Identification and Analysis of Stitching Defects at the Stitching Unit: A Case Study

Usama Khursheed Mughal
Under Graduate Final Year Student & Group Leader (Final Year Thesis),
Department of Industrial Engineering & Management,
Mehran University of Engineering & Technology, Jamshoro, 76062,
Sindh, Pakistan.
f16in29@student.muet.edu.pk

Muhammad Ali Khan
Assistant Professor & PhD Scholar,
Department of Industrial Engineering & Management,
Mehran University of Engineering & Technology, Jamshoro, 76062,
Sindh, Pakistan.
muhammad.nagar@faculty.muet.edu.pk

Pawan Kumar
Under Graduate Final Year Student & Assistant Group Leader (Final Year Thesis),
Department of Industrial Engineering & Management,
Mehran University of Engineering & Technology, Jamshoro, 76062,
Sindh, Pakistan.
f16in48@student.muet.edu.pk

Suneel Kumar
Under Graduate Final Year Student & Group Member (Final Year Thesis),
Department of Industrial Engineering & Management,
Mehran University of Engineering & Technology, Jamshoro, 76062,
Sindh, Pakistan
f16in03@student.muet.edu.pk

Abstract

The purpose of the research is to highlight and minimize the defects in selected stitching unit. The data was obtained from quality reports and on field by researchers. The data is analyzed by MS excel, Pareto charts and Fish bone diagrams. The skip stitch and stain spot are identified as the most frequent defects. It is found that around 50% of the skip stitch defects were due to machine causes, 25% due to material related issues, 15% due to method issues and rest of 10% were due to manpower issues. In stain spot defect machine, material, method and manpower contributed equally (25% each) as a cause. When there are defects in the production, it cost the company in terms of material, labor, overheads, transportation (from one process to another). In this regard, it is necessary to highlight the defects and reduce/eliminate them to save production cost. This research aimed to highlight two major defects and suggested the ways i.e. lean six sigma, TPM, OEE and DMAIC to minimize them. Future researches can be carried out on remaining defects. It is also suggested to choose DMAIC tool for calculation of sigma level and minimization of defects in future research.

Keywords
Stitching, defects, textile, garments.

1. Introduction

Although people's first articles of clothing and furnishing were probably animal skin wraps, occasionally sewn together using bone needles and animal sinews, he quickly tried to manipulate fibrous products into textile fabrics, encouraged by experience gained from interlacing branches, leaves and grasses in the manufacturing of primitive sanctuaries (Gebru 2014). Sewing procedure is one of the most important stages in garments production (Gopalakrishnan 2020). In nowadays, garments 'defect is perhaps the major components of the apparel fabricating market because it makes a negative effect on authentic productivity (Akbar et al. 2020). Quality is defined as the level of acceptance of an items or service. It is a really necessary need- ment for any type of sort of product (Mridha et al. 2015). In garment production, it is normal that there might be couple of denied garments after freight (Tahiduzzaman et al. 2018). Gebru (2014) observed material problems are needle-line, hole, lycra jump, oil discolor, sinker mark; and this issue has resulted in high being rejected rate (7.87%) which is accounted to a loss of 150,101.5 birr each month and also it additionally damages the image of the firm (Gebru 2014). The quick changing economic problems such as worldwide competitors, declining profit margin and client demand for premium quality product at low cost push the makes to minimize their manufacturing cost without compromising quality in order to make it through in service field (Uddin and Rahman, 2014).

Clothing production is traditionally labor extensive due to the considerable designs and also textile variations of the items (Samuel and Poojitha 2010). Production the quality product is required to sustain in this global open market (Mridha et al. 2019). Quality and defects have been the key issue in manufacturing industries and the textile industry is no exception (Khan 2018, Kumar et al. 2020b, Mughal et al. 2020). The increasing trends of published case studies is the evidence of the growing awareness and increasing scope of lean manufacturing in the major industrial sectors of Pakistan to minimize the defects and improve the quality (Khan et al. 2020c). Various kinds of quality defects/problems are observed in garment products throughout its manufacturing. These problems/ damages come from during fabric manufacturing as well as throughout its garment conversion.

These defects/damages lower the quality of the garment, which eventually develops a substantial effect on the profit percentage (Choudhary et al. 2018). Quality is eventually an issue of client complete satisfaction (Uddin and Akter 2018). The quality of the garments any vary depends upon the cost market they are being produced so as a result customers anticipate producers expect suppliers to comply with various techniques of examination strategies all through the manufacturing and before delivery launch from manufacturing facility (Mia et al. 2018). Because there are many factors associated with determining the quality of product, opportunity for events of flaws is also extremely high. In order to attain optimum performance as well as efficiency in sewing space, it is necessary to regulate as well as reduce the problems in sewing process (Gopalakrishnan 2020). It was discovered that the most typical problem for all items results from human-related concerns and also second of all on the methods which are also set by a human (Iqbal et al. 2020).In this regard, present research was conducted to highlight the quality issues in terms of defects at sewing line of the case company.

2. Literature Review

Quality represents enterprise credibility and also customer satisfaction. So every sector tries to make certain high quality of product (Ferdous et al. 2020). Faults play an essential role in the performance of the garments manufacturing facility. If a flaw is found in the last inspection, the defective item has gone a long way prior to the deformity is found. The cost of the manufacturing process for a faulty garment is completely lost as the item cannot be exported. In some cases the faulty items can be made exportable with modifications, yet it sets you back more money, which has no worth to a factory proprietor (Uddin and Rahman 2014). Khan (2018) conducted the case study in textile industry about the seven wastes of lean manufacturing and the applications of lean manufacturing practices. The author used the Gemba, Waste Relations Matrix, Cause & effect analysis, ranking and statistical techniques to identify and analyse the seven wastes of lean manufacturing. The seven deadly wastes of lean manufacturing are investigated and defect is identified as the most significant waste in the textile manufacturing industry. The author suggested most relevant lean practices to eliminate /reduce the defects (Khan, 2018). Embroidery damages/defects are caused when material restricts the infiltration of the stitching needle. This not only relies on the areas in the fabric but likewise on needle account, needle size, stitching device setting and also stitching thread (Choudhary et al. 2018). In the relevance to the pointed out issue, literature was examined carefully; some of the study jobs are specified and also cited listed below.

Akbar et al. (2020) subjected the number of faults in their study, faults included; skip fasten 151(10%), tension free/close 53(4%), label/size botch 20(1%), oil spot 46(3%), damaged line 109(8%), open crease 169(12%), box/plate skewed 48(3%), stitching termination 58(4%), pleat 166(11%), label askew 26(2%), raw-edge 111(8%), tuck missing 78(5%), unclean spot 128(9%), part up down 170(12%) as well as hole 105(7%). Bukhsh et al. (2021) conducted the case study research at Printing machine in a leading textile industry of Pakistan. The lean practices of Gemba, VSM, 5S, Single minute exchange of dies (SMED) and time & motion study are used to improve the changeover time, minimize the defects and improve the quality of the end product (Bukhsh et al. 2021).

Gebru (2014) aims to resolve the above quality trouble of knitting area by recognizing the 80% reasons for quality deformities as well as proposing the feasible option for the critical ones. In taking care of the quality issue, direct observation, interview, check sheet & records were made use of to accumulate data as well as these data were likewise examined using Pareto technique, as well as focus group conversation. After the data is examined, the 4 crucial textile defects (Needle line, Hole, Thread variation and Lycra jump) are accomplished as well as these textile defects need to be dealt with to minimize the being rejected rate by 80%. The outcome of the study showed that the existing 7.87% being rejected rate can be lowered to 1.574% which resulted in the internet difference of 6.296. This suggests that the online monthly reduction in fabric denial price has to do with 5533.6 kilo which actually influences the overall production in the area. This study has actually found outcomes with a collection of recommendation, counter steps and common operation procedure (SOP) that are suggested to be done by the organization (Gebru 2014).

Mughal et al. (2020) reviewed previous studies and mentioned that there is the tremendous potential about the applications of Six sigma (DMAIC) & Lean Six Sigma (LSS) in Production Systems to reduce/elimiate the production defects. There are remarkable advantages of applying Six sigma (DMAIC) & Lean Six Sigma (LSS) to reduce/elimiate the production defects (Mughal et al. 2020, Kumar et al. 2020b). Gopalakrishnan (2020) located that defective garment made in the sewing room differs according to the garment design as well as it varies from 7.3% to 27.5%. Out of the numerous deformities happen in garments, textile opening and also oil tarnish make up 18 to 43% for numerous designs. Therefore by taking on a cautious material inspection prior to sewing will certainly help to minimize defectives significantly (Gopalakrishnan 2020).

Uddin and Rahman (2014) discovered that the use of DMAIC technique of six sigma minimized the defects rate in a picked garment manufacturing facility. This is a methodical method in the direction of deformities minimization through five stages of DMAIC methodology called define, measure, examine, boost as well as control. Different six sigma tools were made use of in various phases. Pareto evaluation was done to recognize the significant types of defects. Origin of those defects were identified by cause and effect analysis. Lastly some possible remedies are recommended to overcome those causes. The outcome discovered after implementation of the options is extremely considerable. The fault percentage has been reduced from 12.61 to 7.7 and as a result the Sigma level has actually been boosted from 2.64 to 2.9255 (Uddin and Rahman 2014). Weseley and Poojitha (2010) aimed to simplify the skip stitch detection arrangement so that it could be utilized in the sector as an additional attachment in existing machines and provide operator-friendly job processes at a reduced price.

Mridha et al. (2019) complied with the DMAIC approach of Six Sigma to discover the significant faults, their origin and then suggests rational services to reduce those faults. This research study identified some faults (damaged stitch, skip stitch, raw side, irregular stitch, down stitch, process missing, puckering as well as joint stitch) those was accountable for more than 80% of total defects happening in the sewing section of the garment factory for the product of a polo shirt. After finding the significant deformities, conceptualizing tool was utilized to recognize the potential causes and after that we determined potential origin by online assessments as well as origin analysis (Mridha et al. 2019).

Sharifuzzaman and Islam (2018) examined and also observe two knit garment industries few days for stitching faults, which are frequently occurring throughout production procedure process by employee. In our study we located some mistakes like damaged stitch 8.91%, skip stitch 16.80%, open joint 15.78% and other sewing faults at suprov composite weaved ltd. and also in a similar way when we observed at amantex ltd. we found damaged stitch 4.81%, sign up with stitch 4.39%, uncut thread 20.33%, up-down 17.31%, dust cloth side 7.28% as well as others. Lastly we discovered complete 6.38% garments are defective sources of stitching trouble for a solitary calculation for two sectors (Sharifuzzaman and Islam 2018). Islam and Ahsan (2018) examined 17 various defects in their

research yet maximum numbers of mistakes are Skip stitch 30%, Broken stitch 8%, Needle cut 9%, Uncut thread 25%. and others 30% fault (Islam and Ahsan 2018).

Tahiduzzaman et al. (2018) analyzed the garment sewing defects making use of lean tools i.e. Pareto chart, cause-effect representation, 5S application, PDCA cycle for minimizing faults and resulting boosting quality as well as making more revenue. The Pareto chart showed that the significant cumulative faults are others (19%), busted stitch (36%), slip stitch (48%), the open seam (59%) etc. (Tahiduzzaman et al. 2018).

Uddin et al. (2014) made use of Pareto evaluation to determine the leading happening faults. After determining the significant deformities, conceptualizing tool was utilized to identify the possible causes and afterwards potential source were identified by online examinations and origin evaluation. The result located after implementation of the methodology was extremely considerable. The deformity portion was minimized from 11.229 to 7.604 as well as the Sigma degree was enhanced from 2.714 to 2.93 (Uddin et al. 2014).

3. Problem Statement

Stitching is a major component of any textile or apparel industry, the slightest mistake in them or their processes may therefore cost the business both in terms of quality and monetary value. The data collected shows that the defects that occur in the selected company's T5 stitching unit lead to incompetence in quality standards and much longer process durations than anticipated. This evaluation gives us an insight into the variables that are either directly or related to these vulnerabilities in some way. The project team's main objective was to highlight and minimize the defects at the stitching department.

4. Research Objectives

The aim of the present research paper was achieved by following objectives.

1. To identify the stitching defects in the selected stitching unit.
2. To analyze the main causes of the critical stitching defects.
3. To suggest the standardized structure to reduce/eliminate the main causes of the critical stitching defects.

5. Research Methodology

Research methodology is well presented descriptions of methods which are used to collect, analyze, interpret and conclude the research. Thorough research methodology is presented in below given headings.

5.1 Data Collection

The project team developed a data collection plan to collect industry data in the measurement phase after defining the particular area of stitching faults. It is important that the team gathers and produces a reliable and comprehensive set of numerical information to better understand the situation. From the main office of the stitching division, the team collected the annual production report. The required data was sorted to find the precise set of numerical details. The primary data was collected on the basis of Industrial visits to the Nazim Din Apparel plant located in Karachi. The team assessed the overall process of stitching and gathered relevant information on the machine perimeters and cumulative defect counts. Other source of primary data was the annual quality report of the production of Jeans and Bags (company`s previous data of 6 months). Moreover, other sources of data were the various research papers, articles, and journals which comprised of the use of our selected approach in the same industrial sector in other countries. The secondary data also helped us plot the comparison between our roadmap and the ones used in the previously published papers.

5.2 Data Analysis

Gathered data was then put into MS excel for the analysis which included the frequency distribution of production and defects across six months. Moreover, the Pareto analysis for the overall defects was carried and then two of the main defects were individually in terms of cause and effect analysis and Pareto analysis respectively. Pareto analysis was presented by using combo (bar and line) charts and cause and effect analysis was presented by the use of fish bone diagrams.

6. Results

Results is based on three sections i.e. summary of the production and defects of the case unit of the case company, Pareto analysis of defects of the case unit, cause and effect analysis and Pareto analysis of the define defects. Each of the section is well presented in the below given headings.

6.1 Summary of Production and Defects

Data of production and defects was obtained from the quality department of the stitching section was obtained. The data was of six months i.e. April to September as presented in the table 1.

Table 1. Summary of carried out production during the month (April to September)

Months	Production	Good Production	Defects	Defects (%)
April	62193	37193	25000	40.20%
May	637775	472611	165164	25.90%
June	131088	88403	42685	32.56%
July	400939	293319	107620	26.84%
August	519357	382965	136392	26.26%
September	299029	216485	82544	27.61%
Total	**2,050,381**	**1490976**	**559,405**	**27.28%**

A look at the table 1 indicates that in the period of six months, the percentage of counted defects was calculated to be 27.28%. In this regard, it was necessary to highlight defects and suggest the way to improve them in order to save the tremendous amount of cost (material cost, overheads and labor cost). In the next heading, the defects were highlighted along with their frequency.

6.2 Pareto Analysis of Defects

Pareto analysis of defects was conducted (see figure 1). Twelve different types of stitching defects were identified. A look at the figure 1 indicates that the frequency of first three defects reaches to the 65% of total count and out first three, skip stitch and stain spot had the cumulative percentage of 44.94%.

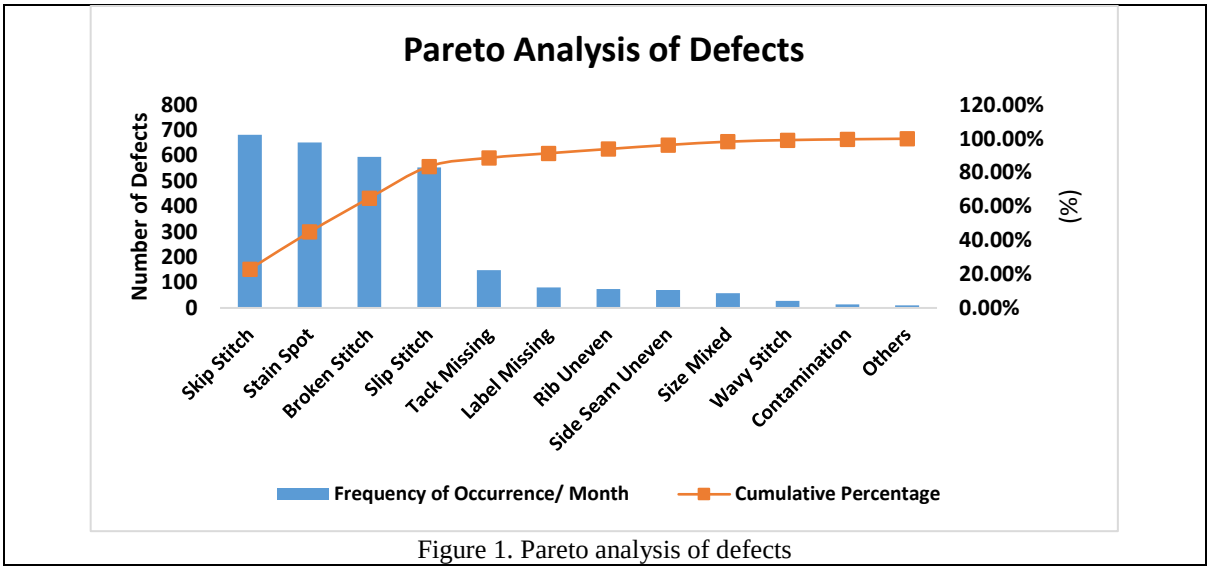

Figure 1. Pareto analysis of defects

In this regard, the cause and effect analysis and Pareto analysis of these two defects were conducted separately. Each of the analysis is presented in separate heading.

6.3 Analysis of Defects

The Cause and effect analysis and Pareto analysis were conducted to determine the primary defects of the open seam, broken stitch, and location individually, which had an extremely negative effect on the optimality of overall output. The Fish bone diagram (cause and effect diagram) was generated and organized into four sections i.e.

machine, manpower, process and material. Through brainstorming with the workers who are directly or indirectly related to the development process, all possible influences and triggers that may adversely affect the garment in this environment were listed down. All these possible factors and causes are involved in Fishbone diagrams in a sequential way at that stage. Furthermore, the Pareto analysis of each of the defects was presented individually in below given headings.

6.3.1 Skip Stitch Defect

During the sewing process, torn, skipped or missing stitches occur and are typically either due to a fault with the sewing machine or a worker error. Skipped stitches can be activated by several variables, including: wrong thread according to needle and fabric. Skip stitch defects can be seen in figure 2 that some stitches are skipped; this was the most frequency defects in the stitched garments at the case unit of the case company.

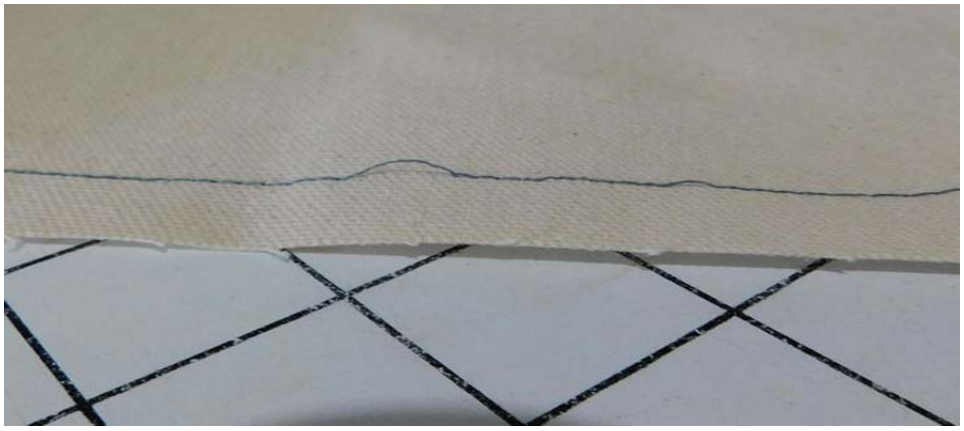

Figure 2. skip stitch representation

6.3.2 Cause and Effect Analysis of Skip Stitch Defect

Four causes of the defect can be seen in the figure 3 i.e. manpower, machine, material and method. In the material section four causes are associated with threads by which the appropriateness of the material selection is highlighted. In the manpower section, the causes were; wrong settings, low awareness and skill etc. it was reflected that employed manpower had not the required skill level. From machine section it was also indicated that it was somehow due to the labor and the lacking at the end of maintenance department as well.

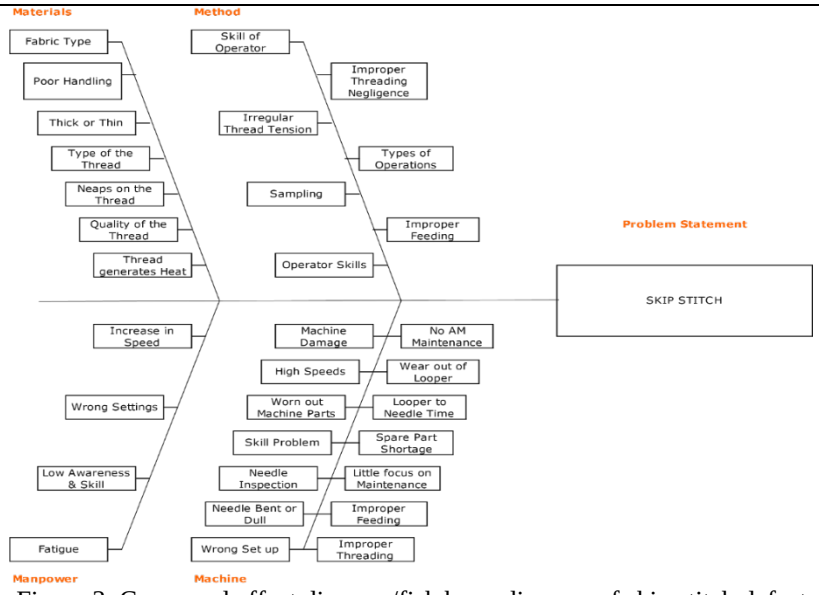

Figure 3. Cause and effect diagram/fish bone diagram of skip stitch defect

6.3.3 Pareto Analysis of Skip Stitch Defect

Pareto analysis indicated that 50% of the skip stitch defects were due to machine causes i.e. inability of worker to operate the machine, a maintenance issue or unavailability of spare part needed. Moreover, the 25% of the skip stitch defects were due to material related issues i.e. thread problem or less than required skill of labor. 15% of the total skip stitch defects were due to method issues and rest of 10% were due to manpower issues.

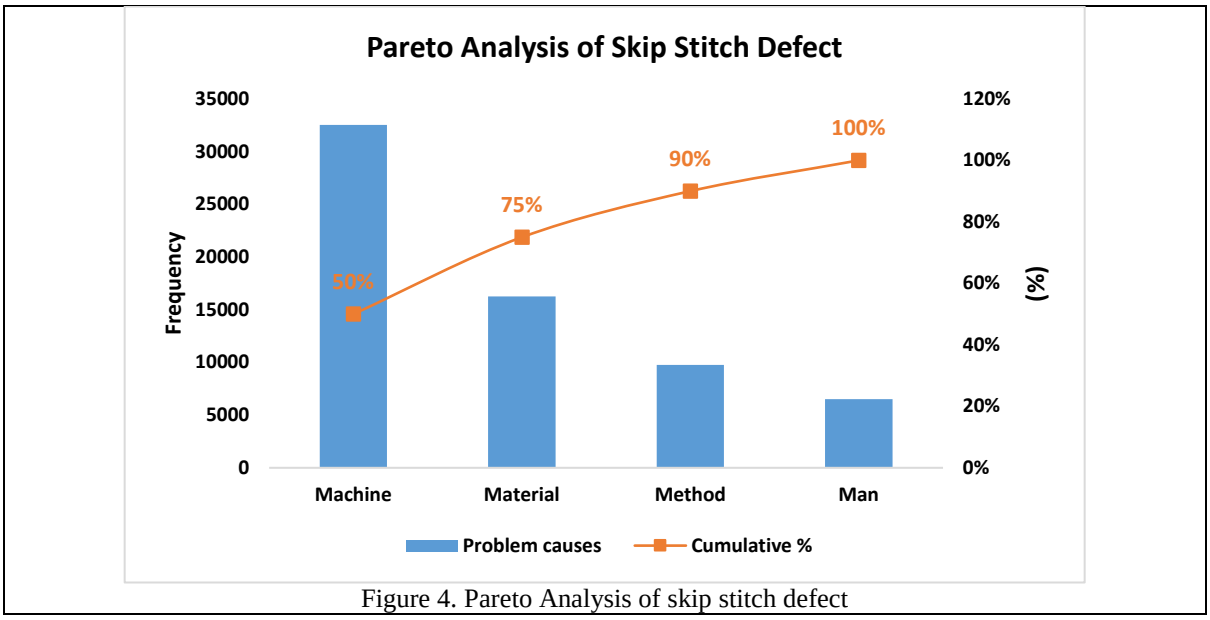

Figure 4. Pareto Analysis of skip stitch defect

6.3.4 Stain Spot Defect

Oil and lubricants used in traditional sewing machines that dip through the needle bar and scatter over the feed dog, throat plate and spaces around the needle. A piece of cloth would absorb the oil by working on such a table. The stain spot defect can be seen in the figure 5 given below.

Figure 5. Representation of stain spot defect

6.3.5 Cause and Effect Analysis of Stain Spot Defect

Similarly to the earlier cause and effect diagram, this one is also divided into four sections i.e. manpower, machine, materials and methods.

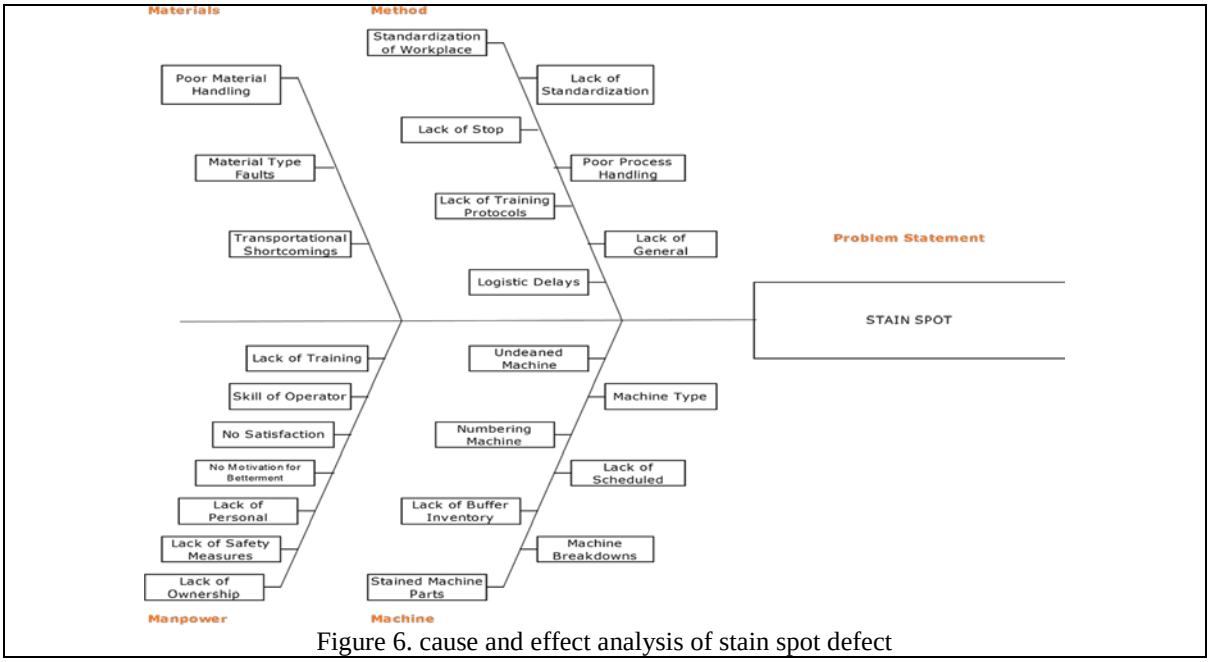

Figure 6. cause and effect analysis of stain spot defect

6.3.6 Pareto Analysis of Stain Spot Defect

A look at the combo chart presented in the figure 7 indicates that machine, material, method and manpower contributed equally (25% each) as a cause of stain spot defect at the case stitching units of the case company.

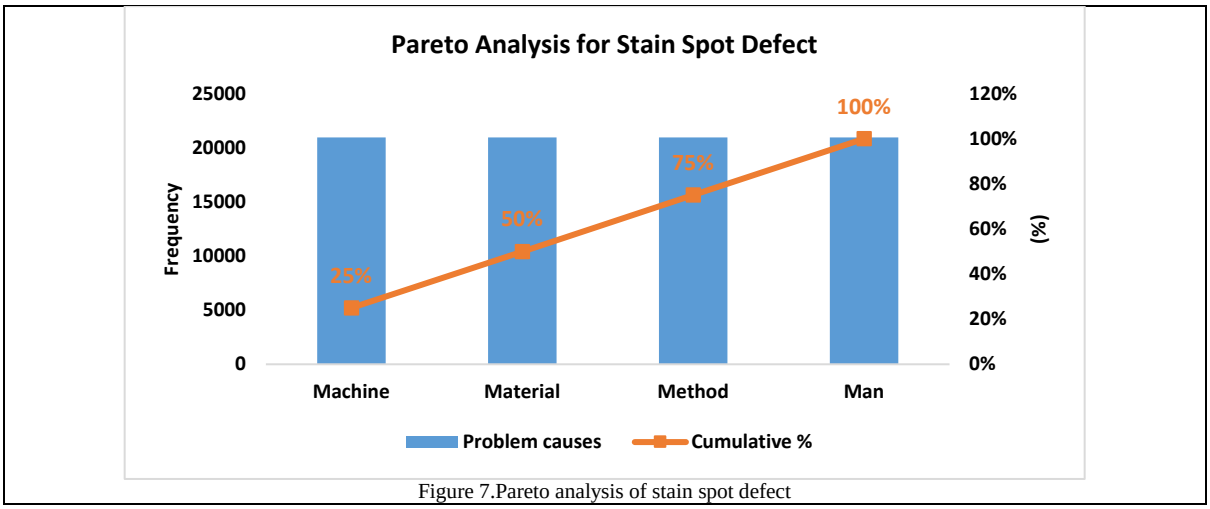

Figure 7.Pareto analysis of stain spot defect

6.4 Suggestions for the Improvement

Since, the defects are cost inclusive thus the way to minimize the mentioned defects various suggestions were made for various corresponding causes of those defects. Table 2 presents all those brainstormed suggestions for manpower, machines, methods and material.

7. Discussion

Quality is important for any manufacturing or services industry to guarantee sufficient market share as well as attaining client demands there by to win client loyalty. Actually, in today's extremely open market, it can be said that quality is the major factor in figuring out the success or failing of a company (Gebru 2014). Fast discovery of a sewing flaw is considerable to optimization of the interrelationship between quality as well as productivity. Issues located after sewing adversely influence prices of the item (Gopalakrishnan 2020). The lean manufacturing has shown the great potential in various manufacturing sectors throughout the world to minimize the defects and

improve the quality and like many other industries, lean manufacturing is the appropriate option also for textile industries to minimize the defects (Khan et al. 2020g, Zaidi et al. 2021). Initially, the textile industry was slow to adapt the lean philosophy as compare to automobile and pharma industry. But, during the last decade or so the textile industry has also shown the interest in lean philosophy & practices to minimize the defects and improve the quality (Khan 2018, Khan et al. 2020b). The garments sector of the textile industry is faster to adapt the lean philosophy & practices and has shown the proven benefits of implementing lean philosophy and many lean practices to minimize the defects and improve the quality (Khan 2018, Khan et al. 2020a, Khan et al. 2020d). Defects minimization is the initial problem of reducing production expense as well as boosting the quality. It will also lower the cycle time by minimizing reworks and finally result greater performance (Uddin and Rahman 2014).

Table 2. Suggestions for different categories of causes of the defects

Areas of Improvement	Causes	Suggested Solutions
Manpower	Insufficient trainings and worker's shortcomings.	Frequent workshops and operational trainings for workers.
	Inattentiveness.	Enhancing employee's interest level.
Machine	Machine is strung inaccurately or unreasonable string tension.	Rethread machine and keep up appropriate string pressures, make sure the string goes through the tension discs.
	Dull or bent stitching machine Needle and knife.	Replace with new part or needle.
	Excessive pressure on the presser foot.	Decrease the tension on the presser foot by loosening the two strains.
	Worn out Machine parts.	Preventive and Scheduled Maintenance.
	Incomplete Specifications.	Include Proper Machine Specifications.
	Overuse of Needles.	Changing the Needle Frequently.
	Numbering stain.	Proper Numbering.
	Dirty Machinery.	Cleaning the Machinery and Machine parts more often.
Method	Incorrect size of the needle and thread for operation.	The size of the needle and string ought to be synchronized. Ensure both the needle and bottom (looper) positions are appropriately taken care of by the right string type and size.
	Incorrectly inserted needle.	Add the needle on right position. Check that the robin is wound effectively, and no loose strings or loops stand out.
	Relatively long stitch for the short-stitched stitching during work.	Shorten the stitch length by means of the stitch regulator, especially when stitching fine stitching.
	Careless Handling.	Adapting Better Handling Techniques.
	Lack of SOP.	Using of Structured SOP.
	Lack of Transportation.	Using Appropriate Transportation Means.
	Standardization.	Every work should be Standardized.
	Packing Shortcomings.	Using Proper Packaging Material.
Material	Poor Quality of Thread.	Using Good Quality Thread.
	Poor Quality of Needle.	Utilize excellent needle from another brand, Needle ought to have high Warmth Resistance Limit.
	Poor Quality of Scissors.	Using Good Quality Scissor.

Some of the researchers have actually worked with the issue as Uddin and Rahman (2014) found that the stitching section of chosen garment manufacturing facility was running at a defect percent of 12.61. The rate was very high at this present company context. After introducing the DMAIC Method of Six Sigma the percentage of issue is reduced to 7.7. There is likewise found a considerable renovation of the Sigma degree of the industry. It is shifted from 2.64 to 2.9255. So, this method is very reliable to the minimization of flaws. As the reduction of problems is a continual process better application of this technique will aid the company appreciating more reduction on flaw rate and enhancement on efficiency (Uddin and Rahman 2014). The automobile sector is the leading industrial sector throughout the world to adapt and implement the lean philosophy and most of the lean manufacturing practices (Khan et al. 2020f). The large pharmaceutical industries are not far behind also throughout the world to adapt and implement the lean philosophy and most of the lean manufacturing practices (Khan et al. 2020e). Both sectors have shown the proven benefits of implementing lean philosophy and many lean practices to minimize the defects and improve the quality (Khan et al. 2020e, Khan et al. 2020f). Kumar et al. (2020a) and Rajput et al. (2020) conducted the case studies at the automobile assembling plants. The proposed lean teachniques of VSM, TPM, OEE & Takt Time have shown the remarkable improvement to minimize the defects and improve the quality at the automobile assembling plants (Rajput et al. 2020, Kumar et al. 2020a). Mridha et al. (2019) found a considerable improvement in the Sigma degree of the market. So DMAIC approach is very operative to the reduction of flaws. If lots of garment factories in Bangladesh comply with the 6 sigma concept, after that they can reduce the majority of the

problems in the stitching section (Mridha et al. 2019). Lakho et al. (2020) discussed the case studies about the implementation of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) in various manufacturing industries. The lean practices of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) have shown the remarkable improvement to minimize the defects and improve the quality in various manufacturing industries (Lakho et al. 2020, Virk et al. 2020).

Sahito et al. (2020) conducted the case study at the pharmaceutical plant. The lean practices of Gemba, VSM, time & motion study and cause & effect analysis have shown the remarkable improvement to identify, analyse and reduce/eliminate the defects and improve the quality at the pharmaceutical plant (Sahito et al. 2020). Khan et al. (2020) discussed the applications of Waste Relations Matrix (WRM) to investigate the relationship of defects with other wastes of lean manufacturing and its affect on the cost of production. Khan (2018) and Khan et al. (2020b) suggested most relevant lean practices for textile industry to eliminate /reduce the defect waste of lean manufacturing which include Lean Six Sigma (LSS) and (DMAIC) as well. Mughal et al. (2020) and Kumar et al. (2020b) presented the case studies about defects in textile & non textile industries. The applications of lean practices specially the Six sigma (DMAIC) & Lean Six Sigma (LSS) have the tremendous potential in Production Systems to reduce/elimiate the production defects (Mughal et al. 2020, Kumar et al. 2020b). Uddin et al. (2014) made use of Pareto evaluation to identify the leading happening problems. After determining the major issues, brainstorming device was utilized to recognize the probable reasons and after that possible root causes were recognized by on-line assessments and also source analysis. The result found after execution of the approach was really significant. The issue portion was lowered from 11.229 to 7.604 as well as the Sigma degree was boosted from 2.714 to 2.93 (Uddin et al. 2014).

In the present research, Pareto analysis indicated that 50% of the skip stitch defects were due to machine causes i.e. inability of worker to operate the machine, a maintenance issue or unavailability of spare part needed. Moreover, the 25% of the skip stitch defects were due to material related issues i.e. thread problem or less than required skill of labor. 15% of the total skip stitch defects were due to method issues and rest of 10% were due to manpower issues. Furthermore, Pareto analysis of stain spot defect indicated that machine, material, method and manpower contributed equally (25% each) as a cause of stain spot defect at the case stitching units of the case company.

8. Conclusion

Tremendous amount of money and resources are wasted due to occurrence of defects and therefore, they affect the profitability of the company. In this regard, they must be eradicated or at least minimized by the use of technology. There are various techniques to minimize the defects. Defects can be minimized by just organizing the setup and little care during the production is carried out. The lean practices i.e. lean six sigma, TPM, OEE and DMAIC are also suggested to minimize the defects. Future researches can be carried out on remaining defects. Little mistake can cause numerous defects at the various levels of production as revealed in the present research paper.

9. Future Implications

Future researches can be carried out on the remaining defects that were not worked on in the present research in terms of cause and effect analysis and Pareto analysis. It is also feasible to choose the DMAIC tool for calculation of sigma level and minimization of defects in the future research.

10. Limitations

There were total twelve defects in the case stitching unit and in the present research, only two were focused because of shortage of time.

Acknowledgement

We are very thankful to our colleagues and well-wishers at the department of Industrial engineering & management and Mehran UET, Jamshoro, Sindh, Pakistan to motivate and guide us. We also acknowledge our textile industry friends to guide us in the local & global scenario of lean manufacturing in textile industry. We are also very thankful to the administrative and technical support from the administration & management of Mehran UET, Jamshoro, Sindh, Pakistan for their cooperation and support. We are especially thankful to Mehran UET Library & Online Information Centre to provide the free access to the valuable databases and relevant books, magazines, journals etc.

Conflict Of Interest

Team of researchers of the present paper bear no conflict of interest.

References

Akbar, A., Hosssain, Z., & Rahman, A., Comparative Study on Sewing Faults of Different Buyers in a Knit Garments Industry, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2020.

Bukhsh, M., Khan, M.A., Zaidi, I.H., Yaseen, R., Khalid, A., Razzaque, A., and Ali, M., Productivity Improvement in Textile Industry using Lean Manufacturing Practice of Single Minute Die Exchange (SMED), *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management, Singapore,* March 7-11, 2021.

Choudhary, A. K., M. P. Sikka, and P. Bansal, The study of sewing damages and defects in garments, *Res. J. Text. Appar.*, vol. 22, no. 2, pp. 109–125, 2018, doi: 10.1108/RJTA-08-2017-0041, 2018.

Ferdous, M. K., T. H. Pranta, and M. S. Hossain, Study on Finished Fabric & Knit Garments Inspection Report, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2020.

Gebru, K., Identifying defect causes of weft greige knitted fabric: the Case of MAA-Garment & Textiles Factory. *Ethiopian Institute of Technology, Mekelle University*, 2014.

Gopalakrishnan, P., Analysis of sewing defects and control measures for apparel industry, *International Journal of Polymer and Textile Engineering*, vol. 7, no. 2, pp. 18–24, 2020.

Iqbal, A., M. F. H. Yousuf, and M. A. Salam, Analysis of and effective quality control system: A Study on Woven Garments, *EPRA Int. J. Res. Dev.*, vol. 3, no. 12, pp. 144–152, 2020, doi: 10.13140/RG.2.2.17363.20004, 2018.

Islam, M. S. bin and M. R. Ahsan, Study on Cutting, Sewing and Finishing Section at a Garments industry, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2018.

Khan, M. A., Preliminary study on lean manufacturing practices at yarn manufacturing industry: A case study, *Masters of Engineering (Thesis), Department of Industrial Engineering & Management, Mehran University of Engineering & Technology*, Jamshoro, 76062, Sindh, Pakistan, 2018.

Khan, M. A., Marri, H. B., and Katri, A., Exploring The Applications Of Lean Manufacturing Practices In Textile Industry, *Proceedings of the International Conference on Industrial Engineering and Operations Management,* Dubai, UAE, March 10-12, 2020a.

Khan, M. A., Marri, H. B., and Katri, A., Preliminary Study on the Identification, Analysis and Elimination of Lean Manufacturing Wastes through Lean Manufacturing Practices at Yarn Manufacturing Industry, *Proceedings of the International Conference on Industrial Engineering and Operations Management,* Dubai, UAE, March 10-12, 2020b.

Khan, M. A., Soomro, A. S., Shaikh, S. A., Memon, M. S., and Marri, S., Lean Manufacturing in Pakistan: A Comprehensive Review, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management,* Detroit, Michigan, USA, August 10 - 14, 2020c.

Khan, M. A., Khatri, A., and Marri, H. B., Descriptive Analysis of Lean Manufacturing Practices in Textile Industry, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management,* Detroit, Michigan, USA, August 10 - 14, 2020d.

Khan, M. A., Shaikh, S. A., and Marri, S., Systematic review of lean manufacturing practices in pharmaceutical industry, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management,* Detroit, Michigan, USA, August 10 - 14, 2020e.

Khan, M. A., Memon, M. S., and Soomro, A. S., Exploring the Applications of Lean Manufacturing Practices in Automobile Industry, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management,* Detroit, Michigan, USA, August 10 - 14, 2020f.

Khan, M. A., Shaikh, S. A., Lakho, T. H., and Mughal, U. K., Potential of Lean Tool of Value Stream Mapping (VSM) in Manufacturing Industries, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Harare, Zimbabwe, December 07-10, 2020g.

Khan, M.A., Khatri, A., and Marri, H.B., Applications of Waste Relations Matrix (WRM) in Lean Wastes Identification, *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management,* Singapore, March 7-11, 2021.

Kumar, S., Khan, M. A., Ahmed, S., Rehman, A., and Luhar, E., A Case Study for Performance Evaluation of Motorcycle Assembly Line through the Lean Manufacturing Practice of Overall Equipment Effectiveness

(OEE), *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Dubai, UAE, March 10-12, 2020a.

Kumar, P., Khan, M. A., Mughal, U. K., and Kumar, S., Exploring the Potential of Six Sigma (DMAIC) in Minimizing the Production Defects, *Proceedings of the International Conference on Industrial & Mechanical Engineering and Operations Management*, Dhaka, Bangladesh, December 26-27, 2020b.

Lakho, T. H., Khan, M. A., Virk, S. I., and Indher, A. A., Implementation of Overall Equipment Effectiveness (OEE) in Maintenance Management, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Harare, Zimbabwe, December 07-10, 2020.

Mia, S., S. . Amanullah, and M. M. Rahman, Study on Garments Inspection, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2018.

Mridha, A. K., Sutradhar, A., & Monoranjan Kha., Investigation on causes and remedies of quality problems in knit garments production, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2015.

Mridha, J. H., Hasan, S. M. M., Shahjalal, M., & Ahmed, F., Implementation of Six Sigma to Minimize Defects in Sewing Section of Apparel Industry in Bangladesh. *Global Journal of Researches in Engineering: J General Engineering*, vol. 19, no. 3, pp. 1–7, 2019.

Mughal, U. K., Khan, M. A., Kumar, P., and Kumar, S., Applications of Lean Six Sigma (LSS) in Production Systems, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Harare, Zimbabwe, December 07-10, 2020.

Rajput, S., Khan, M. A., Samejo, S., Murtaza, G., and Rao, A. A.,, Productivity Improvement by the Implementation of lean manufacturing practice (takt time) in an automobile assembling plant, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Dubai, UAE, March 10-12, 2020.

Sahito. S. A., Khan, M. A., Arain, A. A., Bhutto, S. A., Wadhyo, R., and Memon, S. A., A Study For The Identification And Elimination Of Lean Manufacturing Wastes At The Pharmaceutical Production Plant Improvement By The Implementation Of Lean Manufacturing Practice (Takt Time) In An Automobile Assembling Plant, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Dubai, UAE, March 10-12, 2020.

Samuel, W. D., &Poojitha, V., A simple system for the online detection of SKIP/LOOP stitches in single needle lockstitch sewing machines. *Autex Research Journal*, vol. 10, no. 3, pp. 69–72, 2010.

Sharifuzzaman, A. B. M. and M. M. Islam, Identification of Different Types of Sewing Faults and their Remedies in Knit Garment Production, *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2018.

Tahiduzzaman, M., Rahman, M., Dey, K., &Kapuria, T. K., Minimization of Sewing Defects of an Apparel Industry in Bangladesh with 5S & PDCA. *American Journal of Industrial Engineering*, vol. 5, no. 1, pp. 17–24, https://doi.org/10.12691/ajie-5-1-3, 2018.

Uddin, M. N. and S. Akter, Impact analysis of sewing Defects in garments industry & their remedies (A Case Study), *Bachelor of Science in Textile Engineering (Thesis), Daffodil International University, Dhaka, Bangladesh*, 2018.

Uddin, S. M., R. Hasan, and S. Hosen, Defects Minimization through DMAIC Methodology of Six Sigma, *Proceedings of the International Conference on Mechanical, Industrial and Energy Engineering*, 2014.

Uddin, S M, & Rahman, C. M. L., Minimization of Defects in the Sewing Section of a Garment Factory through DMAIC Methodology of Six Sigma. *Research Journal of Engineering Sciences*, vol. 3, no. 9, pp. 21–26, 2014.

Virk, S. I., Khan, M. A., Lakho, T. H., and Indher, A. A., Review of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) Practices in Manufacturing Sectors, *Proceedings of the International Conference on Industrial & Mechanical Engineering and Operations Management, Dhaka, Bangladesh*, December 26-27, 2020.

Zaidi, I. H., Khan, M. A., Bukhsh, M., Yaseen, R., and Shaikh, S. A., Implementation of Lean Manufacturing Practices in Diverse Manufacturing Industries, *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management*, Singapore, March 7-11, 2021.