ABSTRACT

Due to global competition, declining profit margin and customer demand for high quality product at low cost, push the manufacturers 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].

![Global Footwear Demand](image)

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...
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

Selection of footwear Industry

Information about sewing defects

Data collection on sewing defects

Cause-effect analysis through Fishbone Diagram

Hierarchy of Problems Pareto chart analysis

Proposed Solutions for reducing defects

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.

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.

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

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.

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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 rejected 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 Pucker Damage of Fabrics on Seam Line, Needle Heating and Needle Breakage. These types of defect occur due to some specific causes.
Table 03: Data of ‘X’ & ‘Y’ Footwear Limited (Oct-16 to Mar-17)

<table>
<thead>
<tr>
<th></th>
<th>OCT (PRS)</th>
<th>NOV (PRS)</th>
<th>DEC (PRS)</th>
<th>JAN (PRS)</th>
<th>FEB (PRS)</th>
<th>MAR (PRS)</th>
<th>TOTAL (PRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of production PRS</td>
<td>21188</td>
<td>13515</td>
<td>15831</td>
<td>14661</td>
<td>17174</td>
<td>15551</td>
<td>97920</td>
</tr>
<tr>
<td>No. of rejected PRS</td>
<td>180.75</td>
<td>150.43</td>
<td>115.20</td>
<td>104.65</td>
<td>128.15</td>
<td>113.42</td>
<td>792.6</td>
</tr>
<tr>
<td>No. of rework products</td>
<td>633.86</td>
<td>404.31</td>
<td>473.60</td>
<td>438.59</td>
<td>513.77</td>
<td>465.22</td>
<td>2929.35</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Month</th>
<th>Total no. of defects</th>
<th>Selected Top ten major Defect Codes in amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SA</td>
</tr>
<tr>
<td>OCT</td>
<td>16542</td>
<td>1450</td>
</tr>
<tr>
<td>NOV</td>
<td>9438</td>
<td>656</td>
</tr>
<tr>
<td>DEC</td>
<td>10442</td>
<td>764</td>
</tr>
<tr>
<td>JAN</td>
<td>11399</td>
<td>809</td>
</tr>
<tr>
<td>FEB</td>
<td>12786</td>
<td>1002</td>
</tr>
<tr>
<td>MAR</td>
<td>10272</td>
<td>966</td>
</tr>
<tr>
<td>Gross Total defects</td>
<td>70879</td>
<td>5647</td>
</tr>
</tbody>
</table>
Calculation:
Total % of defects of top ten defects = 7.96 + 14.05 + 11.12 + 17.20 + 11.45 + 4.78 + 2.00 + 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%

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

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

#### 3.1 Categorization of Defects: Parito Chart analysis
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 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.

![Defects name Vs. Total defects amount](image)

**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].

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
[31] Dr P Khanna: Work study, time and motion study, Dhanpat Rai and Sons, New Delhi, (pp 21-31).