P-ISSN: 2987-7261
E-ISSN: 2987-7253

Jurnal Riset Ilmu Teknik
Journal homepage: https://jurnaljepip.com/index.php/jurit
Vol. 4, No. 3, pp. 351-361, 2026
DOI: https://doi.org/10.59976/jurit.v4i3.459

JURIT

Analysis of Standard Times and Operator Requirements for the Sewing of IS 1200-900 Type FIBCs Using Time Study and Workload Analysis

Nabiilah Nur Khoiriyyah[1]*, Moh. Jufriyanto[2]
[1,2] Universitas Muhammadiyah Gresik, Gresik, Indonesia
*Correesponding Author: nabiilahnurkhoiriyyah17@gmail.com

ABSTRACT

This study was conducted on the sewing process of IS 1200-900 type Flexible Intermediate Bulk Containers (FIBCs) on Line 8 at PT X. During observations in July–August 2026, six operators produced 85 units per shift out of a target of 86 units. This study aims to determine standard times and standard rates, assess line capacity and each operator's workload, calculate the minimum number of operators required, and propose a task allocation plan. The processing time for 12 elements was measured with a stopwatch 30 times per element. Standard time was calculated with a 15% allowance and used in the Workload Analysis (WLA) to compare scenarios with six, seven, and eight operators. Normal time and standard time were 29.25 and 34.41 minutes per unit, respectively. The theoretical capacity for six operators is 86.15 units per shift based on standard time and 73.23 units per shift based on standard time. Actual production closely matches the estimate based on standard time. In this scenario, the target requires 99.83% of working time before the allowance is factored in. At the production target, the total workload reached 49.33 operator-hours per shift, while the available time was only 42 hours. The line's WLA reached 117.45%, with individual workloads ranging from 53.8% to 180.0%. Four operators were estimated to be overloaded. The seven-operator scenario still yields a line WLA of 100.67%, making eight operators the minimum requirement based on standard time, with an estimated line WLA of 88.08%. The proposed workload balancing divides the work volume among elements A6, A7, and A12 so that each operator's workload aligns with the available working time. In practice, the research results provide a basis for PT X to determine the number of operators per shift and to develop a task allocation plan before testing the design under actual production conditions.

Keywords: *Flexible Intermediate Bulk Container (FIBC), Stopwatch Time Study, Workload Analysis, Standard Time, Operator Staffing Requirements.*

This is an open-access article under the CC-BY license

Manuscript received 30 October, 2026; revised 24 November 2026; accepted 27 November, 2026.

INTRODUCTION

Line 8 at PT X is reported to produce 85 units per shift, while the company's target is 86 units per shift. This line sews IS 1200-900-type Flexible Intermediate Bulk Containers (FIBCs), which are large woven polypropylene containers. Six operators perform 12 sewing steps, ranging from attaching lifting straps to joining the top and bottom panels to the body of the container. Each operator has seven hours of available work time per shift. A one-unit shortfall from the target may seem small, but the company needs to determine whether this shortfall is due to insufficient work time across the entire line, a backlog of tasks for specific operators, or both. The answer to this question is necessary to decide whether tasks need to be redistributed, the number of operators needs to be increased, or both measures need to be taken.

Research on garment sewing lines shows that cycle times can be used to evaluate and improve task allocation. [1] divided tasks based on cycle time and then assigned operators according to their skill levels. In a shirt production simulation, this method helped reduce time discrepancies between workstations. [2] used stopwatch measurements to reorganize a denim pants sewing line while maintaining the same production target. Line efficiency increased from 70% to 80%. [3] expanded this approach by using real-time data during production to adjust operator assignments when order volume or garment type changed. All three studies demonstrate that both task duration and the method of task allocation are equally important. To apply this approach to FIBCs, the time for each sewing step must be measured on the specific products and production lines under study.

In jumbo bag production, [4] established standard times for belt manufacturing, while [5] internship report calculated standard times for the ten sewing steps of the MCCI PTGA-type FIBC. These two references provide a basis for time measurement, at the component level and the finished product level, respectively. A research gap evident in both references is the use of standard times to address two decisions simultaneously: how many operators are needed to meet a single production target per shift, and how the volume of each task should be allocated so that each operator's workload aligns with their working hours.

The novelty of this study lies in how the measurement results of the 12 sewing steps for the IS 1200-900 FIBC were translated into decisions regarding the number of operators and task allocation on Line 8. Processing times were measured with a stopwatch, and the standard times were then used in a Workload Analysis (WLA) to compare scenarios involving six, seven, and eight operators working toward the same target. When a single step requires more than seven hours to complete the entire target, the workload for that step is divided based on the number of bags. In this way, two or more operators can perform the same step on different bags.

This study aims to calculate the standard time and benchmark time for each sewing step, compare capacity based on these two time measures with actual production, and measure the percentage of the line's workload and that of each operator for a target of 86 units per shift. The measurement results are used to estimate the minimum number of operators and to formulate a proposed task allocation. The practical contribution to PT X is the provision of a basis for determining the number of operators per shift, identifying tasks that need to be divided, and developing a task allocation plan to be tested on the production line.

METHOD

Research Design and Data Collection

This study employed a descriptive quantitative approach to examine the sewing process for the IS 1200-900 Flexible Intermediate Bulk Container (FIBC) on Line 8 at PT X. A stopwatch time study was conducted to determine the normal and standard sewing times. The standard times were then used in a Workload Analysis (WLA) to assess the workload of the line and each operator at a production target of 86 units per shift and to estimate the minimum staffing requirement.

Observations were conducted from July to August 2026 during the 07:00–15:00 shift (Western Indonesian Time). The sewing process was divided into 12 work elements, labeled A1 through A12. Each element was timed 30 times with a stopwatch, and the durations were recorded in seconds. The analysis used the work assignments of the six existing operators, an available working time of 7 hours (25,200 seconds) per operator per shift, and records of target and actual production.

Data Adequacy and Uniformity

Data adequacy was assessed for each work element by comparing the number of observations collected with the required sample size [6], [7]. The latter was calculated using Equation (1).

$$N_i' = \left\lceil \frac{K}{e} \frac{\sqrt{N_i \sum_{j=1}^{N_i} x_{ij}^2 - \left(\sum_{j=1}^{N_i} x_{ij}\right)^2}}{\sum_{j=1}^{N_i} x_{ij}} \right\rceil^2 \quad (1)$$

Here, x_ij is the duration of observation j for element i, N_i is the number of observations collected, N_i' is the required sample size, K=2 is the coefficient used in the calculation, and e is the relative precision level. The data were considered adequate when N_i'≤ N_i. Both 5% and 10% precision levels were evaluated. The main analysis used the 10% level because 30 observations were insufficient for five elements at the 5% level.

Data uniformity was assessed by comparing the observed durations of each element with its upper and lower control limits [8].

$$UCL_i = \bar{x}_i + 2s_i, \qquad LCL_i = \bar{x}_i - 2s_i \quad (2)$$

Here, bar{x}_i and s_i are the sample mean and sample standard deviation of the observed durations for element i, respectively. The observations for an element were classified as uniform if all recorded durations fell within its control limits [9], [10].

Determination of Normal and Standard Times

The observed cycle time for each element was calculated as the average of its recorded durations. Normal time was obtained by multiplying the cycle time by the Westinghouse performance rating factor, which accounts for skill, effort,

working conditions, and consistency. All operators were rated Average (D) on these four factors, resulting in a performance rating factor of 1.00 for each element [11], [12].

$$W_{s,i} = \frac{1}{N_i}\sum_{i=1}^{N_i} x_{ij}, \qquad W_{n,i} = W_{s,i} \times PR_i \tag{3}$$

Here, W_s,i is the observed cycle time, W_n,i is the normal time, and PR_i is the performance rating factor for element i.

A total allowance of 15% was applied. It consisted of 5% for personal needs, 4% for basic fatigue, 2% for standing, 2% for environmental conditions, and 2% for the level of attention required. The standard time for each element was first calculated per occurrence and then multiplied by the number of occurrences per finished unit [13], [14].

$$w_{b,i} = \frac{W_{n,i}}{1-a}, \qquad W_{b,i} = f_i w_{b,i}, \qquad W_B = \sum_{i=1}^{12} W_{b,i} \tag{4}$$

Here, a = 0.15 is the allowance, w_{b,i} is the standard time per occurrence, f_i is the number of occurrences of element i per unit, and W_B is the total standard labor time required to sew one unit. Element A4 was performed twice per unit because each FIBC required two top belt rings. Each of the other elements was performed once per unit.

Estimation of Production Capacity

The theoretical line capacity was estimated by dividing the total available operator time by the standard labor time per unit [15], [16]. The equivalent capacity of one operator and the line capacity with *m* operators were calculated as follows.

$$C_{eq} = \frac{H}{W_B}, \qquad C_m = \frac{mH}{W_B} \tag{5}$$

H is the available working time per operator per shift. The estimated line capacity, expressed in units per shift, was compared with the production target. The estimate assumes that work can be allocated among operators within their individual time limits.

Workload Analysis by Element, Operator, and Line

The workload for each element was calculated by multiplying its standard time per finished unit by the production target of Q = 86 units per shift. The total line workload was obtained by summing the workloads of all elements [17].

$$B_i = QW_{b,i}, \qquad B_L = \sum_{i=1}^{12} B_i \tag{6}$$

B_i is the workload of element i, and B_L is the total line workload, both expressed in labor seconds per shift. These values were divided by 3,600 to obtain labor hours. Each element's share of the total workload was calculated as 100% × B_i/B_L.

The workload of each operator was calculated based on the elements assigned to that operator. Let p_ik denote the proportion of the required volume of element i assigned to operator k [18], [19]. The operator workload and the WLA percentages for each operator and the line were calculated using Equation (7).

$$B_{OP,k} = \sum_{i=1}^{12} p_{ik} B_i, \qquad WLA_{OP,k} = \frac{B_{OP,k}}{H} \times 100\backslash\%, \qquad WLA_L(m) = \frac{B_L}{mH} \times 100\% \tag{7}$$

Under the existing assignments, p_ik = 1 if operator k performed element i on all units, and p_ik = 0 if it was assigned entirely to another operator. A WLA above 100% indicated that the workload exceeded the available time. A WLA of 100% indicated that the workload fully occupied the available time [20], [21].

Sensitivity Analysis and Comparison with Actual Production

The sensitivity analysis evaluated four scenarios using the shortest observed times, normal times with a 0% allowance, standard times based on the mean observed times, and the longest observed times. The shortest- and longest-time scenarios combined the minimum and maximum observations, respectively, from each work element to represent theoretical extremes. Element frequencies and performance rating factors were held constant across all scenarios. The 15% allowance was applied to all scenarios that used standard times. The total labor time per unit in each scenario was used to recalculate production capacity, line WLA, and the minimum staffing requirement.

Actual production was also compared with the capacities estimated from standard and normal times. The labor time per unit implied by actual output with six operators was calculated as follows [22].

$$W_impl = 6H/Q_actual \quad (8)$$

RESULTS

Data Adequacy and Uniformity

Before standard times were calculated, the adequacy and uniformity of the measurement data for each sewing element were examined. Table 1 presents the average duration, standard deviation, number of observations required, and upper and lower control limits for the 12 work elements.

Table 1. Results of the Adequacy and Uniformity Test for Data on 12 Work Elements

Element	Mean (s)	Std. dev.	N'	BKA	BKB
A1 Tying tape at the bottom of the spout	30.43	3.22	4.34	36.88	23.99
A2 Kikuwari + bottom panel tying rope	90.03	22.50	24.15	135.03	45.03
A3 Bottom Flap + bottom spout	79.90	7.14	3.09	94.18	65.62
A4 1 Ring top belt on hanging belt	40.27	7.46	13.27	55.19	25.35
A5 2 Hanging belt + holding rope	133.93	17.01	6.24	167.95	99.92
A6 Joint between bottom panel and main body	273.30	32.98	5.63	339.27	207.33
A7 4 S, Reinforcement + 2 CCL hanging belts	367.90	73.00	15.22	513.90	221.90
A8 Circular Belt middle main body	185.77	47.88	25.69	281.53	90.00
A9 Tying tape for spout top	30.17	3.40	4.93	36.98	23.36
A10 Kikuwari + tying rope on the top panel	104.77	3.30	0.38	111.36	98.17
A11 Top spout on the top panel	82.00	7.04	2.85	96.07	67.93
A12 Top panel joint + main body	296.40	77.24	26.26	450.89	141.91

At a 10% confidence level, 30 observations are sufficient for all elements. The highest requirement is for A12, at 26.26 observations, followed by A8 at 25.69 and A2 at 24.15. These three elements also have the greatest relative variation. Their standard deviations reach approximately 25–26% of the average processing time, compared to about 3% for A10. This difference indicates that the durations of A12, A8, and A2 vary more significantly across units. If measurements are continued at a higher precision level, these three elements should be prioritized for additional observations.

Performance Rating, Standard Time, and Actual Time

The standard time for each element is adjusted to account for a 15% work allowance and the frequency of its execution on a single FIBC unit. Table 2 shows the standard time per operation, the frequency of each element, and the standard time required to complete a single unit.

Table1. Table of Normal Times and Standard Times per Work Element

Element	Normal time (s)	Frequency	Standard Time (s)
A1	30.43	1	35.80
A2	90.03	1	105.92
A3	79.90	1	94.00
A4	40.27	2	94.75
A5	133.93	1	157.57
A6	273.30	1	321.53
A7	367.90	1	432.82
A8	185.77	1	218.55
A9	30.17	1	35.49
A10	104.77	1	123.25
A11	82.00	1	96.47
A12	296.40	1	348.71

Element	Normal time (s)	Frequency	Standard Time (s)
Total			2,064.86

After accounting for the work frequency, the standard total sewing time is 29.25 minutes per unit. Applying the allowance increases this time to 34.41 minutes, or an increase of 5.16 minutes. Frequency also affects the time required for element A4. Installing one top belt ring has a standard time of approximately 47.37 seconds, while installing two rings takes 94.75 seconds per unit. Based on the total standard time and the available 42 cumulative working hours, the theoretical capacity of six operators is 73.23 units per shift. This capacity is equivalent to 85.15% of the 86-unit target.

Production Capacity

With six operators and 42 cumulative working hours per shift, the theoretical production capacity for sewing FIBC IS 1200-900, based on a standard time of 34.41 minutes per unit, is 73.23 units per shift. This capacity is equivalent to 85.15% of the target of 86 units, resulting in a shortfall of 12.77 units. This means that the available working time on the line is insufficient to meet the target if the planning uses standard time that already includes a 15% allowance.

The actual production of 85 units per shift is closer to the capacity calculated based on standard time, which is 86.15 units per shift. This proximity indicates that capacity estimates are significantly influenced by the allowance factored into the calculation. The use of this allowance during the shift needs to be traced through work time records and actual assignments so that the cause of the discrepancy between theoretical capacity and actual output can be explained.

Workload Analysis

To achieve the target of 86 units per shift, the sewing line requires 49.33 hours of operator work, while the six operators provide 42 hours. The cumulative shortfall of 7.33 hours results in a line WLA of 117.45%. The workload is also uneven. Four operators have a WLA above 100%, with the highest value at OP 3 at 180.0%. The remaining available time for OP 1 and OP 2 is only 4.60 hours, while the total overload for the other four operators reaches 11.93 hours. Thus, task reassignment could reduce the imbalance, but the six operators still do not provide enough time to meet the target based on standard time.

OP 3's assignment pattern also helps explain the limits of the line's estimated capacity. If OP 3 were to handle all elements of A4 and A7 for 85 units, these two tasks would be estimated to take 10.59 hours, even under normal conditions without any buffer time. Since each operator has only 7 hours of work time, the recorded task allocation needs to be reconciled with the actual assignments during the shift that produced 85 units. This verification is essential to ensure that the proposed number of operators accounts for both sufficient line time and a manageable workload for each operator.

The standard time per unit is multiplied by the production target to determine the time required for each element in a single shift. Table 3 shows the workload for each element and its proportion of the total sewing workload.

Table 2. Table of Workload Per Element at A Target Of 86 Pcs/Shift

Element	Standard Time (s)	Workload (s/shift)	Workload (hours)	Portion
A1	35.80	3,079.14	0.86	1.73%
A2	105.92	9,109.25	2.53	5.13%
A3	94.00	8,084.00	2.25	4.55%
A4	94.75	8,148.08	2.26	4.59%
A5	157.57	13,550.90	3.76	7.63%
A6	321.53	27,651.53	7.68	15.57%
A7	432.82	37,222.82	10.34	20.96%
A8	218.55	18,795.22	5.22	10.58%
A9	35.49	3,052.16	0.85	1.72%
A10	123.25	10,599.92	2.94	5.97%
A11	96.47	8,296.47	2.30	4.67%
A12	348.71	129,988.71	8.33	16.89%
Total	2,064.86	177,578.20	49.33	100%

Elements A7, A12, and A6 account for 26.35 of the total 49.33 operator hours per shift, or 53.42% of the total sewing workload. For a target of 86 units, these three elements require 10.34 hours, 8.33 hours, and 7.68 hours, respectively. Each of these values exceeds the 7 hours of work time available to a single operator. Therefore, the workload for these three elements must be divided among operators so that all units can be processed in a single shift. Dividing the workload allows operators to work on the same element across different units.

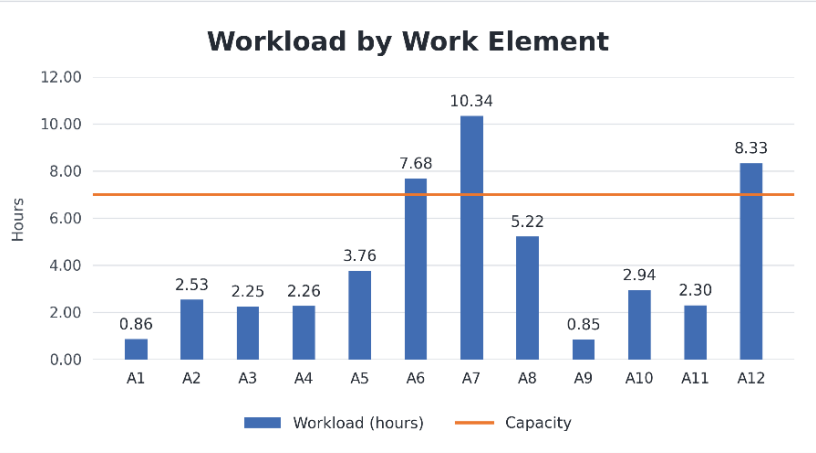

Figure 1. Workload Chart by Element

Workload Analysis Line

To achieve the target of 86 units per shift, the sewing line requires 49.33 hours of operator work time. Six operators each have a 7-hour work shift, so the total available time is 42 hours per shift. This comparison results in a line WLA of 117.45%, meaning that the required work time exceeds the available capacity by 17.45%. The cumulative shortfall of 7.33 work hours per shift indicates that the current number of operators is insufficient to meet the production target based on standard time.

Workload Analysis Per Operator (Existing Assignments)

Based on Table 4, four out of six operators have a workload exceeding 100%. The highest workload is on OP 3 at 180.0% because the assignments for elements A4 and A7 require 12.60 working hours per shift. Meanwhile, OP 2 has the lowest workload at 53.8% with an assignment on element A5. This disparity indicates that the current distribution of work elements concentrates the workload on a few operators.

Table 3 . WLA per Operator Based on Existing Assignments

Operator	Element	Standard Time (s)	Workload (hours)	WLA	Category
OP 1	A1, A2, A3	235.73	5.63	80.4%	Normal
OP 2	A5	157.57	3.76	53.8%	Underload
OP 3	A4, A7	527.57	12.60	180.0%	Overload
OP 4	A6	321.53	7.68	109.7%	Overload
OP 5	A8, A10, A11	438.27	10.47	149.6%	Overload
OP 6	A9, A12	384.20	9.18	131.1%	Overload
Total		2,064.86	49.33	117.45%	

Four of the six operators had workloads above 100%, with the highest workload on OP 3 at 180.0%. Assigning tasks A4 and A7 to OP 3 required 12.60 hours per shift. Overall, the four overloaded operators required an additional 11.93 hours of work, while OP 1 and OP 2 had only 4.60 hours remaining. This discrepancy explains why reassigning tasks to operators with lower workloads can reduce imbalances, but still leaves a capacity shortfall on the line with six operators.

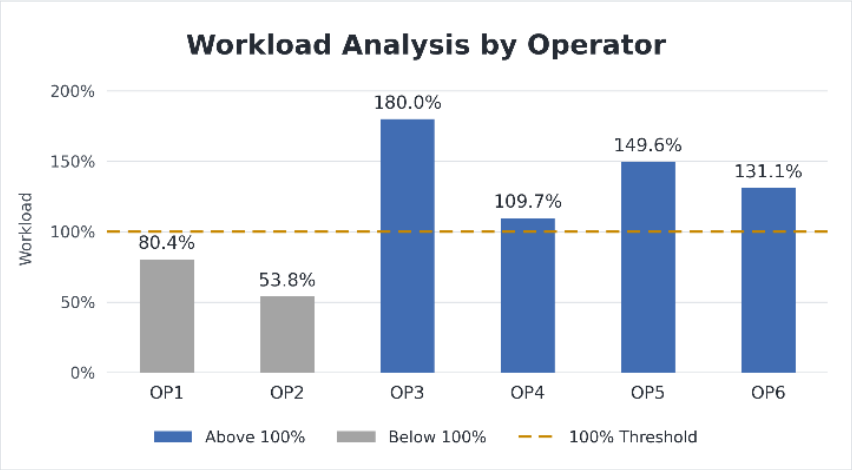

Figure1 . WLA Graph by Operator

Operator Requirements

Three operator-count scenarios were compared to determine the workforce size capable of handling the target workload of 86 units per shift. Table 5 presents the cumulative working hours and line workload percentage for each scenario.

Table 4 . Comparison Table of WLA for 6, 7, and 8 Operators

Scenario	Operators	Available Time (hours)	WLA	Conclusion
Existing	6	42	117.45%	Overload
Alternative	7	49	100.67%	Limit, without reserve
Proposal	8	56	88.08%	No overload; there is room for variation

Assigning seven operators still leaves a capacity shortfall equivalent to 0.05 operators. Although small, this shortfall makes achieving production targets more vulnerable to variations in processing time, particularly for elements A7, A8, and A12, which have relatively large standard deviations in processing time. With eight operators, the workload is estimated to drop to 88.08%, leaving a capacity reserve of approximately 12%. This finding aligns with study [8], which shows that adding one worker can reduce the workload from 108% to 86%. Study [9] also reports that production target achievement increased to 91% after adding two workers.

Overtime can also be used to compensate for capacity shortfalls, as suggested in study [2]. Under initial conditions, the additional time required amounts to 7.33 working hours per shift cumulatively, or about 17% of the total available working time. If done routinely, this amount of overtime has the potential to increase operator fatigue; therefore, it is more appropriate as a temporary measure. The economic feasibility of adding two operators still needs to be assessed through a cost analysis.

Workload Balancing Plan for 8 Operators

The results of the workload analysis (WLA) show that the average workload for eight operators is 88.08%. The total workload of 49.33 hours is equivalent to an average of 6.17 hours per operator, with a work capacity of 7 hours per operator per shift. Although this average is below capacity, work elements need to be reallocated so that each operator's workload remains within the 7-hour limit.

Three elements have workloads that exceed the capacity of a single operator: A7 (10.34 hours), A12 (8.33 hours), and A6 (7.68 hours). The workload for each of these elements is distributed among several operators based on the number of bags being processed. With this distribution, some operators may work on the same element across different bags.

The following table presents the proposed allocation of work elements according to the production process sequence. The "Portion" column shows the share of the total 86 bags handled by each operator for the relevant work element.

Table 5 . Work Element Allocation Table For 8 Operators

Operator	Element (portion)	Workload (hours)	WLA
OP-1	A1, A2, A3, A4 (24%)	6.17	88.1%
OP-2	A4 (76%), A5, A6 (9%)	6.16	88.1%
OP-3	A6 (80%)	6.17	88.1%
OP-4	A6 (11%), A7 (51%)	6.16	88.1%
OP-5	A7 (49%), A8 (22%)	6.17	88.1%
OP-6	A8 (78%), A9, A10 (42%)	6.17	88.1%
OP-7	A10 (58%), A11, A12 (26%)	6.16	88.1%
OP-8	A12 (74%)	6.17	88.1%

This design reduces work backlog by dividing the volume of elements that require a long time to complete. For example, the 51% share of A7 for OP 4 and 49% for OP 5 can be translated into 44 and 42 units, respectively, out of a target of 86 units. This division provides a basis for organizing assignments into units that can be directly applied on the production line. Each operator's workload must be recalculated after all portions are converted to unit counts. The feasibility of the design also depends on the availability of suitable sewing machines and the time required to transfer materials between operators.

Sensitivity of Operator Requirements

The effect of variations in processing time on operator requirements was tested through four scenarios. Table 7 compares the scenario with the shortest observed time, normal time without allowance, standard time based on the observed average, and the longest observed time.

Table6 . Sensitivity of Operator Requirements to Variations in Time

Condition	Time per unit (s)	Workload (hours/shift)	Minimum number of operators	WLA 6 Operators
Best (shortest observation time)	1,509.4	36.06	6 (5.15)	85.85%
Normal time without allowance	1,755.1	41.93	6 (5.99)	99.83
Average, research reference	2,064.9	49.33	8 (7.05)	117.45%
Worst (longest observation time)	2,705.9	64.64	10 (9.23)	153.91%

In a normal-time scenario without any buffer, six operators achieved a WLA of 99.83%, with approximately 4.3 minutes of cumulative work time remaining per shift. These results indicate that even a slight delay can exhaust available capacity. Using standard times as the basis for planning, the requirement increases to eight operators. If all elements simultaneously take the longest time ever recorded, the theoretical requirement rises to ten operators, and the WLA with eight operators reaches approximately 115.43%. The latter scenario represents the theoretical upper limit. The proposal for eight operators is based on average conditions with the buffer established in the study.

Actual output of 85 units versus a capacity of 73.23 units

During the observation period in July–August 2026, Line 8 recorded a production of 85 units per shift with six operators during regular working hours. This achievement exceeded the highest capacity based on standard time, which is 73.23 units per shift, by 11.77 units (16.1%). If the total working time of the six operators is divided by the number of units produced, the available working time per unit is 6 × 25,200 ÷ 85 = 1,778.8 seconds. This value is 13.9% lower than the standard time (2,064.86 seconds) and 1.4% higher than the normal time (1,755.1 seconds).

Based on the normal time, the theoretical capacity of the six operators reaches 86.15 units per shift, approaching the target of 86 units. In this scenario, the 86-unit target requires 99.83% of the total available work time, while producing 85 units requires 98.7%. A 15% allowance is allocated for personal needs, recovery from fatigue, and unavoidable obstacles [6]. Thus, achieving the 86-unit target with six operators leaves only about 0.17% of the available work time before this allowance is taken into account.

DISCUSSION

To achieve the target of 86 FIBC units per shift, Line 8 at PT X requires 49.33 operator work hours, whereas six operators provide only 42 hours. The line's workload reaches 117.45%, with the highest workload on OP 3 at 180.0% and the lowest on OP 2 at 53.8%. These findings are consistent with those of [23], [24], [25], who estimated the need for additional workers when available working hours are insufficient to meet production needs. In terms of task allocation, [26], [27] demonstrated that shifting some work to stations with available idle time can even out the workload, while a simulation by [28], [29] showed an increase in output from 288 to 381 units after the sewing lines were rebalanced. At PT X, reassigning tasks can reduce imbalances, but the 4.60 hours of spare time at OP 1 and OP 2 only partially offset the 11.93-hour overload among the other four operators. Different results were found by [30], [31], who reported that operator requirements can be reduced after line balancing or process improvements. [32], [33] also showed that, although workload calculations point toward adding workers, overtime can be a more economical option under certain production conditions. For PT X, eight operators represent the minimum requirement based on standard time and regular working hours, with an estimated line workload of 88.08%. The decision to add operators still requires a cost comparison. The feasibility of dividing elements A6, A7, and A12 can also be further examined through three approaches. [34], [35] consider operator skills in task allocation; [3] use current production data to adjust assignments; and [13], [33] link sewing work conditions to muscle and joint complaints. These three studies provide a basis for evaluating Company X's design by recording the number of completed units, waiting times and material transfers, as well as the use of downtime during shifts.

CONCLUSION

Measurements of the 12 sewing elements for the FIBC IS 1200-900 on Line 8 at PT X yielded a standard time of 29.25 minutes per unit and a standard time of 34.41 minutes per unit after accounting for a 15% allowance. With six operators, the theoretical capacity reached 86.15 units per shift based on the normal time and 73.23 units per shift based on the standard time. The actual output of 85 units per shift was closer to the estimate based on the normal time. To achieve the target of 86 units per shift based on the standard time, the line would require 49.33 hours of operator work, whereas only 42 hours were available. This situation results in a line workload of 117.45%, with four out of six operators having a workload above 100%. The seven-operator scenario still results in a line workload of 100.67%, so eight operators represent the minimum requirement based on the calculations, with an estimated line workload of 88.08%. To balance the workload for each operator, it is proposed that the production volume for elements A6, A7, and A12 be divided among the operators. This assignment plan needs to be tested on the production line, taking into account the availability of sewing machines and material transfer times.

ACKNOWLEDGMENTS
The authors thank the Line 8 operators at PT X for their cooperation during the sewing time study.

CONFLICT OF INTEREST
The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT
The article presents summary data from the stopwatch measurements for the 12 sewing operations, along with production figures and workload calculations for Line 8 at PT X.

FUNDING
This study received no external funding.

DECLARATION OF AI TOOL USAGE
The authors did not use artificial intelligence (AI) tools to collect or analyze the data or to interpret the findings.

REFERENCES

[1] M. Kim and S. Kim, "Effects of step-by-step line balancing in apparel assembly line," *J. Eng. Fiber. Fabr.*, vol. 18, pp. 1–10, 2023, doi: 10.1177/15589250231191196.

[2] M. Erol, "Assembly line balancing: a case study for increasing and optimizing productivity in the clothing sector," *Sādhanā*, vol. 50, p. 188, 2025, doi: 10.1007/s12046-025-02856-1.

[3] B. Koç and S. H. Eryürük, "Optimizing sewing line balancing in apparel manufacturing through digitalization," *Fibres Text. East. Eur.*, vol. 33, no. 1, pp. 10–26, 2025, doi: 10.2478/ftee-2025-0002.

[4] M. F. Santoso, A. E. Apsari, N. Oktyajati, and S. Purwati, "Penentuan waktu baku pada produksi sabuk jumbo bag menggunakan metode time study pada PT. Sami Surya Perkasa," 2022. [Online]. Available: https://repository.uniba.ac.id/1149/

[5] S. A. Setiawan and Y. P. Utamana, "Penentuan output standart produksi yang optimal untuk produk jumbo bag tipe FIBC MCCI PTGA di PT. Wiharta Karya Agung Gresik," Universitas Internasional Semen Indonesia, 2021. [Online]. Available: https://repository.uisi.ac.id/4848/

[6] S. Auladi, P. Azzahra, and T. Juniarto, "Optimalisasi kebutuhan tenaga kerja produksi dengan metode stopwatch time study," *J. Tek. Ibnu Sina*, vol. 11, no. 1, pp. 1–12, 2026, doi: 10.36352/jt-ibsi.v11i01.1458.

[7] Y. Fernanda, J. Hutabarat, and K. Kiswandono, "Analisa beban kerja dengan pendekatan Workload Analysis (WLA) untuk menentukan jumlah tenaga kerja yang optimal pada industri dupa," *J. Valtech*, vol. 6, no. 2, pp. 252–257, 2023, doi: 10.36040/valtech.v6i2.7407.

[8] Z. F. Rosyada and K. T. Zafi, "Optimalisasi proses produksi di lini sewing produk TM6535S24 menggunakan metode Workload Analysis dan Line Balancing dengan simulasi ExtendSim," *Ind. Eng. Online J.*, vol. 1, no. 3, 2026, [Online]. Available: https://ejournal3.undip.ac.id/index.php/ieoj/article/view/58922

[9] F. K. Wardhani and Y. Primasanti, "Analisis beban kerja operator jahit dalam satu line dan pemerataan beban kerja dengan metode line balancing: Studi kasus PT. PB," *Mars J. Tek. Mesin, Ind. Elektro dan Ilmu Komput.*, vol. 4, no. 2, pp. 14–24, 2026, doi: 10.61132/mars.v4i2.1528.

[10] M. M. Teshome, T. Y. Meles, and C.-L. Yang, "Productivity improvement through assembly line balancing by using simulation modeling in case of Abay garment industry Gondar," *Heliyon*, vol. 10, no. 1, p. e23585, 2024, doi: 10.1016/j.heliyon.2023.e23585.

[11] R. A. Joy, M. S. Hawlader, M. S. Rahman, M. R. Hossain, S. I. Shamim, and H. Mahmud, "Improving quality, productivity, and cost aspects of a sewing line of apparel industry using TQM approach," *Math. Probl. Eng.*, vol. 2024, p. 6697213, 2024, doi: 10.1155/2024/6697213.

[12] F. N. A. Fairuz and H. F. Satoto, "Workload analysis to determine labor requirements using the Workload Analysis (WLA) method," *J. Rekayasa Sist. dan Ind.*, vol. 13, no. 1, pp. 55–64, 2026, doi: 10.25124/jrsi.v13i01.11033.

[13] B. Bizuneh and B. Kidanemariam, "Prevalence of musculoskeletal disorders among industrial sewing machine operators and their associated factors," *Int. J. Occup. Saf. Ergon.*, vol. 32, no. 1, pp. 98–112, 2026, doi: 10.1080/10803548.2025.2506229.

[14] Y. A. Nurdiansyah and H. F. Satoto, "Optimasi waktu standar kerja menggunakan metode stopwatch time study," *JURMATIS J. Manaj. Teknol. dan Tek. Ind.*, vol. 5, no. 1, pp. 59–68, 2023, doi: 10.30737/jurmatis.v5i1.2913.

[15] M. R. Aldiansyah and Kusnadi, "Analisis beban kerja dan jumlah pekerja menggunakan metode Workload Analysis (studi kasus PT. Metal Stamping)," *J. Tek.*, vol. 21, no. 1, pp. 68–76, 2023, doi: 10.37031/jt.v21i1.293.

[16] R. Syarifuddin, E. J. Hayat, and D. S. Tjaptjani, "Estimasi kebutuhan tenaga kerja langsung menggunakan Workload Analysis untuk optimalisasi beban produksi," *J. Kalibr.*, vol. 23, no. 2, pp. 430–442, 2025, doi: 10.33364/kalibrasi/v.23-2.3128.

[17] R. Wahyudi, A. T. Nugraha, and A. S. Kinasih, "Penentuan waktu baku dengan stopwatch time study untuk pengukuran kerja operator di PT XYZ Lampung Tengah," *J. Sains dan Apl. Keilmuan Tek. Ind.*, vol. 3, no. 2, pp. 79–88, 2023, doi: 10.33479/jtiumc.v3i2.76.

[18] V. A. Putra and H. F. Satoto, "Analisa beban kerja dan studi waktu kerja guna optimalisasi proses produksi: Studi kasus CV. XYZ," *J. Surya Tek.*, vol. 12, no. 1, pp. 169–175, 2025, doi: 10.37859/jst.v12i1.9344.

[19] R. Maulana, S. K. Ratoko, and Suhaeri, "Penerapan metode time study pada Workload Analysis (WLA) untuk mengetahui beban kerja dalam menentukan jumlah tenaga kerja optimal di PT XYZ," *Indones. J. Innov. Sci. Knowl.*, vol. 3, no. 3, pp. 716–735, 2026, doi: 10.31004/ijisk.v3i3.277.

[20] F. W. Al-Muqaffa, R. Yohanes, and N. Winarsih, "Analisis beban kerja dengan metode Work Load Analysis pada departemen produksi di PT. X," *Ind. J. Ilm. Tek. Ind.*, vol. 9, no. 1, pp. 69–80, 2025, doi: 10.37090/indstrk.v9i1.1558.

[21] M. A. Ara, N. Anjum, D. Ahbab, M. T. Sidiika, and R. R. Chowdhury, "Productivity improvement of garments industry by implementing line balancing algorithms—A case study," *Eng. Reports*, vol. 7, no. 4, p. e70125, 2025, doi: 10.1002/eng2.70125.

[22] S. S. Hailemariam, "Scheduling problems in the apparel industries: a systematic literature review," *Res. J. Text. Appar.*, pp. 1–20, 2026, doi: 10.1108/RJTA-09-2025-0213.

[23] S. Kirin, A. Hursa Šajatović, and S. Firšt Rogale, "Use of MTM, RAV and ZAK methods in determining working methods and time norms in technological operations of sewing clothes," *Processes*, vol. 12, no. 4, p. 740, 2024, doi: 10.3390/pr12040740.

[24] Sumardiyono, Y. A. Putri, and W. Y. Rha, "Impact of work-fit stretching on occupational fatigue among industrial sewing operators," *Indones. J. Occup. Saf. Heal.*, vol. 14, no. 3, pp. 293–304, 2025, doi: 10.20473/ijosh.v14i3.2025.293-304.

[25] A. E. Abate and S. S. Hailemariam, "Improving work-related musculoskeletal disorders for sewing machine operators in Ethiopia," *Int. J. Occup. Saf. Ergon.*, vol. 29, no. 2, pp. 573–585, 2023, doi: 10.1080/10803548.2022.2058747.

[26] F. Parvin, M. Rafiquzzaman, M. S. Parvez, and A. Aziz, "Ergonomic compatibility between sewing workstation and Bangladeshi apparel workers," *Int. J. Occup. Saf. Ergon.*, vol. 30, no. 4, pp. 1234–1249, 2024, doi: 10.1080/10803548.2024.2385786.

[27] R. K. Seidu, E. A. Ofori, B. Eghan, G. K. Fobiri, A. O. Afriyie, and R. Acquaye, "A systematic review of work-related health problems of factory workers in the textile and fashion industry," *J. Occup. Health*, vol. 66, no. 1, p. uiae007, 2024, doi: 10.1093/joccuh/uiae007.

[28] A. Ayough and B. Khorshidvand, "Robust optimization for the integrated worker-cell assignment and sequencing problem in a lean U-shaped assembly line," *Comput. Ind. Eng.*, vol. 178, p. 109139, 2023, doi: 10.1016/j.cie.2023.109139.

[29] N. Katiraee, M. Calzavara, S. Finco, O. Battaïa, and D. Battini, "Assembly line balancing and worker assignment considering workers' expertise and perceived physical effort," *Int. J. Prod. Res.*, vol. 61, no. 20, pp. 6939–6959, 2023, doi: 10.1080/00207543.2022.2140219.

[30] G. Y. Kim, J. Yun, C. Lee, J. Lim, Y. Kim, and S. D. Noh, "Data-driven analysis and human-centric assignment for manual assembly production lines," *Comput. Ind. Eng.*, vol. 188, p. 109896, 2024, doi: 10.1016/j.cie.2024.109896.

[31] L. Tiacci, "Assigning rest times to workers in assembly lines with ergonomically hazardous tasks: an approach to defend companies' profitability," *Int. J. Prod. Res.*, vol. 62, no. 4, pp. 1239–1261, 2024, doi: 10.1080/00207543.2023.2180304.

[32] P. Albulescu, I. Macsinga, A. Rusu, C. Sulea, A. Bodnaru, and B. T. Tulbure, "'Give me a break!' A systematic review and meta-analysis on the efficacy of micro-breaks for increasing well-being and performance," *PLoS One*, vol. 17, no. 8, p. e0272460, 2022, doi: 10.1371/journal.pone.0272460.

[33] B. Bizuneh and R. Mamecha, "Evaluation of an industrial sewing workstation design and its impact on perceived productivity," *J. Eng.*, vol. 2025, p. 7388434, 2025, doi: 10.1155/je/7388434.

[34] M.-A. Abdous, X. Delorme, D. Battini, and F. Sgarbossa, "Scenario-based optimization and simulation framework for human-centered assembly line balancing," *Int. J. Prod. Econ.*, vol. 282, p. 109513, 2025, doi: 10.1016/j.ijpe.2024.109513.

[35] H. Yang, J. H. Lee, S. H. Lee, S. G. Lee, H. R. Kim, and H. J. Kim, "A multi-manned assembly line worker assignment and balancing problem with positional constraints," *IEEE Robot. Autom. Lett.*, vol. 7, no. 3, pp. 7786–7793, 2022, doi: 10.1109/LRA.2022.3185784.