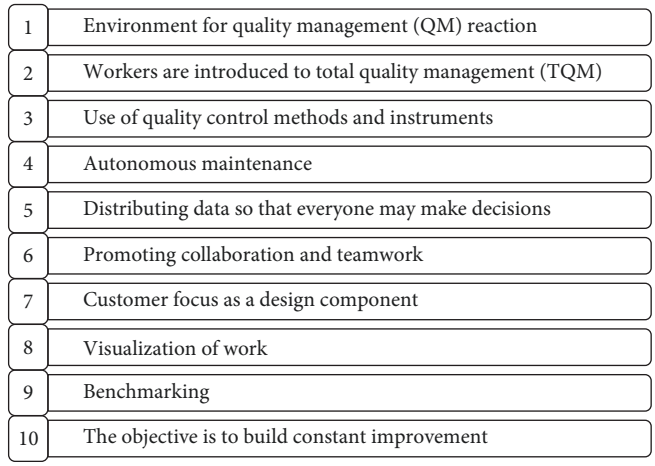

Figure 2: Pillars of TQM.

3.4. Data Collection. A complete garment production has some specific process to make the final output from raw materials. Sewing is one of the most important processes among all sections where maximum value-addition processes are required for achieving the organizational goals. To complete this work, a garment style was taken for analysis of the process for achieving our research goals of this paper.

3.4.1. Operation Breakdown Summary. A proper breakdown is analyzed here to show the effect after implementing TQM in the sewing line. By implementing the TQM approach and cellular manufacturing system (CMS) methodology, the total operations of the sewing line were broken down accordingly. The total working minutes were fixed in this investigation.

Table 1: Corrective and preventive action for reducing defects.

Defect name	Corrective action	Preventive action
Uncut thread	1. This process is strictly maintained by the maintenance team with appropriate inspections	1. All machines must be configured according to specifications and require accurate machine maintenance
	2. The machine wiper has previously been configured appropriately by this process maintenance crew	2. The maintenance crew needs to thread-trim the working wipers
	3. The line leader and operator have already received advice regarding the thread trimming issue	3. The leader should educate and teach the operator, and follow-up on accurate thread trimming should be ensured
	4. The thread trimming technique training system has already been started by the line leader	4. The assistance operator should practice thread trimming in a clockwise direction
	5. Everyone who is trimming has already been counseled and cautioned about inappropriate trimming	5. Because all of the trimmers have received training and are aware of the negative effects of bad trimming, they will all recover
Broken stitch	1. The complete machine has already been modified to account for the fabric's characteristics and customer requests	1. According to the fabric's characteristics, all thread tension should be adjusted before manufacturing starts
	2. The marketing team has already had a conversation about the issue, and steps have been taken to secure a high-quality thread	2. The marketing team should guarantee proper thread quality before reserving the thread
	3. We already maintain this web structure, and this work is ongoing	3. Line QC should be done before production starts to make sure that all thread supply routes are working properly
	4. Operator training has already been used to put this into practice	4. It is necessary to train the operator's method before manufacturing can start
	5. After receiving training, the operator and section leader are now in charge of maintaining all procedures	5. The section leader must offer proper follow-up and the operator or assistant must get training
Down stitch	1. Operator and machine upkeep before beginning the stitching, check the machine guide	1. The machine guides need to receive the proper maintenance
	2. The repair crew has already acted by carrying out the buyer's requests	2. During the line layout time, all damaged components should be replaced if necessary, and the problem will then be fixed completely
	3. Instruct the maintenance crew to fix it by the need	3. The machine maintenance staff does the necessary repairs
	4. The operator has already been instructed on how to do the process correctly	4. The operator needs to be in a dense area
	5. The system for training operators about critical processes and how they recover has begun	5. All operators must receive thorough training and instructions on how to perform their work obligations
Joint stitch	1. This is the continual process to which we are obligated	1. Make use of good thread, a suitable needle, and a fid dock
	2. Recommend and start using this procedure; tightly control it	2. After determining how many pieces may be sewn with one loaded bobbin case, the operator should replace it
	3. Machine upkeep has taken proper action to set up the machine properly with the appropriate follow-up	3. The needle should be correctly adjusted during machine maintenance
	4. We instructed the operator on the trimming issue and gave them advice	4. Awareness of the significance of meticulously cutting people's threads and, if required, completely opening the process and restitching
	5. As this procedure is already underway, we encourage the operator to keep a constant eye on it	5. Explain the alter-rectify process to the operator

However, the actual average output, line balance efficiency, and output per machine per day were increased. Machine utilization is also described below to show the improvement. The operation breakdown enlists only processes with SAM except for all other criteria that are essential for complete garments. The complete operation breakdown is listed below in Table 2.

3.4.2. Defects Summary. Defects are a very common phenomenon in any process for production procedures. Defects affect the production processes as well as incurred costs for rework. For this study, the defects were collected consecutively for 12 days (2 weeks) based on sewing operation. Tables 3 and 4 show the breakdown in the process accordingly with quality standards of the garments before and after applying TQM philosophy with 10 pillars as well as applying corrective and preventive action.

4. Result and Discussion

Results and discussion will be presented in some steps accordingly.

Table 2: Operation breakdown for sewing section of a garment.

SL	Processes	SAM	SL	Process	SAM	SL	Process	SAM
1	Coin pkt rolling	0.20	18	Two-part join	0.18	35	Check & trimming	0.21
2	Coin pkt marking	0.20	19	Two-part top stc	0.19	36	S/Seam join	0.51
3	Coin pkt attach	0.21	20	Front part edge overlock	0.40	37	Side seam safety stc	0.35
4	Facing overlock	0.18	21	Back pkt Rolling	0.06	38	Over-hip top stitch	0.35
5	Facing attached to pocketing	0.26	22	Back pkt edge overlock	0.20	39	Waist run stc	0.20
6	Pkt bag overlock	0.20	23	Loop make (CPU)	0.08	40	W/B tack remove	0.15
7	Pkt bag turn and top stitch	0.28	24	Bk. pkt attach	0.34	41	W/B attach to body	0.35
8	Pocket bag bartack-2x	0.11	25	Bk. Yoke join	0.20	42	W/B excess cut and tr. open with turn	0.60
9	Care label poly and attach with poly with pkt bag wash	0.36	26	Check & trimming	0.18	43	Mouth closed with mark	0.70
10	S/F & D/F overlock	0.20	27	Size label attach	0.18	44	Coin pkt-2x, Fly-3x & Cord stc-2x bartack-7x	0.35
11	Front rise overlock with S/F	0.20	28	Bk part edge overlock	0.37	45	Back pkt bartack-3x	0.18
12	S/F top stc & trimming for overlock	0.20	29	W/B match & tack & loop bundle match	0.20	46	Bottom hem overlock	0.32
13	Zipper join with S/F	0.17	30	Front and back assorting with opening mark	0.28	47	Loop attaches with Bartack-10x	0.30
14	"J" round stc	0.19	31	Inseam join (*for left*)	0.25	48	W/B mouth hole	0.08
15	Front pkt attach with mouth top stc	0.42	32	Inseam join (*for right*)	0.25	49	W/B mouth tack	0.08
16	Side & waist tack	0.42	33	Check & trimming	0.21	50	Btm cut	0.55
17	D/F join	0.17	34	Front @ back rise join	0.42	51	Btm bartack-4x	0.20

Table 3: Defects data before TQM for 12 days.

DHU before implementing TQM													
Defects	Week 1							Week 2					Grand total
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	
Uncut thread	48	44	47	46	46	43	45	42	46	46	43	44	540
Updown	19	19	20	18	20	19	17	19	18	18	19	17	223
Broken stitch	26	26	28	26	28	26	25	23	27	24	26	26	311
Joint stitch	16	16	17	17	18	15	16	16	17	15	16	16	195
Raw edge	8	8	9	7	8	6	7	5	6	7	6	7	84
Open seam	5	5	6	6	5	6	6	5	6	6	6	4	66
Pleat	4	4	4	4	5	4	4	4	4	4	4	3	48
Skip stitch	7	7	7	7	8	5	7	6	7	7	8	5	81
Twisting	2	2	3	3	3	3	3	2	3	3	3	2	32
Uneven	7	7	5	7	6	5	5	7	5	7	6	5	72
Others	30	27	21	21	21	20	18	20	16	18	23	18	253
Total	172	131	141	134	141	127	130	122	134	130	131	124	1,580
Production	2,151	2,165	2,064	2,090	2,156	2,070	2,065	2,054	2,161	2,144	2,070	2,151	25,341
DHU	8.00%	6.05%	6.83%	6.41%	6.54%	6.14%	6.30%	5.94%	6.20%	6.06%	6.33%	5.76%	7.52%

4.1. Analysis of Defects with QC Tools. The Pareto chart, sometimes referred to as Pareto analysis, is a statistical technique for choosing a small number of tasks that have a substantial overall impact. It applies the Pareto principle, which holds that 80% of the benefits of accomplishing the complete job can be obtained by doing just 20% of it, or in terms of quality improvement, most issues (80%) are brought on by a small number of crucial factors (20%). The 20% flaws that caused 80% of the problems were discovered after all the data from the check sheet was shown in a Pareto chart. Uncut thread, up-down, broken stitches, and joint stitches make up 20% of faults based on the 80–20 rule according to Figure 3. Also, the defects were categorized according to their importance and severity, which are shown in Table 5.

Table 4: Defects data after TQM for 12 days.

Defects	DHU after implementing TQM												Grand total
	Week 1							Week 2					
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	
Uncut thread	41	38	36	37	34	35	33	33	31	30	31	31	410
Updown	15	15	14	15	13	14	13	13	12	12	12	12	160
Broken stitch	23	22	21	22	20	21	19	20	18	17	18	18	239
Joint stitch	13	12	12	12	11	11	11	11	10	10	10	10	133
Raw edge	8	8	8	8	7	7	7	7	7	6	6	7	86
Open seam	5	5	5	5	5	5	4	5	4	4	4	4	55
Pleat	4	4	4	4	3	3	3	3	3	3	3	3	40
Skip stitch	7	7	6	6	6	6	6	6	5	5	5	5	70
Twisting	2	2	3	2	2	3	2	2	4	2	2	3	29
Uneven	7	7	6	6	6	6	6	6	5	5	5	5	70
Others	20	22	19	21	19	21	19	19	19	18	20	19	236
Total	145	142	134	138	126	132	123	125	118	112	116	117	1,528
Production	2,156	2,152	2,152	2,128	2,139	2,110	2,076	2,066	2,088	2,076	2,161	2,103	25,407
DHU	6.73%	6.60%	6.23%	6.48%	5.89%	6.26%	5.92%	6.05%	5.65%	5.39%	5.37%	5.56%	6.01%

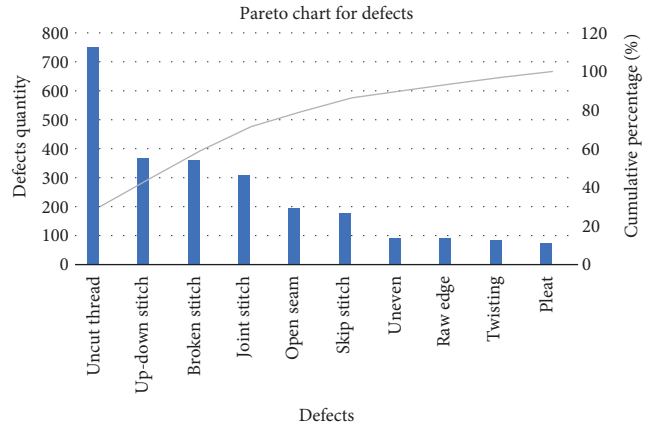

Figure 3: Top 10 defects without TQM.

Table 5: Defect categorization.

Defect name	Minor defect	Major defect	Critical
Broken stitch	—	✓	—
Drop/skip stitch	—	✓	—
Needle hole	✓	—	—
Joint stitch	—	✓	—
Up-down	—	✓	—
Uncut thread	✓	—	✓
Twisting	—	—	—
Pleat	✓	—	—
Open seam	✓	—	—
Uneven	✓	—	—

The causes of the development of a flaw were determined using a cause-and-effect diagram. Four serious faults were detected and evaluated to reduce the number of serious defects. Figures 4–7 represent many reasons behind the different defects by using the cause-and-effect diagram. The four major defects have some obstacles which are related to man, machine, method, and material. Finally, Figure 8 shows the defects graphs.

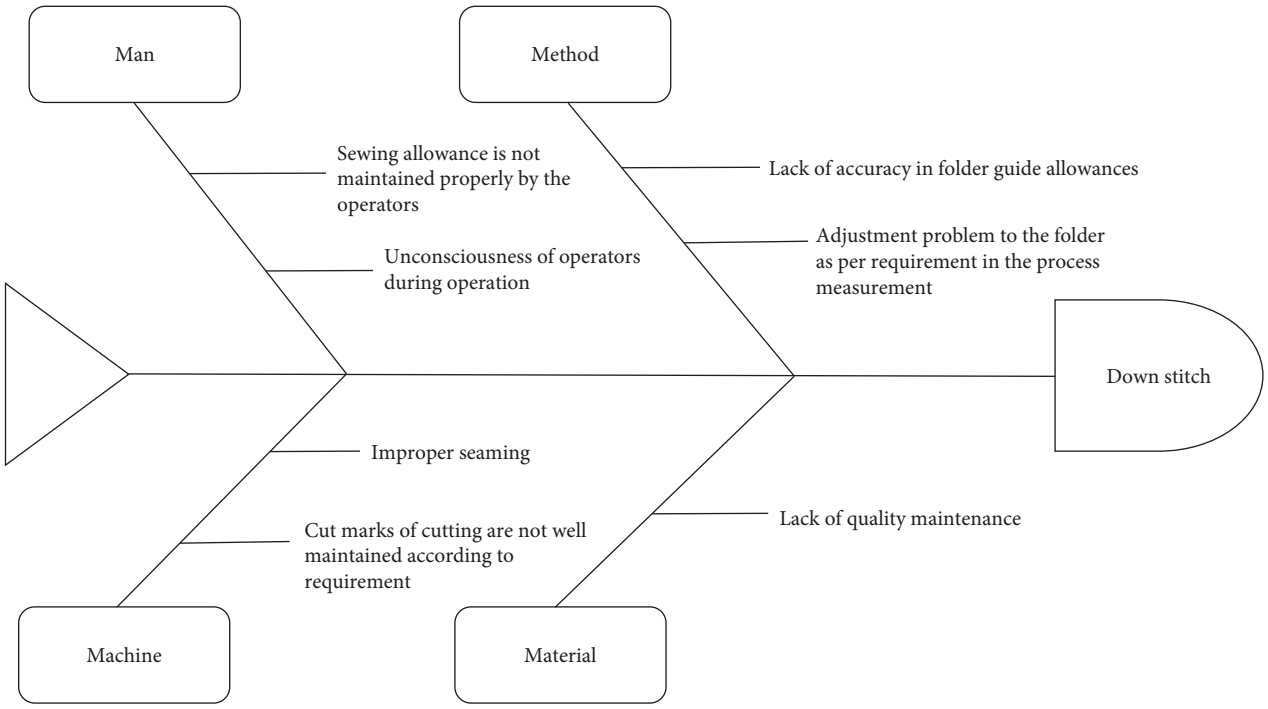

Figure 4: Cause-and-effect diagram of down stitch.

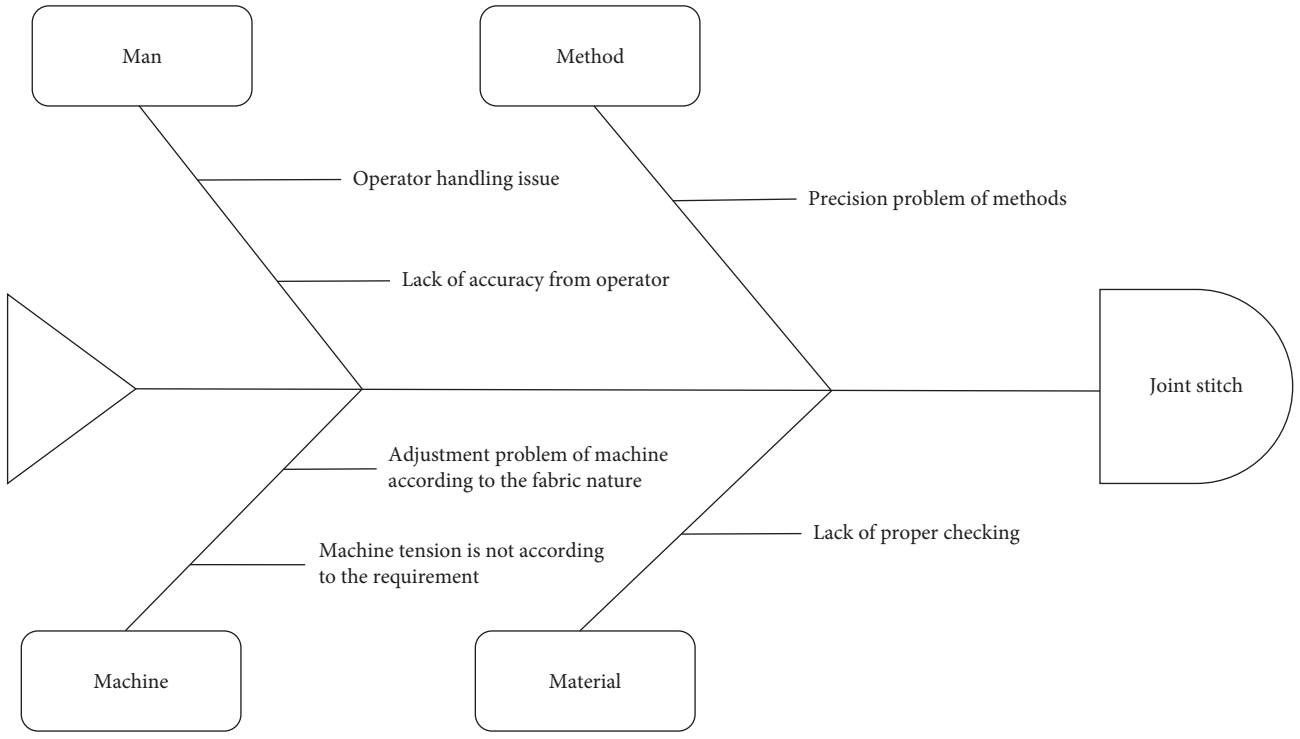

Figure 5: Cause-and-effect diagram of joint stitch.

Figure 9 shows the defects graphs for four serious defects (uncut thread, joint stitch, up-down stitch, and broken stitch) accordingly for 2 weeks.

Here, Figure 10 describes the BPT analysis to compare precisely between the quality conditions before and after the implementation of TQM. We can see the processes which ones are in control or which ones are out of control in between the control limit.

After analyzing all the defects applying several methods, now it is high time to show the summary of production.

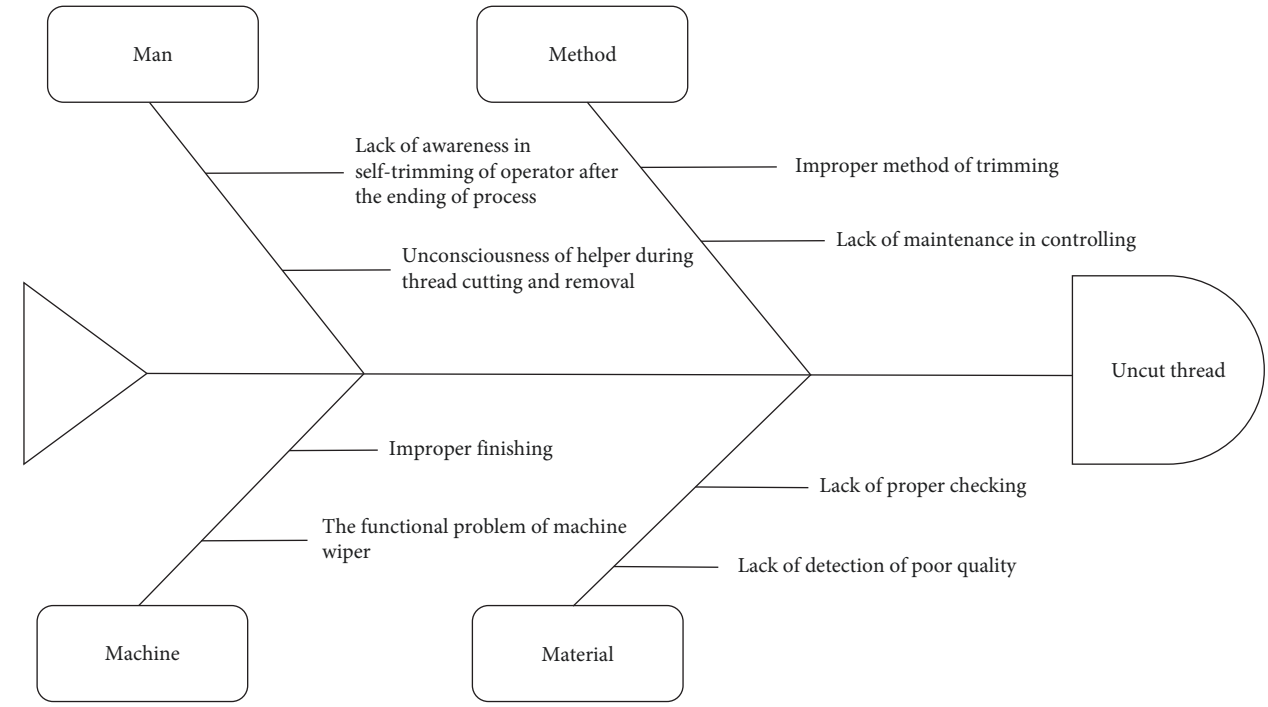

Figure 6: Cause-and-effect diagram of uncut thread.

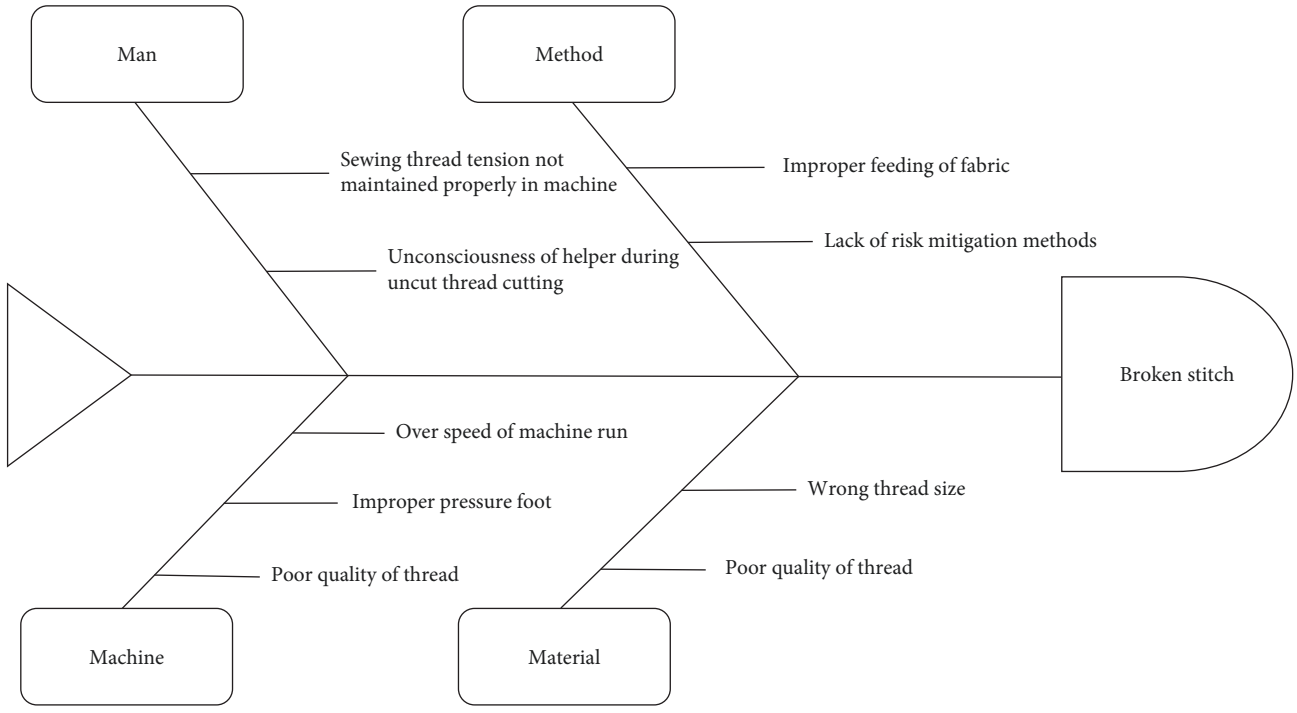

Figure 7: Cause-and-effect diagram of broken stitch.

Significant improvements were noticed in several important factors which are demonstrated in Table 6. Machine utilization summary are also analyzed in Table 7, which shows significant savings, actually improvement.

4.2. Quality and Productivity Improvement with Cost Reduction. Analyzing defects (both before and after TQM deployment) is followed by a discussion of quality and productivity analysis. Following accurate calculations of performance,

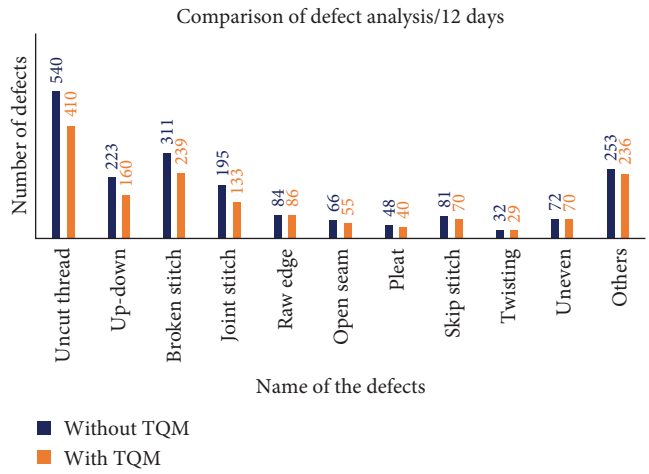

Figure 8: Comparison of defects with and without TQM.

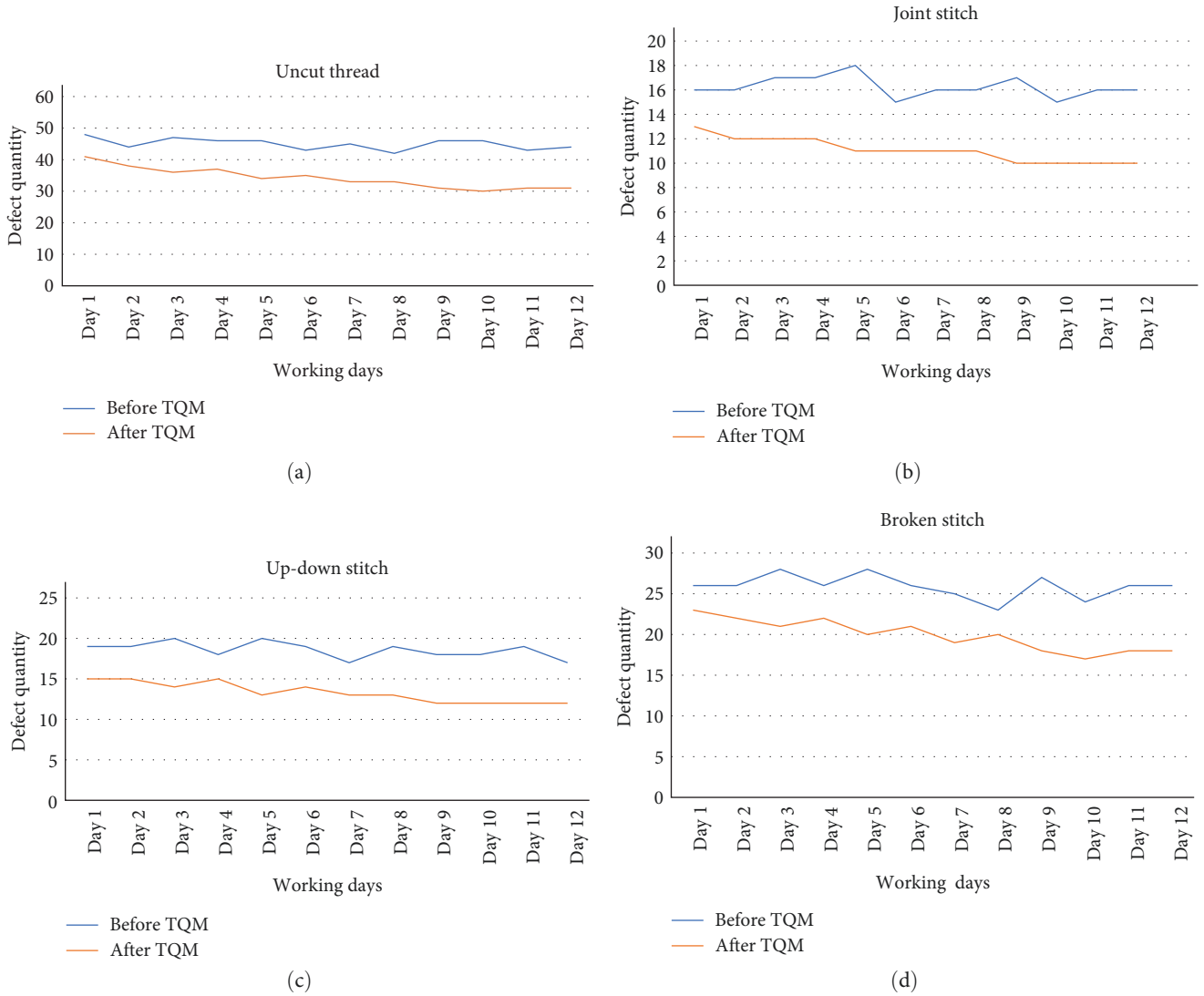

Figure 9: Defects graph for 12 days: (a) uncut thread, (b) joint stitch, (c) up-down stitch, and (d) broken stitch.

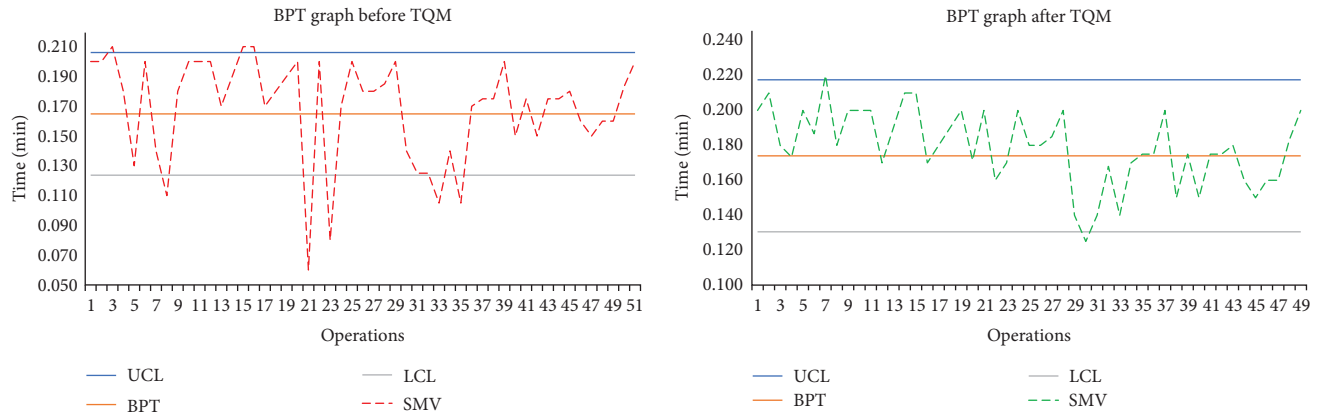

Figure 10: Basic pitch time (BPT) graph before and after TQM.

Table 6: Production summary and improvement analysis.

Production summary			
Criteria	Before TQM	After TQM	Savings/improvement
Actual average output (for 12 days)	2,111	2,117	6
Working minutes per day	600	600	0
Operator required	68	65	3
Helper required	13	11	2
Total manpower required	81	76	5
Total SAM	12.53	12.33	0.20
Line balance efficiency	88%	93%	5%
Output per hour (Pcs)	320	320	0
Total expected output (Pcs)	3,200	3,200	0
Output per M/C per day (Pcs)	47	49	2

Table 7: Machine utilization analysis.

Machine utilization summary			
Sewing machines	Quantity		
	Before TQM	After TQM	Saving
SNLS w/UBT	27	26	1
DNLS F/B	4	4	0
3THOL	3	3	0
Bartack	5	4.5	0.5
4THOL	8	8	0
Auto "J" stitch	1	1	0
Auto rolling Mc	1	0.5	0.5
Flat lock flat bed w/UBT	1	0.5	0.5
Auto pocket setter mc	2	2	0
FOA	8	7.5	0.5
5THOL	3	3	0
Kansai	2	2	0
Auto loop setter	2	2	0
Eyelet B/hole	0.5	0.5	0
Button attach	0.5	0.5	0
Total	68	65	3

Table 8: OEE calculation.

Factor	Category	Before TQM	After TQM	Factor	Category	Before TQM	After TQM
Availability	Manpower	81	76	Efficiency	Manpower	81	76
	Working hour	10	10		Working hour	10	10
	Working minutes	600	600		Working minutes	600	600
	Machine quantity	68	65		Available minutes	48,600	45,600
	Loss time	680	600		Production quantity	2,111	2,117
	Operating time	40,170	38,370		SAM	12.53	12.33
	Available time	40,800	39,000		Earned minutes	26,450	26,102
	Availability %	98.46	98.38		Efficiency %	54.43	57.24
Performance	Production quantity	2,111	2,117	Quality	Total production	25,431	25,407
	SAM	12.53	12.33		Defect quantity	1,905	1,528
	Earned minutes	26,450	26,102		Good output	23,526	23,879
	Operating minutes	40,170	38,370		DHU %	7.49	6.01
	Performance %	65.85	68.03		Quality %	92.51	93.99
Quality	Total production	25,431	25,407	Cost	Manpower	81	76
	Defect quantity	1,905	1,528		Working hour	10	10
	Good output	23,526	23,879		Working minutes	48,600	45,600
	Quality %	92.51	93.99		CPM*	x	y
Overall	OEE %	59.97	62.90		Production cost	48,600x	45,600y

*CPM values depend on the total cost of the organization ($x \geq y$).

availability, and quality, the OEE is determined in Table 8. The significant development of OEE is seen here. Moreover, the efficiency and quality aspects are also analyzed and found the development after applying TQM. Lastly, another important parameter that is called cost aspects, is also analyzed. The total production cost is seen to be decreased depending on the total cost per minute (CPM) values.

5. Conclusion

No industry could thrive in the competitive atmosphere of today's market if it did not make an ongoing effort to improve the effectiveness of its operations. In our study, we examine how an industry may employ the TQM idea to raise quality, and productivity and to reduce cost. It has been found that the garment industry can implement TQM by creating and putting into practice its pillars. It can improve quality and worker satisfaction by taking an appropriate approach to the creation of a quality full environment, encouraging collaboration and teamwork, developing products with a focus on the customer, and designing processes. Lowering mistakes and reworking can produce considerable advantages when TQM technologies are used to analyze the process and product quality. This research discusses many of the sewing mistakes or defects that could occur as well as possible remedies or solutions. To guarantee product quality, faults must be kept to a minimum. The Pareto chart showed that more than 80% of the errors detected in the stitching of the denim item made by DMC Apparels Ltd. could be attributed to a total of four flaws. After identifying the key defects, the cause-and-effect diagram was used to identify the most likely reasons, and any potential root causes were then identified using root cause analysis, physical inspections, and reviews. This strategy has had a great deal of success in reducing errors. Continuous application of this methodology will allow the company to further reduce its failure rate and increase productivity because defect minimization is a continuous activity. The current study, which is primarily focused on the sewing component, can be more beneficial in minimizing errors than an integrated analysis of the other factory sections, such as knitting, dying, cutting, and finishing.

6. Future Recommendation

The TQM philosophy has only been implemented in a small number of the clothing manufacturing industries because it is a very broad concept that requires changing the organizational behavior of the factory. The factory's sewing line configuration must be altered by the suggested line structure. The cost aspect is an important concern for any industry. In our research, we analyzed the cost aspect by calculating manpower and the working hour, respectively. CPM was not possible to know accordingly. So, anyone can investigate the CPM and may analyze further to complete the proper analysis of the cost aspect. Altogether, this research conveys the industries a great message regarding the improvements in implementing TQM.

Data Availability

The data of this manuscript are taken practically and properly analyzed in the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The urgency of this study was to ensure a better outcome in an apparel industry. The authors of this study visited that industry, observed every related activity and took the data practically. A small amount of funding was needed to complete this investigation. The funding was funded by the authors themselves. The fund was needed for the transportation purpose and other general activities. We have not mentioned any financially supporting body as no huge funding was needed to complete the study.

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