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Analysis of Workforce Requirements Based on Production Capacity and Work Time Utilization to Improve Operational Efficiency at PT XYZ

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ABSTRACT

The rapid development of the industrial sector requires manufacturing companies to manage resources effectively and efficiently, particularly in workforce allocation and working time utilization, in order to maintain productivity and operational performance. This study was conducted at PT XYZ, a stove manufacturing company, with the aim of analyzing employee workload, evaluating the utilization of working time, and determining the optimal number of workers based on production capacity requirements. Based on preliminary observations, several production divisions were found to experience ineffective working time utilization, resulting in workload imbalances and less optimal operational efficiency. This study applies the Workload Analysis (WLA) method supported by stopwatch time study measurements and the Cardiovascular Load (CVL) method to assess both operational and physical workload conditions. The collected data include work element times, number of workers, production output, non-productive time, and workers' heart rate measurements. The data were processed through normal time and standard time calculations, performance rating determination, allowance calculations, workload analysis, and workforce requirement evaluation. The results show that all workers were classified within the light workload category based on CVL values below 30%, indicating that the physical workload remained within acceptable limits. Furthermore, the WLA results showed that several production divisions experienced different workload levels, leading to recommendations for workforce adjustments and improved labor utilization. Based on these findings, workforce adjustments were recommended by reducing the number of workers in the welding division from 3 to 2 employees and in the assembly division from 4 to 3 employees, while maintaining the existing workforce in the other divisions. By implementing appropriate workload management, the company is expected to reduce ineffective working time, improve labor productivity, and enhance overall operational efficiency.

1. Introduction

The The current development of the industrial sector requires companies to manage all available resources effectively and efficiently in order to remain competitive and meet market demands. In the era of global competition, manufacturing companies are expected not only to achieve production targets but also to optimize operational efficiency in order to maintain productivity and sustainability [1]. Human resources play a significant role in supporting production performance because labor directly influences production continuity, product quality, and operational effectiveness. Therefore, proper workforce planning and workload distribution are essential factors that need to be considered by companies to improve organizational performance [2].

One important factor in supporting smooth production processes is the proper arrangement of employee workload in accordance with production capacity and available working time [3]. A balanced workload not only affects productivity levels but also determines how optimally labor can be utilized. An imbalance between workload and working capacity may result in worker fatigue, idle time, reduced productivity, and increased operational costs. Consequently, companies need to conduct workload evaluations regularly in order to ensure that the allocation of workers is aligned with actual production requirements [4].

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PT XYZ is a manufacturing company engaged in the production of stoves with a production capacity of up to 250 units per month. The company was established in 2012 and is located in east java. In its production activities, the company implements a continuous production system by manufacturing various stove models. The products have been trusted and marketed throughout Indonesia and partially exported to Australia. Currently, PT XYZ has around 40 active employees who play a role in fulfilling production demands. Based on field observations, although production targets have been achieved, there is still working time that has not been utilized optimally. This indicates a mismatch between workload and available working time, meaning that labor utilization has not been maximized. The products produced by the company are made according to customer needs, with the main raw materials used in the production process being sheet metal, commonly known as stainless steel. Based on initial calculations, the productivity levels of workers in each division vary. The welding division has a productivity of 84%, assembly 98%, cutting 97%, bending 67,71%, and preparation 95%. Productivity values below 100% do not directly indicate poor performance, but rather suggest the presence of non-effective working time, such as waiting time, work adjustments, and other operational factors. Based on field observations, several types of non-effective working time were identified across the production divisions. These included waiting time for materials or workpieces, machine setup and adjustment activities, temporary interruptions during material handling, and other operational delays occurring during the production process. These activities reduced the effective utilization of available working time and contributed to differences in productivity levels among divisions. As a result, labor capacity could not be utilized optimally, which may negatively affect productivity and overall operational efficiency. Therefore, further analysis is required to identify the causes of these inefficiencies and determine appropriate improvement measures to increase labor productivity.

Based on field observations, several types of non-effective working time were identified across the production divisions. These included waiting time for materials or workpieces, machine setup and adjustment activities, temporary interruptions during material handling, and other operational delays occurring during the production process. These activities reduced the effective utilization of available working time and contributed to differences in productivity levels among divisions. Therefore, workload analysis was required to evaluate workforce allocation and identify opportunities for operational improvement.

The production process at PT XYZ consists of several main divisions. The preparation division is responsible for preparing raw materials and supporting production requirements. The cutting division performs sheet metal cutting according to product specifications. The bending division shapes the cut materials into the required forms using bending machines. The welding division joins the formed components based on technical drawings, while the assembly division performs the final assembly of all components into finished stove products. These divisions are interconnected and play important roles in achieving the company's production targets.

Several previous studies have highlighted the importance of workload analysis and work measurement in improving labor efficiency and determining the optimal number of workers in manufacturing industries. Research conducted by Prabowo and Purnama [5] demonstrated that workforce optimization using workload analysis can improve labor productivity and production efficiency in stove manufacturing companies. In addition, studies by Putra et al. [6] and Ristika and Prastawa [7] explained that Workload Analysis (WLA) is effective in identifying workload imbalances and supporting manpower planning decisions. Meanwhile, research by Pradana and Pulansari [8] emphasized that stopwatch time study methods can provide accurate work standard measurements for evaluating production performance. These studies indicate that workload analysis and work measurement are important approaches for improving operational effectiveness and labor utilization.

There are two types of work time measurement, namely direct measurement and indirect measurement. Direct measurement is conducted when the researcher is present at the workplace to perform the measurement, while indirect measurement is conducted when the researcher is not present at the location and the data are obtained by reading tables or existing data records [9]. Workload is the overall amount of work or activities that become the responsibility of individuals or teams to be completed within a certain period, which is influenced by working time, the number of tasks, the level of complexity, and job responsibilities [10] - [12]. In indirect work time measurement, the time study procedure is divided into several steps, such as selecting the job to be studied, collecting information about the job, dividing the job into work elements, measuring the work time accurately, giving a rating level to the operator, and performing the necessary calculations [13]. In the calculation process mentioned above, one of the important elements is cycle time. Cycle time is the average time required to complete an operation or work process [5], [14]. Performance is the work result achieved by an individual or a group within an organization in accordance with their duties and responsibilities to achieve organizational goals while adhering to laws, morals, and ethics [7] - [8]. Workload is an important factor that must be considered by companies because it affects employee productivity. The workload assigned to employees should be adjusted to their abilities and capacities in order to avoid negative impacts on work performance [15]. Standard time is a guideline that describes the amount of time required by a qualified operator to complete a job according to the standard time for each work element. However, in practice, operators cannot work continuously throughout the day without interruptions or rest periods [16]. Performance rating is an assessment method used to measure the ability and work speed of workers based on the applicable normal work standards [17] - [18]. The CVL method is a method used to assess the level of workload based on the increase in workers' heart rate during work activities [19]. Workload analysis is the process of determining the labor or working time required to complete a job within a certain period of time [7]. Work measurement or time study is an effort to determine the standard time required to complete a job. In general, work time measurement techniques can be classified into two main categories [20] - [21]. Allowances are provided as additional time for personal needs, reducing work fatigue, and dealing with unavoidable obstacles during the work process [22]. Performance is a form of work implementation carried out by employees in performing their duties. The level of employee performance can be seen from their contribution to the organization, which includes the quantity of work results, quality of work, timeliness of completion, and attendance at the workplace [22].

Although previous studies have widely applied Workload Analysis (WLA), Cardiovascular Load (CVL), and work measurement techniques separately, limited studies have integrated these approaches simultaneously to evaluate workforce requirements, physical workload conditions, labor productivity, and workforce allocation decisions within stove manufacturing industries. This study contributes by combining WLA, CVL, Stopwatch Time Study, and Total Expected Cost (TEC) analysis in a single evaluation framework to support workforce planning and operational efficiency improvement at PT XYZ. Therefore, the novelty of this research lies in the integrated application of these methods within a real manufacturing environment to provide comprehensive workforce optimization recommendations.

Based on the problems identified at PT XYZ and supported by previous studies, this research focuses on analyzing workforce requirements based on production capacity and work time utilization using the Workload Analysis (WLA) method and Cardiovascular Load (CVL) approach. The purpose of this study is to determine the optimal number of workers, evaluate employee workload conditions, and improve labor productivity through a more effective workforce allocation strategy. The results of this research are expected to provide recommendations for improving operational efficiency and optimizing labor utilization in the company.

2. Research methods

In carrying out research so that it produces results and runs well, the following steps are taken [18]. This study was conducted systematically to analyze workforce requirements and evaluate the utilization of working time in the production process at PT XYZ. The research methodology was designed to obtain accurate data regarding employee workload, work effectiveness, and labor productivity through direct observation and quantitative analysis (see Figure 1). The stages of the research were arranged sequentially, starting from problem identification to the formulation of conclusions and recommendations. The research framework adopted in this study is presented in Figure 1, which summarizes the sequence of research activities from problem identification, data collection, and data analysis to the formulation of conclusions and recommendations.

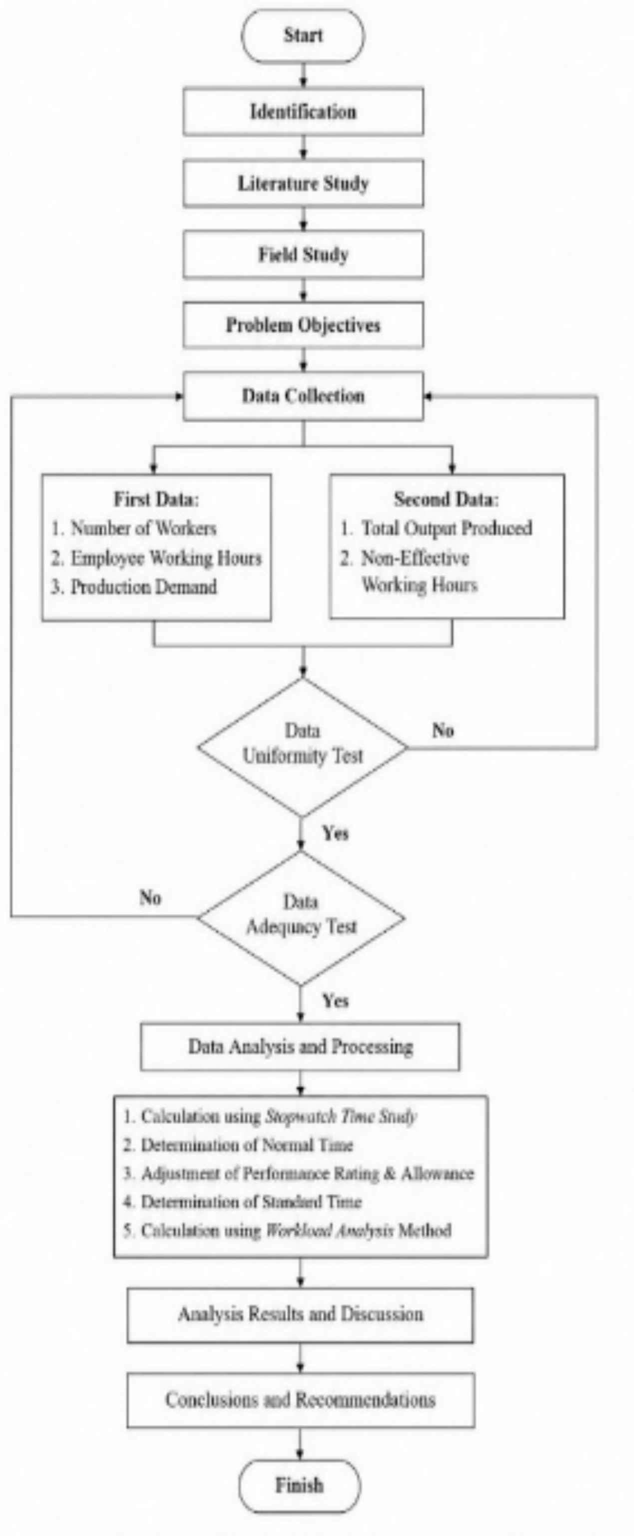

Figure 1 Research Flowchart

2.1 Identification of problems

The problems faced by the company are related to the utilization of working time and the determination of an optimal number of workers, which are analyzed using the WLA method and time study. In addition, there are indications that employee performance has not yet been optimal.

2.2 Literature Study

Literature study or library research is conducted by collecting, reading, and reviewing various reference sources related to the research topic. These sources may include books, scientific journals, articles, and previous research results that are relevant to the problem being discussed.

2.3 Field Study

The field study was conducted to obtain a direct overview of the working conditions at the research site. At this stage, the researcher carried out direct observations of the production process as well as the activities of workers in each section or division.

2.4 Problem Objective

This study was conducted with the aim of analyzing how employees' working time is utilized to support the smooth production process at PT XYZ. The analysis focuses on the extent to which the available working time has been used effectively, as well as identifying potential inefficiencies that occur during production activities.

2.5 Data Collection

Data collection was carried out, including working hours data, number of employees, non-productive time, total output, and several other relevant data. This data serves as an important basis for assessing work efficiency and supports a more accurate workload analysis. The data used in this study consisted of both primary and secondary data. Primary data were obtained directly through observations, stopwatch time studies, and pulse measurements of workers, while secondary data were collected from company records related to production capacity, working schedules, and the number of employees. The data collection process was carried out continuously during the observation period to ensure data validity and reliability.

2.6 Data Analysis and Processing

Data processing in this study was carried out to identify issues related to the utilization of employees' working time and the output produced. One of the problems identified is the potential for labor reduction due to the suboptimal use of working time. This is indicated by the presence of wasted time, which results in less than optimal production output.

2.7 Analysis Result and Discussion

Data processing in this study was carried out to identify problems related to the utilization of employees' working time and the amount of output produced. One of the issues identified is the potential reduction in labor due to the suboptimal use of working time. This is indicated by the presence of wasted time, which results in less-than-optimal production output.

2.8 Conclusions and Recommendations

After the data processing and analysis were carried out in accordance with the applied method, the author was able to draw several conclusions regarding the issues under study. These conclusions are based on the results of the calculations and discussions that have been conducted, thereby providing a clear and systematic overview of the actual conditions in the field. Recommendations were also formulated as suggestions for the company in improving workforce planning and optimizing labor utilization. These recommendations are expected to help the company create a more balanced workload distribution, improve productivity, and enhance overall operational performance.

3. Results and Discussion

In This section the research analysis is carried out using the CVL method and the WLA method to identify and solve the problem. The analysis was conducted based on data collected directly from the production process, including working hours, production output, work element duration, number of workers, and employee physiological conditions. The purpose of this analysis is to evaluate the effectiveness of labor utilization and determine the optimal number of workers required in each production division.

The results obtained from this study are expected to provide a comprehensive overview of the existing workload conditions in the company, identify inefficiencies occurring during production activities, and formulate recommendations to improve operational performance. Furthermore, the integration of CVL and WLA methods allows the evaluation process to consider not only production capacity and work time, but also the physical workload experienced by workers during operational activities.

3.1 Cardiovascular Load Method

Data collection was carried out, including working hours data, number of employees, non-productive time, total output, and several other relevant data. This data serves as an important basis for assessing work efficiency and supports a more accurate workload analysis.

The Cardiovascular Load (CVL) method was used in this study to evaluate the physical workload experienced by workers based on their heart rate conditions during work activities [23]. This method measures the level of cardiovascular strain by comparing the working pulse rate, resting pulse rate, and maximum heart rate of each operator. Through the CVL method, the researcher can determine whether the workload experienced by workers falls into light, moderate, or heavy workload categories.

In this study, pulse measurements were conducted on workers from several production divisions, including welding, assembly, cutting, bending, and preparation. The collected physiological data were then processed to calculate the percentage of Cardiovascular Load (%CVL) for each operator. The calculation results were subsequently analyzed to determine the overall physical workload conditions of employees at PT XYZ.

As shown in Table 1, there are 15 operators involved in the production process. The operators vary in age, height, and body weight, with ages ranging from 24 to 40 years, heights ranging from 158 cm to 175 cm, and body weights ranging from 47 kg to 85 kg. The youngest employee is 24 years old, while the oldest is 40 years old.

Table 1
Employee Characteristics Data

Subjek	Division	Age	Weight	Height
OP 1	Welding	29	80	173
OP 2	Welding	35	85	165
OP 3	Welding	30	69	164
OP 4	Assembly	31	70	170
OP 5	Assembly	40	50	159
OP 6	Assembly	36	74	169
OP 7	Assembly	24	76	175
OP 8	Cutting	24	63	165
OP 9	Cutting	28	59	167
OP 10	Bending	25	74	172
OP 11	Bending	26	71	170
OP 12	Bending	38	83	168
OP 13	Banding	28	67	173
OP 14	Preparation	24	47	158
OP 15	Preparation	29	65	168

After identifying the characteristics of all employees, pulse rate measurements were conducted 30 times. Subsequently, the maximum heart rate and CVL (Cardiovascular Load) were calculated. For females, 220 is replaced with 200.
The maximum heart rate (MHR) was calculated using the following formula:

$$\textit{Maximum Heart Rate (MHR)} = 220 - \textit{Age}$$

Since all operators involved in this study were male, this formula was applied to all respondents. For example, for Operator 1, who was 29 years old, the maximum heart rate was calculated as follows:

$$\textit{MHR} = 220 - 29 = 191 \textit{ beats/minute}$$

Therefore, the maximum heart rate of Operator 1 was 191 beats/minute. Meanwhile, the CVL is determined using the following method:

$$\%\text{CVL} = \frac{100 \text{ x } (77-70)}{191-70} = 6{,}14\%$$

Based on the calculation results presented above, it is known that all employees have a physical workload level below 30%. This indicates that, in general, the working conditions experienced by the workers are relatively low or not overly demanding. According to the CVL (Cardiovascular Load) classification method, a value of 30% is considered the threshold for the light workload category. Therefore, if the physical workload value is below this threshold, it can be categorized as a light workload. Hence, it can be concluded that all employees are not exposed to a high level of physical strain in performing their work activities, and the working conditions remain within a safe limit based on the CVL assessment standard. The results of the Cardiovascular Load (CVL) calculations for all operators are presented in Table 2.

Table 2
Cardiovascular Load

Subjek	Cardiovascular Load			
	DNK	DNI	DNM	CVL%
OP 1	77	70	191	6,14%
OP 2	84	76	185	7,95%
OP 3	99	88	190	10,33%
OP 4	98	78	189	18,16%
OP 5	76	58	180	14,50%
OP 6	97	69	184	24,22%
OP 7	99	70	196	23,03%
OP 8	86	65	196	16,06%
OP 9	112	85	192	25,62%
OP 10	97	75	195	18,77%
OP 11	111	86	194	23,03%
OP 12	81	73	182	7,66%
OP 13	96	75	192	17,95%
OP 14	63	86	196	3,93%
OP 15	88	73	191	7,52%

As presented in Table 2, the highest CVL value was recorded by Operator 9 (25.62%), while the lowest CVL value was observed for Operator 14 (3.93%). The average CVL value of all operators was approximately 14.86%, indicating that the overall physical workload remained relatively low. Based on the CVL classification criteria, all operators had CVL values below 30%, which indicates that their workload falls within the light workload category. These results suggest that the physical demands of the production activities are still within acceptable limits and do not require immediate corrective actions related to physical workload reduction.

3.2 *Workload Analysis*

Time studies were conducted at each workstation to observe and measure the duration of work activities performed in every station. The table above presents the time data obtained from 30 observation cycles conducted at each workstation. These observations were carried out to record and evaluate the duration of work activities performed in every station during the production process. Each workstation in the study is represented using alphabetical codes, ranging from A to K, to simplify identification and data organization. The Table 3 provides a detailed breakdown of the observed processing times for each workstation, allowing a clearer understanding of the time required to complete tasks at different stages of the work process. The recorded data is then used as a basis for further analysis, particularly in evaluating work efficiency, identifying variations in processing time, and supporting subsequent calculations related to work measurement and standard time determination.

The codes presented in Table 4 are used to classify and organize the various work activities within the production process in a systematic and structured manner. Each letter from A to K represents a different type of activity that corresponds to each specific stage in the production workflow, allowing the entire process to be clearly identified and analyzed in sequence. The process begins with code A, which refers to production material preparation as the initial step before production activities commence. This stage is essential to ensure that all required raw materials are available and ready for use. Code B represents the machine setup process, which is carried out to ensure that all production equipment is properly adjusted and in a ready-to-operate condition. Code C indicates the part cutting process, where materials are cut according to the required dimensions and specifications. This is followed by code D, which involves bend line marking, serving as a guideline to ensure accuracy during the bending process. Next, code E refers to the part bending process, which is carried out based on the established design specifications to form the required shape of the component. Code F involves welding according to the working drawing, which functions to permanently join components together in accordance with the production design. Code G represents the product cooling process, which is conducted after welding to stabilize the material and ensure product quality. Code H is the foil peeling process, which is performed on the product surface as part of the finishing preparation stage.

Table 3
Observation Time

Work Code	Observation Time (Minute)									
	1	2	3	4	5	6	7	8	9	10
A	0,49	0,45	0,48	0,46	0,43	0,45	0,47	0,43	0,45	0,45
	0,46	0,49	0,45	0,47	0,47	0,49	0,48	0,49	0,49	0,48
	0,45	0,47	0,43	0,45	0,47	0,43	0,45	0,48	0,49	0,43
B	1,45	1,33	1,46	1,31	1,45	1,34	1,36	1,46	1,34	1,47
	1,33	1,44	1,40	1,36	1,34	1,36	1,45	1,33	1,35	1,48
	1,48	1,46	1,36	1,48	1,36	1,33	1,31	1,39	1,48	1,35
C	40,10	40,11	40,10	40,11	40,10	40,12	40,10	40,12	40,11	40,11
	40,10	40,15	40,11	40,10	40,09	40,14	40,10	40,16	40,15	40,16
	40,14	40,15	40,11	40,16	40,10	40,10	40,14	40,10	40,11	40,11
D	0,37	0,36	0,35	0,37	0,33	0,35	0,37	0,37	0,36	0,33
	0,33	0,33	0,35	0,33	0,35	0,35	0,36	0,33	0,33	0,33
	0,35	0,33	0,36	0,35	0,36	0,37	0,35	0,36	0,35	0,36
E	59,36	59,36	59,47	59,11	59,34	59,12	59,06	59,24	59,01	59,24
	59,15	59,21	59,08	59,02	59,47	59,34	59,23	59,12	59,12	59,24
	59,15	59,36	59,44	59,03	59,34	59,03	59,34	59,03	59,24	59,12
F	34,02	34,22	34,26	34,22	34,28	34,26	34,03	34,22	34,02	34,26
	34,28	34,22	34,04	34,22	34,24	34,24	34,04	34,28	34,24	34,22
	34,26	34,04	34,22	34,28	34,26	34,28	34,24	34,26	34,22	34,26
G	4,33	4,44	4,40	4,36	4,34	4,36	4,45	4,33	4,35	4,48
	4,48	4,46	4,36	4,48	4,36	4,33	4,31	4,39	4,48	4,36
	4,45	4,33	4,46	4,31	4,45	4,47	4,34	4,36	4,46	4,34
H	3,23	3,27	3,24	3,29	3,23	3,29	3,23	3,23	3,23	3,24
	3,27	3,24	3,27	3,23	3,24	3,24	3,27	3,23	3,29	3,23
	3,29	3,23	3,27	3,24	3,27	3,23	3,29	3,24	3,27	3,23
I	38,01	38,12	38,10	38,06	38,03	38,07	38,48	38,02	38,19	38,05
	38,03	38,28	38,03	38,13	38,21	38,01	38,17	38,35	38,11	38,08
	38,02	38,26	38,06	38,34	38,10	38,05	38,32	38,36	38,34	38,10
J	55,59	55,54	55,34	55,41	55,43	55,47	55,36	55,47	55,49	55,38
	55,38	55,37	55,45	55,37	55,35	55,31	55,57	55,47	55,37	55,28
	55,28	55,38	55,39	55,38	54,47	55,48	55,32	55,45	55,51	55,19
K	8,32	8,33	8,19	8,31	8,21	8,22	8,34	8,36	8,15	8,34
	8,33	8,11	8,17	8,36	8,34	8,36	8,45	8,33	8,35	8,48
	8,48	8,46	8,36	8,48	8,36	8,33	8,31	8,39	8,48	8,35

Tabel 4
Code Activity

Code Activities	Work Activities
A	Production Material Preparation
B	Machine Setup
C	Part Cutting Process
D	Bend Line Marking
E	Part Bending Process
F	Welding According to Working Drawing
G	Product Cooling Process
H	Foil Peeling Process
I	Smoothing the Product Surface
J	Product Assembly
K	Product Function Testing

Overall, codes A to K describe a complete and sequential flow of production activities, starting from the initial preparation of materials, continuing through various manufacturing and finishing processes, and ultimately ending with final product testing. his structured sequence highlights that each stage plays an important role in ensuring the efficiency, consistency, and quality of the overall production process.

3.2.1 Data Uniformity Test

A data uniformity test is a method used to check whether the collected data is stable and does not show excessive variation. The following is the data uniformity test for work code A.

$$\partial = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}} = \frac{0{,}49+0{,}45+0{,}48+\cdots+1{,}35}{30-1} = 0{,}462$$

$$BKA = \bar{X} + k.\ \sigma\bar{x} = 0{,}462 + 2(0{,}0208) = 0{,}5043$$
$$BKB = \bar{X} - k.\ \sigma\bar{x} = 0{,}462 - 2(0{,}0208) = 0{,}4210$$

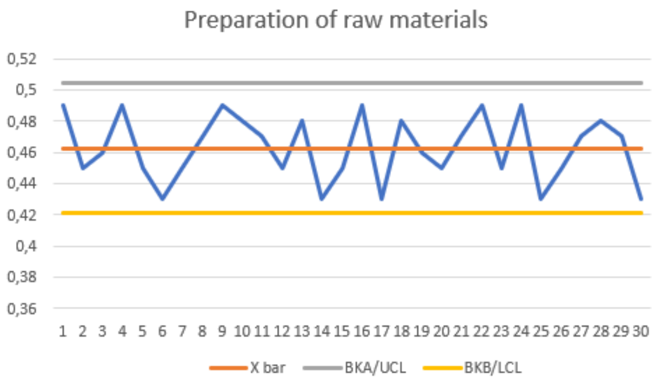

Figure 2. Data uniformity test graph

The yellow line represents X̄ (X-bar), which is the average value of the observed data and is used as the main reference in the analysis. The upper control line represents BKA/UCL (Upper Control Limit), which is the maximum allowable limit in data control. If the observed values exceed this line, the data is considered out of control. The lower control line represents BKB/LCL (Lower Control Limit), which is the minimum allowable limit. If the values fall below this line, the data is considered unstable. Overall, X̄, BKA/UCL, and BKB/LCL are used toevaluate data uniformity and ensure that all observation results remain within statistical control limits.

3.2.2 Data adequacy test

A data adequacy test is a method used to assess whether the amount of collected data is sufficient to represent the actual conditions or still needs to be increased The following is the formula for the data adequacy test, and below is the calculation performed for the cutting division The uniformity test was conducted using a 95% confidence level, i.e., K 2 = 95%.

$$N' = \frac{\left[\frac{K}{S}\left\{\sqrt{\{N\sum x^2 - (\sum x)^2\}}\right\}\right]}{\sum x}$$

$$N' = \frac{\left[\frac{2}{5}\left\{\sqrt{\{30\ (0{,}614^2 - (192{,}65)^2\}}\right\}\right]}{13{,}88} = 3{,}13$$

$N' < N$ = 3,13 < 30 Therefore, it is considered sufficient

a. Degree of accuracy

The level of accuracy is a measure that indicates the allowable margin of error in a measurement or dataset The following is the formula for the level of accuracy:

$$S = \frac{\partial}{\bar{x}} \times 100\%$$

$$S = \frac{0{,}020}{0{,}462} \times 100\% = 0{,}450$$

b. Confidence level

This study uses a 95% confidence level. Therefore, the resulting Contingency Level (CL) is 95%, indicating that 95% of the total capacity is effectively available after considering the allowance factor.

CL = (100% - X)
CL = (100% - 5%)
= 95%

c. Performance Rating

Performance rating is a method used to evaluate an operator's performance based on several factors, such as work speed, skill level, effort, and consistency in performing tasks, by comparing it to a predetermined standard level of performance, which is generally set at 100%. In a time study, each operator may work at different speeds when completing a task. This variation means that the observed time cannot be used directly for further analysis. Therefore, performance rating is required to adjust the observed time his adjustment aims to ensure that the resulting time reflects normal working conditions, so that the analysis becomes more accurate and can be used as a basis for determining standard time.

The following is the performance rating for the material preparation activity, which consists of four assessment factors skill, condition, effort, and consistency. For skill, it is categorized as Excellent with code B2 and a score of 0.08. For condition, it is categorized as Good with code C2 and a score of 0.02. Meanwhile, effort is categorized as Good with code C1and has a score of 0.05. Lastly, consistency is also categorized as Good with code C, with a score of 0.01. The total of the performance rating determination above is 0.16.

Table 5
Performance Rating

Performance Rating Preparation Of Paper			
Performance Factor	Class	Code	Score
Skill	Excellent	B2	0,08
Condition	Good	C2	0,02
Effort	Good	C1	0,05
Consisten	Good	C	0,01

d. Determination of allowances

Normal time determination represents the time required for a qualified worker to complete a task at a normal working pace. However, workers cannot work continuously without breaks, so allowances are needed for personal needs such as resting, drinking, or going to the restroom.

Table 6
allowance

Allowance				
Code Activity Score	**Personal**	**Fatigue**	**Delay**	**Allowance**
A	0,03	0,04	0,02	9%
B	0,03	0,02	0,02	7%
C	0,03	0,02	0,02	7%
D	0,04	0,02	0,02	8%
E	0,04	0,03	0,02	9%
F	0,05	0,03	0,02	10%
G	0,05	0,02	0,02	9%
H	0,02	0,02	0,02	6%
I	0,02	0,03	0,02	7%
J	0,02	0,02	0,02	6%
K	0,02	0,02	0,02	6%

e. Standard time calculation

Standard time calculation is a method used to determine the amount of time required by a worker with normal ability and average performance to complete a specific task under defined working conditions. This calculation not only considers the observed work pace or performance level of the operator, but also includes additional allowance time to account for factors such as fatigue, personal needs, and unavoidable delays. By incorporating these elements, standard time provides a more realistic and fair measurement of the time needed to complete a job, which can be used as a basis for planning, scheduling, and evaluating production a system.

Table 7
Standart Time

Standart Time			
Code Activity Score	**Normal Time**	**Allowance**	**Standart Time**
A	0,56	9%	0,62
B	1,67	7%	1,77
C	48,67	7%	52,33
D	0,42	8%	0,46
E	72,23	9%	79,37
F	40,36	10%	44,85
G	5,32	9%	5,84
H	4	6%	4,26
I	46,18	7%	49,65
J	67,05	6%	71,33
K	10,5	6%	11,17

f. Manpower calculation

Manpower calculation is a method used to determine the required number of workers to achieve production targets by considering available working time and standard time.

$$\frac{\textit{Standard Time x Quantity Demand Production}}{\textit{Working Days x Working Hours}} \textit{x 1 person}$$

Work Load Analysis (WLA) is used to determine the level of employee workload and to calculate the optimal number of workers required in a production process. This method helps the company evaluate whether the current workforce is sufficient to handle the existing workload or if there is a shortage or excess of workers. In addition, WLA results are used to classify workload conditions, whether they are light, ormal, or excessive. This information becomes a basis for decision-making, such as adding or reducing workers and improving job distribution.By implementing WLA, the company can improve work efficiency, reduce the risk of fatigue due to excessive workload, and ensure that the production process runs more effectively and meets the established targets.

Table 8
Workload Analysis

Workload Analyasis					
Number Of Worker	**Proces**	**Total Standar Time**	**Total Working Hours**	**Production Capacity**	**WLA**
3	Welding	55,88	9600	260	1,513
4	Assembly	82,5	9600	260	2,234
2	Cutting	54,71	9600	260	1,482
3	Bending	79,83	9600	260	2,162
2	Preparation	48,76	9600	260	1,321

Table 8 presents a detailed workload analysis for each production process, namely welding, assembly, cutting, bending, and preparation. The analysis was conducted by considering several important factors, including the number of workers assigned to each workstation, the total standard time required for each process, the total available working hours, production capacity, and the resulting Workload Analysis (WLA) value. This analysis aims to evaluate the distribution of workload across the production department and determine whether the existing workforce allocation is balanced and efficient.

Based on Table 8, all production processes use the same total available working time of 9,600 hours and a production capacity target of 260 units. However, despite having the same working hours and production target, the WLA values differ in each process due to variations in workload demands, work complexity, and the number of workers assigned. These differences indicate that each workstation experiences a different level of workload intensity. The welding process, which is handled by 3 workers, has a WLA value of 1.513. This result indicates that the workload in the welding division is relatively moderate and still manageable with the current number of workers. Meanwhile, the assembly process, operated by 4 workers, shows the highest WLA value of 2.234. This high value indicates that the assembly division experiences the heaviest workload among all production processes, suggesting that the workers in this section may be required to work with a higher level of effort and productivity to meet production targets. The cutting process, handled by 2 workers, has a WLA value of 1.482, which reflects a moderate workload level. In comparison, the bending process with 3 workers records a WLA value of 2.162, which is also considered relatively high. This condition shows that the bending division experiences a significant workload pressure like the assembly division. On the other hand, the preparation process, which is operated by 2 workers, shows the lowest WLA value of 1.321. This result indicates that the preparation division has the lightest workload compared to the other production processes. Overall, the workload analysis results demonstrate that the workload distribution across the production workstations is not evenly balanced. Some divisions, particularly assembly and bending, experience considerably higher workload levels than the others. These conditions may potentially affect worker performance, productivity, and operational efficiency if not properly managed. Therefore, the company may need to conduct further evaluations regarding workforce allocation, work distribution, or possible manpower adjustments in order to create a more balanced workload distribution. By improving workload balance, the company is expected to enhance production efficiency, optimize worker performance, and support the achievement of production targets more effectively.

Table 9
Workforce

Workforce		
Number Of Worker Before WLA	**Proess**	**Number Of Worker After WLA**
3	Welding	2
4	Assembly	3
2	Cutting	2
4	Bending	3
2	Preparation	2

The table presents the workforce distribution across several production processes before and after the implementation of WLA. The processes include welding, assembly, cutting, bending, and preparation. Before the WLA was applied, the number of workers allocated to each process was relatively higher. Welding involved 3 workers, assembly had 4 workers, cutting used 2 workers, bending involved 3 workers, and preparation required 2 workers. After the WLA implementation, adjustments were made to optimize workforce allocation based on workload requirements. The number of workers in the welding process was reduced from 3 to 2 workers, while the assembly process was reduced from 4 to 3 workers. Meanwhile, the cutting, bending, and preparation processes remained unchanged, each still employing 2, 3, and 2 workers respectively. Overall, the results indicate that the WLA implementation contributed to a more efficient workforce distribution, particularly by reducing excess labor in welding and assembly processes without affecting other operational activities.

The findings indicate that workload distribution across production divisions is not always proportional to the number of workers assigned. Although production targets were achieved, the WLA results revealed the presence of underutilized labor capacity in several divisions. From an industrial engineering perspective, these results support the principle that workforce allocation should be determined based on actual workload requirements rather than solely on existing staffing practices. Furthermore, the integration of WLA and CVL demonstrates that workforce optimization can be achieved without increasing physical workload levels, as all operators remained within the light workload category. Practically, these findings provide useful guidance for manufacturing companies in improving labor utilization, reducing inefficiencies, and supporting more effective workforce planning decisions.

g. Productivity Calculation

The following is the productivity formula

$$\text{Productivity} = \frac{\text{Production Output}}{\text{Number Of Workers x Working Hours}} \text{x } 100\%$$

$$\text{Productivity} = \frac{13}{3 \, x \, 480} x \; 100\% = 90{,}28\%$$

Table 10
Labor Productivity Before WLA Calculation

Production Calculation				
Process	**Production Output /day**	**Number Of Worker**	**Working Hours**	**Productivity%**
Welding	13	3	480	90,28%
Assembly	13	4	480	67,71%
Cutting	13	2	480	135,42%
Bending	13	4	480	67,71%
Preparation	13	2	480	135,42%

The results of the productivity calculation before the implementation of WLA, which are presented in the table, can also be displayed in the form of a diagram as shown below. This visual representation is provided to make the data easier to read, interpret, and understand, so that the differences in productivity levels across each production process can be seen more clearly.

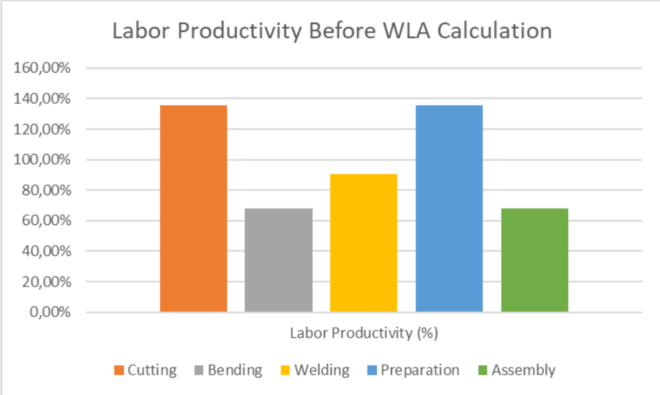

Figure 3. Labor Productivity Before WLA

Before the Workload Analysis (WLA) calculation was carried out, the productivity levels of labor in each production process were first determined based on the available observation data collected from the field. These initial results were used to describe the actual performance conditions of each workstation prior to any workload adjustment or balancing.

The findings showed that the cutting process achieved a productivity level of 135.42%, which indicates a relatively high level of output compared to the standard performance. The bending process recorded a productivity value of 67.71%, reflecting a lower output level when compared to the standard. Meanwhile, the welding process reached 90.28%, which can be considered relatively close to the expected standard performance level. In addition, the preparation process also obtained a productivity value of 135.42%, similar to the cutting process, showing that this stage operates with a relatively high level of efficiency. On the other hand, the assembly process recorded a productivity of 67.71%, which is comparatively lower than several other processes within the production flow.

Overall, these productivity values illustrate the initial condition of labor performance across different production stages before the implementation of WLA. At this stage, workload distribution among workers has not yet been optimized, and further analysis is still required to achieve a more balanced and efficient production system.

Table 11
Labor Productivity After WLA Calculation

Production Calculation				
Process	**Production Output /day**	**Number Of Worker**	**Working Hours**	**Productivity%**
Welding	13	2	480	90,28%
Assembly	13	3	480	90,28%
Cutting	13	2	480	135,42%
Bending	13	3	480	67,71%
Preparation	13	2	480	135,42%

The results of the productivity calculation after the implementation of WLA, as presented in the table, can also be displayed in the form of a diagram as shown below. This visual presentation is intended to make the data easier to read, understand, and interpret, so that the differences in productivity levels across each production process can be seen more clearly.

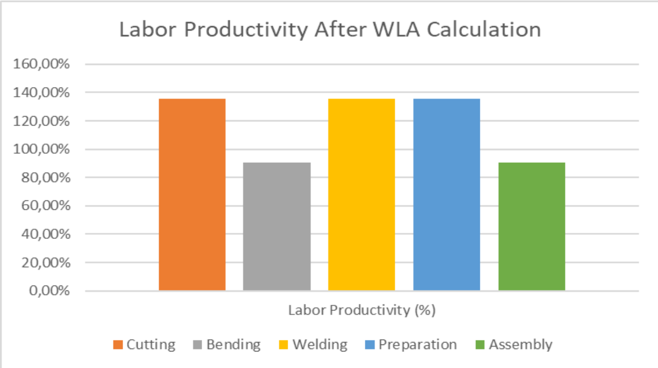

Figure 4. Labor Productivity After WLA Calculation

After the Workload Analysis (WLA) calculation was carried out, the results showed that there was an imbalance in workload across several production processes, particularly in the bending, welding, and assembly sections. Therefore, adjustments were required in the form of workload reduction in these areas in order to achieve a more even distribution of work and ensure that it is aligned with each operator's capacity. After these improvements were made, changes occurred in the productivity levels of each process. In the cutting process, productivity remained at 135.42% as it was not affected by any changes. Then, in the bending process, after workload adjustments were implemented, productivity changed to 90.28%, indicating a more balanced working condition.

In the welding process, the results after WLA also showed a value of 135.42%, reflecting improvements in workload distribution within this stage. Meanwhile, the preparation process remained at 135.42%, as it was already considered stable and efficient from the beginning. For the assembly process, after workload reduction, productivity also changed to 90.28%, making the workload in this section more proportional. Overall, the results after the implementation of WLA indicate that workload adjustments were able to create a more even distribution of work. As a result, several processes experienced improved productivity stability and became more efficient compared to the previous condition.

h. Total Expected Cost

The following is the Total Expected Cost formula when rounded down, Employee salary : Rp 176.000 and Overtime Pay : Rp 40.0000.

$$Cost_{under} = (N - N_b) \times C_u$$

The following is the Total Expected Cost formula when rounded up

$$Cost_{over} = (N_a - N) \times C_0$$

Table 12
Preliminary TEC calculation

Total Expected Cost			
Proces	N	NB	NA
Cutting	1,48	1	2
Bending	2,16	2	3
Welding	1,51	1	2
Preperation	1,32	1	2
Assembly	2,23	2	3

After determining the results of the employee calculation, it was found that the cutting process had a value of 1.48. To determine the most cost-efficient number of employees, rounding down and rounding up calculations were carried out. For NB, the value 1.48 was rounded down to 1 employee, while for NA, the value 1.48 was rounded up to 2 employees.

As presented in Table 13, the determination was carried out by performing the calculations. For the rounding down calculation (NB), it was calculated using the formula N − Nb, while for the rounding up calculation (NA), it was calculated using the formula Na − N. In addition, Cu represents the daily wage, while Co represents the overtime cost. After performing the initial calculation and the advanced calculation, the final result of the TEC calculation was obtained, as shown in the following table.

Based on the TEC (Total Expected Cost) calculation results presented in Table 14, it can be seen that each production process has different Cost Under and Cost Over values. The selection of alternatives was carried out by considering the lowest cost in order to determine a more efficient and economical workforce allocation for each production process.

In the cutting process, the Cost Under value obtained was Rp 83,339.15, while the Cost Over value was Rp 20,730.83. From these results, it can be seen that the Cost Over value is lower than the Cost Under value. Therefore, the Cost Over alternative was selected for the cutting process because it provides lower expenses and greater cost efficiency for the company. Furthermore, in the bending process, the Cost Under value was Rp 28,036.81, while the Cost Over value was Rp 33,571.50. Based on these results, the Cost Under value is lower than the Cost Over value. Therefore, the Cost Under alternative was selected for the bending process because it is considered more economical and capable of minimizing the company's expenses.

Table 13
Continued TEC calculation

Total Expected Cost			
(N-Nb)	(Na - N)	Cu	Co
0,48	0,52	Rp173.000	Rp. 40.000
0,16	0,84	Rp173.000	Rp. 40.000
0,51	0,49	Rp173.000	Rp. 40.000
0,32	0,68	Rp173.000	Rp. 40.000
0,23	0,77	Rp173.000	Rp. 40.000

Table 14
Final TEC result

Cost Under	**Cost Over**
(N-Nb)*Cu	**(Na – N)*Co**
Rp 83.339,15	Rp 20.730,83
Rp 28.036,81	Rp 33.571,50
Rp 88.821,08	Rp 19.463,33
Rp 55.460,92	Rp 27.176,67
Rp 40.546,88	Rp 30.625,00

In the welding process, the calculation results showed that the Cost Under value was Rp 88,821.08, while the Cost Over value was Rp 19,463.33. Since the Cost Over value is significantly lower than the Cost Under value, the Cost Over alternative was selected for the welding process. This selection was made because it provides more economical costs and greater benefits for the company. Next, in the preparation process, the Cost Under value obtained was Rp 55,460.92, while the Cost Over value was Rp 27,176.67. From these results, it can be concluded that the Cost Over value is lower than the Cost Under value. Therefore, the Cost Over alternative was selected because it is able to reduce operational costs more efficiently.

Lastly, in the assembly process, the Cost Under value obtained was Rp 40,546.88, while the Cost Over value was Rp 30,625.00. Based on this comparison, the Cost Over value is lower than the Cost Under value. Therefore, the Cost Over alternative was selected for the assembly process because it is considered more efficient in terms of company expenses. Overall, the TEC calculation results indicate that most production processes are more efficient when using the Cost Over alternative, except for the bending process, which is more efficient when using the Cost Under alternative. The selection of these alternatives was carried out to achieve minimum labor costs and improve the company's operational cost efficiency.

The workforce recommendations proposed in this study were derived from the combined results of Workload Analysis (WLA), Stopwatch Time Study, productivity evaluation, and Total Expected Cost (TEC) analysis. The recommended workforce adjustments were not based solely on workload values, but also considered labor utilization levels and cost efficiency. The results indicate that the recommended workforce allocation is capable of supporting the existing production capacity while maintaining acceptable workload conditions, as evidenced by the CVL results. However, future studies may further validate these recommendations through sensitivity analysis, simulation models, or comparisons with alternative manpower planning approaches.

4 Conclusion

Based on the calculation results using the Cardiovascular Load (CVL) method, it was found that all 15 workers were classified within the light workload category, as all CVL values were below 30%. This indicates that the physical workload experienced by the workers remained within acceptable limits and did not pose significant physiological strain. Furthermore, based on the results of the Workload Analysis (WLA) and Total Expected Cost (TEC) analysis, workforce adjustments were recommended in several production divisions. The welding division was reduced from 3 workers to 2 workers, and the assembly division was reduced from 4 workers to 3 workers, while the cutting, bending, and preparation divisions maintained their existing workforce levels of 2, 3, and 2 workers, respectively. These workforce adjustments are expected to improve labor utilization, reduce ineffective working time, and support better operational efficiency without increasing workers' physical workload.

This study was conducted in a single stove manufacturing company; therefore, the findings should be interpreted within the context of PT XYZ and may not be directly generalizable to other manufacturing industries with different production systems, workforce structures, or operational characteristics. Future studies are encouraged to involve multiple companies or different manufacturing sectors to enhance the generalizability and external validity of the findings, as well as to validate the applicability of the proposed workforce planning approach in different industrial environments.

5 Reference

[1] J. Purnama, Z. Arief, N. R. Athirah, and L. Wiratama, "Strategi berkelanjutan dengan pendekatan interpretive structural modeling (ISM) kondisi pandemi Covid 19 pada UKM furniture," *Journal of Research and Technology*, vol. 8, no. 1, pp. 1–13, 2022.

[2] V. H. Abdillah, and J. Purnama, "Penentuan jumlah tenaga kerja pada proses pembuatan batu bata dengan metode Work Load Analysis (WLA) guna memenuhi permintaan," *Jurnal Ilmiah Teknik dan Manajemen Industri*, vol. 3, no. 2, pp. 1542–1552, 2023.

[3] M. Ewnetu and Y. Gzate, "Assembly operation productivity improvement for garment production industry through the integration of lean and work-study, a case study on Bahir Dar textile share company in garment, Bahir Dar, Ethiopia," *Heliyon*, vol. 9, no. 7, 2023.

[4] M. C. Leva, M. Demichela, L. Comberti, and A. Caimo, "Human performance in manufacturing tasks: Optimization and assessment of required workload and capabilities," *Safety Science*, vol. 154, p. 105838, 2022.

[5] B. A. Prabowo and J. Purnama, "Penentuan jumlah tenaga kerja untuk mengoptimalkan produktivitas pada produk tungku kompor: Studi kasus pada PT. Elang Jagad di Sidoarjo," *Jurnal Ilmiah Teknik dan Manajemen Industri*, vol. 3, no. 2, pp. 1102–1118, 2023.

[6] S. Putra, F. Handoko, and S. Haryanto, "Analisis beban kerja menggunakan metode Workload Analysis dalam penentuan jumlah tenaga kerja yang optimal di CV. Jaya Perkasa Teknik, Kota Pasuruan," *Jurnal Valtech*, vol. 3, no. 2, pp. 82–85, 2020.

[7] N. Ristika and H. Prastawa, "Penggunaan metode Work Load Analysis (WLA) dalam pengukuran beban kerja produksi jok bus seri SR 2 HDDG Suite Class (Sleeper) untuk optimalisasi jumlah tenaga kerja (Studi Kasus: CV. Laksana Karoseri Semarang)," *Industrial Engineering Online Journal*, vol. 13, no. 1, 2024.

[8] A. Y. Pradana and F. Pulansari, "Analisis pengukuran waktu kerja dengan stopwatch time study untuk meningkatkan target produksi di PT. XYZ," *Jurnal Manajemen Industri dan Teknologi*, vol. 2, no. 1, pp. 13–24, 2021.

[9] N. V. Febriana, E. R. Lestari, and S. Anggarini, "Analisis pengukuran waktu kerja dengan metode pengukuran kerja secara tidak langsung pada bagian pengemasan di PT JAPFA COMFEED INDONESIA TBK," *Jurnal Industri*, vol. 4, no. 1, pp. 66–73, 2020.

[10] R. Irawati and D. A. Carollina, "Analisis pengaruh beban kerja terhadap kinerja karyawan operator pada PT Giken Precision Indonesia," *Inovbiz: Jurnal Inovasi Bisnis*, vol. 5, no. 1, p. 51, 2017.

[11] I. Khadijah and A. Kusumawardhani, "Analisis pengukuran kerja untuk mengoptimalkan produktivitas menggunakan metode Time and Motion Study," *Jurnal Manajemen Diponegoro*, vol. 5, no. 3, pp. 1–15, 2021.

[12] A. Latief, P. F. Melu, and I. H. Lahay, "Pengukuran waktu kerja karyawan pada pengemasan es kristal menggunakan metode Time Study," *Jurnal Industri Jambura*, vol. 1, no. 2, p. 48, 2021.

[13] C. Meisya, N. F. Fajriah, and S. Sari, "Workload analysis to optimize labor of tofu factory X with Workload Analysis and Workforce Analysis methods," *Journal of Industrial Engineering Management*, vol. 7, no. 2, pp. 101–107, 2022.

[14] Nafisatul Ilim, A. Khairul Wahyudi, F. Kurniadi, S. Hairunnisa, and M. Is Anshori, "Pengaruh pengalaman kerja, pelatihan, dan motivasi kerja karyawan dalam meningkatkan kinerja karyawan," *Jurnal Manajemen dan Bisnis Ekonomi*, vol. 2, no. 1, pp. 39–54, 2023.

[15] J. Purnama, "Analisis pengukuran waktu kerja pada alat penuang air proses mixing untuk meningkatkan kapasitas produksi bata tahan api," *Prosiding Senakama*, vol. 1, pp. 171–181, 2022.

[16] A. K. Aziz and M. Oktaviana, "Analisis pengaruh penilaian kinerja karyawan terhadap kinerja karyawan (Tinjauan Literatur)," vol. 13, no. 4, 2025.

[17] S. Oktavia and R. R. S. Uslianti, "Pengukuran beban kerja fisik dan tingkat kelelahan karyawan PT. XYZ menggunakan metode CVL dan IFRC".

[18] M. Rahayu and S. Juhara, "Pengukuran waktu baku perakitan pena dengan menggunakan waktu jam henti saat praktikum analisa perancangan kerja," *UNISTEK*, vol. 7, no. 2, pp. 93–97, 2020, doi: 10.33592/unistek.v7i2.650.

[19] K. Roidelindho, "Penentuan beban kerja dan jumlah tenaga kerja optimal pada produksi tahu," vol. 3, no. 1, 2017.

[20] A. N. Suci and A. M. Suyono, "Evaluasi tenaga kerja QC bahan baku dan bahan kemas berdasarkan metode WLA dan WFA," 2025.

[21] Supatmi, "Pengaruh pelatihan, kompensasi terhadap kepuasan kerja karyawan dan kinerja karyawan," 2023.

[22] B. Moores, "A comparison of work-load using physiological and time study assessments," *Ergonomics*, vol. 13, no. 6, pp. 769–776, 1970.

[23] M. Dias, L. Silva, D. Folgado, M. L. Nunes, C. Cepeda, M. Cheetham, and H. Gamboa, "Cardiovascular load assessment in the workplace," 2023.