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Single and Multifactor Productivity Analysis of Manual and Automatic Machines at Powder Coating Company PT. TKM in Bekasi

Christie H. K. Pasaribu[1], Sugiyono Madelan, Ahmad Badawi Saluy.
[1]Magister Management, Mercubuana University, Jakarta, Indonesia

Abstract:- PT.TKM has 3 Powder Coating (PC), they are PC-1, PC-2, and PC-3. Time of painting (TOP) and consumption of fuel gas (COFG) data from 2017 to 2019 stated, that PC-1 exceeds standard. In 2020 PT.TKM's made decision to develop PC-1, but it requires a study science, to know which the most efficient PC is. This study uses 2 analysis methods, they are Single Productivity (SP) and Multi Factor Productivity (MFP) analysis. From results of SP and MFP analysis, PC-3 is declared to be the most efficient PC, and PC-3 can be a reference model for PC-1 and PC-2 development projects.

Keyword:- *Powder Coating, Single Productivity, Multi Factor Productivity.*

I. INTRODUCTION

The key to success in the high-tech industry is how companies develop their productivity. Increased productivity can create significant profits for the company. The higher the productivity level of the company, the more likely the company will achieve and maintain its profits. PT TKM is a company engaged in manufacturing lightweight steel construction, which produces doors, windows, frames and lovera roofs located in Bekasi, Indonesia. PT.TKM has 3 Powder Coating (PC) production lines, they are PC-1, PC-2, and PC-3. PC-2 and PC-3 are units that already use automatic spray arms, and PC-1 is a unit that still uses manual procedures, namely by human power.

In Figure 1, it can be seen that from 2017 to 2019, the PC-1 unit was the slowest PC that had the highest Time of Painting (TOP), which was 0.023 hours per m^2 of painting area, with a standard TOP was 0.020 hours per m2 of painting area. PC-2 TOP was 0.018 hours per m^2, while PC-3 was the fastest, 0.014 hours per m^2.

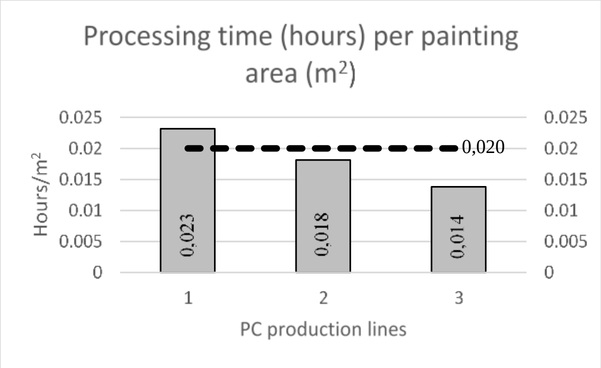

Figure 1 Time of the Painting Process
(Source PT.TKM 2020)

In Figure 2, it is known that from 2017 to 2019, the PC-1 was the highest consumption of fuel gas (COGF), which was 0.286 Kg of LPG per m^2 of painting area, with the standard COFG for painting was 0.27 Kg of LPG per m^2. The COFG for PC-2 was 0.258 kg of LPG per m^2 of painting area, while PC-3 was 0.268 kg of LPG per m^2. Then PT. TKM in early 2020 decided to develop PC-1. However, this decision requires a scientific study, to determine the most efficient PC, and can be a development reference for the worst.

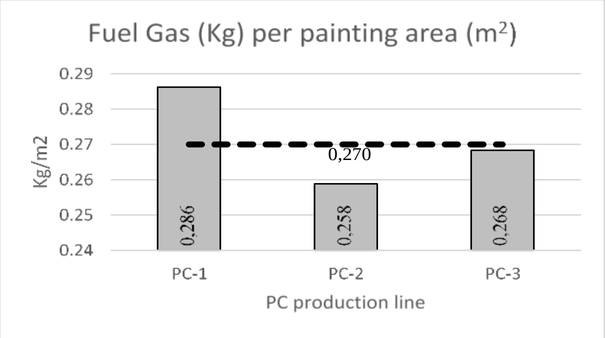

Figure 2 Consumption of Fuel Gas
(Source: PT. TKM 2020)

The research was conducted in a private company, located in Bekasi, Indonesia, which has special regulations for limit of published data in this research. the data source in this study is production data of 3 PC production lines, from 2017 until 2019, it is consumption data of powder, fuel gas, working time, and cost tables per input unit for each PC, also output of each PC unit and the price.

Based on the background that has been explained, problems that need to be carefully formulated are;

1. How is the productivity of the single workforce of the powder coating unit?
2. How is the multi-factor productivity of each powder coating?
3. Which is the most efficient to be the recommendation of development model? Is it PC-1, PC-2, or PC-3?

II. LITERATURE REVIEW

2.1 Research Review

Production is the creation of goods and services while operational management is a series of activities that shape value in the form of goods and services through the process of changing inputs into outputs. (Heizer & Render, 2015). The term "productivity" first appeared in an article by Qusnay in 1966. More than a century earlier, in 1883, Littre defined productivity as a "faculty to produce" and the definition reappeared in the Larouss Dictionary. (Afrooz & Rahim, 2011).

Productivity is simply the efficiency in production of how much output is obtained from a number of inputs used, generally expressed as the ratio of output to input. (Syverson, 2011). Productivity is an index measuring output (products and services) with many inputs, such as labor, raw materials, energy, and other resources used to produce these products or services (Stevenson, 2012).

$$Productivity = \frac{Output}{Input}$$

A productivity ratio can be calculated for an operational department, organization or country. Productivity has major and important implications for an organization and a country. For non-profit organizations, higher productivity means lower costs, for profit-oriented organizations productivity is an important factor that determines how competitive the company is. For a country, the rate of productivity growth is very important. Productivity growth is an increase in productivity from one period to another in the previous period. Productivity measurements can be based on a single input (partial productivity), more than one input (multi-factor productivity), or all inputs (total factor productivity). The choice of productivity measurement is mainly based on measurement objectives. (Stevenson, 2012).

2.2 Research Framework

Before discussing the research framework, the author wants to explain that there are no published studies on powder coating productivity, in free journal publications.

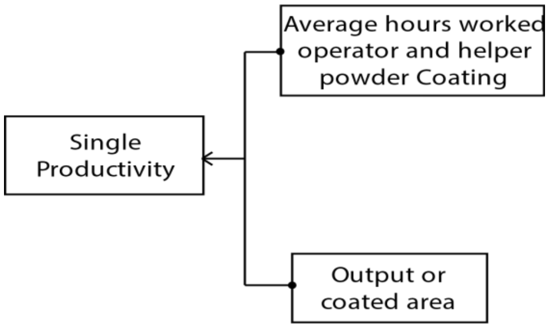

Figure 3 Single Productivity (Heizer & Render, 2015)

Therefore, the authors apply productivity theory in the operation management book created by Heizer and Render. The productivity of Single Powder Coating is greatly influenced by the product output in the paint (the area of the paint) and the length of time the labor force is in.

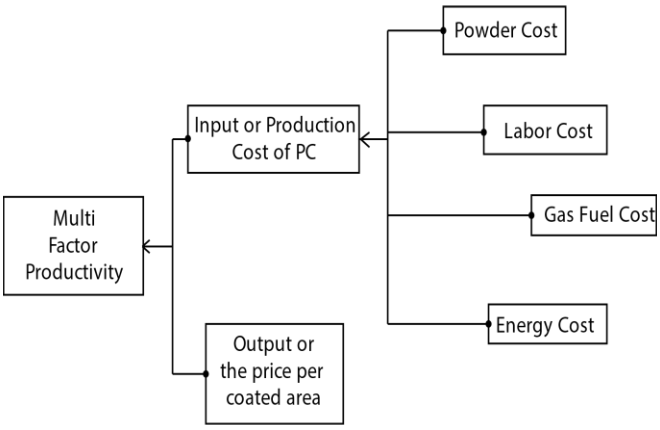

Figure 4 Multi Factor Productivity (Stevenson, 2012)

The multifactor powder coating productivity is influenced by the product output in the paint (paint area) and the powder coating production cost. Meanwhile, the variable production costs are divided into 4 things, namely: powder, labor, gas, and energy costs.

III. RESEARCH METODOLOGY

3.1 Location, Type and Source of Data

The location of the research was conducted at PT TKM, which produces a company engaged in manufacturing mild steel which produces doors, windows, frames and lovera roofs, located in Bekasi, Indonesia. This research is a research with the application process of secondary data from the company, namely the production data of 3 powder coating production lines from January 2017 to December 2019, which are related to the problem being studied. Descriptive quantitative method is the type of research used in this research.

3.2 Operational Definition and Variable Measurement

This research was only conducted on 3 Powder Coating production lines, the results of which can be seen from the Production Table for the last 3 years and to provide the same understanding, the researchers made definitions of the variables to be analyzed as in the table below.

Table 1. Operational Definition

Variable	Definition	Units	Scale
Output	The result of painting or output, how much area has been coated (Coating)	m^2	Average per month
Output Prices	The selling price of powder coating painting services	Rupiah	Average per month
Labor Input	The length of time or hours worked by the workers	Hours	Average per month
Powder Input costs	The cost of consuming powder for a period of 3 years	Rupiah	Average per month
Fuel gas input costs	The cost of consuming LPG gas as fuel	Rupiah	Average per month
Energy Costs	The cost of the required electric power that is calculated from the time the unit is turned on, until the unit is turned off	Rupiah	Average per month
Labor costs	Worker Wages	Rupiah	Average per month

3.3 Population and Sample

Population is a generalization area consisting of objects / subjects that have a certain quantity and characteristics set by the researcher to study and then draw conclusions (Sugiyono, 2015). The population in this study is the company's powder coating activity since 1997 until now.

The sample is a subgroup or part of the population. The sample in this study is a response related to the development designs of aluminum panel door products (Sekaran, 2016). The research sample used was painting activities carried out from 2017 to 2019. The sampling technique used was to take the company's daily painting data from 2017 to 2019.

3.4 Data Collection Methods.

The type of research data is secondary data, PT.TKM's powder coating process data from 2017 to 2019. The objects in this study are 1 set of manual powder units and 2 sets of auto powder coating units. The location of the object of observation is in the light steel industry, in the Bekasi area, West Java. Interviews and discussions are qualitative approaches conducted by researchers to obtain data. Productivity can include all production factors or focus on one factor or part of the production factors used by the company in production (Heizer & Render, 2015). Productivity measures that focus on the relationship between one or some of the input and output factors achieved are called single productivity measures (Blocher, 2007).

Single productivity (PS) is measured by calculating the ratio of output to input, or formulated this way:

$$Single\ Productivity = \frac{Output}{Input\ Man\ Hours}$$

After obtaining a single productivity per PC, the Multi Factor Productivity (MFP) analysis is then carried out. MFP is measured by calculating the ratio of output to all existing inputs, or formulated like this:

$$MFP = \frac{Output}{Salary + Energy + Raw\ Material + Gas\ Fuel}$$

IV. RESULTS AND DISCUSSION

4.1 Results of Data Processing

The sample is the production report data for the powder coating process from January 2017 to December 2019, especially for processes in the PC-1, PC-2, and PC-3 powder coating machines.

Table 2. Annual Production Data of Powder Coating

Information	Powder Coating								
	PC-1			PC-2			PC-3		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
Average Coating Yield per month (m^2)	4244.37	4721.66	4651.30	3534.30	3394.31	3195.19	4923.73	3846.50	2955.07
Average powder consumption per month (Kg)	471.08	528.04	547.21	494.13	428.96	383.50	535.50	462.21	378.88
Average processing time per month (hours)	92.77	112.06	111.43	55.87	66.83	60.30	58.80	56.79	43.63
Average Fuel Gas Consumption per month (Kg)	1190.28	1398.86	1311.05	892.69	909.58	817.60	1199.98	1130.92	789.84

(Source: Data Processing)

From the data above, it is known that PC-1 has done surface coating (output) of 4244.37 m^2 area per month during 2017, 4721.66 m^2 per month during 2018, and 4651.30 m^2 per month during 2019. The powder consumption of PC-1 per month is 471, 08 Kg during 2017, as many as 528.04 Kg during 2018, and as many as 547,208 during 2019. PC-1 has processed 92,768 hours per month throughout 2017, then during 2018 it processed for 112,062 hours per month, and processed for 111.403 hours per month during 2019. The PC-1 consumption of fuel gas (COFG) was 1190.28 Kg of liquid gas during 2017, then 1398.86 Kg during 2018, and 1311,045 Kg during 2019.

Furthermore, it is known that PC-2 has done surface coating (output) covering an area of 3534.30 m^2 per month during 2017, 3394.31 m^2 per month during 2018, and 3195.19 m^2 per month during 2019. The powder consumption of PC-2 per month are 494.12 kg during 2017, 425.96 Kg during 2018, and 383.5 Kg during 2019. The PC-2 had processed 88.86 hours per month throughout 2017, then during 2018 it processes 66.83 hours per month, and processes 60.3 hours per month during 2019. PC-2 COFG is 892.69 kg of liquid gas during 2017, then 909.58 Kg during 2018, and 817.6 Kg during 2019.

Furthermore, it is known that PC-3 has done surface coating (output) covering an area of 4923.73 m^2 per month during 2017, 3846.5 m^2 per month during 2018, and 2955.07 m^2 per month during 2019. The powder consumption of PC-3 per month as much as 535.5 kg during 2017, as much as 462.21 kg during 2018, and as much as 378.89 kg during 2019. PC-3 machines process for 58.8 hours per month throughout in 2017, then during 2018 it was processed for 56.79 hours per month, and processing for 43.63 hours per month during 2019. PC-3 COFG was 1199.98 Kg during 2017, then 1130.92 Kg during 2018, and 789.84 Kg during 2019.

Every powder coating production lines consists of builders, helpers, robo-arm, APP, SB, CC , and Oven. The following is the composition data for the Powder Coating Unit Area:

Table 3. Composition of PC

Composition of *Powder Coating* Unit						
Description	**PC-1**		**PC-2**		**PC-3**	
	Qty	**Unit**	**Qty**	**Unit**	**Qty**	**Unit**
Operator	2	Person	1	Person	1	Person
Helper	2	Person	1	Person	1	Person
Robo-Arm	0	Unit	2	Unit	2	Unit
APP	2	Pcs	6	Pcs	6	Pcs
SB	2	KW	6	KW	6	KW
CC	0,75	KW	1	KW	1	KW
Oven	1	KW	1,75	KW	1,75	KW

(Source: PT.TKM 2020)

From the data above, it is known that PC-1 consists of 2 operators, 2 helpers, 2 pcs of APP (Powder Spraying Equipment). Requires 2 KW (Kilo Watt) of power for the SB (Spray Booth), 0.75 KW of power for the CC (Cyclone), and 1 KW of power for the Oven. Then it was discovered that PC-2 consisted of an operator, a helper, 2 RoboArm, 6 APPs. Requires 6 KW of power for SB, 1.0 KW of power for CC, and 1.75 KW of power for Oven. Then it was discovered that PC-3 consisted of an operator, a helper, 2 RoboArm, 6 APPs. Requires 6 KW of power for SB, 1.0 KW of power for CC, and 1.75 KW of power for Oven. The table above shows the supporting data to determine the output price and costs of each input, to determine the single productivity and the multi-factor productivity for PC-1, PC-2, and PC-3.

4.2 Discussion of Single Productivity

Single productivity is obtained by dividing the average output (m^2) per month by the average labor hours per month, in 2017, 2018, and 2019. The following is a table of labor productivity in the powder coating area for 3 years.

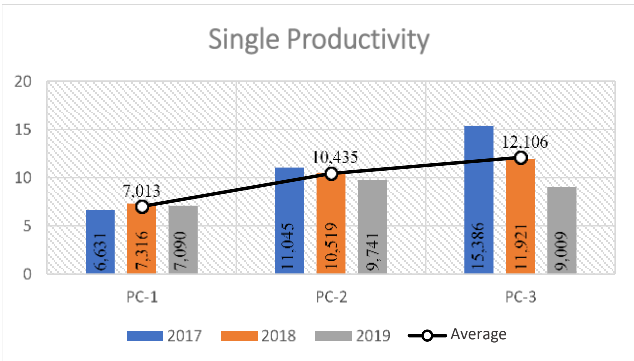

Figure 5. Single Productivity Chart
(Source: Data Processing)

The SP of PC-1 powder has increased and decreased in 3 years, while PC-2 and PC-3 have decreased from 2017 to 2019. Looking at Figure 5, it can be seen that PC-3 units were the most productive in 2017. -2018, and the PC-2 unit in 2019. The PC-3 won the title of the most productive during 2017 to 2019 due to elements of more modern technology, so that the workforce on duty is also more efficient at work.

4.2 Discussion of Multi Factor Productivity

After we know the single productivity of each input component, then the writer needs to find the multi-factor productivity of the three Powder coating units. The output used to find productivity is the area of powder coating paint. Then there are 4 categories for input, namely: raw materials, energy, fuel gas and labor. The raw materials consist of powder and gas. Then for capital consists of a cyclone, Spray Booth, and oven. Then the last one is a workforce consisting of Operators and Helpers.

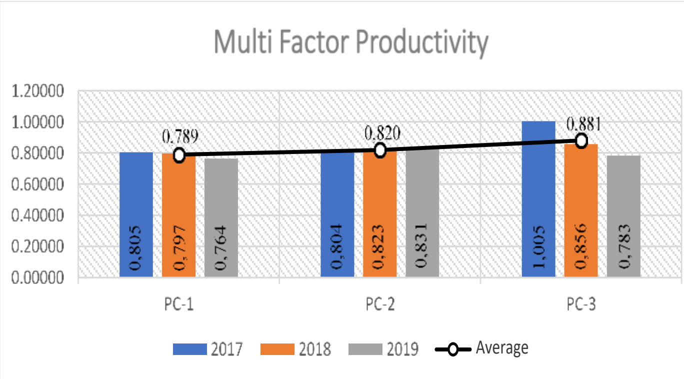

Figure 6. Multi Factor Productivity Chart
(Source: Data Processing)

After knowing the average output value, and each input in the same unit, namely Rupiah, it is possible to find out the annual multi-factor productivity value of each powder coating unit. PC-1 units experienced a significant decrease in MFP every year from 2017 to 2019. PC-2 units experienced a significant increase in MFP every year from 2017 to 2019. PC-3 units experienced a significant decrease in PMF every year from 2017 to 2019. Based on a series of years, the highest MFPs in 2017 were PC-3, 2018 PC-3, and 2019 PC-2.

Looking at the MFP results in Figure 6, it can be seen that the PC-1 unit is not productive. This is due to the systematic workmanship that still uses human labor, and 2 powder guns are used. When compared to the PC-2 and PC-3 units that already use a robot arm that can work continuously without resting, plus the robot arm is equipped with 3 powders per robot arm. PC-2 and PC-3 have 6 powder guns which make the coating process faster, the resulting paint area is also more, even though it is wasteful of powder consumption.

V. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusion

Based on the objectives of the research that have been determined and the results of the research and discussion that has been carried out in chapter 4, it can be concluded that;

1. Single Productivity Analysis states that the most productive PC production line is PC-3, and the least productive is PC-1.
2. Multi Factor Productivity Analysis states that the most productive PC production line is PC-3, and the least productive is PC-1.
3. The PC-3 Production Line is the most efficient, and can be used as a reference model for the development of the PC-1 and PC-2 production lines.

5.2 Suggestions

The author's suggestions for further research regarding and related to this multifactor productivity, it is;

1. There needs to be other multi-factor productivity in order to get total factor productivity.
2. Then need additional data such as time and maintenance costs for each powder coating unit.
3. To train operators to be more agile at work, so that workforce productivity can be better
4. The need for data collection on machine (capital) depreciation in order to be sharper in future analysis.

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APPENDIX A

Table A1 TOP and COFG Standard each PC

Year		TOP		COFG	
		Value	Standard	Value	Standard
PC-1	2017	0.021856779	0.02	0.280437259	0.27
	2018	0.023733511	0.02	0.296264898	0.27
	2019	0.023956931	0.02	0.281866458	0.27
	Mean	0.023182407	0.02	0.286189539	0.27
PC-2	2017	0.015806754	0.02	0.252578444	0.27
	2018	0.01968861	0.02	0.267973291	0.27
	2019	0.018870805	0.02	0.255883995	0.27
	Mean	0.018122057	0.02	0.25881191	0.27
PC-3	2017	0.01194165	0.02	0.243713123	0.27
	2018	0.014764946	0.02	0.294011853	0.27
	2019	0.014765583	0.02	0.26728372	0.27
	Mean	0.01382406	0.02	0.268336232	0.27

Note: this table is linked to the Figure 1. Time of Painting Process and Figure 2. Consumption of Fuel Gas

Table A2 Single Productivity

PC	Years	Output	Input	Single
		m2/bulan	Man Hour	Productivity
PC-1	2017	4244.37	640.00	6.631831879
	2018	4721.66	645.33	7.316628245
	2019	4651.30	656.00	7.090393867
	Mean	4539.11	647.11	7.0130
PC-2	2017	3534.30	320.00	11.04469167
	2018	3394.31	322.67	10.51954321
	2019	3195.19	328.00	9.741437111
	Mean	3374.60	323.56	10.4352
PC-3	2017	4923.73	320.00	15.3866663
	2018	3846.50	322.67	11.92095886
	2019	2955.07	328.00	9.009360119
	Mean	3908.43	323.56	12.1057

Note: this table is linked to the Figure 5. Single Productivity Chart

Table A3 Multi Factor Productivity

PC	Years	Output (Rupiah)	Input (Rupiah)					Multi Factor Productivity
			Powder	Gas	Energi	T. Kerja	total	
PC-1	2017	33954979.22	21198750	8331961	370076	12297618	42198405	0.80465
	2018	37773312.75	23761875	9792043	447042	13368740	47369701	0.79742
	2019	37210387.01	24624375	9177315	444525	14442252	48688467	0.76425
	Mean							**0.789**
PC-2	2017	28274410.68	22235625	6248818	520013	6148809	35153266	0.80432
	2018	27154447.55	19303125	6367083	622063	6684370	32976641	0.82344
	2019	25561530.98	17257500	5723188	561249	7221126	30763063	0.83092
	Mean							**0.820**
PC-3	2017	39389865.73	24097500	8399849	547302	6148809	39193460	1.00501
	2018	30771968.46	20799375	7916408	528646	6684370	35928800	0.85647
	2019	23640560.95	17049375	5528895	406150	7221126	30205546	0.78266
	Mean							**0.881**

Note: this table is linked to the Figure 6. Multi Factor Productivity Chart