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# IMPROVING QUALITY AND EFFICIENCY: A SIX SIGMA APPROACH TO PROBLEM SOLVING IN THE SEWING UNIT OF A GARMENTS MANUFACTURER BASED IN PAKISTAN

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**ABSTRACT**

Garment sectors are a core component of Pakistan's industries. The escalating issues of productivity and quality, coupled with rising operational costs and time constraints, have had a significant adverse impact on garment manufacturing firms. Therefore, this research was conducted within a well-recognized garment industry in Karachi, Pakistan. The DMAIC approach of Six Sigma was chosen for this study to provide a structured framework for the identification, quantification, and elimination of sources of variation in operational procedures. Additionally, it focused on the optimization and improvement of operational variables, along with ensuring performance sustainability through the integration of multiple lean techniques. In conclusion, the results indicate a notable reduction in defect rates, enhanced cost-effectiveness, improved quality, reduced production time, and increased productivity following the implementation of problem-solving practices in the sewing (production) section. The study also highlights the evident relationship among the mentioned constraints.

**Keywords:** quality, garments, productivity, defects rate, profitability, six-sigma.

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## INTRODUCTION

The rapid substitution of economic constraints like variation in profit margins, global competition, product variety, reduced lead time, and demand for qualitative products had an exert influence on manufacturing firms. With the increasing demand for high quality at low cost, garment manufacturers need to sustain operational improvement through the production of products right at the first time and to reduce wastage [1]. Waste is non-value-added for each industry and increases product cost for manufacturers as time, cost, quality, and waste minimization have significant impacts on organizational economy. Therefore, the application of lean practices helps industries to minimize wastage with the fundamental objective of reduced cost and optimized utilization of resources [2]. The charges paid with the intent of procurement or purchase of anything are said as cost. A particular product or production quantity has a specified quota which is designed by industries to fulfill additional demand with operational procedures for the achievement of targeted outcomes with economic growth [3]. The operational interval dedicated to anything is said as time. In business, it is required duration to produce the product and named cycle or normal time of an item which has core worth for achievement of targets in given time as well as it is studied in several researches with comparison of cost [4]. Mark for Brilliance or distinction of something is called as quality while in organizational perspective it is defined as an attainment of predefined standards or given requirements along with the reduced defects rate. An explanation of aspects or characteristics such as proportions, construction, appearance, adaption, finish, color, and strength is claimed as quality by Spiegel [5]. It is a complex and core part of business strategy as it leads to customer satisfaction and profitability for the firm as well as stake part in the Nation’s economic progress [6].

## LITERATURE REVIEW

As the sense of flying communication has been developed in the field of clothing Fashion for customers and the duration of each fashion season becomes too short garment manufacturers have to reduce the lead times and bound them to strictly respond to product delivery in a given time frame besides that they would be shown a huge consequence on the next business opportunity [7]. Quality is something for which customers pay the value or price [8]., Lead times, cost, and quality can be worked in the right path with the help of operational modifications in industries [9]. Furthermore, a task that is performed by a skilled individual according to given standards in a particular duration is considered as the operational time of the task [5]. However, a certain duration is dedicated, "to attain the order may vary, depends on the actual activities which may be carried out to obtain order” is named as total time. in short, each task is specified with a fixed amount of time [10]. while Soeharto indicated the value of cost for the production floor [11]. The term quality control relates to the scientific variables (Man, Machine, Material & manufacturing conditions) by Beatty and Alford as these can impact the quality and operational goodness of the finished product. It works on cost, quality, and when, what, and how much to inspect. So, the measurement of the degree of perfection is Quality [12]. The strategic and operational levels can focus on targeting the quality as first related to the latest technology whereas the second one is the center of the firm as it works on the minimization of variances in procedure for achieving better results [13].

**Relationship among Production, Quality, Cost and Time**

With the help of production or quality techniques, various advantages can be observed such as proper utilization of resources, idle time, and attaining better quality with minimum cost which also help firms to take strong supervision on budget utilization and in the sense of formation of Financial statements [14]. The manufacturers might pursue a strategy that majorly focuses on the elements of cost, time, and quality [15]., quality assists firms to attain market competitiveness, higher production and customer satisfaction, and reduced cost. Scarification of cost is considered for achieving quality (products or services) so business firms work on both simultaneously as the cost may be reduced by developing appropriate standards [12]. Whereas Soeharto described the close interaction of time and cost and considered the quality termed as the Ironic Triangle as its Edges are indestructible, however these can lengthen or shrink. Their mutual dependency can impact the quality and cost as taking a high time duration for production leads to paying more cost and strict scheduling can cause a decrease in quality. In brief, trio constraints have a direct impact on one another [11]. Due to improper standards of the time, organizations have to survive with High Operating Costs [16]. It is postulated that cost could interact with the requirement of products with the right quantity and quantity, sales, and market as well [14].

In earlier concepts, garments were used for protection from circumstances of climate. Contrary, these days' individuals are more conscious about garments carrying consolation and durability [17]. Where corporations are paying more attention to cost. Therefore, industrial engineering is the center of firm structure with the fundamental object of cost Reduction and provides exclusive assistance to production departments, like as time study, methods improvement, and Job evaluation and to identify new opportunities for bettermen [18]. For removing any kind of additional expenditures (external or internal) that have an impact on product quality, cost, and customer pleasure, several quality-related practices have been focused in recent years [19]. Where process improvement approaches are considered one of the primary actions for quality of service or product, minimizing lead times and cost, and gaining special attention from customers. It is mentioned as an integrated approach by Wiklund, 2002 as the execution of the particular approach consists of multiple problem-solving practices like classic statistical analysis, DRIVE, TQM, PDCA, and DMAIC as well as quality advancement tool kit including Statistical process control (SPC), Brainstorming, Pareto analysis, Root Causes Analysis, force field analysis, process mapping, flow charts, and others cannot be neglected [20]. Whereas, the appropriate approach can be chosen as the Six Sigma “DMAIC” practice [21, 22]. Six Sigma is a confirmed and a business approach, applied for improvement and statistic variance measurement in industries. It assists corporations in the smooth-running of procedures with an accuracy rate of 99. 9997% [23]. as it does not allow the system to produce more than 3.4 defects per million opportunities [24]. DMAIC is a closed-loop exercise, which puts an end to non-value-added steps for continuous improvement by identifying new opportunities. The history determines the frequent application of DMAIC where each phase of it stands for a unique aim as the Define phase is numbered with steps of recognition, rating and the appropriate venture selection as well as describes its scope and objectives. The Measurement phase includes the steps of target development by examining the parameters' scope and tracking the major elements. The analyze grade is concerned with system determinants, comparison tasks, and reasons recognition. Furthermore, the improvement phase works to impose alternative solutions for putting an end to problems. In the end, the control phase aims to sustain the improvements by monitoring the system and documentation of facts. In the present climate, Manufacturing industries face machine issues regularly as high rates of breakdowns, repair tasks, and quality defects which have a huge impact on cost, delivery time, and quality [25, 26]. The significant improvements have been counted by applying TPM in plant performance as its successes indicated 50% reductions in corrective maintenance while enhancement in labor productivity, lost production reduced by 70%, capacity increased by 25-40%, and maintenance cost reduction up to 60%. Therefore, the primary strategy of maintenance is regarded as a competitive tool nowadays [27, 28]. Additionally, total productive maintenance (TPM) is a resource utilization approach that focuses on employees' involvement in maintenance activities to avoid any breakdowns, disruptions, failures, and stoppages for better performance the reason competitive manufacturing firms work on machine capacity and reliability for achieving desired manufacturing outcomes in sense of flexibility, cost reduction, on-time delivery, and high-quality products. It emphasis taking advantage of skills and the abilities of production workers by encouraging them to fix various small defects by attaining minor changes as machine accountability is essential for the success of the TPM program. Autonomous maintenance is one of the pillars of the TPM technique which specifically focuses on the maintenance activities carried out by employees' involvement which is responsible for meeting customer demands with standardized quality, price, and lead times [29, 30].

**PROBLEM STATEMENT**

As, the garment sectors are facing a large number of issues in production areas in the sense of production, quality, cost, and time. The issues raised by the rising number of defects occurring at the stitching section lead to high lead times, excessive operational costs, and low-quality products with low production rates. So, this is carried out in the garment of Pakistan to examine the actual.

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## RESEARCH OBJECTIVE

The research aims to find out the relationship among the major four constraints time, cost, quality, and production rate by minimizing the defects rate in the garment industry. Where the main focus of the study is to improve the quality of products for recognition of outcomes.

## METHODOLOGY

### Define Phase

Defects on the production floor are quoted as waste and it has an impact on time effort and cost. To reduce cost and time without compromising on quality, the study is carried out in the well-recognized garment sector of Pakistan where unit 07 the targeted and the stitching section is focused which is mainly taken as the production floor in garments. Garment manufacturing industries consist of a large number of operations so therefore number of variations and opportunities are also high that's the main reason to choose the concerned discipline. The stitching section consists of three major sections named front, back, and assembly and each section comprises multiple operations a flow chart of the floor can be seen in Figure-1.

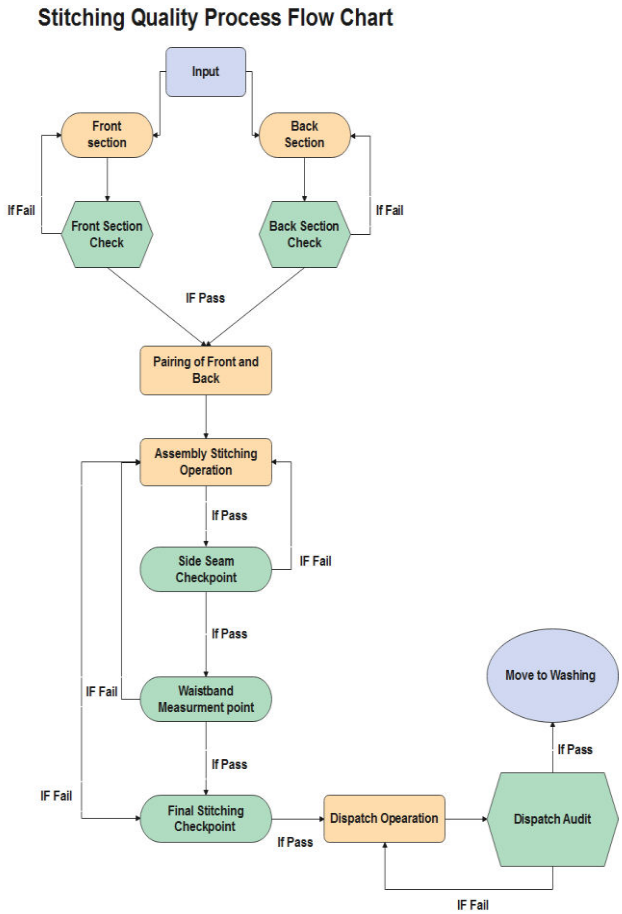


**Figure-1.** Flow chart for the correction of the roll forming process design.

Furthermore, Quality Check Sheets are taken into account to measure the initial and final results as it is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes [31]. 4Ms (Man, Machine, Material & method) are found to improve to achieve the objective where man and method are covered by training and development (TQM tool), machine issues are dealt with maintenance activities majorly Autonomous maintenance (TPM tool), the material is gone with inspection task as well as quality tools are applied for the attainment of the target so collectively the study is carried out by DMAIC approach of six-sigma. The defect rate data are gathered for the 3 months say November 2021, December 2021, and January 2022, and after the application of improvement techniques, the final results of May, June, and July 2022 were calculated in terms of quality, time, and cost to examine the relationship and attained outcomes.

### Measure Phase

The Pareto diagram is used to measure the frequency of the defects as it is a graphical representation of the process problems in descending order from left to right [31]. Here, in this study, the top six defects are focused which are ranked as Uncut thread, broken stitch, drop stitch, skipped stitches, mismatched parts or unbalanced parts, and raw edges with defect rates of 123248, 59370, 42323, 38977, 38602, and 34692 respectively. Besides that, earlier measurements of DHU 55.01% of DHU, 3.6736 of sigma level, 3950103.5 *sec*or 65835.6583 minutes or 1097.25 hours and 320016.5 PKR applied amount of cost were measured as follows for the total production of 953008 pieces as shown in Figure-2 and Table-1.

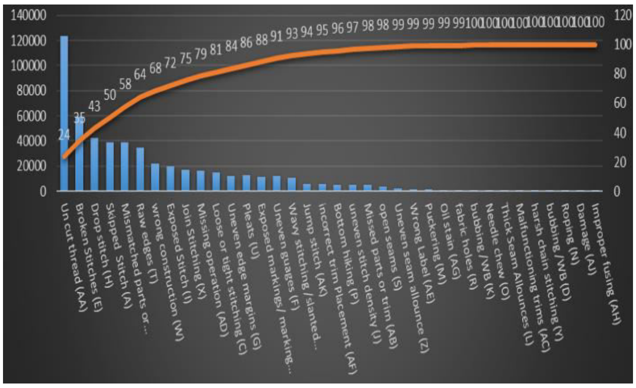


**Figure-2.** Pareto chart before implementation.

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**Table-1.** Measure the DHU and sigma level.

| Total Defects 524250 | Total Production 953008 |
|---|---|
| Total Opportunities of Production 35261296 | No: of Opportunities/Piece 37 |
| DHU=(Total Defetc)/ (Total Production)*10 | DHU=55.01% |
| DPO=(Total Defects)/(Total Production) *No:of Opportunities/_Piece ) | DPO=0.01487 |
| DPMO= DPO*1000000 | DPMO=14867.6 |
| Sigmalevel=Normsinv((Total Defects)/(Total Opportunities of Production))+1.5 | Sigma Level= 3.6736 |

$\boldsymbol{Overall\ Total\ Cost}$ = 320016.5
$\boldsymbol{Overall\ Total\ Time}$ = 3950103.5 $sec$ or 65835.6583 minutes or 1097.25 hours

**Analysis Phase**

The Fishbone Diagram as depicted in Figure-3 is a framework used to identify potential root causes leading to poor quality. It is a demonstration of the RCA (Route Cause Analysis) approach. In this study, it was analyzed that the excessive defect rate was caused due to technical problems besides that the major reason was improper. Supervision, defective fabrics as well as workers were not much acknowledged about quality. Therefore, autonomous maintenance, training, and proper supervision schedule were major focuses for this study.

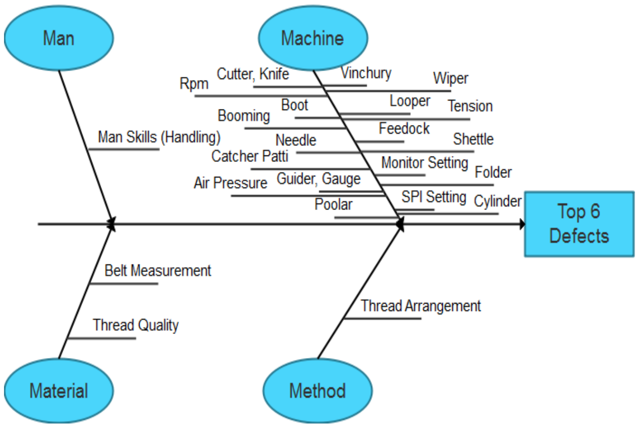


**Figure-3.** Pareto chart of top 6 defects.

**Improve Phase**

**Man and Method**

The operators of the production floor are majorly targeted for Training and Development sessions as they are responsible for various operations. These are trained in such a manner that they can recognize the variations in quality and try to minimize them. The training was conducted by the application of Microsoft Office in terms of Presentation which consisted of the text in the local language (Urdu) and graphical representation to make the perceptions more clear. Before the training, it was examined how much operators knew how to generate accurate, interesting, and inform able data. That, the handling issue and the right way to fix the problems were taught to operators. The following Table-2 is demonstrating the operators' performance rating results before and after. Here are a few critical operational stations and more producing operators are considered to rate. The TPM training concept is used to develop on the production floor.

**Table-2.** Measure the DHU and sigma level.

| Front Section | | | | |
|---|---|---|---|---|
| **Op. Name** | **Attend:** | **Perfor:** | **Before Rating** | **After Rating** |
| Uzma | Present | Coin Pocket hem | 6/10 | 9/10 |
| Shugufta | Present | Coin Pocket attached | 5/10 | 9/10 |
| Shaista | Present | Coin Pocket Guider | 510 | 9/10 |
| Javed | Present | Facing Attach | 7/10 | 10/10 |
| Kanwal | Present | Front Pocket Top | 7/10 | 9/10 |
| Tahir | Present | front Pocket Notches | 5/10 | 9/10 |
| Shazia | Present | Fly Attach on Panel | 8/10 | 10/10 |
| Rehan | Present | J stitch | 7/10 | 9/10 |
| Humza | Present | Panel Attach | 7/10 | 9/10 |
| A. Razak | Present | Crotch | 6/10 | 9/10 |
| Nouman | Present | 7 Stitch | 6/10 | 9/10 |
| Naseem | Present | Label Attach | 8/10 | 10/10 |
| Rehan | Present | Panel Overlock | 7/10 | 9/10 |
| Fazal | Present | Bartack | 7/10 | 9/10 |
| **Back Section** | | | | |
| Ubaid | Present | Back Yoke | 7/10 | 9/10 |
| Shafique | Present | Back Rise | 7/10 | 10/10 |
| Ameera | Present | Back Pocket Marking | 8/10 | 10/10 |
| Sidra | Present | Back Pocket Heming | 8/10 | 10/10 |
| Amir | Present | Back Pocket Press | 9/10 | 10/10 |
| Arsalan | Present | Back Pocket Attach | 6/10 | 9/10 |
| Nadeem | Present | back Pocket Guider | 6/10 | 9/10 |
| Aziz | Present | Back Panel Overlock | 7/10 | 9/10 |
| Azeem | Present | Label Attach | 8/10 | 10/10 |
| Asghar | Present | Back Pocket Bartack | 7/10 | 9/10 |
| **Assembly Section** | | | | |
| M. Awais | Present | Front and Back Pairing | 7/10 | 10/10 |
| Hassan | Present | Kaj on Belt Point | 8/10 | 10/10 |
| Sharif | Present | Inseam Safety | 7/10 | 9/10 |
| Rabia | Present | Side Seam Safety | 7/10 | 9/10 |
| Shubat Khan | Present | Inseam Top Stitch | 8/10 | 10/10 |
| Farhan | Present | Side Top Stitch | 7/10 | 9/10 |
| Nadir Ali | present | Gather | 8/10 | 10/10 |
| Kanwal | Present | Waist Band Paring | 8/10 | 10/10 |
| Zakir | Present | Waist band Attach | 6/10 | 9/10 |
| Alam | Present | Belt Point | 7/10 | 9/10 |
| Faisal | Present | Bottom Heming | 6/10 | 9/10 |
| Imran | Present | Loop Attach | 7/10 | 10/10 |
| Naseem | Present | Label | 8/10 | 10/10 |
| Rasheeda | Present | Bartack | 6/10 | 9/10 |

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**Machine**

In general, Maintenance is taken as a support system because it is a non-productive act as it can never make organizations generate cash directly but helps them to make more profit [32]. Autonomous maintenance is maintenance kind in which machines' general maintenance is done by workers regularly like Lubricating and cleaning etc. This leads to saving time for skilled to wait for maintenance individuals and enhances the production rate. The major difficulty is people resist accepting the change for implementation of this technique[30]. Here, we have made it possible and continued it regularly during the project duration besides that we also focused on the planned or predictive maintenance and quality maintenance where ever we found it essential as the first one relates to proactive activities of maintenance. It includes these four maintenance Corrective maintenance, preventive maintenance, scheduled inspection of the process output, and maintenance in response to output-quality signals. while the second one works with superior quality and customer satisfaction by producing defects-free products in the first attain [27, 31]. Figure-4 shows a few demonstrations of this maintenance training session has been shown which are generated in local languages and visual Images to make the concept easy to receive.

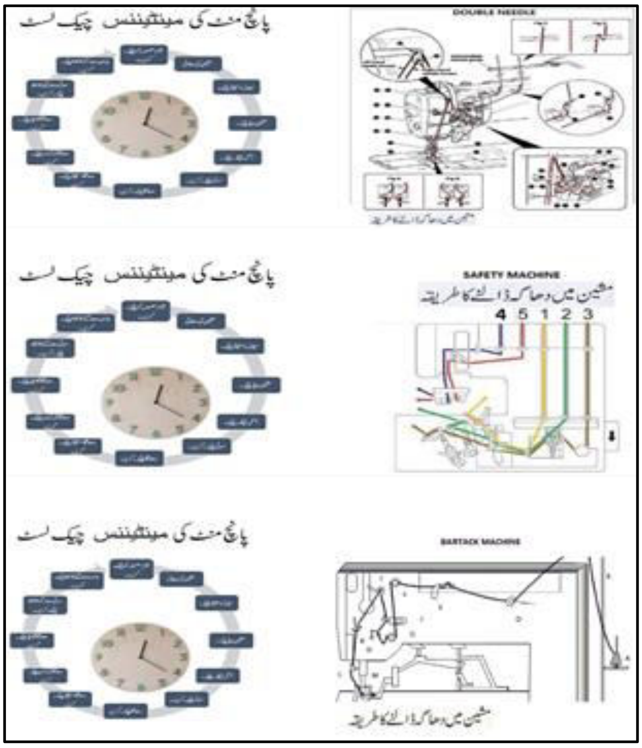


**Figure-4.** Visuals of autonomous maintenance.

## RESULT AND IMPLEMENTATION

The following Pareto chart as demonstrated in Figure-5 and Table-4 a significant reduction in the frequency of defects occurring. As ranked as Uncut thread, broken stitch, drop stitch, skipped stitches, mismatched parts or unbalanced parts, and raw edges with reduced defect rates of 30652, 20231, 15698, 13157, 11874, and 8407 respectively.


**Figure-5.** Pareto chart after implementation.

**Table-3.** Measure the DHU and sigma level.

| Total Defects 211269 | Total Production 973017 |
|---|---|
| Total Opportunities of Production 36001296 | No: of Opportunities/Piece 37 |
| DHU=(Total Defetc)/ (Total Production)*10 | DHU= 21.713% |
| DPO=(Total Defects)/(Total Production) *No:of Opportunities/_Piece ) | DPO= 0.00587 |
| DPMO= DPO*1000000 | DPMO= 5868.37 |
| Sigmalevel=Normsinv((Total Defects)/(Total Opportunities of Production))+1.5 | Sigma Level= 4.01996 |

***Overall Total Cost*** = 86552.08
***Overall Total Time*** = 1312742*sec* or 21879.033 minutes or 364.65hours

Whereas, enhanced sigma level to 4.01996 and enhanced production rate with the value of 973008 were observed with the reduction of time and cost as 1312742*sec* or 21879.033minutes or364.65hours and 86552.08 PKR. Quality is improved from 45% to 79% as shown in Figure-6.

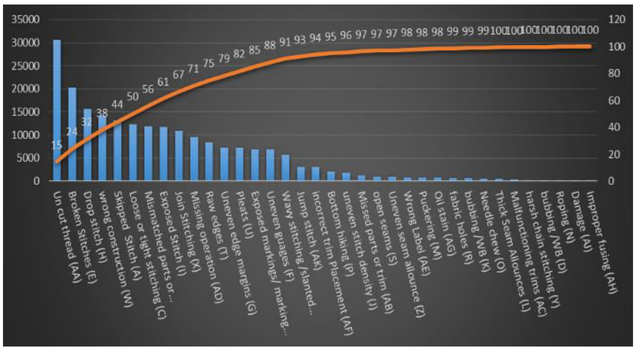


**Figure-6.** Compression of results of before and after.

**Material**

In this phase, we strengthen the inspection team to inspect the fabric quality and provide the right number

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of threads to the production floor according to requirements and guide individuals who work on belt measurement to check the right number of belts for the right piece to avoid any material-related issues.

**Control Phase**

In this phase, we generally sustain the development and submit the documented formats to authorized bodies to sustain this progress after getting evidence of better results. Furthermore, it has been suggested to follow the schedules of maintenance and keep a good system of supervision on the production floor.

## CONCLUSIONS

The results evident that quality has a strong relationship with time, cost, and production rate. With the help of DMAIC practice along with various techniques like, the Pareto chart, fishbone, training and education, autonomous maintenance, and proper inspection and supervision, enormous results have been observed in this study. It shows the minimization of the top six defects as Uncut thread, broken stitch, drop stitch, skipped stitches, mismatched parts or unbalanced parts, and raw edge. Besides that, earlier measurements of DHU reduced from 55.01% to 21.713% as the total defects occurring rate minimized from 524250 to 211269 with an improved sigma level of 4.01996 from 3.6736. In addition, 65835.6583minutes of time were reduced to 21879.033minutes and applied operational cost as from 320016.5 PKR to 86552.08 PKR whereas earlier total production was 953008 pieces for three months and after that, it enhanced to973008 along with improvement of quality percentage of 79% from 45% previous. The study has achieved its objective and proved the correlation of the constraints.

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