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by Fitra Lestari

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American Productivity Center Method for Measuring Productivity in Palm Oil Milling Industry

Fitra Lestari[1], Irsan Nuari[1], Vera Devani[1]
[1]Department of Industrial Engineering, Sultan Syarif Kasim State Islamic University, Riau, Indonesia
(e-mail address: fitra_lestari@yahoo.com; irsanriandika27@gmail.com; veradevani@gmail.com)

Abstract - **The main products of palm oil milling in this case are Crude Palm Oil and Kernels. This industry shows production targets are not achieving that cause fluctuations in profits due to not optimal use of resources in production activities. The aim of this study is to measure the productivity of palm oil milling industry and identify its factors. Integration of American Productivity Center (APC) method and Failure Modes and Effect Analysis (FMEA) was used to measure productivity. The finding in year 2015 to 2016 showed that there were decreasing of productivity index (9.81% to 0.68%) and profitability index (-7.23% to -20.27%) which both of them were caused by variable input of labor. Then, focus of improvements should be done in the sterilizer process, boiler process and sorting process. Further research is suggested to direct in maintenance case in order to know the effect of each machine on industry.**

Keywords - **American productivity center, failure modes and effect analysis, palm oil milling, productivity**

I. INTRODUCTION

Most of manufactures in producing their products consider the resource availability to determine production capacity. Pargar (2017) stated that resource utilization plays an important role in the production process. Therefore, using of appropriate resources produced optimal production and it gain high profit. To earning profits, companies need to increase the utilization of resources by determining their level of productivity [2].

The case study examines a palm oil milling industry located in Riau Province of Indonesia. The industry used FFB (fresh fruit bunches) as raw materials derived from its own plantation and some other suppliers to produce CPO (Crude Palm Oil) and Kernels. Furthermore, this product will be sold to local and international refinery. The problems that occur in this case study was not achieving production targets. It caused profit fluctuations due to not optimal use of resources. Ideal conditions occur when the resources used optimally; as the result, the products produced in accordance with production planning [3]. It aims to be a benchmark of future improvement and able to know the efficiency of the use of previous resources. Moreover, measurement is necessary to evaluate system and practice improvement [4].

Several studies related to productivity measurement have been done. Productivity was the ratio between output and input on a company that can be determined based on the ratio between the amount of output produced by the number of inputs used [5]. Thus, productivity was related to the effectiveness and efficiency of input use in producing the output. There were several methods used in measuring productivity. Yosan at al. (2018) used Objective Matrix (OMAX) method in the case study of processing industry. The result described the level of efficiency and effectiveness of resources in the form of labor, machinery and energy. This method measured the partial productivity that was developed to monitor productivity in every part of the company with variable of productivity. Then, Aponno and Siahaya (2017) used Marvin E. Mundel method which it was used to measure productivity level by focusing on production cost only as input and product produced as output in processing industry. Gustanto et al. (2015) used the Multi Factor Productivity Measurement Model (MFPMM) method to measure changes in labor productivity, capital, raw materials and energy. It method was to measure the impact of each input on profitability for the company. Prasetyo (2017) adopted the American Productivity Center (APC) method to compare productivity levels between periods with another period which this model able to measure the level of productivity, profitability and improvement of company prices.

The description above methods showed that there were many methods for measuring productivity including the Objective Matrix (OMAX), Multi Factor Productivity Measurement Model (MFPMM), Marvin E. Mundel and American Productivity Center (APC). For measurement of productivity, profitability and price improvement, this research used APC (American Productivity Center) method. In addition, this method need be integrated with Failure Modes and Effects Analysis (FMEA) to know main problem of the improvement process.

Moreover, the purpose of this study is to measure the productivity of the company and identify the factors that are not achieved production targets. There were limitations of the problem in this study in the form of data in year 2014 to be the base year. Furthermore, processing data for productivity measurement was done for the year 2015 and 2016. For the data input, it was in the form of labor, raw materials, energy and capital while the data output examined was Crude Palm Oil (CPO) and Kernels. This study also established a return on assets of 0.1.

II. METHODOLOGY

The case study in this paper was one of the palm oil milling industry located in Riau Province of Indonesia.

The industry produced Crude Palm Oil (CPO) and Kernels that come from Fruit Fresh Bunch (FFB) as the main raw material. The industry had working hours for 8 hours every day and the working system of 2 shifts per day. Then, the production capacity of this industry was 60 tons per hour. Data collection was conducted in January to December in 2014, 2015 and 2016. The data types used consisted of primary and secondary data in which primary data involved labor costs, materials, energy, capital and total production while secondary data involved company profile and organizational structure.

This study adopted mix method involving qualitative method which used interview and observation techniques. Anderson (2010) revealed that qualitative methods able to examine case studies based on phenomena that occur and obtain detailed data. Furthermore, the data collection was done by interviewing stakeholder related with the production process and conducting question and answer on the company. Then, the data collection was continued by observing the production process. This observed the supply of raw materials to become finished product. To make a proposed system improvement, it was necessary to adopt qualitative method through spread the questionnaire for 5 respondents involving processing assistant, head of labor, head of workshop, head of warehouse and one operator.

The collected data was then processed by integrating American Productivity Center (APC) method and Failure Modes and Effects Analysis (FMEA) method. Stages of data processing can be described below:

1. *Determining productivity*

Productivity is measured by calculating using constant prices. For more detail, it is done by calculating each quantity of product and its price. Furthermore, it calculates the output of productivity index and input of productivity index using APC method.

2. *Determining profitability*

Measurement of profitability is done by the similar stages with determining productivity. Nevertheless, it was different on the price of variable which it used the prevailing price.

3. *Measuring price improvements*

Measurement of price improvement is done by calculating the input value of profitability index divided by the value of productivity index. In this step, it can be obtained the value of price change index. After obtained the value of price change index, then it does the proposed improvement of productivity by using FMEA method.

4. *Failure Modes and Effect Analysis (FMEA)*

Calculation of Failure Modes and Effects Analysis (FMEA) is done after Fault tree analysis (FTA) analysis. it is obtained to find the cause of problem from American Productivity Center (APC) method. The calculation of FMEA is done by using Severity, Occurrence and Detection in order to obtain RPN (Risk Priority Number) value. It aims to find out problems in workstations and to know the process that most affect the production process in the industry.

III. RESULTS

Results of data processing in productivity index using the APC method for year 2015 and 2016 can be found at Table 1. This table explained that there was a decrease in year 2015 on productivity index at labor variables by 19.47%. This is due to an increase in the use of labor inputs of 3.10%. Productivity of material increased by 10.89% due to decrease of material input by 25.13%. For years 2016, the decline in productivity of labor variables by 35.33%. This is due to a decrease in the use of labor input of 1.33%. While the productivity of energy variables experienced an increase of 37.44% caused by the decrease of energy input usage by 53.57%.

The result of profitability index using APC method can be seen in table 2. This table explained that there was a decrease in profitability in labor variables by 23.47% in year 2015. This is due to an increase in labor input usage of 13.20%. Profitability of capital increased 8.63% caused by decreased use of capital input of 20.25%. For the year 2016, the decrease in profitability of labor variables amounted to 38.79% caused by an increase in use of labor input of 13.80%. While the profitability of the energy variables experienced an increase of 16.65% caused by the decrease of capital input usage by 17.79%.

The result of price improvement index using American Productivity Center (APC) method can be seen in table 3. This table explained that price change has an effect on productivity and profitability. The highest impact of price improvement in 2015 was due to material input of 17.98% and the effect of price improvement on the highest in 2016 due to material input of 24.39%.

Moreover, The APC (American Productivity Center) calculation earned some decreases in productivity and profitability variables. To know the decrease of variable value, then it usd Fault Tree Analysis (FTA) method. The dominant inputs that cause productivity, profitability and price improvement were variable of labor and materials.

Moreover, the result of Failure Mode and Effect Analysis (FMEA) obtained that the highest RPN value found in Sterilizer process with value of 308. Furthermore, there is in boiler process and sorting process with each value around 263.6 and 242.4.

IV. DISCUSSION

Data analysis was done through 4 stages including determining productivity, determining profitability, price improvement and failure mode effect and analysis. Stages

of determining productivity obtained that the total productivity in 2015 was better than in 2016. As the result, the variable input of labor affects significantly. Shehata and El-Gohary (2011) stated that variable of labor was the most influential input in a company because this variable was responsible for controlling the production processes. Furthermore, they claim that productivity provided an indication of the efficient use of resources in generating company output. In this case study, one of the causes of productivity decline which it was caused by variable labor. There was mistake from operator in operating the machine. Thus, results in the production was not optimal. Furthermore, the labor of maintenance division's takes a long time to fix and adjust the production machine.

Moreover, total profitability in 2015 was better than profitability in 2016. In 2015, it decreased by 7.23% and then it declined by 20.23% in 2016. The dominant input affect profitability also variable input of labor. Fibirova and Petera (2013) revealed that profitability was directly related to productivity and price improvements. Consequently, increased profitability able to increase productivity and price improvement. The cause of the decline in profitability was due to the salary of labor that goes up every year. Then, the high frequent cessation of the production process also give impact because several processes does not run then the labor still get a monthly salary.

Prices improvement was influenced by productivity and profitability. The highest impact of price improvement in 2015 was due to variable input of material by 17.98% and in 2016 caused by variable input of material by 24.39%. Thus, high profitability was compared with productivity providing price changes which it has a good impact for the company. Thus, the company should conduct a survey and choose appropriate the supplier with the cheapest price and has quality standards required. Whenever there was an increase in price then the company must conduct a re-survey of suppliers.

The result of failure mode and effect analysis (FMEA) found that the process that most affect productivity was the process on the sterilizer. This was directly proportional to the actual facts because the boiling process affect the subsequent processes resulting in high losses. Whenever the boiling time was not perfect, then the resulting Nut was not clean from the flesh. Thus, the separation of the shell and kernel in the claybath process in the kernel station was not effective. Furthermore, this also causes the fruit to be separated from the bunches which resulted in an increase in oil losses in the empty bare. The digestion on the digester was also not perfect because most of the meat is not separated from the nut that causes oil losses. It also resulted in an imperfect press process that caused the lack of oil produced at the clarification station. Moreover, fibers become large which causes incomplete boiler combustion.

The priority of the second improvement proposal was on the boiler process. It can be done by considering the ratio of the amount and condition of fuel (shells and fibers). whenever the shell was too much then from the fiber will inhibit the combustion process due to the buildup of charcoal lot and flame less perfect. Meanwhile, whenever the shell is too limited then the resulting heat was low. Thus, it takes more time to get the steam that will flow on one of sterilizer process. The wet condition of the fibers also affects the combustion of the boiler because it causes uneven combustion.

The priority of the third improvement proposal was the process of sorting. Sorting process requires skilled workers because it determined the condition of the fruit to be processed. The condition of the fruit was very important in the production process because it affects the quality and quantity. Sort imperfect will cause the fruit in the lane of boiling. The condition of different or mixed fruit that affects the boiling process. By focusing on the sterilizer, boiler and boiling process, it can optimize the production result. Thus, the company's productivity will increase.

V. CONCLUSION

Method of American Productivity Center and Failure Mode and Effect Analysis is successfully to implement in this case study in order to measures productivity in palm oil milling industry. Finding of the study showed that the inputs that most influence is not achieved production targets are labor variable and materials variable. Then, the focus of improvements that should be done on the process of sterilizer, boiler process and sorting process. Suggestions for further research is consider many inputs that are used in the measurement. In addition, it able to direct in the maintenance case in order to know the effect of each machine on the industry in detail.

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TABLE 1
PRODUCTIVITY INDEX

Variabels	Based on Constant Price			Productivity Index		Change Index (%)	
	2014	2015	2016	2015	2016	2015	2016
Total *of Output* (Rp)	568	471	362	0.83	0.64	-16.98	-36.19
Input of Labor (Rp)	3	3	3	1.03	0.99	3.10	-1.33
Input of Material (Rp)	438	327	266	0.75	0.61	-25.13	-39.07
Input of Energy (Rp)	2	1	1	0.78	0.46	-21.95	-53.57
Input of Capital (Rp)	52	41	42	0.80	0.82	-20.25	-17.79
Total of Input (Rp)	496	375	314	0.76	0.63	-24.39	-36.62
Productivity of Labor (%)	151.70	122.16	98.10	0.81	0.65	-19.47	-35.33
Productivity of Material (%)	1.30	1.44	1.36	1.11	1.05	10.89	4.73
Productivity of Energy (%)	233.23	248.07	320.54	1.06	1.37	6.36	37.44
Productivity of Capital (%)	10.90	11.34	8.46	1.04	0.78	4.10	-22.38
Productivity of Total (%)	1.14	1.26	1.15	1.10	1.01	9.81	0.68

(Note : Price in term of 1 x Billion Rupiah)

TABLE 2
PROFITABILITY INDEX

Variabels	Based on Prevailing Price			Profitability Index		Change Index (%)	
	2014	2015	2016	2015	2016	2015	2016
Total *of Output* (Rp)	568	492	395	0.87	0.70	-13.37	-30.33
Input of Labor (Rp)	3	4	4	1.13	1.14	13.20	13.80
Input of Material (Rp)	365	347	321	0.95	0.88	-4.85	-12.02
Input of Energy (Rp)	2	2	1	0.89	0.60	-10.85	-40.28
Input of Capital (Rp)	52	41	42	0.80	0.82	-20.25	-17.79
Total of Input (Rp)	423	395	369	0.93	0.87	-6.62	-12.66
Profitability of Labor (%)	151.70	116.09	92.86	0.77	0.61	-23.47	-38.79
Profitability of Material (%)	1.56	1.42	1.23	0.91	0.79	-9.00	-20.82
Profitability of Energy (%)	239.82	233.03	279.75	0.97	1.17	-2.83	16.65
Profitability of Capital (%)	10.90	11.84	9.24	1.09	0.85	8.63	-15.25
Profitability of Total (%)	1.34	1.25	1.07	0.93	0.80	-7.23	-20.27

(Note : Price in term of 1 x Billion Rupiah)

TABLE 3
PRICE IMPROVEMENTS INDEX

Variabel	Productivity Index	Profitability Index	Price Change Index	Change Index (%)
		2015		
Labor	0.81	0.77	0.95	-4.96
Material	1.11	0.91	0.82	-17.98
Energy	1.06	0.97	0.91	-8.65
Capital	1.04	1.09	1.04	4.35
Total	1.10	0.93	0.84	-15.49
		2016		
Labor	0.65	0.61	0.95	-5.34
Material	1.05	0.79	0.76	-24.39
Energy	1.37	1.17	0.85	-15.12
Capital	0.78	0.85	1.09	9.18
Total	1.01	0.80	0.79	-20.77

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