Open Access Library Journal
2023, Volume 10, e10697
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Investigation and Design Set up of Style Change over Delay and Implementation of a Lean Tool SMED in Ready-Made Garments Industry: A Cost-Effective Lean Concept with Enhancing Profitability

Md Saifur Rahman[1], Tangina Tania[2], Md Hasan Ali[3], Raihan Ahmed Joy[1]

[1]Department of Industrial and Production Engineering, National Institute of Textile Engineering and Research, Dhaka, Bangladesh
[2]Department of Industrial and Production Engineering, Lee Wrangler Asia Ltd., Dhaka, Bangladesh
[3]Department of Industrial Engineering, Dalhousie University, Halifax, Canada
Email: saifur.sarsa@gmail.com

How to cite this paper: Rahman, M.S., Tania, T., Ali, M.H. and Joy, R.A. (2023) Investigation and Design Set up of Style Change over Delay and Implementation of a Lean Tool SMED in Ready-Made Garments Industry: A Cost-Effective Lean Concept with Enhancing Profitability. *Open Access Library Journal*, **10**: e10697.
https://doi.org/10.4236/oalib.1110697

Received: September 6, 2023
Accepted: November 27, 2023
Published: November 30, 2023

Abstract

There is very little time to waste at present because the market need is always growing, and there is a worldwide lack of manpower. The quickest approach for improving output and revenue is to reduce expenses on time. This means that employing a new lean technique will help to shorten the time. There are several methods utilized to reduce downtime in a worldwide industry. We employ the Single Minute Exchange of Die (SMED) method to shorten the time involved in all of this. In this study, we describe the SMED technique's use and how it contributes to productivity gains and time savings. The findings of this study indicated that setup time was reduced by 49.40% and enhanced profitability per style change by $112.86. The setup time is calculated before and after the SMED technology is applied to the type of garments. The different process is observed by time and motion study by analyzing quick change over time from the previous style to the new style. Some basic tools and techniques are used in the procedure to find out the main cause for delayed changeover and less productivity. After applying SMED techniques the style change over time decreases and production time increases. As a result, the profitability is enhanced for the organization.

Subject Areas

Educational Technology

Keywords

SMED, Internal, External, NVA, QCO, CPM

1. Introduction

Today's consumer wants a high-quality item that will take less time and less money to produce. Employing standard production techniques is not feasible. Only current methods and equipment, used in accordance with the process requirements, are necessary to achieve this. So, to fulfill the criteria, we have shortened the operational duration of the current machines using the SMED technology [1] [2] [3]. Single Minute Exchange of Dies (SMED) is a great method for reducing the amount of time needed for Internal Setup (IED), which includes mounting or removing dies, and External Setup (OED), which includes moving old dies to storage or conveying new dies to the machine while the machine is still running [4] [5] [6] [7].

Stages in SMED (**Figure 1**):

Stage 1: Analysis through work sampling, interviewing operators, etc.

Stage 2: Distinguish between Internal and External Setup.

Stage 3: Converting Internal Set-up to external Set-up.

Stage 4: Eliminating additional non-value added (NVAs), standardizing the setup process, and streamlining every step of setup operations.

One of the several lean production techniques for minimizing waste in a manufacturing process is SMED. It offers a quick and effective solution to switch a manufacturing process from producing the current product to producing the following one. Using the term "single minute" instead of "single-digit minute" indicates that changeovers and startup times should be fewer than 10 minutes, not just one [5] [7] [8] [9]. The SMED approach is used to create the best standard operating procedure for changeover procedures on a specific machine. The problems that caused the shift in focus for long-run producers have not been as prevalent for small-batch manufacturers, though. To assess how well SMED works in lowering cycle time, outcomes and accomplishments before and after its introduction were compared. SMED is only one of the several lean production techniques available for cutting waste in a manufacturing process [2]. It offers a quick and effective solution to change a production process from producing the present product to producing the next product. Quick Changeover (QCO) is another common name for it. The SMED method is done in four steps: combine, remove, simplify, and measure shown in **Figure 2** [3].

SMED's goal of cutting setup times by getting rid of waste associated with tool changes is one of its main priorities. Therefore, the purpose of SMED is to attempt to separate internal operations, such as die exchanges or equipment fittings, which must be carried out with the machine in standby mode, from external operations, such as the preparation of tools, which must be carried out with the machine in normal operation mode [5]. Shingo (1985) suggested that

SMED should be applied in four stages [3]:

- Phase A, during this phase, the company does not differentiate between internal and external setup procedures, causing equipment to sit idle for very lengthy periods of time. The SMED technique is primarily intended to examine the circumstances on the shop floor in-depth through production analysis, employee interviews, and videotaping of setup activities [10].
- Phase B, the division of internal from external setup operations by the company. This technique often reduces setup operation time by 30% to 50%. Getting this distinction right is crucial to deploying SMED successfully [5].
- Phase C, in which the company outsources most internal setup tasks. Reexamining every activity to see whether it was mistakenly believed to be an internal one and converting it to an external one is crucial at this step.
- Phase D, simplifying every step of the setup process. This phase aims to systematically enhance each fundamental internal and external setup function, developing approaches to complete various activities more quickly, safely, and easily.

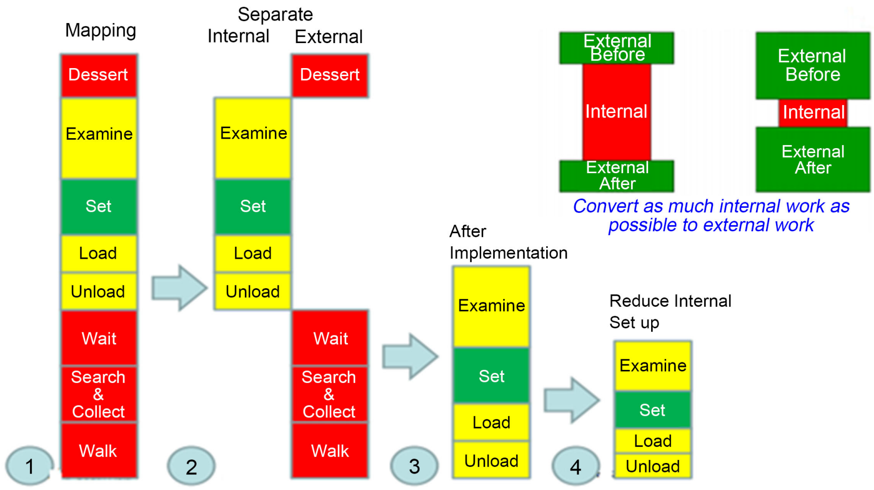

Figure 1. Stages of SMED.

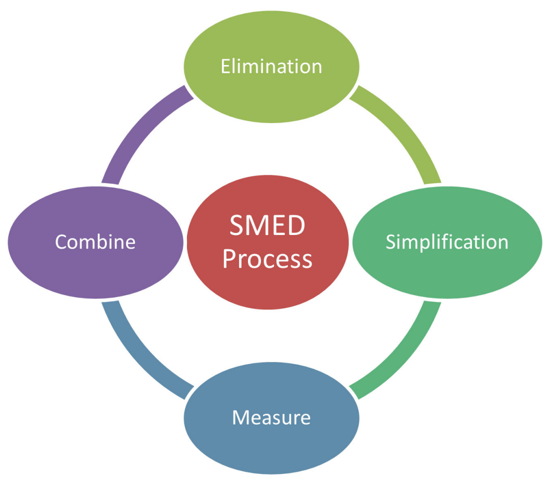

Figure 2. SMED cycle [3].

Figure 3 exhibits the different phases of the whole process. Clearly, the idle production time diminishes as the process moves forward.

The identification and classification of the operations is one of the primary challenges in the deployment of this technique. All possible external setup tasks that can be carried out while the system is in use are included [1] [11]. Internal setup operations, on the other hand, are all those that can only be carried out while the machine is halted. The concept outlines a series of steps that must be taken to achieve worldwide success during the SMED implementation in detail [5]:

- To assess the real process.
- To categorize the various operations as either internal or external ones.
- To outsource internal processes to external ones.
- To provide solutions that shorten the duration of internal processes.
- To provide solutions that make it possible to reduce the amount of time that external processes take to complete.
- To develop strict protocols to minimize errors during setup.
- To continually shorten setup time, go back to the beginning of the process and repeat the entire process.

To get good outcomes from this combination of methods, the process must be continuously examined. Every time the process is used, fresh, better solutions must be attained. [9]. Systematic use of a learning and preparation phase to improve SMED implementation and identify four categories of activities: confirmatory, operational, preparatory, and strategic activities [3] [9]. Due to the initial goal of this research, a technique was first employed, and during the diffusion process, recommendations were presented [9] [12].

In 1950, Ohno at Toyota created SMED. Ohno's concept was to create a mechanism that could more quickly swap dies. SMED's fundamental goal is to speed up equipment setup. Setups come in two sections: internal and external. External setup activities can be completed while the machine is running, however, internal setup activities can only be completed after the unit is stopped. The fundamental concept is to shift as many tasks as you can from internal to external,

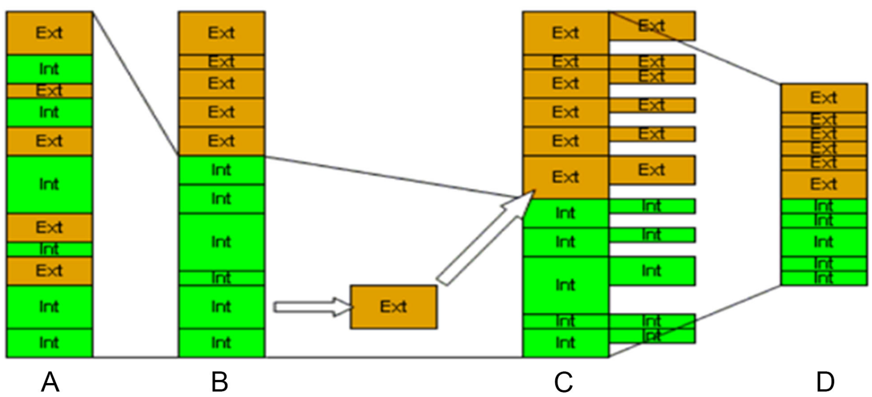

Figure 3. The phases of the SMED methodology [5].

and it has been determined that up reduction is a method that is widely applicable [10] [13]. There has been a great deal of research done on the SMED methodology in the textile processing industry, and it is suggested that to implement SMED successfully, a few fundamental conditions must be met. These conditions include teamwork, visual factory control, performance measurement, Kaizen, and discussion of the manufacturing environment [2] [4]. The cost of each component will rise when the batch size lowers because the change over time will be spread over fewer parts, according to research on the link between changeover and production leveling. It also addressed the extensive changeover analysis and concluded that when creating a component, every degree of freedom of the machine must be specified and fixed. This results in high manufacturing costs when changeover durations are significant. The capacity to make components in smaller batches is the biggest advantage of a shorter changeover time, and SMED is also utilized as a tool to increase flexibility [14]. The relationship between SMED and equipment design is also associated, indicating that SMED is beneficial for both equipment creation and production enhancement [2] [3] [12]. Empirically, the effective use of the SMED tool in the garment factory led to a decrease in setup time and highlights the significance of lean in the application of the lean manufacturing methodology. The application of design modifications to the changeover process and the balancing of production lines utilizing setup reduction have both been addressed in a new modified improvement framework for lean implementation [4].

The previous study described production systems and set up time reduction with SMED tools of lean concept. There are many concepts regarding small process breakdown. Here the processes are described complete system with input to output system with a single department of an organization considering profitability including the cost per minute. There are some common objectives of the study are given below:

- ✓ To investigate the existing and new layout for garment manufacturing with external and internal activities.
- ✓ To develop the activities according to SMED and reduce layout set-up time.
- ✓ To evaluate the time savings and increase profit by considering cost per minute (CPM).

2. Methodology

This whole study was done in a reputed garments industry in Bangladesh. There are sonic processes of SMED that are applied to minimize the delay time and improvement of productive time. The following process is taken step-by-step procedures.

- ➢ Firstly, the observation of the current methodology which contains current procedures generally recorded manually all the changeover processes. It covers the complete changeover from one model to another model.
- ➢ Secondly, activities that were internal and external were divided. While external activities can be carried out while the last batch is being produced or

after the next batch has begun, internal actions can only be carried out after the process has stopped.

- Thirdly, streamline the changeover process; it may take multiple rounds to reach the ten-minute requirement because each repetition of the aforesaid procedure should result in a significant reduction in setup times.
- Finally, the primary need changes to the training of all open operators in the cell after the first iteration of the SMED application is successful. The cell champion (Master of Changeover) has imparted training. Figure 4 shows the SMED setup time.

After we studied the different sources, we found the procedure to implement the SMED technique the procedure is shown in Figure 5, in which first we classify the internal and external setup to convert internal to external setup [13] and streamline all aspects of the setup operation with sequentially described as below.

- Observe the continuing procedure.
- Organize the activities into INTERNAL and EXTERNAL
- categories and, if you can, turn Internal activities into External ones.
- Improve the flow of the remaining internal activities.
- Like steps forward, we also need to maximize external activities.
- Record the new process.
- Aim for excellence.

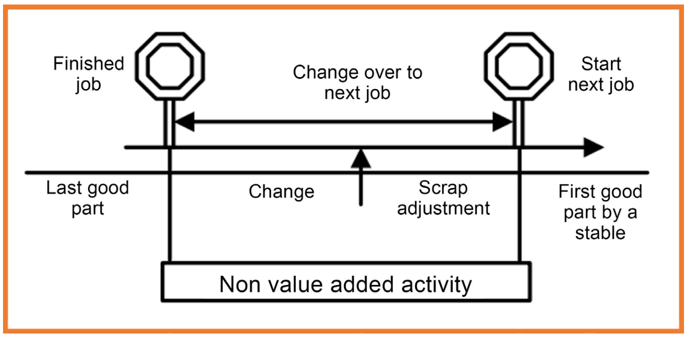

Figure 4. SMED setup time [6].

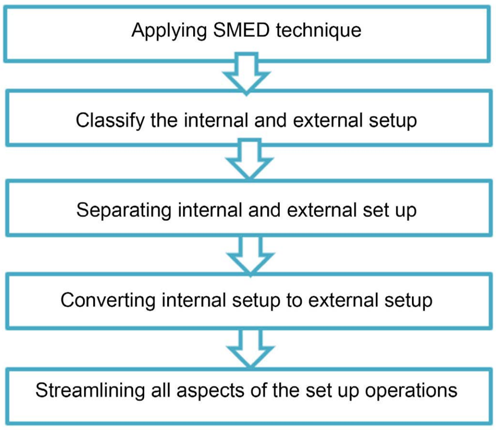

Figure 5. Procedures to implement SMED.

We also use the MISER tricks such as M—Merge, I—Integrate, S—Simplify, E—Eliminate, R—Reduce. Our target is to minimize the style change over time. All the processes are not removed from the procedure. If some processes are merged or integrated with another, the processing time decreases. Some processes need to be simplified with an easy process by using extra devices and tools also minimize the time. After all, if possible, some non-value-added time needs to be removed and reduced. The cycle to implement SMED is shown in **Figure 6**. During the observation of delay factors, there are some common delay factors found. The major delay factor is resource arranging time for new style changes over time. Besides, using one of the quality control tools called cause-effect diagram or fishbone diagram. The fishbone diagram is analyzed with different sub-delay factors.

3. Results and Discussion

3.1. Observation Procedures and Find Out Delay Factors

Analysis of Sewing Layout of ready-made garments industry during style change. Every style is combined with some sub-styles such as small parts, front parts, back parts, and assembly sections to complete garments in a sewing layout of the renowned garment industry of Bangladesh. Every subsection has some small activities. The activities are analyzed and categorized by six major causes with time and motion study according to the Industrial Engineering (IE) concept. Then all activities are cumulated according to time duration (**Table 1**).

According to the Single Minute Exchange of Dies (SMED) definition, some NVA processes are included during a change over to the next style from the last good output of the existing style to the first good output. Within this change over time, the organization was prepared to continue the next style by minimizing the setup time which is interrelated from one production team to another responsible department in an organization. By close observations of procedures, the major causes behind the delay factors with possible action are driven by respective departments for utilizing the maximum time provided by the organization without breakdown are listed below in **Table 2**.

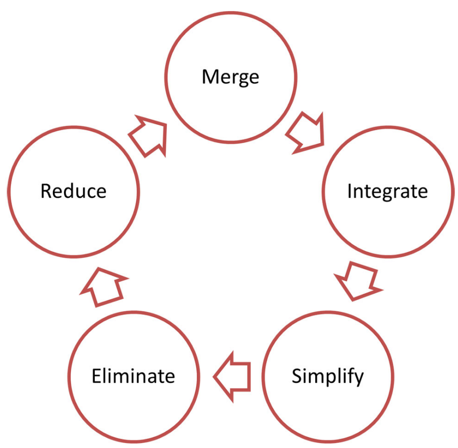

Figure 6. Cycle to implement SMED.

Table 1. Main description of product style.

Product Layout	Parameters		
	Manpower	SMV	No. of Machines
Existing	83	22.17	64
Upcoming	96	34.10	72

Table 2. Main delay factors for the previous style to the new style considering time and motion study.

Main Delay Factor	Sub Factor	Responsible Department	Action
Resource arranging time	Searching time for a skilled operator	Production	Need skill matrix, need at least multi-skilled operator
	Reluctances of worker		Tagging
	No prior planning about the placement of workers	Industrial Engineering	Comparing the drawing layout previous & new style
	No prior planning about the place element of the machine		Analysis of Sample and pilot run stage
	Waiting for input	Production	Proxy machine
	No critical operation analysis	Industrial Engineering	Analysis of Sample and pilot run stage
	No drawing of the layout		Drawing layout previous & new style
Machine setting time	No attachment in an extra machine	Maintenance	Attachment in the extra machine beforehand
	Going dept. to take tools		Need machine toolbox
Technician time with a mechanic	Pattern/Guide problem	Technical	Need feeding box

Moreover, the delaying factor is the huge resource arranging time and technician time also explained by the cause-effect diagram which is shown in Figure 7 and Figure 8.

3.2. Improvement Techniques and Possible Recommendations

The improvement techniques required an improvement cycle for SMED techniques shown in Figure 9. The improvement techniques required an improvement cycle for SMED techniques which also enhances the cost-efficiency.

- Analysis of processes with SMV of the previous and new layout.
- Identification of internal and external activities.
- Converting internal activities to external activities to minimize the initial setup time.
- After comparing these two we can identify the placement of new machines, the number of extra machines, and the number of idle machines. So that maximum utilization of resources can be ensured.

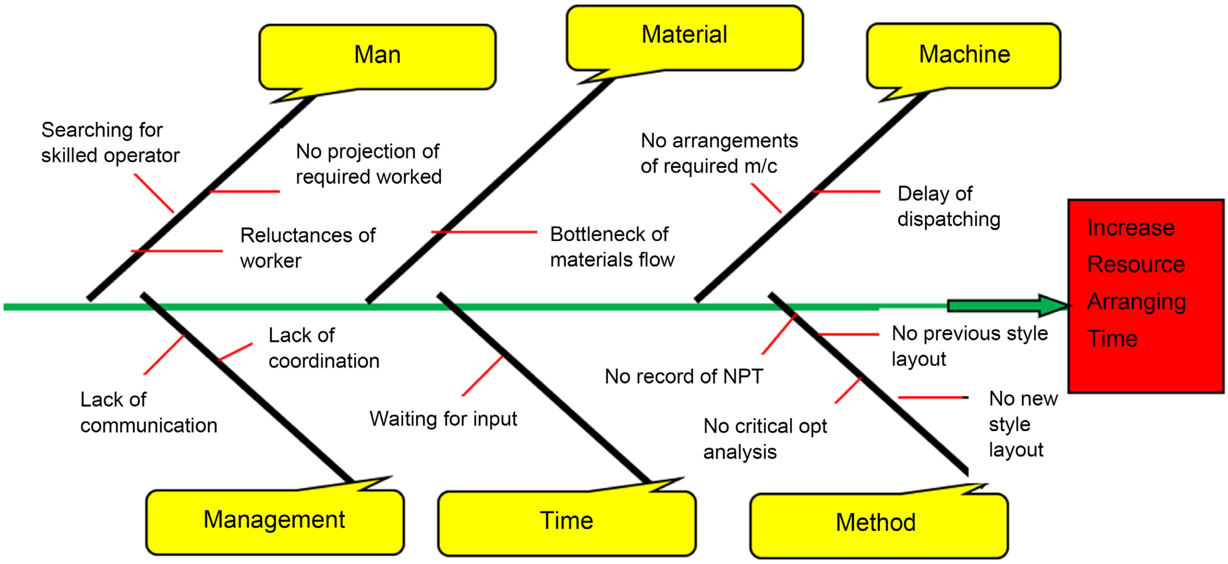

Figure 7. Fishbone diagram of high setup time of huge technician time.

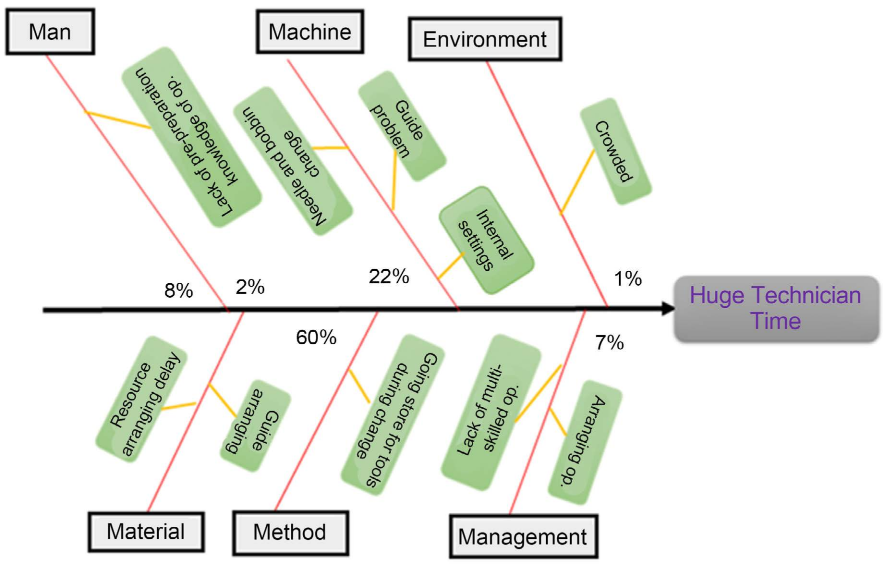

Figure 8. Fishbone diagram of high setup time of huge technician time.

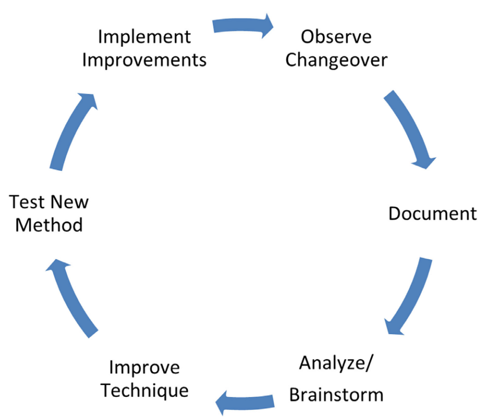

Figure 9. Cycle to implement SMED.

Besides these, we should also do the following.

- Compare the previous style with a new style by drawing the layout.
- Critical operation analysis to identify what problem may arise.
- Consult with the selected operator so she/he is ready to do that operation.
- Need 10 multi-skill operators for operator replacement.
- Provide a feeding box to the machine beforehand.
- Need an extra machine for feeding.
- Provide a tooling box to a mechanic.
- All involved persons should be informed prior to the change.

This improvement technique requires some basic tools and documentation. This toolbox was designed to facilitate the machine setter to bring all the tools needed when the setup was done [5]. To reduce machine tool movement technicians can provide a feeding box as designed which is shown in **Figure 10**.

The proposed activities need to convert from internal to external due to the implementation of SMED [2] [14] in the sewing layout. The list of recommendations for possible conversion from internal activities to external activities considering the delay factor is shown in **Table 3**.

Figure 10. Feeding box (Designed by Auto CAD).

Table 3. Convert internal activities to external activities.

Sl. No	Internal Activities	External Activities
1	Placement of machine	Pre-planning arranging machine
2	Arranging manpower	Pre-planning arranging manpower Critical operation and operator analysis
3	Machine tool arranging	Feeding machine toolbox beforehand Previous style layout analysis New style layout analysis Consult with the selected operator
4	No attachment in an extra machine	Attachment in extra machine beforehand

3.3. Activities Time Study with Causes before SMED

A sewing layout activity combined with four different segments of each style such as small parts, front parts, back parts, and assembly parts for data analysis to operation breakdown based on major factors behind the delay factors.

The small parts activities were analyzed based on causes before SMED in the sewing layout in Figure 11.

Similarly, the front parts, back parts, and assembly activities were analyzed based on causes before SMED in the sewing layout in Figures 12-14.

3.4. Activities Time Study with Causes after SMED

After SMED Implementation, the new four parts are analyzed according to time and motion study. The data are given below according to small parts, front parts, back parts, and assembly sections. Similarly, the activities are analyzed by categorizing six major causes with time and motion study according to industrial engineering concept. The small parts activities were analyzed based on causes after SMED in the sewing layout. The small parts, front parts, back parts, and assembly activities were analyzed based on causes before SMED in the sewing layout in Figures 15-18.

3.5. Cost Effective Profitability Analysis

The analysis of the data with and without the implementation of SMED showed cost-effective profitability enhancement in the organizations. The analysis of the data is provided in Table 4. The profit was enhanced $112.86 per layout changeover of style.

Table 4. Main description of product style.

Sl. No	Parts	Activities						
		Machine Setting time (min)	MC Tool arrange a time (min)	Resource Arranging time (min)	Power Setting (min)	Manpower arranging time (min)	Technician Time with a mechanic (min)	Total Time (min)
Before SMED	Small	33	72	86	2	0	0	193
	Front	150	33	686	0	49	81	999
	Back	93	0	458	20	18	39	628
	Assembly	167	0	1684	86	50	0	1987
	Total Time	443	105	2914	108	117	120	3807
After SMED	Small	33	72	86	2	0	0	193
	Front	67	89	25	1	7	84	273
	Back	74	4	38	2	5	276	399
	Assembly	256	7	20	5	137	211	636
	Total Time (min)	430	172	169	10	149	996	1926
Savings Time (min)		13	−67	2745	98	−32	−876	1881
CPM[a] ($)					0.06			
Profit ($)/SMED					112.86			

a. Depends on the total (direct and indirect) cost of organizations.

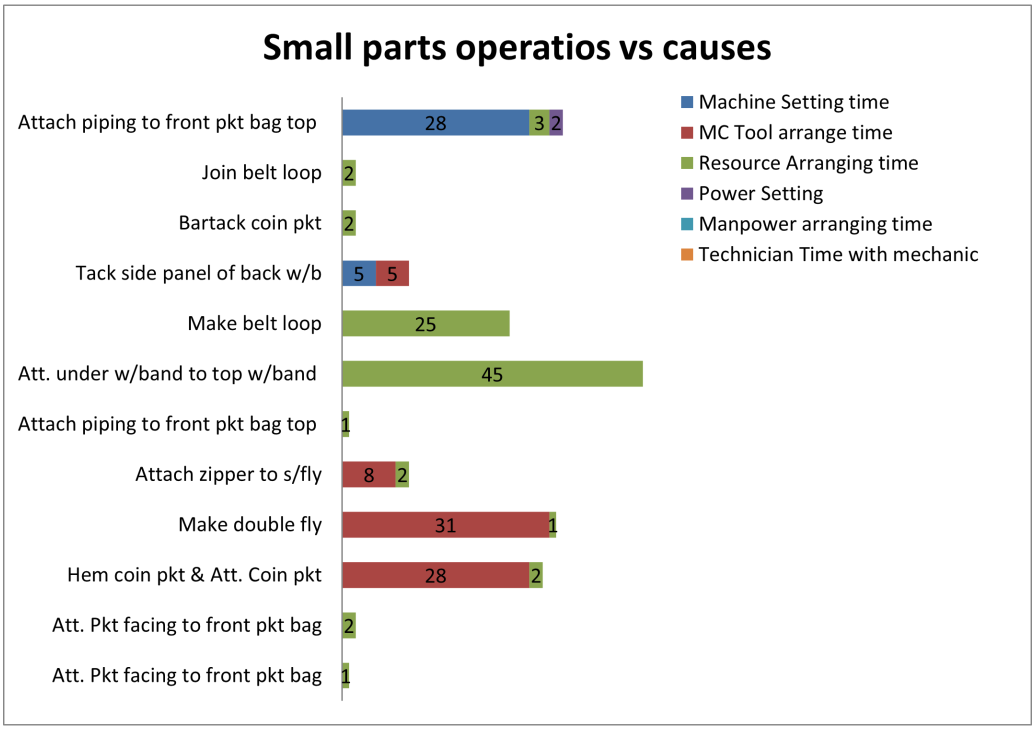

Figure 11. Small part operations vs. causes of different factors.

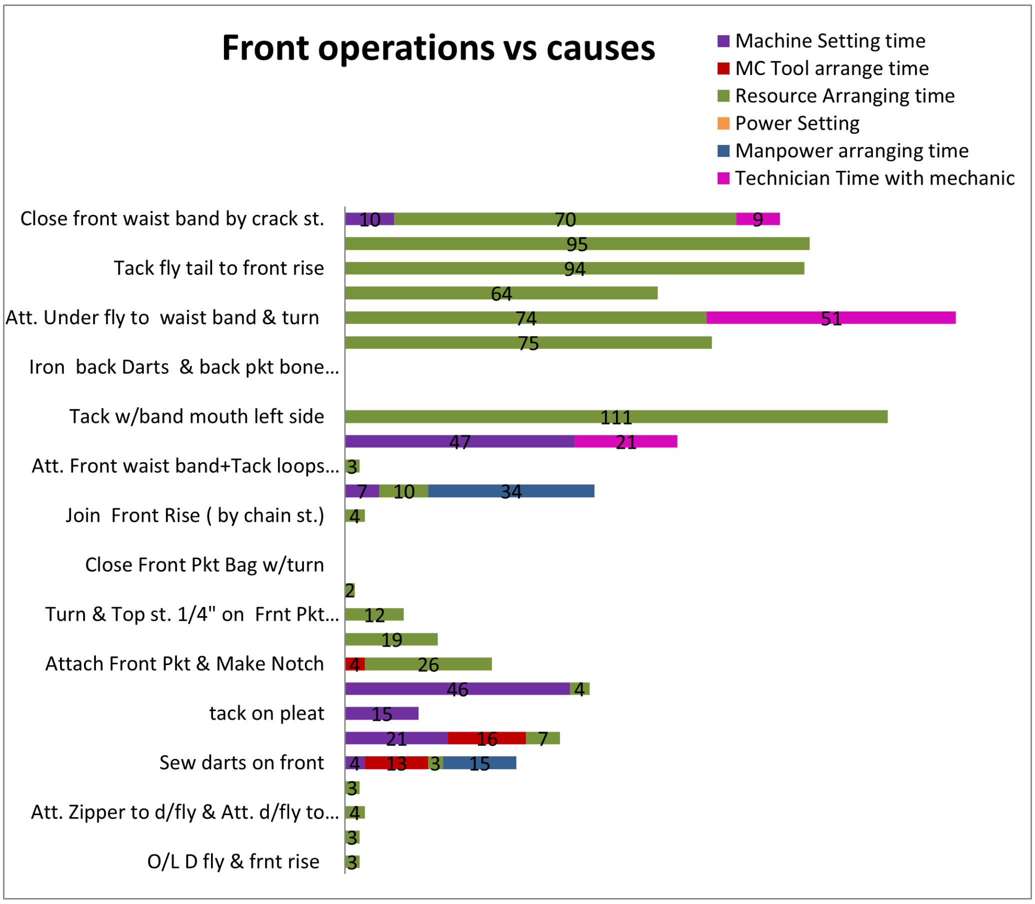

Figure 12. Front part operations vs. causes of different factors.

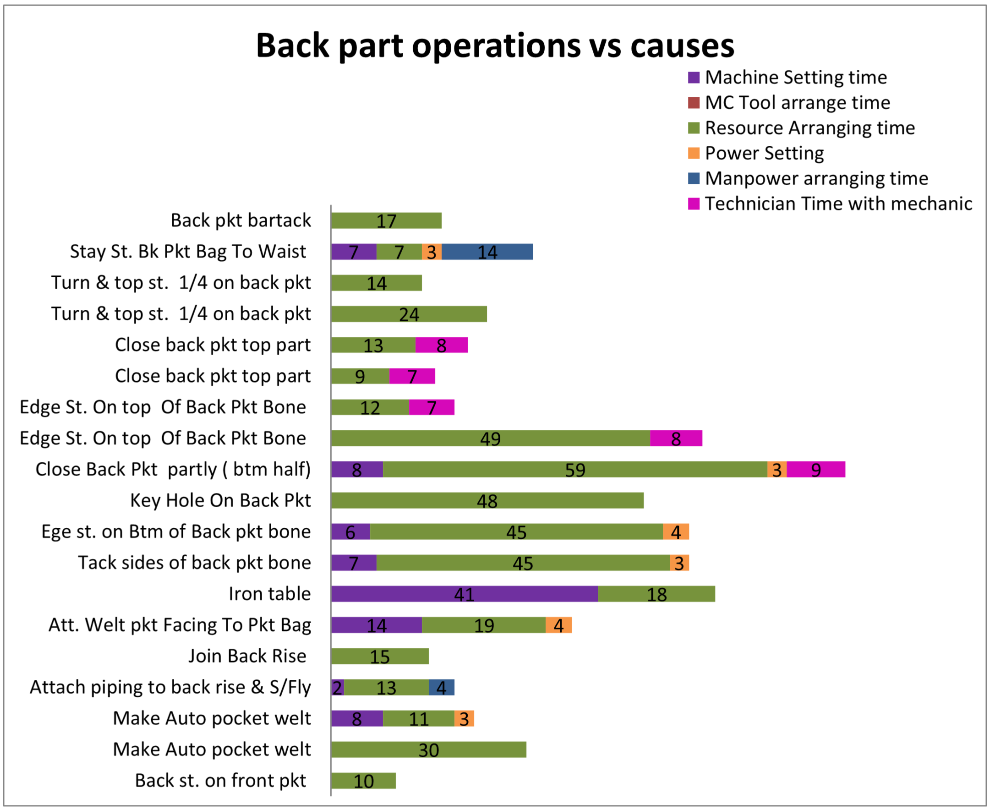

Figure 13. Back part operations vs. causes of different factors.

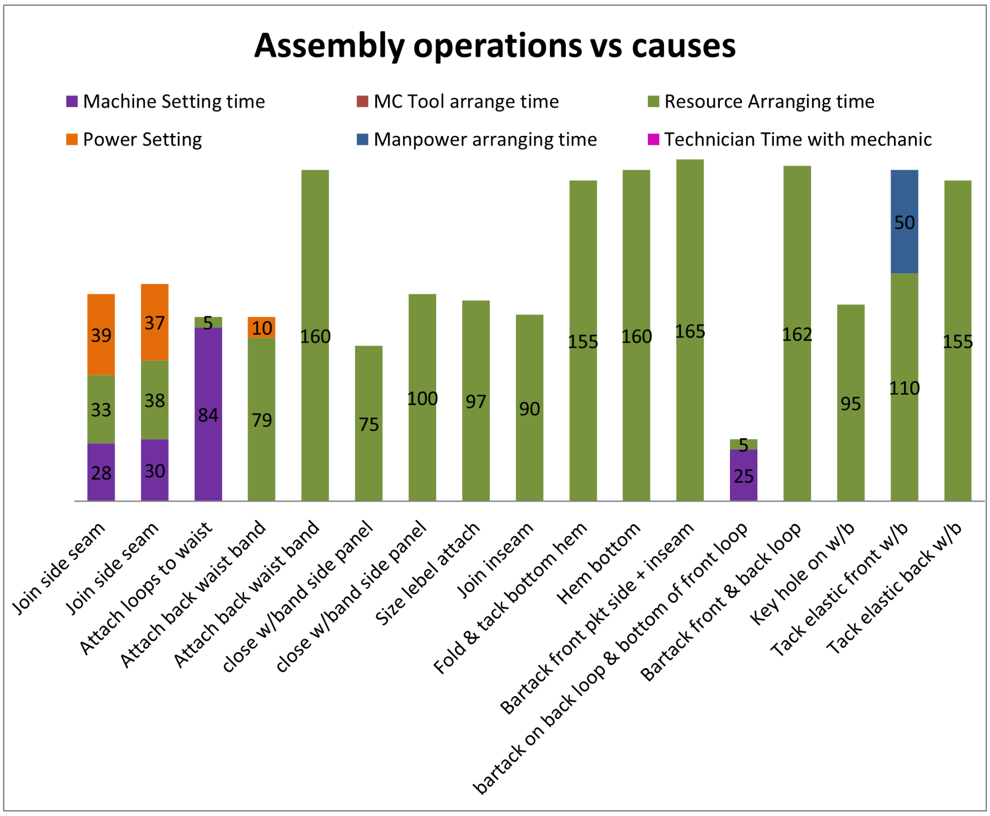

Figure 14. Assembly operations vs. causes of different factors.

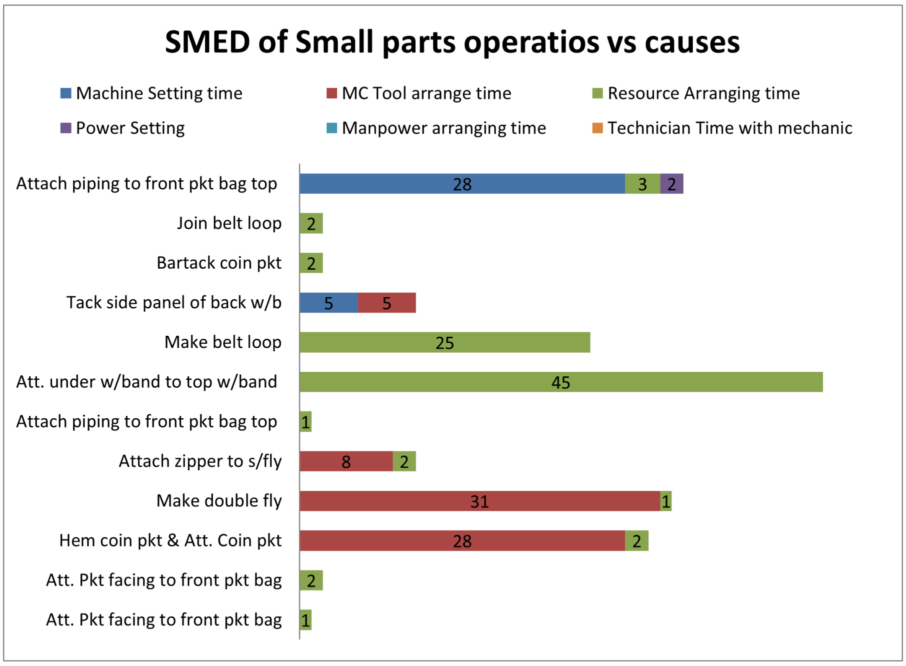

Figure 15. Small parts operations vs. causes of different factors.

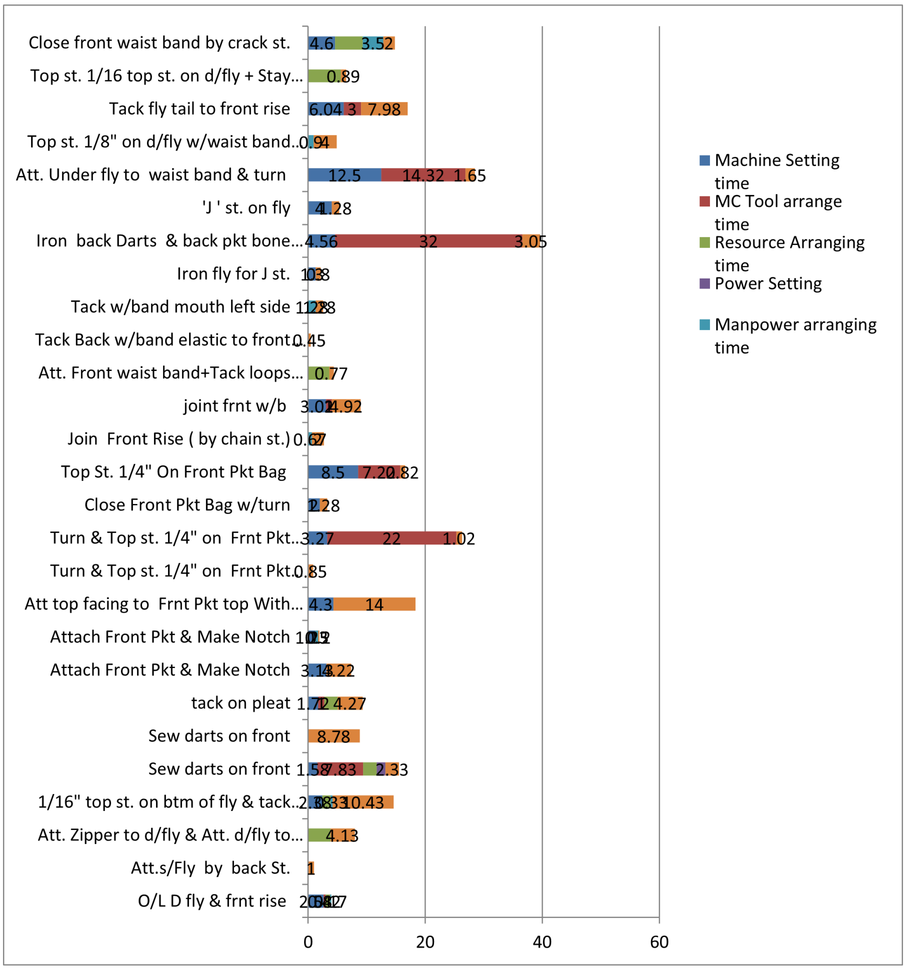

Figure 16. Front part operations vs. causes of different factors.

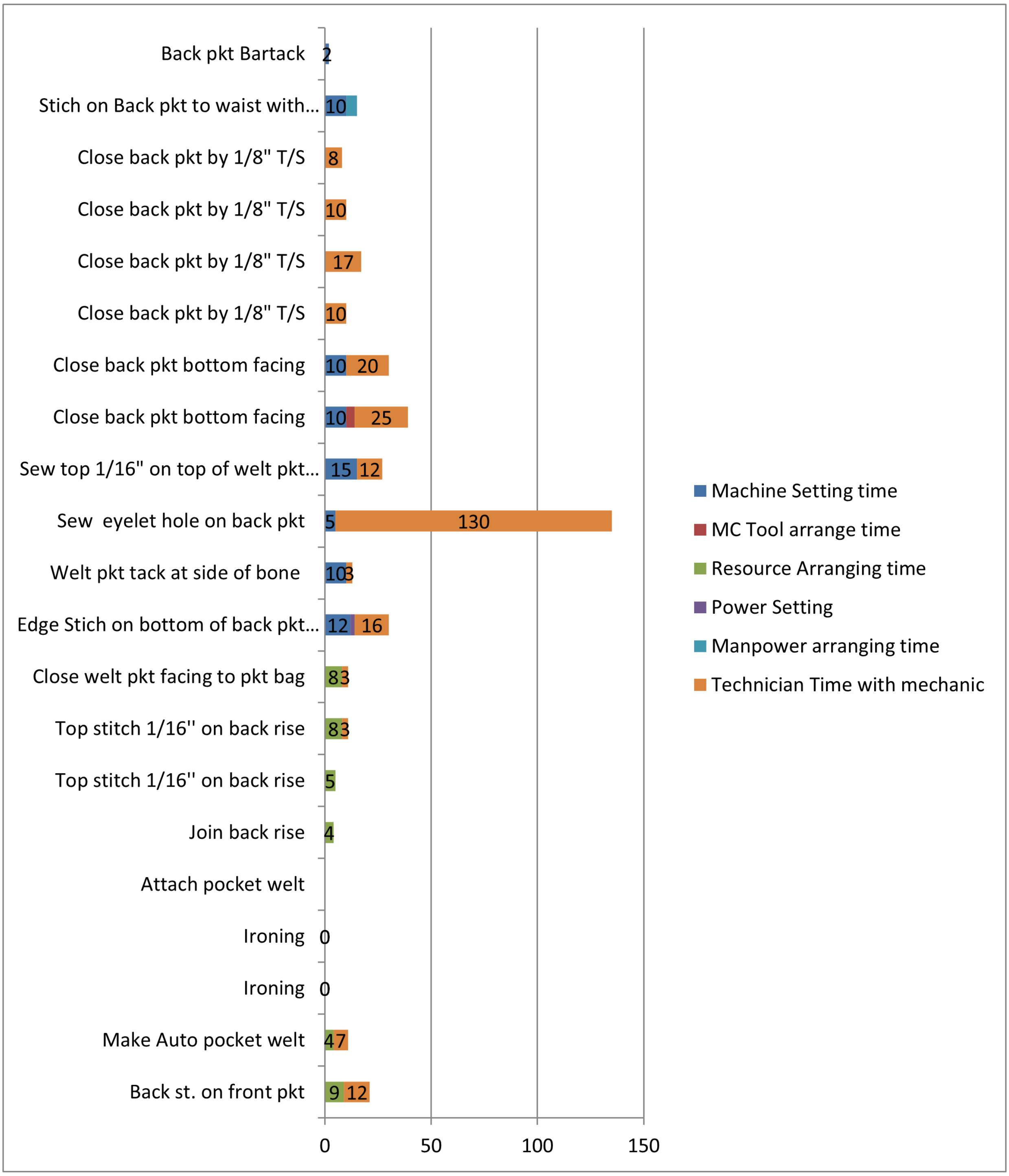

Figure 17. Back part operations vs. causes of different factors.

4. Limitations

There are some limitations in the study such as

1) Data is collected by manually

2) So, there might be inaccuracy and biasness

3) Data is collected by some novice engineers

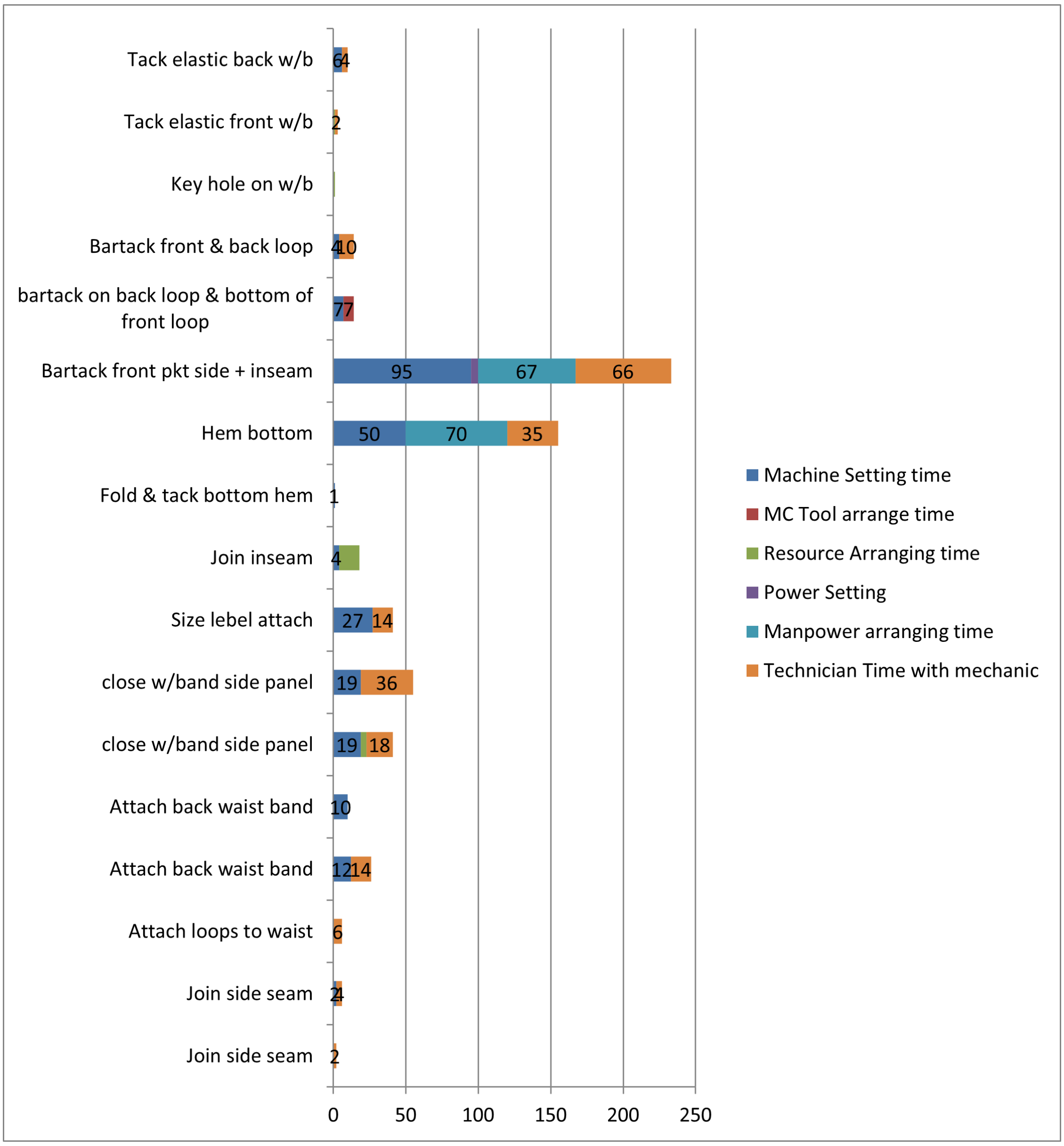

Figure 18. Assembly operations vs. causes of different factors.

5. Conclusion

In this study, the before and after SMED procedures of product styles were analyzed. The different major causes behind the delay are factors such as resource arranging time, Technician time with a mechanic, machine setting time, MC tool arrange time, etc. For SMED analysis, Resource Arranging time is abundant in the process more than 76% of the time. We can conclude that reducing resource arranging and technician time with mechanics is our main challenge. All the causes are interlinked. To tackle this challenge, we need to take some steps like providing feeding, and a toolbox, detailed planning about machines and manpower, etc. The new process time with SMED time was used new style was arranged. Both cause-effect and SMED analysis approaches generally provide the styles with different delay factors with time which depends on different activities of the product styles. However, SMED analysis of the style which scientifically developed by examining the procedures, setup, layout, and manpower. Also, the addition of the cause-effect diagram determined the cause associated with delay factors. Productivity increased with reducing change over time with the SMED lean approach. Therefore, they showed technical evidence with a lean tool where a combination of quality tools is desired with productivity analysis.

Acknowledgements

The authors would like to express their gratitude to Mr. Shahiduzzaman Shimul, Lead Production Engineer, TGT Sourcing Asia Ltd, Dhaka, Bangladesh for providing insightful thought, and fruitful discussions about the SMED process.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Toki, G.F.I., Ahmed, T., Hossain, M.E., Alave, R.K.K., Faruk, M.O, Mia, R. and Islam, S.R. (2023) Single Minute Exchange Die (SMED): A Sustainable and Well-Timed Approach for Bangladeshi Garments Industry. *Cleaner Engineering and Technology*, **12**, Article ID: 100592. https://doi.org/10.1016/j.clet.2022.100592

[2] Fuentes, S., Torres, K., Cespedes, C., Torres, C., Cano, M., Raymundo, C., and Dominguez, F. (2023) Increased Productivity in the Garment Manufacturing Process using the SMED Methodology of Lean Manufacturing. *Proceedings of the 21st LACCEI International MultiConference for Engineering, Education, and Technology*, Buenos Aires, Argentina, 17-21 July 2023, 1-10.

[3] Kumar, V. and Bajaj, A. (2015) The Implementation of Single Minute Exchange of Die with 5'S in Machining Processes for Reduction of Setup Time. *International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE)*, **2**, 32-39.

[4] Sayem, A., Islam, M.A. and Khan, M.M.A. (2014) Productivity Enhancement through Reduction of Changeover Time by Implementing SMED Technique in Furniture Industry. *International Journal of Industrial and Systems Engineering*, **17**, 15-33. https://doi.org/10.1504/IJISE.2014.060820

[5] Moreira A.C., Campos, G. and Pais, S. (2011) Single Minute Exchange Die (SMED): A Sustainable and Well-Timed Approach for Bangladeshi Garments Industry. *Journal of Technology Management & Innovation*, **6**, 129-146. https://doi.org/10.4067/S0718-27242011000100011

[6] Bin Che Ani, M.N. and Bin Shafei, M.S.S. (2014) The Effectiveness of the Single Minute Exchange of Die (SMED) Technique for the Productivity Improvement. *Applied Mechanics and Materials*, **465-466**, 1144-1148. https://doi.org/10.4028/www.scientific.net/AMM.465-466.1144

[7] Sahin, R. and Kologlu, A. (2022) A Case Study on Reducing Setup Time Using SMED on a Turning Line. *International Journal of Engineering & Technology*, **35**, 60-71. https://doi.org/10.35378/gujs.735969

[8] Karim, R. (2013) Impact of Changeover Time on Productivity: A Case Study. *Gazi University Journal of Science*, **13**, 42-48.

[9] Costa, E., Sousa, R.M, Bragança, S. and Alves, A.C. (2013) An Industrial Application of the SMED Methodology and Other Lean Production Tools. *Proceedings of the* 4*th International Conference on Integrity, Reliability, and Failure*, Funchal, Madeira, 23-27 June 2013, 1-8.

[10] Pattaro Jr., R.G., Inácio, R.H., da Silva, I.B., Hassui, A. and Barbosa, G.F. (2022) A Novel Framework for Single-Minute Exchange of Die (SMED) Assisted by Lean Tools. *International Journal of Advanced Manufacturing Technology*, **119**, 6469-6487. https://doi.org/10.1007/s00170-021-08534-w

[11] Silva-Castro, D., Campoblanco-Carhuachin, R. and León-Chavarri, C. (2022) Production Management Model to Reduce Non-Fulfillment of Orders in Peruvian Garment SMEs through 5S, SMED, and Standardization Tools. *Proceedings of the* 2nd *LACCEI International Multiconference on Entrepreneurship, Innovation, and Regional Development—LEIRD 2022*, Bogota, Colombia, 6-7 December 2022, 1-8. https://doi.org/10.18687/LEIRD2022.1.1.73

[12] Hossain, M.M., Khan, S.A., Islam, S.S., Fattah, J. and Rahman Bipul, M. (2018) SMV and Lead Time for T-Shirt Manufacturing. *American Journal of Engineering Research* (*AJER*), **7**, 21-25.

[13] Díaz-Reza, J.R., García-Alcaraz, J.L., Mendoza-Fong, J.R., Martínez-Loya, V., Macías, E.J. and Blanco-Fernández, J. (2017) Interrelations among SMED Stages: A Causal Model. *Complexity,* **2017**, Article ID: 5912940. https://doi.org/10.1155/2017/5912940

[14] Pellegrini, S., Shetty, D. and Manzione, L. (2012) Study and Implementation of Single Minute Exchange of Die (SMED) Methodology in a Setup Reduction Kaizen. *Proceedings of the* 2012 *International Conference on Industrial Engineering and Operations Management*, Istanbul, Turkey, 3-6 July 2012, 2353-2363.