Determination of standard time with the stopwatch time study method at PT BI

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ABSTRACT

In the manufacturing industry, the effectiveness of the work process is one of the key factors to increase the efficiency and competitiveness of the company. One of the main challenges is the accurate determination of standard working times, especially in processes involving manual inspections. Without a clear standard time, setting work targets is often not optimal, which can result in uneven workload, decreased productivity, and worker fatigue. PT BI is an automotive component manufacturing company that uses cold forging technology. One of the important processes in this company is visual inspection to guarantee product quality. However, the company has not established a standard time for the visual inspection process, so the daily target is determined based on the less effective cycle time. This study aims to analyze the effectiveness of operators in using standard time in achieving targets. The study used the stopwatch time study method to measure the work cycle time in visual inspection operators. Data was collected through observations and interviews with operators as well as analysis using Minitab software. The results of the study show that the application of standard time is able to increase the effectiveness of operators in achieving daily targets. In addition, precise determination of standard timing provides companies with advantages, with better process efficiency and reduced operator fatigue levels. In conclusion, the application of standard time can be the optimal solution to increase company productivity while maintaining worker welfare.

1. Introduction

PT. BI is a manufacturing company engaged in the production and distribution of automotive components. In producing its products, this company is very protective of its quality. The company has a Visual Inspection Team that plays an important role in ensuring customer satisfaction and minimizing the level of product defects. The operator visually inspects the product to determine it meets the set quality standards (Yudisha, 2021). The time it takes for a job to pass through the factory is the work cycle time, which means the flow time or production lead time, where shortening the cycle time is very important for the company (Bon & Samsudin, 2018). Companies will have a more competitive advantage if they can reduce the cycle time of a job so that they can respond more quickly to changes in customer demand and increase process efficiency (Purbasari et al., 2023). The company sets the cycle time as a reference in determining the target that must be achieved by the operator in a day (Rahma & Pratama, 2019). It can be said that cycle time is the result of direct observation expressed in the stopwatch, generally has a variety of cycle times even though the operator works at a normal and uniform speed, and each different element of the cycle cannot always be adjusted at the same time (Marasabessy et al., 2023). In terms of ergonomics, cycle time is not effective if used as a reference to determine targets (Nurunni'mah, 2019). It is necessary to add adjustments and leeway in determining the targets of a company, because humans must have personal needs and fatigue in carrying out their work (Mayselah, 2023). Determining the standard time for visual inspection operators is the key to optimizing the efficiency of the production process. Standard time is a time required by an operator to complete his work by a certain method, at the best conditions at that time (Daryanto, 2021). The right standard time will ensure that the operator has enough time to conduct a thorough inspection without rushing, but also not to waste excessive time (Lestari et al., 2022). The use of the stopwatch method can be an effective solution in determining the standard time for visual inspection operators (Pradana & Pulansari, 2021). The downtime measurement method can be applied to short and repetitive time measurements on ongoing or ongoing work. Time measurement by reading and recording the working time of the work repeatedly is done by returning the needle to zero (Achmadi et al., 2021; Ramadhani, 2020). The time successfully measured and recorded is then modified by taking into account the operator's work tempo and adding it with allowances. The work activities that will be measured must first be divided into work elements in detail. By observing the activities to be measured, then the measurement of the time required to complete the work element is measured and recorded. From the measurement results, a standard time to complete one work cycle will be obtained, where this time is used as a standard time for completing work for all workers who will do the same work.

The research was conducted by (Krisnaningsih et al., 2020), in the packing operator with the downtime method by obtaining a standard time of 152.98 seconds or 153 seconds per product unit as a reference in determining the 5S work attitude. Montororing (2018), through a study on powder-coating operations for Amplimesh products using the downtime method, determined a standard time of 2 minutes and 9 seconds for producing one unit. This resulted in a productivity level of 61% and a capacity increase of 39.38%, or 55 units per shift. The research was conducted by (Wahid & Chumaedi, 2020), The production operator after calculating the Stopwatch Time Study found that the standard time of the Manifold manufacturing process was 2460 seconds/41 minutes per product. The research was conducted by (Prayuda, 2020), In the production operator from the analysis results, the results of the veil making cycle time were obtained of 917.4 seconds or 15.29 minutes, the normal time was 990.79 seconds or 16.51 minutes and the standard time was 1347.474 seconds or 22.45 minutes. Meanwhile, the research conducted by (Sutaarga & Setiawan, 2021), in the production operator with the determination of the standard time of each shoe sample, it is hoped that each operator will be able to complete each sample according to the standard time that has been determined, so that the specified target can be achieved. However, these studies predominantly focus on processes such as packing, coating, and assembly work, which involve repetitive physical tasks. Limited research has specifically addressed the standard time determination for visual inspection activities, especially in the context of the automotive component industry. At PT BI, the visual inspection process plays a vital role in maintaining product quality, yet the absence of a defined standard time has led to ineffective and potentially unrealistic daily target settings. Therefore, this study seeks to fill that gap by applying the stopwatch time study method to establish a reliable standard time for visual inspection tasks, thereby improving both operator efficiency and company productivity.

Based on the above problems and previous research, the problem of this research is the ineffectiveness in setting daily work targets at PT BI due to the absence of a standard time standard applied to the visual inspection process. The company uses cycle time as a reference, which does not fully reflect the actual working conditions. This can lead to unrealistic target setting, decreased productivity, and increased operator fatigue levels. Thus, the purpose of this study is to analyze the effect of the application of standard time on the determination of daily targets for visual inspection operators. The method used in this study is a stopwatch time study. This method involves direct measurement of the cycle time of each working element performed by the visual inspection operator. This method is used because it is effective in determining accurate standard time, so it can be a reference in improving the efficiency and productivity of the operator's work. This research is expected to be useful in helping companies determine more realistic and efficient daily work targets based on standard time.

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2. Methods

Research Object

The object of this practical work research is for visual inspection operators in the Quality Control Department at PT. Boltz Indonesia. Standard time measurement and analysis will be carried out to produce the ideal daily target for the company. Through the results of the work sampling measurement, which in the processing has been adjusted with the addition of allowances, the final output will be obtained in the form of a recommendation for the target number per day for an operator. Thus, the company will benefit if it implements these recommendations and employee welfare will increase due to the appropriate targets.

Data Collection Techniques

The data collection techniques carried out in this study include the following techniques:

a. Observation
   This observation method aims to be able to understand the workflow or process that occurs in the series of work contained in the Visual Inspection Team of the Quality Control Department.
b. Interview
   Interviews in this study were conducted directly to visual inspection operators. The data obtained from several data collection methods carried out include the cycle time of the work carried out, as well as data about the operator to be researched.

Data Processing Engineering

The data processing in this study follows a systematic approach aligned with the stopwatch time study method. The crank-cap product, which has high production demand, was selected as the research focus. Each operator's work cycle was broken down into detailed work elements and measured 30 times using a stopwatch to obtain accurate cycle time data. This data then underwent data adequacy and uniformity testing to ensure consistency and reliability. Once validated, the average cycle time was calculated and adjusted using performance rating factors to obtain the normal time. Finally, a relaxation factor was added to account for fatigue, personal needs, and delays, resulting in the standard time. This final value serves as the benchmark for setting realistic and fair daily production targets for visual inspection operators. Uptime measurement with stopwatch can be seen in Fig. 1.

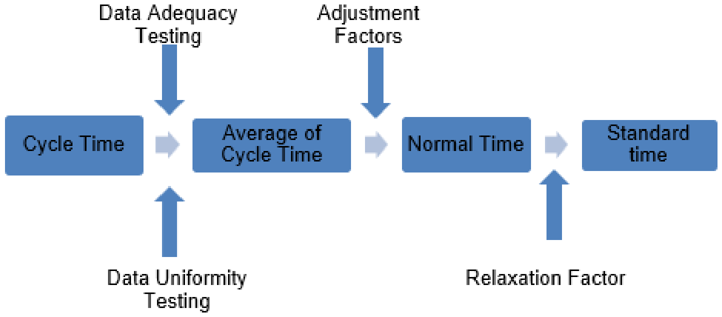

Fig. 1 Uptime measurement with stopwatch.

Data Analysis Techniques

The data analysis in this study follows the standard procedure of the stopwatch time study method. First, the work cycle is divided into clearly defined work elements. Each element is measured repeatedly using a stopwatch 30 times per element to obtain representative cycle time data. The data is then tested for normality, adequacy, and uniformity to ensure validity and consistency. Once validated, the average cycle time for each work element is calculated. Next, adjustment factors are applied to account for differences in operator performance, using both the Westinghouse system (subjective rating) and objective method based on physical task characteristics. The result is the normal time, which reflects the time an average skilled worker would take under standard conditions. To ensure the result accounts for human needs and fatigue, a relaxation allowance is added, including

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allowances for rest, personal needs, and unavoidable delays. The result is the standard time, which serves as a reliable reference for determining fair and achievable daily production targets.

Research Flow

The series of flows or steps carried out in this study are outlined in the flowchart in Fig. 2.

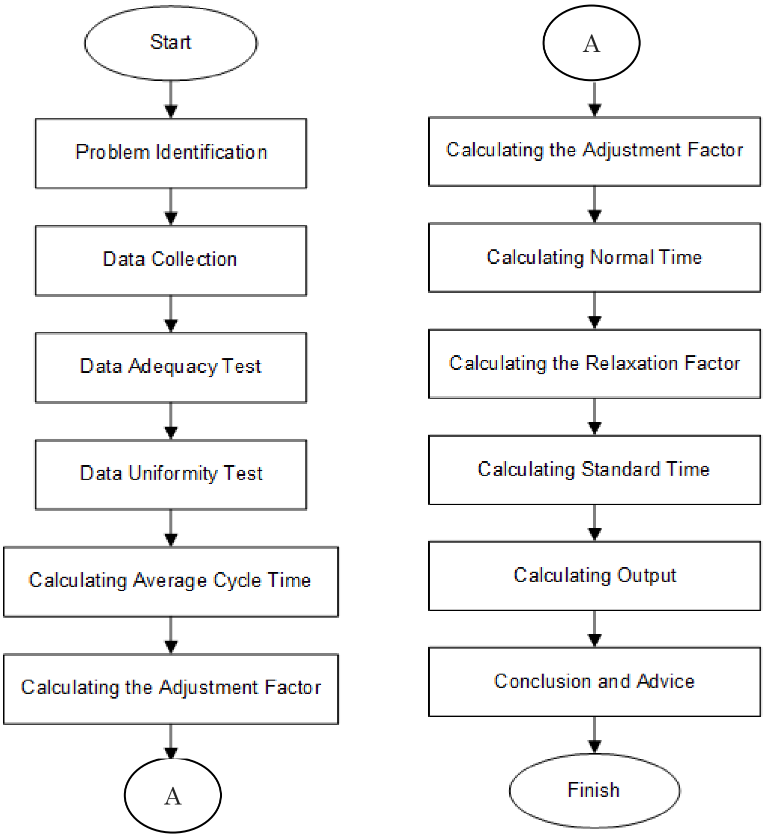

Fig. 2 Research flow.

3. Results and Discussion

The first measurement was made to a female operator named Atin, 23 years old with measurements taken 30 times.

a. Measurement of the 1st Movement element can be seen in Table 1.

Table 1 Measurement of the 1st movement element

Take to-	Time (x)	x^2
1	1.72	2.95
2	1.62	2.62
3	1.35	1.82
4	1.32	1.74
5	1.5	2.25
6	1.47	2.16
7	1.13	1.27
8	1.48	2.19
9	1.31	1.71
10	1.36	1.84
11	1.11	1.23
12	1.39	1.93
13	1.42	2.01

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Take to-	Time (x)	x^2
14	1.15	1.32
15	1.20	1.44
16	1.73	2.99
17	1.65	2.72
18	1.75	3.06
19	1.71	2.92
20	1.25	1.56
21	1.44	2.07
22	1.43	2.04
23	1.70	2.89
24	1.49	2.22
25	1.13	1.27
26	1.26	1.58
27	1.38	1.90
28	1.53	2.34
29	1.35	1.82
30	1.46	2.13
xj	**42.79**	**62.09**
xj^2	**1830.98**	**3855.37**
Time	**1.42**	**2.06**

$$Cycle\ Time = \frac{42.79}{30} = 1.42 \text{ second} \qquad (1)$$

b. Data Normality Test

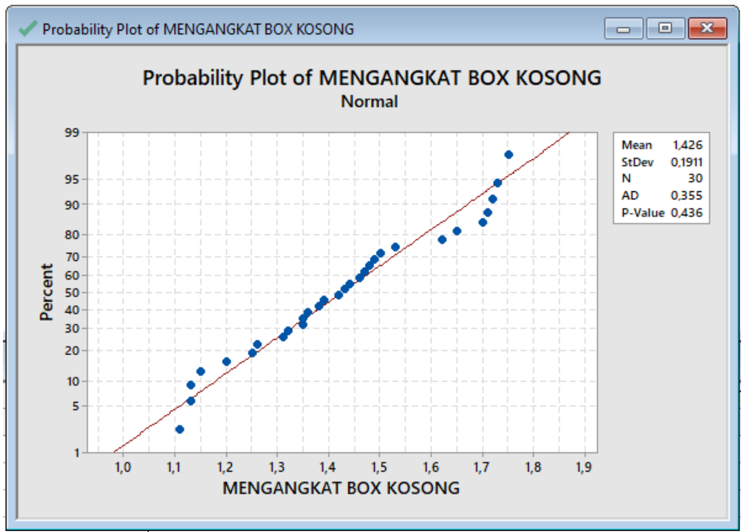

Fig. 3 The 1st movement data normality test

Fig. 3 shows that the distribution of observation time follows a normal distribution with a P-value of 0.436 > 0.05, so the data is considered valid for further statistical analysis. After using the help of Minitab software, the data lifting the empty box data is said to be normal, because the P-Value is 0.436 which is more than 0.05.

c. Data Adequacy Test

Data adequacy tests are carried out to ensure that the data that has been collected is objectively sufficient.

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$$N' = \left(\frac{\frac{k}{s}\sqrt{N\sum xj^2 - (\sum xj)^2}}{\sum xj}\right) \quad (2)$$

where k is the level of confidence, where the level of confidence k = 95% = 2, S = degree of precision, N amount of observation data, N' = amount of theoretical data.

$$N' = \left(\frac{\frac{2}{0.5}\sqrt{30\sum 62.09^2 - (\sum 42.79)^2}}{42.79}\right)$$

$N' =$ 27.75

So, the data is said to be sufficient because $N' < N$.

d. Data Uniformity Test

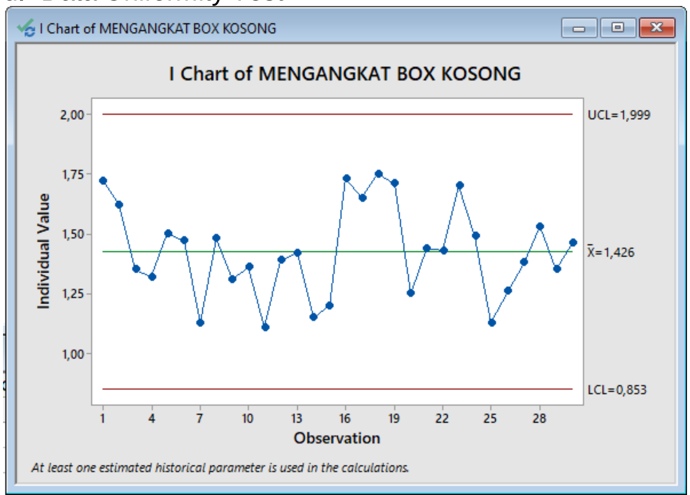

Fig. 4 The 1st movement data uniformity test.

Fig. 4 shows that all observation points are within the upper (UCL) and lower (LCL) control limits, indicating a uniform and stable work process. After using the help of Minitab software, the data can be said to be uniform because it is within the control range of UCL and LCL.

e. Determining the Adjustment Factor (P)

Westinghouse Method

Table 2 Adjustment factor 1st movement

Factor	Class	Symbol	Adjustment
Skills	Good	C1	0.06
Effort	Good	C2	0.03
Working Conditions	Average	D	0
Consistency	Poor	F	-0.04
Total			0.05
P1 total			1.05

Objective Method

Table 3 The 1st movement objective method

Conditions	Symbol	Adjustment
Used limbs	C	2
Forearms, wrists and fingers		
Pedal Kaki	F	0
No Pedals or one pedal with an axis under the foot		
Hand use	H	0
Both hands help each other alternately		

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Conditions	Symbol	Adjustment
Eye coordination with hands Very few	I	0
Equipment Can be handled easily	N	0
Load Weight 0.45	B1-Hand	2
Total		4
P2		1.04

Adjustment total= Adjustment 1 × Adjustment 2
Adjustment total=1.05 ×1.04
Adjustment total=1.09

f. Normal Time Calculation (WN)
Normal Time (WN)=Cycle Time (WS)×Adjustment
Normal Time (WN)=1.42 ×1.09
Normal Time (WN)=1.55 second

g. Calculation of Allowance Value

Table 4 Relaxation values of the 1st movement

Factor	Allowance
Energy Output: Very Light	6.00
Work Attitude: Stand on 2 feet	1.00
Work Movement: Normal	0.00
Eye Fatigue: Disjointed Vision	0.00
Workplace Temperature Condition: High	5.00
Atmospheric Conditions: Sufficient	2.00
Good environmental conditions: Very Bising	3.00
Total	17.00

Note: Inevitable obstacles = 5%
Allowance for personal needs (women) = 5%
Allowance =17%+5%+3%=27%

h. Standard Time Calculation (WB)
Standard Time (WB)=WN+(i×WN)
Standard Time (WB)=1.55+(0.27×1.55)
Standard Time (WB)=1.97 second

This calculation is from movement 1 to movement 6 on 3 operators, the following is a summary of data processing.

i. Atin (Woman 24 tahun)

Table 5. Summary data processing Atin 24th

Movement Elements	N	N'	Average Cycle Time (seconds)	P1	P2	Normal Time (seconds)	i	Standard Time (seconds)
1	30	27.75	1.42	1.05	1.04	1.55	0.27	1.97
2	30	29.28	1.53	1.04	1.04	1.65	0.27	2.1
3	30	23.15	1.65	1.09	1.48	2.65	0.27	3.37
4	30	17.76	166.07	1.12	1.04	93.43	0.27	245.65
5	30	23.4	1.62	1.1	1.04	1.86	0.27	2.36
6	30	28.65	1.98	1.05	1.54	3.2	0.27	4.05
Total			174.27			104.34		259.5

Trained in an operator named Atin, the average cycle time is 174.27 seconds, normal time is 104.34 seconds and standard time is 259.5 seconds.

Table 6 Additional motion elements Atin 24th

Add Movement Elements	N	N'	Average Cycle Time (seconds)	P1	P2	Normal Time (seconds)	i	Standard Time (seconds)
1	15	10.24	32.10	1.1	1.1	38.84	28.50%	49.91
Total			32.1			38.84		49.91

It is obtained on the Atin operator for additional movement elements has a cycle time value of 32.1 seconds, normal time 38.84 seconds and standard time 49.91 seconds.

j. Hilmi (Man 20 years)

Table 7 Summary data processing Hilmi 20th

Movement Elements	N	N'	Average Cycle Time (seconds)	P1	P2	Normal Time (seconds)	i	Standard Time (seconds)
1	30	28.25	2.02	1.05	1.04	2.21	24.00%	2.74
2	30	19.72	1.90	1.09	1.08	2.23	26.00%	2.81
3	33	14.88	2.76	1.12	1.54	4.79	27.50%	6.11
4	30	4.71	203	1.09	1.54	238.97	30.00%	310.66
5	30	9.00	1.99	1.13	1.04	2.35	24.00%	2.91
6	30	29.88	2.53	1.07	1.54	4.23	25.50%	5.30
Total			214.20			254.77		330.5

Equipped with an operator named Hilmi, the average cycle time value is 214.20 seconds, normal time 254.773 seconds and standard time 330.5 seconds.

Table 8 Additional motion elements Hilmi 20th

Add Movement Elements	**N**	**N'**	**Average Cycle Time (seconds)**	**P1**	**P2**	**Normal Time (seconds)**	**i**	**Standard Time (seconds)**
1	15	13.99	33.06	1.07	1.1	38.92	25.50%	48.84
Total			**33.06**			**38.92**		**48.84**

It was obtained on the Atin operator for the additional movement elements had a cycle time value of 33.06 seconds, a normal time of 38.92 seconds and a standard time of 48.84 seconds.

k. Yulan (Woman 21 years)

Table 9 Summary data processing data yulan 21th

Movement Elements	N	N'	Average Cycle Time (seconds)	P1	P2	Normal Time (seconds)	i	Standard Time (seconds)
1	30	27.76	1.43	1.05	1.04	1.56	27.00%	1.98
2	30	11.70	1.69	1.04	1.04	1.83	27.00%	2.33
3	33	16.22	2.71	1.09	1.48	4.38	27.00%	5.56
4	30	5.07	205.43	1.11	1.04	237.15	33.00%	315.41
5	30	9.00	1.94	1.1	1.04	2.22	27.00%	2.82
6	30	20.81	2.49	1.05	1.54	4.03	27.00	5.11
Total			215.7			251.16		333.2

Equipped with an operator named Hilmi, the average cycle time value is 215.7 seconds, normal time 251.16 seconds and standard time 333.2 seconds.

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Table 10 Additional motion elements Yulan 21th

Add Movement Elements	N	N'	Average Cycle Time (seconds)	P1	P2	Normal Time (seconds)	i	Standard Time (seconds)
1	15	13.59	38.14	1.1	1.1	46.15	28.50%	59.30
Total			38.14			46.15		59.30

It was obtained on the Atin operator for the additional movement elements had a cycle time value of 38.14 seconds, a normal time of 46.15 seconds and a standard time of 59.30 seconds. The following is a summary of the time data per operator shown in Table 11 and in Fig. 5.

Table 11 Average summary

Operator	Ws	Wn	Wb
Atin	174.27	104.34	259.50
Hilmi	214,2	254.77	330.53
Yulan	215.7	251.17	333.21
Average	201.39	203.43	307.75

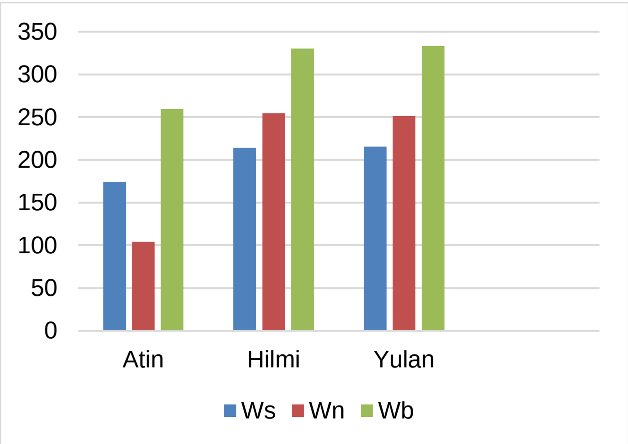

Fig. 5 Summary data time per operator.

From the results of data processing, the standard time value of the main work movement for crank-cap products was obtained which was 307.75 seconds or 5.13 minutes/box. The following is a summary of additional moves from the time data per operator shown in Table 12.

Table 12 *Summary of additional moves*

Operator	Ws	Wn	Wb
Atin	32.1	38.84	49.91
Hilmi	33.06	38.92	48.84
Yulan	38.14	46.15	59.30
Average	34.43	41.30	52.68

Based on Tabel 11 and Fig. 5, the data shows that Hilmi has the highest normal time (254.77 seconds), while Atin has the lowest (104.34 seconds). This significant difference may be influenced by several factors. Firstly, ergonomic conditions such as posture, hand height relative to the inspection table, and lighting may not be equally optimal for all operators. Secondly, gender-based differences could play a role, where male operators might apply more force or speed, but with lower precision, causing inconsistencies and rechecking during inspection. In contrast, female operators such as Atin might exhibit more careful and consistent movements, resulting in lower but steadier work cycles. In addition, tool-handling variation or differences in familiarity with inspection criteria could also affect performance. Furthermore, the high variance in cycle times between operators indicates potential inconsistency in workstations, suggesting a need for workstation standardization or layout improvement. Ensuring that every operator works under identical ergonomic and tool-access conditions could reduce time disparities and improve overall efficiency.

The standard time value for additional work movements is 52.68 seconds or 0.88 minutes. So to complete 1 box takes time:

Total Main Movement Time + Total Additional Movement Time =307.75+52.68
=360.43 seconds or 6 minutes.

So to complete 1 daisha as many as 20 boxes takes as much time: =360.43 × 20box
=7208.66 seconds
=120.14 minutes

In a day, visual inspection operators can inspect products with the following amounts: =480÷120.14
=3.99 daisha
≈4 daisha

Based on the results of the standard time calculation, it is known that it takes 360.43 seconds (6 minutes) to complete one box, which is a combination of the main movement time (307.75 seconds) and additional movement time (52.68 seconds). Thus, to complete 1 daisha containing 20 boxes, it takes 7208.66 seconds or about 120.14 minutes. With an effective working time allocation of 480 minutes per day, the visual inspection operator can optimally complete 4 daishas per day. This figure gives a concrete idea of the visual inspection operator's work capacity in a day and provides a realistic reference point for setting daily production targets. If the company currently sets a target of more than 4 daishas per day per operator, then it is likely that the target is unrealistic, and may lead to overload, operator fatigue, or reduced inspection quality. In addition, the proportion of additional movement time of 52.68 seconds (about 14.6% of the total time per box) indicates that non-inspection activities such as moving items, repositioning, or retrieving tools, are still quite significant. This could indicate the need to evaluate the work layout, tool arrangement, and material flow, to reduce non-productive time and improve efficiency. Thus, these results not only help in labor capacity planning, but also open up room for work system improvements so that additional time can be reduced and operator productivity increased without compromising on quality.

4. Conclusion

Based on the research that has been conducted, it can be concluded that the application of the stopwatch time study method has provided accurate and objective standard time values for visual inspection tasks at PT BI. The results show that operators require approximately 6 minutes to complete one box, or 120.14 minutes to complete one daisha (20 boxes). With a working time of 480 minutes per day, the realistic capacity for each operator is around 4 daisha per day, compared to the company's previous target of 6 daisha, which was set based on rough cycle time estimation.

This significant gap reaffirms the importance of using time study methods. By adopting standard time that includes performance rating and allowance factors, the company can set more realistic and achievable daily targets, avoiding overburdening operators, reduce the risk of operator fatigue, which contributes to human error and lower inspection quality, improve long-term productivity by fostering a sustainable work pace and better ergonomic conditions.

Furthermore, the time study results revealed that 14.6% of work time is spent on additional movements, indicating an opportunity to streamline workflows through layout improvements. Thus, the use of time study not only enhances output planning but also supports continuous improvement (Kaizen) in operational efficiency and employee well-being.

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