

CHAPTER 5

DATA ANALYSIS AND DISCUSSION

5.1. Data Analysis in Manual Page Sequencing Process

5.1.1. Current Work Method Analysis

1. First Current Work Method Analysis

a. Amount of Subgroup

$$k = 1 + 3.3 \log N$$

$$k = 1 + 3.3 \log 45$$

$$k = 6.4556 \approx 7$$

b. Average Value of Subgroup

Table 5.1. Average Value of Sub Group

Subgroup	Time (Xi)							Average of Subgroup (\bar{X})
1-7	251.122	248.071	248.744	248.654	250.186	252.373	249.753	249.843
8-15	249.443	250.212	254.341	247.719	249.659	249.278	250.325	250.140
16-23	252.184	250.092	254.893	254.263	251.867	251.782	249.313	252.056
23-30	249.369	255.627	255.066	249.676	250.813	248.898	253.121	251.796
30-37	254.975	251.451	249.643	251.798	249.059	245.128	249.022	250.154
37-44	250.673	253.674	252.894	254.914	248.816	248.761	251.382	251.588
44-51	250.792	253.283	248.564					250.880
							□	1756.456

$$\bar{X} = \frac{\sum \bar{X}_i}{k}$$

$$\bar{X} = \frac{1756.456}{7}$$

$$\bar{X} = 250.922$$

c. Standard Deviation of Time

Table 5.2. Standard Deviation of Time

No	Xi	Xi ²	(Xi- \bar{X})	(Xi- \bar{X}) ²
1	251.122	63062.259	0.196	0.038
2	248.071	61539.221	-2.855	8.151
3	248.744	61873.578	-2.182	4.761
4	248.654	61828.812	-2.272	5.162
5	250.186	62593.035	-0.740	0.548
6	252.373	63692.131	1.447	2.094
7	249.753	62376.561	-1.173	1.376
8	249.443	62221.81	-1.483	2.199
9	250.212	62606.045	-0.714	0.510
10	254.341	64689.344	3.415	11.662
11	247.719	61364.703	-3.207	10.285
12	249.659	62329.616	-1.267	1.605
13	249.278	62139.521	-1.648	2.716
14	250.325	62662.606	-0.601	0.361
15	252.184	63596.77	1.258	1.583
16	250.092	62546.008	-0.834	0.696
17	254.893	64970.441	3.967	15.737
18	254.263	64649.673	3.337	11.136
19	251.867	63436.986	0.941	0.885
20	251.782	63394.176	0.856	0.733
21	249.313	62156.972	-1.613	2.602
22	249.369	62184.898	-1.557	2.424
23	255.627	65345.163	4.701	22.099
24	255.066	65058.664	4.140	17.140
25	249.676	62338.105	-1.250	1.563
26	250.813	62907.161	-0.113	0.013
27	248.898	61950.214	-2.028	4.113

No	X_i	X_i^2	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$
28	253.121	64070.241	2.195	4.818
29	254.975	65012.251	4.049	16.394
30	251.451	63227.605	0.525	0.276
31	249.643	62321.627	-1.283	1.646
32	251.798	63402.233	0.872	0.760
33	249.059	62030.385	-1.867	3.486
34	245.128	60087.736	-5.798	33.617
35	249.022	62011.956	-1.904	3.625
36	250.673	62836.953	-0.253	0.064
37	253.674	64350.498	2.748	7.552
38	252.894	63955.375	1.968	3.873
39	254.914	64981.147	3.988	15.904
40	248.816	61909.402	-2.110	4.452
41	248.761	61882.035	-2.165	4.687
42	251.382	63192.91	0.456	0.208
43	250.792	62896.627	-0.134	0.018
44	253.283	64152.278	2.357	5.555
45	248.564	61784.062	-2.362	5.579
□	11291.67	2833619.8	-	244.7051

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

$$\sigma = \sqrt{\frac{244.7058}{44}}$$

$$\sigma = 2.358$$

d. Standard deviation from sub group average distribution

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

$$\sigma_{\bar{X}} = \frac{2.358}{\sqrt{7}}$$

$$\sigma_{\bar{X}} = 0.891$$

e. Upper Control Limit (UCL) and Lower Control Limit (LCL)

$$\begin{aligned}UCL &= \bar{X} + (3 \times \sigma_{\bar{X}}) \\&= 250.922 + (3 \times 0.891) \\&= 253.595\end{aligned}$$

$$\begin{aligned}LCL &= \bar{X} - (3 \times \sigma_{\bar{X}}) \\&= 250.922 - (3 \times 0.891) \\&= 248.249\end{aligned}$$

Control data Test

$$LCL \leq \bar{X}_i \leq UCL$$

$$248.249 \leq 249.843 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 250.140 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 252.056 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 251.796 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 250.154 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 251.588 \leq 253.595 \longrightarrow \text{Data is constant}$$

$$248.249 \leq 250.880 \leq 253.595 \longrightarrow \text{Data is constant}$$

f. Sufficiency data test

The test used 5 % for precision and 95% for confidence rate.

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

$$N' = \left[\frac{40 \sqrt{N \sum X_i^2 - (\sum X_i)^2}}{\sum X_i} \right]^2$$

$$N' = \left[\frac{40 \sqrt{45 \times 2833619.8 - 127501811.4}}{11291.67} \right]^2$$

$$N' = 0.139$$

$N' \leq N$; $0,139 \leq 45$ \longrightarrow Data is sufficient

g. Cycle Time Average

$$Ct = \frac{\sum X_i}{N}$$

$$Ct = \frac{\sum X_i}{N}$$

$$Ct = \frac{11291.67}{45}$$

$$Ct = 250.926 \text{ second}$$

2. Second Current Work Method Analysis

The second current work method analysis is done same with the previous analysis for 1st work method analysis. The analysis is shown in Appendix 1. The result of the analysis shown as :

- a. Amount of Subgroup = 7
- b. Average Value of Subgroup = 262.852
- c. Standard Deviation of Time = 2.871
- d. Standard Deviation From
Subgroup Average Distribution = 1.085
- e. Upper Control Limit = 265.545
Lower Control Limit = 258.940
Control data Test = Data is Constant
- f. Sufficiency Data Test = Data is Sufficient
- g. Cycle Time Average = 262. 915 second

3. Third Current Work Method Analysis

The third current work method analysis is done same with the previous analysis for 1st work method analysis. The analysis is shown in Appendix 1. The result of the analysis is shown as :

- a. Amount of Subgroup = 7
- b. Average Value of Subgroup = 285.008
- c. Standard Deviation of Time = 3.328
- d. Standard Deviation From
Subgroup Average Distribution = 1.258
- e. Upper Control Limit = 288.726
Lower Control Limit = 281.178
Control data Test = Data is Constant

- f. Sufficiency Data Test = Data is Sufficient
- g. Cycle Time Average = 284.952 second

5.1.2. Recommended Work Method Analysis

The recommended work method analysis is done same with the previous analysis for 1st work method analysis. The analysis is shown in Appendix 1. The result of the analysis is shown as :

- a. Amount of Subgroup = 9
- b. Average Value of Subgroup = 210.32
- c. Standard Deviation of Time = 2.120
- d. Standard Deviation From
Subgroup Average Distribution = 0.547
- e. Upper Control Limit = 211.961
Lower Control Limit = 208.679
Control data Test = Data is Constant
- f. Sufficiency Data Test = Data is Sufficient
- g. Cycle Time Average = 210.318 second
- h. Recommended Left Hand-Right Hand Side Chart

The improvement of current work method in manual page sequencing process is done by eliminating, combining, simplifying and changing the sequencing of the motion elements. After made the improvement of the worker motion elements, the analysis has been done by right hand-left hand chart that shown in Appendix 7.

5.1.3. Standard Time for Current and Recommended Work Method

1. Rating Factor

Table 5.3. Objective Rating Factor

No	Condition	Symbol	Rate
1	Body parts used		
	Upper arm, wrist, and fingers	C	2
2	Foot Pedal		
	Without Pedal	F	0
3	Hand Used		
	Hands help each other or work repetitively	H	0
4	Coordination between eyes and hand		
	Constant and closely	K	4
5	Equipment		
	Can be controlled easily	N	0
6	Weight (kg)		
	4.5	B-10	22
		□	28%

Source : Based on Appendix 4

The workers did their works in normal speed. So p_1 has been valued by 1 or $p_1 = 1$

$$P_2 = 1 + 0.28$$

$$= 1.28$$

$$P = 1 \times 1.28$$

$$= 1.28$$

2. Allowance Factor

Table 5.4. Allowance Factor

No.	Factor	Allowance (%)
1	Energy Expenditures	
	Negligible (work in Table, sit down)	4
2	Work Position	
	Sit	0.3
3	Work Movement	
	Normal (free swing of the hammer)	0
4	Eye Fatigue	
	Continuously views with changeable focus (arrange some bundles of paper)	2
5	Temperature	
	Normal (27 °C)	6
6	Atmosphere Condition	
	Poor (unpoisonous dust)	7
7	Good Environmental Condition	
	Feel The Floor Vibration (The vibration from machine))	8
	□	27.3

Source : Based on Appendix 5

For the personal needs = 1 %

For inevitable obstacles = 2 %

Allowance Factor = 27.3 % + 1 & + 2 &

= 30.3 %

2. Standard Time

a. Standard Time for 1st Current Work Method

$$\begin{aligned}\text{Normal Time} &= Ct \times p \\ &= 250.926 \times 1.28 \\ &= 321.185 \text{ second}\end{aligned}$$

$$\begin{aligned}\text{Standard Time} &= Nt \times (1 + a) \\ &= 321.185 \times (1 + 0.303) \\ &= 418.504 \text{ second}\end{aligned}$$

b. Standard Time for 2nd Current Work Method

$$\begin{aligned}\text{Normal Time} &= Ct \times p \\ &= 262.915 \times 1.28 \\ &= 336.531 \text{ second}\end{aligned}$$

$$\begin{aligned}\text{Standard Time} &= Nt \times (1 + a) \\ &= 382.805 \times (1 + 0.303) \\ &= 438.500 \text{ second}\end{aligned}$$

c. Standard Time for 3rd Current Work Method

$$\begin{aligned}\text{Normal Time} &= Ct \times p \\ &= 284.952 \times 1.28 \\ &= 364.739 \text{ second}\end{aligned}$$

$$\begin{aligned}\text{Standard Time} &= Nt \times (1 + a) \\ &= 364.739 \times (1 + 0.303) \\ &= 475.254 \text{ second}\end{aligned}$$

d. Standard Time for Recommended Work Method

$$\begin{aligned}\text{Normal Time} &= Ct \times p \\ &= 210.318 \times 1.28 \\ &= 269.207 \text{ second} \\ \text{Standard Time} &= Nt \times (1 + a) \\ &= 210.318 \times (1 + 0.303) \\ &= 350.777 \text{ second}\end{aligned}$$

5.1.4. Evaluation of Work Method Improvement

1. Percentage Improvement for 1st Method

$$\begin{aligned}\% \text{ St Improvement} &= \frac{\text{St}_1 - \text{St recommended}}{\text{St}_1} \times 100\% \\ &= \frac{418.504 - 350.777}{418.504} \times 100\% \\ &= 16.183 \%\end{aligned}$$

2. Percentage Improvement for 2nd Method

$$\begin{aligned}\% \text{ St Improvement} &= \frac{\text{St}_2 - \text{St recommended}}{\text{St}_2} \times 100\% \\ &= \frac{438.500 - 350.777}{438.500} \times 100\% \\ &= 19.786 \%\end{aligned}$$

3. Percentage Improvement for 3rd Method

$$\begin{aligned}\% \text{ St Improvement} &= \frac{\text{St}_3 - \text{St recommended}}{\text{St}_3} \times 100\% \\ &= \frac{475.254 - 350.777}{475.254} \times 100\% \\ &= 26.192 \%\end{aligned}$$

5.2. Data Analysis in Binding Process

$$\begin{aligned}\text{Standard Time} &= \frac{\text{Output}}{\text{Second}} \\ &= \frac{3600 \text{ second}}{3000 \text{ books}} \\ &= 1.2 \text{ second/ book} \\ \text{St for 300 books} &= 1.2 \text{ second/ books} \times 300 \\ &= 360 \text{ second}\end{aligned}$$

5.3. Data Analysis in Cutting Process

$$\begin{aligned}\text{Standard Time} &= \frac{\text{Output}}{\text{Second}} \\ &= \frac{900 \text{ second}}{3000 \text{ books}} \\ &= 0.3 \text{ second/ book} \\ \text{St for 300 books} &= 0.3 \text{ second/ books} \times 300 \\ &= 90 \text{ second}\end{aligned}$$

5.4. Data Analysis in Inspection and Packaging

The data analysis is done same with the previous analysis for 1st current work method analysis in manual page sequencing process. The analysis is shown in Appendix 2. The result of the analysis shown as :

- a. Amount of Subgroup = 5
- b. Average Value of Subgroup = 48.191
- c. Standard Deviation of Time = 2.644
- d. Standard Deviation From

Subgroup Average	
Distribution	= 1.079
e. Upper Control Limit	= 51.428
Lower Control Limit	= 44.954
Control data Test	= Data is Constant
f. Sufficiency Data Test	= Data is Sufficient
g. Cycle Time Average	= 48.191 second
h. Rating Factor	= 1.33
i. Normal Time	= 64.094
j. Allowance Factor	= 0.303
k. Standard Time	= 83.515
l. Standard Time for 30 boxes	= 2505.436

5.5. Transport Time

5.5.1. Transport Time from Manual Page Sequencing Process to Binding Process

The transport time from manual page sequencing process to binding process is shown in Appendix 3. The result of the analysis shown as :

a. Amount of Subgroup	= 5
b. Average Value of Subgroup	= 72.309
c. Standard Deviation of Time	= 1.127
d. Standard Deviation From	
Subgroup Average Distribution	= 0.564
e. Upper Control Limit	= 74.001
Lower Control Limit	= 70.167
Control data Test	= Data is Constant
f. Sufficiency Data Test	= Data is Sufficient
g. Transport Time Average	= 72.309 second

5.5.2. Transport Time from Binding Process to Cutting Process

The transport time from binding process to cutting process analysis is shown in Appendix 3. The result of the analysis shown as :

- a. Amount of Subgroup = 5
- b. Average Value of Subgroup = 42.989
- c. Standard Deviation of Time = 1.797
- d. Standard Deviation From
Subgroup Average Distribution = 0.898
- e. Upper Control Limit = 45.683
Lower Control Limit = 40.295
Control data Test = Data is Constant
- f. Sufficiency Data Test = Data is Sufficient
- g. Transport Time Average = 42.989 second

5.5.3. Transport Time Cutting Process to Inspection and Packaging Process

The transport time from cutting process to inspection and packaging process analysis is shown in Appendix 3. The result of the analysis shown as :

- a. Amount of Subgroup = 5
- b. Average Value of Subgroup = 21.913
- c. Standard Deviation of Time = 1.263
- d. Standard Deviation From
Subgroup Average Distribution= 0.632
- e. Upper Control Limit = 23.089
Lower Control Limit = 20.017
Control data Test = Data is Constant

- f. Sufficiency Data Test = Data is Sufficient
 g. Transport Time Average = 21.912 second

5.6. Standard Time in Finishing Department

5.6.1. Standard Time per 30 boxes

$$\begin{aligned}
 St_{30 \text{ box}} &= St_1 + Tt_1 + St_2 + Tt_2 + St_3 + Tt_3 + St_4 \\
 &= 350.777 + 72.309 + 360 + 42.989 + 90 + \\
 &\quad 21.912 + 2505.436 \\
 &= 3443.423 \text{ second}
 \end{aligned}$$

Notice :

- St₁ : Standard Time for Manual Page Sequencing
 St₂ : Standard Time for Binding Process
 St₃ : Standard Time for Cutting Process
 St₄ : Standard Time for Inspection and Packaging
 Tt₁ : Transport Time from Manual Page Sequencing to Binding
 Tt₂ : Transport Time from Binding to Cutting
 Tt₃ : Transport Time from Cutting to Packaging

5.6.1. Standard Time per box

$$\begin{aligned} St_{\text{box}} &= \frac{St_{30 \text{ box}}}{30} \\ St_{\text{box}} &= \frac{3443.423}{30} \\ &= 114.781 \text{ second / box} \end{aligned}$$

5.6.2 Standard Time per Book

$$\begin{aligned} St_{\text{box}} &= \frac{St_{\text{box}}}{10} \\ St_{\text{box}} &= \frac{114.781}{10} \\ &= 11.478 \text{ second / book} \end{aligned}$$

5.7. Discussion

The standard time is very important in production process. It becomes a basic to determines the total time of order fulfillment. The condition will be better if the standard time defined is the time done by the workers with their optimum work. Before determining the standard time for whole process in finishing department, the analysis of work motion is done in manual sequencing process division. The motion done by a worker sometimes is right, but sometimes not. The worker often did unuseful movement or it usually called uneffective motion. Motion study is an analysis of the worker in finishing their work. Thus, the analysis proposed to determine the better work method done by the worker. The better work method can reduce the working time or minimized the standard time.

5.7.1. Work Method Improvement Step

The improvement of work method is done in the manual sequencing process for optimizing the work method of the workers and also to minimizing the standard time in this division. The improvements done in manual sequencing by eliminating all unnecessary work motion, combining operations, changing the sequences, and simplifying unnecessary operations. The steps is shown as :

1. Eliminate all unnecessary work motion

In this improvement, there are some eliminations done in three of the methods. For the first work method, the elimination is done in activity put the bundle vertically in table. For the second work method, the activity of put the bundle vertically in table and set the bundle horizontally are eliminated. For the third work method, the activity of take the bundle vertically, put the bundle vertically, rotate the bundle horizontally. Put the bundle horizontally and set the bundle horizontally are eliminated. The eliminations are done to minimized time because of the useless motion.

Table 5.5. Elimination of The Work Element

No	1st Current Work Method	2nd Current Work Method	3rd Current Work Method
1	Put the bundle vertically in table	Put the bundle vertically in table	Take the bundle vertically
2	-	Set the bundle horizontally	Put the bundle vertically
3	-	-	Rotate the bundle horizontally
4	-	-	Put the bundle horizontally
5	-	-	Set the bundle horizontally (2 x)

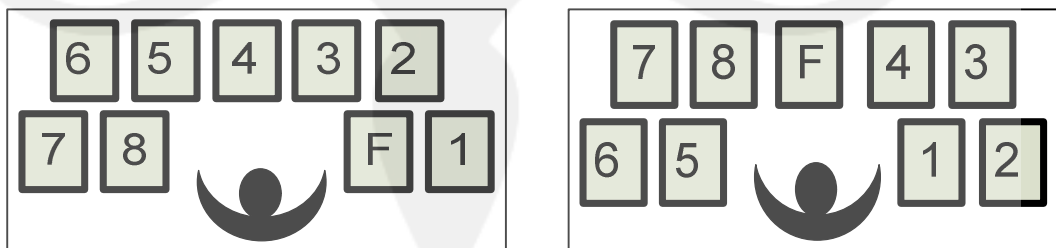
2. Combine operations or elements

All of the current work method has been improved by combining their motions. For the first method, the combining activity of right hand activities are done in activity 3 and 4, 5 and 6, and 7 and 8. For the left hand side, the combining is done in activity 3 and 4; 5 and 6; and 7 and 8; For the second method, the improvement of right hand activities are done in activity 2 and 3; 4 and 5; 6 and 7; and 8 and 9. For the left hand, the combining is done in activity 3 and 4; 5,6, and 7; and 8 and 9. For the third method, the combining of right hand activity is done in activity 5, 6, 7, and 8. And for the left hand side, the combining is done in activity 1,2,and 3; and 7 and 8. The combining improvement could be done because of unefficient work motion between right hand and left hand. There are some idle activities in right hand or left hand motions that can be improved by

combining the motions. The complete data of combining improvement is shown in appendix 12.

3. Change the sequence of operations

The work method sequences in manual page sequencing is done to design recommended work method. The sequences of work method is changed in reach in the bundle 5, 6, 7, and 8. The improvement is done caused of the symmetric and in opposite direction of the hand activity. The current method is asymmetric and not in opposite direction. The condition is not appropriated with the theory of motion economy. The recommended work method is proposed the motion of reach bundle 1 and reach bundle 5, reach bundle 2 and reach bundle 6, reach bundle 3 and reach bundle 7, and reach bundle 4 and reach bundle 8. The sequences is different from the current work method because of the relayout of the work area. The layout is changed by arranged the positions of the bundle and the finished place. The improvement of the layout is shown in Figure 5.1.



Current Work Layout

Recommended Work Layout

Figure 5.1. Relayout of The Work Area

4. Simplify the unnecessary operations

The improvement of simplifying the unnecessary operations is done in 2nd work method. The activity of set the bundle vertically three times is simplified into two times. The simplification is also done for the layout. The simplifying of the layout is done because of the theory of motion economy.

The all of the improvements are done to make a better work method in sequence Detik-Detik books. The work methods improvement steps is completely shown in Appendix 10, 11, and 12.

5.7.2. The Comparison of Standard Time in manual Page Sequencing Process

The analysis and the improvement of work methods is implemented by time and motion study analysis. The improvement is generate a better standard time. The improvement can made the standard time minimized. The comparison result between current work method and recommended work method is shown in Table 5.6.

Table 5.6. Time Comparison

Type of Time	1st Work Method		2nd Work Method		3rd Work Method		Recommended Work Method (second)
	Time (second)	Saving time (second)	Time (second)	Saving time (second)	Time (second)	Saving time (second)	
Cycle Time	250.926	40.608	262.915	52.597	284.952	74.634	210.318
Normal Time	321.185	51.978	336.531	67.324	364.739	95.532	269.207
Standard Time	418.504	67.727	438.500	87.723	475.254	124.477	350.777

The better work method is proved by the minimizing of time. The time comparison above showed that the recommended work method give a better standard time for all of the current methods. The improvement of 1st current work method to the recommended work method as amount as 16.183 %. The improvement of 2nd work method is 19,786 % and for the third method is 26.192%. From the standard time improvement, the recommended work method can be defined as better work method.

5.7.3. Standard Time of Whole Process in Finishing

In finishing department of PT.Macanan Jaya Cemerlang, there are no standard time determined before. The production time is only determined depends on the prediction of the PPIC.

Determining the standard time in finishing department of PT. Macanan Jaya Cemerlang is very important. Because of the function, analysis of each division has been calculated to determine the standard time. Because of the different process between manually and by machine, the analysis is also different.

In manual page sequencing division, the standard time is calculated by time and motion study analysis. The calculation of standard time for whole process in finishing department is shown in chapter 5.6.

The standard time of each division in finishing department is shown in Table 5.7.

Table 5.7. Standard Time of All Division

No	Division	Standard Time (second)
1	Manual Page Sequencing Process	350.777
2	Binding Process	360.000
3	Cutting Process	90.000
4	Inspection and Packaging Process	2505.436

After calculating standard time for each division, the transportation time through the divisions is properly measured. The transportation time is determined by stopwatch time measurement. All of the transportation among the divisions are used manual hand truck to deliver the books. The data of transport time is shown in table 5.8.

Table 5.8. Transport Time

No	Route	Transportation Time (second)
1	Manual Sequencing Process to Binding Process	72.309
2	Binding Process to Cutting Process	42.989
3	Cutting Process to Inspection and Packaging Process	21.912

The standard time of finishing department is determined by summarize all of the standard time in each division and also the transport time through the process. The total standard time is shown in table 5.9.

Table 5.9. Standard Time of Finishing Department

No	Unit	Standard Time (second)
1	Standard time per 30 box	3443.243
2	Standard time per box	114.781
3	Standard time per books	11.478

The standard time of finishing department can be determined in some time per unit. The standard time per 30 box is 3443.243 second or 57.387 minutes. If the standard time is determined in time per unit box, the standard time becomes 114.781 second or 1.913 minutes. If the order in the unit of books, the standard time for finishing department is 11.478 second. The standard time of finishing department can be used to determine how long the order can be fulfilled in scheduling system.