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ANALYSIS OF SEWING DEFECTS THROUGH AN INTEGRATED APPROACH OF 5S AND PDCA CYCLE

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A B S T R A C T

Due to a large number of defects, which results in high rework and scrap rates in the sewing production line, around 3784 rework rates have been recorded in the last 3 three months, the objective of this research is Analysis of Sewing Defects and Suggesting Improvement mechanism through 5S & PDCA.
To assess the quality-related problems of the company, primary and secondary data were collected using interviews, personal observations, and review of companies' daily production records, to analyze the collected data, the mathematical tools and techniques employed in statistical quality control are used. Excel spreadsheet, QM for Windows software, Pareto chart, cause and effect diagram, and control chart are used. After finding the major defects, a brainstorming tool was used to identify the probable causes and then potential root causes were identified by online inspections and root cause analysis. This method is very effective in the minimization of defects. The result indicates that the major problem of the company is stain, skip stitch and seam broken are the major problem. If the company implements in minimization of the suggested problem of defects and gives the same corrective action for the suggested problem, productivity will be increased and high customer satisfaction will be created. The company needs to analyze the daily recording defects data and interpret it to identify the root causes of the problem. Most of the time the company uses two main types of SQC Tools need to use another tool. Need Implementation of SQC tools in the company.

1. INTRODUCTION

In this study we have found that it is very essential to know about different types of sewing defects. In garments industry these defects are dependent upon the classification of defects and an inspector's ability to make decisions. If there is no idea of garments defects identification then it will be a tough job, but if it is known properly then it is an easy task to identify defects (Kumar & Pang, 2002). So must know all types of Garments defects if we are involved with the apparel industry. It is the responsibility of the garments manufacturers to maintain a required Garments quality standard for each and every product they are offering or delivering to the buyers. (Ahmed, Islam & Ali 2019)
The study is conducted in one of the firm of Adama Industrial Park that is called Antex Textile Plc. In this garment manufacturing, it is usual few rejected garments

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after shipment. Reason, most of the manufacturers believe that garments are soft goods and non-repairable defect may occur due to low quality, raw materials or faulty process or employee casual behaviors (Islam et al., 2013). Reworks in this garments industry is a common works that hampers the smooth production rate and focus poor quality products having an impact on overall factory economy. However, factory must have check points to control over this issue (Morel, et al. 2007). There is no ready-made solution that can reduce rejection percentage overnight. Each order is unique. But this project works suggest how to handle this issue and bring down rejection rate to minimum.

The stated problem assessed and improvement mechanism suggested through a structured tool in the form of Combined with the Plan Do Check and Act (PDCA) cycle, 5S for Managers brings to completion a methodology which can promote continual management improvement (Randhawa & Ahuja, 2017). The Plan Do Check and Act (PDCA) cycle, also known as the Deming Cycle, coined after W Edwards Deming, one of the acclaimed quality gurus, is a model for kicking in continuous improvement in the work process and PDCA also as Plan-Do-Check-Action cycle (PDCA) to easily define improvement for the defects (Isniah, Purba & Debora 2020). This method applies to all processes to control the production quality. In order for sustaining the gains controlling the process is crucial and within this there are various tools and techniques used for analyzing the defects (Flynn et al., 1995).

1.1. Problem Statement

Due to these large number of defects, which results in high rework and scrap rates especially in sewing production lines usually did not produce qualified garments and their productivity gone to decrease. However, this amount of rework rate 3784 is there the last 3 months from the section's recorded data. This in turn paves the way for the problem to remain inherent and make difficulty in solving them. Therefore, this work incorporates the process of finding the leading defect with their particular root cause and in turn solving them accordingly. By considering all the mentioned above problems of large number of defects exposed to high rework rate, low output production, longer lead time in the sewing lines which shows that there are quality problems on production lines.

According to report of 12 weeks we plot the graphically representing the number of defects occurred on products as shown in Figure 1.

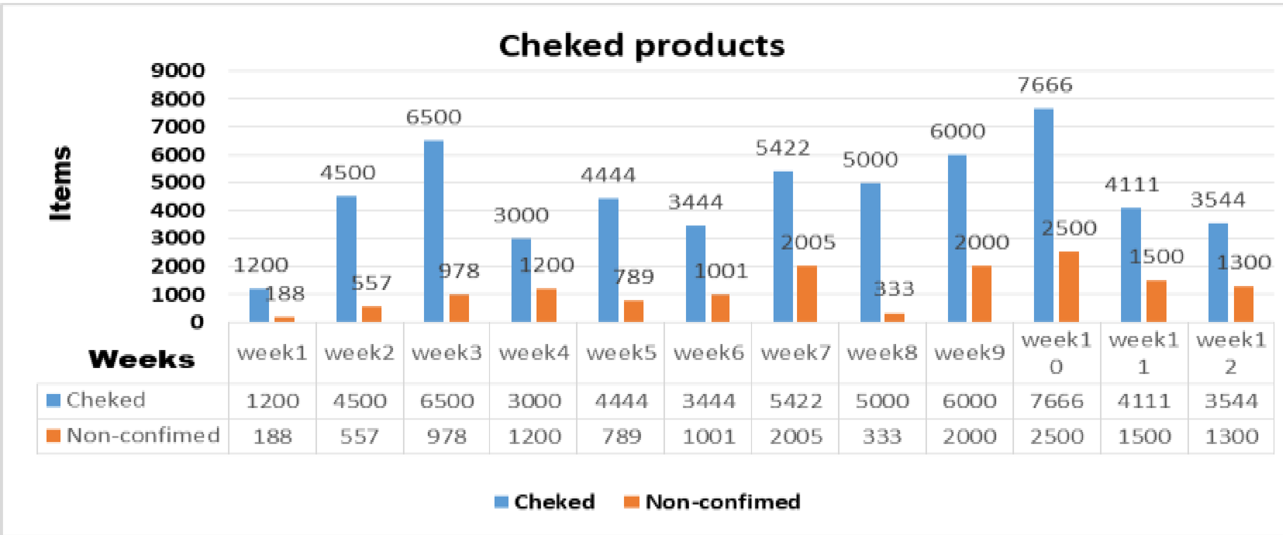


Figure 1. Company defect report

1.2. General Objective

The general objective of this project is Analysis of Sewing Defects and Suggesting Improvement mechanism through 5S & PDCA.

2. LITERATURE REVIEW

2.1 Defects in garment industry

Defects are all those non-conformances that are not acceptable by end customer. The non-conformances may be improper shape of garment, broken button or other trims, holes in fabric, skip stitch, broken seam etc. Now a days Garments defect is one of the most important factors of the apparel manufacturing industry because it creates a negative effect on actual productivity. In garments industry these defects are dependent upon the classification of defects and an inspector's ability to make decisions (Srinivasan et al., 1992). If there is no idea of garments defects identification then it will be a tough job, but if it is known properly then it is an easy task to identify defects. So must know all types of Garments defects if we are involved with the apparel industry. It is the responsibility of the garments manufacturers to maintain a required Garments quality standard for each and every product they are offering or delivering to the buyers (Huq et al., 2016). After reading this project we have found that the idea about all types of garments defects like all section have specific defect which effect on whole garments quality like fabric defects, cutting defects, Spreading defects, sewing defects, washing defects and finishing defect.

2.2 Improving quality in sewing department

Improving product quality is generally not difficult, but requires deliberate and ongoing attention, and it requires the commitment of every individual within the manufacturing company, from the person who cleans the floors to the most senior manager (Yashini, 2020). Specific steps that can enhance quality include.

Inline inspection: In the assembly line generally check pints are kept for the critical operations. In these checkpoints, 100% checking is done for partially stitched garments and defect-free pieces are forwarded to the next process. This type of checking is used

Roaming inspection: In this case, checkers roam around the line and randomly check pieces at each operation.

Traffic light inspection system: Some garment manufacturers use this inspection system. In this system, each operator is given a card for measuring their quality performance. The quality checker goes to the operator and does a random check for few pieces and according to the inspection result, the checker marked red or green on card following rating criteria.

End of line inspection or table checking: A checker checks a completely stitched garment at the end of the line. 100% checking is done here, Audit of the checked pieces: some manufacturers follow this audit procedure but it is a very essential checkpoint to assure that only 100% of the inspected garment is sent to finishing from the sewing department. And all defective pieces are repaired before sending it to the finishing section. Full inspection of work in process and finished garments to include adherence to size specifications and stitching related defects such as needle cutting, open seam, broken seam, jump stitch, variable gathering etc. Recording defects by garment production lot, source (fabric, cutting, or assembly), type, and operator Analysis of defect data to identify sources of quality problems. Implementing even a few of these steps will result in improved quality, but each additional suggestion put into practice will yield significant improvements in product quality. Generally, quality is always the key to determining the standard of a product. And to maintain such standards there are universal tools that are being used throughout the industries. These are known as the seven basic tools of quality. These are a fixed set of graphical techniques that are used to identify all the issues related to quality and assist in solving those issues. The following are all the seven tools of quality control with examples. These 7 tools can be implemented in garment manufacturing to improve the process and product quality. Improving product quality is generally not difficult, but requires deliberate and ongoing attention, and it requires the commitment of every individual within the manufacturing company, from the person who cleans the floors to the most senior manager. (Chandna & Chandra, 2009).

2.3. The Seven Quality Control Tools

A large number of studies have determined major quality improvement tools According to (White et al. 2009) their study discusses the quality and productivity improvement in a manufacturing enterprise through practical study. (Agus & Shukri Hajinoor, 2012). The Quality Control Tools such as check list, Pareto analysis and cause-effect diagram were used. The frequencies of sewing defects in the both workshop A&B production lines of sewing department are determined by check list. The major sewing defects and the cumulative percentages of the three critical defects such as, seam broken, stain and skip stitch were examined by using the Pareto analysis. The reasons of the defects are analyzed with the cause-effect diagram for finding out the root causes of these three major sewing defects. According to (Bhadiyadara et al., 2019) provide an easy introduction of 7 QC tools and to improve the quality level of manufacturing processes by applying it. An application of methodology in an industry which provides a framework to identify the major defects in sewing department and find the root causes in sewing production lines, to minimize the defects, improve and sustain producing of high quality of garments with acceptable quality level. There are Seven Basic Tools of Quality which can be used to analyze and subsequently intervene to eliminate the problems from the production system. Despite a lofty title, such as Statistical Quality Control or Statistical Process Control (SQC/SPC), understanding and using does not require advanced knowledge of statistics. Rather, the seven basic tools of quality and formalized body of techniques involve tabulating, depicting, and describing data sets. Once the system is visible, the describing and identifying appropriate actions to improve the processes and systems are generally self-evident.

2.4. C-Chart

The c chart plots the number of non-conformities that occur in a constant area of opportunity or inspection unit. The constant means that the area of opportunity and the inspection unit are equal. Examples of a constant inspection unit are fixed length, area, and quantity. Fixed length could section of road, a roll of paper, etc. Fixed area could be the hood of a car, a defined portion of a circuit board, etc. Fixed quantity could be a work week, three computers, etc.

In most applications, the center line, or mean, of the c chart is based on the average number of non-conformities per inspection unit. This can be determined by:

$$\mathbf{CL} = \frac{\textbf{Number Defects}}{\textbf{Number of Sample}}$$

Where, *CL* is the mean of observed number of non-conformities found in inspection unit *i*.

Therefore, the control limits for the c chart are determined from

Centerline= CL $\boldsymbol{UCL = CL + 3}$

$$\boldsymbol{UCL = CL + 3\sqrt{CL}}$$

As with the p and np charts, if the calculation of the lower control limit is less than zero, then the lower control limit is set to zero.

2.5 PDCA Cycle

The PDCA cycle, also known as Deming cycle or Shewhart cycle (Strotmann, et al., 2017), is a lean manufacturing methodology that was developed in 1930, when there was no more exclusive products and a more quality management focusing on competitiveness raised in the global market (Silva et al., 2017) According to several authors, the creator of the original PDCA cycle was an American statistician named Walter A. Shewart (Silva et al., 2017). However, William Edward Deming was who, in the 1950s, developed this method, which, today, is one of the most worldwide known and applied. In its beginnings, the PDCA cycle was used as a tool for the quality control of products (Silva et al., 2017; Sangpikul, 2017). However, rapidly, it was highlighted as a method that allowed developing improvements in process at organizational level (Silva, Medeiros & Vieira 2017). Currently, the PDCA cycle is characterized by its continuous improvement approach and it is recognized as a logic program that allows improving the activities (Sangpikul, 2017)

Several authors state that the PDCA cycle is much more than a simple lean manufacturing tool. Instead, they mention that the PDCA cycle is a philosophy of continuous processes improvement introduced in the organizational culture of companies that is focused in the continuous learning and the knowledge creation (Jones et al., 2010) The following rows describe the four stages of the PDCA cycle (Realyvásquez-Vargas et al., 2018).

3. METHODOLOGY

Direct observations were used for identifying the causes for the critical defects in different department of such as: Sewing department. Cutting department, Printing department, Embroidery department, finishing department Formal interview with worker for the brainstorming session for specifying the root causes of each defect in some sewing lines

The collected data were analyzed using Microsoft excel for forming Pareto diagram and EDRAW software to draw Cause and effect diagram and different charts. Why-why Population size 30 participant's-25 answered because they were related persons with the work. The Sampling sizes 240 swim wear were checked for the location of the defects. This study identified that is very essential to apply quality improvement technique for troubleshooting issues within production processes in the organizations. Doubtlessly, all of the aforementioned quality tools should be considered and used by management for identifying and solving quality problems during producing the products and services. In order to apply appropriately these quality tools for solving quality problems and quality improvement and use the seven basic tools of quality. These are a fixed set of graphical techniques that are used to identify all the issues related to quality and assist in solving those issues.

3.1. Research Methodology frame work

Methodology means the procedures to obtain the result. For this study, we have conducted the following procedures to Analysis the defects (Figure 2). Steps involved in the study.

Step 1: Factory Selection: After gathering information, we have selected a factory, which is situated in Adama Industrial park.

Step 2: Conducting a Case Study:

Step 3: Finally, we conduct our research work in a particular garment factory named “Antes Textile plc.”

Step 4: Identification of Problems

Identifying the problem is the major concern for this study. From our observation, we have seen repetitive defects occur in the sewing section. Therefore, we tried to do our research work on this section, which is our major concern.

Step 5: Data Collection: The related data was collected through primary and secondary method.

Step 6: Tools selection: In this step the tools that can analysis a collected data have been selected.

Step 7: Analysis and Suggestions

In this step, Pareto Analysis is performed which is required to identify major concerning areas. After that, Cause-Effect Diagrams have been constructed for top finishing defect types (Figure 3). Then we have provided some respective suggestions to minimize the frequency of those defects through quality improvement mechanism of 5S and PDCA..

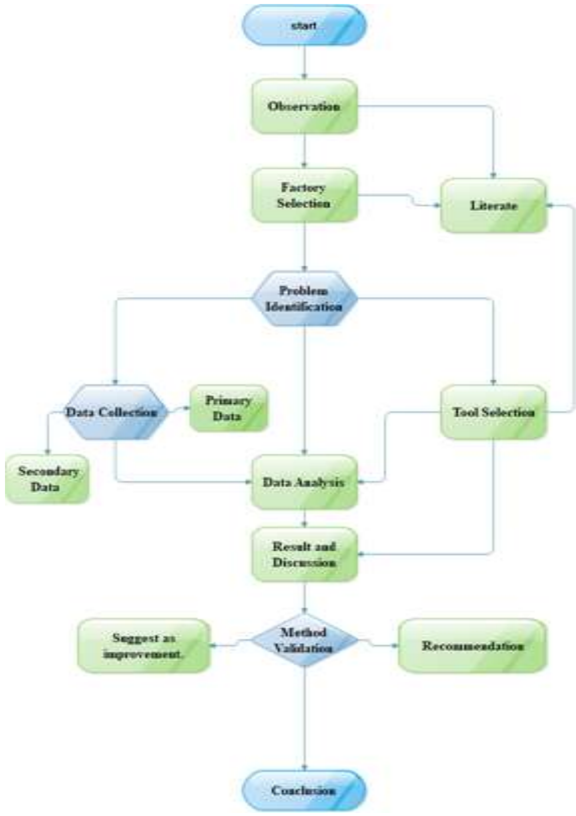


Figure 1. Research Methodology frame work

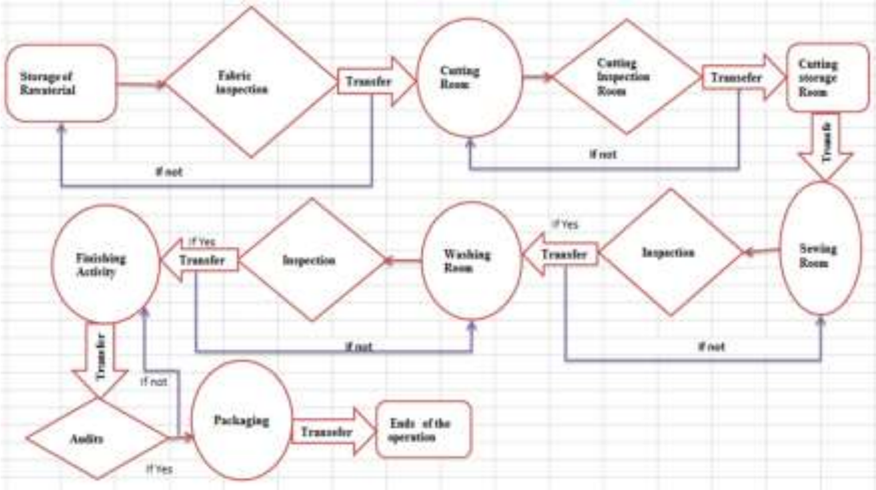


Figure 3. The type of production process and quality inspection area in the company

4. DATA COLLECTION AND ANALYSIS

To know the most common source of defects, the frequency of defect occurs in sewing section of we have collected various defects data from company report three months from November 2020 to January 2021 in both workshop A and B of production lines for our project. This data is obtained by QC man by 100% inspection in the end line QC and simple recorded data on Check sheet which is arranged weekly. We also collected the total garments checked in that time to know the current status of sewing defects (Table 1).

Table 1. All types of defect data collected in sewing department

		FREQUENCY OF DEFECTS IN BOTH SEWING WORKSHOP (A&B)											
Period of occup.		**Month 1**				**Month 2**				**Month 3**			
S/N	Types of defects	**Week1**	**Week2**	**Week3**	**Week4**	**Week1**	**Week2**	**Week3**	**Week4**	**Week1**	**Week2**	**Week3**	**Week4**
1	Mismatch	5	12	32	3	11	7	0	17	9	4	7	6
2	Skip Stitch	65	30	95	54	76	16	114	70	55	35	95	69
3	Un Even	20	0	26	5	0	30	8	0	1	7	6	4
4	Thread Cut	14	32	20	28	13	35	24	18	30	15	38	21
5	Open Seam	11	31	21	13	22	19	30	44	4	27	9	26
6	Stain	110	120	135	70	180	65	185	121	134	109	141	130
7	Seam Broken	15	79	47	33	45	20	74	100	27	20	35	59
8	Puckering	4	7	5	4	3	0	15	20	6	7	0	10
9	Print Defects	10	9	0	12	6	0	5	2	8	0	2	4
10	Slip Out	2	2	4	2	4	9	1	0	0	2	0	2
11	Oil Mark	0	0	4	0	0	6	0	1	1	0	2	0
12	Poor Tack	0	4	0	1	0	0	0	3	1	0	0	1

Defects in both workshops A and B of according to the objective of our project recorded data in three months (Table 2). The collected data were critically discussed and analyzed using QC tools like Pareto chart to identify the major defects that occurs frequently, cause & effect diagram to identify the causes and sub-causes. Also to identify for which reasons the major defects occur i.e. man, machine, material and method and also finally we analysis the stain defect by c-chart to know if it is in statistical control or out of control as shown below on (table 2, 3, 4) sequentially.

Ta**ble 2.** Three month total number of defects data in both A&B sewing workshop.

S/N	Defect type	No. of defects
1	Stain	1500
2	skip stitch	774
3	seam broken	554
4	Thread cut	288
5	Open seam	257
6	Mismatch	113
7	Un even	107
8	Puckering	81
9	Print defects	58
10	slip out	28
11	oil mark	14
12	poor tack	10
	Total	*3784*

Analysis defects collected in both workshops Three Months Defect Chart for Both A&B Workshop Sewing lines. After analysis through table 3 we make the Pareto chart for both sewing workshop as shown on Figure 4.

Table 3. Defect type

S/N	**Defect type**	**No. of defects**	**Cumulative total**	**Over all percentage**	**Cumulative percentage**
1	Stain	1500	1500	0.39640592	**39.6%**
2	skip stitch	774	2274	0.204545455	**60.1%**
3	seam broken	554	2828	0.14640592	**74.7%**
4	Thread cut	288	3116	0.076109937	**82.3%**
5	Open seam	257	3373	0.067917548	**89.1%**
6	Mismatch	113	3486	0.029862579	**92.1%**
7	Un even	107	3593	0.028276956	**95.0%**
8	Puckering	81	3674	0.02140592	**97.1%**
9	Print defects	58	3732	0.015327696	**98.6%**
10	slip out	28	3760	0.007399577	**99.4%**
11	oil mark	14	3774	0.003699789	**99.7%**
12	poor tack	10	3784	0.002642706	**100.0%**
	Total	**3784**			

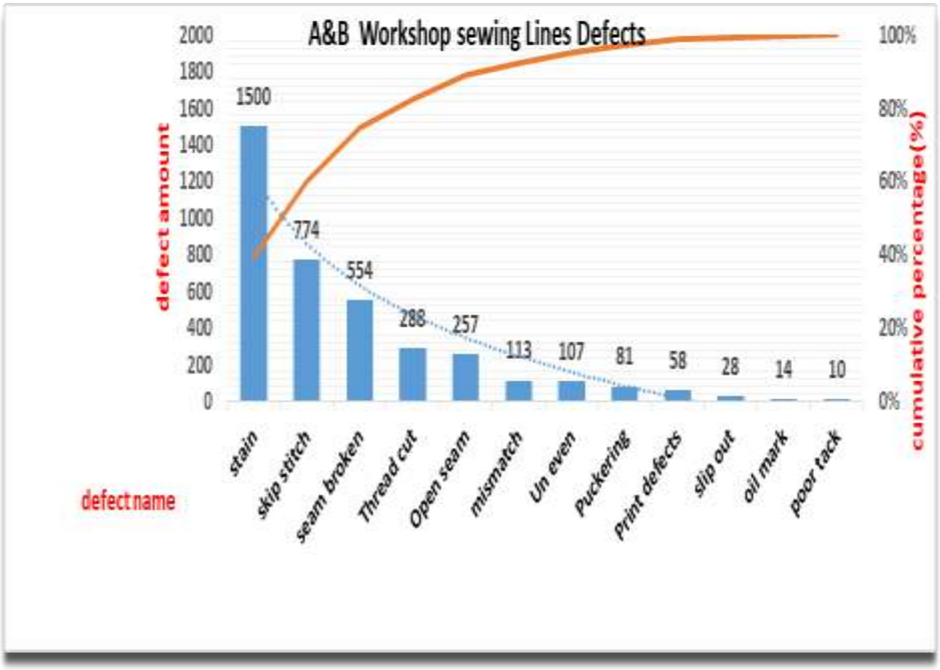
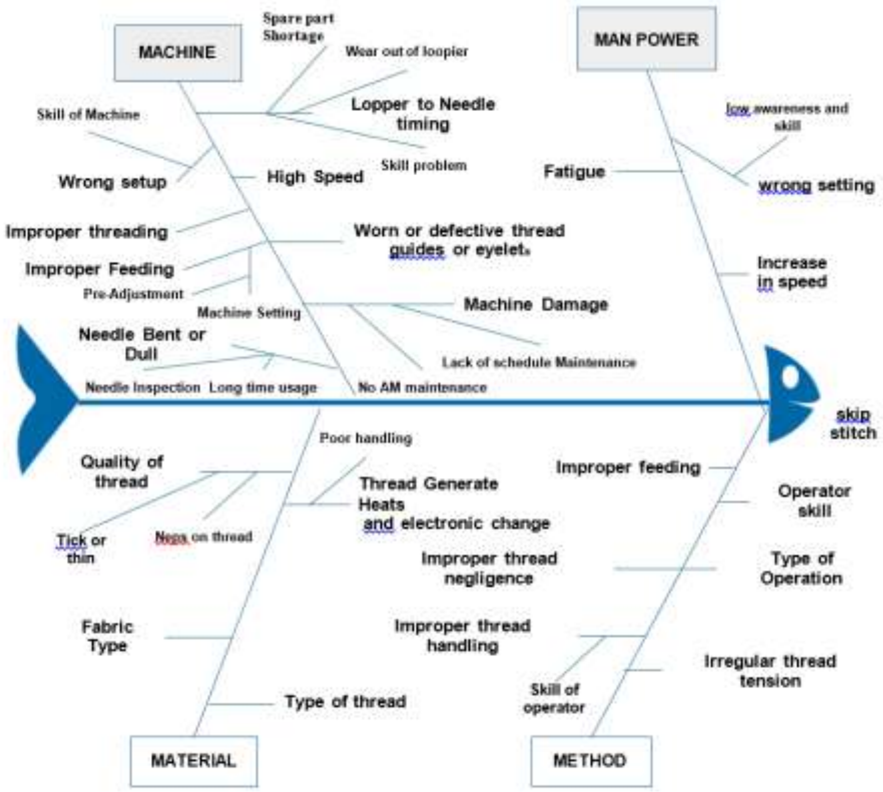
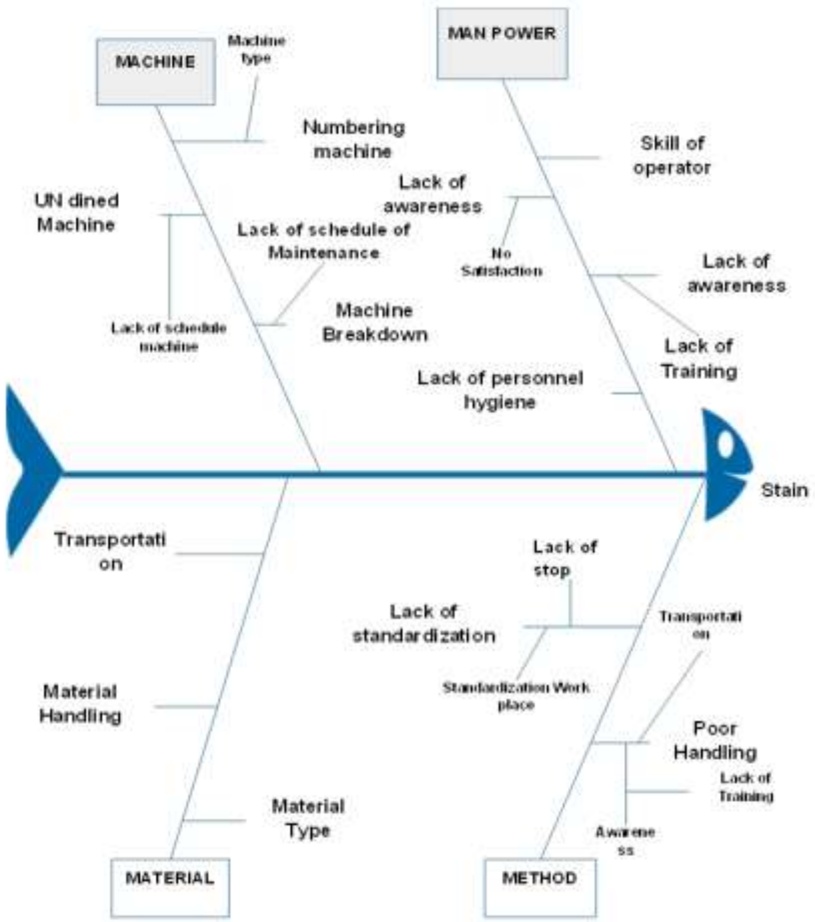


Figure 4. Three Months Defect Pareto Chart for A&B sewing workshop.

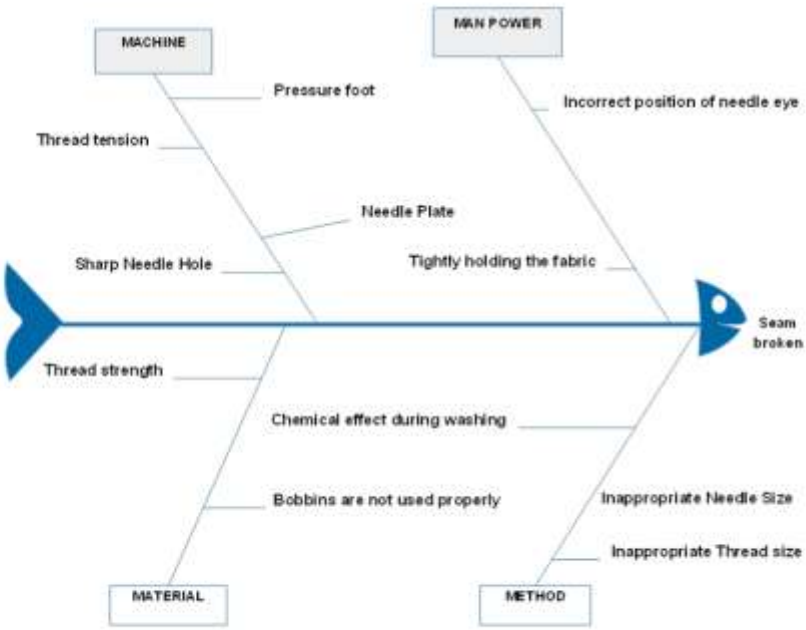
Based on the Pareto Chart the stain, skip stich and seam broken are the major problem of the company. The next figure show that cause and effect diagram of the potential causes were identified by root cause analysis of the three major sewing workshop defects (Figure 5, Figure 5A, 5B, 5C).



A Cause and effect diagram for skip stitch,



B Cause and effect diagram for stain and



C Cause and effect diagram of seam broken respectively

Figure 5. Cause and effect diagrams
A Cause and effect diagram for skip stitch,
B Cause and effect diagram for stain and
C Cause and effect diagram of seam broken respectively

The figures 5 (Figures 5A, Figures 5B, Figures 5C) shows the cause and effect diagram of the potential causes were identified by root cause analysis of the three major sewing workshop defects from Pareto Analysis types such skipped stitch, seam broken and stain have been identified. By our own observation and data provided by supervisors from some production lines through questionnaires the causes for each specific defect types have been identified. Then these causes are ordered in a hierarchy according to the frequency of the feedback provided by QC supervisors.

C-Chart

After we have specified the major defects in both sewing workshop by Pareto chart, we have analysis the three month non-conformities by currently producing garment workshop (A&B) sewing lines. For this, we are using the number of weekly non-conformities of products cause of stain defect type as sample among twelve types sewing defects to develop three sigma control limits using the data from Table 4.

Table 4. Data collected on stain defect.

Weeks in Three Months	Number of non-conformities
1	110
2	120
3	135
4	70
5	180
6	65
7	185
8	121
9	134
10	109
11	141
12	130
Total	**1500**

In most applications, the center line, or mean, of the c chart is based on the average number of number defects per number of sample. This can be determined by number of non-conformities from table 5.

Table 5. Non- conformities

WEEKS	Non- conformities	C L	UCL	LCL
Week1	110	125	232.9166	17.08337
week2	120	125	232.9166	17.08337
week3	135	125	232.9166	17.08337
week4	70	125	232.9166	17.08337
week5	180	125	232.9166	17.08337
week6	65	125	232.9166	17.08337

week7	185	125	232.9166	17.08337
week8	121	125	232.9166	17.08337
week9	134	125	232.9166	17.08337
week10	109	125	232.9166	17.08337
week11	141	125	232.9166	17.08337
week12	130	125	232.9166	17.08337
TOTAL	1500			

From the table analysis we plot c-chart for stain and found the three sigma control limit as shown on Figure 6.

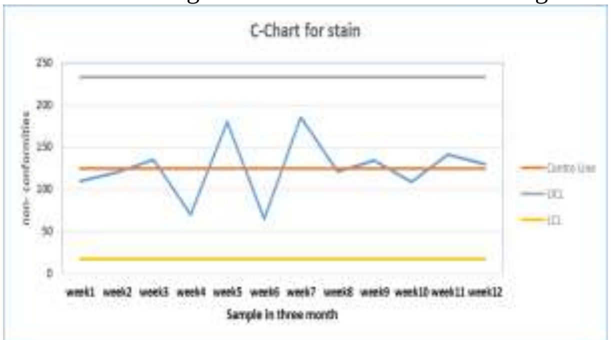


Figure 6. C-chart for stain

5. CONCLUSION

Results from the Analysis of workshop (A&B) by Pareto chart.

I. STAIN is the most frequent defect with as much as 39.6% of the total defects of both sewing workshop lines,
II. SKIP STITCH is the second most frequent defect with 20.4% of the total.
III. among other three major defects contribution of SEAM BROKEN is14.6%.
IV. These three major defects are the "vital few" where 74.7% of total defects occur.

Results from the Analysis of c-chart
The analysis data do not exhibit lack of statistical control; therefore, the analysis control limits given here would be adopted for monitoring of future operations once again, note that, although the process is in control, the average number of defects per sample is high. Action should be taken to improve the supply chain system.
A process is said to be "IN CONTROL" If the following are true:

I. There are no sample points outside the control limits.
II. Most points are near the process average without too many close to the control limits.
III. There is approximately equal number of sample points above and below the center line.
IV. The points appear to be randomly distributed around the center line.

So, the analyzed data cannot meet some of the above mentioned rules, in case there are problems in the process that should have to improve. Since the process is in control, the system must be changed to decrease the number of injuries. This is management's responsibility. However, the people closest to the job will usually have great ideas about what needs to be done to improve the process. They usually do not have the authority to make the required changes. Attempting to decrease the number of non-conformities by encouraging the workforce to be more careful will not work. The process must be changed. Examine the reasons why injuries occur (Table 6).
Prioritize the defects, Pareto diagram can be used for this. Look for ways or improvement mechanism to prevent defects from occurring in the first place.

Table 6. Application of 5S (Table shows the application of 5S).

Category	Item
Sort	Remove what is not needed and keep what is needed.
	Waste materials on the floor, corner area.
	Fabric kept on the floor in wrong ways.
	Low skilled worker.
	Which worker violates "clean" conduct?
Set In Order	Arrange essential items in order for easy access.
	Garments are not arranged.
	Operators are not maintaining work flow.
Shine	Keep things clean and tidy.
	Machines are not properly cleaned.
	Floors, walls and stairs are not properly cleaned.
	Operator hands are not cleaned properly.

Application of PDCA
The theory of the PDCA cycle process was promoted by ISO 9001:2000, which systematically identifies and manages the processes that combine the quality systems and the interactions between the processes. This process is explained as Plan-Do-Check-Action cycle (PDCA). This method applies to all processes to control the production quality. For implementing PDCA cycle, initially, it is required finding the opportunity. The PDCA will be applied to reduce and eliminate waste (Table 7).

Table 3. Cause identification using PDCA and WH questions

PLAN	**5 WH Questions:** Q (1): What is needed to be done? Q (2): How much is needed to be done? Q (3): Where it is needed to be done? Q (4): Who should do it? Q (5): When it is needed to be done?	**Answers of the 5 WH Questions:** A (1): Perfect stitching is needed. A (2): Goal is to reach zero defects. A (3): In every stitch on seam line. A (4): The Operator should do it. A (5): It is needed to be done during Sewing.
DO	**Process implementation according to PLAN** Install, adjust and use the machine properly. Using a good needle, quality-sewing thread and supported equipment's. Recruit expert operator & Spend proper time for each operation.	
CHECK	**Inspection of the process** Planned monitoring and measure the process and the products. Check if the defects are reduced or not? If the defects are not occurring or reducing then continue the action of the process successfully. If defects are occurring, then go back to the PLAN stage and develop some more ideas for solving and reducing defects and go through the cycle again.	
ACTION	Take action on the accurate process for continually improving process performance. If any defects are found, then start the PLAN stage for solving it.	

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