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Analysis of Optimal Workforce Determination Using The Work Load Analysis Method in The Plastic Medicine Packaging Production Process

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ABSTRACT

PT XYZ is a company engaged in the production of plastic medicine packaging using a make to order system, where fluctuating customer demand often causes workload imbalance among production workstations. One of the main problems identified in the production process is the printing workstation, which has a longer processing time compared to other workstations, resulting in bottlenecks, overtime implementation, and unmet production targets. This study aims to determine standard working time using the Stopwatch Time Study method and calculate the optimal workforce requirement using the Work Load Analysis (WLA) method. Data collection was conducted through direct observation, interviews, and documentation of production activities at each workstation. The work time measurements were performed 30 times for each operator to obtain cycle time, normal time, and standard time. The results showed that the printing process had the highest standard time of 7.32 minutes/pcs, resulting in the highest workload among all workstations. Based on the WLA calculation, the company requires 30 workers, while the current workforce consists of only 24 workers, indicating a shortage of 6 workers in the printing process. Furthermore, labor cost analysis was conducted using three alternatives: permanent workers, overtime systems, and daily workers. The results indicated that the daily worker alternative was the most cost-efficient solution with a total cost of Rp125,270,481. Therefore, the addition of daily workers is recommended to balance workload distribution, reduce overtime usage, and improve production effectiveness at PT XYZ.

1. Introduction

PT XYZ is a company engaged in the production of plastic medicine packaging using a make to order system, where production activities depend on customer demand. The company is located at Jl. Masangan Kulon No. 234, Panjunan, Sukodono District, Sidoarjo Regency, East Java. Fluctuating demand causes workload imbalance in several production stations, especially in the printing process which requires a longer processing time compared to other processes. This condition affects production effectiveness and causes the company to implement overtime work to meet production targets. The make to order production system applied by the company requires production flexibility and accurate workforce planning because the quantity and type of orders continuously change according to customer requests. In this system, the company must be able to respond quickly to changing demand while maintaining production efficiency and delivery performance. However, unstable production demand often causes differences in workload distribution among workstations, resulting in bottlenecks in several production processes.

In manufacturing industries, workforce productivity and workload balance are important factors that influence production performance, operational efficiency, and the company's ability to fulfill customer demand. An imbalance in workload distribution may lead to bottlenecks, production delays, excessive overtime, increased operational costs, and decreased worker productivity. Therefore, companies need proper workforce planning and work measurement systems to ensure that production targets can be achieved effectively and efficiently. In addition, ineffective workforce allocation can reduce machine utilization efficiency and increase idle time at certain workstations. If this condition continues, it may negatively affect the company's competitiveness, especially in industries that require high production speed and delivery

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accuracy such as the plastic packaging industry. Therefore, workload balancing and workforce optimization become important aspects in improving production system performance and maintaining customer satisfaction.

In the production process at PT XYZ, one of the problems faced by the company is the uneven distribution of working time at each production station. Based on direct observation, the printing process requires a longer processing time compared to cutting, quality control, and packaging processes. The printing workstation becomes a critical point in the production flow because the process involves machine setup activities, color adjustment, printing alignment, and quality checking which require higher precision and longer processing time. This condition causes work accumulation in the printing area and disrupts the continuity of the next production stages. Meanwhile, several other workstations experience lower workloads, resulting in an imbalance in labor utilization between production stations.

In addition, the company still relies on manual activities in several production stages, causing work accumulation and reduced production efficiency. This condition indicates that the current workforce allocation and working time have not been fully optimized. As a result, several customer demands could not be fulfilled completely and caused additional overtime costs for the company. The production demand and fulfillment data at PT XYZ are presented in Table 1.

Table 1.
Production Demand and Fulfillment Data

No.	Month	Demand (Pcs)	Fulfillment (Pcs)	Unfulfilled (Pcs)
1	February 2025	352,000	350,000	2,000
2	Mach 2025	375,000	374,000	1,000
3	April 2025	340,000	339,000	1,000
4	May 2025	300,000	300,000	0
5	June 2025	332,000	331,800	200
6	July 2025	315,000	315,000	0
7	August 2025	295,000	295,000	0
8	September 2025	328,000	328,000	0
9	October 2025	320,000	320,000	0
10	November 2025	350,000	348,000	2,000
11	December 2025	325,000	325,000	0
12	January 2026	345,000	343,500	1,500
	Total	**3,977,000**	**3,969,300**	**7,700**

Based on Table 1, it can be seen that several customer demands could not be fully fulfilled by the company. This condition indicates that the current production capacity and workforce allocation are still not optimal. Therefore, it is necessary to analyze standard working time and workforce requirements to improve production efficiency and achieve production targets.

Work measurement is one of the important approaches in industrial engineering used to determine the time required by workers to complete a task under normal working conditions. Standard working time can be used as the basis for production planning, workforce allocation, productivity evaluation, and workload balancing. One of the commonly used techniques for measuring work time is the Stopwatch Time Study method because it is relatively simple, systematic, and suitable for repetitive production activities.

Furthermore, workload analysis is required to determine whether the number of workers currently employed is proportional to the production workload. Work Load Analysis (WLA) is a method used to calculate workforce requirements based on workload and effective working time. Through this method, companies can identify workstations experiencing overload or underload conditions and determine the optimal number of workers needed to improve operational effectiveness.

This research aims to determine standard working time using the Stopwatch Time Study method and calculate the optimal workforce requirement using the Work Load Analysis (WLA) method. The theoretical concepts used in this research include work measurement, standard time calculation, and workload analysis. Work Load Analysis (WLA) is a method used to calculate workload based on the type of work and the time required to complete each work activity [1]. The proposed method begins with direct observation of working time at each production station using a stopwatch, followed by standard time calculation and workforce analysis using the WLA method. The results of this research are expected to improve production efficiency, reduce overtime usage, and provide a more balanced workforce distribution.

Several previous studies have discussed workforce requirement analysis and standard time determination in manufacturing industries. However, most previous studies only focused on work measurement or workforce analysis separately without integrating both approaches comprehensively. In addition, previous studies generally emphasized workforce requirement calculation without considering alternative labor cost analysis as a managerial decision-making basis. Therefore, further research is still needed to provide a more integrated analysis between standard time measurement, workload analysis, and workforce cost evaluation.

Previous studies generally focused only on work measurement or workforce analysis separately. The novelty of this research lies in the integrated implementation of Stopwatch Time Study and WLA methods in the plastic medicine packaging production process, combined with labor cost alternative analysis to determine the most efficient solution for the company.

This research contributes both theoretically and practically. Theoretically, this study enriches the implementation of integrated work measurement and workload analysis methods in the manufacturing sector. Practically, the results of this research can be used as a reference by PT XYZ in determining workforce planning policies, minimizing overtime usage, improving workload distribution, and selecting the most cost-efficient workforce alternative to support production effectiveness.

2. Research methods

This research was conducted at PT XYZ located at Jl. Masangan Kulon No. 234, Panjunan, Sukodono District, Sidoarjo Regency, East Java. The research used a case study method focusing on working time analysis and workforce requirement in the production process of plastic medicine packaging.

Data collection was carried out through direct observation, interviews, and documentation. The collected data included production demand, working hours, overtime data, number of workers, and working time measurements for each production activity.

Working time measurement was conducted using the Stopwatch Time Study method to determine cycle time, normal time, and standard time. Furthermore, the Work Load Analysis (WLA) method was used to calculate the optimal workforce requirement based on workload and effective working time at each production station. The research stages carried out in this study are presented in the form of a research flowchart as follows.

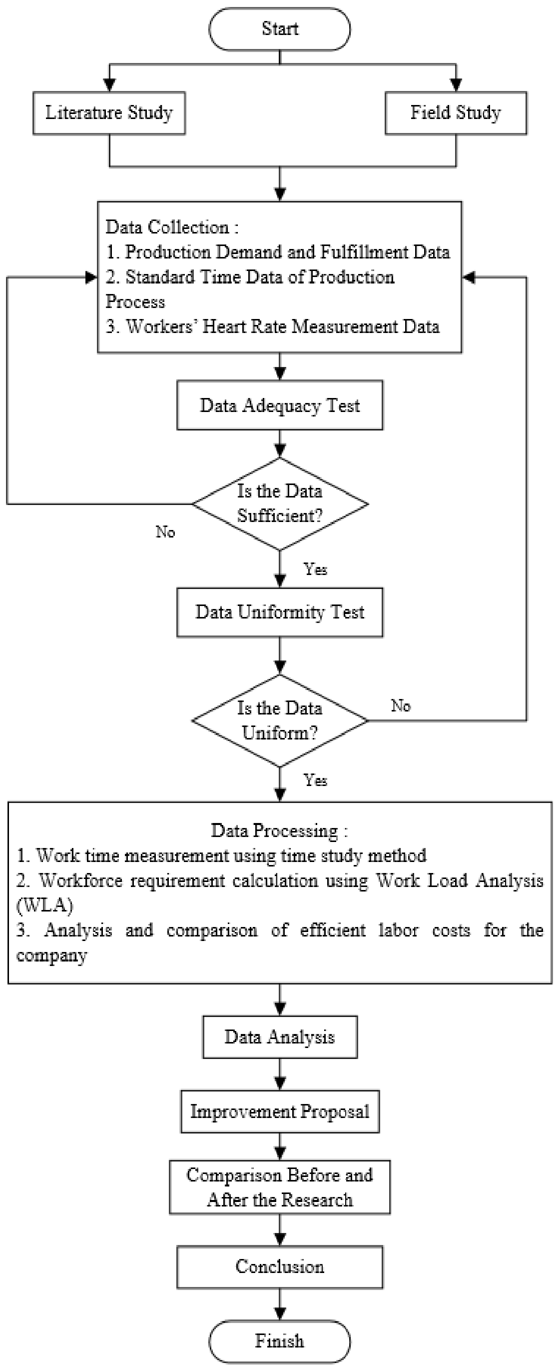

Figure 1 Research Flowchart

2.1 *Field Study*

Field study was conducted through direct observation of the production activities at PT. Plastikatama Maju Perkasa. This stage aimed to obtain actual information regarding the production process, working conditions, production time, and workforce activities at each workstation. Data collection was carried out through direct observation and interviews with production workers and company management to identify problems related to workload and labor requirements. According to previous research, primary data collection can be conducted through observation and interviews directly in the production area to obtain work process data and production time data [2].

2.2 *Problem Identification*

The problem identification stage was conducted after obtaining information from field observations. Based on the observation results, the company experienced workload imbalance at several production workstations, especially in the printing process which required longer processing time compared to other workstations. This condition caused production targets to be difficult to achieve and increased the use of overtime work. In addition, the production process had not yet implemented standard working time, resulting in frequent overtime to fulfill unmet daily production targets [3]. Work measurement aims to obtain the standard time that workers must achieve in completing a job [4]. As the name implies, this method uses a stopwatch as a tool to record work duration. This technique is widely used because the procedure is simple and easy to implement [5]. Therefore, analysis of standard time and optimal workforce requirements was needed to improve production effectiveness and balance the workload distribution among workers.

2.3 *Data Collection*

Data collection was carried out through direct observation, interviews, and documentation during the research process at PT XYZ. The collected data included production demand and fulfillment data, working hours, number of workers, overtime data, and work time measurement data for each production activity. Work time measurements were conducted 30 times for each operator during working hours from 08.00 to 16.00 WIB using the Stopwatch Time Study method. According to previous studies, data collection can be conducted through direct observation and measurement of work activities using a stopwatch and observation sheets to obtain production process time data [6]. The collected data were then used for standard time calculation and workforce requirement analysis using the Work Load Analysis (WLA) method.

2.4 *Stopwatch Time Study*

The Stopwatch Time Study method was used to measure the working time required for each production activity. Work measurement aims to obtain the standard time that workers must achieve in completing a job [7]. As the name implies, this method uses a stopwatch as a tool to record work duration. This technique is widely used because the procedure is simple and easy to implement [5]. The working time data were collected through direct observation at each production workstation.

2.5 Work Time Measurement

The measurement results are used to determine the standard time as a work completion standard. The stages of work time measurement using the stopwatch time study method are as follows [5].

2.5.1 Data Uniformity Test

a. Calculating the Mean

$$\bar{X} = \frac{\sum X}{n}$$

Description:
$\bar{X}$ = average observation time
$\sum i$ = total observation data
n = number of observations

b. Calculating Standard Deviation

$$\sigma = \frac{\sqrt{\sum(xi - \bar{X})^2}}{n-1}$$

Description:
σ = standard deviation
$\bar{X}$ = average observation time
$\sum i$ = total observation data
n = number of observations

c. Calculating Accuracy Level

$$S = \frac{\sigma}{\bar{X}} \times 100\%$$

Description:
S = accuracy level
σ = standard deviation

d. Calculating Confidence Level

CL = 100% - S

Description:
S = accuracy level
CL = confidence level
Based on the CL value obtained from the normal curve calculation, the constant value (k) can be determined as follows:

- $0\% \leq CL \leq 68\%$, then $k = 1$
- $68\% \leq CL \leq 95\%$, then $k = 2$
- $CL \geq 95\%$, then $k = 3$

e. Calculating Data Adequacy Test

$$N' = \left[\frac{\frac{k}{s}\sqrt{N\sum X^2 - \left(\sum X\right)^2}}{\sum X}\right]^2$$

Description:
N' = data adequacy
K = confidence level
S = accuracy level
N = number of observations conducted
$\sum X$ = total observation data

2.5.2 Data Uniform Test

After the data are declared sufficient, the next step is conducting the data uniformity test [5].

$$BKA = \bar{X} + k.\sigma$$

$$BKB = \bar{X} - k.\sigma$$

Description :
BKA = upper control limit
BKB = lower control limit
k = confidence constant
σ = standard deviation
$\bar{X}$ = average observation time

2.6 Performance Rating

Performance rating is an assessment conducted by comparing the operator's actual performance during work with the predetermined normal performance standard. This assessment aims to determine whether the operator's working pace is categorized as fast, slow, or in accordance with normal working conditions [7]. Work time adjustment is carried out by multiplying the average observation time by the adjustment factor (performance rating) "P". The assessment uses the Westinghouse method, which consists of several factors and different rating levels. The performance rating factors and assessment levels based on the Westinghouse method are presented in Table 2.

Table 2.
Westing House System's Rating

Factor	Class	Symbol	Adjusment
Skill	Super skil	A1	+0.15
		A2	+0.13
		B1	+0.11
		B2	+0.08
	Good	C1	+0.06
		C2	+0.03
	Average	D	0
	Fair	E1	-0.05
		E2	-0.1
	Poor	F1	-0.16
		F2	-0.22
Effort	Excessive	A1	+0.13
		A2	+0.12

	Excellent	B1	+0.1
		B2	+0.08
	Good	C1	+0.05
		C2	+0.02
	Average	D	0
	Fair	E1	-0.04
		E2	-0.08
	Poor	F1	-0.12
		F2	-0.17
Condition	Ideal	A	+0.06
	Excellent	B	+0.04
	Good	C	+0.02
	Average	D	0
	Fair	E	-0.03
	Poor	F	-0.07
Consistency	Perfect	A	+0.04
	Excellent	B	+0.03
	Good	C	+0.01
	Average	D	0
	Fair	E	-0.02
	Poor	F	-0.04

2.7 *Allowance*

Allowance is additional time provided as a break during daily work activities. In practice, workers cannot continuously work without stopping because there are certain needs or interruptions during the work process. Therefore, allowance time is necessary to ensure that workers can maintain normal performance levels [7].

2.8 *Normal Time*

Normal time is the working time that has been adjusted using the performance rating factor, so it reflects the normal time required by workers to complete a task with average performance ability [4].

$$Wn = Ws \times P$$

Sumber : [5]
Description :
Wn = normal time
Ws = cycle time
P = adjustment factor

2.9 *Standard Time*

Standard time is the working time that has been calculated by considering the performance adjustment factor and allowance time, resulting in a more realistic and feasible standard time for completing a task [4].

$$Wb = Wn \times \frac{100\%}{100\% \ - Allowance}$$

Description :
Wb = standard time
Wn = normal time
Allowance = allowance given to workers

2.10 *Work Load Analysis*

Work Load Analysis (WLA) is a method used to determine workforce requirements based on the workload received by workers. Workload consists of physical workload and mental workload [8]. The physical workload index is presented in Table 3 [8].

Table 3.
Physical Workload Indeks

Index	Definition
0,9 – 1	*High*
0,75 – 0,89	*Medium*
0,6 – 0,74	*Low*

In the WLA calculation, several data are used, including working hours, production quantity, working days, and standard time. Based on these data, the appropriate workforce requirement can be calculated using the WLA formula.

$$WLA = \frac{Waktu\ baku \times Permintaan}{hari\ kerja/bulan\ x\ jam\ kerja\ x\ 60\ menit}$$

3. Results and Discussion

3.1 *Data Collection*

Work time measurement data represent the duration required to complete production activities at each workstation. The measurements were conducted 30 times for each operator during working hours from 08.00 to 16.00 WIB. The data presented are an example of the work time measurement data from the raw material preparation process 1. The work time measurement data are presented in Table 2.

Table 4.
Work Time Measurement Data of Raw Material Preparation Process 1

No.	Raw Material Preparation 1					Σx	Σx²	x̄
1	71.2	11	71.8	21	71.6	2181.3	158636.59	72.71
2	74.1	12	73.5	22	74			
3	72	13	71.5	23	71.9			
4	73.6	14	74.1	24	73.5			
5	71.7	15	72	25	71.4			
6	73.9	16	73.7	26	74.1			
7	72.1	17	71.3	27	72.1			
8	73.4	18	73.9	28	73.3			
9	71.3	19	72.1	29	71.3			
10	73.9	20	73.2	30	73.8			

3.2 *Data Uniformity Test*

The data uniformity test was conducted by performing direct field observations and collecting 30 observations for each work activity. The calculation process used the work time measurement data presented in Table 4, which contains the observation results of the raw material preparation process 1. The following is an example of the data uniformity test calculation for the raw material preparation process 1. The data adequacy test calculation was carried out using the following formulas [9] :

3.2.1 *Calculating Standard Deviation*

$$\sigma = \frac{\sqrt{\sum (xi - \bar{X})^2}}{n-1}$$

$$\sigma = \sqrt{\frac{(71{,}2 - 72{,}71)^2 + (74{,}1{,}2 - 72{,}71)^2 + (72 - 72{,}71)^2 + \ldots + (73{,}8 - 72{,}71)^2}{30 - 1}}$$

$$\sigma = \sqrt{\frac{34{,}27}{29}} = 1{,}09$$

3.2.2 Calculating Accuracy Level

$$S = \frac{\sigma}{\bar{X}} \times 100\%$$

$$S = \frac{1{,}09}{72{,}71} \times 100\% = 1{,}50\%$$

3.2.3 Calculating Confidence Level

$$CL = 100\% - S$$
$$CL = 100\% - 1{,}48\% = 98{,}5\%$$

3.2.4 Calculating Confidence Level

BKA = $\bar{x}$ + k. ∂ = 72,71+ 3.1,09 = 75,98
BKB = $\bar{x}$ - k. ∂ = 72,71 - 3.1,09 = 69,44

Figure 2 shows the data uniformity test graph for the raw material preparation process 1.

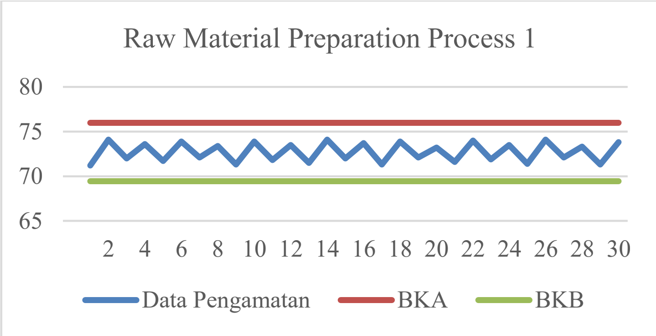

Figure 2 Data Uniformity Test Graph of Raw Material Preparation Process 1

Based on the data uniformity test graph of the raw material preparation process 1, it can be seen that all observation data are within the Upper Control Limit (UCL) of 76.44 and the Lower Control Limit (LCL) of 69.90. There are no data points outside the control limits or significant deviation patterns, indicating that the raw material preparation process 1 is in a controlled condition. The following table presents the recapitulation results of the data uniformity test for each workstation.

Table 5.
Recapitulation of Data Uniformity Test Results

No	Workstation	Result Recapitulation					
		x̄	k	σ	UCL	LCL	Uniform
1	Raw Material 1	72.71	3.00	1.09	75.98	69.44	Uniform
2	Raw Material 2	73.17	3.00	1.09	76.44	69.90	Uniform
3	Raw Material 3	72.94	3.00	1.08	76.18	69.70	Uniform
4	Raw Material 4	73.03	3.00	1.08	76.27	69.79	Uniform
5	Printing 1	301.46	3.00	2.00	307.46	295.46	Uniform
6	Printing 2	301.58	3.00	2.00	307.58	295.58	Uniform
7	Printing 3	301.68	3.00	2.01	307.71	295.65	Uniform
8	Printing 4	301.78	3.00	2.00	307.78	295.78	Uniform
9	Printing 5	301.88	3.00	2.00	307.88	295.88	Uniform
10	Printing 6	302.66	3.00	2.13	309.05	296.27	Uniform
11	Cutting 1	29.74	3.00	0.96	32.62	26.86	Uniform
12	Cutting 2	29.84	3.00	0.96	32.72	26.96	Uniform
13	Cutting 3	29.94	3.00	0.96	32.82	27.06	Uniform
14	Cutting 4	30.04	3.00	0.96	32.92	27.16	Uniform
15	Cutting 5	30.14	3.00	0.96	33.02	27.26	Uniform
16	Cutting 6	30.54	3.00	0.96	33.42	27.66	Uniform
17	Quality Control 1	78.01	3.00	1.17	81.52	74.50	Uniform
18	Quality Control 2	56.00	3.00	0.37	57.11	54.89	Uniform
19	Quality Control 3	70.87	3.00	0.36	71.95	69.79	Uniform
20	Quality Control 4	65.33	3.00	0.30	66.23	64.43	Uniform
21	Packaging 1	101.14	3.00	1.18	104.68	97.60	Uniform
22	Packaging 2	77.68	3.00	0.45	79.03	76.33	Uniform
23	Packaging 3	82.97	3.00	0.36	84.05	81.89	Uniform
24	Packaging 4	85.72	3.00	0.46	87.10	84.34	Uniform

3.3 Data Adequacy Test

The data adequacy test was conducted to determine whether the number of observations collected was sufficient for further analysis. This test ensures that the collected data represent actual working conditions and meet the required confidence level and accuracy [10]. The following is an example of the work time observation calculation obtained from Raw Material 1.

$$N' = \left[\frac{\frac{k}{s}\sqrt{N\sum X^2 - \left(\sum X\right)^2}}{\sum X}\right]^2$$

$$N' = \left[\frac{\frac{3}{2,82}\sqrt{30 \times 200673,68 - (2452,67)^2}}{2452,67}\right]^2$$

$$N' = \left[\frac{2\sqrt{4.759.097,7 - 4.758.069,7}}{2181.3}\right]^2 = 0,00087$$

Based on the calculation results above, the value of N^\primeis 0.00087, indicating that the data for Raw Material 1 are sufficient because N^\prime<N. The following table 6 presents the recapitulation results of the data adequacy test for each workstation.

Table 6.
Recapitulation of Data Adequacy Test Results

No.	Workstation	Result Recapitulation		
		N'	N	Descriptiom
1	Raw Material 1	0.00087	30	Sufficient Data
2	Raw Material 2	0.00087	30	Sufficient Data
3	Raw Material 3	0.00087	30	Sufficient Data
4	Raw Material 4	0.00087	30	Sufficient Data
5	Printing 1	0.00087	30	Sufficient Data
6	Printing 2	0.00087	30	Sufficient Data
7	Printing 3	0.00086	30	Sufficient Data
8	Printing 4	0.00087	30	Sufficient Data
9	Printing 5	0.00087	30	Sufficient Data
10	Printing 6	0.00087	30	Sufficient Data
11	Cutting 1	0.00087	30	Sufficient Data
12	Cutting 2	0.00087	30	Sufficient Data
13	Cutting 3	0.00087	30	Sufficient Data
14	Cutting 4	0.00087	30	Sufficient Data
15	Cutting 5	0.00087	30	Sufficient Data
16	Cutting 6	0.00087	30	Sufficient Data
17	Quality Control 1	0.00087	30	Sufficient Data
18	Quality Control 2	0.00087	30	Sufficient Data
19	Quality Control 3	0.00087	30	Sufficient Data
20	Quality Control 4	0.00087	30	Sufficient Data
21	Packaging 1	0.00087	30	Sufficient Data
22	Packaging 2	0.00087	30	Sufficient Data
23	Packaging 3	0.00087	30	Sufficient Data
24	Packaging 4	0.00087	30	Sufficient Data

3.4 Performance Rating

Performance rating was conducted to assess the operator's performance based on skill, effort, working condition, and consistency factors. One of the commonly used methods for determining performance rating is the Westinghouse method [11]. The next stage is conducting the performance rating assessment as the basis for calculating normal time. The results of the data processing are presented in the following table 7.

Table 7.
Performance Rating

No.	Workstation	Skill	Effort	Condition	Consistency	Performance Rating
1	Raw Material 1	0.08 (B2)	0.08 (B2)	0.02 (C)	0.01 (C)	1.19
2	Raw Material 2	0.08 (B2)	0.05 (C1)	0.02 (C)	0.03 (B)	1.18
3	Raw Material 3	0.06 (C1)	0.05 (C1)	0.02 (C)	0.01 (C)	1.14
4	Raw Material 4	0.06 (C1)	0.02 (C2)	0.04 (B)	0.03 (B)	1.15
5	Printing 1	0.08 (B2)	0.08 (B2)	0.04 (B)	0.03 (B)	1.23
6	Printing 2	0.08 (B2)	0.05 (C1)	0.04 (B)	0.03 (B)	1.2
7	Printing 3	0.06 (C1)	0.08 (B2)	0.02 (C)	0.03 (B)	1.19
8	Printing 4	0.08 (B2)	0.02 (C2)	0.04 (B)	0.03 (B)	1.17
9	Printing 5	0.06 (C1)	0.05 (C1)	0.02 (C)	0.03 (B)	1.16
10	Printing 6	0.08 (B2)	0.08 (B2)	0.02 (C)	0.01 (C)	1.19
11	Cutting 1	0.06 (C1)	0.02 (C2)	0.02 (C)	0.01 (C)	1.11
12	Cutting 2	0.06 (C1)	0.05 (C1)	0.02 (C)	0.03 (B)	1.16
13	Cutting 3	0.08 (B2)	0.02 (C2)	0.02 (C)	0.01 (C)	1.13
14	Cutting 4	0.06 (C1)	0.05 (C1)	0.04 (B)	0.01 (C)	1.16
15	Cutting 5	0.08 (B2)	0.05 (C1)	0.02 (C)	0.03 (B)	1.18
16	Cutting 6	0.06 (C1)	0.02 (C2)	0.04 (B)	0.03 (B)	1.15
17	Quality Control 1	0.08 (B2)	0.05 (C1)	0.02 (C)	0.03 (B)	1.18
18	Quality Control 2	0.06 (C1)	0.05 (C1)	0.02 (C)	0.01 (C)	1.14
19	Quality Control 3	0.08 (B2)	0.08 (B2)	0.02 (C)	0.03 (B)	1.21
20	Quality Control 4	0.06 (C1)	0.02 (C2)	0.04 (B)	0.03 (B)	1.15
21	Packaging 1	0.06 (C1)	0.05 (C1)	0.00 (C)	0.03 (B)	1.14
22	Packaging 2	0.08 (B2)	0.05 (C1)	0.00 (C)	0.03 (B)	1.16
23	Packaging 3	0.06 (C1)	0.02 (C2)	0.02 (C)	0.01 (C)	1.11
24	Packaging 4	0.08 (B2)	0.08 (B2)	0.00 (C)	0.03 (B)	1.19

3.5 Allowance

After determining the performance rating, the next step is to determine the allowance value. The allowance value is determined based on direct observations of workers' activities during the work process. PT XYZ applies a working duration of 7 hours or 420 minutes for each shift. The formula used to calculate allowance is as follows [2] :

$$Allowance = \frac{Personal + Fatigue + Personal}{Effectif\ Working\ Hours \times 60\ minutes} \times 100\%$$

The following is an example of the allowance calculation for Raw Material 1 worker using the formula above:

$$Allowance = \frac{10 + 9 + 13}{7 \times 60\ minutes} \times 100\%$$

$$Allowance = \frac{32}{420\ minutes} \times 100\% = 7{,}6\%$$

The following table 8 presents the recapitulation results of allowance calculation for 24 workers.

Table 8.
Recapitulation Results of Allowance Calculation for 24 Workers

No.	Workstation	Personal	Fatigue	Delay	Total (minute)	Allowance (%)
1	Raw Material 1	10	9	13	32	7.6
2	Raw Material 2	11	10	12	33	7.9
3	Raw Material 3	9	11	12	32	7.6
4	Raw Material 4	10	10	13	33	7.9
5	Printing 1	9	12	11	32	7.6
6	Printing 2	10	11	12	33	7.9
7	Printing 3	8	12	12	32	7.6
8	Printing 4	9	11	13	33	7.9
9	Printing 5	10	10	12	32	7.6
10	Printing 6	9	12	13	34	8.1
11	Cutting 1	8	11	10	29	6.9
12	Cutting 2	9	10	11	30	7.1
13	Cutting 3	8	12	11	31	7.4
14	Cutting 4	9	11	12	32	7.6
15	Cutting 5	8	10	12	30	7.1
16	Cutting 6	9	12	10	31	7.4
17	Quality Control 1	7	8	9	24	5.7
18	Quality Control 2	8	9	9	26	6.2
19	Quality Control 3	7	10	8	25	6.0
20	Quality Control 4	8	8	10	26	6.2
21	Packaging 1	10	9	13	32	7.6
22	Packaging 2	9	10	14	33	7.9
23	Packaging 3	10	8	13	31	7.4
24	Packaging 4	9	9	14	32	7.6

3.6 Normal Time Calculation

Normal time was calculated by multiplying cycle time by the performance rating factor. Normal time represents the time required by operators under normal working conditions to complete production activities [9]. The following is an example of the normal time calculation for Raw Material 1 workstation.

Wn = Ws x P
Wn = 72,71 x 1,19
Wn = 86,52 seconds = 1,44 minutes

Based on the calculation results, the resulting normal time can describe a more realistic work time requirement in accordance with actual working conditions. The following table 9 presents the recapitulation results of the normal time calculation for each worker.

Table 9.
Recapitulation Results of Normal Time Calculation for Each Worker

No.	Workstation	$\bar{x}$	*Performance Rating*	WN (second)	WN (minutes)
1	Raw Material 1	72.71	1.19	86.52	1.44
2	Raw Material 2	73.17	1.18	86.34	1.44
3	Raw Material 3	72.94	1.14	83.16	1.39
4	Raw Material 4	73.03	1.15	83.98	1.40
5	Printing 1	301.46	1.23	370.80	6.18
6	Printing 2	301.58	1.20	361.89	6.03
7	Printing 3	301.68	1.19	359.00	5.98
8	Printing 4	301.78	1.17	353.08	5.88
9	Printing 5	301.88	1.16	350.18	5.84
10	Printing 6	302.66	1.19	360.16	6.00
11	Cutting 1	29.74	1.11	33.01	0.55
12	Cutting 2	29.84	1.16	34.61	0.58
13	Cutting 3	29.94	1.13	33.83	0.56
14	Cutting 4	30.04	1.16	34.84	0.58
15	Cutting 5	30.14	1.18	35.56	0.59
16	Cutting 6	30.54	1.15	35.12	0.59
17	Quality Control 1	78.01	1.18	92.05	1.53
18	Quality Control 2	56.00	1.14	63.84	1.06
19	Quality Control 3	70.87	1.21	85.75	1.43
20	Quality Control 4	65.33	1.15	75.13	1.25
21	Packaging 1	101.14	1.14	115.30	1.92
22	Packaging 2	77.68	1.16	90.11	1.50
23	Packaging 3	82.97	1.11	92.09	1.53
24	Packaging 4	85.72	1.19	102.00	1.70

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3.7 Standard Time Calculation

Standard time was obtained from normal time plus allowance factors. Standard time is used as the basis for workforce planning and workload analysis [12]. The standard time calculation can be written using the following formula [13] :

$$Wb = Wn \times \frac{100\%}{100\% - Allowance}$$

The following is an example of the standard time calculation for Raw Material 1 workstation:

$$Wb = 72{,}71 \times \frac{100\%}{100\% - 7{,}6\%} = 78{,}71\ seconds = 1{,}31 minutes$$

The following table 10 presents the recapitulation results of standard time calculation for 24 workers in the plastic medicine packaging production process at each workstation.

Table 10.
Recapitulation Results of Standard Time Calculation for 24 Production Workers at Each Workstation

No.	Workstation	WN (seconds)	Allowance (%)	Wb (seconds/45 pcs)	Wb (minutes/45pcs)	Wb (seconds/pcs)
1	Raw Material 1	72.71	7.6	78.71	1.31	1.75
2	Raw Material 2	73.17	7.9	79.41	1.32	1.76
3	Raw Material 3	72.94	7.6	78.96	1.32	1.75
4	Raw Material 4	73.03	7.9	79.25	1.32	1.76
5	Printing 1	301.46	7.6	326.33	5.44	7.25
6	Printing 2	301.58	7.9	327.29	5.45	7.27
7	Printing 3	301.68	7.6	326.56	5.44	7.26
8	Printing 4	301.78	7.9	327.51	5.46	7.28
9	Printing 5	301.88	7.6	326.77	5.45	7.26
10	Printing 6	302.66	8.1	329.31	5.49	7.32
11	Cutting 1	29.74	6.9	31.94	0.53	0.71
12	Cutting 2	29.84	7.1	32.13	0.54	0.71
13	Cutting 3	29.94	7.4	32.32	0.54	0.72
14	Cutting 4	30.04	7.6	32.51	0.54	0.72
15	Cutting 5	30.14	7.1	32.45	0.54	0.72
16	Cutting 6	30.54	7.4	32.97	0.55	0.73
17	Quality Control 1	78.01	5.7	82.74	1.38	1.84
18	Quality Control 2	56.00	6.2	59.70	0.99	1.33
19	Quality Control 3	70.87	6.0	75.35	1.26	1.67
20	Quality Control 4	65.33	6.2	69.64	1.16	1.55
21	Packaging 1	101.14	7.6	109.48	1.82	2.43
22	Packaging 2	77.68	7.9	84.30	1.41	1.87
23	Packaging 3	82.97	7.4	89.58	1.49	1.99
24	Packaging 4	85.72	7.6	92.79	1.55	2.06

3.8 Work Load Analysis (WLA) Calculation Based on Standard Time

PT XYZ applies a 2-shift working system with an effective working time of 26 working days per month and 1 hour break time per day, resulting in a total effective working time of 14 hours per day.
Data :

- Working hours per day (2 shifts) = 14 hours × 60 minutes = 840 minutes
- Working hours per month = 14 hours × 26 days × 60 minutes = 21,840 minutes
- Highest demand quantity = 160,000 pcs

Furthermore, the *Work Load Analysis* (WLA) calculation

Furthermore, the Work Load Analysis (WLA) calculation was conducted to determine the workload level of each worker at every workstation. The WLA calculation uses standard time, production output per operator, and available effective working time during the production process.

$$WLA = \frac{(Standar\ Time\ x\ Demand)}{(working\ days/month\ x\ working\ hours\ x\ 60\ minutes)}$$

The following is an example of the workload calculation using the *Work Load Analysis* (WLA) method for Raw Material 1 workstation :

$$WLA = \frac{0{,}03 \times 375000}{21840}$$

$$WLA = 0{,}50 \approx 1$$

The following table 11 presents the recapitulation results of workforce calculation using the Work Analysis (WLA) method:

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Table 11.
Workforce Calculation Results Using the WLA Method

No.	Workstation	Wb (minutes/pcs)	WLA	Actual Workforce	Workforce Based on WLA
1	Raw Material 1	0.03	0.50	1	1
2	Raw Material 2	0.03	0.51	1	1
3	Raw Material 3	0.03	0.50	1	1
4	Raw Material 4	0.03	0.50	1	1
5	Printing 1	0.12	2.08	1	2
6	Printing 2	0.12	2.08	1	2
7	Printing 3	0.12	2.08	1	2
8	Printing 4	0.12	2.08	1	2
9	Printing 5	0.12	2.08	1	2
10	Printing 6	0.12	2.09	1	2
11	Cutting 1	0.01	0.20	1	0
12	Cutting 2	0.01	0.20	1	0
13	Cutting 3	0.01	0.21	1	0
14	Cutting 4	0.01	0.21	1	0
15	Cutting 5	0.01	0.21	1	0
16	Cutting 6	0.01	0.21	1	0
17	Quality Control 1	0.03	0.53	1	1
18	Quality Control 2	0.02	0.38	1	0
19	Quality Control 3	0.03	0.48	1	0
20	Quality Control 4	0.03	0.44	1	0
21	Packaging 1	0.04	0.70	1	1
22	Packaging 2	0.03	0.54	1	1
23	Packaging 3	0.03	0.57	1	1
24	Packaging 4	0.03	0.59	1	1

Based on the results of the Work Load Analysis (WLA) calculation, the current actual workforce across all workstations is 24 workers, while the workforce requirement calculation shows a total of 30 workers. The difference in workforce requirement occurs in the printing process, where the actual workforce at each workstation is only 1 worker, while the calculation results indicate a requirement of 2 workers. This condition shows that the printing process is still experiencing a workforce shortage, therefore additional workers are needed to achieve a more balanced workload and improve production effectiveness.

3.9 Workforce Planning Based on Cost Analysis

3.9.1 Permanent Worker Cost Calculation

Alternative 1 is the calculation of permanent worker addition in the printing workstation by adding 6 workers. The following is the cost calculation for adding permanent workers in the printing process.

a. Regular labor cost before WLA calculation
Reguler Time = Rp28.542
Overtime = Rp 30.000/jam
Reguler Time = 24 workers x 26 days x 7 hours x Rp28.542 = Rp124.671.456

b. Regular labor cost after WLA calculation
Regular Cost = 30 Workers × 26 days× 7 hours x Rp28.542 = Rp155,839,320

Based on the labor cost calculation results, the company's actual condition with 24 workers generates a total labor cost of Rp124,671,456. After conducting the *Work Load Analysis* (WLA), the workforce requirement increased to 30 workers, resulting in a total labor cost of Rp155,839,320. The addition of 6 workers was carried out to fulfill production requirements in the printing process.

3.9.2 Overtime System Labor Cost Calculation

Alternative 2 is the labor cost calculation using the overtime system for the printing workstation requiring 6 workers to fulfill additional production demand.

a. Company Overtime Labor Cost
Highest additional production (February 2025) = 2,000 pcs
Number of overtime workers = 6 workers
Overtime duration = 7 hours
Shift distribution:
Shift 1 = 3 hours
Shift 2 = 4 hours
Overtime time = Rp30,000/hour
Reguler Time = 24 workers x 26 days x 7 hours x Rp28.542 = Rp124.671.456
Overtime Cost = 6 workers x 7 hours x 1 day x Rp30.000 = Rp1.260.000
Total Cost = Rp124.671.456 + Rp1.260.000 = Rp125.931.456

b. Overtime calculation based on WLA
Highest additional production = 2,000 pcs
Production capacity per line = 724 pcs/day
Number of machines = 3 machines
Normal working hours = 7 hours/day
Number of operators:
Shift 1 = 3 workers
Shift 2 = 3 workers
Production Capacity per Hour = $\frac{724}{7} = 103{,}43\ pcs/hours$

Total Capacity 3 machine/shift = 3 x 103,43 = 310,29 pcs/jam
2 shift capacity = 310,29 x 2 = 620,58 pcs/worker/jam
Overtime requirement = $\frac{2000}{620,58} = 3,22 \approx 4\ jam/orang/hari$
Overtime = Rp 30.000/jam
Reguler Time = 24 TK x 26 hari x 7 jam x Rp28.542 = Rp124.671.456
Overtime Cost = 6 TK x 4 jam x 1 hari x Rp30.000 = Rp720.000
Total Cost = Rp124.671.456 + Rp720.000= Rp125.391.456

Based on the calculation results, the overtime method based on WLA produces a total cost of Rp125,391,456, which is lower than the company overtime system cost of Rp125,931,456.

3.9.3 Daily Worker Cost Calculation

Alternative 3 is the labor cost calculation using daily workers for the printing workstation based on the WLA calculation results.

Highest additional production = 2,000 pcs
Production capacity per line = 724 pcs/day
Worker requirement : $\frac{2000}{724} = 2,76 \approx 3\ workers/day$
Additional capacity = 3 workers x 724 pcs = 2.172 pcs/day
Production duration = $\frac{2000}{2172} = 0,92 \approx 1\ day$
Therefore, the additional production of 2,000 pcs can be completed within 1 day by using 3 daily workers.
Monthly wage = Rp5.191.541/bulan
Daily wage = $\frac{Rp5.191.541}{26\ hari} = Rp199.675/hari$
Reguler Time = 24 TK x 26 hari x 7 jam x Rp28.542 = Rp124.671.456
Daily worker cost = 3 TK x 1 hari x Rp199.675 = Rp599.025
Total cost = Rp124.671.456 + Rp599.025 = Rp125.270.481

Based on the calculation results of daily worker labor costs, the additional production demand of 2,000 pcs in February 2025 can be fulfilled by adding 3 daily workers. With a labor wage of Rp199,675/day, the company incurs a cost of Rp599,025/day. These results indicate that daily workers can be an alternative solution to fulfill increased production demand without increasing the working hours of permanent workers.

3.9.4 Comparison and Selection of Workforce Alternatives

The following table 12 presents the comparison results of each workforce alternative.

Table 12
Cost Comparison Results of Each Alternative

No.	Alternative	Number of Workers	Work System	Total Cost
1	Permanent Workers	6 workers	Additional permanents workers	Rp155,839,320
2	Overtime System	6 workers	4 hours overtime	Rp125,391,456
3	Daily Workers	3 workers	1-day daily workers	Rp125,270,481

Based on the cost comparison results, the daily worker alternative is the most economical compared to the other alternatives. In addition to lower costs, daily workers are also more flexible because additional workers are only employed when needed.

4. Conclusion

Based on the results of this research conducted in the plastic medicine packaging production department at PT XYZ, it can be concluded that the implementation of the Stopwatch Time Study and Work Load Analysis (WLA) methods was able to identify workload imbalance and determine the optimal workforce requirement in the production process. The results of work time measurement showed that the printing workstation had the highest standard time, reaching 7.32 minutes/pcs, compared to other workstations. This condition indicates that the printing process became the main bottleneck in the production flow and contributed to production delays, overtime implementation, and unmet customer demand. The Work Load Analysis (WLA) results indicated that the company currently employs 24 workers, while the optimal workforce requirement is 30 workers. Therefore, an additional 6 workers are required, particularly in the printing process, to achieve a more balanced workload distribution and improve production effectiveness. The addition of workers is expected to reduce excessive workload, minimize overtime usage, and improve the company's ability to fulfill production targets according to customer demand.

Furthermore, workforce planning analysis based on labor cost comparison showed that the daily worker alternative was the most efficient option compared to permanent worker addition and overtime systems. The use of 3 daily workers generated the lowest total cost of Rp125,270,481 while still being able to fulfill additional production demand effectively. Therefore, PT XYZ is recommended to implement additional daily workers during periods of increased production demand because this alternative is more flexible, cost-efficient, and capable of supporting smoother production operations.

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