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Determination of Standard Time and Output Production of Spring Frame Mattress Components using Work Sampling Method

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Abstract. PT.CMAP which is a company that manufactures mattresses with production process starts from making foam (foaming), mattress covers, spring frames and finishing. Based on observations, obtained that the process of spring frame has the lowest percentage of daily production results. The purpose of this research is to determine the percentage of productive activities, cycle time, normal time, standard time and daily output of the spring frame mattress production process at PT.CMAP. The method used in this research is work sampling method that begins with preliminary sampling, data uniformity test, data adequacy test, calculating cycle time, calculating normal time by including performance factors, calculating standard time by including allowance factor and calculating daily output. The results obtained from this research that the standard time for the process of spring frame mattress components at PT.CMAP which consists of the spring round process is 5.04 minutes with the daily output is 90 pcs, the semi-finished spring frame process is 10.99 minute with the daily output is 41 pcs, the list frame process is 14.81 minutes with the daily output is 31 pcs and spring frame shooting CL process is 13.40 minutes with the daily output is 34 pcs.
Keywords: work sampling, sampling, cycle time, normal time, standard time

1. INTRODUCTION

In the current situation of business competition, productivity is one of the factors that support the company to grow and survive. Productivity cannot be realized suddenly, but through gradual and continuous improvement, which must always be done continuously, in order to create a good habit in increasing work productivity.[1]

PT.CMAP which is a company that manufactures mattresses with production process starts from making foam (foaming), mattress covers, spring frames and finishing. Based on observations obtained that the percentage of the daily production results for the making foam (foaming) process is 100%. For the mattress cover process is consisting of quilting process is 94%, cutting process is 115%, and sewing process is 101%. For the spring frame process is consisting of spring round process is 91%, list frame process is 68%, semi-finished frame process is 48%, and spring frame shooting CL process is 47%. For the finishing process which consists of assembling is 100%, sewing corner process is 97% and packing process is 107%. Based on these data it can be seen that the spring frame process has the smallest percentage and must get attention to be immediately improved so that productivity can increase.

Work sampling method is very suitable for use in observing work that is non-repetitive and has a relatively long time. Basically the implementation steps are quite simple, by observing work activities for randomly taken time intervals of one or more machines or operators and then recording whether they are working or idle. Work sampling is very useful in industry, especially in the manufacture of quality products. The number of observations that must be carried out in work sampling activities is influenced by two factors, are confidence level and degree of accuracy. Generally, the work sampling method can be used for several things, among others: [5, 7]

1) Measure the Delay Ratio of a number of machines, operators/employees or other work facilities.
2) Determine the Performance Level of someone in working time based on the times when the person works or idle, especially for manual work.
3) Determine a standard time for a work operation process.

Work sampling method is one method that can be used to overcome these problems which is a statistical sampling technique based on sampling theory. This method can estimate a certain amount, for example the proportion of productive activities through sampling.

Based on the problems that occur at PT.CMAP, the purpose of this research is to determine the percentage of productive activities, cycle time, normal time and standard time and daily output in the production process of spring frames mattress at PT.CMAP.

2. METHODS

This research used work sampling method to determine the standard time of the production process of skeletal components in PT. CMAP which consists of 4 processes, among others spring round process, semi-finished spring frames process, list frame process, and spring frame shooting CL process, so that it can know the amount of daily production output. There are several stages in this research, among others:

1) Preliminary sampling
   In this step a number of observations are made on the work activities of the observed operators to find out the best work system and find out the time interval taken at random. In this step, productive percentages can determine using formula: [6]

$$\bar{p} = (\Sigma X_i / \Sigma n_i) \times 100 \tag{1}$$

   Where X_i is percentage of productive period i and n_i is number of observations of the period i.
2) Data uniformity test
   Data uniformity test aims to determine whether the data taken is within the control limits or not between the upper control limit (UCL/BKA) and the lower control limit (LCL/BKB), with the equation used is: [6]

$$BKA = \bar{p} + 3\sqrt{\bar{p}\,(1 - \bar{p})/n} \quad \text{and} \quad BKB = \bar{p} - 3\sqrt{\bar{p}\,(1 - \bar{p})/n} \tag{2}$$

3) Data adequacy test
   The number of observations needed for the level of accuracy and confidence that has been determined, known through the formula: [6]

$$N' = K^2\,(1 - \bar{p})/S^2 \times \bar{p} \tag{3}$$

   Where $\bar{p}$ is the productive percentage, N’ is amount of data required, K is the amount of the constant depends on the confidence level (this research used 90%) and S is the degree of accuracy in decimal numbers (this research used 10% ≈ 0.1).
4) Calculate cycle times (WS)
   In the work sampling method, in order to determine the cycle time it must first be known the time for 1 output and the productive percentage of each process obtained from the preliminary sampling. For productive percentages use formula (1), while for time for 1 output uses the following formula. [2, 3, 4]

$$\text{Time for 1 output} = \sum \text{Output time} / \sum \text{Output} \quad (4)$$

After time for 1 output and productive percentage are known, the cycle time can be determined using the following formula. [2, 3, 4]

$$\text{WS} = \text{The productive percentage} \times \text{Time for 1 output} \quad (5)$$

5) Calculate normal time (WN)
To be able to determine the normal time, performance factors must first be determined, which in this research uses the Westinghouse method that directs the assessment of four factors that are considered to determine fairness or irregularities in work, namely skills, effort, working conditions, and consistency. Determination of the performance value using the westinghouse method performance table contained in Sutalaksana, dkk. (6). After the performance value is obtained, the performance factor value (P) can be calculated using the following formula.

$$\text{P} = 1 + \sum \text{Westinghouse performance value} \quad (6)$$

After the performance factor value is obtained, the normal time can be calculated using the following formula. [6]

$$\text{WN} = \text{WS} \times \text{P} \quad (7)$$

6) Calculate standard time (WB)
To be able to determine the standard time, it must first be determined the allowance factor value are given for three things namely personal needs, eliminating fatigue and inevitable obstacles. Determination of the allowance factor value (A) uses the allowance table contained in Sutalaksana, dkk. (6). After the allowance factor value is known, the standard time can be calculated by the following formula. [6]

$$\text{WB} = \text{WN} + \text{A}(\text{WN}) \quad (8)$$

3. RESULT AND DISCUSSION

In each production process, there are regulations that must be obeyed, especially in terms of achieving the daily production targets set by the company. Table 1 is a mattress daily production data in PT.CMAP.

Table 1. Mattress daily production data

No	Component	Process	Target	Daily Production Result					Total	% Achieving
				1	2	3	4	5		
1	Foaming	Sponge beam	13	13	13	13	13	13	65	100
		Rolling foam	12	12	12	12	12	12	60	100
2	Mattress cover	Quilting	220	189	210	206	218	210	1033	94
		Cutting	80	80	85	100	120	86	471	118
		Sewing	35	36	35	35	36	36	178	102
3	Spring frame	Spring round	110	107	96	109	102	97	511	93
		Semi-finished spring frame	40	25	15	25	20	15	100	50
		List frame	25	18	17	16	17	18	86	69
		Spring frame CL shooting	40	25	20	18	15	20	98	49
4	Finishing	Assembling	25	25	25	25	25	25	125	100
		Corner sewing	25	24	24	25	25	23	121	97
		Packing	70	70	80	77	80	73	380	109

From Table 1 it can be seen that in the components of spring frame process have a low achieving value, which will then be the focus of this research.

3.1. Preliminary Sampling Data

Preliminary sampling is carried out in each process of manufacture spring frame components with the number of observations as much as 4 times with different times in each process. For spring round process carried out for 30 minutes, for semi-finished spring frames process is carried out for 30 minutes, for list frame process is carried out for 120 minutes, and for spring frame shooting CL process carried out for 120 minutes. In table 2 can be seen the results of preliminary sampling for all processes in the manufacture of spring frame components at PT. CMAP.

Table 2. Observation data in the components of spring frame process

Process	Activities	Observation Number				Total
		1	2	3	4	
Spring Round Process	Productive	56	55	53	57	221
	Non-productive	4	4	7	3	18
	Inevitable	0	1	0	0	1
	Total	60	60	60	60	240
	% Productive	93.3	91.7	88.3	95.0	
	Output	8	7	7	6	28
Semi-finished Spring Frames Process	Productive	152	146	148	146	592
	Non-productive	3	11	10	11	35
	Inevitable	3	1	0	1	5
	Total	158	158	158	158	632
	% Productive	96.2	92.4	93.7	92.4	
	Output	4	3	4	3	14
List Frame Process	Productive	40	39	41	38	158
	Non-productive	11	12	10	13	46
	Inevitable	0	0	0	0	0
	Total	51	51	51	51	204
	% Productive	78.4	76.5	80.4	74.5	
	Output	8	8	8	8	32
Spring Frame Shooting CL Process	Productive	38	37	38	36	149
	Non-productive	2	2	4	5	13
	Inevitable	3	4	1	2	10
	Total	43	43	43	43	72
	% Productive	88.4	86.0	88.4	83.7	
	Output	12	11	12	10	45

3.2. Data Uniformity Test

Data uniformity test is conducted to determine whether the data obtained from preliminary observations are uniform and do not exceed the upper control limit (UCL/BKA) and the lower control limit (LCL/BKB) that have been determined. Following are the calculation of BKA and BKB for the manufacturing spring round process which use equation (1) dan (2).

$$\bar{p} = \frac{221}{240} \times 100\% = 92.1\%$$

$$\text{BKA} = 92.1 + 3\sqrt{\frac{92.1\ (100 - 92.1)}{240}} = 97.3\% \quad \text{and} \quad \text{BKB} = 92.1 - 3\sqrt{\frac{92.1\ (100 - 92.1)}{240}} = 86.9\%$$

For the results of other process calculations can be seen in Table 3.

Table 3. Result of Data Uniformity Test

Process	$\bar{p}$	BKA	BKB	Result
Spring round	92.1	97.3	86.9	Uniform
Semi-finished spring frame	93.7	96.6	90.8	Uniform
List frame	77.5	86.2	68.7	Uniform
Spring frame CL shooting	86.6	94.4	78.8	Uniform

Based on Table 3 it can be seen that the average percentage of productive activity ($\bar{p}$) for the whole process is in the range of BKA and BKB, so it can be concluded that the data of all processes are uniform and can be continued to the next stage.

3.3. *Data Adequacy Test*

To test the adequacy of the data, the confidence level used is 90% with a value of 1,645 and the level of accuracy used is 10% (0.10). The following is the calculation of the data sufficiency test for the manufacturing spring round process which use equation (3).

$$N' = \frac{1.645^2\ (100 - 92.1)}{0.10^2 \times 92.1} = 23.26 \approx 24$$

The calculation results of the data adequacy test for the manufacturing spring round process obtained an N' value of 23.26 (equivalent to 24 data) which means that the amount of data needed to be said to be sufficient is 24 data. With the number of preliminary observational data (N) for the manufacturing spring round process of 240 data, it can be concluded that the data is adequate because N'<N. For the results of data adequacy tests for other process can be seen in Table 4.

Table 4. Result of Data Adequacy Test

Process	N	N'	Result
Spring round	240	23.26 ≈ 24	Adequate
Semi-finished spring frame	204	18.28 ≈ 19	Adequate
List frame	632	78.78 ≈ 79	Adequate
Spring frame CL shooting	172	41.77 ≈ 42	Adequate

Based on Table 4 it can be seen that the amount of observational data (N) for the whole process is greater than the calculation of the amount of data needed (N'), so it can be concluded that the data of the entire process is sufficient and can be continued to the next stage.

3.4. *Calculation of Cycle Times (WS)*

Cycle time is the time needed for each time the manufacturing process. The following is the calculation of the cycle time (WS) for the manufacturing spring round process which use equation (4) dan (5).

$$\text{Time for 1 output} = \frac{30 + 30 + 30 + 30}{8 + 7 + 7 + 6} = 4.29 \text{ minute} \quad \text{and} \quad \text{The productive percentage} = 92.1\%$$

$$WS = 0.921 \times 4.29 = 3.95 \text{ minute}$$

For the results of other process calculations can be seen in Table 5.

Table 5. Cycle Time Calculation Results

Process	Time for 1 Output (minute)	Cycle Time/WS (minute)
Spring round	4.29	3.95
Semi-finished spring frame	8.57	8.03
List frame	15.00	11.62
Spring frame CL shooting	10.67	9.24

3.5. Calculation of Normal Time (WN)

For the normal time calculation, an performance factor is needed because in the time measurements made on observations there are some irregularities that occur. There are many factors that influence these irregularities, so that performance factors are needed. The method used to determine the performance factor is the Westinghouse method, which consists of four factors, namely skills, effort, working conditions, and consistency. Table 6 is the value of the performance factor of all the processes that exist in the manufacture of spring frame components.

Table 6. Performance Factor Value

Process	Performance Factor	Class	Symbol	Performance	Total
Spring round	Skills	Good	C2	0.03	0.06
	Effort	Good	C1	0.05	
	Working conditions	Fair	E	−0.03	
	Consistency	Good	C	0.01	
Semi-finished spring frame	Skills	Good	C1	0.06	0.09
	Effort	Good	C2	0.02	
	Working conditions	Average	D	0.00	
	Consistency	Good	C	0.01	
List frame	Skills	Good	C1	0.06	0.08
	Effort	Good	C1	0.05	
	Working conditions	Fair	E	−0.03	
	Consistency	Average	D	0.00	
Spring frame CL shooting	Skills	Good	C1	0.06	0.12
	Effort	Excellent	B2	0.08	
	Working conditions	Fair	E	−0.03	
	Consistency	Good	C	0.01	

After the performance factor value is determined, the normal time calculation can be done. The following is the calculation of the normal time for the manufacturing spring round process which use equation (6) dan (7).

$P = 1 + 0.06 = 1.06$ And $WN = 3.95 \text{ minute} \times 1.06 = 4.18 \text{ minute}$

For the results of other process calculations can be seen in Table 7.

Table 7. Normal Time Calculation Results

Process	Performance Factor (P)	Normal Time/WN (minute)
Spring round	1.06	4.18
Semi-finished spring frame	1.09	8.75
List frame	1.08	12.55
Spring frame CL shooting	1.12	10.35

3.6. Calculation of Standard Time (WB)

For the calculation of the standard time needed allowance factor which is the time required by the operator for the needs of resting after a cycle of product execution. The allowance factor is also useful in delaying the activity carried out which is caused by several factors. The value of allowance factors for all processes in the manufacture of spring frame components can be seen in Table 8.

After the allowance factors for each process are determined, the standard time calculation can be done with the detailed calculation for the spring round process which use equation (8) as follows.

$WB = 4.18 + 20.30\%(4.18) = 5.03 \text{ minute}$

For the results of other process calculations can be seen in Table 9.

Table 8. Allowance Factor Value

Process	Allowance Types	Allowance (%)	Total (%)
Spring round	Personal	2.00	20.30
	Fatigue	18.00	
	Inevitable	0.30	
Semi-finished spring frame	Personal	2.00	24.83
	Fatigue	18.00	
	Inevitable	4.83	
List frame	Personal	2.00	18.00
	Fatigue	16.00	
	Inevitable	0.00	
Spring frame CL shooting	Personal	2.00	28.50
	Fatigue	24.00	
	Inevitable	2.50	

Table 9. Standard Time Calculation Results

Process	Allowance Factor/A (%)	Standard Time/WB (minute)
Spring round	20.30	5.03
Semi-finished spring frame	10.99	10.92
List frame	14.81	14.81
Spring frame CL shooting	13.40	13.30

3.7. Output Calculation

From the calculation of standard time which is the time needed to work on 1 set of frame components per, it can be determined the output generated from each process for each day with a total working hours of 450 minutes. Calculation of output per day for the manufacturing process per round is as follows.

$$\text{Output} = \frac{\text{Total work hours}}{\text{Standard time}} = \frac{450}{5.03} = 89.29 \approx 90 \text{ pcs}$$

In Table 10, the daily output is displayed for each process of spring frame components.

Table 10. Output of Each Process in the Spring Frame Manufacturing

Process	Standard Time/WB (minute)	Output (pcs)	Target
Spring round	5.03	90	110
Semi-finished spring frame	10.92	41	40
List frame	14.81	31	25
Spring frame CL shooting	13.30	34	40

From Table 10 which is the daily output in each process of spring frame components, it can be seen that there are two processes in the production of spring frame components which cannot meet the targets of PT. CMAP, namely spring round process and spring frame CL shooting process.

4. CONCLUSION

Based on the low achievement of the target of the production of spring frame components compared with the other components production in the manufacture of mattresses at PT. CMAP, obtained several conclusions, including:

1) Percentage of productive activities for the process of spring frame mattress components at PT.CMAP consisting of spring round process is 92.1%, semi-finished spring frame process is 93.7%, list frame process is 77.5% and spring frame CL shooting process is 86.6%.

2) The cycle time for spring frame mattress at PT.CMAP which consists of spring round process is 3.95 minutes, semi-finished spring frame process is 8.03 minutes, frame lists process is 11.62 minutes and spring frame CL shooting process is 9.24 minutes.
3) The normal time for spring frame mattress at PT. CMAP which consists of spring round process is 4.18 minutes, semi-finished spring frame process is 8.75 minutes, frame lists process is 12.55 minutes and spring frame CL shooting process is 10.35 minutes.
4) The standard time for spring frame mattress at PT. CMAP which consists of spring round process is 5.03 minutes, semi-finished spring frame process is 10.92 minutes, frame lists process is 14.81 minutes and spring frame CL shooting process is 13.30 minutes.
5) The daily output of spring round processes is is 90 pcs, semi-finished spring frame process is 41 pcs, frame lists process is 31 pcs and spring frame CL shooting process is 34 pcs.
6) PT. CMAP must review the targets set in the production process of spring frame component, because based on the calculation of standard time and daily output there are two processes that cannot meet the set targets.

This research only uses four preliminary sampling for each process, so that for continuous research it can use a larger preliminary sampling so that the results obtained can be better.

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