VOL. 19, NO. 12, JUNE 2024 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

USING THE POTENTIAL OF SIX SIGMA (DMAIC) AT SEWING SECTION OF A PAKISTAN BASED GARMENTS MANUFACTURING COMPANY

Ali Akbar, Imran Khan, Darya Khan, Shahnawaz Ali, Kaka Shuaib, Jansher Ansari and Rano Khan Wassan
Department of Industrial Engineering and Management, Dawood University of Engineering and Technology, Pakistan
E-Mail: ali.akbar@duet.edu.pk

ABSTRACT

This research paper focuses on addressing challenges prevalent in the garment industry, specifically emphasizing the importance of producing high-quality products efficiently. A key aspect of this study involves analyzing the sewing section to pinpoint and rectify rework issues, thereby optimizing time, reducing costs, and enhancing product excellence. Operational inefficiencies and wastage are key concerns that necessitate a thorough examination. Consequently, a comprehensive investigation was conducted within the sewing division of Artistic Milliners PVT, aiming to identify and eliminate defects. This initiative is critical for sustaining and advancing product standards while also bolstering overall quality and operational effectiveness.

Keywords: Six Sigma, DMAIC, quality management.

Manuscript Received 3 May 2024; Revised 17 July 2024; Published 5 September 2024

INTRODUCTION

It is traditional to have few rejected garments in the garment sector. Most of the manufacturers believe that garments are tender goods and have non-repairable defects and these might be due to improper materials, operations, and employee casual conduct [1]. Product defects usually lead to rejection, remodel, time-consuming, and customer dissatisfaction [2]. Multiple check points have to be generated to control this difficulty. There is no ready-made solution that can reduce the rejection percentage overnight because each order is unique. Because numerous possible types of defects may be located on garment products, one of the essential factors in making plans for first-rate improvement is to find out the pattern among defects [3]. The first concern for any producer should be to produce and deliver high-quality products at the proper time. On the way to remedy all of these issues and minimizing waste, lean tools are carried out in garment industries [2]. In this paper, we have applied several lean techniques like the Pareto chart, Ishikawa diagram, why-why analysis, and Six-sigma (DMAIC) to overcome these types of issues at Sewing section (unit AM_07) in the garment manufacturing industry named Artistic Milliners. Whereas, the top three defects i-e Uncut thread, broken stitch and skip stitch have been taken into consideration for this study.

LITERATURE REVIEW

In earlier days, the simple necessity of garments was to cover and protect the frame from climatic modifications. But, nowadays people have become more solicitous about the consolation of carrying and also the durability of the garment [4] as well nowadays organizations are increasingly becoming regardful for cost. In recent years, various practices of quality programs have been applied by several organizations to avoid any kind of internal or external failure that impacts customer satisfaction and quality as well as minimizes the cost of quality [5]. It is primarily judged from the extent of resources that have been utilized to breed the control over the operations to maintain the quality and its cost [6]. Process improvement is picked as one of the major strategies by organizations to improve the quality of products or services, optimize costs, achieve customer satisfaction, and reduce lead times. This integrated practice is carried out by applying problem-solving approaches like PDCA, TQM, DRIVE, and DMAIC as well as classic statistical analysis and quality improvement tools like Statistical process control (SPC), Brainstorming, process mapping, force field analysis, Pareto analysis, Root Causes Analysis, flow chart sand other quality tools [7]. Lean and Six Sigma have followed independent paths since the 1980s, The first applications of Lean were recorded in the Michigan plants of Ford in 1913, and those were then developed to mastery in Japan (within the Toyota Production System), while Six Sigma saw the light in the US (within the Motorola Research Centre) Lean is a process improvement methodology used to deliver products and services better, faster, and at a lower cost. Womack and Jones (1996) defined it as "a way to specify value"[8] while Six Sigma is an improvement approach to quality, based on statistical data, assists firms in reducing costs and wastages associated with poor quality levels by polishing up the production processes as well as boosts efficiency and effectiveness of Operations [5].

The negligence it will impact the profit while good management will produce motivated employees which can be a great achievement for an organization [6]. The reason that fifties lean production has been gaining a reputation in a wide variety of industries all over the globe, disseminating the concept of waste reduction as traditionally, profitability and performance objectives were the winning hobby for businesses. It also carried out the DMAIC methodology [9]. Six Sigma is an enterprise-standard and confirmed technique used for commercial enterprise system improvement and allows a company to acquire an advanced performance progressed profitability, and numerous specialized talent sets to streamline operations. Six Sigma is a statistical measure of version. The total Six Sigma equals 99. 9997% accuracy as [10] it is used to attain its miles a method cannot produce more than 3.4 defects per million opportunities [11]. Besides that, the terms lean Six Sigma, simulation, and optimization have accelerated during the last 6 years because corporations by no means stop the use of the center techniques that they have developed or applied to reducing extra prices. Those tools are awareness around head matter optimization, downtime discount, and in the end, an increase in production throughput that is commonly measured in units consistent with plant hour. Then groups extend their tools to include six-sigma which focuses on first-class quality yield indicators [12]. It had been located frequent applications of the DMAIC method in past years where each section is described because the defined section of DMAIC consists of identifying, prioritizing, and selecting the proper venture/project as well as clarifying the venture's scope and defining objectives. The measured degree of DMAIC is composed of setting up dependable metrics to assist in tracking key system characteristics, the scope of the parameters considered, and their overall performance to recognize their progress toward the targets. The analyze section includes comparing and identifying key reasons and system determinants While the improvement phase consists of featuring, checking out, and imposing alternative solutions to put off the foundation reasons of problems. Lastly, the control section entails setting the mechanisms for ongoing monitoring and institutionalizing improvements [13] and for documentation. Therefore, it does improve while work flow is made more predictable, for this reason enabling a higher match of to be had work load with capacity (hard work hours). These findings can help to discover the actual drivers of productiveness [14].

GARMENT SECTOR AND QUALITY

Quality assumes an essential component in sewing articles of clothing technology. Nowadays patron calls for unique satisfaction in each single actual piece of the articles of clothing object. It is seen as the level of recognition of goods or services [15]. Consistent with the Worldwide Agency for Standardization (*ISO*) - "high quality is the success of the required requirements for a product or service" [16]. As the extent of popularity of true or carrier advert, this fine depends on each segment of an industry [17]. Where User satisfaction is the ultimate object of garment quality as "the right Product of right Quality at the right Time & Undamaged Condition". Materials, Employees, Processes, and Customers are major factors for quality [16]. The sewing line contains several operations. Therefore, working capacity frequently varies from person to person. The first step for improving productivity and quality is to identify the factors affecting and by reducing these can easily achieve quality as well as the production in sewing line [4]. In our country, various garment factories follow various quality control and administration systems especially different view systems for garment inspection [18]. Quality Control is The systems required for programming and coordinating the efforts of the various groups in an organization to maintain the requisite quality or "The frameworks required for programming and planning the endeavors of the different gatherings in an association to keep up the imperative quality [16]. Process control where the process must be provided with the necessary accurate parameters Product control is The control that is used to decrease defective items within different lots of produced goods and this product control has been undertaken for this study [15]. The Acceptable Quality level fluctuates from procedure to process, item to item, and even purchaser to purchaser in garments Quality will not come automatically till, and if not it is systemized. To earn Quality in Garments everybody has to be Quality Conscious and. Some Quality should be limited by Formats, Some by numbers, some by aesthetic eye, some with general sense, and some with limitation [18]. Skilled workers are required for a high production rate. Accurate production methods and processes, proper training, and supervision are essential to achieve the optimum improvements in productivity and quality. Industrial Engineering is another factor in the garment industry to upgrade work nature, and work method [4].

PROBLEM STATEMENT

The increasing cost of carrying out business has been the highest concern for customers and businessmen around the country. The garment industries also lie on the same ground including Artistic Milliner, Ltd as they are troubled with multiple issues mainly of quality and cost related. The project team target Stitching Unit A.M 7 to tackle its arising issue of high defect rates. The issues arise as a result of Loss of capacity, Productivity declines, the quality of work has deteriorated and that is costly to rework and other related ones.

OBJECTIVES

To improve the quality of garments products, to know about the reasons for defects in the sewing section, to implement technical solutions, to know which faults can highly occur in garments, and to increase efficiency and productivity and reduce the DHU level.

RESEARCH METHOD

Define Phase

A defect is defined as anything outside the customer's specifications [11]. Stitching quality checks Quality is checked whether garment construction meets the buyer's requirements garment measurement, stitching quality, seam quality, trims, and labels are attached correctly [19]. Quality Staff in Sewing Department: Q.C general manager, Q.C Manager, Q.C Officer, Q.C. In Charge· Because of the error-prone nature of labor-intensive manufacturing processes, inspection of semi-finished products and finished products is critical in labor-intensive industries [3] Inspection is the function of judging the quality of product in terms of established

VOL. 19, NO. 12, JUNE 2024 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

standards. In garment productions, [17] Fabric Inspection, Garment Inspection, Input Materials Checking, End Line Inspection, In Line QC Check, and in Process Inspection all Inspection are important aspects followed to produce qualitative products [16]. Here, it is worked on in Process Inspection that is done in the front part, back part, and output/ assembling. A process inspection report is done during sewing in line. Mainly process inspection is done to find out the sewing fault during sewing in different parts. Sewing Defects could be Open stitch, Skipped, stitch Seam pucker · Broken stitch, Pleat, Thread breaks, missing stitch, Uneven stitches and points · Raw edges, etc. But the top three (Uncut thread, broken stitches & skip stitches) have been focused on for this research as these faults affect the DHU% level majorly. D.H.U. – It stands for Defect per Hundred Units. It means the number of defects found or detected per 100 garments. As a result End line inspection reports are noticed for monitoring the final DHU level.

Measure Phase

Pareto charts

Pareto analysis is performed to identify top defect positions where 80% of defects occur which should be the major concerning areas to minimize defects percentage [2]. The pared chart is a bar chart of frequencies sorted by frequency. The Pareto dot plot has been designed to address a particular applied problem in quality assurance [20]. Typically, a useful or ideal Pareto chart as shown in Figure-1 is one where about 20% of the attributes have an 80% weight in terms of relative frequency, thus revealing critical features. Despite its high potential value and many applications, the Pareto principle has been the subject of few research and academic studies [21].

Pareto Analysis From the above data, we have performed a Pareto analysis. Pareto analysis shows the top defect positions. Other is the most frequent defect with as much as 19% of the total. 2. Broken stitch is the second most frequent defect with 17% of the total. Also, skip stitch 12% [2],

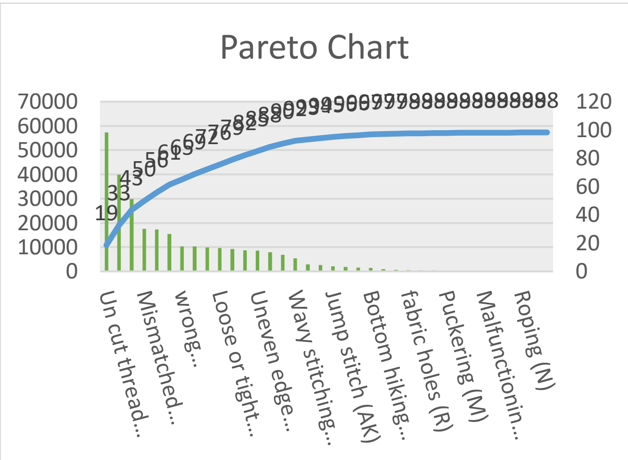

Figure-1. Pareto analysis.

Measure D. H. U

To measure the DHU of any process, one needs to record several total pieces checked and the number of total defects detected in the inspected garments. It is several defects, not the defective garments. One defective garment may have more than one defect. The Six Sigma concept facilitates to achievement of nearly 'zero defect manufacturing' and garners high profit. The Six Sigma concept permits organizations to make mistakes with less than 3.4 defects per million opportunities (DPMO) [22]. Table 1 represents the total defects per opportunity whereas, Figure-2 shows the category of the defects.

Table-1. Defects ratio.

Total Defects	Total Production	No: of Opportunities per Piece	Total Opportunities of Production
280832	622408	36	22406688

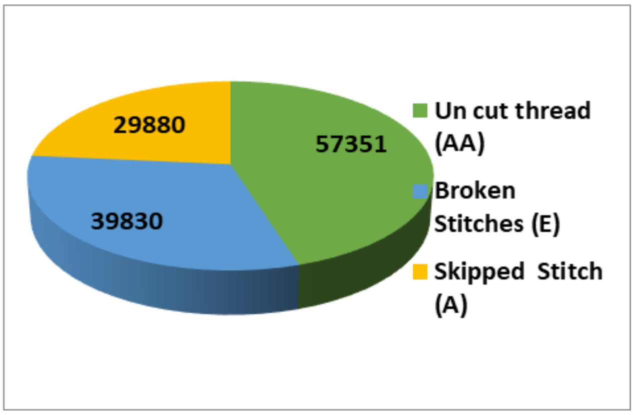

Figure-2. Defects category.

To Calculate the D.H.U Equation-1 has been utilized.

$$DHU = \frac{Total\ Defects}{Total\ Production} * 100 \qquad \text{Eq-1}$$

DHU = 45.1202%

Analyse Phase

Root cause analysis (RCA)

Identifying root causes is the key to preventing similar recurrences [23]. It can be conducted at several levels of depth and complexity. The simplest way to perform a root cause analysis is to ask why 5 times [24].In 2005, the Canadian Root Cause Analysis Framework described that root because evaluation is a crucial element of information and finding the source of defects. Cause-effect diagrams are constructed to show the root cause, and effect, and 5S & PDCA are used to minimize the defects effectively [2]. Fishbone analysis is useful in root cause analysis, which is increasingly being used in health services to improve safety and care quality. Usually, there are six categories, but the number can be changed depending on the problem as indicated in Figure-3. It has

VOL. 19, NO. 12, JUNE 2024 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

explained certain steps to carry out its method for root cause analysis [25].

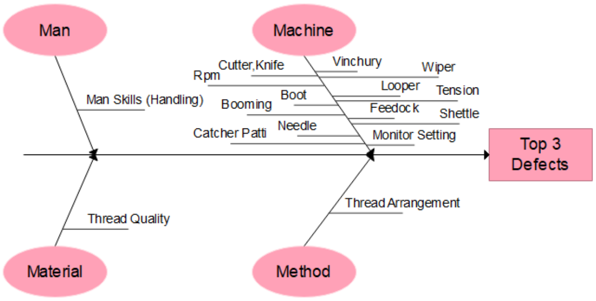

Figure-3. Fishbone analysis of different categories.

Uncut thread issues can be encountered due to missing items of machines like wipers, vinchuries, and others broken stitch creates increasing defects for the tendency of producing more, and garments become tampered while a Skip stitch can be caused by rough handling of materials. The major causes are responsible for man, machine materials, and methods. It is analyzed that, setting out the tension of the thread, Inspection of the needlepoint at regular intervals, checking for sharp or burred points, operator training, and appropriate maintenance might help achieve the objectives.

IMPROVE PHASE

Men and method

According to Coleman *et al*., [26] human capital relates to individuals'" abilities and knowledge that allow improvement in accomplishment and economic growth. These competencies include knowledge, skills, or behaviors that are critical for successful job performance. at a particular job and to void on-the-job errors and mistakes to achieve better results in terms of quantity, quality, time, and cost [27]. Menzel *et al*. [28] provide evidence of the positive effects of organizational learning- the sharing of knowledge among co-workers in firms. Therefore, effective training sessions have been carried out for employee performance. Direct supervisors who manage production lines have also been noted as a group that needs skills development. Local language and culture workbooks and exercises are used for operators' training sessions. Figure-4 to Figure-7 shows the raining awareness program information which deals with every type of machine individually as well right method to deal with threads, handling issues, and others while from a material perspective, it leads to inspecting the right needle quality, thread or other accessories are available according to the fabric quality.

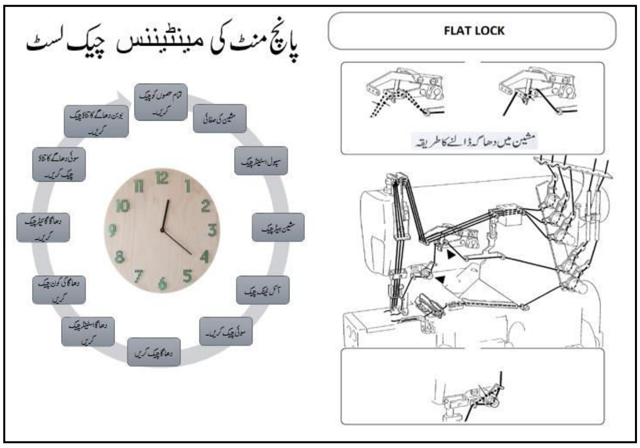

Figure-4. Checklist awareness for flat lock.

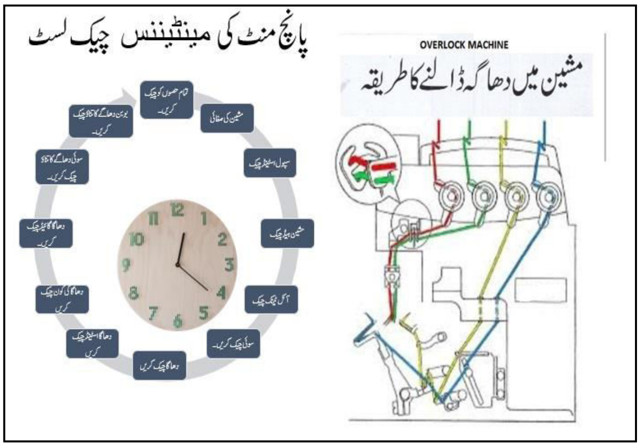

Figure-5. Checklist awareness for machine overlock.

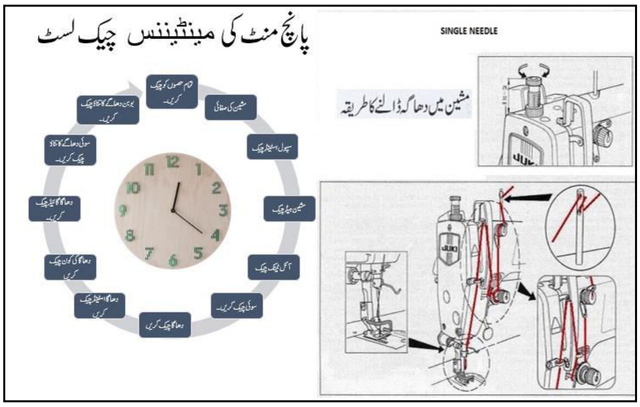

Figure-6. Checklist awareness for the single needle.

VOL. 19, NO. 12, JUNE 2024 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

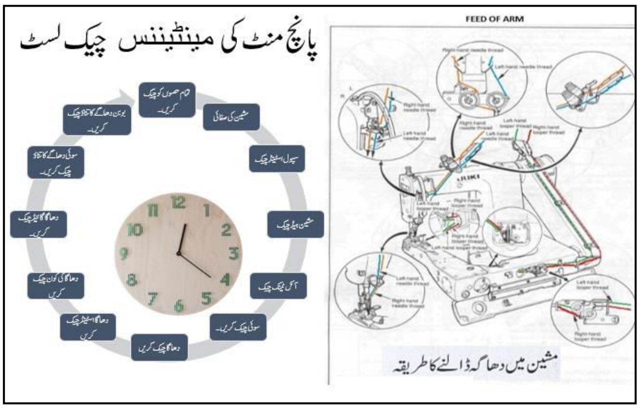

Figure-7. Checklist awareness for a feed of arm.

This training was conducted with 30 operators out of 55 approximately taking 10 operators from each section and those were responsible for performing critical operations as well as major defect-producing stations Table-2 shows the details list of operators and their performance for different sections.

Table-2. List of operators and their performance.

Front Section			
Name	**Att:**	**Performance**	**Rating**
Operator 1	Present	Coint pkt hem	9/10
Operator 2	Present	Coint pkt attached	8/10
Operator 3	Present	Facing Attach	8/10
Operator 4	Present	Front Pkt Top	9/10
Operator 5	Present	front Pkt Notches	7/10
Operator 6	Present	Fly Patti Attach	9/10
Operator 7	Present	J stitch	9/10
Operator 8	Present	Panel Attach	8/10
Operator 9	Present	Crotch	8/10
Operator 10	Present	Bartack	7/10
Back Section			
Operator 1	Present	Back Yoke	910
Operator 2	Present	Back Rise	8/10
Operator 3	Present	Back pkt marking	10/10
Operator 4	Present	Back Pkt attach	8/10
Operator 5	Present	back Pkt Guider	9/10
Operator 6	Present	Back Panel Overlock	8/10
Operator 7	Present	label attach	10/10
Operator 8	Present	Back pkt Bartack	9/10
Assembly Section			
Operator 1	Present	Inseam Safety	9/10
Operator 2	Present	SideSeam	9/10
		Safety/busted	
Operator 3	Present	Inseam Top Stitch	8/10
Operator 4	Present	Side Top Stitch	8/10
Operator 5	Present	Waist band attach	8/10
Operator 6	Present	Belt Point	9/10
Operator 7	Present	Bottom Hem	8/10
Operator 8	Present	Loops attach	9/10
Operator 9	Present	Label	10/10
Operator 10	Present	bartack	9/10

Material

Inspecting product conformance against the pre-set technical requirements and the fitness for full-scale production has been the prime task of pre-production. Thus, the reason for undergoing preproduction is ultimate aim is to ensure product quality and reliability. The collaboration is between the design and production teams to generate a preventive plan using mistake mistake-proofing technique to avoid non-conformances from escaping to the production lines [29]. The deformed regions that damage the appearance and performance of a fabric may be called ‘a fabric defect’. The defects encountered within production must be detected and corrected at the early stages of the production process. Most defects arising in the production process of a fabric are still detected by human inspection [30].

Machine

Machine Stoppage The term machine stoppage is used to refer to periods when a machine's working time is unavailable [31]. As the sewing machines are a critical production resource, the breakdowns are unpredictable so there are some reasons behind the sewing machine stoppage like needle breaks, delay input, electricity problems, mechanical problems, oil problems, etc [32]. The main reason for the failure rate is that there is no preventive maintenance carried out properly The purpose of preventive maintenance is directed to maximize availability and minimize the cost of an increase in reliability [33]. Corrective maintenance should take place after the breakdown encounter as quickly. Therefore, in the garment industry; preventive maintenance should be carried out in the interval of two months. We change the sewing machine settings like reset tensioner, synchronization in loop formation during stitching, and awareness in operators about the physical properties of fabric which help to reduce DHU%.

Upon completion of the implementations, two months of data were collected and analyzed to conclude the DHU% metric. The analysis revealed a significant reduction in occurring defects, approximately halving the initial level, as illustrated in Table-3.

Table-3. Defects ratio after reduction.

Total Defects	Total Production	No: of Opportunities per Piece	Total Opportunities of Production
148263	653734	36	23534424

$$DHU = \frac{Total\ Defects}{Total\ Production}*100 \quad \text{Eq-1}$$
DHU = 22.67%

CONTROL PHASE

During this phase, all work and standards have been documented and submitted to authorize individuals to facilitate ongoing progress. Specifically, this phase establishes and defines standards for key training sessions, corrective and preventive actions (CAPA) maintenance, rigorous supervision, and inspection methodologies that may contribute to achieving improved results.

CONCLUSIONS

Quality control during the stitching phase plays a crucial role in ensuring the production of high-quality garments. In-process inspections conducted on the front part, back component, and assembly data help identify faults during the sewing process. Maintaining good quality not only enhances the value of the product and builds a brand reputation for garment exporters but also contributes to higher profit margins and customer satisfaction. The research focuses on eliminating non-productive functions like reworks in garment industries, which saves time and costs by ensuring quality production, thereby significantly impacting the overall factory economy. Before implementing corrective actions, the overall Defects per Hundred Units (DHU) rate was 45%. After the corrective actions were taken, the DHU rate decreased to 4%.

REFERENCES

[1] Patil N., *et al*. 2017. Minimization of defects in the garment during stitching. 3(1): 24-29.

[2] Tahiduzzaman M., *et al*. 2018. Minimization of sewing defects in an apparel industry in Bangladesh with 5S & PDCA. 5(1): 17-24.

[3] Lee C., et al. 2013. A hybrid OLAP-association rule mining-based quality management system for extracting defect patterns in the garment industry. 40(7): 2435-2446.

[4] Rajput D., *et al.* 2018. Enhancing efficiency and productivity of the garment industry by using different techniques. 4(1): 5-8.

[5] Hung H.-C., M.-H. J. S. R. Sung and Essays. 2011. Applying Six Sigma to manufacturing processes in the food industry to reduce quality cost. 6(3): 580-591.

[6] Siyanbola T. T., G. M. J. I. J. O. M. Raji and S. S. Research. 2013. The impact of cost control on manufacturing industries profitability. 2(4): 1-7.

[7] Aichouni A. B. E., *et al*. 2021. Process improvement methodology selection in manufacturing: A literature review perspective. 8(3): 12-20.

[8] Laureani A., J. J. I. J. O. P. Antony and P. 2012. Management, Standards for Lean Six Sigma certification.

[9] Garza-Reyes J. A., *et al*. 2014. Lean and green synergies, differences, limitations, and the need for Six Sigma. In IFIP international conference on advances in production management systems. Springer.

[10] Krishnan B. R., K. A. J. I. J. O. B. Prasath. 2013. Management, and Research, Six Sigma concept, and DMAIC implementation. 3(2): 111-114.

[11] Smętkowska M., B. J. P.-S. Mrugalska and B. Sciences. 2018. Using Six Sigma DMAIC to improve the quality of the production process: a case study. 238: 590-596.

[12] Zugelder T. J. 2012. Lean Six Sigma literature: a review and agenda for future research. The Ohio State University.

[13] Garza-Reyes, J. A. J. I. J. O. L. S. S. 2015. Green lean and the need for Six Sigma.

[14] Liu, M. and G. Ballard. 2008. Improving labor productivity through production control. In Proceedings of the 11th Annual Conference of International Group for Lean Construction.

[15] Bepary B. C. and M. Islam. 2018. Study on Quality Assurance & Ways to Avoid Fault in Sewing Section. Daffodil International University.

[16] Hossain M. and M. Anam. 2018. Quality control in the sewing section of the Denim Garments Industry. Daffodil International University.

[17] Santo S. M., M. Tuhin and R. Ahmed. 2018. Study on Finishing Faults in Garments Industry. Daffodil International University.

[18] Islam M. 2019. Study on Quality Problem in Polo Shirt Production with Their Remedies.

[19] Lynch D. P., S. Bertolino and E. J. Q. P. Cloutier. 2003. How to scope DMAIC projects. 36(1): 37-41.

[20] Wilkinson L. J. T. A. S. 2006. Revising the Pareto chart. 60(4): 332-334.

[21] Grosfeld-Nir A., B. Ronen and N. J. I. J. O. P. R. Kozlovsky. 2007. The Pareto managerial principle: when does it apply? 45(10): 2317-2325.

[22] Srinivasan K., *et al*. 2016. Six Sigma through DMAIC phases: a literature review. 17(2): 236-257.

[23] Rooney J. J. and L. N. V. J. Q. P. Heuvel. 2004. Root cause analysis for beginners. 37(7): 45-56.

[24] Williams 2001. P. M. Techniques for root cause analysis. In Baylor University Medical Center Proceedings. Taylor & Francis.

[25] Phillips J. and L. J. N. T. Simmonds. 2013. Using fishbone analysis to investigate problems. 109(15): 18-20.

[26] Kamal M. A. J. J. O. S. E. R. 2019. Factors influencing human capital in the ready-made garments industry in Bangladesh. 6(1): 34-49.

[27] Mamy M. M. B., *et al*. 2020. The influence of training and development on employee performance: A study on garments sector, Dhaka Bangladesh. pp. 44-58.

[28] Hearle C. J. L. O. 2016. Skills, employment, and productivity in the garments and construction sectors in Bangladesh and elsewhere.

[29] Jamaludin R. and R. Young. 2005. The pre-production process: A pre-emptive improvement strategy. In Proceedings of the 3rd International Conference on Manufacturing Research (ICMR2005).

[30] Çelik H. I., *et al*. 2015. Real-time denim fabric inspection using image analysis.

[31] Topu M., *et al*. 2018. Study on machine stoppage time during garment production. Daffodil International University.

[32] Guduru R. R., *et al*. 2018. A dynamic optimization model for multi-objective maintenance of sewing machine. 118(20): 33-43.

[33] Pardiyono R. and R. Indrayani. 2020. Product Quality Control with Six Sigma and Preventive Maintenance. In Journal of Physics: Conference Series. IOP Publishing.