ICMIEE18-261

Studies on Sewing Complication through Pareto Chart and Cause-Effect Diagram analysis of a Footwear Industry

Adhir Chandra Paul[*], *Md. Atikul Islam, Md. Shohag Hossain*
Department of Leather Engineering, Khulna University of Engineering & Technology, Khulna-9203, BANGLADESH

ABSTRACT
Due to global competition, declining profit margin and customer demand for high quality product at low cost, push the manufactures to reduce their production cost without compromising quality in order to survive in business arena. The quality and productivity of footwear largely depends on various organized operations especially on the sewing operation. Defects minimization is the first condition of reducing production cost and improving the quality. In this study, information of different types of defects of sewing sections had collected and analyzed through Pareto chart and Cause-effect diagram. The main purpose of the work is to reduce the defects, which will also minimize the rejection and reworks rate. Here we were concentrating on five major defects in sewing process. Finally, these working policies able to % of defects decrease 79.28% to 17.5%. The study also facilitates the process performance of the critical operational processes. It will also reduce the cycle time by reducing reworks and finally result higher productivity.

Keywords: Profit margin, Sewing defects, production cycle time, Pareto chart and Cause-effect diagram

1. Introduction

Footwear is a human made outer covering of foot. When the human beings came into existence, they were required to protect themselves from, cold dampness, dust, heat, and roughness of ground while standing, walking or even running. So they originate shoes for the protection of their feet. Footwear sector is the most potential and booming export sector in Bangladesh after RMG. Besides that, Bangladesh is set to emerge as a next manufacturing hub for global footwear industry. In recent times, more than 50 foreign countries are the substantial export destination of Bangladesh's footwear. In addition, more than half of finished leather (54%) has exported to the EU market[1]. Germany, France, United Kingdom and Italy are the top four buyers among 10 global footwear but now, US buyers are showing intent for import footwear from Bangladesh [2]. According to the EPB, the first two months of the current fiscal year 2016-2017, the country posted 23.62% growth in footwear exports over than that of the last year. Bangladesh has received $ 120.59 million foreign exchange from exports of finished leather and footwear in current years[3]. Global footwear industry is now at upward trajectory. Contemporary, rising global demand for footwear which is expected to reach $ 211 billion by the end of 2018. Bangladesh has the potential to tap into the growing market by offering quality type footwear that depend on the manufacturing process like sewing, lasting, finishing and so on [4]. Sewing is the craft of fastening or attaching objects using stitches made with a needle and thread. Sewing is one of the oldest of the textile arts, arising in the Paleolithic era[5]. Before the invention of spinning yarn or weaving fabric, archaeologists believe Stone Age people across Europe and Asia sewed fur and skin clothing using bone, antler or ivory needles and "thread" made of various animal body parts including sinew, catgut, and veins [6]. For thousands of years, all sewing was done by hand. The invention of the sewing machine in the 19th century and the rise of computerization in the 20th century led to mass production and export of sewn objects, but hand sewing is still practiced around the world [7]. The Inuit, for example, used sinew from caribou for thread and needles made of bone; the indigenous peoples of the American Plains and Canadian Prairies used sophisticated sewing methods to assemble tipi shelters [9]. The weaving of cloth from natural fibers originated in the Middle East around 4000 BCE, and perhaps earlier during the Neolithic Age, and the sewing of cloth accompanied this development [10]. Advances in industrial technology, such as the development of synthetic fibers during the early 20th century, have brought profound changes to the textile industry as a whole. According to the U.S. Department of Labor "employment of sewers and tailors is expected to experience little or no change, growing 1 percent from 2010 to 2020" [22].

Fig. 01: Global footwear demand

A Parito chart, also called a Pareto distribution diagram, contains a vertical bar graph in which values are plotted in decreasing order of relative frequency from left to right. Pareto Chart is used to graphically summarize and display the contribution of each type of defects. The lengths of the bars represent occurrence and are organized with longest bars on the left and the shortest

* Corresponding author. Tel.: +88-01723316621
E-mail addresses: adhirkuet@gmail.com

to the right [23]. Fishbone diagram is a one kind of cause-effect diagram which contains many causes for a specific effect or problem. It looks like the shape of a fish. That's why it is called fishbone diagram [24].
From Pareto Chart analysis we had identified top ten defects. By our own observation we had identified the causes for each specific defect types from the sewing lines operations through questionnaires. After that we had constructed the cause-effect diagram for each type of defect by using 4M (Man, Machine, Material and Method) bones. These Cause-Effect Diagrams are shown in figure for top three defects that had identified.

2. Methodology

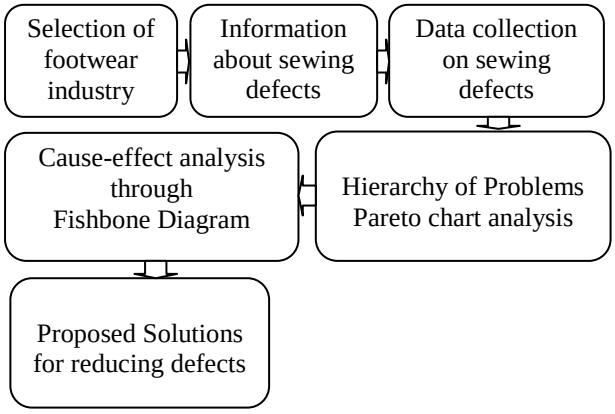


Fig.02: Overview of the study

2.1 Factory Selection
After gathering information we made contact with some footwear 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. Finally we conduct our research work in two particular footwear factories named "X Footwear Industry" established in 2006 which situated in Tongi, Abdullahpur, Gazipur, Dhaka and "Y Footwear Industry" established in 1994 which situates in Safipur , Gazipur , Dhaka . In these organizations we worked in a particular section (i.e. sewing section) for a particular product (i.e. Derby Footwear). One days defect data has been collected from the management of each industry and Pareto Analysis is performed on them. 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.

Company Name	**'X' Industry**	**'Y' Industry**
Location	Dhaka	Dhaka
Establishment	2010	1990
Product Type	Footwear	Footwear
Total workers	1000	7000
Production capacity per day	4000	16000
Working hour per day	8	8

2.2 Gathering information about defects
We have gathered information on the Quality Control system of the sewing section of the selected footwear industry. 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.
2.3 Identify the defects
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.

2.4 Analysis the defects
In this step Pareto chart Analysis is performed which is required to identify the top defects and it's major concerning areas of defects. 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.

3. Result and Discussion

During shoe production, we had identified ten types of defects like Stitch Slip, Stitch allowance uneven, Irregular Stitch and so on. In visited factory, various defect types of sewing department are denoted by some specific alphabetical defect codes.

S.L NO	**DEFECTS**	**DEFECT CODES**
01.	Stitch Slip	SA
02.	Stitch allowance uneven	SB
03.	Irregular Stitch	SC
04.	Wavy stitching	SE
05.	Leather cut	SH
06.	Loose leather	SO
07.	Color shade	SQ
08.	Wrinkle at upper	ST
09.	Pasting problem	SZ
10.	Needle Scratch	SL

Fig.03: Defect types with their corresponding codes

Quality Inspection (100% Sewing) in Royal Footwear Ltd: Observing product style number, order number, QC name, line number and date was OR-001, 005, 'M' 12 and 10.10.2016 respectively.
Quality Inspection (100% Sewing) in Apex Footwear Ltd: Observing product style number, order number, QC name, line number and date was Roho-003, 008, 'N' 16 and 10.01.2017 respectively.

Table 01: Data of 'X' Footwear Limited

	Jan	Feb	Mar	Apr	May	June	Total
No. of pieces checked	50	55	45	43	40	48	365
No. of rejected pieces	7	12	6	4	5	10	57
Total defects	250	300	215	205	195	240	1405

Table 02: Data of 'Y' Footwear Limited

	Jan	Feb	Mar	Apr	May	June	Total
No. of pieces checked	50	55	45	43	40	48	365
No. of rejected pieces	4	7	3	4	2	8	38
Total defects	165	154	185	176	169	151	1000

Calculation for 'X' Footwear Ltd.:

% of rejection rate (cause of defects) = Total no. of rejected pieces *100/ Total no. of pieces checked=57*100/365=15.6%

% of defects= Total defects*100/ Total no. of rejected pieces=1405*100/57=2464%

Calculation for 'Y' Footwear Ltd.:

% of rejection rate (cause of defects) = Total no. of rejected pieces *100/ Total no. of pieces checked=38*100/365=10%

% of defects= Total defects*100/ Total no. of rej pieces=1000*100/38=2631%

3.1 Pareto Analysis for Defect:

A Pareto chart, also called a Pareto distribution diagram, contains a vertical bar graph in which values are plotted in decreasing order of relative frequency from left to right. Pareto Chart is used to graphic ally summarize and display the contribution of each type of defect. It is a bar graph. The lengths of the bars represent occurrence and are organized with longest bars on the left and the shortest to the right. In this way the chart visually shows which defects are more significant. By using Pareto Chart major types of defects were identified which is shown in in chart are those defect types are Slipped Stitch, Staggered Stitch, Unbalance Stitch, Variable Stitch Density, Frequent Thread Breakage, Seam Puckering Damage of Fabrics on Seam Line, Needle Heating and Needle Breakage. These types of defect occur due to some specific causes.

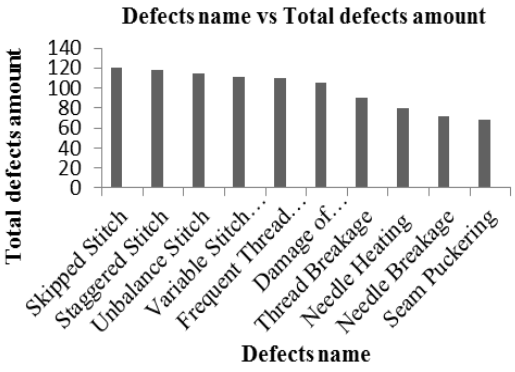


Fig.04: Pareto chart for defects of 'X' Footwear Ltd.

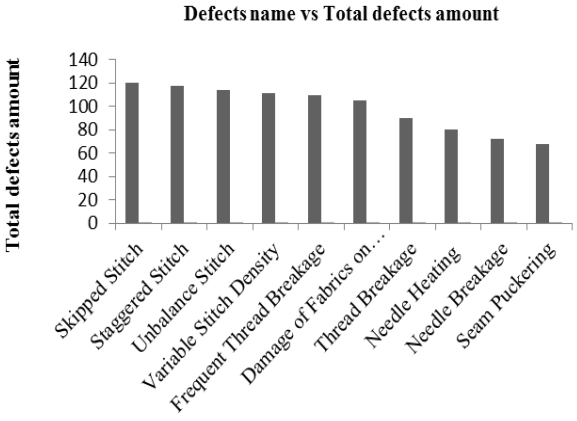


Fig.05: Pareto chart for defects of 'Y' Footwear Ltd.

Table 03: Data of 'X' & 'Y' Footwear Limited (Oct-16 to Mar-17)

	OCT (PRS)	NOV (PRS)	DEC (PRS)	JAN (PRS)	FEB (PRS)	MAR (PRS)	TOTAL (PRS)
No. of production PRS	21188	13515	15831	14661	17174	15551	97920
No. of rejected PRS	180.75	150.43	115.20	104.65	128.15	113.42	792.6
No. of rework products	633.86	404.31	473.60	438.59	513.77	465.22	2929.35
Defects Exist in Rework Items							
No. of Major Defects	9786	5958	6280	6971	7769	6483	43247
No. of Minor Defects	6756	3480	4162	4428	5017	3789	27632
Total No. Of Defects	16542	9438	10442	11399	12786	10272	70879

Table 04: Defects analysis of 'X' & 'Y' Footwear Ltd.

Month	**Total no. of defects**	**Selected Top ten major Defect Codes in amount**									
		SA	SB	SC	SE	SH	SO	SQ	ST	SZ	SL
OCT	16542	1450	2368	1368	1944	2850	1647	959	455	250	168
NOV	9438	656	1620	550	1264	1822	1208	356	188	198	175
DEC	10442	764	1405	455	1200	1905	1100	381	205	205	186
JAN	11399	809	1559	542	993	2108	1218	428	195	350	229
FEB	12786	1002	1706	614	1462	1806	1383	512	286	281	233
MAR	10272	966	1306	755	1123	1702	1554	757	105	409	250
Gross Total defects	70879	5647	9964	4284	7886	12193	8118	3393	1434	1693	1241

Table 05: Defects percentage of top ten defects ('X' & 'Y' Footwear Ltd.)

SL No.	Defects Name	Defects Code	Calculation	% of Defects
01	Stitch slip	SA	5647×100/70879	7.96
02	Stitch allowance uneven	SB	9964×100/70879	14.05
03	Irregular stitch	SC	4284×100/70879	6.04
04	Wavy stitch	SE	7886×100/70879	11.12
05	Leather cut	SH	12193×100/70879	17.20
06	Loose leather	SO	8118×00/70879	11.45
07	Color shade	SQ	3393×100/70879	4.78
08	Wrinkle at upper	ST	1434×100/70879	2.00
09	Pasting problem	SZ	1693×100/70879	2.93
10	Needle scratch	SL	1241×100/70879	1.80

Calculation:

Total % of defects of top ten defects= 7.96+ 14.05+6.04+11.12+17.20+11.45+4.78+2.0+2.93+1.75= 79.28 %

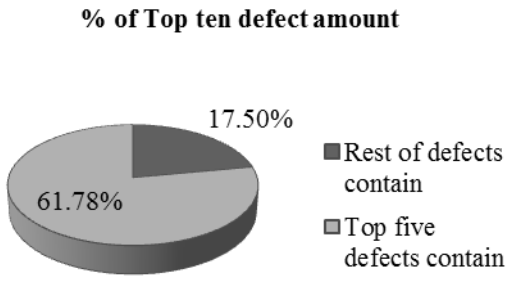
Rest of percentage of defects=20.72 %

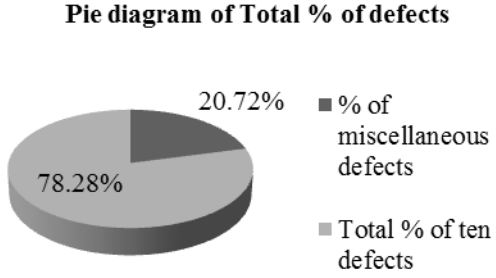
We see, here is the total % of defects is not 100% because rest of % of defects is negligible.

Now, Major five defects code (SH, SB, SO, SE, SA) containing = 17.20 + 14.05 + 11.45 + 11.12 + 7.96 = 61.78%

If we reduced these five defects, then % of defects decrease 79.28% to 17.50%

So, we can focus on these five major defects. Actually this 61.78% is the amount of major five defects of 'X' & 'Y' Footwear Ltd. Which can be eliminated by taking necessary solutions. Then the amount of defects reduced to 17.50%





3.1 Categorization of Defects: Parito Chart analysis

A Parito Chart, also called a Pareto distribution diagram, contains a vertical bar graph in which values are plotted in decreasing order of relative frequency from left to right. Pareto Chart is used to graphically summarize and display the contribution of each type of defects.

The lengths of the bars represent occurrence and are organized with longest bars on the left and the shortest to the right. In this way the chart visually shows which defects are more significant [5]. By using Parito Chart major types of defects are identified which were shown in chart . These types of defects occur due to some specific causes.

Parito Chart analysis regarding top ten defects of 'X' & 'Y' Footwear Ltd.

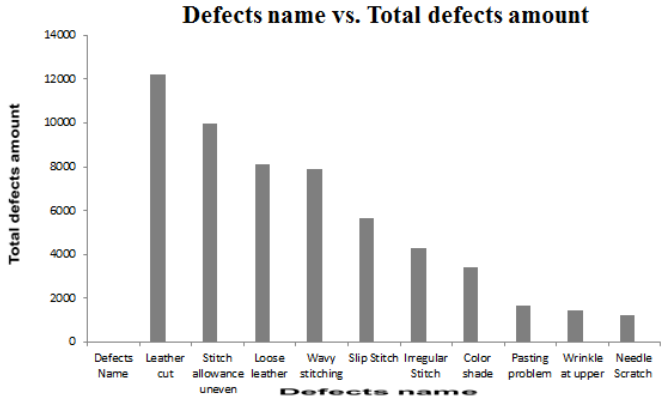


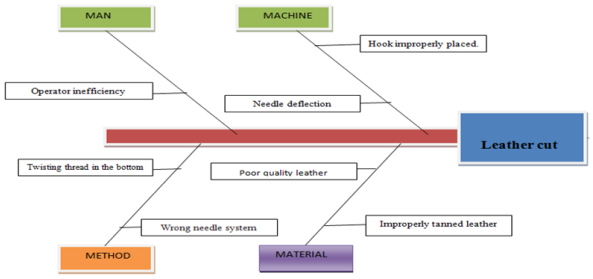
Fig.06: Defects name Vs. Total defects amount

3.2 Cause-Effect analysis with Fish-Bone Diagram:

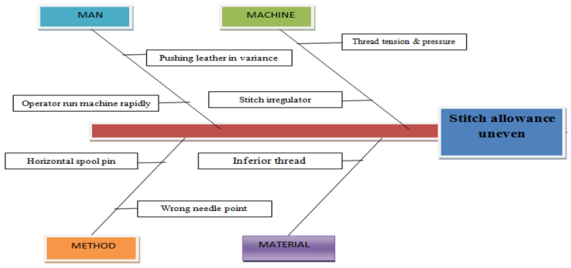
Fishbone diagram is a one kind of cause-effect diagram which contains many causes for a specific effect or problem . It looks like the shape of a fish . That's why it is called fishbone diagram [6]. From Pareto Analysis we had identified top ten defects. By our own observation we had identified the causes for each specific defect types from the sewing lines operations through questionnaires.

After that we had constructed the cause-effect diagram for each type of defect by using 4M (Man, Machine, Material and Method) bones. These Cause-Effect Diagrams are shown in figure for top three defect that had identified [7].

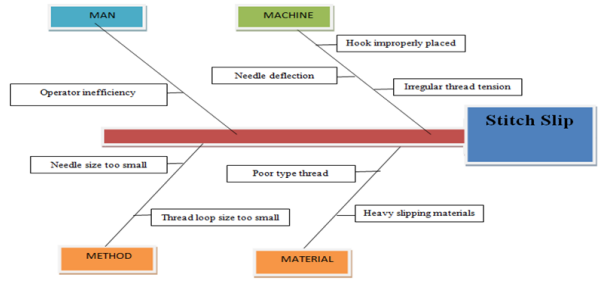
❖ Cause-effect diagram for LEATHER CUT:



❖ Cause-effect diagram for STITCH ALLOWANCE UNEVEN:



❖ Cause-effect diagram for STITCH SLIP:



4. Conclusion

Defect minimization are concerning for ensuring the quality of footwear which also helps to sustain global competitive market. This study try to find out the major defects through Pareto chart analysis and cause-effect diagram and suggests logical solutions in order to minimize defects. By the Pareto chart, top ten defects had identified with a descending order that were responsible for major defects occurring in sewing section of a factory . This study found that the sewing section of selected footwear factory was operating at a high defect percentage. The rate was very high at this present business context. So, it is very essential to minimize the defects and enhance productivity as well.

Many footwear factories in Bangladesh are not conscious about the sewing defects and this study will start a positive impact across the footwear industries and make them more competitive.

5. References

[1] Raluca BRAD, Eugen HĂLOIU and Remus BRAD.(2010), "Seam Puckering Evaluation Method for Sewing Process.

[2] Islam, Md. Mazedul, Maroof Khan, Adnan and Khan, Md. Mashiur Rahman.(2013), Minimization Of Reworks In Quality And Productivity Improvement In The Apparel Industry, International Journal of Engineering and Applied Sciences, 1 (4):

[3] Ahmed Tanvir, Narayan Acharjee Raj, Rahim MD.Abdur, Sikder Noman, Akther Taslima, Khan Mohd. Rifat, Rabbi, MD. Fazle and Saha Anup.(2013), An Application of Pareto Analysis and Cause-Effect Diagram for Minimizing Defect Percentage in Sewing Section of a Garment Factory in Bangladesh, International Journal of Modern Engineering Research (IJMER), 3 (6): 3700-3715

[4] Parthasarathi V., Revathy, S., Praveena, R. and Saranya, S.(2014),Investigation of Fabric Sewability Problems And Solutions: An Overview,International Journal of Applied Engineering and Technology, 4 (1): 32-26

[5]https://www.scribd.com/document/319609202/MinimizingThread-BreakageSkips-2-5-10-pdf

[6]https ://www.scribd.com/document/319607830/Solution-to-Sewing-Problemstck35-166621-Pdf.

[7] https ://www.coatsindustrial.com/en/images/Solution%20to%20Sewing%20Problems_tcm35- 166621.Pdf

[8] Abdul Quddus, Md. And Nazmul Ahsan, A.M.A.(2014), A Shop-floor Kaizen Breakthrough Approach to Improve Working Environment and Productivity of a Sewing Floor in RMG Industry, Journal of Textile and Apparel, Technology and Management, 8 (4)

[9] C. Chen, James, Chen, Jeff.,and Su, Yung-Sheng.(2014), Simulation Modeling and Analysis for Stitching Line of Footwear Industry, Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management ,Bali, Indonesia.

[10] 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,

[11] K. L. Mak and Wei Li, "Objective Evaluation of Seam Pucker on Textiles by Using Self-Organizing Map", IAENG International Journal of Computer Science, 35:1, IJCS_35_1_07. Available http://www.iaeng.org/IJCS/issues_v35/issue_1/IJCS_35_1_07.pdf

[12] 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,

[13] 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.

[14] A&E Visual Examples of Stitch & Seam Defects - Garmento.orghttp://www.garmento.org/quality/a&estitchseamdefects.pdf (date of retrieval: July 25, 2012)
[15] O.H. Khan, "A Study of Six SigmaImplementation and Critical Success Factor", Pakistan's NinthInternatio International Convention on Quality Improvement, Karachi, Pakistan, pp. 1-12, Nov. 2005
[16] Saroj Bala, Factors Influencing Costing of woven Fabrics, The Indian Textile Journal, 2003
[17] F.M. Gryna, J.A. DeFeo, "Quality Planning & Analysis for Enterprise Quality", Tata McGraw-Hill, Edition, 2008
[18] Florida, R. "Lean and Green The Move to Environmentally Conscious Manufacturing." California Management Review 39, (1996) 80-105
[19] M.Mahajan, "Statistical Quality Control",Dhanpat Rai & Co. (P) LTD. pp.186-206,
[20] Hawken, Paul, Amory Lovins, and L. Hunter Lovins. Natural Capitalism: Creating the Next Industrial Revolution (New York Little, Brown and Company, 1999)
[21] 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.
[22] 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.
[23] Defects of Sewing, http://www.jukiindia.com/item-list/defcts_of_sewing.pdf (date of retrieval: July 19, 2012)
[24]Garmentdefects,http://www.slideshare.net/2008000400034/garment-defects (date of retrieval: July 19, 2012)
[25] 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)
[26] Major/Minor/Critical defects: what are they? http://www.asiaqualityfocus.com/blog/major-minor-critical-defects (date of retrieval: July 25, 2012)
[27] 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)
[28] 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,
[29] I. G. Mariolis & E. S. Dermatas, "Automated assessment of textile seam quality based on surface roughness estimation", Journal of Textile Institute, vol. 101:7, pp. 653-659, 2010
[30] T. Aibara, T. Mabuchi, O. Kenji, "Automatic evaluation of the appearance of seam puckers on suits", Proc. SPIE, vol. 3652: 110, 1999.
[31] Dr P Khanna: *Work study, time and motion study*, Dhanpat Rai and Sons, New Delhi, (pp 21-31).
[32] Dean J W and Bowen D E., 1994, Management Theory and Total Quality: Improving Research and Practice and Theory Development, *the Academy of Management Review* 19, (3) PP 392-418.
[33]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)
[34] I. G. Mariolis & E. S. Dermatas, "Automated quality control of textile seams based on puckering evaluation", 37th Int. Symp. on Nov. in Text., Ljubljana, Slovenia, June 2006.
[35] Environmental Technology Best Practice Programmed. (1996). saving money through waste minimization raw material use, GG25, Crown Copyright.
[36] F.M. Gryna, J.A. DeFeo, "Quality Planning & Analysis for Enterprise Quality", Tata McGraw-Hill, Edition, 2008