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ANALYSIS OF LINE EFFICIENCY IN FINISHING DEPARTMENT PT PURA NUSAPERSADA UNIT PAPER MILL 7/8

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ABSTRACT

Measuring line efficiency and productivity are very important to do to find out in which level the efficiency and productivity of the business process has been carried out by the company. This paper aims to determine line efficiency analysis and provide suggestions for improvements to increase line efficiency at the finishing department of PT Pura Nusapersada. Measurement of line efficiency in the finishing department of PT Pura Nusapersada paper mill unit 7 has not yet reached the company's line efficiency value target. The initial line efficiency assessment obtained a percentage of 65.14% while the company's target was 70%. In this paper, a fishbone diagram is used to determine the root cause of the problem. Based on the research results, it was found that the most dominant cause of the problem was the inefficient work elements at the cutter, sorting, pollar, and packing work stations. Improvements were made using the eliminate, combine, re-arrange, and simplify (ECRS) method and the results of the line efficiency improvements in the finishing department increased to 71.90% and the company's target can be met.

Keywords: line efficiency, finishing department, fishbone diagram, ECRS

INTRODUCTION

Productivity is important for companies in the context of competitive business competition, so that companies are required to improve its performance in order to be able to compete with other companies (Wignjosoebroto, 1995). Measurement of efficiency, productivity and line balancing is very important to determine in which level the efficiency and productivity of business processes has been carried out by the company, whether there has been an increase or a decrease. Increased productivity affects economic progress and company profits (Nasution, 2006).

PT Pura Nusapersada is a subsidiary of Pura Group which is a manufacturing company that produces paper. It consists of two Paper Mill units, namely Paper Mill units 7 and 8 with three types of paper produced, namely sack kraft paper, white kraft and B kraft paper. There are several stages of paper production, namely the stage of raw material preparation, stock preparation, additives, paper machine, slitter and finishing. In this finishing department, there are six stages of work, including the roll and cutter installation stage, which is cutting paper rolls into sheets of certain sizes. Then the sorting stage is the stage for selecting paper between paper that has good quality and poor quality, then the pollar stage, which is the stage for tidying the paper, then the packing stage, which is the stage for wrapping the paper, and the last stage, namely the balling stage for binding the products that have been produced.

Based on observations in the finishing department, there are frequent problems such as bottle necks which hinder the smooth running of production. The process that often occurs with bottle neck is the sorting and packing stages. This is due to the excessive and repetitive elements of work performed at the workstation, causing imbalance between lines in the finishing department and resulting in the productivity targets set by the company. PT Pura Nusapersada has a production capacity target that must be completed in the finishing department every day of 35,000 kg of paper and a line efficiency of 70%. However, in reality, these targets are often not achieved. The average paper that can be completed in the last three months each day is only 21,045 kg. Factors that have not achieved the production target are ineffective work elements such as searching and repetitive movements that affect line efficiency. Low line efficiency has a direct negative impact on the overall production performance of a company. Therefore, this paper identifies the problem to find the causes of not achieving the line efficiency target by using a tool in the form of a fishbone diagram, then find the root of the problem and make improvements to solve these problems and increase the line efficiency value in the finishing department.

LITERARATUR REVIEW

Line Balancing

According to Gaspersz (2004), line balancing is balancing the assignment of the elements of a task assembly lines to work stations to minimize numbers work station and minimize the total idle time price at all station for a specific output level. The following are the mathematical equations used in this paper (Nabi, F. et.al., 2015):

1. *Cycle time* (Tc), is the time needed to make one unit of product per one station. If the production time and production target have been determined, the cycle time can be seen from the production time quotient and production target.
$$Tc = \sum \text{time} \tag{1}$$
2. *Takt Time* is the time available to produce a good or product divided by the demand within a certain time period. The formula of takt time is showed as follows :
$$TaktTime = MaxCycleTime \times (100\% + 5\% allowance) \tag{2}$$

3. *Production Capacity* is the maximum amount of output that can be produced in a certain unit of time. The formula of production capacity is showed as follows :

$$PC = \frac{NetWorkingTime \times LineEfficiency \times 60\sec}{TaktTime} \tag{3}$$

4. *Production/Head/Hour* (PHH) is the number of products that can be produced by an operator in 1 hour. The formula of production/head/hour is showed as follows :

$$PHH = \frac{PC \times 60\sec}{TotalWorkStation \times NetWorkingTime} \tag{4}$$

5. *Process Time* is time needed to complete a production process. The formula of process time is showed as follows :

$$PT = \frac{NetWorkingTime \times TotalWorkStation}{PC} \tag{5}$$

6. *Line efficiency* (LE), is the ratio of the total time at a workstation divided by the cycle time times the number of work stations. A line is said to be balanced if the LE value is 100%, meaning that the line balance is achieved. The formula of line efficiency is showed as follows :

$$LE = \frac{TotalTackTime - TotalCycleTime}{TotalTackTime} \times 100\% \tag{6}$$

Fishbone Diagram

The basic function of a fishbone diagram is to identify and organize the possible causes of a specific effect and then to separate out the root causes (Tague, 2005). With this diagram, everything becomes clearer and allows us to be able to see all possible "causes" and look for the real "root" of the problem (Gaspersz and Fontana, 2011). According to Scarvada (2004), the basic concept of meaning fishbone diagram is a fundamental problem placed on the right side of the diagram or on the head of the fishbone framework. The cause of the problem is depicted on the fins and spines. Categories of causes of problems that are often used as a starting point include machines, man, materials, methods, environment.

ECRS Method

The work improvement method used to increase work efficiency is the ECRS method. ECRS method consist of the Eliminate, Combine, Rearrange, and Simplify which is a simple way to reduce losses as well. (Wajanawichakon and Srimitte, 2012)

1. Eliminate, which eliminates work elements that are deemed ineffective in order to reduce process time.
2. Combine, which combines different work elements so that they can be done at the same time to reduce process time.
3. Re-arrange, namely rearrange the elements of work so that they can be done more effectively.
4. Simplify, namely simplifying the elements of the same work which were initially carried out at different times then carried out at the same time so that the process time can decrease.

RESEARCH METHODOLOGY

In this paper, data collection was in the form of cycle time data and productivity target data. Then calculated the line efficiency in the finishing department. Furthermore, analysis of the causes of the problems that occur was carried out using a fishbone diagram. The next step was analyzed and improvement proposals for the finishing department to increase the line efficiency value of the product so that it is in line with the company's expected target. The work improvement method used to increase work efficiency was the ECRS method.

RESULTS AND DISCUSSION

The line efficiency target of the company is 70% and the line efficiency calculation results are presented in Table 1.

Table 1.

Recapitulation of Initial Line Efficiency Calculations

Line Name : Finishing		Model : White Craft						Total
Operator No		1	2	3	4	5	6	
AT or Takt Time		2056.03	2056.03	2056.03	2056.03	2056.03	2056.03	12336.2
Cycle Time of each Element	1	221.80	10.98	13.95	9.26	12.96	13.70	
	2	83.20	3.28	8.45	23.78	12.24	10.18	
	3	28.10	6.20	291.55	75.84	2.54	7.55	
	4	21.40	14.44	792.30	76.78	55.28	4.12	
	5	6.10	499.40	263.33	76.96	52.88	8.98	
	6	15.00	30.96	431.90	114.76	64.70	8.07	
	7	27.60	35.40	40.65	58.96	20.06	5.00	
	8	11.60	25.08	23.93	40.26	21.88	3.03	
	9	22.40	49.02	15.40	20.52	23.18	10.05	
	10	29.40	5.98	47.95	10.64	22.42	11.65	
	11	9.80	16.66	4.68	37.46	58.24	4.85	
	12	12.10		24.05	4.30	10.10	3.28	
	13	18.00			21.56	8.74		
	14	14.10				11.12		
	15	254.10				5.36		
Total Cycle Time		774.7	697.4	1958.13	571.08	381.7	90.47	
Total Cycle Time 1 bale		129.12	697.4	1958.13	571.08	763.4	180.93	4300.06
Line Balance Efficiency		93.72%	66.08%	4.76%	72.22%	62.87%	91.20%	65.14%

Table 2.

Recapitulation of Line Balancing Indicator

No	Indicator	Calculation Result of Average Tc
1	*Takt Time*	2056.03 sec
2	*Total Cyle Time*	4300.06 sec
3	*Working Hour/shift*	415 minute
4	*Production Capacity/shift*	78.88 bale
5	*Production /Head/ Hour*	18.98 bale
6	*Process Time*	31.59 minute
7	*Line Efficiency*	65.14%

According to table 1, it was found that the line efficiency value in the finishing department was 65.14%. Then the line efficiency results above can be compared with the company's target. There is difference in line efficiency, namely 4.86%. After it is known that the line efficiency percentage does not reach the company's target, the next step is to make a cause-effect diagram to determine the factors that cause it. The fishbone diagram of the causes for not achieving the company's targets is shown in Figure 1.

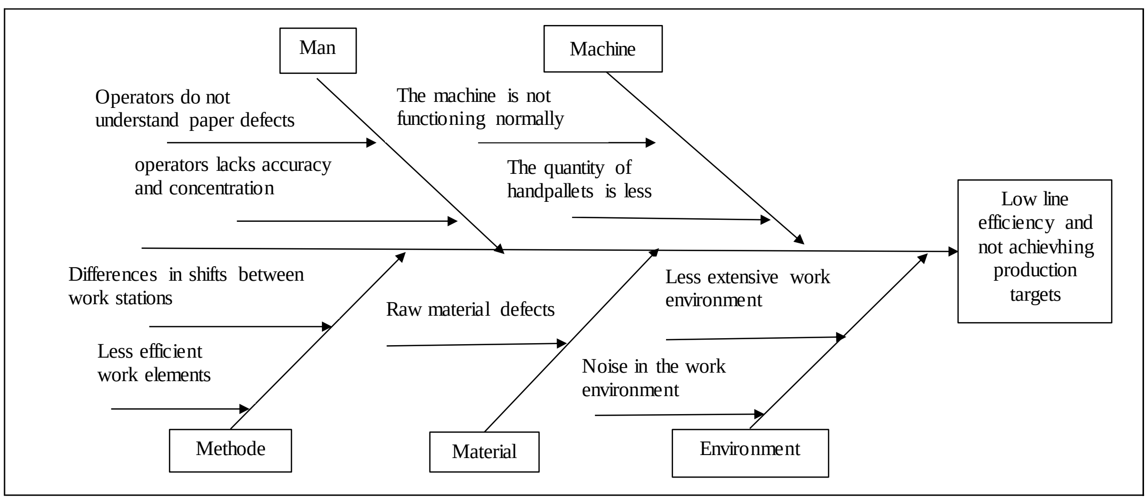

Figure 1. *Fishbone Diagram*

The company's line efficiency target has not been achieved due to several factors, including man, machine, material, method and environment. Based on figure 1, it is known that the root of the problem is the most dominant and needs to be repaired immediately, namely the inefficient work element method factor. Inefficient work elements such as ineffective movements and repetitive movements will affect line efficiency, causing imbalance between lines in the finishing section and resulting in not achieving the productivity target set by the company. ECRS method is used to improve the productivity target. It consists of Eliminate, Combine, Re-arrange, and Simplify. In the paper roll installation work station on the cutter machine and balling work station, there are no work elements that are improved because the work elements are already effective so that improvement are only made to the cutter, sorting, pollar, and packing work stations as described in the table below.

Table 3.

Information of ECRS

Eliminate		Re-Arrange	
Combine		Simplify	

Table 4.

Proposed Improvements Work Station.

	Before Condition		
	No	Work Element of Cutter Work Station	Time (s)
1	1	Operator 1 takes pallet board	10.98
	2	Operator 1 places the pallet board on the cutter machine	3.28
	3	Operator 1 puts placers on the pallet boards	6.2
	4	Operators 1 and 2 set up the machine	14.44
	5	Cutter process	499.4
2	6	Operator 1 is looking for a hand pallet	30.96
	7	Operator 1 carries out hand pallet transportation to cutter place	35.4
	8	Operator 2 pumps the hand pallet on the cutter ballean	25.08
	9	Operators 1 and 2 carry out hand pallet transportation to the sorting place	49.02
	10	Operators 1 and 2 put the results from the cutter work station	5.98
1	11	Operators 1 and 2 carry out transportation back to the cutter work station	16.66
		Total for 1 bale	697.4

	After Condition		
	No	Work Element of Cutter Work Station	Time (s)
	1	Operator 1 places the pallet board on the cutter machine	3.28
	2	Operator 1 puts placers on the pallet boards	6.2
	3	Operators 1 and 2 set up the machine	14.44
	4	Cutter process	499.4
2	5	Operator 2 takes the hand pallet	10.96
	6	Operator 2 pumps the hand pallet on the cutter ballean	25.08
	7	Operators 1 and 2 carry out hand pallet transportation to the sorting place	49.02
	8	Operators 1 and 2 put the results from the cutter work station	5.98
1	9	Operators 1 carry out transportation back to the cutter work station dan operator 2 takes the pallet board	16.66
		Total for 1 bale	631.02

	Before Condition		
	No	Work Element of Sorting Work Station	Time (s)
1	1	Operators 1 and 2 set up ballean	13.95
	2	Operator 1 puts a placemat on the ballean	8.45
2	3	Operators 1 and 2 takes the paper	291.55
	4	Operator 1 and 2 smoothed papers (track)	792.3
	5	Operators 1 and 2 put the paper	263.325
	6	Operators 1 and 2 count papers	431.9
3	7	Operator 1 looking for hand pallet	40.65
	8	Operator 1 carries out hand pallet transportation to the sorting place	23.925
	9	Operator 2 pumps the hand pallet on the sorting ballean	15.4
	10	Operator 1 and 2 carry out hand pallet transportation to the pollar work station	47.95
	11	Operator 1 and 2 put the results from the sorting work station	4.675
1	12	Operators 1 and 2 carry out transportation back to the sorting work station	24.05
		Total for 1 bale @30 pack	1958.13

	After Condition		
	No	Work Element of Sorting Work Station	Time (s)
2	1	Operator 1 dan 2 takes the paper	202.425
	2	Operator 1 and 2 smoothed papers (track)	592.35
	3	Operators 1 and 2 put the paper	182.025
	4	Operators 1 and 2 count papers	276.9
3	5	Operator 1 takes the hand pallet	23.92
	6	Operator 2 pumps the hand pallet on the sorting ballean	15.4
	7	Operator 2 carry out hand pallet transportation to the pollar work station	47.95
	8	Operator 2 put the results from the sorting work station	4.675
1	9	Operators 2 carry out transportation back to the sorting work station dan operator 1 preparing the ballean and placemat	24.05
		Total for 1 bale @30 pack	1369.7

Table 5.

Proposed Improvements Work Station

	Before Condition		
	No	Work Element of Pollar Work Station	Time (s)
	1	Operator 1 and 2 set up the machine	9.26
1	2	Operator 1 prepares a ballean and placemat	23.78
	3	Operator 1 takes the paper from the pallet board	75.84
	4	Operator 1 puts paper into the pollar machine	76.78
	5	Pollar process	76.96
	6	Operator 2 takes scrap and pulls paper	114.76
	7	Operator 2 places the trimmed paper onto the pallet board	58.96
2	8	Operator 1 looking for hand pallet	40.26
2	9	Operator 1 carries out hand pallet transportation to the pollar place	20.52
	10	Operator 2 pumps the hand pallet on the pollar ballean	10.64
	11	Operator 1 and 2 carry out hand pallet transportation to the packing work station	37.46
	12	Operator 1 and 2 put the results from the pollar work station	4.3
1	13	Operators 1 and 2 carry out transportation back to the pollar work station	21.56
		Total for 1 bale @30 pack	571.08

	After Condition		
	No	Work Element of Pollar Work Station	Time (s)
	1	Operator 1 and 2 set up the machine	9.26
	3	Operator 1 takes the paper from the pallet board	75.84
	4	Operator 1 puts paper into the pollar machine	76.78
	5	Pollar process	76.96
	6	Operator 2 takes scrap and pulls paper	114.76
	7	Operator 2 places the trimmed paper onto the pallet board	58.96
2	8	Operator 1 takes the hand pallet	15.52
	10	Operator 2 pumps the hand pallet on the pollar ballean	10.64
	11	Operator 2 carry out hand pallet transportation to the packing work station	37.46
	12	Operator 2 put the results from the pollar work station	4.3
1	13	Operator 2 carry out transportation back to the pollar work station and Operator 1 preparing the ballean and placemat	23.78
		Total for 1 bale @30 pack	504.26

	Before Condition		
	No	Work Element of Packing Work Station	Time (s)
1	1	Operator 1 takes the pallet board and plastic	12.96
	2	Operator 1 places the plastic and tray on the pallet board	12.24
	3	Operator 1 puts the wrapper on the table	2.54
	4	Operators 1 and 2 pick up paper	55.28
	5	Operators 1 and 2 put the paper on the table	52.88
	6	Operators 1 and 2 fold the top and bottom wraps	64.7
2	7	Operator 1 folds the wrapper on the right side	20.06
2	8	Operator 2 glues the wrapper on the right side	21.88
2	9	Operator 1 folds the wrapper on the left side	23.18
2	10	Operator 2 glues the wrapper to the left side	22.42
	11	Operators 1 and 2 put the paper on the pallet	58.24
1	12	Operator 1 takes the pallet board and plastic	10.1
	13	Operator 1 puts the cover paper	8.74
	14	Operator 1 put the plastic	11.12
	15	Operator 2 places a pallet board on top	5.36
		Total for 1 bale @15 pack	381.7
		Total for 1 bale @30 pack	763.4

	After Condition		
	No	Work Element of Packing Work Station	Time (s)
1	1	Operator 1 takes two pallet board and plastic	12.96
	2	Operator 1 places the plastic and tray on the pallet board	12.24
	3	Operator 1 puts the wrapper on the table	2.54
	4	Operators 1 and 2 pick up paper	55.28
	5	Operators 1 and 2 put the paper on the table	52.88
	6	Operators 1 and 2 fold the top and bottom wraps	64.7
2	7	Operator 1 folds the wrapper on the right side and Operator 2 on the left side	20.06
2	8	Operator 1 glue the wrapper on the right side and Operator 2 on the left side	21.88
	9	Operators 1 and 2 put the paper on the pallet	58.24
	11	Operator 1 puts the cover paper	8.74
	12	Operator 1 put the plastic	11.12
	13	Operator 2 places a pallet board on top	5.36
		Total for 1 bale @15 pack	326
		Total for 1 bale @30 pack	652

Improvements of work elements by eliminating occurs at cutter, sorting and pollar work stations. This work element is removed and replaced into one work element, namely taking the hand pallet so that it requires providing hand pallet at each work station so as no need to find and transport to the work station so that it can reduce delay times. Improvements to work elements by combining occurred at cutter, sorting and pollar work stations. Proposed improvements are made by combining these work elements into a single unit. This improvement is done because these work elements can be carried out simultaneously by both operators at each work station. Improvements to work elements by simplifying occur at the sorting and packing workstations. The work element is simplified and reduced to save time. Based on the above improvements, line efficiency calculations are then carried out in the finishing department as shown in Table 6 below.

Table 6.

Recapitulation of Line Efficiency Calculation Results After Improvement.

Line Name : Finishing		Model : White Craft						Total
Operator No		1	2	3	4	5	6	
AT or Takt Time		1438.18	1438.18	1438.18	1438.18	1438.18	1438.18	8629.08
Cycle Time of each Element	1	221.80	3.28	202.43	9.26	12.96	13.70	
	2	83.20	6.20	592.35	75.84	12.24	10.18	
	3	28.10	14.44	182.03	76.78	2.54	7.55	
	4	21.40	499.40	276.90	76.96	55.28	4.12	
	5	6.10	10.96	23.92	114.76	52.88	8.98	
	6	15.00	25.08	15.40	58.96	64.70	8.07	
	7	27.60	49.02	47.95	15.52	20.06	5.00	
	8	11.60	5.98	4.68	10.64	21.88	3.03	
	9	22.40	16.66	24.05	37.46	58.24	10.05	
	10	29.40			4.30	8.74	11.65	
	11	9.80			23.78	11.12	4.85	
	12	12.10				5.36	3.28	
	13	18.00						
	14	14.10						
	15	254.10						
Total Cycle Time		774.70	631.02	1369.7	504.26	326	90.47	
Total Cycle Time 1 bale		129.12	631.02	1369.7	504.26	652	180.93	3467.03
Line Balance Efficiency		93.72%	69.31%	33.38%	75.47%	68.29%	91.20%	71.90%

Table 7.

Recapitulation of Line Balancing Indicator After Improvement.

No	Indicator	Calculation Result of Average Tc
1	*Takt Time*	1438.18 sec
2	*Total Cyle Time*	3452.39 sec
3	*Working Hour/shift*	415 minute
4	*Production Capacity/shift*	87 bale
5	*Production /Head/ Hour*	21 bale
6	*Process Time*	28.62 minute
7	*Line Efficiency*	71.90%

In Table 6, it is shown that the line efficiency improvement is 71.90% with a production capacity is 87 bale units of product. Compared to the previous line efficiency and the company's target, the results of the improvements show that the line efficiency is increasing which causes product output to increase and can meet the line efficiency target expected by the company.

CONCLUSSION

Based on the calculation of the initial line efficiency value in the finishing department is 65.14% with a takt time value is 2056.03 seconds, a production capacity is 78.88 bale, PHH is 18.98 bale, and a process time is 31.59 minutes. The line efficiency value in the data calculation is smaller than the company's target, so it can be said that the productivity target of the finishing department was not achieved. Based on the fishbone diagram, it is known that there are 9 factors that cause the finishing department's productivity target not to be fulfilled. From the 9 root causes found from the identification of the problem, it can be seen that the root of the problem is the most dominant in terms of the method, namely the element of work that is less efficient. Then the finishing department was made improvements using the ECRS method so that processing time can be decreased and line balance is more evenly distributed. From the results of improvement obtained the new line efficiency value is 71.90% with takt time value is 1438.18 sec, production capacity is 87 Bale, PHH is 21 Bale and process time is 28.62 minutes. This suggests that with the proposed improvements it can improve the line efficiency of the finishing department and can meet the targets expected by the company.

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