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Quality improvement through export item rejection reduction using the implementation of statistical quality control (SQC) tools: a case study

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A B S T R A C T

Garment sector is one of the industrial sectors in Ethiopia. In this sector the final products are always with defect(s) which reduces attraction from customers and economic benefit from the business. With this intention, quality enhancement of shirt products through defect(s) rejection reduction using SQC tools was a vital task of this research. The study applied Pareto Analysis and Cause-and-effect diagrams for detailed examination of top defects. From the Pareto-analysis six top defect types; cuff assembly seam slip out, sleeve hemming, button slip out, side seam puckering, button missed, and placket seam out have been identified. These defects contributed 81.68% of all defects happening in the case company. Then root-cause analyses for these top defect types have been done and solutions have been suggested to overcome causes to reduce rejected shirts. Finally, the suggested solutions have been practically implemented through the organized implementation team from different departments of the case company including the researcher. This has given remarkable results of almost 67.3%, 2222 shirts, of export rejected shirts have been saved. These saved shirts have been exported additionally to the international market in line with the defect free products of that month and increased the income of the case company by 444,400 ETB to 555,500 ETB per month.

1. Introduction

Garment industry in the Ethiopia has great advantages to the investors as a business, employees as an employment opportunity and Ethiopian government as a source of hard currency. The Ethiopian government has focused on the garment sector that has the greatest market potential in Africa, Europe and western for garment products[1]. Sustaining in the market is crucial for continuing the business, however the products in the sector had rejected garments after sewing and inspection. Therefore, to benefit from the sector improvement of the quality of products through minimization of defects be done (Tejaningrum, 2017). Applying practical implementation of statistical quality control (SQC) tools is very important in identifying and solving quality related problems in production and service giving industries to increase competitiveness and business performance(Memon et al., 2019)(Sanny & Ria, 2015). During observation of the case company, I have seen quality related problems in the sewing section of the case company called “Lucy Garment Industries plc”. Defective outputs from the sewing section of the case company, shirts, were rejected from export so that they were supplied to the local market which needs strict and continuous attention. In general, due to the following reasons the sector has been selected for this research. Firstly, garment industries have many advantages to the Ethiopian national economy, employment opportunities and of course the sector becomes international in scope. Secondly, in the garment industry rejected export items have reduced the potential benefit obtained from the international market and of course is a source of revenue loss due to the selling price difference of defect products and

[1] https://www.german-tech.org/Download/MEK_Ethiopia_Presentation_ETIDI_10.10.14.pdf

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quality products in the local market and international market respectively. The study conducted by (Islam & Hossain, 2013) revealed the application of the seven SQC tools to get a better result in continuous improvement of manufacturing sectors. In addition to this, the study conducted by (Neyestani, 2017) revealed the application of seven basic tools of quality control as an appropriate technique for solving quality problems in the organizations. Some of the industries where the SQC tools have been applied can be shown by reviewing the conducted studies in the sectors. Among them the seven quality tools have been applied as quality improvement strategy to reduce defects in food manufacturing industry in Indonesia (Sanny & Ria, 2015) and critical assessment on the implementation of SQC tool has been conducted by(Yunus et al., 2017) to reveal its implication in food manufacturing industry. The seven quality control tools are very prominent to reduce defects so as to improve productivity in the automobile industry(Memon et al., 2019)(G.R.Naik, 2015). The study conducted by(Nurdin & Purba, 2018) has presented the application of SQC tools to reduce defect products in a surfactant and chemicals industry. Analysis of SQC by control charts has been conducted to reduce variability in product (Tejaningrum, 2017). Raman and Basavaraj (2019) have presented the application of fishbone diagram and Pareto analysis in the capacitor manufacturing industry to reveal its importance in quality improvement of the products. (Erdhianto, 2021) has presented the analysis of SQC tools to reduce the defects in packaging of PG KREMBOONG sugar products using seven tools method. The study conducted by(Addis, 2019) addressed the application of SQC tools in the shoe manufacturing sector for quality improvement. The study conducted by Bhatt and Singla (2017) and Terwadkar et al. (2020) revealed the investigation and analysis of metal casting defects. The finding of this study has shown that quality control tools like Pareto Chart, Cause and Effect Diagram are used to identify and classify the reasons for defects in the production system and reduce them by using various remedial measures. Also, the study conducted by Chokkalingam et al. (2017) investigated the implication of Ishikawa diagram in shrinkage defects minimizations in casting processes. The seven SQC is also applied to improve the construction industry quality(Abdel-Hamid & Abdelhaleem, 2019).

Like other manufacturing sectors (Suryoputro et al., 2017) presented the application of the implementation of the seven SQC tools to reduce defective products in the Batik textile manufacturing industry. According to this study check sheet results obtained types of defects in the grey fabric. Based on the analysis of the control chart indicates that the process is out of control. Based on a scatter diagram shows a positive correlation between the percentage of disability and the number of productions. Based on Pareto diagram, repair needs priority for the dominant type of defect is warp and based on double warp value histogram is also the highest with a value. In addition, based on the analysis of the factors causing defects by fishbone diagram double warp or other types of defects originating from the materials, methods, machines, measurements, man, and environment. Thus, the company can take SQC tools to minimize the prevention and repair of defects and improve product quality. The study conducted by (Kolte & Chandurkar, 2018) revealed the improvement in the performance of the apparel industry by reducing garment defects and sewing defects. The application of SQC tools revealed a tremendous result in terms of defect and rework on the shop floor workers of the garment industry(Nitesh Kumar Sahoo, 2020). The study by (Islam & Hossain, 2013) addressed the benefit of SQC tools to reduce defects and improve quality of products in sewing and finishing section of the garment industry. The study conducted by(Ahmed et al., 2019) revealed the different types of defects and their cause and possible remedies in garment manufacturing industries. According to this study we must know all types of garments defects if we are involved with the apparel industry. It is the responsibility of the garment manufacturers to maintain a required garments quality standard for each product they are offering or delivering to the buyers. During this study all fabric defects, cutting & spreading defects, sewing defects and finishing defects have been investigated using SQC tools.(Patil et al., 2017) have presented in their research output about the minimization of garment defects using SQC tools. The study conducted by (Miglani & Rana, 2018) showed that the quality of the product can be enhanced through defect and rework minimization so that after all productivity can be improved using the application of SQC tools. In the literature review, most of the studies on quality were defect assessment using SQC tools and suggesting solutions to overcome defect problems. The studies conducted on the practical implementation of the SQC tools after identifying root causes in the manufacturing sector were not enough especially for developing countries like Ethiopia. Since Ethiopia is a developing country still the practical implementation of SQC tools is in the infant stage and because of that, practical implementation of SQC tools in an integrated way starting from assessment is crucial. In general, this research has aimed to determine the top defect types using Pareto analysis, root cause analysis for the top defects, generating suggested solutions to reduce top problems through team discussion, practical implementation of the suggested solutions to minimize rejected export shirts and measurement of the improvement in terms of by how much percent the rejected items are reduced, and how much money the sector industries could save by applying SQC tools. Due to this, the research has contributed significant implication for the case company and similar firms in quality improvement to create export item rejection reduction to increase income and sustain in the business environment.

2. Materials and Methods

The method used to collect the data, tools used to solve the problem, and steps on how tools are constructed to arrive at proper solutions are discussed here.

2.1 Data Collection Methodology

The study was carried out at “Lucy garment industry plc” located in Addis Ababa, Ethiopia. The company produces mainly shirts. The products are export standard products in case if there are rejected items due to one or more types of defects, the product goes to the local market which interns reduces the selling price of an item. The industry consists of different work sections. After careful

observation of the departments of the case company, where most of the defects have occurred has been identified. Among these work sections, the sewing department suffers from defect problems and hence is selected for the study. The study was conducted from December 25, 2021 to March 29, 2022. The information was gathered for Shirt only; indeed, the plant produces shirts only, and utilizing the end line quality information (from record) given by the quality work section to distinguish some tedious defect types that happen in the sewing work section. The process flow of the case company consisted of design/sketch, sample making, production pattern, grading, marker making, spreading, cutting, sorting/bundling, sewing/assembling, inspection, ironing/pressing/finishing, final inspection, and packing/dispatching.

2.2 Data Analysis Tools

The information gathered from the case company was organized so that further analysis has been performed by utilizing the SQC tools. There are different techniques to identify and investigate quality problems. The most prominent of these techniques are Pareto chart, and fishbone diagram. In addition, the application of Pareto analysis and cause-and-effect diagrams helped to minimize rework and rejection which ultimately improves the efficiency of the system(Nitesh Kumar Sahoo, 2020). For improvement of the quality of the product Ishikawa diagram helped to formulate solution directions for the businesses(Silva de Santis & Pereira Marcicano, 2016). In this research, Pareto analysis was utilized to distinguish the top happening defects, then, at that point cause-and-effect diagrams were built for those defects. Here in my research Microsoft Excel and SQC tools' templates are used.

3. Results and discussion

3.1 Pareto Analysis

Pareto analysis has been done for the three months[2] combined defect data of the sewing department for the product shirts. From this examination the vital few regions where, greatest defects happen have been identified.

Table 1
Defect data for shirts[3]

Months	Weeks	Defect Code														
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
1	1	16	120	94	106	129	154	35	7	14	11	7	23	7	20	121
	2	13	132	67	120	189	120	14	19	16	24	13	21	13	42	166
	3	13	105	49	120	184	157	56	13	13	24	13	7	3	46	139
	4	17	124	64	131	135	142	62	12	21	7	27	9	20	40	200
2	1	19	97	68	131	142	163	11	32	31	7	6	7	1	48	97
	2	22	116	122	125	203	127	18	5	17	11	10	4	23	40	182
	3	21	133	78	111	154	151	23	41	15	8	2	11	6	36	133
	4	18	109	92	93	142	161	28	23	16	5	28	7	23	45	146
3	1	18	113	77	87	149	124	9	9	18	9	7	13	4	39	171
	2	21	114	55	66	169	127	40	11	14	6	7	12	1	48	125
	3	27	108	71	108	165	120	33	12	18	8	13	9	6	54	116
	4	10	124	86	99	165	142	16	21	30	9	13	9	20	39	178
Total		**215**	**1395**	**923**	**1297**	**1926**	**1688**	**345**	**205**	**223**	**129**	**146**	**132**	**127**	**497**	**1774**

Table 1 shows the three-month defect data with a total of 15 defect types with respective weekly defect amounts.

Table 2
Total number of exports rejected shirts[4]

Months	Weeks	Total number of rejected shirts per week	Total number of rejected shirts per month	Average number of rejected shirts per month
1	1	702	3320	
	2	806		
	3	874		
	4	938		
2	1	800	3490	
	2	967		(3320+3490+3092)/3=**3301**
	3	900		
	4	823		
3	1	724	3092	
	2	767		
	3	789		

In Table 2 we have seen the total amount of the weekly defects, for this we add the defect amount of each defect type horizontally in each row. In this sense, I need to know that there can be a chance of more than one defect type in a single product called a shirt.

[2] The case company has no long experience recording and documenting the daily defect data in regular manner, with this limitation the researcher tried to organize the 3-month data out of the 6-month data to arrange as an input for Parato analysis as shown in Table 1.
[3] The data was taken from the quality department of the case company
[4] Own arrangement from Table 1

Table 3
Defect type, respective defect amount and cumulative distribution[5]

Defect type	Defect code	Total	Cumulative total	%age of overall total	%age cumulative
Cuff assembly seam slip out	E	1926	1926	17.47414	17.47414
Sleeve hemming	Q	1774	3700	16.09508	33.56923
Button slip out	F	1688	5388	15.31482	48.88405
Side seam puckering	B	1395	6783	12.65651	61.54056
Button missed	D	1297	8080	11.76737	73.30793
Placket seam out	C	923	9003	8.374161	81.68209
Collar top stitch	P	497	9500	4.509163	86.19125
Armhole attach	G	345	9845	3.130103	89.32136
Shoulder top stitch slip out	J	223	10068	2.023226	91.34458
Collar assembly slip out	A	215	10283	1.950644	93.29523
Armhole slip out	H	205	10488	1.859917	95.15514
Back & yoke seam slip out	L	146	10634	1.324623	96.47977
Incomplete shoulder top stitch	M	132	10766	1.197605	97.67737
Button hole missed	K	129	10895	1.170386	98.84776
Collar shifted	N	127	11022	1.152241	100
	Grand total	**11022**			**100**

From Table 3 we understood that by considering defect types and its respective defect code and total amount of defects, the cumulative total and percentage cumulative out of 11022 defect amounts have been calculated. This computation is used as an input for drawing the Pareto curve shown in Fig.2 below.

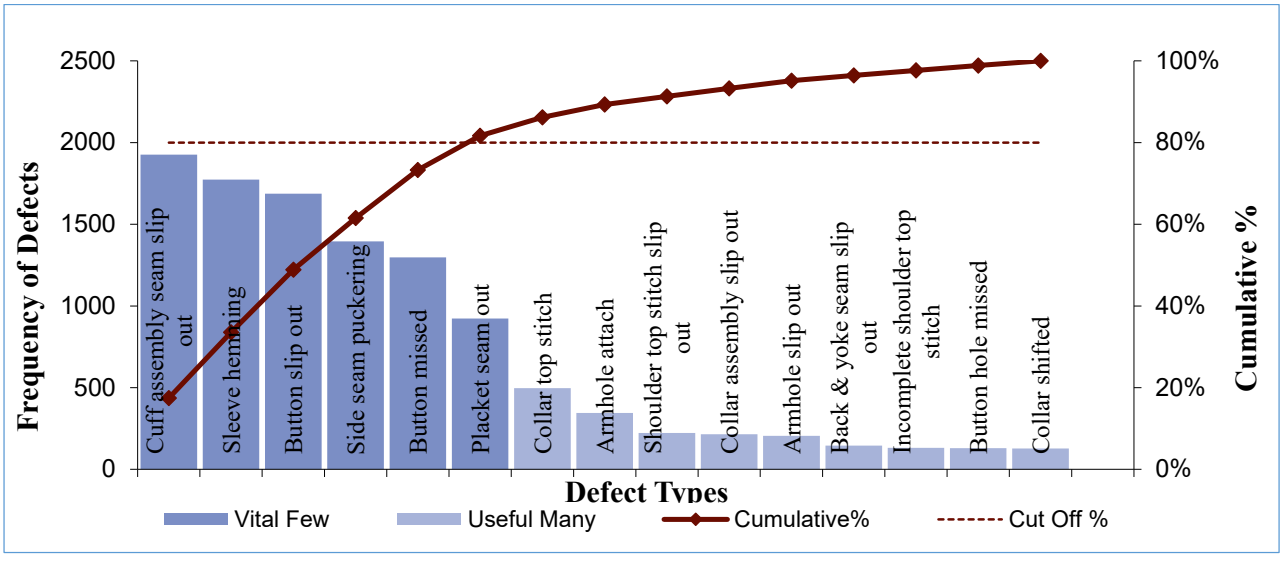
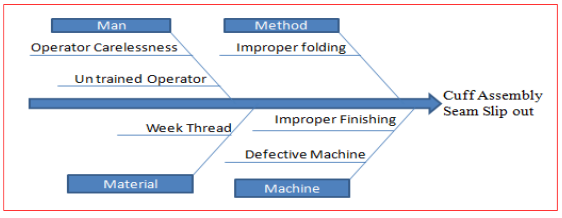
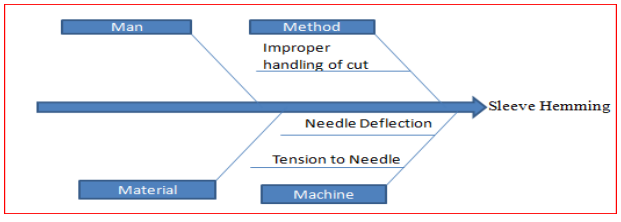


Fig. 1. Pareto curve

3.2 Cause-and-Effect Diagram

From Pareto analysis in Fig. 1 the first six top defects cover 81.68% of the total defects. These types of defects occur due to some specific causes. In general, the main causes for top defects of the garment industries are identified as man (people), machines, materials, methods, measurement, and environment as major causes (Liliana, 2016). But specifically, regarding this research the main causes for the identified vital few defect types in Fig. 2 are, obtained through discussion with quality control supervisors, man, machine, material, and method.





[5] Own arrangement from Table 1

Fig. 2. Cause-and-effect diagram for cuff assembly seam slip out

Fig. 3. Cause-and-effect diagram for sleeve hemming

As shown in Fig. 2 above; man, machine, method and material are identified as a main root causes for defect called cuff assembly seam slip out. From the team's detail discussion, the operator carelessness, untrained operator, improper folding, week thread, improper finishing and defective machine are the specific causes under the main root causes. From the team's detail discussion and investigation, as shown in Fig. 3 above, man, machine (needle deflection, tension of needle), method (improper handling of cut) and material are identified as causes for defect called sleeve hemming.

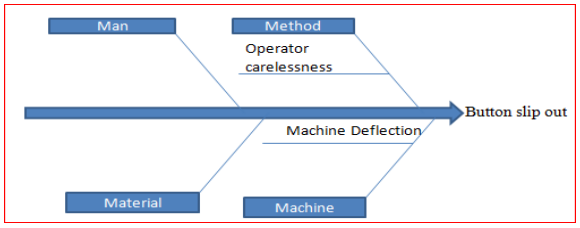


Fig. 4. Cause-and-effect diagram for button slip out

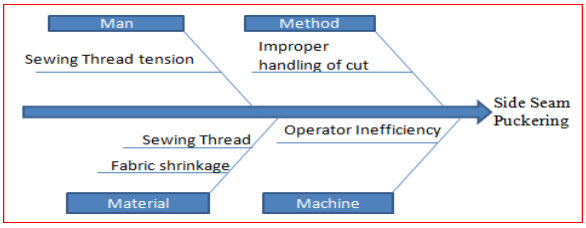


Fig. 5. Cause-and-effect diagram for side seam puckering

From the team's detail discussion and investigation, as shown in Fig. 4 above, man, machine (machine deflection), method (operator carelessness) and material are identified as causes for the button slip out defect. As shown in Fig. 5 above; man, machine, method and material are identified as the main root causes for defect called side seam puckering. From the team's detailed discussion, the operator inefficiency, improper handling of cut, sewing thread tension, sewing thread and fabric shrinkage are the specific causes under the main root causes.

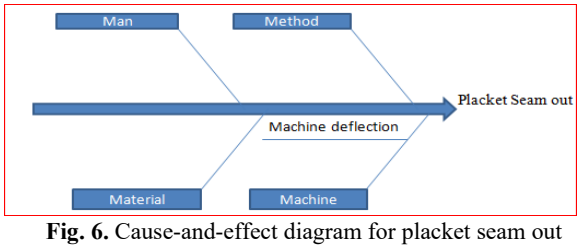


Fig. 6. Cause-and-effect diagram for placket seam out

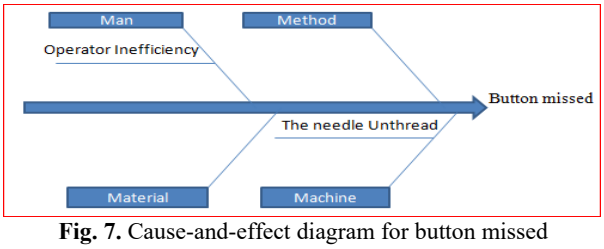


Fig. 7. Cause-and-effect diagram for button missed

As shown in Fig.7 above; man, machine, method and material are identified as the main root causes for defect button missed defect type. From the team's detailed discussion, the operator inefficiency under the main cause man, and the needle unthread under the main cause machine have been identified as the specific causes.

Table 4
Suggested solution to minimize root causes for vital few shirts defects[6]

Main causes	Root Causes	Solutions to be done
	Suggested solution to cuff assembly seam slip out	
Man	1.Operator carelessness	Continuous follow-ups of the operator assigned
	2.Operator inefficiency	Provide appropriate training to perform the task
	3.Improper finishing	Develop a system that will check the progress of the work
Machine	1.Deflective machine	Proper cleaning of machines before and after work
Material	1.Weak thread	Select quality thread vendors from the available markets
Method	1.Improper folding	Implement proper folding systems and take enough training
	Suggested solution to sleeve hemming	
Man	1.Operator speedup machine	Machine speed control with appropriate speed feed up
Machine	1.Needle deflection	Properly placing of the needle on the machine
	2.Tension to needle thread	Sewing thread should fit with the hole of the needle
Method	1.Inappropriate treatment of cut pieces	Decrease hole presser foot and the opening of needle plate
	Suggested solution to button slip out	
Man	1.Operation carelessness	Follow-ups of workers with enough tea breaks to refresh
Machine	1.Machine deflection	Clean machines properly before and after work
	Suggested solution to side seam puckering	
Man	1.Operator inefficiency	Provide adequate training to operators
Machine	1.Sewing thread tension	Choice of sewing thread in accordance with the needle size.
Material	1.Fabric shrinkage	Use good quality fabric keep it out of wet area
	2.Sewingthreadshrinkage	Use good quality thread keep it out of wet area
Method	1.Improper selection of sewing thread	Properly select the thread depending on the hole/size of the needle
	Suggested solution to placket slip out	
Machine	1.Machine deflection	Clean the machine deflection properly before our work
	Suggested solution to button missed	
Man	1.Operator Inefficiency	Proper follow-ups

[6] Sourced from the detail discussion among supervisor of production line, supervisor of quality department, the company manager &researcher and actual observation of the shopfloor activities

Machine	1.The needle un thread	Check the needle is done continuously

The suggested solutions in Table 4 have been obtained through the detailed discussion of the case company personnel and the researcher and from the detailed investigation of the shop floor activities of the production line. This was done during the data collection time. In general, this integration helped us to get the root causes of each defect type and the suggested solutions to solve the problems due to the root causes.

3.3 Improvement Analysis

After the top defects of export rejected shirts have been analyzed using Pareto chart and cause-effect diagram, the researcher discussed with different personnel of the case company to successfully implement the suggested solutions. For this, a team has been organized which comprises head of purchasing department, supervisor of production line (total 3 supervisors), supervisor of the quality department, the company manager, head of marketing department, and the researcher. The suggested solutions in Table 4 have been implemented in two phases.

3.3.1 Pre-Implementation Phase

During the one-week pre implementation phase, with a great ambition of the organized team, a set of procedures to be followed in the implementation phase have been constructed. So, in this phase the team has done detailed discussion on how they lead the improvement to reduce the export of rejected shirts. Finally, they have put the following set of tasks in step by considering all the points in the suggested solutions.

· Step 1: The improvement team believes that it is important to have work division between team members to fully cover the production line.
· Step 2: The improvement team has been decided to guide, help, and motivate workers to correctly implement the suggested solutions in each day's production session.
· Step 3: The improvement team has decided to have 10 minutes tea breaks around 4:30 local time in the morning and 9:30 local time in the afternoon to refresh stressed workers.
· Step 4: The improvement team has been decided to evaluate the progress of daily production during the implementation phase. Here they agreed on recording the total number of the export rejected shirts per week for a one month time horizon to compare with the average weekly export rejected shirt. According to the level of success there may be rotation in the work division of the team.

3.3.2 Implementation Phase

After successful follow up of the daily activities of the workers to implement the suggested solutions, the following remarkable improvement has been obtained. Afterward the number of rejected shirts due to one or more defect type has been recorded for four weeks are shown in Table 5 below for the level of comparison with the average amount of rejected shirts before implementation of suggested solutions. Here the daily production capacity is almost the same with production capacity before implementation of the suggested solutions.

Table 5
Total number of exports rejected shirts after implementation of suggested solutions[7]

Weeks	Average number of exports rejected shirts per month before the implementation of suggested solutions	Number of exports rejected shirts per month after implementation of suggested solutions
1st	(702+800+724) =742	302
2nd	(806+967+767)/3=847	289
3rd	(874+900+789)/3=855	255
4th	(938+823+812)/3=858	234
Total	**3302**	**1080**

3.3.3 Saved revenue analysis

Lucy garment industry plc is established mainly for export standard Products called shirts. As the researcher collected the data about the selling price of a single shirt form the company's marketing department, he has understood that it varies from 350 ETB to 450 ETB in the international markets. On the other way the selling price of the export rejected shirt, in case if the products are rejected from export line due to one or more defect types the goes to local market and the data have been obtained from the company's wholesaling and retailing shops, varies from 150 ETB to 200 ETB per shirt.

After successful implementation of suggested solutions for one month, almost 67.3% of export rejected shirts have been saved from rejection which is shown in Table 6. These saved shirts from rejection have been exported to the international market and add income of 200 Ethiopian Birr (ETB) to 250ETB per shirt to the case company. In other words, the monthly saved 2222 shirts increases the income of the company by 67.3% or by 444,400 ETB to 555,500 ETB.

[7] The result was obtained after implementing the suggested solutions in Table 4 to reduce rejected shirts

Table 6
Cost reduction after implementation of suggested solutions

Total number of exports rejected shirts per month before the implementation of suggested solutions	Total number of exports rejected shirts per month after implementation of suggested solutions	Number of saved shirts from defects after implementation of suggested solutions	Money saved per shirt [international market price-local market price]	Money Saved per month[8]
3302	1080	2222	200 ETB to 250ETB	2222*200 ETB to 2222*250 ETB =444400 ETB to 555500 ETB

4. Conclusion

Quality improvement is a continuous task to satisfy the potential customers in the market through reduction of rejected items. In this study using SQC tools, Pareto analysis and cause-and effect diagram, six vital few defects have been identified which covers 81.18% of the total defects. For these vital few defects, using cause-and-effect diagrams, the root cause analysis has been identified in line with suggested solutions for solving the root problems with the discussion of the improvement teams. Finally, the improvement team has implemented the solutions for one month. After the improvement team has successfully implemented the suggested solutions for one month, almost 67.3% of export rejected shirts have been saved from rejection. These saved shirts have been exported to the international market and add selling price of 200 ETB to 250ETB per shirt to the case company. In other words, the monthly saved 2222 shirts increases the income of the company by 67.3% or by 444,400 ETB to 555,500 ETB. Therefore, successful implementation SQC tools have improved the quality of the products which interns reduce the number of exported rejected items and increases the revenue obtained from the international market.

Acknowledgement

The author would like to take a moment to express my gratitude to the improvement team, which is the head of purchasing department, supervisor of production line, supervisor of the quality department, the company manager, head of marketing department and the shop floor workers for their support and remarkable hospitality. Their cooperation in providing data, availing themselves for motivating the workers during implementation phase and record and providing very valuable information were inspirational.

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[8] Money save was obtained, first subtract total number of rejected shirts after implementation of suggested solution from number of rejected shirts before implementation through the organized team. Then multiply the difference by unit price difference of international and local market (Ethiopian market).

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