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Single Minute Exchange Die (SMED): A sustainable and well-timed approach for Bangladeshi garments industry

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A R T I C L E I N F O

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A B S T R A C T

Bangladesh is the second largest Ready-Made Garments (RMG) exporting country after China. The cost of cotton and other raw materials, labor cost, and subsidiary cost increased much in post COVID-19 with the comparison of pre-Covid-19 times, but from the prospect of buyer's price is not increasing that much. In this context, our study focused on the RMG's very first time extensive Quick Changeover (QCO) process to minimize cost reduction as well as wastage and time using Single Minute Exchange Die (SMED). Initially, concentrated on the learning period to make acknowledge the changing phase of one style to another. At the same time, tried to figure out the overall weekly performance before and after implementing QCO on the floors, efficiency, before and after implementing QCO hit rate and time consumption, and wastages. According to the case study, floor one had the best average weekly performance, action achieved percentage, and efficiency performance of 57%, 48%, and 46%, respectively, among the five, analyzed floors. From the investigated five floors, the third one had the lowest weekly performance, percentage of actions completed, and efficiency, at 52%, 40%, and 34%, respectively. In the case of hit styles, floor two and floor five both achieved 83% after QCO apply in the floors. During the QCO, the highest production loss on floor one was the alarming sign which was 21,940 pieces and on floor three loss production was the lowest 2605 pieces after QCO implementation.

1. Introduction

People are compelled to seek a high standard of living and improve services, especially as the global population rises, by the enduring commitment to new technologies and the rapid growth of technology supported by this commitment. Therefore, organizations must be able to adapt, differentiate, and thrive in a competitive and saturated market (Silva et al., 2020). When the product to be produced changes, one of the most crucial aspects of the industry is the setup change, as these are activities that do not add value to the product but are necessary for its products due to the need for equipment adjustments, tool changes, and raw material preparation for the new product (Islam, M.R. et al., 2022b). Bangladesh is the second largest exporter of ready-made garments in the world. However, in terms of productivity, its performance falls short of expectations. A lot of research has been done on how to improve the efficiency of our ready-made garment industry by using things like line balance, time study, lean manufacturing systems, etc. (Md. Monirul and Adnan, 2016).

Cycle time reduction, lower manufacturing costs, and less inventory are the fundamental needs that each manufacturing company must meet to realize its potential as a world-class organization (Sk et al., 2022). To maintain a competitive edge in today's increasingly digitized and fast-paced world, it is essential to have a production method that is both lean and agile. The elimination of monotonous, low-valued operations in the manufacturing cycle is at the core of the lean manufacturing philosophy, which places value creation at the forefront (Ahmed et al., 2022). During all stages of development, agile manufacturing encourages process improvements such as optimization, standardization, and

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automation (Hemalatha et al., 2021). In today's world, the manufacturing business is becoming more industrialized and competitive. Customers place a high level of importance on the quality of the product, as well as its cost, its variety, and the punctuality with which they receive it (Islam, M.D. et al., 2022a). As a result, for businesses to better satisfy, they need to locate solutions that will make their processes more adaptable and efficient. Getting rid of waste so that it can spend as much time as possible on activities that add value often lead to less time that equipment needs to be out of service in modern manufacturing environments (Mia et al., 2021). In addition, enterprises must optimize their equipment setup processes to generate various essential references as a result of product diversification and lower orders (Wan et al., 2022). The goal of reducing machine downtime by speeding up setups are achieved by reducing non-value-adding procedures at the same time. One way to achieve the reduction of setup changeover time is through Single Minute Exchange of Die (SMED) (Godina et al., 2018).

Reaching global markets is a huge problem for developing countries like Bangladesh. As a small business owner, you must be aware of what it takes to compete globally. New ways of making things, like lean manufacturing, must be used to get the most money out of limited time, increase productivity, and cut down on waste (Garcia-Garcia et al., 2022). To remain in today's competitive marketplace, producers must meet customer demand in a shorter period with the finest quality and lowest cost (Adeel et al., 2022). This can be done by reducing production costs by removing waste operations in a manufacturing system. Machine adjustment processes are activities that do not create value and SMED, a lean manufacturing tool, has been developed to reduce these activities (Zhang et al., 2019). SMED technology has been conducted in various industries to minimize costs by eliminating waste in an organization. Sahin et al. reported on reducing the machine setup time on the turning line using the SMED in a bearing manufacturing company (ŞAHİN and Aycan, 2021). Sousa et al. describe a technique for reducing the changeover time by applying SMED methodology in cork stoppers production (Sousa et al., 2018). Kordoghli et al. documented the Influence of Waste on changeover time in the Tunisian garment industry (Kordoghli and Moussa, 2013). Monteiro et al. demonstrated the utilizing SMED lean tool to effect positive change in the metalworking industry's machining process (Monteiro et al., 2019). Vieira et al. presented a study to propose a project that aims to use the SMED approach in the cold profiling process, using a population of five distinct profiling equipment (Vieira et al., 2019). Umap et al. (2016) depicted the SMED technique that was applied to a company that manufactures auto accessory products, specifically shock absorbers, the primary aim was to cut down on waste, more specifically, time wasted. Few studies have looked into training about lean tools, but none have been implemented in the workplace during setup. Additionally, very few studies have tracked the activities of manufactured parts during setup throughout the day. Recently a study following the SMED setup through the standardized work (SW) is advised during production and enquire of the setup time target has been obtained. Additionally, the setup time must be documented, and the overall equipment efficiency (OEE) must be calculated and compared to the target (Junior et al., 2022). Another recent study concentrated details on how to apply lean instruments and principles to the Industry 4.0 context as well as two Lean tools/methods are used to highlight the difference between a pure digital translation of a Lean tool (Visual Management Boards) and a hypothetical "new" Lean method (SMED) enabled by its digitization. The analysis in this study demonstrates it is feasible to enhance and automate established Lean tools and processes, boosting their efficiency and effectiveness, and giving some of them additional features and scope, creating not only an improvement but a transformation (Peças et al., 2022).

From the above literature, it is evident that there has been no attempt to conduct a study on the Bangladeshi garment industry to develop a method that is both sustainable and efficient through the utilization of SMED. In response, the SMED framework that has been proposed urges a reduction in setup time, training of the work team in fundamental concepts, and the development of an atmosphere of involvement, commitment, and motivation. Therefore, this study provided suggestions for eliminating waste and making their processes more effective and leaner. In this way, our research contribution displays and emphasizes these unique distinctions to improve productivity and efficiency from other studies. It is time for the Bangladeshi apparel industry to completely embrace the lean concept and pursue continuous improvement.

2. Experimental details

2.1. Materials and machinery

This whole study was done in a reputed garments industry in Bangladesh. It produces garments for various renowned fashion retailers such as H&M, Zara, Walmart, C&A, VF Asia, Next, Target, S. Oliver, etc. All their buyers are large enterprises, and they have many distributing showrooms in Asia, Europe, and America. In this industry, our study took place on 5 different production floors to enhance productivity and performance. On every production floor, there are several production lines. Each line produces different garments. It mostly varies as per the required production for each buyer before the shipment deadline. In every garment amount of operation may vary as per the requirement of the garments and buyers. It also may vary from season to season, size to size. There are several sections in the garments. Each section contains many operators, helpers, ironmen, quality inspectors, quality controllers, production officers, industrial engineers, etc. It may vary from section to section or department to department of the production floors. These sections are the storehouse, cutting, pre-assembly section, front section, back section, main assembly section, setting linings, and finishing. Several types of machinery are used in the sewing section mentioned in Table 1.

2.2. Methodology

Throughout the overall SMED study, we observed layout change through external and internal management, machine availability, critical machine presence, quick change over (QCO) activities and checklist preparation, standardized man, machine, efficiency set up, feeding time analysis, feeding loss time capture, key performance indicator (KPI) measurement, work in progress (WPI) follow-up, hourly production status, failure mode and effects analysis (FMEA) meeting template, and 5pcs review meeting accordingly stepwise. The main objectives of the SMED allow for the reduction of time through changeover, tuning, and setup for every new startup over new production. After changeover and

Table 1
The list of sewing machines used in the sewing section.

Sl.	Machine Name	Sl.	Machine Name
1	Single Needle Lock Stitch machine (Plain machine)	16	Two Needle Vertical machine
2	Double-needle lockstitch machine	17	Single needle Chain stitch machine
3	Three threads Over Lock Machine	18	Two-needle chain stitch machine
4	Four threads overlock machine	19	Kansai machine
5	Five threads overlock machine	20	The feed of the arm
6	Six threads Over Lock Machine	21	Saddle stitch binding sewing machine
7	Flatlock machine	22	Bar tack machine
8	Velcro attach machine	23	Buttonhole machine
9	Velcro automatic cutting machine	24	Button stitch machine
10	Eyelet hole machine	25	Snap buttons attach machine
11	Blind stitch machine	26	Label cutter machine
12	Zigzag machine	27	APW sewing machine
13	Rectangular Sewing machines	28	Embroidery machine
14	Round hole machine	29	Automatic 2-needle Belt-loop Attaching Machine
15	Cover stitch machine	30	Decorative Stitch Machine

proper setup, observation in feeding time analysis, feeding loss time capture, key performance indicator (KPI) measurement, work in progress (WPI) follow-up, and hourly production status is the key factor to find out the best optimization performance. Finally, a failure mode and effects analysis (FMEA) meeting is conducted to identify whether the lackings and improvements are needed or not upon ongoing products. The production control point starts from the buyer's estimated date to deliver the goods, and, in these circumstances, the production team urges the fabrics from the supplier to produce two months before. Supervision of production is controlled daily in every stage of production before and after starting any new styles of production. After completing production and quality inspection of the garments, the finished products are supplied to warehouse the garments. The whole process is illustrated in the following flowchart depicted in Fig. 1.

Moreover, this study for resolution and reformation focuses on the production procedure, input of raw materials and output of the finished products, control and maintaining the machine on the production floor, following up the production procedure, maintaining the prepared standard, finding out the faults during the production, familiar with the respective workers to maintain the standard of the study. Additionally, a properly trained team always deals with each day's production; continues to analyze as per the prepared standard, and try to focus on further improvements, and discusses the implementations for more efficiency and effectiveness. From the improvement purpose of the production, productivity along with efficiency SMED is allowed in the garments industry through the mentioned four phages in the production floor.

3. Results and discussion

3.1. Learning period

It is only applicable for change over a period once the changeover is complete and will go for the as-usual production procedure. This will run on daily production achieved percentage based on industrial engineering operation bulletin target for every individual line. The target will be set based on the line working hours and the types of styles of the garments (Jiang et al., 2022). The quality controller (QC) passed output finished garments will be considered as a line output. This production must acknowledge and signed by the QC head on daily basis. From the learning curve, the line must hit at least 3 days for basic, 4 days for semi-critical and 5 days for critical styles, for eligible line must hit the minimum of 75% on the last day of the learning curve, the same will be applicable for repeat or similar style. To make every style hit the industrial engineering department provides proper training about the change as well as adapt to make every style production fruitful as standard.

Table 2 illustrates among the five days evaluated a minimum of three days of production have to reach up to a pre-determined standard to become hit style while target production was 2000 pieces. For basic style day one, the intended achievement percentage was 40%, while the production would be 800 pieces. Similarly, for days two, three, four, and

Fig. 1. Flowchart of the SMED on Quick Changeover Process (QCO) in the production floor.

Table 2
Basic style target per single line during the learning period.

Basic Style					
Target	2000 Pcs				
Day	Intended achieve %	Intended Required Production	Case 1 (Pcs)	Case 2 (Pcs)	Case 3 (Pcs)
1	40%	800	600	600	600
2	50%	1000	1000	1000	1000
3	60%	1200	1200	1200	1200
4	70%	1400	1400	1300	1400
5	80%	1600	1500	1500	1450
Performance Status			**Eligible**	**Not Eligible**	**Not Eligible**

* Pcs indicates Pieces of garments.

five predetermined achievement percent were 50, 60, 70, and 80%, when the production target was 1000, 1200, 1400, and 1600 pieces. From the table for case 1, three days of production were 1000, 1200, and 1400; whereas for cases 2 and 3, two days and three days of production were 1000, 1200 and 1000, 1200, and 1400 reached up to the mark respectively. Although in case 3, production should have to reach at least 75% on day five to become eligible for hit style like case 1. That's why only case one was eligible for becoming hit here in between the three studied cases.

Among six days, an evaluated minimum of four days of production have to reach up to a pre-determined standard to become hit style as shown in Table 3. For semi-critical style day one, the intended achievement percentage was 35%, while the production would be 490 pieces. Similarly, for days two, three, four, five, and six predetermined achievement percent was 45, 55, 65, 75, and 80%, when the production target was 630, 770, 910, 1050, and 1120 pieces. From the table for case 1, four days production were 630, 770, 910, 1050; whereas for cases 2 and 3, three- and four-days production were 630, 770, 910, and 630, 770, 910, 1050 reached up to the mark respectively. In case 3, production should have to reach at least 75% on day six to become eligible for hit style like case 1. That's why only case one was eligible for becoming hit here in between the three studied cases.

Table 4 illustrates that among seven days, an evaluation minimum of five days of production have to reach up to a pre-determined standard to become a hit style. For critical style day one, the intended achievement percentage was 30%, while the production would be 270 pieces. Similarly, for days two, three, four, five, six, and seven predetermined achievement percent was 35, 45, 55, 65, 75, and 80%, when the production target was 315, 405, 495, 585, 675, and 720 pieces. The table noted that for case 1, five days of production were 315, 405, 495, 585, 675; whereas for cases 2 and 3, four days and five days of production were 315, 405, 495, 585 and 315, 405, 495, 585, 675 reached up to the mark respectively. Here in case 3, production should have to reach at least 75% on day six to become eligible for hit style like case 1. That's why only case one was eligible for becoming hit here in between the three studied cases.

Table 3
Semi-critical style target per single line during the learning period.

Semi-Critical Style					
Target	1400 Pcs				
Day	Intended achieve %	Intended Required Production	Case 1 (Pcs)	Case 2 (Pcs)	Case 3 (Pcs)
1	35%	490	400	400	400
2	45%	630	630	630	630
3	55%	770	770	770	770
4	65%	910	910	910	910
5	75%	1050	1050	989	1050
6	80%	1120	1050	1050	1000
Performance Status			**Eligible**	**Not Eligible**	**Not Eligible**

* Pcs indicates Pieces of garments.

Table 4
Critical style target per single line during the learning period.

Critical Style					
Target	900 Pcs				
Day	Incentive achieves %	Incentive Required Production	Case 1 (Pcs)	Case 2 (Pcs)	Case 3 (Pcs)
1	30%	270	200	200	200
2	35%	315	315	315	315
3	45%	405	405	405	405
4	55%	495	495	495	495
5	65%	585	585	585	585
6	75%	675	675	600	675
7	80%	720	675	675	650
Incentive Status			**Eligible**	**Not Eligible**	**Not Eligible**

* Pcs indicates Pieces of garments.

3.2. Average weekly performance evaluation before and after QCO

After a quick change-over implementation weekly average performance varies on every floor. The average plan achievement percentage depends on the amount of the execution of the action achieve percentage and it does reflect on the action efficiency as well. Before QCO implementation, average plan achievement, action achievement, and action efficiency were 22%, 21%, and 20% respectively. On the contrary, after QCO implementation, on floor one average plan achievement, action achievement, and action efficiency were 57%, 48%, and 46% respectively. In comparison with before and after QCO implementation, floor one was the maximum among all five floors. Moreover, before QCO implementation, on floor three average plan achievement, action achievement, and action efficiency were 18%, 15%, and 14% respectively. And after QCO implementation, on floor three average plan achievement, action achievement, and action efficiency were 52%, 40%, and 34% respectively, which was the lowest average weekly performance among the five floors in Fig. 2.

3.3. QCO action achieve percentage on the production floor

Daily performance evaluation is one of the most important parameters of sustainability of the QCO. After starting one style for production, it is essential to check the achievement ratio as per our standardization. On this basis, we measured our hit percentage of any style. In Fig. 3, from day one to day three action achievement percentage was increased gradually on all floors. From day four, achieve the percentage of floor four started to decrease whereas the other four floor's action achievement percentage was decreased from day six. In case, the action achieves a percentage was zero from day five to seven on the fourth floor. That means production is over. The highest amount of action achieve percentage was on floor five of 82% on day five. In comparison with floor five, floor four has the lowest amount of increment of 51% which was on day three.

3.4. QCO efficiency performance

In the case of, efficiency performance of the production floors is dependent on the percentage of plan achievement and action achievement percentage for the styles. Styles to styles, floor to floor, and type of styles are also the catalyst to affect the action efficiency percentage. As like action achieve, action efficiency was increased on most of the floors till day five except on floor four. In case, the action efficiency percentage was zero from day five to seven on the fourth floor. The highest amount

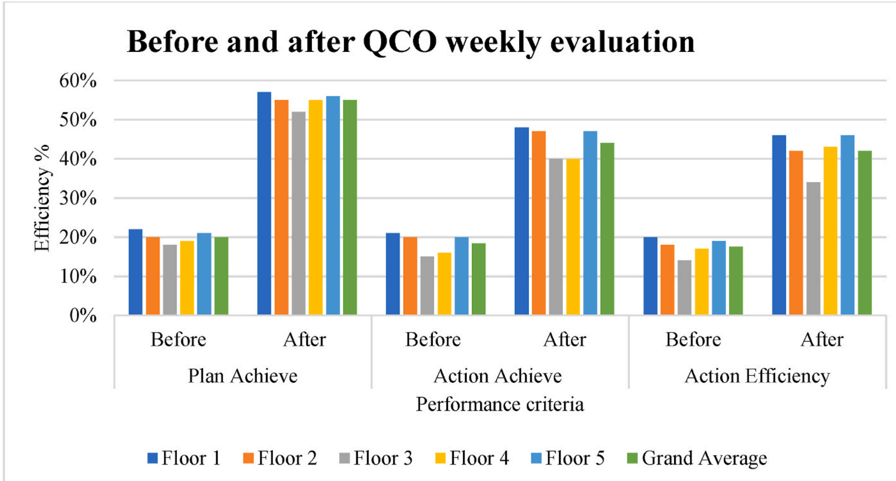

Fig. 2. Average performance of the production floors before and after implementing QCO after one week.

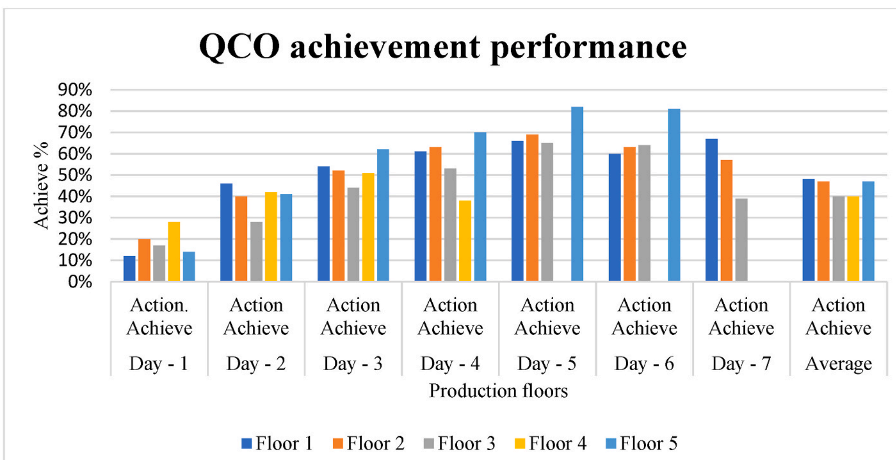

Fig. 3. Daily QCO achievement performance comparison.

of action efficiency was 79% found on floor five whereas 52% was found on floor four (Table 5).

3.5. *Time consumption after QCO implementation*

Table 6 illustrates the QCO implementation time before and after the application of SMED in the studied production floors. Among five floors, before applying QCO time consumption was 13, 13.5, 14, 14.4, and 14.8 h respectively. After implementing QCO time consumption was reduced by 1.4, 1.5, 1.6, 1.8, and 1.7. The main reason for lowering style changeover time is that the teams ensured preparation layout seven days before changeover day and confirmed fabrics, trims, accessories, and patterns remained in-house.

Table 6
Before and after QCO implementation time consumption.

Floor	Before time consumption (hours)	After time consumption (hours)	Saving time (hours)
Floor 1	13	11.6	1.4
Floor 2	13.5	12	1.5
Floor 3	14	12.4	1.6
Floor 4	14.4	12.6	1.8
Floor 5	14.8	13.1	1.7

Table 5
QCO action efficiency performance of the production floors.

Floor	Day - 1	Day - 2	Day - 3	Day - 4	Day - 5	Day - 6	Day - 7	AVERAGE
	Action Efficiency	Action Efficiency	Action Efficiency	Action Efficiency	Action Efficiency	Action Efficiency	Action Efficiency	Action Efficiency
Floor 1	11%	45%	52%	58%	63%	58%	66%	46%
Floor 2	18%	36%	47%	54%	61%	55%	48%	42%
Floor 3	14%	24%	37%	46%	56%	55%	34%	34%
Floor 4	31%	44%	52%	40%	0%	0%	0%	43%
Floor 5	14%	42%	60%	68%	79%	67%	0%	46%

3.6. Hit percentage among the ran styles

Hit percentage defines as per the QCO implementation in the production floor. It varies from the type of garment as well as its style. As the styles can be basic, semi-critical, and critical. It is measured by the successful attempt of producing the number of styles divided by the total amount of styles that ran into the production. From Table 7, it was found that initially among ran 31 styles, 14 styles became a hit which was below 50% of average hit styles. On the contrary, among five floors both floors two and five achieved the highest amount of hit percentage of 83% whereas floor four achieved zero. Although both floor two and five has a difference in the number of styles run there. Most importantly the hit style percentage increased by more than 20% after QCO implementation.

3.7. Quick Changeover (QCO) loss production

Loss of production occurs due to failure of implementation maintenance, marketing, technical, and industrial engineering, production, and quality stages. Floor to floor above-mentioned failures are varied. Mostly maintenance, production, and quality are the most concern areas here. From Table 8 before QCO implementation, floors one and three had the maximum and the minimum number of production losses 25,121 and 4086 pieces, respectively. In the case of after QCO implementation, floor one had the highest amount of loss of production pieces about 21,940 pieces while floor three had the lowest amount of loss of production about 2605 pieces. From the overall study, before and after QCO implementation, the total production loss was 54,581 and 45,416 pieces, which showed a reduction of 9165 pieces. In the case of individual departments, production/quality contained the highest amount of production loss after implementing QCO while due to technical defaults contained the lowest (Fig. 4).

Fig. 4(a) reflected that on floor one after applying QCO, due to the production and quality loss percentage was 75%, whereas maintenance and technical departments shown 15% and 8% respectively. On the other hand, marketing, and industrial engineering cause zero percent loss. Similarly, Fig. 4(b) shown that on floor two, due to the production and quality loss percentage was 56%, whereas maintenance departments shown 44% production loss. On the other hand, marketing, technical and industrial engineering caused zero percent loss respectively. Then in Fig. 4(c), it reflected that on floor three, due to the production and quality loss percentage was 34%, whereas maintenance departments shown 66% production loss. On the other hand, marketing, technical and industrial engineering causes zero percent loss respectively. Additionally, Fig. 4(d) reflected that on floor four, due to the production and quality loss percentage was 100%, whereas maintenance, marketing, technical, and industrial engineering cause zero percent loss respectively. Furthermore, Fig. 4(e), it reflected that on floor five, due to the production and quality loss percentage was 36%, whereas maintenance and technical departments shown 58% and 6% respectively. On the other hand, marketing, and industrial engineering cause zero percent loss.

Table 7
Before and after QCO implementation number of styles, amount of hit styles, and hit percentage of the month.

Floor	No. of Styles		Hit Style Number		After QCO Hit %
	Before	After	Before	After	
Floor-01	5	8	2	4	50%
Floor-02	10	18	6	15	83%
Floor-03	12	15	5	9	60%
Floor-04	0	1	0	0	0%
Floor-05	4	6	1	5	83%
Grand Total	31	48	14	33	(Average) 69%

3.8. Floor-wise performance

After implementing QCO, for a while plan achievement percentage, achievement percentage, and efficiency percentage are interrelated with each other. From Table 9, it was noticeable that the initial plan achievement percentage is not that high. With the increases of plan achievement percentage, achieved percentage and efficiency increase gradually day by day. It varies from floor to floor, types of styles, and implantation different criteria. And Fig. 5 illustrated the details of daily performance comparison as per the plan achieves versus achieve the percentage of the production floor.

From Fig. 5(a), the plan achievement percentage was 37% and at that point, the achievement percentage was 12% on day one. Gradually increased day by day. Plan achievement percentage was 46%, 56%, 66%, 76%, 79%, and 67% respectively on days two, three, four, five, six, and seven. Whereas achievement percentage was 46%, 54%, 61%, 66%, 60%, and 67% respectively on days two, three, four, five, six, and seven. From the overall prospect, floor one performance is the best among all the floors. Fig. 5(b) shown the plan achievement percentage was 36% and at that point, the achievement percentage was 20% on day one. Plan achievement percentage was 44%, 54%, 64%, 74%, 78%, and 80% respectively on days two, three, four, five, six, and seven. Whereas achievement percentage was 40%, 52%, 63%, 69%, 63%, and 57% respectively on days two, three, four, five, six, and seven. Fig. 5(c) illustrated, the plan achievement percentage was 36% and at that point, the achievement percentage was 17% on day one. Plan achievement percentage was 46%, 56%, 66%, 76%, 80%, and 80% respectively on days two, three, four, five, six, and seven. Whereas achievement percentage was 28%, 44%, 53%, 65%, 64%, and 39% respectively on days two, three, four, five, six, and seven. In comparison with all five floors, the overall performance of floor three is the lowest. From Fig. 5(d), the plan achievement percentage was 40% and at that point, the achievement percentage was 28% on day one. Plans achieve percentage was 50%, 60%, 70%, 0%, 0%, and 0% respectively on days two, three, four, five, six, and seven. Whereas achievement percentage was 42%, 51%, 38%, 0%, 0%, and 0% respectively on days two, three, four, five, six, and seven. From Fig. 5(e), the plan achievement percentage was 39% and at that point, the achievement percentage was 14% on day one. The plan achieve percentages were 50%, 60%, 70%, 79%, 80%, and 0% respectively on days two, three, four, five, six, and seven. Whereas achievement percentage was 41%, 62%, 70%, 82%, 81%, and 0% respectively on days two, three, four, five, six, and seven. From the overall performance, floor five had the second highest production after floor one.

4. Conclusion

SMED plays a vital role in the process of QCO in our study to enhance efficiency and less time consumption. At the same time, it was observed that through this approach we enable to reduce the amount of time consumed and trained the operators as compared to previous studies. An arrangement of proper training for different styles of the respective maintenance officers, executives, and workers of the production has to be acknowledged with it. From the weekly average performance point of view, the plan achieves, action achieves, and action efficiency a percentage of floor one being the best and floor three being the lowest among all five floors in comparison before and after QCO implementation. For average action achievement percentage, floor one and five has the best performance, on the contrary floors, three and four have the lowest performance. In the case of average action efficiency floor, one and five has the highest amount of performance, on the contrary, floor three has the lowest performance. In the case of before and after QCO time consumption, floor four and floor one consume 1.8 h and 1.4 h, respectively, which was the most and less among the five floors. From the hit styles perspective, floors two and five have the most numbers of hit styles production and 20% more increment of hit styles after QCO apply. Whereas floor one concedes most amount loss pieces and floor

Table 8
Production loss (in pieces) before and after QCO implementation in the various stages of the production floors.

Department		QCO Loss Production Pcs					
		Floor 01	Floor 02	Floor 03	Floor 04	Floor 05	Grand Total
Maintenance	Before	−4100	−6856	−2216	−500	−2428	−16,100
	After	−3619	−6338	−1730	0	−2198	−13,885
Marketing	Before	0	0	0	0	0	0
	After	0	0	0	0	0	0
Technical	Before	−2100	−300	−120	−232	−430	−3182
	After	−1794	0	0	0	−230	−2024
IE	Before	−600	−520	−410	0	−100	−1630
	After	0	0	0	0	0	0
Production/Quality	Before	−18,321	−8543	−1340	−3587	−1878	−33,669
	After	−16,527	−7936	−875	−2800	−1369	−29,507
Grand Total	Before	−25,121	−16,219	−4086	−4319	−4836	−54,581
	After	−21,940	−14,274	−2605	−2800	−3797	−45,416

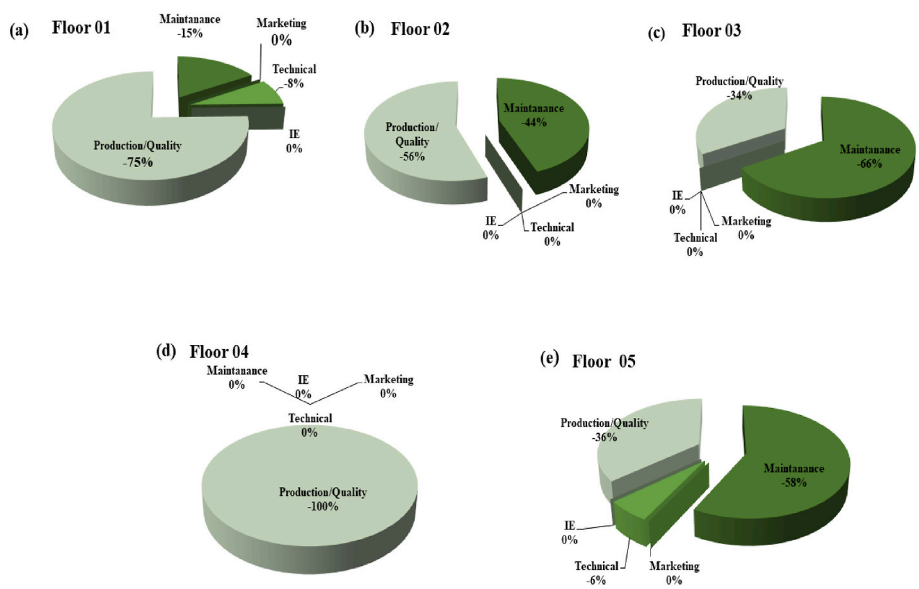

Fig. 4. After implementing QCO production losses of the production **(a)** floor one; **(b)** floor two; **(c)** floor three; **(d)** floor four; **(e)** floor five respectively.

Table 9
Daily performance evaluation of the production floors.

Day		1	2	3	4	5	6	7	Average
Floor 1	**Plan Ach %**	37%	46%	56%	66%	76%	79%	67%	57%
	Achieved %	12%	46%	54%	61%	66%	60%	67%	48%
	Efficiency %	11%	45%	52%	58%	63%	58%	66%	46%
Day		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
Floor 2	**Plan Ach %**	36%	44%	54%	64%	74%	78%	80%	55%
	Achieved %	20%	40%	52%	63%	69%	63%	57%	47%
	Efficiency %	18%	36%	47%	54%	61%	55%	48%	42%
Day		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
Floor 3	**Plan Ach %**	36%	46%	56%	66%	76%	80%	80%	52%
	Achieved %	17%	28%	44%	53%	65%	64%	39%	40%
	Efficiency %	14%	24%	37%	46%	56%	55%	34%	34%
Day		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
Floor 4	**Plan Ach %**	40%	50%	60%	70%	0%	0%	0%	55%
	Achieved %	28%	42%	51%	38%	0%	0%	0%	40%
	Efficiency %	31%	44%	52%	40%	0%	0%	0%	43%
Day		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
Floor 5	**Plan Ach %**	39%	50%	60%	70%	79%	80%	0%	56%
	Achieved %	14%	41%	62%	70%	82%	81%	0%	47%
	Efficiency %	14%	42%	60%	68%	79%	67%	0%	46%

three has a smaller number of losses of production pieces in comparison before and after QCO implementation. From the overall study, we can say that floor one is the most highly effective in sense of plan achievement, action achievement, and action efficiency of SMED. As it is a continuous process, so there are a few scopes to make this approach more effective like Visual Stream Mapping (VSM) before and after the production of every style to find the lacking during the process and minimize the wastage. In addition, the scheme of incentive plan during

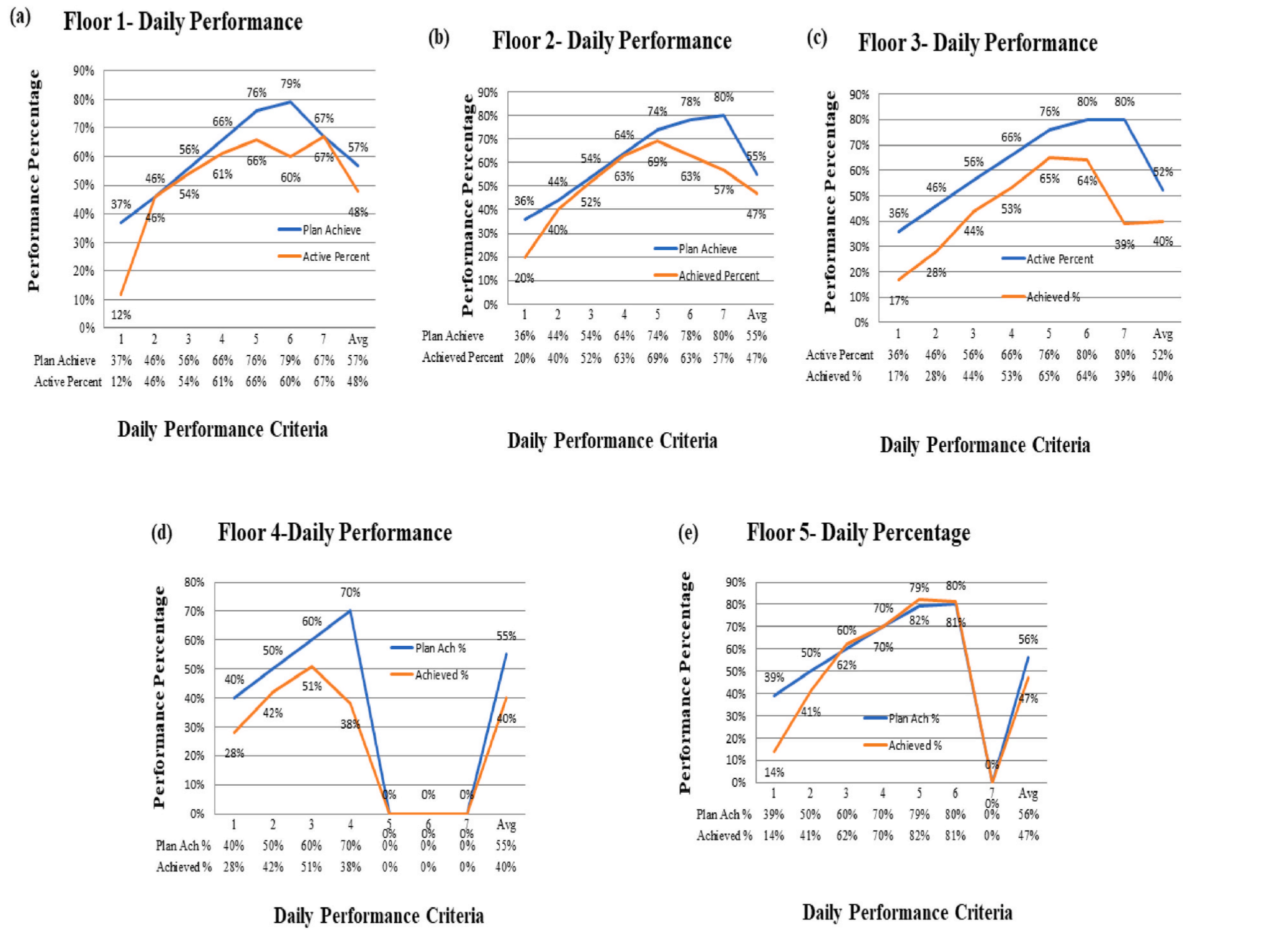

Fig. 5. Daily performance comparison as per plan achieves verses achieve a percentage of the production is the **(a)** floor one; **(b)** floor two; **(c)** floor three; **(d)** floor four; **(e)** floor five respectively.

sewing is a breakthrough approach for encouraging the workers, line staff, and fellow officers which would be a value-added addition to improve it.

Author statement

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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