Mansoura Engineering Journal

Volume 49 | Issue 4 Article 18

2024

Enhancing the Garment Quality through the Integration of Statistical Techniques

Magdi El Messiry
Textile Engineering Department, Faculty of Engineering, Alexandria University, Egypt

Affaf Al-Oufy
Textile Engineering Department, Faculty of Engineering, Alexandria University, Egypt

Heba Marwan
Textile Engineering Department, Faculty of Engineering, Alexandria University, Egypt

Samar Abd-Ellatif
Textile Engineering Department, Faculty of Engineering, Alexandria University, Egypt, samar_eg@yahoo.com

Follow this and additional works at: https://mej.researchcommons.org/home

Part of the Architecture Commons, Engineering Commons, and the Life Sciences Commons

Recommended Citation
Messiry, Magdi El; Al-Oufy, Affaf; Marwan, Heba; and Abd-Ellatif, Samar (2024) "Enhancing the Garment Quality through the Integration of Statistical Techniques," *Mansoura Engineering Journal*: Vol. 49 : Iss. 4 , Article 18.
Available at: https://doi.org/10.58491/2735-4202.3220

This Original Study is brought to you for free and open access by Mansoura Engineering Journal. It has been accepted for inclusion in Mansoura Engineering Journal by an authorized editor of Mansoura Engineering Journal. For more information, please contact mej@mans.edu.eg.

ORIGINAL STUDY

Enhancing Garment Quality Through Integration of Statistical Techniques

Magdi El Messiry [a], Affaf Al-Oufy [a,b], Heba Marwan [a], Samar Abd-Ellatif [a,*]

[a] Department of Textile, Faculty of Engineering, Alexandria University, Alexandria, Egypt
[b] Department of Mechanical Engineering, Faculty of Engineering, Galala University, Suez, Egypt

Abstract

The textile and apparel sector has always held significant strategic value for the economies of numerous developing countries. These industries represent vital components of manufacturing and exports, playing a major role in employment opportunities. Within the realm of garment production, a strong emphasis on quality is maintained throughout the entire process, starting from sourcing raw materials and extending to the final stages of garment completion. This research undertaking involves a comprehensive analysis, classification, and evaluation of defects in fabrics and garments. Frequencies and distributions of these defects are being looked after with great caution. To enhance product quality, application of straightforward quality frameworks is of utmost importance. The proposed approach involves using effective statistical tools such as Pareto diagrams and cause-and-effect diagrams. By adopting this strategy, it becomes possible to systematically reduce variability and rectify defects. Consequently, this methodology has the potential to be consistently applied, resulting in a noteworthy enhancement of garment quality across production cycles. Furthermore, using statistical instruments such as the probability mass function obtained from the binomial distribution is of immense value for evaluating the probabilities of defects' occurrence. An illustrative real-world instance shows its utility in forecasting defect incidents, supporting manufacturers in approximating defective sections, and directing endeavors to elevate quality.

Keywords: Cause-and-effect, Defects, Garment, Pareto, Probability mass function, Quality

1. Introduction

The global textile industry, particularly the apparel industry has witnessed remarkable changes in the past few years. The garment manufacturing industry and the garment companies in Global South countries are now always on the lookout for economical means of garment production. The days are gone when the textile garment industry was in the consumption hubs of US, EU, and the other Global North countries of the world. The clothing wholesale supply is increasing worldwide in all industry sectors. For Global South countries to be able to be competitive in the field of garment industry, special care should be given to the quality of their products which should be able together with the relatively low production cost to put their garment industries in a good position within the world garment industry.

Based on quality aspects, fabrics are classified into first- and second-quality products. A first-quality fabric is totally free of major defects and virtually free of minor structural or surface defects, while a second-quality fabric may contain a few major defects and/or several minor structural or surface defects (Chan and Pang, 2000). Fabric defects are responsible for nearly 85% of the defects found in the garment industry. Out of them, manufacturers recover only 45−65% of their profit from second-quality goods due to which the prices are reduced (Shanbhag et al., 2012). It is, therefore, necessary to detect, identify, and prevent these defects from reoccurring.

Product inspection is an important aspect of modern manufacturing industries; this process is a

Received 24 February 2024; revised 8 April 2024; accepted 11 May 2024.
Available online 9 July 2024

* Corresponding author at: Department of Textile Engineering, Faculty of Engineering, Alexandria University, Alexandria 21544, Egypt.
E-mail address: Samar_eg@yahoo.com (S. Abd-Ellatif).

https://doi.org/10.58491/2735-4202.3220
2735-4202/© 2024 Faculty of Engineering, Mansoura University. This is an open access article under the CC BY 4.0 license (https://creativecommons.org/licenses/by/4.0/).

preventive one that could be broadly defined as the process of determining if a product deviates from a given set of specifications (Newman and Jain, 1995). Mainly, fabric defect detection has two distinct possibilities (Kumar, 2008). The first one is the product or end (offline) inspection in which the manufactured fabric must be inspected through fabric inspection machines (Anagnostopoulos et al., 2001, 2002). The second possibility is the process inspection (online) in which the weaving process (or its parameters) can be constantly monitored for the occurrence of defects. Well-trained (expert) human inspectors must traditionally perform offline inspection (Sengottuvelan et al.; Paladini, 2008; Nishimatsu et al., 1995). The existing methods of fabric inspection vary from mill to mill (Baykut et al., 1998). Most mills have power-driven inspection machines where the manufactured fabric rolls are removed from the weaving machines and unrolled on an inspection table (under adequate light) at a relatively higher speed of 8−20 m/min (Kumar, 2008; Sengottuvelan et al.; Baykut et al., 1998). Lastly, with modern weaving machines, production speeds and consequently productivity are faster than ever. The experiments show that the error rate of visual inspections begins to rise rapidly (Ayres, 1987). Therefore, the traditional visual inspection method cannot cope with today's requirements. Although humans can do the job better than machines (Anagnostopoulos et al., 2001) in many cases, visual inspection suffers from many drawbacks. This led to the introduction of automatic inspection systems. Automatic inspection systems are designed to increase the accuracy, consistency, and speed of defect detection in the fabric manufacturing process to reduce labor costs, improve product quality, and increase manufacturing efficiency. The operation of an automated visual inspection system can be broken down into a sequence of processing stages: image acquisition, feature extraction, comparison, and decision. It is important to note that the success of an automatic inspection system relies on the approach used.

Moreover, during the past two decades, various techniques of automatic fabric inspection systems have been developed in different approaches such as statistical, spectral, and model-based ones. However, as most of these automated inspection systems are offline systems, they give lag time between actual production and fabric inspection. Therefore, more efficient inspection systems such as BarcoVision's Cyclops, Elbit Vision System's I-Tex4, and Zellweger Uster's Fabriscan were developed and implemented online or on loom to form the basis of a method with a very high degree of accuracy for textile inspection (Goyal, 2018). In addition, models for predicting defects have been developed to assist shop floor operators in identifying potential defects in advance. Based on warning signals, the operators are supposed to take corrective actions at the right time to prevent defects.

While many studies have proposed defect prognostic models in high-tech industries, only a few studies have focused on other industries such as textile, ceramic, and so on. Focusing on realistic needs, online defect prognostic models predict types of defects at each manufacturing process based on a backpropagation neural network. Data from the manufacturing processes are collected. Then, control charts are used to transform the collected data into the region data of the product. Based on these data, backpropagation neural networks are designed for predicting defects at each stage (Nhat-ToHuynh, 2020). However, a novel statistical feature extraction method, called the neighborhood preserving neural network (NPNN), was proposed, which can be viewed as a nonlinear data-driven fault detection technique through preserving the local geometrical structure of normal process data. The ‘local geometrical structure’ means that each sample can be constructed as a linear combination of its neighbors. NPNN is characterized by adaptively training a nonlinear neural network that takes the local geometrical structure of the data into consideration (Zhao and Lai, 2019).

Moreover, the statistical field has been offering a series of techniques that proved to be most helpful in troubleshooting issues related to quality. However, companies that set about training their workforces in statistical quality control found that the complexity of these techniques intimidated most of their workers. Therefore, they began to focus primarily on simpler methods which should be sufficient for most quality-related issues. Nevertheless, research works aiming to reduce the percentage of defects in the garment industry through the application of Six Sigma's DMAIC technique was introduced and gave promising results (EL-Hadidy and EL-Sisy, 2023; Beyene, 2017). Taking this as a standpoint, in this research work, the fabric and garment defects are analyzed, classified, and assessed. Their locations, their occurrence frequencies, and their distributions are studied. A new strategy for their reduction is proposed in the form of several statistical tools, which through an accurate application should lead to a substantial improvement in garment quality.

Furthermore, examining the garment defects in depth, it is obvious that yarn imperfections such as knots, slubs, and thick/thin areas can cause issues with the fabric's appearance, texture, and strength and hence lead to substantial defects in the final garments. These imperfections can create variations in the thickness and density of the yarn, which can result in uneven fabrics. Yarn imperfections are also a principal cause of garment sizing problems. They can affect the consistency of the fabrics, which can result in uneven shrinkage during the washing process. This uneven shrinkage can cause the garment to become misshapen and hence affect its sizing. In addition, yarn imperfections are also a principal cause of many fabric defects such as holes, which can further affect the garments' overall quality. Certain types of yarn are more prone to imperfections than others. For example, yarns made from natural fibers such as cotton, wool, and silk are more likely to have imperfections compared with synthetic fibers like polyester or nylon. The difference is attributed to some inherent inconsistencies in the texture and thickness of natural fibers, which can result in irregularities during the spinning process (Defects in garments; Faults of Knit Fabric Observed).

2. Materials and methods

A survey of the major and minor defects occurring in a knitting mill was held to provide an overall view of the faults to deal with in garment mills. The experimental work was conducted in a nominated garment production company composed of one knitting mill and three garment mills.

It is known that faults may exist in a final product due to one or more of the following causes:

(a) Raw materials' defects which the operative must recognize and report.
(b) Machinery defects which the operative must recognize and adjust if the adjustment is his responsibility, or report if not.
(c) Operative defects which the operative must recognize and get assistance to correct when needed.

Statistical process control problem-solving tools such as histograms, cause-and-effect diagrams, and Pareto charts are used as aiding tools to improve the quality control system applied in the mills under investigation.

In addition, the probability mass function (PMF) of the binomial distribution is used as an algorithm for calculating the probability of multiple defects occurring in the same position of a garment.

3. Results and discussions

3.1. Fabric defects

The possible knitted fabric defects which should lead to consequent garment defects were registered. The most relevant fabric faults are shown in Figs. 1—7.

3.2. Garment defects

The possible garment defects are also registered. Figs. 8—16 show the most detected garment faults.

Fig. 1. Holes.

Fig. 2. Skip stitches.

Fig. 3. Tuck stitches.

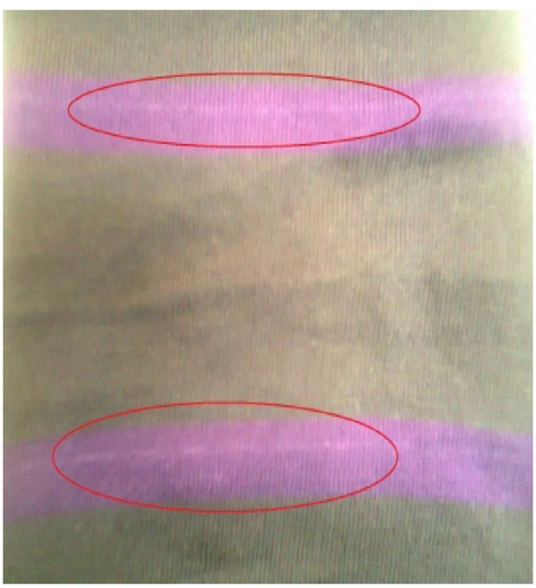

Fig. 4. Horizontal stripes.

3.3. Application of SPC tools to control fabric and garment faults

A total of 7876 pieces out of 264,163 total produced pieces is inspected. A total number of defectives of 772 is recorded. The recorded defects are then classified into four different categories: operator defects, mechanical defects, stain defects, and other defects. The occurrence frequencies of the different defects and the different classes are given in Table 1.

Histograms illustrating the frequencies of the occurrence of the different defects under the different categories are shown in Figs. 17–21.

Fig. 5. Missed yarn.

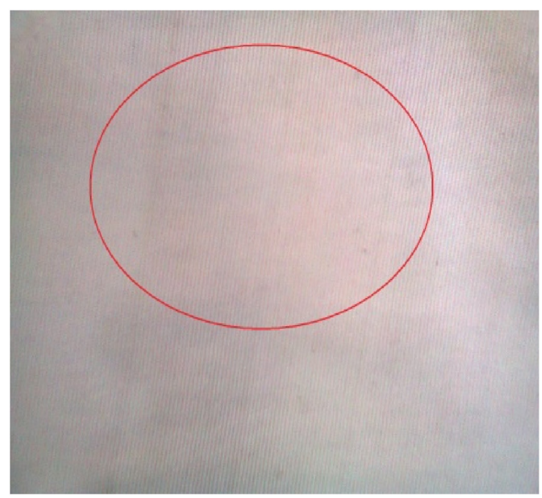

Fig. 6. Oil lines.

Fig. 7. Dirt.

Fig. 8. Needle cut.

Fig. 10. Broken stitch.

Fig. 9. Marker mark.

Fig. 11. Uneven neck rip.

In a subsequent step, Pareto charts are introduced. A Pareto chart is a chart containing both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The purpose of the Pareto chart is to highlight the most important among a large set of factors. In quality control, Pareto charts are useful for finding the defects to prioritize to observe the greatest overall improvement in the production process (Wilkinson, 2006). In this research work, Pareto charts are developed to determine the major defects representing more than 80% of the total defects in each category. These defects should then be primarily considered in the different garment mills as the prevention or at least the reduction of their occurrence should lead to a substantial improvement of the product quality. The Pareto charts representing the operator faults and the mechanical defects are shown in Figs. 22 and 23, respectively.

Fig. 12. Open seam.

Fig. 13. Needle holes.

From Fig. 22, the operator defects that should be taken into consideration in a garment mill are the broken stitch, the wrong size, the missing stage, the uneven sleeves, the poor neck shape, the pleats, and the poor trimming. The prevention of these defects should lead to a reduction of at least 80% of the total operator defects in the garments produced.

Fig. 14. Contamination.

Fig. 15. Dirt.

Similarly, from Fig. 23, the mechanical defects that should be taken into consideration in a garment mill are the holes, the open seams, and the skipped stitches. The prevention of these defects should lead to a reduction of at least 80% of the total mechanical defects in the garments produced. The oil stains should also be taken into consideration as they represent around 17.1% of the total faults in garments. The fabric defects are also important as they

Fig. 16. Out of tolerance.

represent 1.8% of the total defects in garments. It is to be noticed that the mechanical defects and operator defects represent 20% of the total defects and comprise 80% of the defect causes.

As a subsequent step, cause-and-effect diagrams are introduced. A cause-and-effect diagram is a visual tool used to logically organize possible causes for a specific problem or effect by graphically displaying them in increasing detail. It may also be referred to as a fishbone or Ishikawa diagram (Juran, 2018). In this research work, cause-and-effect diagrams are developed for the most frequent defects detected. This statistical tool is of huge importance as it presents extensive help in the prevention of defects by preventing their causes. The cause-and-effect diagrams for the main knitted fabric defects are represented in detail in Figs. 24–30.

Figs. 31–37 represent the cause-and-effect diagrams for the most important mechanical defects to be considered.

3.4. Statistical analysis of defect reduction using the proposed techniques

In a further step, the proposed technique is tested for its suitability to be applied in a garment mill to outline its potential to contribute to the reduction of garment defects and hence in the increase of the quality of the products. As an example of the application of the suggested technique, the mechanical defects displayed and analyzed in the previous section are being tackled. As previously described, the Pareto chart presented in Fig. 23 showed that controlling the main three defects:

Table 1. Plotted defects and their recorded relative frequencies.

Operator defects		Mechanical defects		Stain defects		Others	
Defect	%	Defect	%	Defect	%	Defect	%
Broken stitch	9.7	Hole	10.8	Oil	17.1	Fabric defect	1.8
Wrong size	6	Skip stitch	8.2	Dirt	8.5	Shade color	1
Miss stage	3.9	Open seam	8.4			Dying defect	0.1
Poor neck shape	2.5	Poor pressing	6.5			Twisted	0
Uneven sleeves	2.6	Needle hole	1				
Pleat	2.2	Miss part of the h. seal	0.8				
Poor trimming	1.9	Printing defect	0.6				
Embedded defect	1.6						
Cutter hole	0.3						
Wrong stage	1						
Uneven armhole	0.9						
Puckering	0.4						
Non-straight sewing	0.3						
Uneven at shoulders	0.5						
Slanted label	0.3						
Slanted pocket	0.5						
Drop stitch	0.1						
Poor repairing	0						
Non-centered label	0.3						
Skewing	0						
Wrong sleeve	0.1						
Slanted placket	0						
Hand sewing	0.1						
Raw edge	0						
Total	35.2	Total	36.3	Total	25.6	Total	2.9

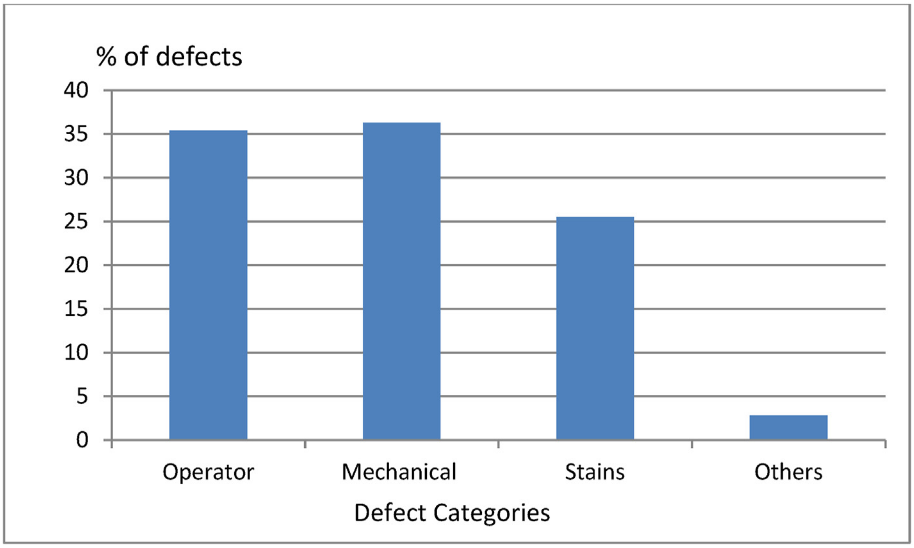

Fig. 17. Frequencies of the different defect categories.

fabric holes, open seams, and skipped stitches should lead to the reduction of at least 80% of the total mechanical defects detected in the garments produced. As fabric holes and skipped stitches are purely fabric defects, the quality control team of a garment mill should handle them solely by applying strict procedures while ordering, purchasing, and inspecting knitted fabrics. Such procedures should lead to a substantial decrease in two of the three most irritating defects in the produced garments. As for the third defect, i.e. open seams, it represents 8.4% of the total defects as previously shown in Table 1. From Fig. 34, it could be noticed that in addition to an accurate material inspection, an open seam would be avoided if the setting of the machine is applied accurately. This being guaranteed, not only open seam would be eluded, but also a considerable decrease in needle holes will be achieved. This is because an accurate machine setting is one of the main causes of needle holes as shown in Fig. 32. Subsequently, a new Pareto chart would be developed as shown in Fig. 38. In this new chart, holes, open seams, and skipped stitches would no longer represent disturbing issues regarding the garment quality. It shows that adopting strict procedures in the inspection of the delivered knitted

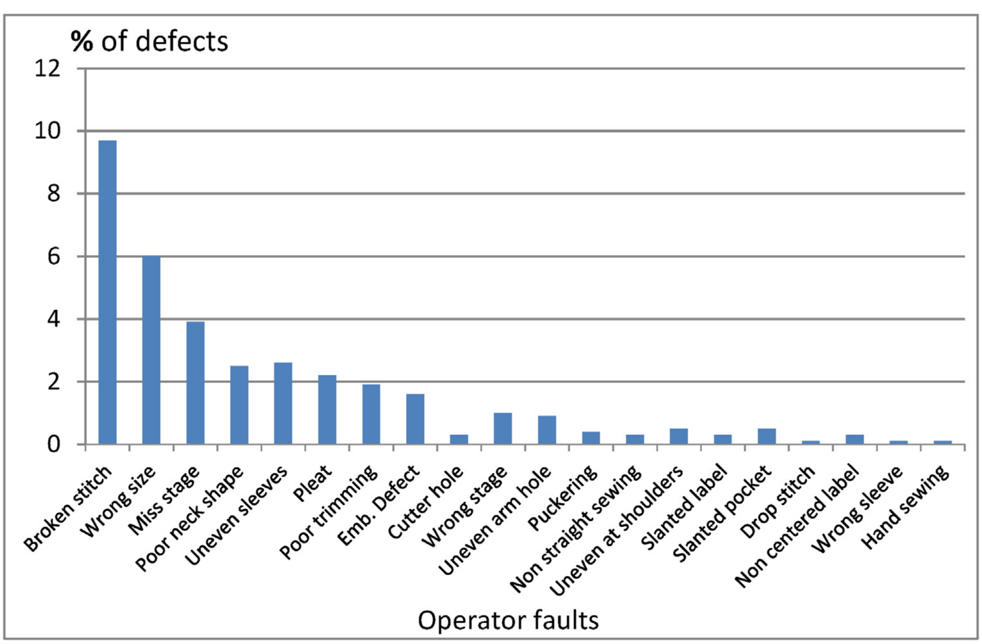

Fig. 18. Frequencies of operator faults.

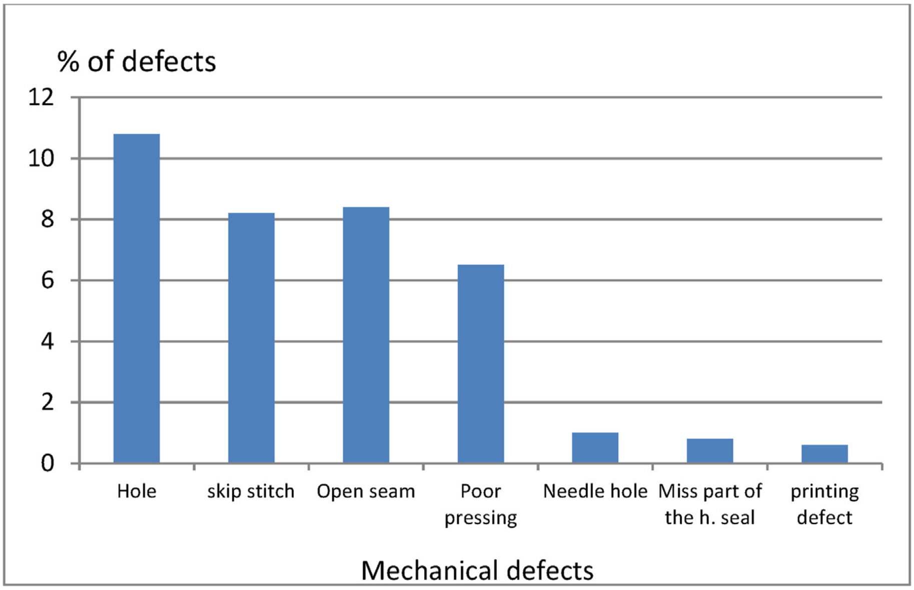

Fig. 19. Frequencies of mechanical defects.

fabric would lead to a reduction in the number of holes and skipped stitches by 70%. Then the application of strict procedures to control the machine setting would decrease the open seams and needle holes by 95% and 75%, respectively. In this case, an overall decrease in the garment defects would attain 63.9%

3.5. Application of PMF to minimize fabric defects in garments

3.5.1. Examining the impact of yarn defects on pattern layout

The presence of yarn defects holds the potential to influence the arrangement of various pattern parts, necessitating adjustments to ensure a final garment of superior quality, devoid of visible imperfections. Yarn defects exert a notable influence over the placement of pattern segments within a fabric that will eventually be cut and sewn into a garment. The precision of pattern piece positioning becomes pivotal in guaranteeing the garment's proper fit and aesthetic appeal. The consequences of yarn defects on pattern layout unfold in several dimensions. Initially, substantial yarn defects within a specific fabric section might render that area unsuitable for certain pattern pieces. For instance, a significant knot or slub in the fabric could render a small pattern piece cut from that region visibly flawed in the finished garment. Moreover, if multiple yarn

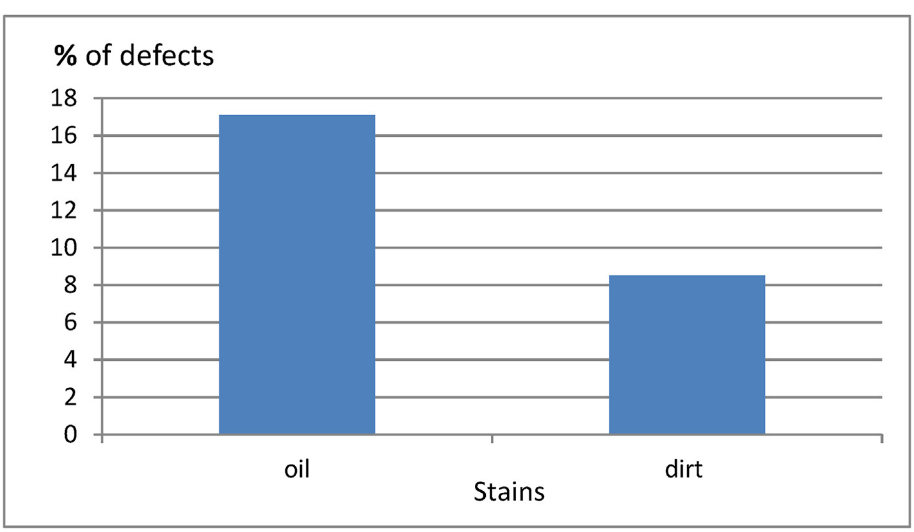

Fig. 20. Frequencies of stains detected.

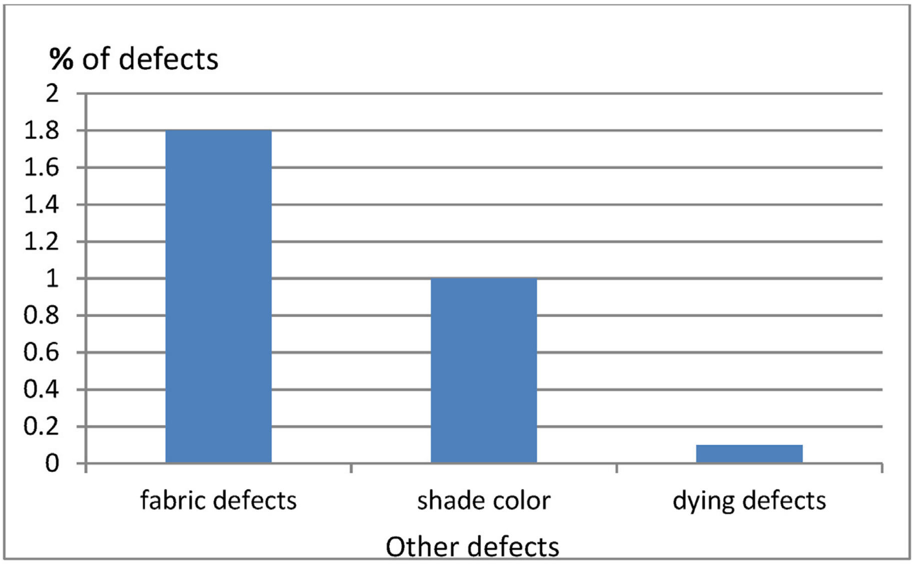

Fig. 21. Frequencies of other defects detected.

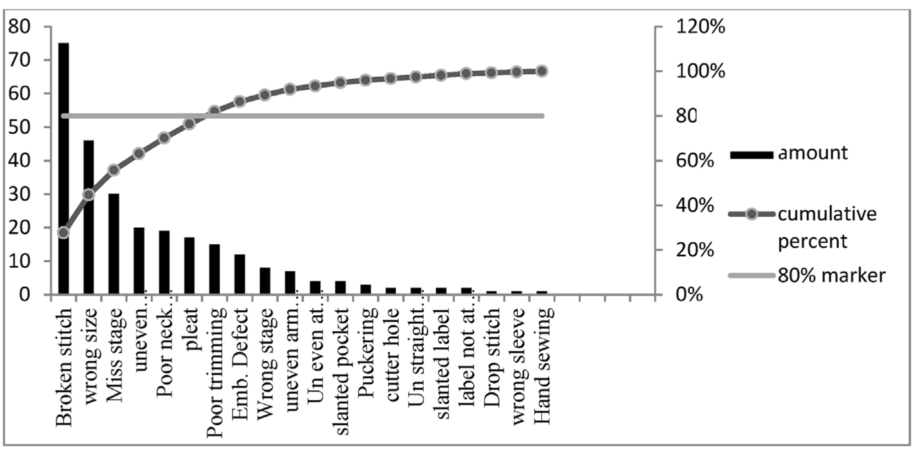

Fig. 22. Pareto chart for the operator faults.

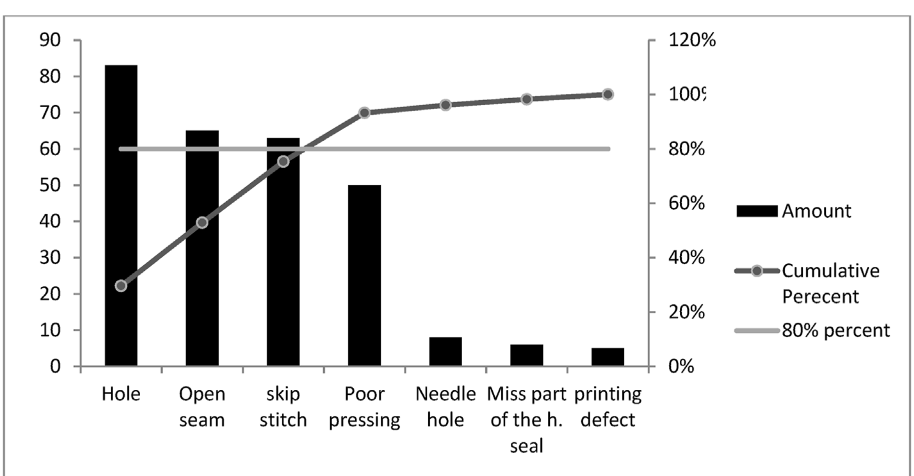

Fig. 23. Pareto chart for mechanical defects.

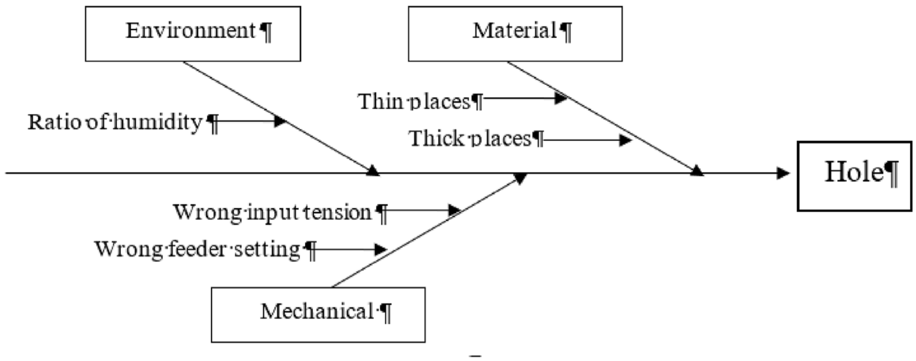

Fig. 24. Cause-and-effect diagram for fabric holes.

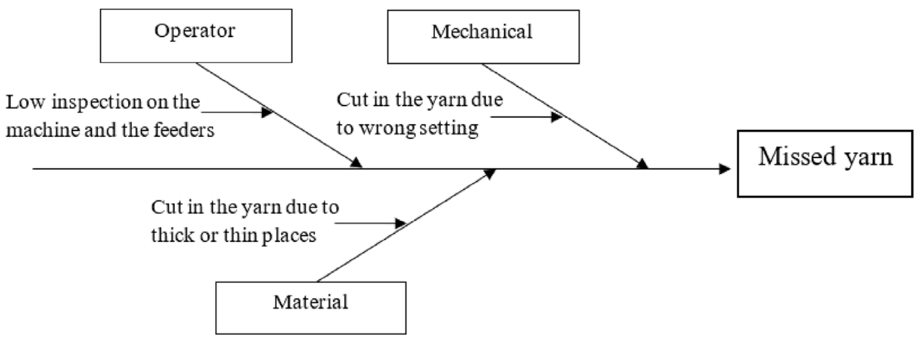

Fig. 25. Cause-and-effect diagram for missed yarns.

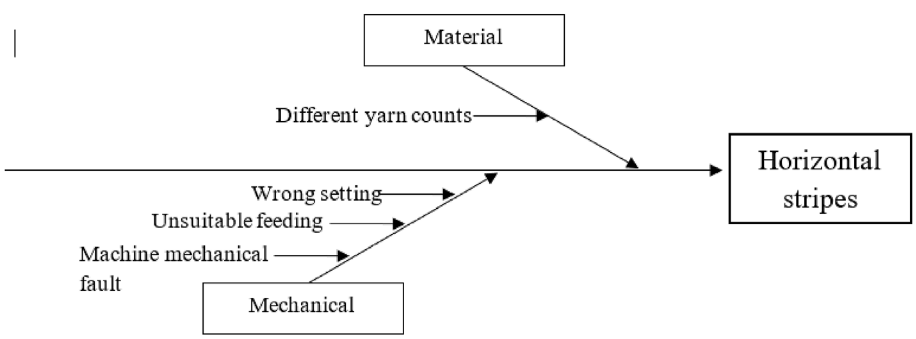

Fig. 26. Cause-and-effect diagram for horizontal stripes.

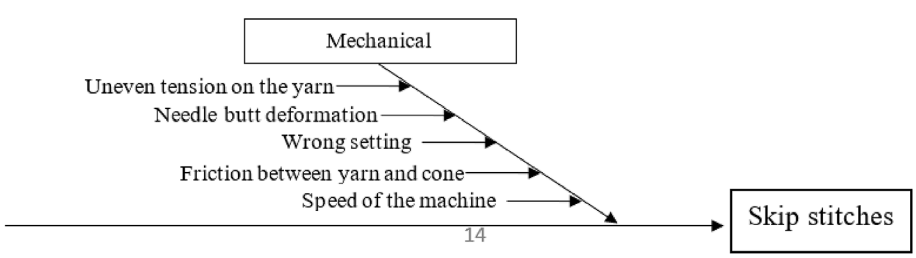

Fig. 27. Cause-and-effect diagram for skipped stitches.

defects are scattered across the fabric, the arrangement of pattern pieces might need alteration to avoid utilizing defect-laden sections. This can prompt modifications to the pattern layout, potentially necessitating increased fabric consumption. Conversely, minor yarn defects could still permit the utilization of corresponding fabric sections for less prominent pattern pieces or for pieces

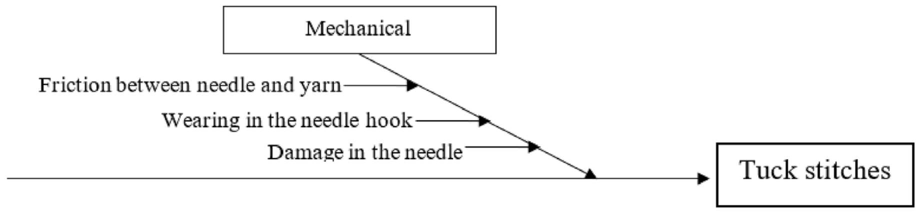

Fig. 28. Cause-and-effect diagram for tuck stitches.

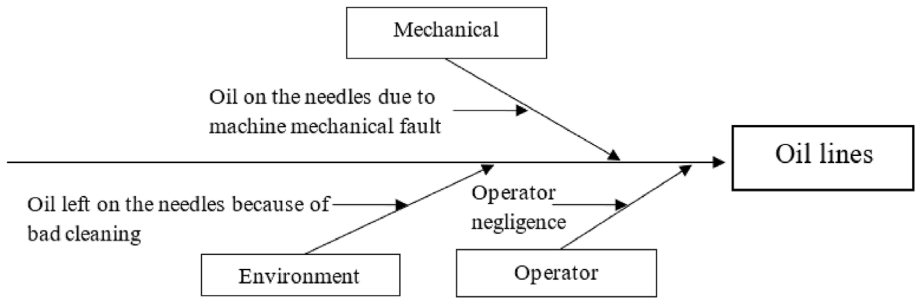

Fig. 29. Cause-and-effect diagram for oil lines.

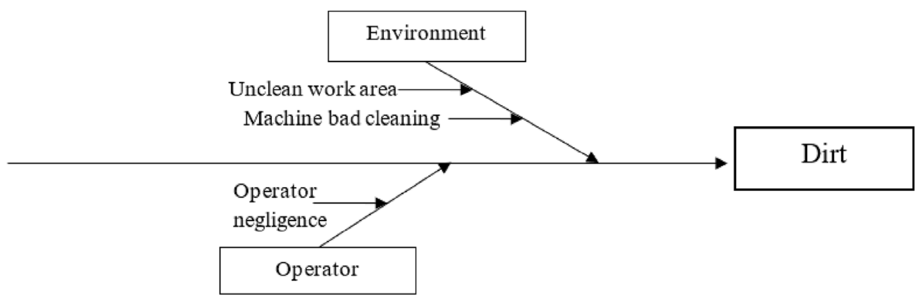

Fig. 30. Cause-and-effect diagram for dirt stains.

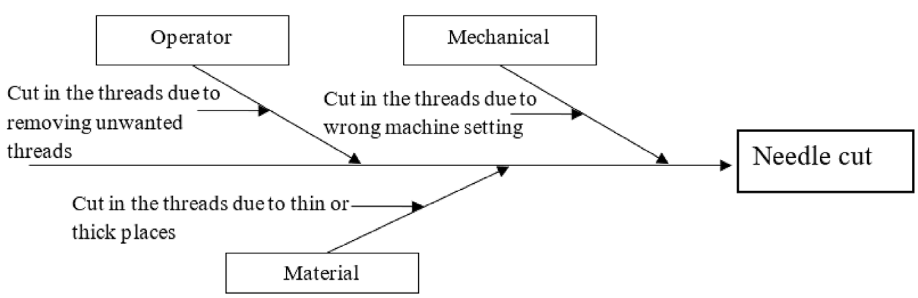

Fig. 31. Cause-and-effect diagram for needle cuts.

strategically placed to obscure the defect. In such scenarios, fundamental pattern layout adjustments might not be extensively required. The positioning of pattern pieces can be hindered by yarn defects present within the fabric. For instance, uneven thicknesses in the fabric might require modifications to prevent placing thin areas in crucial garment portions, such as the bust or waistline. Similarly, knots or slubs might prompt adjustments to avoid positioning these flaws in visible areas.

The probability of recurring yarn defects aligning in identical positions during pattern laying hinges on several variables. Factors include the frequency and regularity of defects, the dimensions and forms of pattern pieces, and the fabric's pattern layout. If periodic yarn defects emerge at consistent intervals

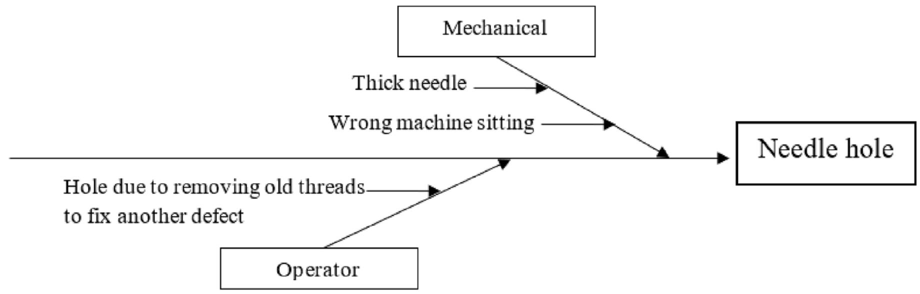

Fig. 32. Cause-and-effect diagram for needle holes.

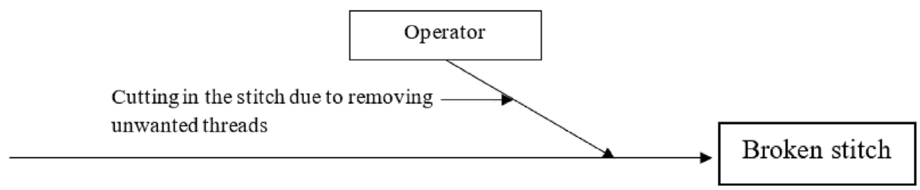

Fig. 33. Cause-and-effect diagram for broken stitches.

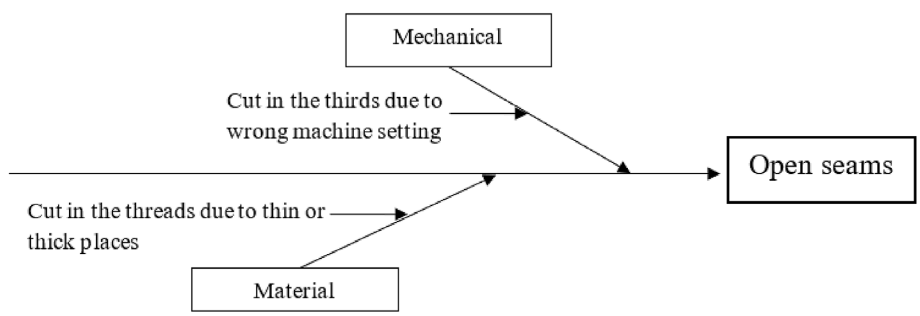

Fig. 34. Cause-and-effect diagram for open seams.

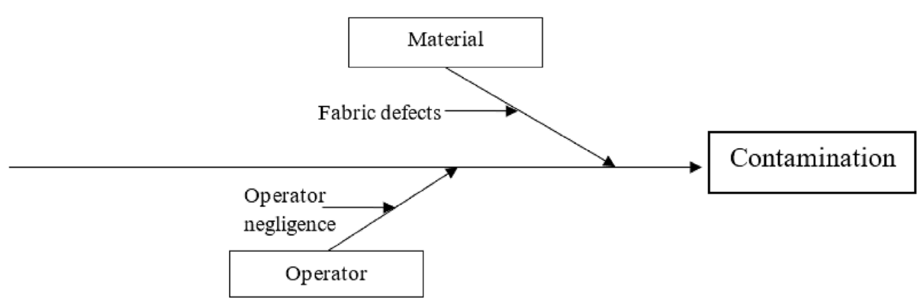

Fig. 35. Cause-and-effect diagram for contaminations.

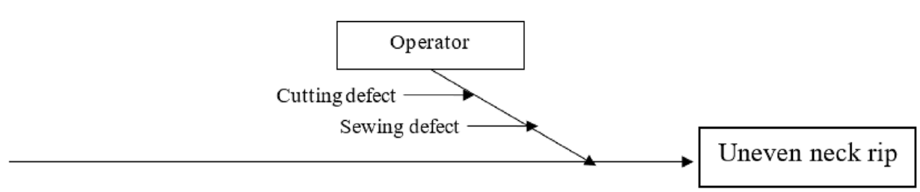

Fig. 36. Cause-and-effect diagram for uneven nick rip.

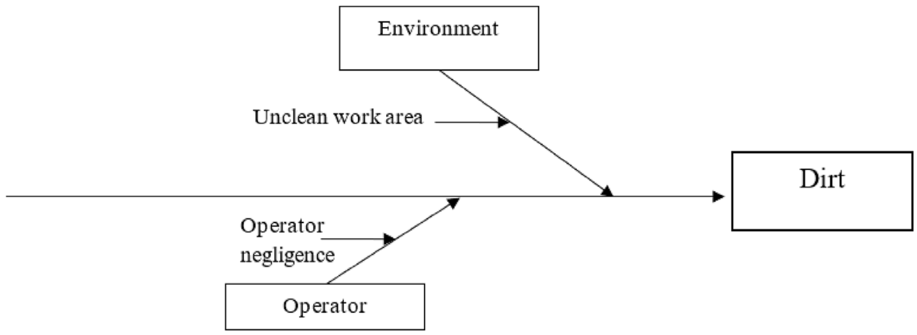

Fig. 37. Cause-and-effect diagram for dirt stains.

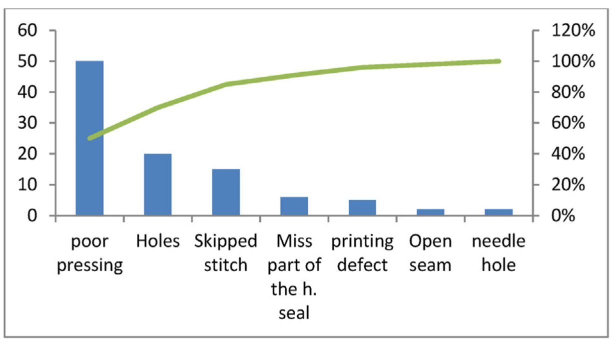

Fig. 38. Pareto chart after remedy of open seam causes.

and maintain uniform size and shape, the likelihood of their recurrence in the same pattern positions increases. On the contrary, irregular defect intervals or variations in size and shape render predictions concerning their appearance within the pattern layout more complicated. Furthermore, the dimensions and shapes of pattern pieces themselves influence the probability of defect recurrence. Compact, closely spaced pattern pieces enhance the probability of defects coinciding in the same position. Conversely, larger and more distantly placed pattern pieces lower the likelihood of such concurrence. Assessing the probability of yarn defects recurring in the same pattern positions during layout can be a complex task, demanding careful fabric inspection and contemplation of multifaceted variables.

Various statistical formulas are available to compute the probability of yarn defects manifesting at identical positions during pattern laying. The specific formula is dependent on factors like yarn type, pattern design, and manufacturing processes. Consulting statisticians or textile manufacturing experts is advisable to determine the suitable formula for distinct circumstances.

One applicable statistical formula for calculating the probability of yarn defects aligning in the same pattern positions is the PMF derived from the binomial distribution. Binomial distribution is commonly used to model the occurrences of success in a sample drawn with replacement from a population. It is suited for trials with two exclusive outcomes, often denoted as 'success' and 'failure.' These outcomes are appropriately labeled 'success' and 'failure.' The PMF is a function that gives the probability that a discrete random variable is exactly equal to some value (Stewart, 2011). The PMF of the binomial distribution is

$$f(x)=P[X=x]=(nx)px(1-p)n-x.$$

$$f\,(x)=P[\,X=x]=(nx)\;px\;(1-p)\;n-x.$$

The PMF offers the likelihood of varying numbers of defects emerging at specific pattern positions. An illustrative example showcases how the PMF can calculate the probability of two defects occurring at the same pattern position:

Consider a garment manufacturer employing fabric with a known defect rate of p% to produce a particular garment with 50 sections. To compute the probability of encountering two defects in the same section, the following steps should be performed:

(a) Calculate the probability of a defect arising in a single garment section using the PMF.
(b) Square this probability to obtain the likelihood of two defects occurring simultaneously.
(c) Multiply this probability by the number of sections in the garment (50) to derive the anticipated count of sections with dual defects.

For instance, if the probability of a defect in one section is 0.03, the probability of two defects in the same section becomes 0.0009, roughly 4.5% of sections exhibiting dual defects.

This calculation aids the manufacturer in estimating the anticipated defective sections within a batch of garments, enabling corrective actions to reduce fabric defect rates or enhance the manufacturing process for better final product quality. Figs. 39–41 depict the probabilities of encountering one, two, or three defects at identical positions, respectively.

The examination of yarn defects' impact on pattern layout underlines their significant role in the quest for high-quality garments devoid of visual imperfections. The strategic positioning of pattern pieces within the fabric, marked by the presence of defects, necessitates careful adjustments for optimal fit and aesthetic appeal. This study unravels the multidimensional complexities wherein yarn defects influence pattern layouts.

From rendering fabric sections unusable due to substantial defects to necessitating alterations in the arrangement of pattern pieces to circumvent defects, the study uncovers the complicated interaction between defects and design. Remarkably, minor defects can be tactically concealed, sparing the need for extensive pattern adjustments. The positioning of pattern pieces is a critical task influenced by the fabric's inherent defects. Uneven fabric thicknesses

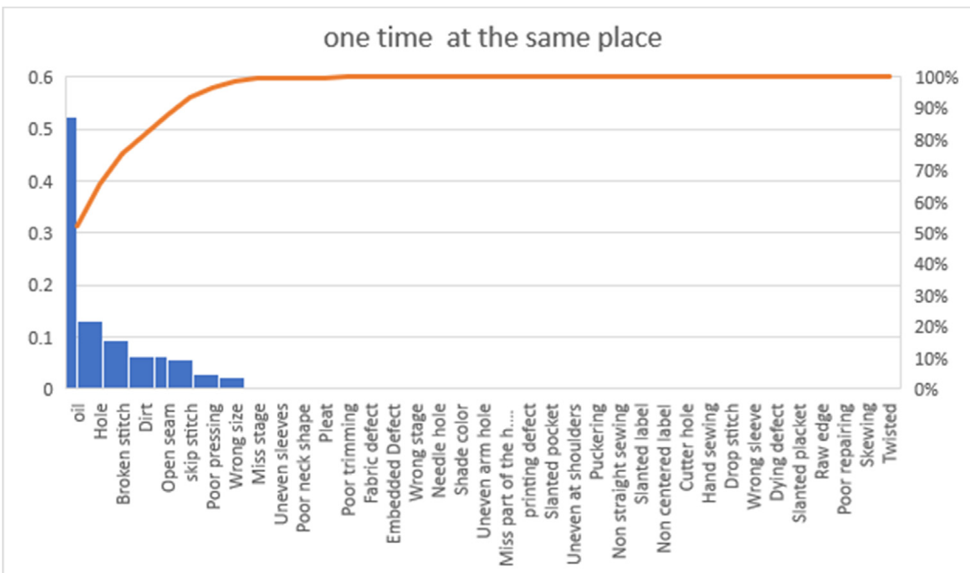

Fig. 39. Probability of encountering one defect in a specific position of garment.

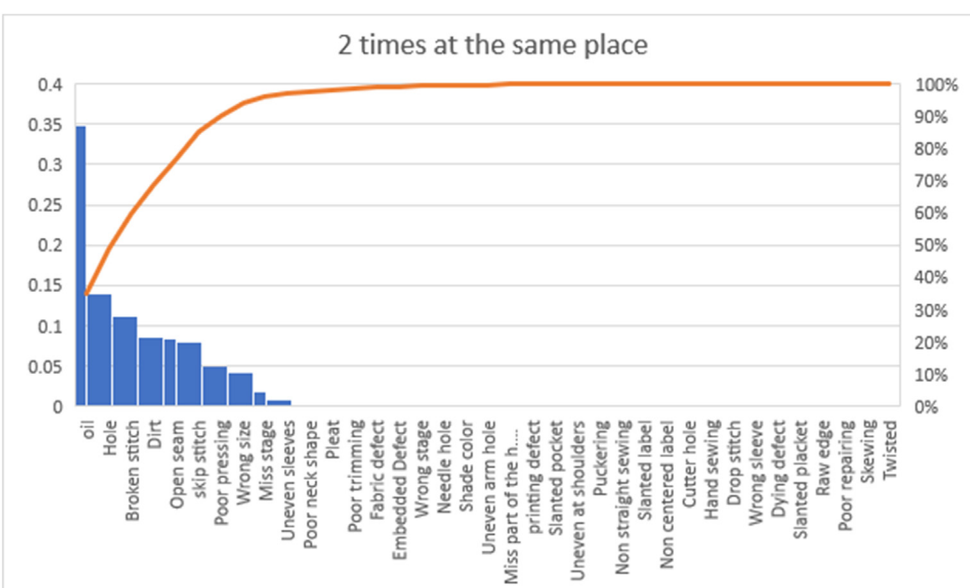

Fig. 40. Probability of encountering two defects in a specific position of garment.

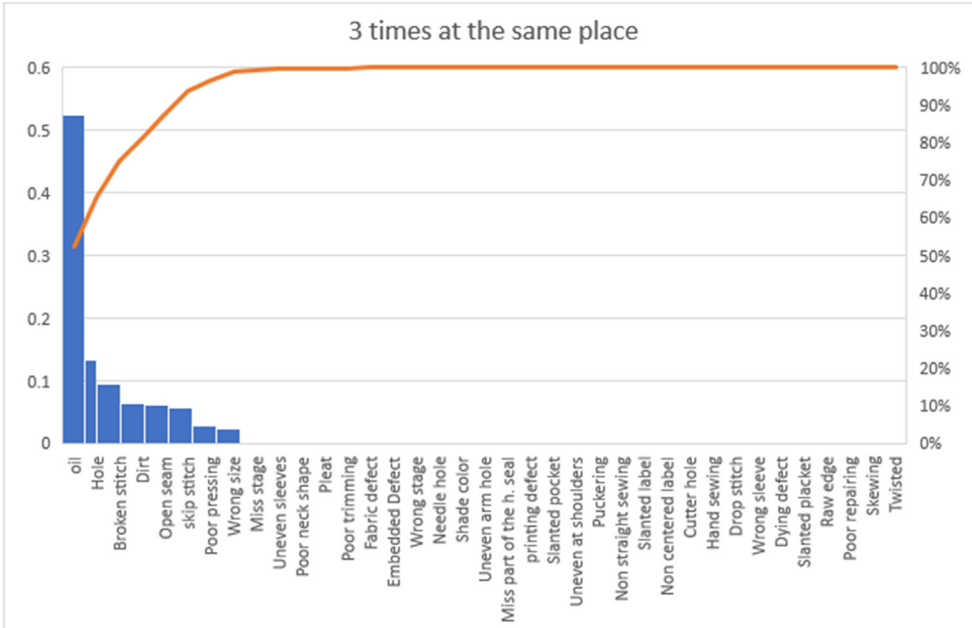

Fig. 41. Probability of encountering three defects in a specific position of garment.

and the presence of knots or slubs can necessitate modifications to ensure critical garment portions remain flaw-free.

The probability of recurring defects aligning with pattern layouts hinges on various factors, from defect frequency to pattern piece dimensions. The study reveals that systematic defect recurrence is influenced by regular intervals and uniform characteristics. Conversely, irregularities make predictions more intricate.

Statistical tools like the PMF derived from the binomial distribution prove invaluable in assessing defect probabilities. A practical example demonstrates its application in predicting defect occurrences, aiding manufacturers in estimating defective sections, and guiding quality enhancement efforts. Figs. 38–40 illuminate the probabilities of encountering defects at identical positions, encapsulating the insights gained from this research. By unraveling the intricate relationship between yarn defects and pattern layout, this study offers valuable guidance for producing garments of exceptional quality.

3.6. Conclusion

A comprehensive investigation was undertaken, encompassing diverse defect types present in one knitting mill and three garment mills. A novel classification system was devised, effectively categorizing all conceivable fabric and garment flaws into four distinct groups: operator-related errors, mechanical irregularities, stains, and miscellaneous defects. Through the application of Pareto charts, the most critical defects within each category were identified, paving the way for focused defect prevention efforts that have the potential to significantly heighten garment quality.

The research uses statistical process Ccontrol problem-solving tools, an approach whose widespread adoption is advocated across various garment mills. The routine utilization of these tools can pinpoint areas for enhancement and play a pivotal role in diminishing variations and eliminating defects.

The developed classification system holds promise for contemporary online prognostic systems, benefiting from its thorough categorization of potential defects. This enhancement is anticipated to optimize online models, contributing to more effective operations.

Furthermore, an algorithm using probability calculations is introduced for detecting multiple defects occurring in the same position. The PMF of the binomial distribution serves as the foundation for this algorithm.

Authors' contribution

MEM: study conception or design of the work. Data analysis and interpretation. Investigation. Methodology. Supervision. Drafting the article. Critical revision of the article. Final approval of the version to be published. AA-O: Study conception or design of the work. Investigation. Methodology.

Project administration. Supervision. Drafting the article. Critical revision of the article. Final approval of the version to be published. HM: Data collection. Investigation. SA: Data collection and tools. Data analysis and interpretation. Investigation. Methodology. Statistical analysis. Drafting the article. Critical revision of the article. Final approval of the version to be published.

Funding

No funding.

Conflict of interest

There are no conflicts of interest.

References

Anagnostopoulos, C., Vergados, D., Kayafas, E., Loumos, V., Stassinopoulos, G., 2001. A computer vision approach for textile quality control. J. Vis. Comput. Animat. 12, 31−44.

Anagnostopoulos, C., Anagnostopoulos, I., Vergados, D., Kouzas, G., Kayafas, E., Loumos, V., Stassinopoulos, G., 2002. High performance computing algorithms for textile quality control. Math. Comput. Simulat. 60, 389−400.

Ayres, R.U., 1987. Manufacturing and Human Labour as Information Processes. Research Report RR-87-9. International Institute for Applied Analysis (IIASA), Luxembourg, Austria.

Baykut, A., Ozdemir, S., Meylani, R., Ercil, A., Ertuzun, A., 1998. Comparative evaluation of texture analysis algorithms for defect inspection of textile products. Proceedings of the 14th International Conference on Pattern Recognition (ICPR) 2, 1738−1741.

Beyene, H.T., 2017. Minimization of defects in sewing section at garment and textile factories through DMAIC methodology of Six Sigma. In: 7th IEOM International Conference on Industrial Engineering and Operations Management in Rabat, Morocco, April 11-13.

Chan, C., Pang, G., 2000. Fabric defect detection by Fourier analysis. IEEE Trans. Ind. Appl. 36, 1267−1276.

Defects in garments (online). https://www.fibre2fashion.com/industry-article/3092/defects-in-garments. (Accessed 16 August 2023).

El-Hadidy, A.M., El-Sisy, W.S., 2023. Defects analysis in the apparel industry. J. Res. Field Specific Edu. 9, 1659−1685.

Faults of Knit Fabric Observed in Textile Industry. (online) https://garmentsmerchandising.com/faults-of-knit-fabric-produced-in-textile-industry/Accessed, August 16, 2023.

Goyal, A., 2018. Automation in Garment Manufacturing. The Textile Institute Book Series, pp. 75−107.

Juran, 2018. The Ultimate Guide to Cause and Effect Diagrams. https://www.juran.com/blog/the-ultimate-guide-to-cause-and-effect-diagrams/.

Kumar, A., 2008. Computer vision-based fabric defect detection: a survey. IEEE Trans. Ind. Electron. 55, 348−363.

Newman, T.S., Jain, A.K., 1995. A survey of automated visual inspection. Comput. Vis. Image Underst. 61, 231−262.

Nhat-ToHuynh, 2020. Online defect prognostic model for textile manufacturing. Resour. Conserv. Recycl. 161, 104910.

Nishimatsu, T., Toba, E., Sakai, T., 1995. Difference of eye-movements between experts and non-experts in fabric inspection. J. Text. Mach. Soc. Jpn. 41, 104−108.

Paladini, E.P., 2008. An expert system approach to quality control (2000). Expert Syst. Appl. 18, 133−151.

Sengottuvelan P, Wahi A, Shanmugam A. ‘Automatic Fault analysis of textile fabric using lmaging systems’. Res. J. Appl. Sci.; 3:26−31.

Shanbhag, P.M., Deshmukh, M.P., Shekhar, R., Suralkar, G.J., 2012. Overview: methods of automatic fabric defect detection. EDT 1, 42−46.

Stewart, W.J., 2011. Probability, Markov Chains, Queues, and Simulation: the Mathematical Basis of Performance Modeling. Princeton University Press, p. 105. ISBN 978-1-4008-3281-1.

Wilkinson, L., 2006. Revising the Pareto chart’ (PDF). Am. Statistician 60, 332−334.

Zhao, H., Lai, Z., 2019. Neighborhood preserving neural network for fault detection. Neural Network. 109, 6−18.