International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol. 3, Issue. 6, Nov - Dec. 2013 pp-3700-3715 ISSN: 2249-6645

An Application of Pareto Analysis and Cause-Effect Diagram for Minimizing Defect Percentage in Sewing Section of a Garment Factory in Bangladesh

Tanvir Ahmed[1], Raj Narayan Acharjee[1], MD.Abdur Rahim[2], Noman Sikder[3], Taslima Akther[3], Mohd. Rifat Khan[3], MD.Fazle Rabbi[3], Anup Saha[3]

[1,3] *Dept. of Industrial and Production Engineering, Shahjalal University of Science and Technology, Bangladesh*
[2] *Dept. of Industrial and Production Engineering, Bangladesh University of Engineering and Technology, Bangladesh*

Abstract: *As Readymade Garments sector is a large industrial sector in Bangladesh, quality improvement can play a vital role for improving productivity as well as economic development for the country. This paper represents a detail investigation on quality improvement of a garment factory by applying Pareto Analysis and Cause-Effect Diagram. The aim of this study is to minimize defects that will reduce rework and rejection rate. Our studied organization is "Rainbow Apparel Limited". In this organization we worked in a particular section (i.e. sewing section) for a particular product (i.e. woven pants). Four months defect data has been collected from the management and Pareto Analysis is performed on them. From this analysis 6 top defect positions are identified where 78.56% defects occur. On those top positions further Pareto Analysis is performed to identify the top defect types. That resulted in total 115 concerning areas where 71.40% defects occur, which should be the major concerning areas to reduce defect percentage. So hierarchies of causes for individual defect types are organized and Cause-Effect Diagrams are constructed for those defect types. Then relative suggestions to those causes are also provided. In the end necessary clues and recommendations have been added for the advancement of the study.*

Keywords: *Defects, Parito Analysis, Root Cause, Parito Analysis, Quality*

I. Introduction

The garment industry has played a pioneering role in the development of industrial sector of Bangladesh. Though it started in late 1970s but it soon established its reputation in the world market within a short span of time. Resultantly garment is now one of the main export items of the country. It accounts for 78% of country's export earnings and contributes more than 10% to Gross Domestic Product (GDP). Besides enriching the country's economy it has played a very important role in alleviating unemployment. With 5,000 factories employing about 3.6 million workers (80% of them women), Bangladesh is clearly ahead of other Southeast Asian suppliers in terms of capacity of the Readymade Garments industry. Around 20 million people are directly and indirectly depending on this sector for their immediate livelihoods.

The export-quota system and the availability of cheap labor are the two main reasons behind the success of the industry. In the 1980s, the Readymade Garments industry of Bangladesh was concentrated mainly in manufacturing and exporting woven products. Since the early 1990s, the knit section of the industry has started to expand. Shirts, T-shirts, trousers, sweaters and jackets are the main products manufactured and exported by the industry. The phase-out of the export-quota system from the beginning of 2005 has raised the competitiveness issue of the Bangladesh Readymade Garments industry as a top priority topic.

As the global economic condition changing in a rapid motion, generally in an industry more focus is given on profit margin, customer demand for high quality product and improved productivity. In garment manufacturing, it is usual to see a lot of rejected garments after shipment. These non-repairable defects may occur due to low quality raw materials or faulty process or employee casual behavior. In the contemporary world of manufacturing, due to high competitive nature of the market, different companies have started to look for different approaches and practices to reduce the defect percentage. Pareto Analysis helps to identify different defects and classify them according to their significance. These defects often lead to the rejection of raw materials. To determine possible root causes of rejection, Cause-Effect Diagram is also a very useful tool. It helps to identify, sort, and display causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome and hence to identify the possible root causes.

In this paper, sewing section of a garment factory is studied where pants are produced in five production lines. In this study Pareto chart and Cause-Effect Diagram have been used with an objective to identify and classify the reasons that are responsible for various defects in the production lines.

II. Background Of The Study

At present the success of the Readymade Garments sector highly depends on several factors such as manufacturing lead time, quality of product, production cost etc. These factors are hampered due to various defects in the products. These defects can be repairable that leads to rework or non-repairable that leads to rejection. Rework in the garments industry is a common work that hampers the smooth production rate and focus poor quality products having an impact on overall factory economy. Minimization of reworks is a must in quality and productivity improvement. Rework is a vital issue for poor quality product and low production rate. Reworks are the non-productive activities focusing on any activity that customer are not willing to pay for. Non-productive activities describe that the customer does not consider as adding value to his product.

By reacting quicker in minimization of reworks to make a product as per customer demand with expected quality, the company can invest less money and more costs savings. Whereas rejection causes waste and deceases resource efficiency.

In this context Readymade Garments sector is selected for research work. The selected garment factory consists of several departments such as cutting, sewing, finishing, packing etc. Among these departments the sewing section is selected. This study tried to extract the common scenario of Readymade Garments sector of Bangladesh by depicting the existing condition of sewing section.

III. Methodology

This study contains use of quality tools to minimize defects and rework on garment industry. It includes the theoretical ideas about various defects, various quality tools specially Pareto Analysis and Cause-Effect diagram. The case study research conducted on the selected garment factory "Rainbow Apparel Limited". This segment includes the understanding about the quality control system of the selected factory and how this could be improved. The conceptual development includes the generation of ideas for minimizing defects by identifying major concerning areas and by providing respective suggestions. Finally, the last segment contains the comparative theoretical and mathematical evaluation about the quality control system. Steps involved in the study

Step 1: Factory Selection

After gathering information we made contact with some garment factories and tried to select a newly established factory where we can place or utilize our knowledge to make some contribution for the development of the factory. Thus we have selected a particular garment factory in Halishahar, Chittagong.

Step 2: Conducting of Case Study

Finally we conduct our research work in a particular garment factory named "Rainbow Apparel Limited" established in 2006 which situates in Halishahar, Chittagong. The demography of the situated organization is presented in Table 1.

Table 1. Demography of "Rainbow Apparel Limited"

Company Name	Rainbow Apparel Limited
Location	Halishahar college road, Chittagong
Established	2006
Product type	Woven shirt, Woven pant
Number of production line	5
Total worker	250
Production capacity per day	3000 PCS
Working hour per day	10 Hours (maximum)
Buyers	Long Street (USA), Target (USA)

Step 3: Gather Information

In this step we have gathered information on the Quality Control system of the sewing section of the selected garment factory. Here we have collected data of various defects from the sewing section provided by the management which is used for the Analysis purpose of the study.

Step 5: Identify the Problem

Identification of the major concerning areas to minimize the defects was next step. According to the observation and using management data we have seen some repetitive defects occur in the sewing section. So we tried to do our research work on this section which is our major concern.

Step 6: 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 defect types. Then we have provided some respective suggestions to minimize the frequency of those defects.

IV. Findings And Data Analysis

In the previous section we have discussed about the research work of some repetitive defects exist in the sewing section of a particular product i.e. woven pant. From our own observation and data given by the management level we saw that there are different types of defects occurred in the production lines. These defects cause reworks and rejection which leads to time waste and decrease in productivity. By concentrating on those few repetitive defects in particular positions, most of the defects can be minimized. So with this respect, we have tried to identify those particular defects and positions using Pareto Analysis. Then we have analyzed the causes of those defects and constructed Cause-Effect diagrams. And finally we have provided some suggestions in relation to those causes that will ultimately reduce those defects.

4.1 Overview of Production Line

We performed our research work in a particular garment factory named "Rainbow Apparel Limited" established in 2006 and situated in Halishahar, Chittagong. There we conduct our research in a particular section (i.e. sewing section) for the woven pant. There are 5 production lines in this section. Here we have seen three types of quality checkpoints in each production line. These are called (1) In-line or process QC table, (2) End line QC table and (3) Finishing QC table. These checkpoints check the products for defects and if found then the defect type and defect position are identified and listed in the check sheet. An overview of the existing layout of a single production line is shown in figure 1.

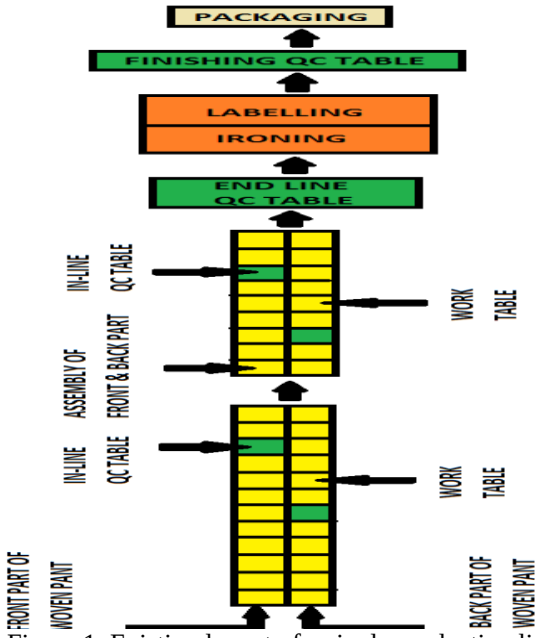

Figure 1. Existing layout of a single production line

4.2 Data Collection

For our research work we have collected four months defect data from management months starting from October 2012 to January 2013. The data has been taken from five production lines of sewing section during the production of woven pant. In the case of woven pant production 50 defect positions are identified where 25 types of defects occur. Among the defect types Uncut Thread for all positions are counted together for 50 positions. Similarly two other defect types, Spot and Oil Mark are also counted together. Number of defects of all the production lines are listed on the Check Sheet by QC supervisors if found any. In our visited factory various defect types of sewing section are expressed by some specific defect codes. The defect types with their corresponding codes are presented in table 2. and sample of a check Sheet is shown in figure 2. Then four months combined defect data is presented in table 3.

Quality Inspection-100% (Sewing)

Style No.	Order No.	QC Name:	Line No.	Date:

	8.00-9.00	9.00-10.00	10.00-11.00	11.00-12.00	12.00-1.00	2.00-3.00	3.00-4.00	4.00-5.00	5.00-6.00	6.00-7.00
No. of Pieces Checked										
Total Defects										
Hourly DHU										
Supervisor										
Line Quality Head										
Operations ↓	Defect Codes									
TOTAL										

Figure 2. Sample of a Check Sheet

Table 2. Defect types with their corresponding codes

SL No.	DEFECT TYPE	DEFECT CODES
1	Skipped Stitch	A
2	Broken Stitch	B
3	Loose Tension	C
4	Uneven Stitch	D
5	Run Off Stitch	E
6	Slanted	F
7	High/Low	G
8	Puckering	H
9	Crooked	I
10	Out of Shape	J

11	Raw Edge	K
12	Position	L
13	Pullness	M
14	Uncut Thread	N
15	Overlap	O
16	Incomplete	P
17	Visible Joint	Q
18	Wrong SPI	R
19	Spot	S
20	Oil Mark	T
21	Twisting	U
22	Label Mistake	V
23	Visible Top Stitch	W
24	Color Shading	X
25	Needle Mark	Y

Table 3. Four months combined defect data for woven pant

Defect Types → / Defect Position ↓	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Total
Uncut Thread for All Position	0	0	0	0	0	0	0	0	0	0	0	0	0	8988	0	0	0	0	0	0	0	0	0	0	0	8988
Spot for All Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7845	0	0	0	0	0	0	7845
Waist Belt	231	976	46	538	154	4	7	134	161	88	765	5	30	0	72	40	14	5	0	0	123	42	987	0	0	4422
Bottom Hem	942	980	95	1043	76	93	72	45	86	18	58	8	12	0	6	66	87	31	0	0	80	1	5	1	0	3805
Side Seam	783	537	26	62	59	22	43	62	72	18	596	6	12	0	2	31	0	4	0	0	4	0	35	0	12	2386
Waist Belt Top Stitch	313	798	36	245	77	7	5	96	22	36	65	13	26	0	61	11	11	2	0	0	12	1	490	0	0	2327
Loop	38	15	2	30	0	389	2	0	56	0	3	11	189	0	0	76	0	0	0	0	0	0	0	0	0	811
Front / Back Rise	211	134	32	23	58	16	15	10	31	16	43	3	31	0	2	21	4	32	0	0	1	0	0	0	0	683
In Seam	126	112	8	26	9	2	0	45	31	5	173	2	4	0	4	23	0	8	0	0	2	6	0	0	0	586
Back Pocket	66	198	13	53	23	2	4	10	108	0	55	0	1	0	31	6	1	1	0	0	0	0	0	0	0	572
Mouth Close	3	29	1	25	14	132	321	6	7	3	3	4	4	0	0	9	0	7	0	0	0	2	0	0	0	570
Front Pocket	93	136	13	26	15	1	57	3	114	0	43	5	29	0	1	14	0	0	0	0	3	0	0	4	0	557
Oil Mark for All Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	432	0	0	0	0	0	432
Loop Joint	2	10	0	2	0	342	19	0	2	0	0	12	0	0	0	10	0	0	0	0	0	1	0	0	0	400
Bartack	6	5	2	0	0	23	10	0	51	0	2	0	144	0	3	132	0	0	0	0	2	3	0	0	0	383
Label Joint	11	50	0	1	6	50	0	2	45	0	11	1	15	0	8	22	0	2	0	0	0	124	0	0	5	353
Front Part	81	127	4	10	8	0	14	2	20	3	33	0	4	0	16	8	0	0	0	0	2	0	0	7	0	339
Loop Tack	2	35	0	0	3	214	2	4	1	0	33	5	4	0	4	2	0	3	0	0	0	0	0	0	0	312
Back Part	101	102	2	10	12	0	2	3	11	0	31	0	6	0	19	0	1	0	0	0	0	0	0	0	0	300
Label	2	42	0	6	3	5	4	0	14	0	1	5	2	0	0	31	0	0	0	0	0	97	0	0	0	212
Loop Bartack	0	2	0	0	0	123	32	0	0	3	0	0	2	0	0	11	0	0	0	0	0	0	0	0	0	173
Front Pocket Bartack	4	8	0	0	0	40	45	3	4	0	2	2	24	0	0	0	0	0	0	0	0	0	0	0	0	132
J Stitch	7	41	1	0	0	0	0	0	2	0	0	0	0	0	4	3	0	0	0	0	0	0	72	0	0	130
Back Dart	35	28	0	6	1	1	1	0	13	2	12	10	0	0	0	8	0	0	0	0	0	1	1	1	0	120
Zipper Joint	0	15	0	0	1	0	0	74	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93
Mouth Tack	1	1	0	4	0	57	26	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	92
Zipper Fly	3	32	0	21	0	0	0	0	28	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	91

Table 3(continued). Four months combined defect data for woven pant

Defect Types → / Defect Position ↓	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Total
Fly Top Stitch	27	15	3	13	0	0	0	10	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	74
Loop Sadel Stitch	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69
Front Dart	57	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	62
Pocket Bartack	0	0	0	0	0	20	0	0	0	0	0	0	9	0	33	0	0	0	0	0	0	0	0	0	0	62
Side Slit	9	21	0	2	0	0	23	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57
Waist Belt Tack	0	0	0	0	0	0	0	0	1	0	0	0	29	0	0	0	0	0	0	0	0	0	18	0	0	48
Sadel Stitch	19	17	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44
Back Pocket Sadel Stitch	15	9	0	0	0	3	0	0	1	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	41
Waist Belt Joint	0	16	1	3	1	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	9	0	0	40
Front Panel	32	1	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	37
Slit at Back Bottom	0	4	0	0	0	0	0	4	12	0	0	0	12	0	0	1	0	0	0	0	0	0	0	0	0	33
Front / Back Pocket	1	10	0	1	3	3	3	1	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	28
Back Yoke	10	10	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
Mouth	0	0	0	0	0	3	13	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
Pocket	2	7	0	2	0	1	0	0	5	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	21
Dart Sadel Stitch	9	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Button	0	0	0	0	0	0	0	0	1	0	0	2	4	0	5	6	0	0	0	0	0	0	0	0	0	18
Front Pocket Sadel Stitch	15	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
Back Pocket Flap	0	0	0	0	0	8	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Reject	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	14
Mending	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
Blind Stitch	1	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Back Pocket Overlock	0	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Hook & Bar	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Front Part Overlock	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Waist Belt Shape	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3327	4555	285	2153	523	1560	733	519	918	194	1947	94	608	8988	274	545	119	95	7845	432	231	278	1621	15	38	37897

Table 3. Shows four months combined defect data where green cells represent defect types and red cells represent defect positions. Here total amount of defects for Uncut Thread are counted together for 50 positions and put in a single cell marked by yellow color. For Spot and Oil Mark similar work have been done.

4.3 Pareto Analysis

We have performed our Pareto Analysis based on four months combined defect data of 5 production lines from the sewing section for woven pants. From this analysis we can identify the "Vital few" areas where maximum defects occur. The analysis is shown in figure 3. Here horizontal axis represents defect positions, vertical axis at left side represents defect amount and vertical axis at right side represents defect percentage. The defect positions with their respective defect amounts have been represented by the blue colored bars. The cumulative percentage and 80% line are represented respectively by red and green color. After the analysis top defect position bars are replaced with yellow color.

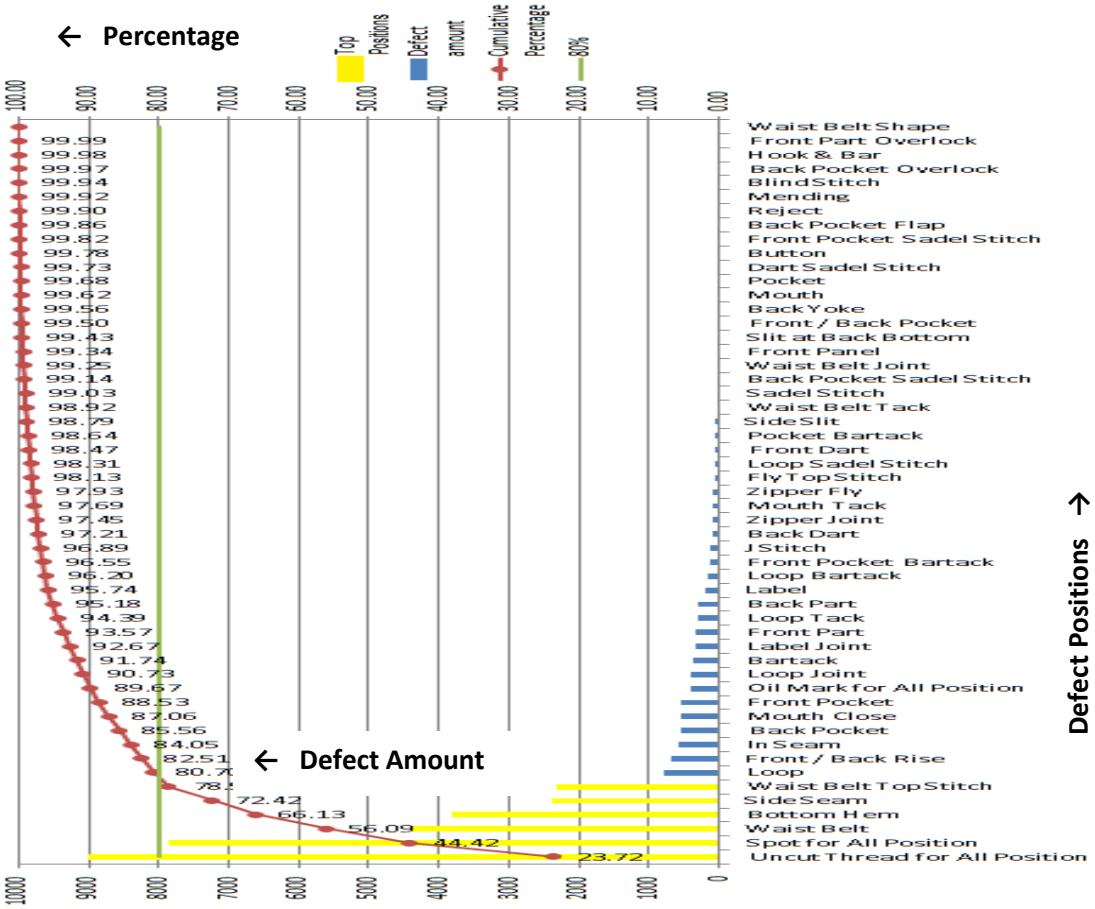

Figure 3. Pareto Analysis for top defect positions

4.3.1 Observations from Pareto Analysis for Top Defect Positions

1. Uncut Thread is the most frequent defect with as much as 23.72% of the total.
2. Spot is the second most frequent defect with 20.70% of the total.
3. Among other defects contribution of Waist Belt is 11.67%, Bottom Hem is 10.04%, Side Seam is 6.30% and Waist Belt Top Stitch is 6.14%.
4. These six top defect positions are the "vital few" where 78.56% of total defects occur.
5. We need to perform further Pareto Analysis on those top defect positions to identify the vital few defect types that are responsible for maximum amount of defect.

4.3.2 Further Pareto Analysis for Top Defect Types

As Uncut Thread and Spot are individually defect types as well as defect positions, there is no need of further analysis for identifying top defect types in those two positions. So we have performed further Pareto Analysis for Waist Belt, Bottom Hem, Side Seam and Waist Belt Top Stitch. From these analysis we have identified "vital few" defect types for each positions.

Pareto Analysis for Waist Belt: Pareto Analysis for Waist Belt for is shown in figure 4.

Table 4. Waist Belt defect data

Waist Belt		
Defect Types	**Defect Codes**	**Defect Amount**
Visible Top Stitch	W	987
Broken Stitch	B	976
Raw Edge	K	765
Uneven Stitch	D	538
Skipped Stitch	A	231
Crooked	I	161
Run Off Stitch	E	154
Puckering	H	134
Twisting	U	123
Out of Shape	J	88
Overlap	O	72
Loose Tension	C	46
Label mistake	V	42
Incomplete	P	40
Pullness	M	30
Visible Joint	Q	14
High/Low	G	7
Position	L	5
Wrong SPI	R	5
Slanted	F	4
TOTAL		4422

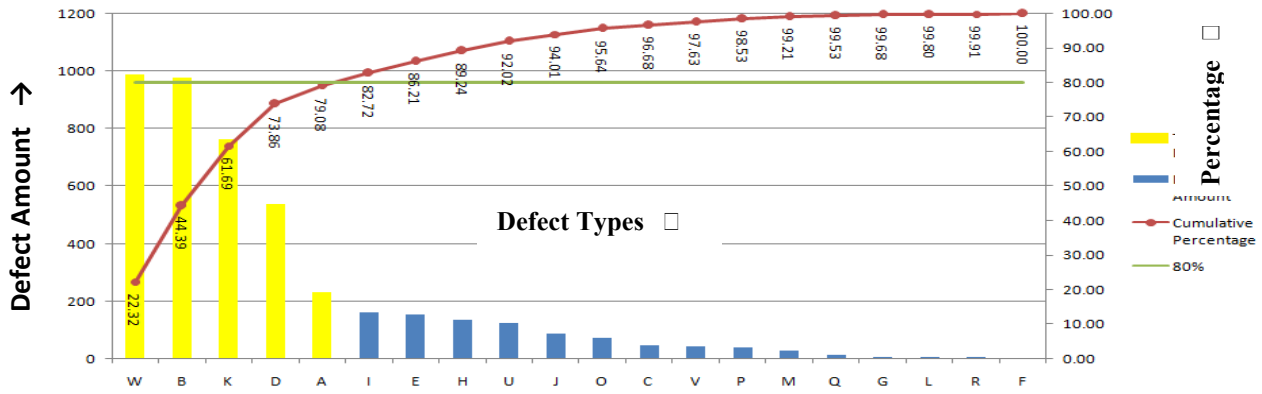

Figure 4. Pareto Analysis for Waist Belt

Observations from the Analysis:

- Visible Top Stitch (W) is the most frequent defect type with 22.32% of total Waist Belt defect.
- Among other defect types contribution of Broken Stitch (B) is 22.07%, Raw Edge (K) is 17.30%, Uneven Stitch (D) is 12.17% and Skipped Stitch (A) is 5.22%.
- So these five defect types are responsible for 79.08% of total Waist Belt defects.
- Pareto Analysis for Bottom Hem: Pareto Analysis for Bottom Hem for is shown in figure 5.

Table 5. Bottom Hem defect data

Bottom Hem		
Defect Types	**Defect Codes**	**Defect Amount**
Uneven Stitch	D	1043
Broken Stitch	B	980
Skipped Stitch	A	942
Loose Tension	C	95
Slanted	F	93
Visible joint	Q	87
Crooked	I	86
Twisting	U	80

Run Off Stitch	E	76
High/Low	G	72
Incomplete	P	66
Raw Edge	K	58
Puckering	H	45
Wrong SPI	R	31
Out of Shape	J	18
Pullness	M	12
Position	L	8
Overlap	O	6
Visible Top stitch	W	5
Label Mistake	V	1
Color Shading	X	1
TOTAL		3805

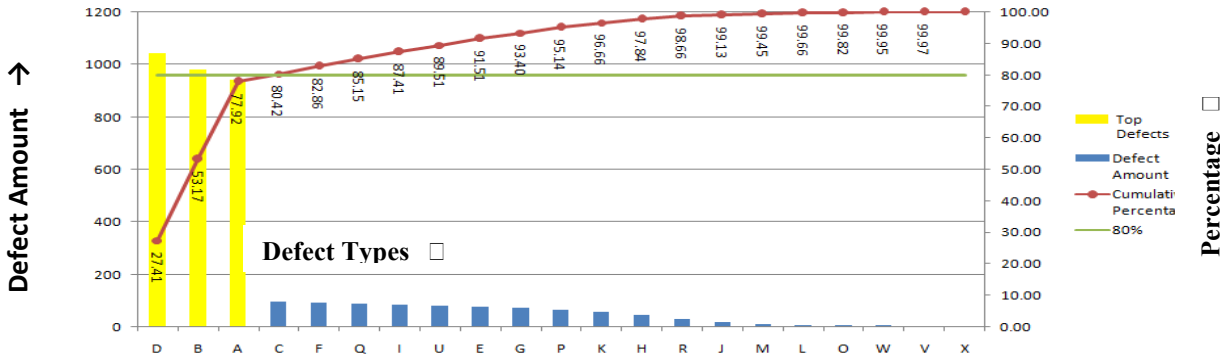

Figure 5. Pareto Analysis for Bottom Hem

Observations from the Analysis:

- Uneven Stitch (D) is the most frequent defect type with 27.41% of total Bottom Hem defect.
- Among other defect types contribution of Broken Stitch (B) is 25.76% and Skipped Stitch (A) is 24.76%.
- So these three defect types are responsible for 77.92% of total Bottom Hem defects.
- **Pareto Analysis for Side Seam:** Pareto Analysis for Side Seam for is shown in figure 6.

Table 6. Side Seam defect data

Side Seam		
Defect Types	**Defect Codes**	**Defect Amount**
Skipped Stitch	A	783
Raw Edge	K	596
Broken Stitch	B	537
Crooked	I	72
Uneven Stitch	D	62
Puckering	H	62
Run Off Stitch	E	59
High/Low	G	43
Visible Top Stitch	W	35
Incomplete	P	31
Loose Tension	C	26
Slanted	F	22
Out of Shape	J	18
Pullness	M	12
Needle Mark	Y	12
Position	L	6

Wrong SPI	R	4
Twisting	U	4
Overlap	O	2
TOTAL		2386

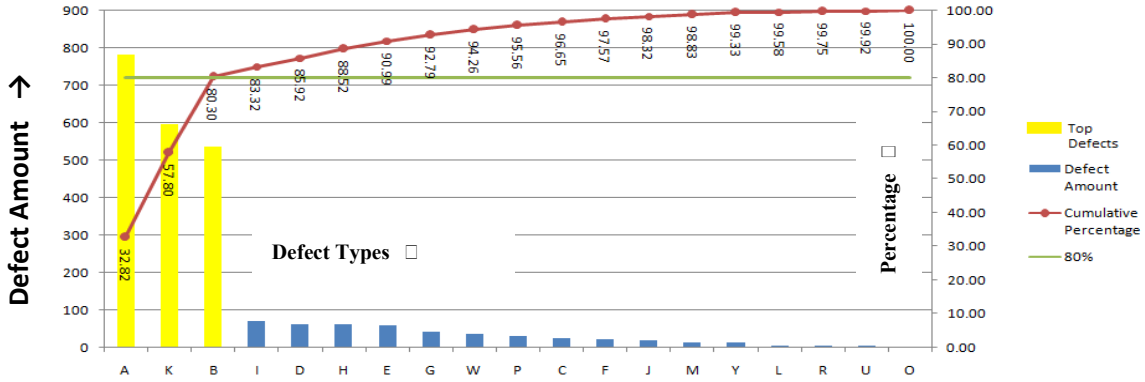

Figure 6. Pareto Analysis for Side Seam

Observations from the Analysis:

- Skipped Stitch (A) is the most frequent defect type with 32.82% of total Side Seam defect.
- Among other defect types contribution of Raw Edge (K) is 24.98%, Broken Stitch (B) is 22.51%
- So these three defect types are responsible for 80.30% of total Side Seam defects.
- **Pareto Analysis for Waist Belt Top Stitch:** Pareto Analysis for Waist Belt Top Stitch for is shown in figure 7.

Table 7. Waist Belt Top Stitch defect data

Waist Belt Top Stitch		
Defect Types	**Defect Codes**	**Defect Amount**
Broken Stitch	B	798
Visible Top Stitch	W	490
Skipped Stitch	A	313
Uneven Stitch	D	245
Puckering	H	96
Run Off Stitch	E	77
Raw Edge	K	65
Overlap	O	61
Loose Tension	C	36
Out of shape	J	36
Pullness	M	26
Crooked	I	22
Position	L	13
Twisting	U	12
Incomplete	P	11
Visible Joint	Q	11
Slanted	F	7
High/Low	G	5
Wrong SPI	R	2
Label Mistake	V	1
TOTAL		2327

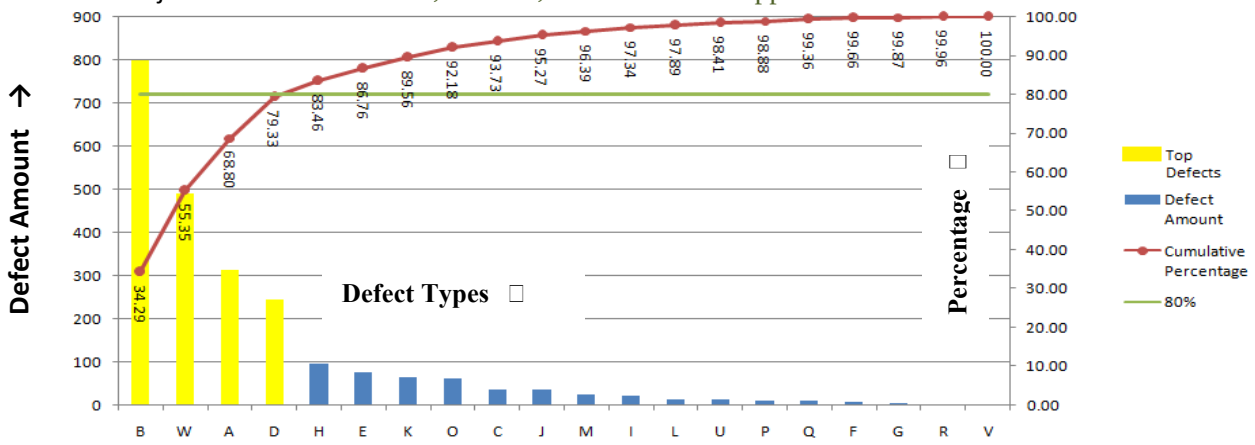

Figure 7. Pareto Analysis for Waist Belt Top Stitch

Observations from the Analysis:

Broken Stitch (B) is the most frequent defect type with 34.29% of total Waist Belt Top Stitch defect. Among other defect types contribution of Visible Top Stitch (W) is 21.06%, Skipped Stitch (A) is 13.45% and Uneven Stitch (D) is 10.53%.

So these four defect types are responsible for 79.33% of total Waist Belt Top Stitch defects.

Major Concerning Areas at a Glance:

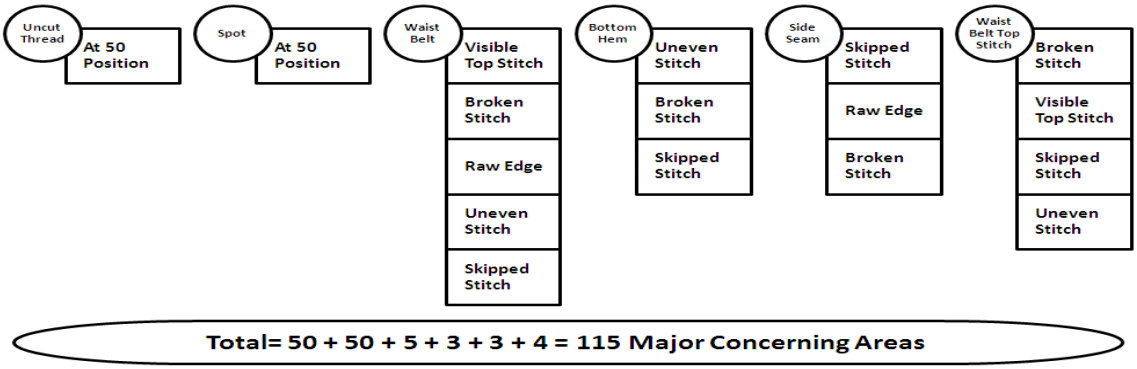

Figure 8. Major Concerning Areas at a Glance

4.4 Result of the Pareto Analysis

After Pareto Analysis it is found that total seven types of defect in the identified top defect positions are responsible for maximum amount of defects. The defect types and the corresponding positions with their respective defect amount are shown in table 8.

Table 8. Total Amount of Defects in Major Concerning Areas

MAJOR CONCERNING AREAS		Defect amount
Defect Types	**Defect Positions**	
Uncut Thread (N)	At 50 positions	8988
Spot (S)	At 50 positions	7845
Skipped Stitch (A)	Waist Belt	231
	Bottom Hem	942
	Waist Belt Top Stitch	313
	Side Seam	783
Broken Stitch (B)	Waist Belt	976
	Bottom Hem	980
	Waist Belt Top Stitch	798
	Side Seam	537
Uneven Stitch (D)	Waist Belt	538
	Bottom Hem	1043
	Waist Belt Top Stitch	245

Raw Edge (K)	Waist Belt	765
	Side Seam	596
Visible Top Stitch (W)	Waist Belt	987
	Waist Belt Top Stitch	490
Total amount		**27057**

Total number of defects = **37897**
Total number of defects in major concerning area = **27057**
Percentage of defects in major concerning area = $\frac{27057\times 100}{37897}\% \approx \mathbf{71.40\%}$

There are 25 defects types of which Uncut Thread, Spot and Oil Mark are individually counted together for 50 positions. Rest of the 22 defect types can occur in 50 different positions of the woven pants. So the number of total concerning area is [22*50 + 50 (Uncut Thread) + 50 (Spot) + 50 (Oil Mark)] = 1250 which is responsible for total amount of defects.
But we have identified total 115 concerning areas by Pareto Analysis which is responsible for 71.40% defects.
Total number of concerning area = **1250**
Total number of major concerning area = **115**
Percentage of major concerning area = $\frac{115\times 100}{1250}\% \approx \mathbf{9.20\%}$
So by concentrating only on 9.20% areas most of the defects can be reduced.

4.5 Hierarchy of Causes and Cause-Effect Diagram

From Pareto Analysis we have identified top defect positions and by further analyzing we have also identified top seven defect types in those positions. Those defect types are Skipped Stitch, Broken Stitch, Uneven Stitch, Raw Edge, Uncut Thread, Spot and Visible Top Stitch. These types of defect occur due to some specific causes. By our own observation and data provided by 20 QC supervisors from five production lines through questionnaires we have identified the causes for each specific defect types. Then these causes are ordered in a hierarchy according to the frequency of the feedback provided by QC supervisors. These hierarchies are shown in table 9, 10, 11, 12, 13, 14 and 15. After that we have constructed Cause-Effect Diagram for each of the defect types using 4M (Man, Machines, Materials and Methods) bones. These Cause-Effect Diagrams are shown in figure 9, 10, 11, 12, 13, 14 and 15.

Table 9. Hierarchy of Causes for Uncut Thread

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Operator inefficiency	**20**
2	Improper trimming	**16**
3	Improper finishing	**11**

Table 10. Hierarchy of Causes for Spot

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Operator carelessness	**20**
2	Mishandling	**17**
3	Defective machine	**13**
4	Dirty work area	**06**

Table 11. Hierarchy of Causes for Visible Top Stitch

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Operator inefficiency	**20**
2	Improper trimming	**15**

Table 12. Hierarchy of Causes for Broken Stitch

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Inappropriate thread tension	**17**
2	Wrong needle size and thread size	**15**
3	Needle plate, pressure foot, needle holes may have sharp edges	**12**
4	Excessive abrasion or chemical degradation of the thread during washing	**07**
5	Weak thread	**06**

Table 13. Hierarchy of Causes for Raw Edge

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)

1	Improper seaming	**20**
2	Improper folding	**20**

Table 14. Hierarchy of Causes for Uneven Stitch

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Operator speeding up machine too rapidly	**17**
2	Operator holding back or pulling fabric through in variance with correct machine feed	**13**

Table 15. Hierarchy of Causes for Skipped Stitch

SL. NO.	CAUSES	FREQUENCY (OUT OF 20)
1	Needle deflection or bending	**17**
2	Loop size or needle is small	**13**
3	Tension variation in lopper and needle thread	**11**
4	Hook, lopper or needle is not able to hold the thread loop in proper time	**11**
5	Improper handling of cut pieces	**07**
6	Operator inefficiency	**02**

Cause-Effect Diagram for Uncut Thread

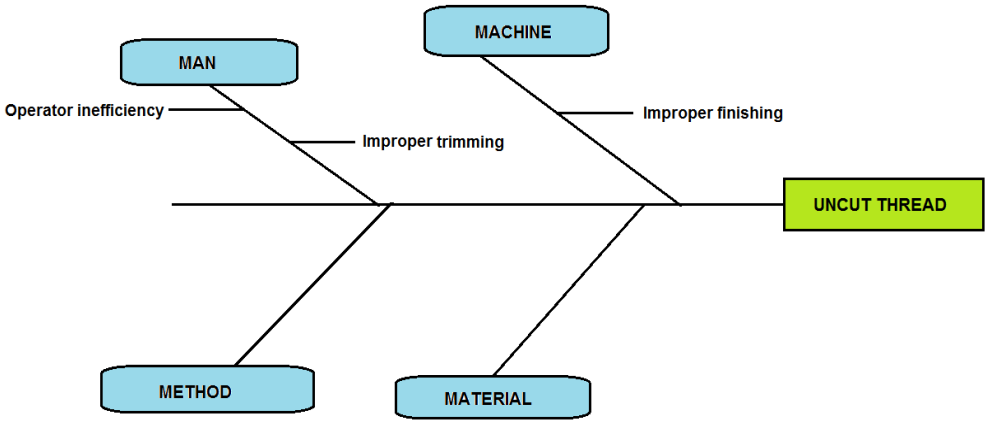

Figure 9. Cause-Effect diagram for Uncut Thread

Cause-Effect Diagram for Spot

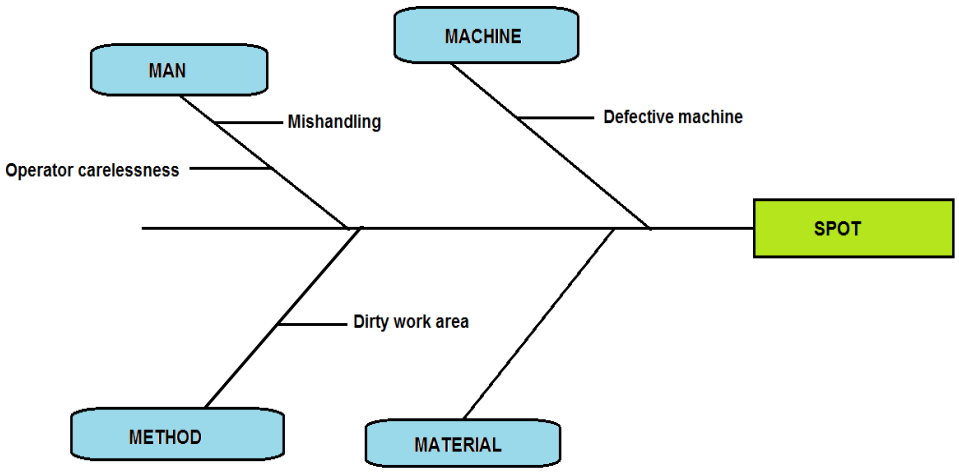

Figure 10. Cause-Effect diagram for Spot

Cause-Effect Diagram for Visible Top Stitch

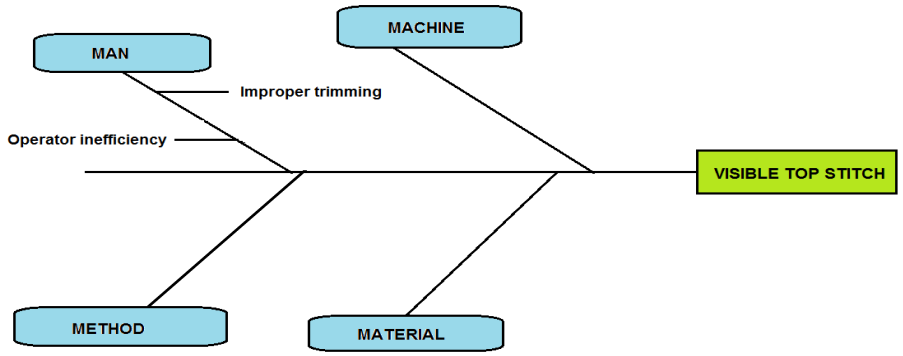

Figure 11. Cause-Effect diagram for Visible Top Stitch

Cause-Effect Diagram for Broken Stitch

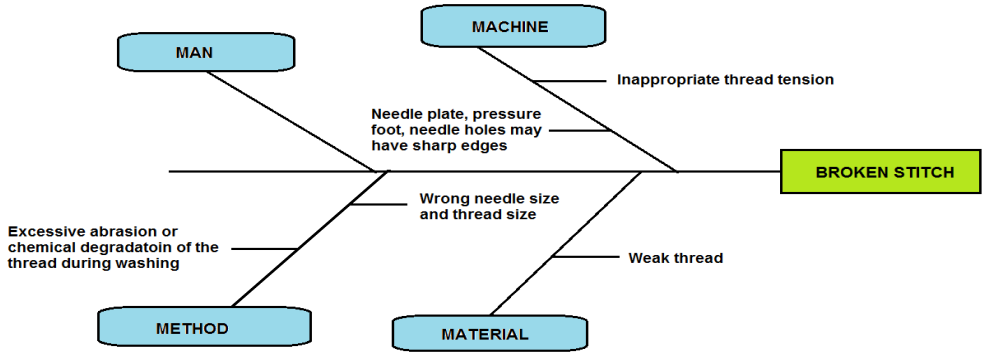

Figure 12. Cause-Effect diagram for Broken Stitch

Cause-Effect Diagram for Raw Edge

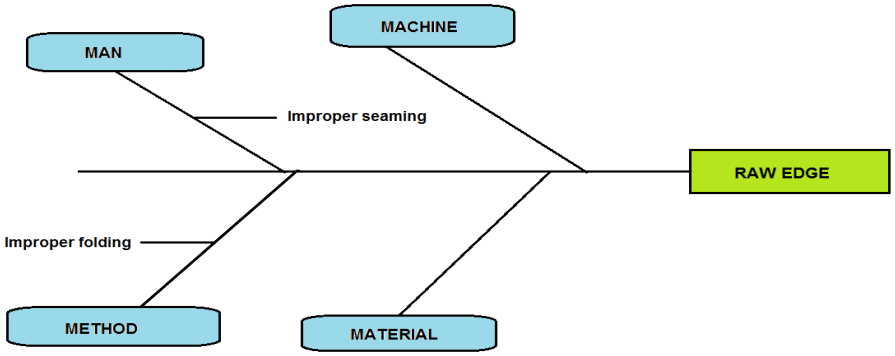

Figure 13. Cause-Effect diagram for Raw Edge

Cause-Effect Diagram for Uneven Stitch

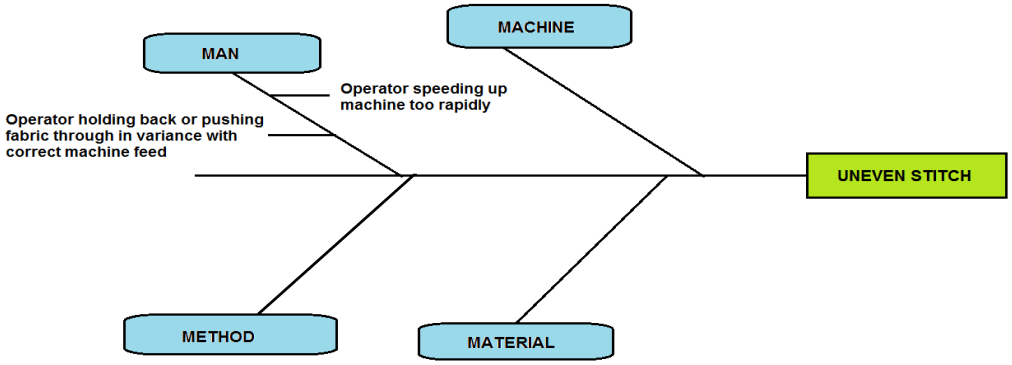

Figure 14. Cause-Effect diagram for Uneven Stitch

Cause-Effect Diagram for Skipped Stitch

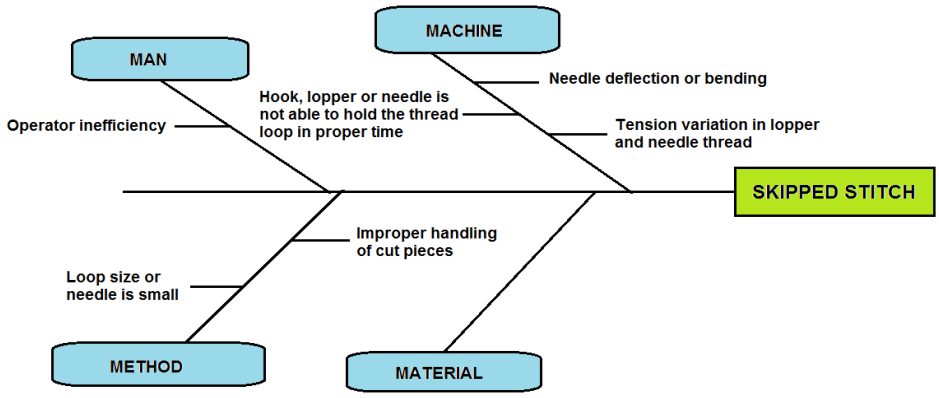

Figure 15. Cause-Effect diagram for Skipped Stitch

4.6 Suggestions to Reduce Top Defects Percentage

From our own observation, literature review and consultation with management some suggestions with their corresponding causes are provided below to reduce defect percentage:

Table 16. Suggested Solutions for Uncut Thread

Cause Types	Causes	Suggested Solutions
Man	Operator inefficiency	Provide adequate training to the operators.
	Improper trimming	Provide thread cutter to every operator and make used to.
Machine	Improper finishing	To cut thread properly, start regularly checking system to check the auto trimming machine is properly functioning or not.
		Improve quality inspection system.

Table 17. Suggested Solutions for Spot

Cause Types	Causes	Suggested Solutions
Man	Mishandling	Wash hands of operator before starting work and after lunch, establish preventive maintenance.
	Operator carelessness	Improve supervision.
Machine	Defective machine	Clean machine properly twice in a day.
Method	Dirty work area	Keep workplace neat and clean.

Table 18. Suggested Solutions for Visible Top Stitch

Cause Types	Causes	Suggested Solutions
Man	Operator inefficiency	Provide adequate training to the operators.
	Improper trimming	Teach operators.

Table 19. Suggested Solutions for Broken Stitch

Cause Types	Causes	Suggested Solutions
Machine	Inappropriate thread tension	Tension of the thread properly adjusted.
	Needle plate, pressure foot, needle holes may have sharp edges	Inspect the needle point at regular intervals and check for sharp or burred points.
		Sharp edges should be removed.
Method	Wrong needle size and thread size	Needle size and thread size should be synchronized.
	Excessive abrasion or chemical degradation of the thread during washing	Special care should be taken during washing.
Material	Weak thread	Select good quality thread which is free from flaws.

Table 20. Suggested Solutions for Raw Edge

Cause Types	Causes	Suggested Solutions
Man	Improper seaming	Teach operator
Method	Improper folding	Improve or change folding system

Table 21. Suggested Solutions for Uneven Stitch

Cause	Causes	Suggested Solutions

Types		
Man	Operator speeding up machine too rapidly	Control the speed of machine, use right needle and correct feed control.
	Operator holding back or pulling fabric through in variance with correct machine feed	Improve the skill of operator, use good quality sewing thread, and provide standard quality specification.
		Never pull on the fabric while sewing, let it be taken up by the machine.

Table 22. Suggested Solutions for Skipped Stitch

Cause Types	Causes	Suggested Solutions
Man	Operator inefficiency	Provide adequate training to the operators.
Machine	Hook, lopper or needle is not able to hold the thread loop in proper time	Timing of hook or lopper with needle should be adjusted properly.
		Use needle which design to facilitate loop formation.
		Repair damage machine parts.
	Needle deflection or bending	Adjust the needle height and testing before bulk sewing.
		Check needle is properly mounted on the sewing machines with right eye position.
	Tension variation in lopper and needle thread	Adjust tension properly.
		Select good quality thread which is free from flaws.
		Choice of sewing thread in accordance with the needle size.
Cause Types	**Causes**	**Suggested Solutions**
Method	Loop size or needle is small	Adjust needle and thread size.
	Improper handling of cut pieces	Reduce gap between presser foot and the hole of needle plate

4.7 Suggested Additional Features for Existing Production Lines

- There are four in-line QC tables in each production line. These are currently placed in such a way that when defects occur in first few work tables, it takes too much time to identify the defects. Before reaching the QC table many operations are performed on those defected pieces and it results in more reworks than necessary. That is why more In-line QC tables should be included which will identify defects earlier, thus reduce rework percentage.
- After performing operation in each work table garments are kept mostly in the floor and sometimes in paper boxes which is one of the major reason for spot. To avoid the occurrence we have suggested providing a trolley between every two workers and that will also result in easy and smooth transportation
- Finally we have suggested to provide paper manual in every work table containing important issues for workers, such as:
  - Clean table and machines before starting day's work.
  - Wash hands properly before starting work and after lunch.
  - Never pull on the fabric while sewing, let it be taken up by the machine.
  - Adjust needle height, thread type and thread tension before bulk sewing.
  - Use right size of needle for specific type of fabrics.

- Keeping all these features in mind an improved version of existing layout of a single production line is shown in figure 16.

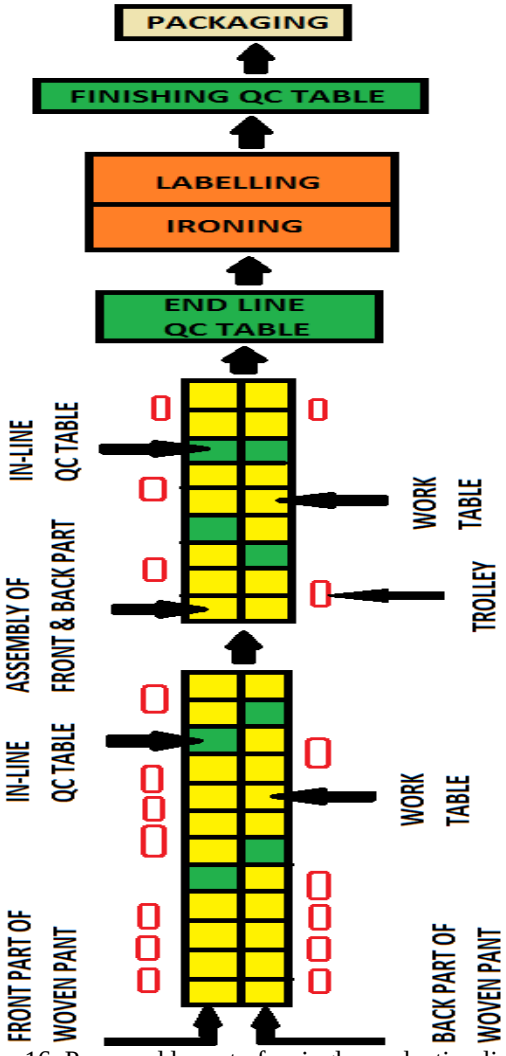

Figure 16. Proposed layout of a single production line

4.8 Result

We have found that up to 71.40% defect can be reduced by concentrating only on 9.20% areas. We have provided some suggestions related to those defect types. It is almost impossible to achieve zero defect. But by taking effective measure it is possible to reach near zero defect. So the more successfully those suggestions can be applied, the more the defects can be minimized.

V. Conclusion

Minimizing defect is very important for ensuring the quality of products. The importance of the garment industry in the economy of Bangladesh is very high. The perceived quality of a garment is the result of a number of aspects, which together help achieve the desired level of satisfaction for the customer. However, we should bear in mind that 1% defective product for an organization is 100% defective for the customer who buys that defective product. So manufacturing the quality product is mandatory to sustain in this global competitive market. Our first objective is to identify the top positions where maximum defects occur and second is to identify the top defect types in those positions. Keeping this in mind we have performed Pareto Analysis and identified top 6 positions out of 50 positions where 78.56% of total defects occur. Then we have performed further Pareto Analysis individually in those top positions to identify the top defect types. Thus we have identified just 115 major concerning areas which are responsible for 71.40% defects in total. Then the hierarchy of causes for each defect types are organized and the causes of those defect types are shown individually using Cause-Effect Diagram. Finally we have provided some suggestions so that the management can apply them to minimize the frequency of those defects. Thus we can effectively minimize reworks, rejection rate and waste of time that will ultimately increase productivity.

References

[1] BGMEA B2B Web Portal, http://www.bgmea.com.bd/home/pages/Strengths (date of retrieval: May 15, 2012)
[2] Production Process of RMG – Essays, http://www.studymode.com/essays/Production-Process-Of-Rmg-580425.html (date of retrieval: May 15, 2012)
[3] Md. Mazedul Islam, Adnan Maroof Khan and Md. Mashiur Rahman Khan, "Minimization of Reworks in Quality and Productivity Improvement in The Apparel Industry", International Journal of Engineering and Applied Sciences, January 2013. Vol. 1, No.4,
[4] Mohiuddin Ahmed and Nafis Ahmad, "An Application of Pareto Analysis and Cause-and-Effect Diagram (CED) for Minimizing Rejection of Raw Materials in Lamp Production Process", Management Science and Engineering, Vol. 5, No. 3, 2011, pp.87-95,
[5] Learn About Sewing Problems/Problems Of Sewing/Different Type Of Sewing Problems, http://textileeducationtips.blogspot.com/2013/03/learn-about-sewing-problemsproblems-of.html (date of retrieval: July 19, 2012)
[6] Common Defects In Denim Jeans Sewing, http://www.denimsandjeans.com/denim/manufacturing-process/common-defects-in-denim-jeans-sewing/ (date of retrieval: July 19, 2012)
[7] Defects of Sewing, http://www.jukiindia.com/item-list/defcts_of_sewing.pdf (date of retrieval: July 19, 2012)
[8] Abhishek Kumar, "Apparel Standards Specifications and Quality Control, Cutting, Sewing & Finishing Defects", National Institute of Fashion technology, http://share.pdfonline.com/7926bbe6d71d4dcbb81ec5c1a603df26/Abhishek.htm (date of retrieval: July 19, 2012)
[9] Glossary of Defect Terminology Used in the Garment Industry, http://www.garmento.org/quality/Glossary_of_Defect_Terminology.pdf (date of retrieval: July 19, 2012)
[10] Garment defects, http://www.slideshare.net/2008000400034/garment-defects (date of retrieval: July 19, 2012)
[11] William J. Kolarik, Creating Quality, International Editions 1995, McGraw-Hill Inc., page: 173-192
[12] Ahsan Akhtar Hasin, Quality Control and Management, First Edition 2007, Bangladesh Business Solutions, page: 30-50
[13] Dung, Nguyen Hoang Phuong, "Improving the quality of service, Case: International SOS Viet Nam", Bachelor's Thesis of Degree Programme in International Business, Lahti University of Applied Sciences, Winter 2010,
[14] Perzyk, M. (2007), "Statistical and Visualization Data Mining Tools for Foundry Production", Foundry Commission of the Polish Academy of Sciences, 7 (3), page: 111 – 116.
[15] Chandna, P., & Chandra, A. (2009), "Quality Tools to Reduce Crankshaft Forging Defects: An Industrial Case Study", Journal of Industrial and Systems Engineering, 3 (1), page: 27-37.
[16] Mahto, D., & Kumar, A. (2008), "Application of Root Cause Analysis in Improvement of Product Quality and Productivity", Journal of Industrial Engineering and Management, 01 (02), page: 16-53.
[17] Khekalei, S. N., Chatpalliwar, A. S., & Thaku, N. (2010), "Minimization of Cord Wastages in Belt Industry Using DMAIC", International Journal of Engineering Science and Technology, 2 (8), page: 3687-3694.
[18] Tips for Better Topstitching,http://www.threadsmagazine.com (date of retrieval: July 25, 2012)
[19] A&E Visual Examples of Stitch & Seam Defects - Garmento.org http://www.garmento.org/quality/a&estitchseamdefects.pdf (date of retrieval: July 25, 2012)
[20] Alterations | Sew for dough http://sewfordough.wordpress.com/category/alterations (date of retrieval: July 25, 2012)
[21] Major/Minor/Critical defects: what are they? http://www.asiaqualityfocus.com/blog/major-minor-critical-defects (date of retrieval: July 25, 2012)