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Increasing Production Yield With Through Feasibility Investment Analysis in Plastic Recycling Industry

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Abstrak

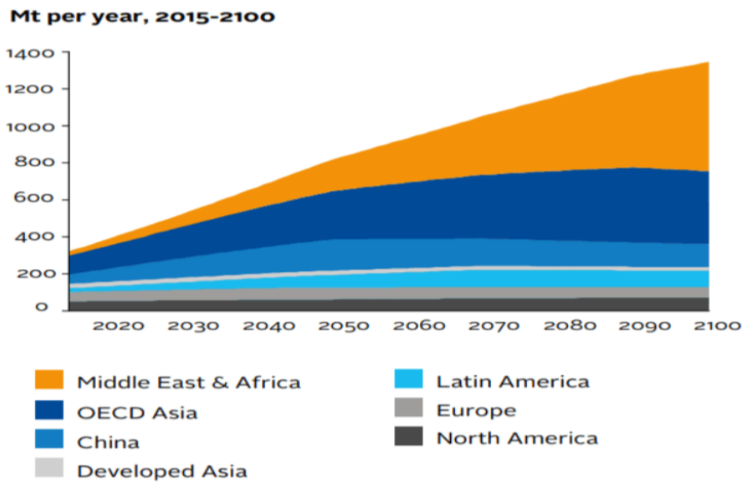
The plastics recycling industry in Indonesia can only fill 82% of national needs. Based on the Survey of this study, plastic recycling industries around Jakarta have a capacity of 80% of their ability. In failure to achieve production capacity, this article aims to increase production yield. By investigating a plastic recycling industry in Bogor with about 320 Kg/hour production from 400 Kg/hour capacity, this study aims to improve the output at Geording Machine Line by replacing old machines, which most contributed to the failure of production yield. In Production Line consists of five Work Stations (WS): WS-1, WS-2, WS-3, WS-4, and WS-5, having bottlenecks of 78.00 minutes that shall be 60 minutes ideally to produce 400 kg/hour on WS-4. Feasibility of Investment Analysis shows that buying a new machine for WS-4 makes it feasible to prevent more loss in failure production yield.

Keywords: Production capacity, Work Station (WS), Visual Stream Mapping (VSM), improvement

INTRODUCTION

The plastic recycling market worldwide increased by USD 34,804.1 million and will reach USD 50,356.1 million by 2022, with an annual growth rate of 6.4% [1]. The market is expanding the use of recycled plastic compared to buying new plastic material. It can also cause severe environmental pollution caused by plastic waste in many countries' oceans and landfills. Most industries are increasing their use of plastic recycling, such as the packaging, automotive, electrical, and electronics industries. They take the initiative to support plastic recycling worldwide by offering a lucrative opportunity for the growth of the plastic recycling market. The prospects for the plastics market show a considerable increase, as Figure 1 below shows.

Figure 1. Attractive Opportunities In The Global Recycled Plastics Market



Source: Material Economic, 2018 (https://tokoplas.com/blog/business/industri-plastik-di-masa-pandemi/c261f887-8de1-11eb-8467-7cd30ae46b32)

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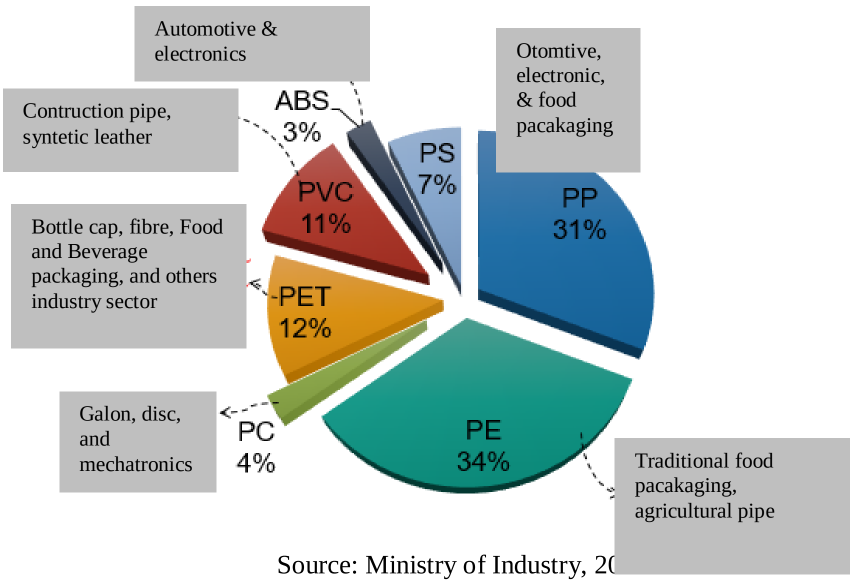
The market price is very competitive. In this case, plastic recycling performance is the main factor holding back market growth. The ban of plastic waste imports in China and the collection of rare plastic waste so that the recycling process is a challenging factor for the growth of plastic recycling globally. Ecological Observation and Wetland Conservation (Ecotone) noted, due to China's policy to stop imports of plastic waste from many countries in Europe and America, plastic waste has shifted its purpose to countries in ASEAN, including Indonesia. Polyethylene

ne Terephthalate (PET) is one of the fastest-growing types of plastic recycling, Polyethylene Terephthalate (PET) is expected to grow more from 2017 to 2022. This type of plastic is expected to have the fastest growth because this type of plastic is easily recycled, such as bottles. PET type plastic source is the least complicated plastic to sort and collect

Recycling the plastic industry has an important role and has linkages with other industries such as food and beverages, cosmetics, pharmaceuticals, electronics, agriculture, automotive, household goods, etc. The level of plastic consumption in Indonesia currently reaches 22.5 kg per capita[2]. Plastic consumption grows 6-7% per year, with current consumption of 7.2 tons per year [2]. The strength of the National Downstream Plastic Industry is spread across large and small-scale industries, with around 1,580 companies producing various types of plastic products, including 892 industrial packaging companies [2]. The National Downstream Plastic Industry absorbed 177,300 workers. The Indonesian plastic industry continues to grow with constraints on raw materials. The local sector supplies about 50% of raw materials with limited product variety.

Figure 2. National Downstream Plastic Consumption Profile



Source: Ministry of Industry, 20

From the author's initial observations on eight plastic material recycling industries in Jabodetabek, almost all have productivity of 80% of their maximum production capacity. The object of study in this research is the workflow of the plastic recycling industry of PT. Parindo Agung Masjaya (PAM) and several other similar companies. Productivity at PT PAM itself can only produce 400 kg/hour from a capacity of 500 kg/hour or 80%. In addition, in conducting the plastic material recycling industry, this research fills in the shortcomings and recommendations of previous research on developing the plastic recycling industry, which is too focused on material studies. [3], and too focused on supply chain problems, material needs, or shortage of supply scarcity [4]. This study offered an improvement approach in the plastic recycling industry in Bogor with a production yield of about 320 Kg/hour production from 400 Kg/hour capacity. This study aims to improve the output at Geording Machine Line by replacing old machines, which most contributed to the failure of production yield

LITERATURE REVIEW

This study conducted a research topic on the plastic recycling industry to meet the national industry needs. What is meant by the plastic industry here is plastic in the form of polymer compounds whose main constituent

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elements are carbon and hydrogen [5]. [10]. Various sectors use plastic materials, so they have an important role in supporting multiple industries such as electronics, automotive, textile, food, beverage, packaging, and almost all types of industries that require plastic materials. So it is natural that the plastic industry is a driving force for the national economy [6] [7]. In Indonesia, the plastic industry, especially the plastic recycling industry, is very important in determining the sustainability of various industries' sustainability because it can only fill 82% of national needs. Based on the Survey of this study, plastic recycling industries around Jakarta have a capacity of 80% of their ability. In failure to achieve production capacity, this article aims to increase production yield.

Various approaches support increased production in the plastics material industry, generally within the scope of increasing productivity and reducing non-value-added processes. The method used to reduce waste and non-value added processes is a lean manufacturing approach [8][9]. Lean thinking provides a way to do things better using optimal resources [10]. Lean is an effort to optimize processes by eliminating waste by simplifying processes as much as possible, saving human labor, materials, equipment, time by continuously approaching what the customer wants.[11][12][13]. In principle, the lean manufacturing approach focuses on equipment-oriented repair techniques and involves the interaction of human relationships, even economic approaches, such as feasibility investment analysis in engineering economics. [14]. The study conducted in this article combines several lean manufacturing methods and engineering economics. By lean approach identifies a process that has less value-added or the most contributed loss in the whole process, then provides feasibility analysis in engineering economic to decide to invest a new machine for boosting productivity.

In general, productivity improvement, waste reduction, and production achievement use lean engineering, quality, engineering, system, and modeling approaches [15][16][17]. This article tries to take an engineering economic approach to increase production achievement. Analysis of the feasibility of investing in technical economics is an approach to deciding a purchase decision's feasibility [18][19]. This approach decided new investment based on observation and Focus Group Discussion (FGD) with experts and top management. An old machine is no longer helpful because of the age factor, chronic trouble, high-cost maintenance, obsolete engine specifications, and any matter that causes high expends. The company shall not carry out any improvement, instead of replacing an old machine. There is no improvement because the impact of losses due to the engine is not optimal, and maintenance costs are higher than the production results. The only way is to invest in new machines

Engineering economics is a discipline that presents economic options used in engineering projects, one of which is investment feasibility analysis. [20]. This approach is used to analyze the feasibility of investing in various industrial engineering projects and other engineering cases by calculating the value of money [21]. In this engineering economics approach, economic factors and criteria are used in the assessment of several choices in decision making, namely [21];

a) Net Present Value (NPV)

NPV is the amount of money spent, and the amount of income earned at any time is converted to the current time.

Formula:

$$NPV = \sum_{t=0} At/(1+k)^t \quad \text{or} \quad \sum PV_{Proceed} - \sum PV_{outlays} \quad \text{................(I)}$$

k = discount rate

At = Cash Flow in (t) period

n = period

$PV_{proceed}$ = PVon going

$PV_{outlays}$ = Total Investment

a) Internal rate of return (IRR)

The IRR model is a method that calculates the percentage of profit from a project and calculates the project's ability to repay the loan interest until the NPV is equal to zero.

Formula:

$$IRR = I_1 + \frac{NPV^{(+)}}{NPV^{(+)} - NPV^{(-)}}(I_2 - I_1) \quad \text{..................................(II)}$$

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Parameter :
If IRR MARR (Minimum Attractive Rate of Return), investment is feasible
If IRR < MARR (Minimum Attractive Rate of Return), investment is not feasible

b) Payback Period (PP)

The payback period is the number of periods required to cover investment costs using the yield or net cash flow.
Formula:

PP = n + [(a-b)/(c-b)] x 1Years..(III)

If cash flows vary each year
n = Last year, the cash flow amount still could not cover the initial investment.
a = Amount of first investment
b = Cumulative amount of cash flows in year n
c = Total cumulative cash flows up to n + 1 year

If the annual cash flows are the same amount, then the formula;

PP = (The Initial Investment/Cashflow) x 1 Years.........(IV)

Parameter:
PP lebih cepat dari jangka waktu investasi; investasinya layak
PP lebih lama dari jangka waktu investasi; investasi tidak layak

c) Benefit-Cost Ratio (BCR)

BCR is a method that considers the comparison of business benefits and costs.

Formula; BCR = Benefit/Cost or $\Sigma PV_{Proceed} / \Sigma PV_{Investment}$.................(V)

Parameter
BCR >1; worth the investment
BCR < 1; the investment is not worth it

This study used the NPV approach, not benefit-cost ratio (BCR), internal rate of return (IRR), or others. BCR is the same as NPV, providing output divided input; otherwise, NPV output minus input. Also, this study did not use the internal rate of return (IRR) approach because not seek alternative investment based on the standpoint of return, just seeking feasibility in investing new machine.

METHOD

This study aims to improve bottlenecks in the production workflow that impact losses. The case study approach in this research seeks to understand better the theoretical construction of the phenomenon or system of research interest [22] by investigating a plastic recycling industry in Bogor. This study also collects various failure cases to achieve the production yield in eight plastic recycling industries in Jakarta. Case analysis was also carried out by reviewing papers on similar problems, industries, & topics, also reviewing books, technical reports, news articles, and the web.

The research in this study includes applied research, in which a model of investment feasibility analysis ensures that solution to terminate the loss by new investment. This approach consists of data collection, analysis, report submission, and information processing. It also includes seeing the impact before and after the solution applied by testing model formulation in the economic simulation of Net Present Value. After seeing the result or effect of simulation from the formula used, determine specific actions to see temporary results. This action research requires that a practitioner be involved in a practical context [23]. This study selects one of the local companies PT PAM in Bogor, Indonesia, and finds out empirically how to improve production yield by terminating the bottleneck in the flow of production in the plastic recycling industry.

RESULT & DISCUSSION

The production data in Table 1. above is processed into production yield performance against capacity, as shown in Table 1 below.

Table 1. Total Production Achievement

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NO.	MONTH	TOTAL QUANTITY (TON)	CAPACITY (TONS)	% COMPARING TO CAPACITY
1	JAN	619	780	79,36%
2	FEB	500	650	76,92%
3	MAR	368	450	81,78%
4	APR	294	400	73,50%
5	MAY	102	135	75,56%
6	JUN	305	390	78,21%
7	JUL	256	315	81,27%
8	AUG	249	300	83,00%
9	SEP	401	500	80,20%
10	OCT	428	600	71,33%
11	NOV	434	550	78,91%
12	DEC	387	480	80,63%
	TOTAL	**4.343**	**5.550**	**78,25%**

The data above shows that achievement of production performance yield against capacity is 4343/5550 = 78 .25% less than target 95% that established by company. This data shows that achieving production against capacity and targets was not achieved, which should have been 97% as the company's target. It is the background of the problem in this research.

The next data collected in this study is the processing time data of one of the lines (Geording Machin Line-1) at PT PAM to look for points in the production process that can cause failure to achieve production performance, as shown in Table 2. above. The data under one of the Geording production lines, which is the object of this research study, represents a general description of the condition of other production lines

Table 2. Production Process Time – Geording Machin Line-1

No	Process Name	Sub-Proses	Target Prod/ 1 Hour (Kg)	Actual 1 Hour Prod/Jam (Kg)	%	Duration 400 kg (Minutes)	Bottleneck
1	Crusher (WS-1)	Crusher	400	383	95,75%	62,66	62,66
2	Washer (WS-2)	Turbo Washer	400	385	96,25%	62,34	62,34
3		Tangki Washer	400	389	97,25%	61,70	
4		Centris Machine	400	386	96,50%	62,18	
5		Screw Conveyor	400	385	96,25%	62,34	
6	Mesin Press (WS-3)	Press Machine	400	310	77,50%	77,42	**77,42**
7		Blower	400	395	98,75%	60,76	
8	Pelletizing (WS-4)	Cello Injection	400	380	95,00%	63,16	63,49
9		Pelettizing	400	381	95,25%	62,99	
		Cutting	400	378	94,50%	63,49	
11		Drying	400	387	96,75%	62,02	
12		Filtering	400	386	96,50%	62,18	
13		Blower	400	392	98,00%	61,22	
14	Packing (WS-5)	Cello Packing	400	370	92,50%	60,45	60,76
15		Packaging	400	395	98,75%	60,76	

Table 2 above describes the production process illustrated in Figure 1 below, which shows a series of processes .

Figure 3. Production Flow of Table 2

CRUSHER (Bottleneck : 62,66)
1. Crusher Machine

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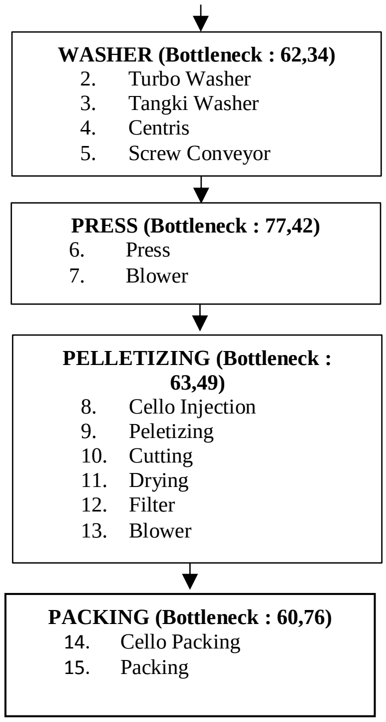
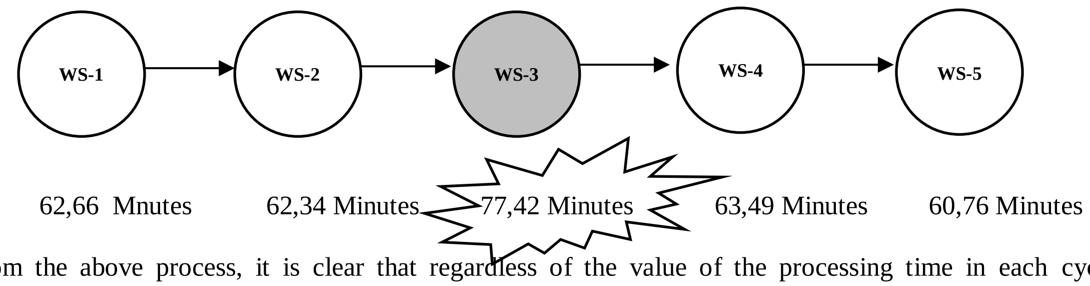


Figure 3. above describes the production process flow chart starting with Material Milling Process (Crusher), which breaks the material into small flakes. Next is the Washing Process (Washer) to clean the grinding results. It continued with the material pressing process, consisting of a press process and a blower process. Next to the Pelletizing Process and finally to the Packaging Process.

Ideally product cycle time based on machine capacity is 60 Minutes / 400 kg = 0.15 Minutes. But the production capability is hindered by bottlenecks in the WS-2 Pressing Process, which takes 77,42 Minutes to reach 400 kg, while in 60 Minutes, it only reaches 310 kg (see Table 1). So the current cycle-time used is 60 Minutes/310 kg = 0.19 Minutes (ideally 0,15 minutes). Figure 4 below shows the actual time (minutes) in production yield 400 kg by taking the longest sub-process in Table 2. Every process depends on the longest time from its subprocess in a production line. Every process operated will take time from the longes time of its sub-process.

Figure 4. Time Diagram of the Plastic Recycling Production Process



From the above process, it is clear that regardless of the value of the processing time in each cycle, the production results only depend on the process that has the most significant bottleneck, namely in WS-1 with the longest time of 75.00 Minutes. From the flow chart above, there are five workstations: WS-1 (Crusher Machine), WS-2 (Washer Machine), WS-3 (Press Machine), WS-4 (Pellet Machine), and WS-5 (Packing). The workstations that focus on improvement are the WS-3 bottlenecks because it has the highest jam, which produces 400 kg / 72.42 Minutes on the sub-process of pressing. The bottleneck on WS-3 can be eliminated by replacing the old press with a new one. An investment feasibility analysis must precede the purchase of this machine.

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Feasibility analysis for new press machine

The loss is due to a bottleneck of 77.42 minutes to produce 400 kg. This gap should have reached 400 kg in 60 minutes. That means a loss of 29.03% or 116.13 kg per hour. If converted into money, with an average product price of Rp. 14,102.48/Kg, the losses per day or 24 hours (three shifts) are:

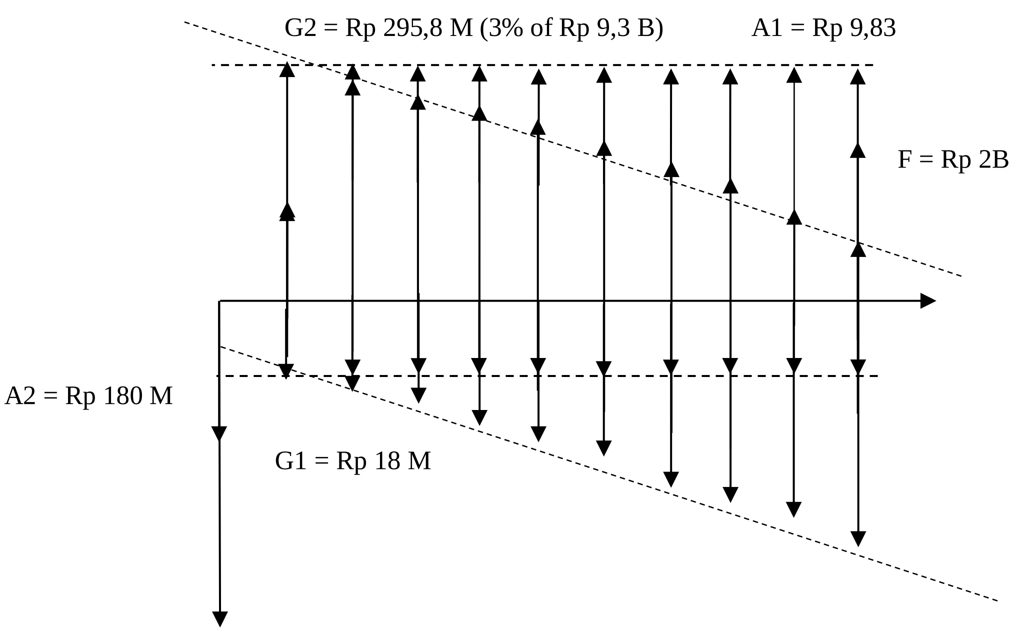
IDR 14,102.48 x 116.13 Kg x 24 Hours = IDR 39,306,432.26 per day or
IDR 14,102.48 x 80 Kg x 24 Hours x 250 Working Days = IDR 9,826,608.064.00 per year

From the Focus Discussion Group, the WS-3 Press Machine with a bottleneck value of 77.42 minutes is the "Given Condition" status because of the age and depreciation of the machine's effectiveness. There is no room for more repairs and maintenance due to the natural factor of engine life and low effective specifications. With the technical economy approach, the measuring point in this approach is a loss per day of Rp. 39,306,432.26 or in one year 250 working days of Rp. 9,826,608,064.00 per year.

Here is the feasibility analysis:

1. A1(Annuity) = Opportunity preventing lost Rp 9,826,608,064.00 per year is the standpoint to primary reference comparing investment new press machine. If buying a new press machine, this loss is assumed to disappear.
2. P1 (Present) = Rp 6,500,000,000 is investment of buying new press machine
3. P2 (Present) = Rp 700,000,000 the selling price of the old press machine (Residual value because replaced by new machine)
4. F (Future) = Rp 2,000,000,000 the selling price of the new press machine in next ten years later
5. n = 10 years = new press machine operational time period (effective machine age)
6. A2 (Annuity) = Rp 180,000,000,000 Manintenance cost
7. G1 (Gradual) = Incremenet at 10% per year for Maintetnace cost Rp 18,000,000
8. G2 (Gradual)= Decreement at 3% of production capacity (From total opportunity cost Rp 9,826,608,064.00
   Rp 294,798,241.9
9. i(interest) = 3,5% Indonesian Bank Interest of this year.
10. Tabel (P/A, 3,5%, 10 years) = 8,317
11. Tabel (P/F, 3,5%, 10 years) = 0,7089
12. Tabel (P/G, 3,5%, 10 years) = 35,069

Figure 5. Financial Flow Diagram of the Feasibility of Machinery Investment



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P1 = Rp 6,5 B

i = 3,5%, n = yeras

Feasibility Analysis by NPV (Net Present Value = Income-Expenditures)

a. Income

= A1 (P/A, 3.5%,10 years) + F (P/F,3.5%,10 years) – G2 (P/G, 3.5%,10 years)
= (Rp 9,826,608,064.00 x 8,317) + (Rp 2,000,000,000 x 0,7089) – (Rp 294,798,241.9 x 35,069)
= Rp72,807,419,723,10

b. Expenditure

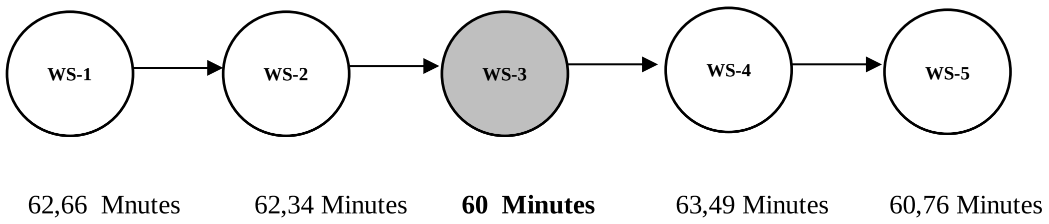
= P1 + A2 (P/A, 3.5%,10 years) + G1 (P/G, 3.5%,10 years)
= Rp 6,500,000,000.00 + (Rp 180,000,000.00 x 8,317)+ (Rp 18,000,000 x x 35,069)
= Rp8.628.302.000,00

NPV = Rp72,807,419,723,10 - Rp8.628.302.000,00
= Rp 64.179.117.723,10

Positive NPV (+) means that the investment in purchasing Crusher and Press Machines is very feasible.

After changing Press Machines, the production flow diagram will have a bottleneck from 77,42 Minutes to 60,00 Minutes because WS-3 with the new press machines has 100% or 60 minutes to produce 400 kg. It means that the current bottleneck moves to the Pellet Process or WS-4 at 63,49, but not so far from the ideal time of 60 Minutes of capacity or 92,52% from capacity. The new investment on the new press machine improved the highest bottleneck from 77,42 Minutes (77,5% of production capacity) into 63,49 Minutes (92,52%) in this production line.

Figure 5. Time Diagram of the Plastic Recycling Production Process After Investment of New Press Machine in WS-3



CONCLUSIONS

Based on the description of the research analysis, the most unbalanced points in the plastic recycling production line at PT PAM are Press Machines, which have bottleneck values of 77.42 Minutes in producing 400 kg. The investment of new press machines to improve the inability of the old press machine based on the Focus Group Discussion (FGD), experts, financial assessment, and field observations. The focus of improvement in this study is to improve production capacity by an investment of a new press machine by feasibility analysis approach to

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reduce the bottleneck time of 77,42 minutes from Press Machine. Finally, the bottleneck remained at WS-4 with a bottleneck of 63,49 minutes, but it is not so far from the ideal time at 60 minutes as maximum capacity.

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