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Time and Method Study Analysis to Improve Productivity of Shirt Manufacturing for Case of JP Garment

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Abstract: Productivity is crucial for global market competitiveness, requiring higher labor and machine efficiency. In the case company, the line efficiency of the shirt sewing line is below the target due to the unbalanced workload distribution and inappropriate working methods. This paper focused on integrating line balancing techniques and method study to improve the efficiency of shirt sewing lines. Method analysis was applied to bottleneck operations to minimize non-value-adding activities performed by operators. Cycle time for all operations was computed after performing adequacy and uniformity tests for time study data. Next, the researcher performed a method analysis on four operations that had bottlenecking behavior using video analysis. A flow process chart and precedence diagram were developed. A flow process chart was used to analyze which event is value-adding, or non-value-adding. The stopwatch time for sleeve attaching operation shows 62 seconds but the Garment Sewing Data is 46 seconds and the delay time is 16 seconds. This can be improved by revising the working method and this study achieved a savings of 13 seconds by eliminating non-value-adding activities. The second sewing operation analyzed was an armhole outline and savings of 14 seconds were gained. The third operation that was analysed was cuff attaches and a saving of 14 seconds was gained and the last was bottom hem outline to gain a saving of 12 seconds.

Keywords: Method study analysis, non-value-adding activities, stopwatch time

1. Introduction

In any apparel sector, productivity is one of the key performance indicators. Experts developed several proven methods for improving productivity and identified several causes for productivity reductions. As a result, selecting and applying an appropriate intervention is essential. The production of the garment passes a series of phases. The conversion of the fabric to the final product in the garment production sewing process is complex among the other processes. One way to calculate productivity is to divide output by one of the production factors. Work study could be a way to increase the company's production by getting rid of waste and unproductive procedures. It identifies non-value-adding operations by examining every factor affecting the process. Method studies and work measurements are included in time and motion study analysis. (Subhashini, 2021) .

Using work measurement tools, standard processing timings are measured and are crucial to effective production management. One popular method for measuring work in repetitive manufacturing processes is time study. The current study employed the time study technique to increase a clothing production line's productivity. The time spent doing the various motions of a work or group of jobs is analyzed in a time-and-motion study, which is used to assess industrial performance. Early in the 20th century, time-and-motion studies were first implemented in American offices and factories (Tanvir, 2019).

JP Garment Ethiopia PLC is a large garment plant in Hawassa Industrial Park (HIP) that manufactures shirts for the global market. The most popular product and one that is produced in greater quantity than others is the medium-

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sized long-sleeve shirt. With the growing client demand for medium-sized long-sleeve shirts, the company intends to raise daily production to 875 pieces. Nevertheless, line number seven is the one, which produces less than half of the desired outcome which is an average daily production of 471 pieces. Therefore, the efficiency of the line is calculated as 43.4 %. This indicates the line is inefficient to meet the target. As evidenced during data collection there is a larger number of waiting items on some workstations. Some operations require substantially more time to produce in real terms than the standard time allotted in their GSD. This issue indicates that the problem is caused due to the involvement of some unnecessary activities being performed by the operators. To eliminate unnecessary activities performed by the operator from such operations, time and method study analysis was used by recording the video and analyzing it. As a result, this research aimed to improve the efficiency of the line by conducting a time and method study on bottlenecking operations.

The ultimate objective of this study is to enhance the productivity of the shirt sewing line through time and method study analysis. The following specific objectives were identified to meet the general objective of the study.

- To calculate the stopwatch time of operations of the sewing line using the time study method.
- To identify bottleneck operations on the sewing line by comparing the stopwatch time with the GSD time.
- To identify non-value-adding activities using time–motion study analysis and flow process chart.

2. Literature Review

Determining a job's standard time using a predetermined method is the focus of work measurement. Standard time is the amount of time needed by a skilled and trained operator to finish a task while working at a consistent yet efficient pace using a particular combination of tools, equipment, workplace setup, and working conditions. Balancing manufacturing/production lines—that is, allocating an equal amount of work to workers and machine operators—is one of the key purposes of work measurement techniques, which promotes increased productivity. (ur Rehman, 2019).

2.1 Time Study

Through time study, Ur Rehman (2019) increased average machine productivity by 36% and concluded that time study is a useful method for enhancing productivity in the clothing manufacturing industry. Additional benefits, such as balanced production lines, optimized material flow, and less work in process, were also accomplished. The apparel business is struggling to improve garment quality and production to remain successful in the highly competitive market. The sustainability and profitability of the clothing industry are determined by its productivity. The production of clothing involves several tasks that operators perform at various locations. To reach the required productivity, all of these tasks must be completed on time, in synchrony, and according to a plan. The finding from Jadhav (2017) shows that the timely supply of pieces and order sheets plays a vital role in improving the productivity of the industry.

In the time study, Standard Minute Value (SMV) has been calculated for each operation or job. Based on this technique each operator's capacity is measured and balanced to eliminate the bottlenecks. Here, by applying these techniques significant improvements in the sewing section have been achieved such as SMV, manpower, bottleneck, capacity achievable, production/hr, performance rating, balance %, and line efficiency (Nabi, 2015).

One of the fastest-paced production environments is the apparel business, where accuracy and speed are essential to satisfying demand from customers throughout the world. Cycle time, which is the total amount of time required to produce a single piece of a product, is crucial to meeting the speed factor. Achieving production line balance requires maintaining a suitable cycle time. Kurnianingtias's (2024) study compares the actual and standard cycle times to assess the cycle time of men's jacket production on a sewing line in the Indonesian garment sector. There were four notable differences between the actual and standard cycle times, ranging from 16% to 95%. These

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differences showed that the actual cycle time was much longer. To comprehend the issue from each factor and sub-factor, the Fishbone and Five Whys analyses were used to determine the underlying reason for the longest cycle time. After six improvement action plans were put into place, the actual cycle time decreased by 57.81%, from 127.66 seconds to 53.85 seconds, which is 17.66% faster than the normal cycle time. Additionally, the hourly total output went from 12 pieces to 38 pieces, an increase of almost 216.67%.

2.2 Method Study

Method study is the process of systematically documenting and analyzing methods to improve them. It examines current work practices to identify areas for improvement to enhance productivity. To accomplish the goals of simplifying or eliminating the task, removing unneeded motions, reducing inherent work content, and engineering the operation, method study finds an appropriate and better way to operate. By implementing method study as one of the work-study techniques, Muqaddim, (2021) improves athletic shirt productivity to 300 pcs/hour from 257 pcs/hour.

In the apparel sector to improve productivity and quality one must concentrate on machine, method, material, and man. So, the industrial engineering concepts will cover and manage the all above said factors and help to improve the productivity as well as the quality of the products that will satisfy the consumer needs. This paper is going to discuss the existing (manufacturing) methods in apparel units and help them to improve productivity by applying recent techniques such as Capacity Study, Work study, Time study, Operator Performance, Follow-ups, Work-in-Progress, and line balancing they are already proven techniques to improve the productivity in different industries (Mekala, 2021).

To increase productivity and efficiency, the garment industry began considering the use of modernization, various technical tools, and techniques in garment production. In order to increase productivity and quality, Rajput (2018) concentrated on time study, visual management, and work standard procedures. The efficiency increased by 8.07% once the aforementioned tools were put into use.

3. Material and Methods

To accomplish this research, a literature survey, data collection using the watch method, and data analysis using a flow process chart were conducted. Mostly a review of books and journal articles was performed to understand how industrial engineering like time study and method study analysis improves line efficiency. The operation breakdown of the garment production system was reviewed to know how each elemental activity was performed on the sewing line, daily production reports were also used to analyze the actual productivity of the case company. The collected data was analyzed using the formulas that are related to the actual cycle time. During the analysis of data, Microsoft Office Excel is used to document the raw data and it is used to present the result of the data through different tables. Video camera recording was performed to conduct a motion study. A flow process chart was used in the method study analysis to represent the necessity of each motion performed by the operators.

$$\text{Line efficiency} = \frac{\text{Output} * \text{SMV}}{\text{number of operators} * \text{available working minutes}}$$

4. Data Analysis and Discussion

China Hong Kong, the mother business of JP Garment business (JP), was founded by the Chinese government in December 2019 at Ethiopia's Hawassa Industrial Park, which spans 5500 square meters. The enterprise is located in Hawassa, which is about 270 kilometers south of Addis Ababa.

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4.1 Process Flow of Shirt Sewing Line

Cutting sections, small-part preparation, front- and back-part preparation, assembly sections, and finishing sections for final inspection and packing comprise the shirt production plant.

4.2 Time study data

The goal of the time study approach was to determine a defined rate of performance as well as the amount of time that a competent worker could complete a given task under specific circumstances. Operations in the sewing line were observed and its processing time was measured 15 times. The time study was conducted by the stopwatch method.

4.3 Uniformity test of time study data

This test is intended to examine whether or not the collected data is homogeneous or uniform. Before using data, it is necessary to determine whether the data was consistently used to establish the standard time for an operation. It assesses uniformity using the upper control limit (UCL) and lower control limit (LCL). It was determined as below at a confidence interval of 95% with multiplier variable (K=1.96)

Therefore, the uniformity of the whole operation concerning its time study data can be shown below:

Table 1. Uniformity test for time study data

No	opr.code	mean(X)	std	UCL	LCL	status	No	opr.code	Std	UCL	LCL	status
1	A07	14.1	0.961	16	12	uniform	19	C21	1.438	18	12	uniform
2	A09	22.9	1.885	27	19	uniform	20	C22	1.907	27	19	uniform
3	A08	30	2.673	35	25	uniform	21	C12	1.740	21	14	uniform
4	A06	20.9	2.066	25	17	uniform	22	A11	2.498	37	27	uniform
5	A05	9.3	0.884	11	8	uniform	23	A03	2.299	28	18	uniform
6	C32	15.1	1.407	18	12	uniform	24	A04	1.668	20	14	uniform
7	C33	24.3	1.486	27	21	uniform	25	A10	2.549	32	22	uniform
8	C34	9.5	0.834	11	8	uniform	26	B01	2.560	43	33	uniform
9	C35	8.7	0.816	10	7	uniform	27	B02	2.384	35	26	uniform
10	C11	12.9	1.280	15	10	uniform	28	C13	1.668	25	18	uniform
11	A12	25.5	2.031	29	22	uniform	29	B03	1.407	65	59	uniform
12	A13	13.3	1.175	16	11	uniform	30	B04	0.990	63	59	uniform
13	C15	15.6	1.352	18	13	uniform	31	B05	2.264	57	48	uniform
14	C24	6.3	0.617	8	5	uniform	32	B06	2.295	39	30	uniform
15	C25	6.3	0.617	8	5	uniform	33	B07	3.441	50	36	uniform
16	C14	19.5	1.922	23	16	uniform	34	B08	1.846	61	53	uniform
17	A01	15.9	1.552	19	13	uniform	35	B09	1.280	25	20	uniform
18	A02	17	1.604	20	14	uniform	36	B10	1.767	62	55	uniform

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Based on the uniformity test the record time of each operation was found between the upper control limit (UCL) and lower control limit (LCL) in the above table.

Existing production line data

- The total process time for long sleeve shirt is 16 minutes
- Number of operators assigned = 35
- Production target per line per shift = 875 shirts (85% efficiency)
- Average actual production per shift per line = 471 shirts

The longest standard time specified in General Sewing Data (GSD) is 53 seconds (side seam stitch). From the time study, four operations took longer time than 53 seconds to complete, and the waiting for parts online. Therefore, these operations are used in method study analysis. For this research, we should take the company's target as the theoretical output (875 pcs).

The average output of line #7 was 471 pcs per day which is lower than the target.

Existing line efficiency = $\frac{Output*SMV}{number\ of\ operators*available\ working\ minutes} = \frac{471*16min}{35*480} * 100\% = 43.4\%$

From the above information, we can understand that actual production is less than the planned production. Therefore, it needs some interventions to enhance the productivity of the line. One of the popular industrial engineering techniques used to enhance the productivity of sewing method study analysis.

4.4 Method Analysis of Bottleneck Operations

By capturing video and analyzing it, the labor movement and working methods are examined, which helps to identify processes that may be enhanced throughout the time measurement. The first step in conducting a method analysis is selecting where to undertake it. In this research, four operations were selected because they exhibited bottlenecking behavior. During analyses of the operation with the use of video, there was a presence of activities carried out by the operators that did not bring value. The operations addressed within the scope of method analysis are: sleeve attach, armhole outline, cuff attach, and bottom hem outline.

Table 2. Recorded Processing time of bottlenecking operations vs processing time in sheet

Activities	Recorded time of time study data (sec)	Standard time in GSD (sec)	Difference (sec)
Sleeve attach	62	46	16
Armhole outline	61	41	20
Cuff attach	57	43	14
Bottom hem outline	59	44	15

The inappropriate methods in attaching sleeves were the quality inspection process and the separation of some tasks that operators might complete concurrently with other operations. The Standard Operating Procedures (SOPs) prohibit the operator from performing inspections.

4.5 Creating a precedence diagram

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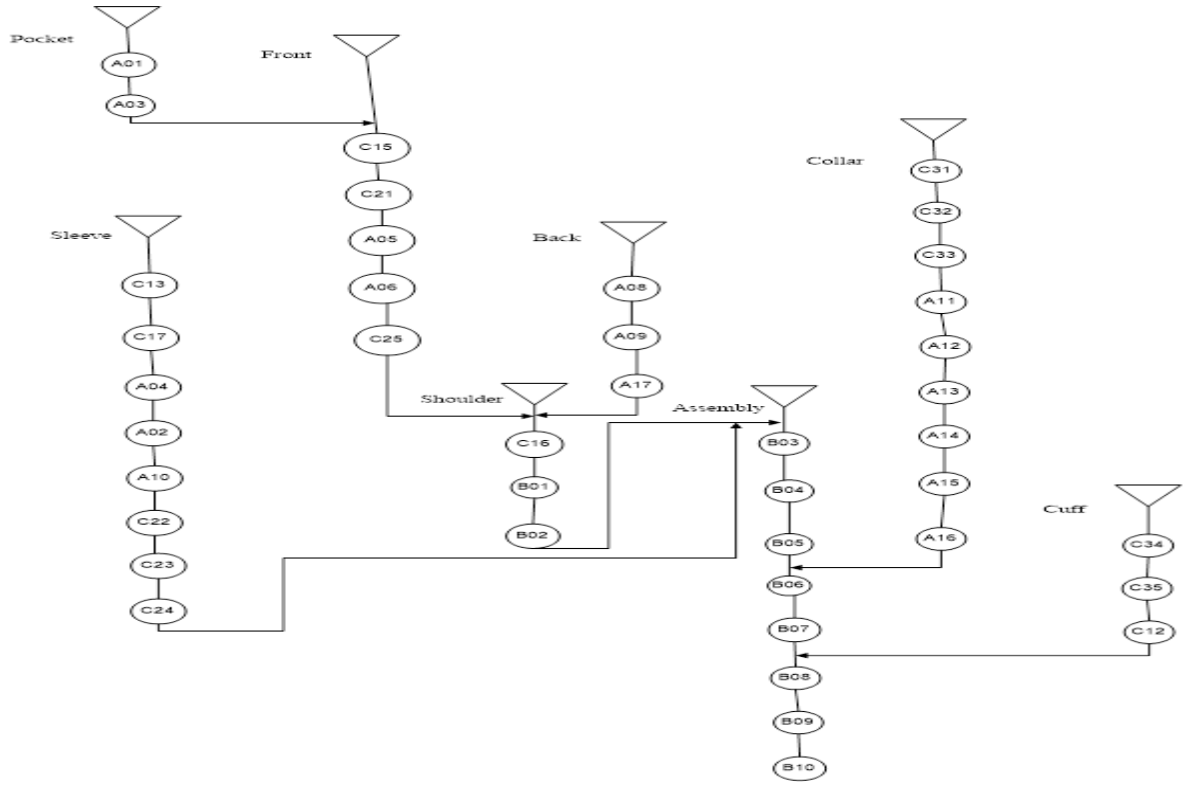

Figure 1. Process flow chart of shirt-making

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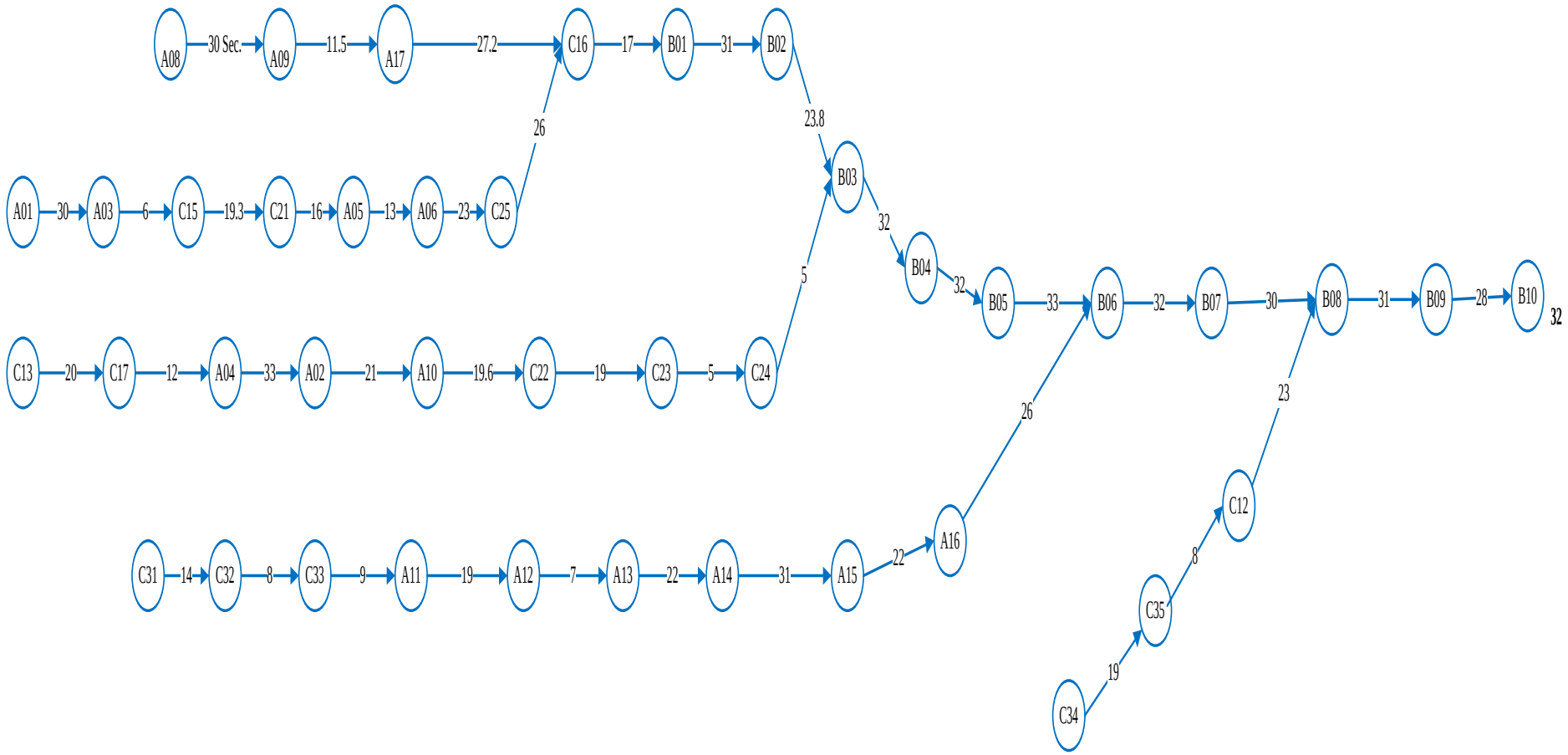

Figure 2. Precedence diagram of shirt making in JP garment

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4.6 Preparing flow process chart

Table 3. The present method for attaching the sleeve

Event description	Symbols	Time (s)	Description
Take a part from the left side box.	● ⇨ □ D ▽	2	Necessary
Put on the table of the machine	⬭ ⇨ □ D ▼	1	Unnecessary
Pick a left sleeve from the box on the right side	● ⇨ □ D ▽	2	Necessary
Match the sleeve with the armhole (parts)	● ⇨ □ D ▽	6	This can be done while pinning it to the machine
Adjust as needed after inserting it into the pressure foot.	● ⇨ □ D ▽	3	Necessary
Stitch the parts	● ⇨ □ D ▽	19	Necessary
Take the right sleeve from the box on the right side	● ⇨ □ D ▽	2	Necessary
Turn the right side of the part	● ⇨ □ D ▽	1	Necessary
Match the right sleeve to the right armhole	● ⇨ □ D ▽	4	This can be done while pinning it into to machine and adjusting
Place into the pressure foot and adjust	● ⇨ □ D ▽	2	Necessary
Stitch	● ⇨ □ D ▽	17	Necessary
Inspect	○ ⇨ ■ D ▽	2	Unnecessary
Dispose	● ⇨ □ D ▽	1	Necessary

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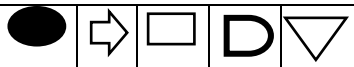
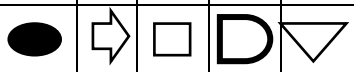
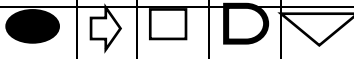
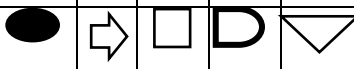
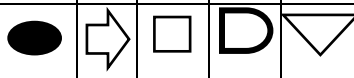
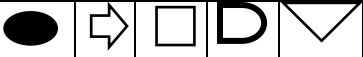
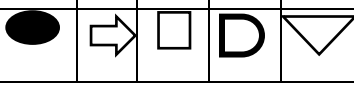
As we have observed in the above table some of the motions performed by operators are identified as non-value-adding and need to be avoided.

Table 4. Proposed method for sleeve attaching operation

Event description	Symbols	Time (Sec.)
Take a part from the box and put it into to pressure foot.		2
Take a sleeve from the box and match it with the part while adjusting the machine.		5
Stitch the left part while adjusting.		19
Turn the right part and put it on the pressure foot.		3
Pick the right sleeve from the box and match it with the right part in the machine while adjusting.		2
Stitch the right part while adjusting.		17
Dispose		1

The proposed method suggests that the manufacturing process can be focused on the value-adding activities and there is a chance to improve productivity.

Table 5. Comparison of the present and proposed method of sleeve attaching

Location: sewing line		Summary			
Activity: sleeve attach		Event	Present	Proposed	Saving (Sec.)
Date: 25/5/2023		Operation	59	49	10
Operator: Manaye	Analyst: Kefitaw	Transport	-		
Circle the appropriate method and type		Inspection	2	0	2
Method: proposed (present)		Delay	1	0	1

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Type: worker material machine	Storage	-		
	Time	62	49	13

Table 6. The present method of armhole outline

Event description	Symbols	Time	
Take the part from the table.		1	Necessary
Find the side to be outlined		6	Unnecessary
Pin in to pressure foot and adjust		2	Necessary
Stitch while adjusting the direction		22	Necessary
Turn the other side while adjusting		2	Necessary
Stitching		19	Necessary
Inspect the quality and trim		8	Unnecessary
Dispose		1	Necessary

In the process of the armhole outline, there are some operations done by operators that are not necessary to be done by operators based on SOP. Inspection and trimming of fabrics were repeatedly seen during the examination of the method.

Table 7. The proposed method for armhole outline

Event description	Symbols	Time
Take the part from the box insert it into the pressure foot and adjust.		3
Stitch while adjusting the direction		22

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Turn the other side while adjusting.	●	⇨	□	D	▽	2
Stitching	●	⇨	□	D	▽	19
Dispose	●	⇨	□	D	▽	1

The proposed method suggests that the manufacturing process can be focused on the value-adding activities and there is a chance to improve productivity. In this operation, a saving of 14 seconds was achieved and this time can be changed effective time.

Table 8. Comparison between the present and proposed method of armhole outline

Location: sewing line		Summary			
Activity: Armhole outline		Event	Present	Proposed	Saving (Sec.)
Date: 26/5/2023		Operation	53	47	6
Operator: Genet	Analyst: Kefitaw	Transport	-	-	
Circle the appropriate method and type.		Inspection	8	0	8
Method: (present) proposed		Delay	-	-	
Type: (worker) material machine		Storage	-	-	
		Time	61	47	14

4.7 **Present Method for Cuff Attaching Operation**

Table 9. Present Method for Cuff Attaching Operation

Event description	Symbols					Time (Sec.)	Description
Take the sleeve part of the shirt.	●	⇨	□	D	▽	2	Necessary
Take a piece of cuff	●	⇨	□	D	▽	2	Necessary

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Check for notches and match the cuff to the notches of the sleeve						6	This can be done while placing the cuff with the fused side of the sleeve
Place the cuff fused side up on the inner side of the sleeve						3	Necessary
Stitch just below the edge of the cuff						16	necessary
cut the thread						2	Unnecessary
Straighten the cuff						3	Unnecessary
Put the excess fabric inside the cuff and put stitches at the edge						19	Necessary
Inspect quality						3	Unnecessary
Dispose						1	Necessary

Here, some non-value-adding motions were performed by operators.

Table 10. Proposed Method for Cuff Attaching Operation

Event description	Symbols					Time (Sec.)
Take the sleeve part of the shirt.						2
Take a piece of cuff.						2
Place the cuff fused side up on the inner side of the sleeve.						3
Stitch just below the edge of the cuff						16
Put the excess fabric inside the cuff and put stitches at the edge.						19
Dispose						1

The proposed method suggests that the manufacturing process can be focused on value-adding activities and there is a chance to improve productivity. In this operation, a saving of 14 seconds was also achieved and this time can be changed to effective time.

Table 11. Comparison between the present and proposed method of cuff attaching operation

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Location: Sewing line		Summary			
Activity: Cuff attaching Operation		Event	Present	Proposed	Saving (Sec.)
Date: 27/5/2023		Operation	54	43	11
Operator: Tewabech	Analyst: Kefitaw	Transport	-	-	
Circle the appropriate method and type.		Inspection	3	0	3
Method: (present) proposed		Delay	-	-	
Type: (worker) material machine		Storage	-	-	
		Time	57	43	14

4.8 Present method for bottom hem outline

Table 12. The present method for bottom hem outline operation

Event description	Symbols	Time (Sec.)	
Take apart	● ⇨ □ D ▽	2	Necessary
Fold the bottom (as per requirement)	● ⇨ □ D ▽	5	This can be done while putting it into the pressure foot
Put in the pressure foot	● ⇨ □ D ▽	3	Necessary
put edge stitch from the left front side to the right side	● ⇨ □ D ▽	40	Necessary
Match the two ends	● ⇨ □ D ▽	3	Unnecessary

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Inspect quality	⬭	⇨	■	D	▽	4	Unnecessary
Dispose	●	⇨	□	D	▽	2	Necessary

Here, some non-value-adding motions were performed by operators and we need to revise the method.

Table 13. The proposed method for bottom hem outline operation

Event description	Symbols					Time
Take a shirt and fold the bottom as per the requirement.	●	⇨	▭	D	▽	2
Put into pressure foot.	●	⇨	▭	D	▽	3
put edge stitch from the left front side to the right side	●	⇨	▭	D	▽	40
Dispose	●	⇨	▭	D	▽	2

The proposed method suggests that the manufacturing process can be focused on the value-adding activities and there is a chance to improve productivity. In this operation, a saving of 12 seconds was also achieved and this time can be changed to effective time.

Table 14. Comparison between the present and proposed method for bottom hem outline

Location: sewing line		Summary			
Activity: Bottom hem outline Operation		Event	Present	Proposed	Saving (Sec.)
Date: 28/5/2023		Operation	55	47	8
Operator: Belaynesh	Analyst: Kefitaw	Transport	-	-	-
Circle the appropriate method and type.		Inspection	4	0	4

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Method: present proposed Type: (worker) material machine	Delay	-	-	-
	Storage	-	-	-
	Time	59	47	12

By using method analysis 53 seconds were saved by avoiding unnecessary activities and techniques.

5. Conclusion

This study aimed to improve line efficiency using time and method study analysis in the JP Garment of Hawassa Industrial Park. To perform the method study analysis, stopwatch time was recorded and compared with the General Garment Data (GSD) time for each of shirt making operations. Four operations of shirt making (sleeve attaching, cuff attaching, armhole attaching, and bottom hem outline) consume time more than the GSD time.

To make these operations faster, a method study analysis was performed to identify and eliminate non-value-adding activities while performing. For sleeve attaching operation 13 seconds were saved by revising the working method and the operation will be completed within 49 seconds. The other operation that was analyzed was an armhole outline and a saving of 14 seconds were saved and the operation will be completed within 47 seconds. The third operation analyzed was the cuff attaching operation and a saving of 14 seconds was achieved and the operation will be completed within 43 seconds. The fourth operation analyzed was the bottom hem outline operation and the operation will be completed within 47 seconds with a saving of 12 seconds.

Therefore, performing a detailed and scientific method study analysis can eliminate non-value-adding activities to improve the productivity of garment industries.

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