A Design Productivity Of Improvement Using "Total Productivity Model" in Water Treatment Plant Deli Tua PDAM Tirtanadi North Sumatra Province

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Abstract: *Water Treatment Plant (IPA) Deli Tua is one of IPA owned by Perusahaan Daerah Air Minum (PDAM) Tirtanadi North Sumatera Province which produces drinking water for public needs. To find out the company's performance needs to be done productivity evaluation is by way of measuring productivity. Productivity measurement is done with the period of measurement per year starting from 2012 until 2016. From a result of productivity measurement by using Total Productivity Model with input source of labor cost, material cost, capital cost and energy cost known that there is the tendency of decrease of IPA Deli Tua productivity. The highest decrease in productivity occurred in 2014 with a decrease of 17.48%, while the lowest occurred in 2016, i.e., a decrease of 1.36%. Alternative design improvement productivity there are three. First, replace the alum with PAC chemicals. Both install a tank capacitor. Thirdly, the change simultaneously by replacing the alum chemicals into PAC and installing the tank capacitor. From experimental results of selected alum and PAC chemicals based on the feasibility of economic and quality aspects (by analyzing factorial variants), PAC was selected as alum substitute. Furthermore, through the PET evaluation approach (Productivity Evaluation Tree), it can be seen that the highest productivity improvement is the third alternative, which is to change the alum chemical and install the bank capacitor, resulting in a productivity increase of 9.84% or input savings of Rp. 4,275,536,624, - a year. For IPU Deli Tua's total productivity improvement plan is prepared based on the 5W + 1H method.*

Keywords: *Productivity, Total Productivity Model, Fishbone, Productivity Evaluation Tree (PET), 5W + 1H*

1. INTRODUCTION:

Productivity is a significant thing that must be considered by every company because it will determine the sustainability of business was going forward. The company will be said well if its productivity is always increasing, on the contrary, if the richness of the company continues to decline then needed a solution to its productivity can be stable again.

According Manuaba (1992), increased productivity can be achieved by pressing the smallest of all kinds of costs including the use of human resources (do the right thing) and increase the maximum output (do the job right). Productivity is a reflection of the level of efficiency and effectiveness of work in total.

Vincent Gaspersz (1998), says that productivity is a combination of effectiveness and efficiency, a success seen from both sides at once, ie, the input and output sides. Thus productivity is related to the efficient use of inputs in producing output (goods and services). The notion of productivity is very different from production. But production is one component of the productivity effort, in addition to the quality and results of its output. Manufacturing is an activity related to the production and is expressed by the volume of production, whereas productivity is related to the efficient use of resources, i.e., inputs in generating the level of comparison between output and input.

Regional Water Company (PDAM) Tirtanadi North Sumatra Province is a regional company owned by North Sumatra Provincial Government which is responsible for managing and producing clean water for public needs. One of the Water Treatment Plant (IPA) owned by PDAM Tirtanadi is IPA Deli Tua which produces regular water supply of 49.3 million m3 a year or an average discharge of 1,587 liters/sec. Based on preliminary observations it is known that the company has not conducted an overall productivity evaluation, so it is not known whether the company has maximized the use of input and output resources owned efficiently and efficiently. Utilization of input resources that have not been optimum mainly are chemical and electrical energy resources resulting in an increase in the cost of use of chemicals, and electrical energy is quite significant. This can be seen in Table 1.

Table 1. Cost and production data of IPA Deli Tua 2012 – 2016 (Rupiah Currency)

Description	2012	2013	2014	2015	2016	% Up / Down from 2012 - 2016
Output Tangible						

1.Production	124.541.891.500	125.974.950.000	124.133.742.500	125.091.750.000	124.940.980.000	0,32%
Tangible Input						
1. Power To	3.764.490.474	4.094.473.383	4.308.272.434	4.295.865.339	4.246.117.538	12,79%
2. Material						
- Raw water	793.990.977	802.056.120	790.088.880	797.785.424	796.619.430	0,33%
- Alas	4.444.960.000	4.666.815.000	5.122.850.000	6.157.375.000	6.195.000.000	39,37%
- Chalk	470.635.000	521.169.000	571.260.000	645.645.000	-	37,19%
- Chlorine	1.248.156.705	1.367.393.749	1.368.817.770	1.157.558.268	1.440.000.000	15,37%
- Soda ash					3.129.440.000	
Chemical amount	6.163.751.705	6.555.377.749	7.062.927.770	7.960.578.268	10.764.440.000	74,64%
3. Capital	11.757.343.109	12.860.267.200	15.657.577.006	17.396.651.961	15.977.743.414,1	35,90%
4. Electrical Energy	8.453.713.695	10.160.380.156	12.786.446.277	14.190.243.838	13.468.309.920	59,32%
5. Other expenses	4.602.028.125	3.343.653.156	4.238.873.574	2.729.550.489	2.724.010.978	-40,81%
Total	35.535.318.084	37.816.207.763	44.844.185.940	47.370.675.319	47.977.241.280	35,01%

Source : PDAM Tirtanadi Province of North Sumatera(2016)

Therefore, productivity improvement efforts should be carried out continuously starting with an appropriate productivity measurement so that the results of the productivity measurement can be a guideline for management and all employees to use resources as efficiently as possible and produce quality products according to customer's wishes. One method that was used as a guide in increasing productivity is "total productivity model" introduced by David J Sumanth (1984).
The following notations and formulas in Total Productivity Model:

$$\text{TPF} = \text{Total Productivity of a Firm} = \frac{output \text{ total of Firm}}{input \text{ total of Firm}} \quad \ldots\ldots (2.8)$$

$$\text{TP}_i = \text{productivity of Product i} = \frac{output \text{ total product i}}{input \text{ total product i}} \quad \ldots\ldots (2.9)$$

Ammara's research on the Total Productivity model (2008), this model is very well applied to any manufacturing company or service company. The purpose of this study is to evaluate the productivity to obtain a design improvement to increase productivity IPA Deli Tua.

2. LITERATURE AND METHODES:

The research was conducted at Water Treatment Plant of Deli Tua PDAM Tirtanadi, North Sumatera Province, located at Jl. Pamah Deli Tua Subdistrict, Deli Serdang District, North Sumatera. Research activities are conducted from December 2016 to July 2017.

The research steps as a systematic step done according to the production cycle of David J. Sumanth (Figure 1), with the aim that research is more directed to the plan as follows:
a. Analyze the company's general overview by conducting observations and interviews with company personnel.
b. Data collection on resource usages such as workforce, material, energy, and capital as input and sales of clean water as output.
c. Measurement of total and partial productivity levels.
d. Evaluate and analyze the factors causing the decline in productivity with the help of fishbone diagrams.
e. Planning for productivity improvement for next year based on "productivity evaluation tree" method approach.
f. Make recommendation of productivity improvement design with 5W + 1H method.
g. Make conclusions and recommendations for the company.

From the evaluation of the result of total productivity measurement and partial productivity in the following period shows that from the output angle there is a difference (decrease) the output value of Rp. 27.538.025.040, - and the difference (increment) of the input value of Rp. 5.638.180.149, - Total productivity decreased by 1.37. The partial productivity of labor fell by 5.03, and the partial capital productivity reduced by 3.54. While the partial productivity of real and partial energy productivity showed the most significant decrease, respectively of 6.35 and 5.89. The results of the total and partial productivity measurements by the base period price can be seen in Figure 1.

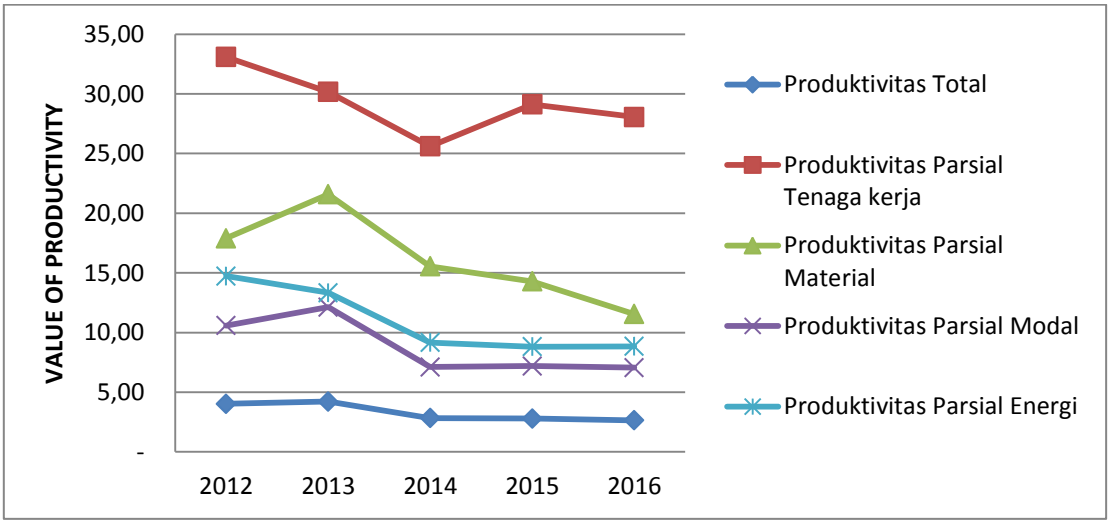


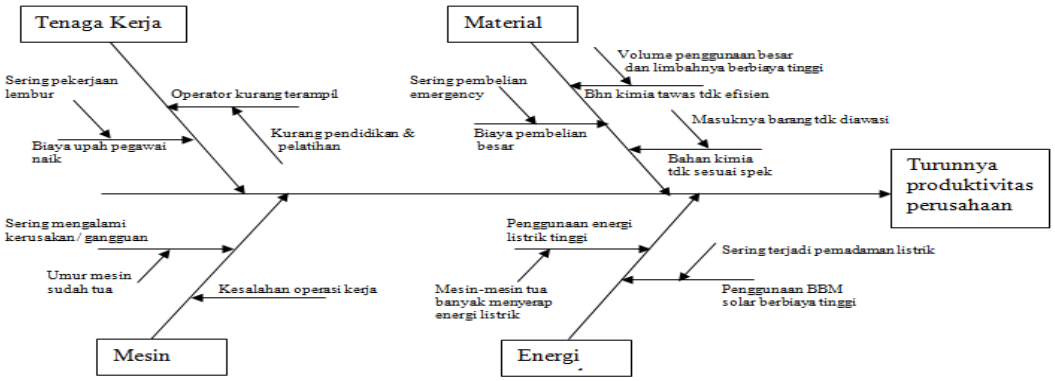
Figure 1. Results of Total and Partial Productivity Measurements.

3. FISHBONE DIAGRAM.

To find the main factors causing the decline in productivity, then taken 4 resource factors are used as input variables, namely:

a. Labor
b. Material
c. Machines or other work equipment
d. Energy

Figure diagram of Fishbone decrease in productivity as shown in Figure 2.



Figures 2. Fishbone Diagram Productivity.

4. PRODUCTIVITY PLANNING.

Based on the results of evaluation and analysis diagram Fishbone can be seen that from the four variables of each input has occurred several causes that affect the decline in productivity. But the significant influence of the causes of the decline in company productivity is the material input and energy input variables. It can also be seen from data of partial productivity of real and partial energy productivity of IPA Deli Tua period of 2012-2016 period, decreasing 39.57% and 37.07% respectively.

Having obtained accurate information about the leading causes of productivity decline, the next step is to plan for productivity improvements for the coming year based on materials and technology-based engineering. The productivity improvement plan is focused on cost savings. Productivity planning in question is by:

1. Replace water treatment chemicals in the form of alum PAC (Poly Aluminum Chloride).
2. Install the bank capacitor for the electrical system at IPA Deli Tua.

3. Changed simultaneously by replacing the water treatment chemicals into PAC and the installation of bank capacitors.

To change the water treatment chemicals from alum to PAC it is necessary to conduct laboratory experiments and then test statistical analysis to see which results are better and efficient regarding quality and cost.

The test jar experiments were performed on alum and PAC. Jar test is a laboratory-scale experiment to determine the optimal dose of coagulant in water treatment process. The Proper dose of coagulant (alum or PAC) will affect water turbidity. Water turbidity is a mandatory parameter for drinking water quality standards. According to Minister of Health Regulation, no 492 / Menkes / Per / IV / 2010 regarding Drinking Water Quality Requirements based on mandatory parameters of physical sub-parameters, the turbidity of drinking water is ≤ 5 NTU and sub-chemical parameters for pH is between 6.5 - 8.5. Raw water samples were taken in 6 categories, namely natural water with turbidity of 11 NTU, 43 NTU, 51,5 NTU, 129 NTU, 277 NTU and 510 NTU. The doses taken were from 10 mg / l to 35 mg / l with an interval increase of 5 mg / l. From the results of statistical tests of variance analysis that the dosage of alum given and the dose of PAC both affect the turbidity of water from the results of the test jar. The alum dosage also affects the degree of acidity of water (pH) produced, although with different levels of turbidity, but for PAC chemicals does not significantly affect pH. To obtain turbidity at ≤ 5.0 NTU using alum dose at 35 mg / l while using PAC is at dose 15 mg / l on different turbidity of different raw water, so next that will be compared is the purchase cost of alum with PAC. Comparison of alum use with PAC to obtain turbidity ≤ 5.0 NTU is 3.5: 1.5.

The alum price is Rp. 3.195 / kg and PAC price of Rp. 6,750 / kg then the ratio of cost usage is: 3.5 x Rp. 3.195 / kg = Rp. 11.182.5 versus 1.5 x Rp. 6,750 / kg = Rp. 10.125. This means to achieve turbidity ≤ 5.0 NTU no difference in cost by using alum with PAC is cheaper PAC with the difference of Rp. 1,057.5.

If used alum 350 kg then it will be comparable to the use of PAC 150 kg then the cost that can be sparing is:

350 kg x Rp.3.195 - 150 kg x Rp. 6,750 = Rp. 105,750 From the calculation results obtained savings in alum costs an average of Rp. 502.164.826, - per year.

To save the cost of electrical energy is done the installation of the total bank capacitor to the electrical system. According to I Putu Agus Didik Hermawan and Titiek Suheta (2012), installation of bank capacitors can save electricity costs up to 31.9%.

If it is assumed that electricity cost savings of 30% only, then the reduction of electricity costs incurred are as follows:

Total Input 2016 = Rp. 47.743.851.801, -

Electricity cost 2016 = Rp. 13.468.309.920, -

The reduction of electricity costs after the installed capacitor bank is 30% x Rp. 13.468.309.920, - = Rp. 4,040,492,976, -

Installation of bank capacitor = Rp. 350,000,000, -

Total input becomes:

Rp. 47.743.851.801 + Rp. 350,000,000 = Rp. 48.093.851.801, -

After the reduction of electricity costs, the total input is reduced to:

Rp. 48.093.851.801 - Rp. 4,040,492,976 = Rp. 44.053.358.825, -

Thus the electricity cost savings that occur after the installed capacitor bank are:

Rp. 47.743.851.801 - Rp. 44.053.358.825 = Rp. 3.690.492.976, -

Productivity planning for the coming year is done by PET analysis (Productivity Evaluation Tree), description of productivity planning as shown in Table 2.

Tables 2. Value of Productivity PET

Alternative Decision	O_{it}	O_{it+1}	ΔO_{it+1}	I_{it}	I_{it+1}	ΔI_{it+1}	PT_{it}	PT_{it+1}	APT_{it+1}
1	124.582.804.437	124.582.804.437	0	47.743.851.801	47.158.808.153	(585.043.648)	2,6094	2,642	0,0324
2	124.582.804.437	124.582.804.437	0	47.743.851.801	44.053.358.825	(3.690.492.976)	2,6094	2,828	0,2186
3	124.582.804.437	124.582.804.437	0	47.743.851.801	43.468.315.177	(4.275.536.624)	2,6094	2,866	0,2567

Information :

1. Alternative 1 = Replacement of alum with PAC
2. Alternative 2 = Installation of bank capacitor
3. Alternative 3 = Replacement of alum with PAC plus installation of bank capacitor

From the above PET analysis, it can be concluded that the productivity was planning to be selected the 3rd alternative, namely the replacement of water treatment chemicals from alum to PAC and the installation of bank capacitors. Changes in productivity compared to the previous year's productivity increase of 9.84% or input savings of Rp. 4,275,536,624, - a year.

5. CONCLUSION:

Measurement of productivity using Total Productivity Model with year 2012 as base year, got Total Productivity Index (IPT) for every year that is: IPT year 2012 = 1,000, IPT year 2013 = 0,953, IPT year 2014 = 0,786, IPT 2015 = 0,750 and IPT year 2016 = 0,739. Fluctuations in the Partial Productivity Index (IPP) of materials and energy decreased significantly: IPP of content (39.6%), IPP of power (37.1%) compared to IPP of labor (11.1%) and IPP capital (13, 1%). Based on the analysis of PET (Productivity Evaluation Tree) obtained that the replacement of water treatment chemicals from alum to PAC and also the installation of bank capacitors in the electrical system in total will increase the total productivity of 9.84% or input savings of Rp. 4.275.536.624, - year.

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