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Workforce Planning in Leather Shoe Stitching Line Using Workload Analysis Method at PT X Sidoarjo

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ABSTRACT

The leather shoe manufacturing industry requires efficient production processes to meet output targets and maintain high quality standards. PT X, a leather shoe manufacturer in Sidoarjo, East Java, produces shoes for the International brand. The stitching line at PT X experiences consistent failure to achieve daily production targets, leading to 1–3 hours of overtime per day. This condition indicates that the existing workforce distribution and workload are not yet optimal. This study aims to measure the actual workload of workers on the stitching line and to determine the optimal number of workers using the Workload Analysis (WLA) method. The research was conducted through direct time measurement (stopwatch time study) combined with work sampling to calculate standard time, performance rating, and allowance for each work element. The workload calculation showed that all 18 work elements exceeded 100 percent, with an average workload of 123.17 percent, indicating overload conditions across the line. Based on the WLA method and standard output calculations, the optimal workforce requirement was determined to be 19 workers. A comparative cost analysis demonstrated that employing 19 workers at regular time (IDR 91,200,000/month) is more cost-effective than retaining 18 workers with overtime (IDR 98,565,120/month). These findings provide a quantitative basis for workforce planning decisions in the stitching production line.

INTRODUCTION

The leather footwear industry is one of the strategic manufacturing sectors in Indonesia, contributing significantly to national export value and employment. PT X, located in Sidoarjo, East Java, is a leather shoe manufacturer producing products for International Inc., a globally recognized brand for outdoor and equestrian footwear. With approximately 800 workers and 8 stitching lines, PT X produces high-quality leather shoes that demand precision and consistency at every production stage [1].

The stitching (upper closing) division is one of the most critical stages of shoe production, as it involves joining multiple components of the shoe upper with high precision. On the stitching line studied (Line 1), 18 operators are assigned to 18 distinct work elements ranging from component preparation (thining) through sewing, buffing, and final quality control. Despite this workforce configuration, daily production targets are consistently unmet, requiring overtime of 1 to 3 hours per day across multiple

production orders. For example, in January–February 2026 alone, seven production orders incurred a total of 37 overtime hours, with shortfalls reaching up to 350 pairs per order [2].

This phenomenon suggests an imbalance between the assigned workforce and the actual workload[3]. Workforce planning is the process of systematically identifying the human resource requirements needed to achieve organizational objectives [4]. One widely used quantitative approach for this purpose is Workload Analysis (WLA), which compares the total work time required to complete all tasks against the available productive working time of each worker [5], [6].

Prior studies confirm the effectiveness of WLA across various industrial contexts. Aldiansyah and Kusnadi [1] reported workload values of 108.56% - 118.11% at a metal stamping facility and recommended workforce restructuring. Darsini et al. [2] demonstrated that adjusting worker allocation to three persons per sub-section effectively improved work distribution and productivity. Wahyulistiani et al. [7] applied WLA using the Full-Time Equivalent approach in soap production, while Ariyani et al. [8] validated WLA effectiveness in establishing ideal staffing levels in manufacturing environments. However, most prior studies do not address scenarios where all work elements simultaneously exceed 100% workload a condition that requires more rigorous analysis to accurately determine workforce needs.

However, most prior WLA studies apply the method to already-balanced production systems and do not account for intra-line workload imbalance. This study addresses that gap by applying WLA on the rebalanced structure to determine the optimal number of workers. This approach provides a more accurate basis for workforce planning decisions. The objective of this research is therefore to (1) measure the actual workload of each work element on the stitching line, and (2) determine the optimal workforce requirement to achieve the daily production target of 400 pairs.

MATERIALS AND METHODS

This research was conducted at PT X, located in Sidoarjo, East Java, Indonesia, from January to June 2026. The research object was the leather shoe stitching line (Line 1), which consists of 18 work elements operated by 18 workers. The production process runs for 10 hours per day (07:00–18:00 with a 1-hour break), 6 days per week. The methodological framework follows a quantitative approach grounded in industrial engineering work measurement techniques, structured as follows:

Work Time Measurement (Stopwatch Time Study). Sixty observations were recorded for each work element using a continuous stopwatch method [9]. The data were subjected to a uniformity test (control chart with BKA and BKB at 95% confidence level) and a sufficiency test (N' < N criterion) to validate statistical reliability before use in further calculations [10].

Performance Rating. Worker performance was evaluated using the Westinghouse Rating System, which rates four criteria: Skill, Effort, Condition, and Consistency [11]. The normal time for each element was calculated as:

$$Wn = \bar{X} \times (1 + PR)$$

Where:
Wn = normal time,
$\bar{X}$ = average cycle time,
PR = performance rating factor.

Allowance Determination (Work Sampling). Work sampling was conducted with 60 observations per operator per day at 10-minute intervals, covering the full 10-hour working period [12]. Observations classified operator activity as productive (active stitching/processing) or non-productive (waiting, personal needs, machine delays). The allowance percentage was calculated as:

$$\% \text{ Allowance} = (\text{Total Idle} / \text{Total Observations}) \times 100\%$$

Standard Time. Standard time (Ws) incorporates both normal time and allowance:

$$Ws = Wn + (Wn \times \% \text{ Allowance})$$

The bottleneck operation O-8 (Vamp stitch quarter thread 2) exhibited the highest standard time of 123.44 seconds and was used as the reference cycle time for the production line.

Workload Analysis (WLA). Workload per work element was computed as:

$$\text{Workload} = \% \text{ Productive} \times \text{Performance Rating} \times (1 + \text{Allowance})$$

A workload value above 100% indicates overload; below 100% indicates underutilization [13].

Standard Output and Workforce Calculation. Standard output per day was derived from the standard time and available working hours. The required number of workers (JTK) was then calculated as:

$$JTK = (\text{Output Target's} \times Ws) / \text{Available Working Time}$$

Monthly demand was set at 13,718 pairs based on company production data, with 864,000 seconds of available productive time per month (240 hours × 3,600 seconds)

Cost Analysis. A cost comparison was conducted between two scenarios: (A) 18 workers with daily overtime, and (B) the WLA-derived optimal workforce at regular time. Cost components include base wages and overtime premiums according to Indonesian labor regulations [13].

Research Flow.



Figure 1 Research Flow

The research flow begins with production flow identification to systematically map the sequence of operations and relationships among work elements. This is followed by cycle time data collection to obtain the observed time for each task as a basis for analysis. The collected data are then tested for adequacy and uniformity to ensure their validity and consistency. Subsequently, performance rating and allowance assessment are conducted to adjust the observed time by considering operator performance and unavoidable delays. Based on these adjustments, normal time and standard time are determined to establish a reliable time standard. Furthermore, workload calculation is

performed to evaluate task distribution and identify potential imbalances within the production system. Finally, standard output calculation is carried out to estimate production capacity, followed by workforce calculation to determine the optimal number of workers required, thereby supporting the development of an efficient and balanced production system.

RESULTS AND DISCUSSIONS

Results

Cycle Time Data Collection

A total of 1,080 time observations (60 per element × 18 elements) were recorded across five production shifts between January and March 2026. Table 3 presents the minimum, maximum, mode, and mean cycle time for each work element.

Table 1. Cycle Time Summary per Work Element (n = 60 observations each)

Code	Work Element	Min (sec)	Max (sec)	Mode (sec)	Mean $\bar{X}$ (sec)
O-5	Thining vamp	14.8	20.1	17.2	17.37
O-6	Installing vamp upholestery	21.3	29.6	25.1	25.33
O-1 & O-9	Thining quarter	8.5	13.2	10.6	10.77
O-2 & O-10	Piping quarter	8.9	14.7	11.3	11.62
O-3 & O-11	Lining Glue	22.1	31.5	26.3	26.63
O-4 & O-12	Lining stitch	27.4	37.8	32.1	32.43
O-7	Thread 1 – vamp quarter	65.2	85.6	74.8	75.20
O-8	Thread 2 – vamp quarter	72.1	96.4	83.8	83.78
O-13	Thining back counter	10.1	16.3	12.9	13.10
O-14	Stitch lining thermo	18.9	26.7	22.6	22.73
O-15	Thread 1 – back counter quarter	31.2	44.7	37.6	37.83
O-16	Thread 2 – back counter quarter	38.4	52.1	43.8	44.77
O-17	Piping side & stitch right	16.3	24.2	20.1	20.20
O-20	Piping side & stitch left	19.8	27.5	23.3	23.53
O-18 & O-21	Stitch upholstery extention	18.5	26.4	22.9	22.60
O-19 & O-22	Buffing extention	16.2	24.5	21.2	20.63
O-23	Pull tab stitch	22.4	31.7	27.6	27.23
I-1	Quality Control	11.8	18.4	14.6	14.93

Source: Processed Research Data (2026)

Mean cycle times ranged from 10.77 seconds (Thining quarter, O-1&O-9) to 83.78 seconds (Thread 2 – vamp quarter, O-8). The considerable range between minimum and maximum values in sewing machine operations (e.g., O-8: 72.1–96.4 sec) reflects natural variability in thread tensioning, material thickness, and operator handling techniques all of which are normal characteristics of manual-assisted machine sewing and were addressed through the performance rating

Work Time Measurement Results

Sixty observations were recorded for each of the 18 work elements. All datasets passed both uniformity (all data points within BKA–BKB control limits) and sufficiency tests ($N' < N = 60$ for all elements). The bottleneck operation was identified as O-8 (Stitch vamp quarter thread 2) with an average cycle time of 83.78 seconds, normal time of 108.92 seconds, and standard time of 123.44 seconds (allowance = 13.33%, performance rating = 0.30). Table 1 presents the standard time, productive percentage, and resulting workload for all 18 work elements.

Table 2. Standard Time, Productive Percentage, and Workload per Work Element

No	Operation	Work Element	Std Time (s)	Productive (%)	Workload (%)
1	O-5	Thining vamp	24.16	80.00	127
2	O-6	Installing vamp upholestery	36.94	85.00	131
3	O-1 & O-9	Thining quarter	15.45	80.00	117
4	O-2 & O-10	Piping quarter	16.23	71.67	110
5	O-3 & O-11	Lining Glue	37.21	78.33	115
6	O-4 & O-12	Lining stitch	44.97	80.00	125
7	O-7	Thread 1 – vamp quarter	103.00	85.00	122
8	O-8	Thread 2 – vamp quarter	123.44	86.67	128
9	O-13	Thining back counter	18.73	73.33	123
10	O-14	Stitch lining thermo	32.45	86.67	126
11	O-15	Thread 1 – back counter quarter	53.87	85.00	128
12	O-16	Thread 2 – back counter quarter	60.21	76.67	130
13	O-17	Piping side & stitch right	28.52	75.00	123
14	O-20	Piping side & stitch left	32.11	73.33	120
15	O-18 & O-21	Stitch upholstery extention	32.08	86.67	126
16	O-19 & O-22	Buffing extention	30.13	88.33	121
17	O-23	Pull tab stitch	38.19	73.33	122
18	I-1	Quality Control	20.66	76.67	123

Source: Processed Research Data (2026)

As shown in Table 1, all 18 work elements exhibit workload values exceeding 100%, ranging from 110% (Piping quarter, O-2 & O-10) to 131% (Installing vamp upholestery,

O-6), with an overall average of 123.17%. This universally overloaded condition confirms that the current 18-worker configuration is insufficient to meet production demands without overtime.

Workforce Planning Results

Based on the standard time of 123.44 seconds (bottleneck O-8), the standard output was calculated as 29 pairs/hour or 290 pairs/day. This falls 110 pairs/day short of the 400-pair daily target, which explains the chronic overtime. Applying the WLA-based workforce formula across all 18 work elements using the monthly demand of 13,718 pairs and 864,000 seconds of available productive time per month, the total optimal workforce was calculated as 19 workers. Table 3 presents the detailed workforce calculation per work element.

Table 3. Optimal Workforce Calculation per Work Element

No	Operation	Work Element	Std Output/hr	Std Output/day	Workers Needed
1	O-5	Thining vamp	149	1490	0.38
2	O-6	Installing vamp upholestery	97	970	0.59
3	O-1 & O-9	Thining quarter	232	2320	0.25
4	O-2 & O-10	Piping quarter	221	2210	0.26
5	O-3 & O-11	Lining Glue	96	960	0.59
6	O-4 & O-12	Lining stitch	80	800	0.71
7	O-7	Thread 1 – vamp quarter	34	340	1.01
8	O-8	Thread 2 – vamp quarter	29	290	1.96
9	O-13	Thining back counter	192	1920	0.30
10	O-14	Stitch lining thermo	110	1100	0.52
11	O-15	Thread 1 – back counter quarter	66	660	0.86
12	O-16	Thread 2 – back counter quarter	59	590	0.96
13	O-17	Piping side & stitch right	126	1260	0.45
14	O-20	Piping side & stitch left	112	1120	0.51
15	O-18 & O-21	Stitch upholstery extention	112	1120	0.51
16	O-19 & O-22	Buffing extention	119	1190	0.48
17	O-23	Pull tab stitch	94	940	0.61
18	I-1	Quality Control	174	1740	0.33
		Total			19

Source: Processed Research Data (2026)

A cost comparison between two workforce scenarios confirms the economic advantage of adding one worker. Retaining 18 workers with daily overtime of 1.28 hours costs Rp

98,565,120/month, whereas employing 19 workers at regular time costs Rp 91,200,000/month a saving of Rp 7,365,120/month (approximately 7.5%).

Cost Comparison Analysis

To validate the economic feasibility of the workforce addition, a cost comparison between two scenarios was conducted. Table 3 presents the monthly labor cost breakdown.

Table 4. Monthly Labor Cost Comparison Between Two Workforce Scenarios

Cost Component	Scenario A: 18 Workers + Overtime	Scenario B: 19 Regular Workers
Number of Workers	18 workers (existing)	19 workers (proposed)
Working Hours	10 hrs/day + avg. 1.28 hrs overtime	10 hrs/day (no overtime)
Regular Wage/month	IDR 75,600,000	IDR 91,200,000
Overtime Cost/month	IDR 22,965,120	IDR 0
Total Cost/month	IDR 98,565,120	IDR 91,200,000
Savings	–	IDR 7,365,120 (7.5%)

Source: Processed Research Data (2026)

Based on Table 3, Scenario B (19 regular workers) yields monthly savings of IDR 7,365,120 (7.5%) compared to Scenario A (18 workers + overtime). This demonstrates that adding one worker not only increases production capacity but also directly reduces the company's operational labor expenditure

Discussions

The finding that all 18 work elements are in an overloaded condition with an average of 123.17% represents a serious structural imbalance between workforce capacity and production demand. This is consistent with Aldiansyah and Kusnadi [1]who reported workloads of 108.56%–118.11% as primary drivers of production inefficiency at a metal stamping plant. The higher average in the present study reflects the more labor-intensive and precision-dependent nature of shoe stitching compared to stamping operations a point supported by Putra and Satoto [15] who noted that repetitive manual operations with tight tolerances inherently generate higher workload values due to accumulated allowance time and operator performance variability.

The variation in performance rating (PR = 0.19–0.37) across work elements reflects differences in operational complexity and required skill. Complex stitching operations such as O-8 (PR = 0.30) and O-16 (PR = 0.37) have higher PR values, indicating greater operator effort and skill requirements. This aligns with findings by Yanti et al. [5] who emphasized that PR variation in manual operations is a critical factor in WLA, and that failure to account for it leads to underestimation of actual workforce requirements.

The WLA-derived recommendation of 19 workers is consistent with patterns reported across the WLA literature, where small workforce additions produce disproportionately large improvements in output capacity. Darsini et al. [2] showed that

adding one to two workers to overloaded sub-sections effectively normalized work distribution and eliminated overtime dependency. Syafarudin and Pasca[4] similarly reported that small gaps between existing and optimal headcounts generate large cumulative capacity deficits in line systems, explaining why even a single worker shortage can cause chronic target failure.

Methodologically, this study employs the combination of stopwatch time study and work sampling an approach recommended by Barnes [16] and Niebel [17] as the industry standard for measuring manual repetitive operations. Compared to Wahyulistiani et al. [7] who used the Full-Time Equivalent (FTE) method, which does not explicitly account for PR and allowance, the WLA approach applied in this study is methodologically more rigorous for manual assembly environments. FTE-based estimates may understate workforce needs where operator performance varies significantly and allowance time is substantial, as is the case in shoe stitching operations[18].

From a financial perspective, the cost analysis reveals that the accumulated overtime cost due to the one-worker shortfall (IDR 22,965,120/month) far exceeds the cost of adding one new worker (IDR 4,800,000/month base wage). This supports the argument by Alvin et al. [6] that WLA-based workforce planning contributes not only to productivity improvement but also to long-term operational cost efficiency. Chronic overtime conditions also carry indirect risks including operator fatigue, product quality degradation, and increased labor turnover [19], which are not captured in direct cost comparisons but further strengthen the case for the proposed workforce adjustment.

A limitation of this study is that the cost analysis is restricted to direct labor wage components. Future research should incorporate indirect costs such as machine energy consumption, workspace utilization, and tool maintenance to provide a more comprehensive total cost comparison. Additionally, the study scope is limited to one stitching line for one product family generalizability to other product types with different complexity levels should be validated through further investigation [14].

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CONCLUSION

This study applied the Workload Analysis (WLA) method to address chronic production target shortfalls on the leather shoe stitching line at PT X Sidoarjo. Three key conclusions are drawn:

First, the workload analysis revealed that all 18 work elements are in an overloaded condition, with values ranging from 110% to 131% and an average of 123.17%. This confirms that the existing 18-worker configuration is structurally insufficient to achieve the 400-pair daily production target without systematic overtime dependency.

Second, applying the WLA-based workforce formula with a monthly demand of 13,718 pairs and 864,000 seconds of available productive time, the optimal workforce requirement for the stitching line is 19 workers one additional worker from the current configuration.

Third, the addition of one worker eliminates systematic overtime and reduces monthly labor costs from IDR 98,565,120 (18 workers + overtime) to IDR 91,200,000 (19 regular workers), achieving monthly savings of IDR 7,365,120 (7.5%). The proposed workforce adjustment therefore constitutes both an operational and financial improvement for the company.

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