

Increasing Production Yield With a Visual Stream Mapping (VSM) in the Plastic Material Recycling Industry

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Abstract

The plastic recycling industry in Indonesia only fill 82% of national need. 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 achievement by the VSM approach. 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 production by focusing on pelletizing. The process consists of five sub-process cello injection pelletizing, cutting, drying, filter, and blower. Improvement focused on two sub-processes with less value sub-cutting with 64.69 minutes and sub process drying with 64.00 to 400 kg. This action reduced the time by 64.69 minutes to 62 minutes. Meanwhile, in the drying sub-process, improvement from the length of the drying process, then it is corrected by increasing the temperature of the vibrator to reduce the bottleneck from 64 minutes to 62 minutes.

Keywords

Production capacity; Work Station (WS); Value Stream Mapping (VSM)

1. Introduction

In 2016, The global plastic recycling market worldwide was increasing was valued at USD 34,804.1 million and it will reach USD 50,356.1 million by 2022, with a CAGR (Compound Annual Growth Rate) of 6.4% (Industry 2022). The growth of the global plastic recycling market is increasing the use of recycled plastic instead of buying virgin plastic. Plastics can also cause severe environmental pollution caused by using used plastic waste in the sea and landfills in many countries. Many industries increase using plastic recycling such as packaging, automotive, electrical, and electronics industries. They took initiatives to support the use of plastic recycling worldwide by offering profitable opportunities for the growth of the plastic recycling market. The prospects of the market in plastics showed a vast increment, as Figure 1 below showed.

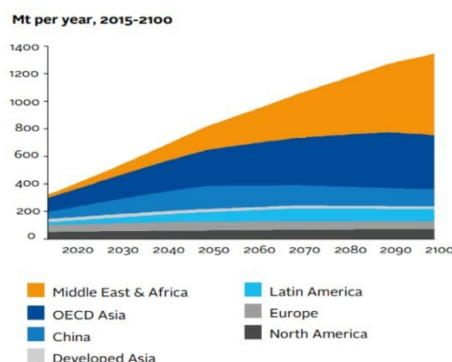


Figure 1. Attractive Opportunities In The Global Recycled Plastics Market

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

The cost of recycling plastic is higher than virgin plastic, so the market price is very competitive. In this case, the performance of plastic recycling is the main factor holding back the market growth. The rejection of plastic waste import in China and the rare collection of plastic waste so that the recycling process is a challenging factor in the growth of plastic recycling globally. Ecological Observation and Wetlands Conservation (Ecotone) noted that due to China's policy to stop imports of plastic waste from many countries in Europe and America, plastic waste had shifted its destination to countries in ASEAN, including Indonesia. Polyethylene Terephthalate (PET) is one of the fastest-growing types of plastic recycling, Polyethylene Terephthalate (PET) is expected to overgrow from 2017 to 2022. This type of plastic is expected to have the fastest growth because this type of plastic is easy to recycle, such as bottles. Source of PET type plastic is the most uncomplicated plastic to sort and collect

The National 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. Plastic consumption grows 6-7% per year, with current consumption of 7.2 tons per year. 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 (Figure 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 (Perindustriaan 2020).

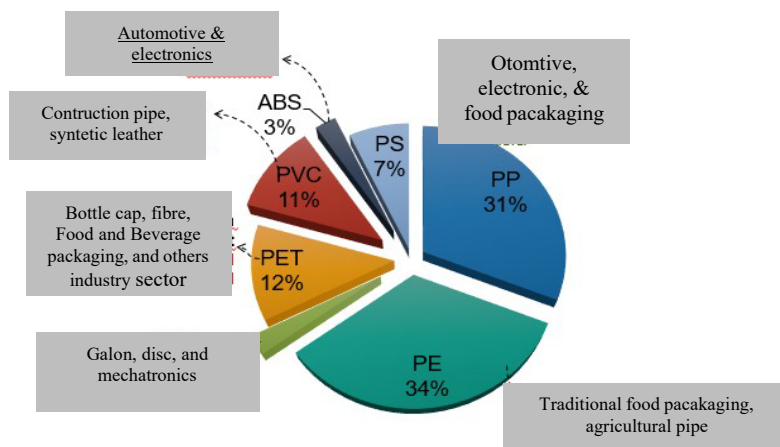


Figure 2. National Downstream Plastic Consumption Profile

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. (Kaiser, Schmid, and Schlummer 2018), and too focused on supply chain problems, material needs, or shortage of supply scarcity (Hapsari and Damanhuri 2009). This study offered an approach to Visual Stream Mapping (VSM) by terminating non-value added processes to increase production achievement.

2. Literature Review

Value Stream Mapping (VSM) is a tool using a lean approach and has been extended to many sectors in the industry (Mudgal et al. 2020, Nick et al. 2020). This paper explores the aspects covered by this VSM in solving the problem of eliminating or reducing processes that do not have added value. Based on a systematic approach, we analyzed the available literature published in reference journals. VSM can make a valuable contribution regarding the evolution, implementation, and performance of workflow mapping in the context of the manufacturing sector (Romero and Arce 2017, Zahra 2015).

VSM will not be effective if the information is inaccurate, incomplete, and late in solving problems on the ability and efficiency of the production system. This study proposes a form of workflow analysis by increasing the ability of one of the processes that have problems related to production capacity constraints. The VSM approach is proposed to improve workflow by mapping and analyzing the characteristics of each process. Therefore, the VSM approach should be tested and evaluated in the field to ensure its effectiveness. The evaluation results in trial applications must show that the proposed workflow mapping method can efficiently solve the problem. From the historical perspective of its application, VSM can effectively increase productivity and efficiency in the manufacturing industry (Purba, Mukhlisin, and Aisyah 2018)(Hipni and Hasbullah 2019)(Roh, Kunz, and Wegener 2019).

Value Stream Mapping is all a series of activities that have value-added or non-value-added processes needed to make products through the main production process flow. Value stream can describe product design, product flow, and flow of information, which support these activities. Value Stream Mapping, also known as Big Picture Mapping, is a tool used to describe the system as a whole and its value streams. This tool describes material and information flow in a value stream (Zahraee et al. 2020)(Gaspersz 2012).

Analysis with VSM can see the whole production as a real picture condition (Ramakrishnan et al. 2019)(Chowdary and George 2011). From the picture generated by VSM regarding the current condition, a value stream mapping can be made for future conditions that will show possible areas for improvement for the system (Ramakrishnan et al. 2019). After the advantages and benefits of the future state map are evaluated, the improvement plan can be implemented (Mudgal et al. 2020). In the context of manufacturing, there are three types of operations performed during the production process. These can be categorized: Non-value added (NVA) is a waste consisting of pure waste that can be eliminated or reduced. For example, waiting times, product stacking, and multiple handling. Value Added (VA) is an activity that has added value to the product. For example, the assembly parts, forging of raw materials, and drawing of work positions. In defining added value to performance, an activity must meet criteria to add to the resulting product's design, suitability, and function. Added value also means something is done that can make customers pay for the products produced.

VSM is lean thinking, a method that can help identify and eliminate waste in engineering operations (Wang et al. 2020). VSM as a lean tool can help improve production performance by streamlining production flow by eliminating all activities that contribute to waste. Experiments to improve production with the VSM approach in many lean manufacturing projects show that VSM is very effective if applied correctly following the principles of lean thinking. The results of the VSM analysis that are considered effective must be applied and standardized to ensure the consistency of the implementation of the improvement results based on the analysis (Jaiganesh and Sudhahar 2013). It is done to ensure that the results of implementing VSM and improvement in the production flow is carried out, controlled, implemented, monitored, and evaluated continuously (Nenni, Giustiniano, and Pirolo 2014). If implemented haphazardly and without monitoring, the best idea will not work effectively, either in the processes in

the results. There are also many cases of VSM implementation failing due to inconsistent implementation (Khlal, Harb, and Kassem 2014).

3. Methods

Add This study investigates how to increase production achievement with the VSM approach. The purpose of this study is to eliminate bottlenecks in the production workflow that impact losses. The first approach in this research uses case studies in several plastic recycling industrial plants to identify the processes at work stations that cause. This case study approach aims to understand better the theoretical construction of the phenomenon or system of interest in research (Koskela-huotari et al. 2016). This study collects various cases of failure to achieve the production of eight plastic recycling industries with various approaches, also carried out by reviewing papers on the same topic, books, technical reports, news articles, and the web. Case analysis was carried out based on a literature review by classifying the research literature for production failures in the plastic recycling industry. The literature review presents three activities; search for articles, select articles, and extract data and information from articles.

The second method used in this research is action research in finding solutions in the plastic recycling industry. Action means all activities consisting of data collection, analysis, report submission, and information processing. It also includes seeing the impact after the researcher tries to see the reaction or impact when the researcher tries to apply certain actions in the research process to see temporary results. This action research requires that a practitioner be involved in a practical context (Huang 2010). This study selects one of the local companies PT PAM in Indonesia, and finds out empirically how the flow of production in the plastic recycling industry. Both case analysis and action research methods can synergistically reduce losses and increase production gains.

4. Data Collection

The production data in Table 1. above is processed into production achievement performance against the target and capacity, as shown in Table 1 below.

Table 1. Total Production Achievement

NO.	MONTH	TOTAL QUANTITY (TON)	TARGET (TONS)	CAPACITY (TONS)	% COMPARING TO TARGET	% COMPARING TO CAPACITY
1	JAN	619	700	780	88,43%	79,36%
2	FEB	500	620	650	80,65%	76,92%
3	MAR	368	389	450	94,60%	81,78%
4	APR	294	324	400	90,74%	73,50%
5	MAY	102	116	135	87,93%	75,56%
6	JUN	305	350	390	87,14%	78,21%
7	JUL	256	279	315	91,76%	81,27%
8	AUG	249	288	300	86,46%	83,00%
9	SEP	401	450	500	89,11%	80,20%
10	OCT	428	430	600	99,53%	71,33%
11	NOV	434	495	550	87,68%	78,91%
12	DEC	387	425	480	91,06%	80,63%
TOTAL		4.343	4.866	5.550	89,25%	78,25%

From the data above, it appears that the achievement of production performance against the target is $4343/4866 = 89.25\%$ with an average of S % Towards Target / 12 Months = 89.59%, while the achievement of production performance against capacity is $4343/5550 = 78.25\%$ with an average of S % of Capacity / 12 Months = 84.91%. The next data collected in this study is the processing time data of one of the lines at PT PAM to look for points in the production process that can cause failure to achieve production performance, as shown in Table 2. 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

No	Nama Sub-Proses	Target Prod/ 1 Hour (Kg)	Actual 1 Hour Prod/Jam (Kg)	%	Duration 400 kg (Minut)	Process	Bottleneck
1	Crusher	400	320	80%	75,00	Crusher	75,00
2	Turbo Washer	400	388	97%	61,86	Washer	62,34
3	Tangki Washer	400	389	94%	61,70		
4	Centris Machine	400	386	95%	62,18		
5	Screw Conveyor	400	385	95%	62,34		
6	Press Machine	400	330	83%	72,73	Mesin Press (Refining)	72,73
7	Blower	400	395	99%	60,76		
8	Cello Injection	400	380	95%	63,16	Peletizing	64,69
9	Peletizing	400	381	95%	62,99		
10	Cutting	400	371	93%	64,69		
11	Drying	400	375	94%	64,00		
12	Filtering	400	385	96%	62,34	Packing	60,45
13	Blower	400	390	98%	61,54		
14	Cello Packing	400	368	92%	60,45		
15	Packaging	400	398	100%	60,30		

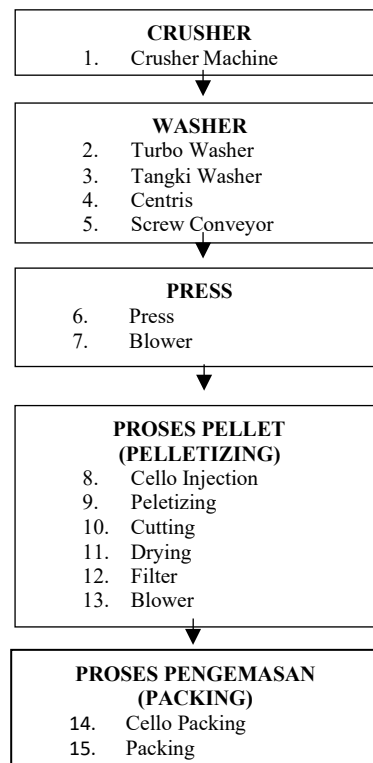


Figure 3. Production Flow of Table 2

Figure 3. above describes the production process flow chart starting with the Material Separation Process (Separator), which ensures that only resin materials are in the process. Continue to the 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, which consists of a press process and a blower process. Next to the Pelletizing Process and finally to the Packaging Process.

5. Results and Discussion

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-1 Crusher Process, which takes 75 Minutes to reach 400 kg, while in 60 Minutes, it only reaches 320 kg. So the current cycle-time used is 60 Minutes/320 kg = 0.19 Minutes. In calculating the number of work stations (WS or Work Stations), it calculates from the Total Processing Time of 336.86 Minutes / 75 Minutes = 4.49 (Rounding the Number of Stations to five Work Stations WS-1, WS-2, WS-3, WS- 4, and WS-5 shown in Figure 4,

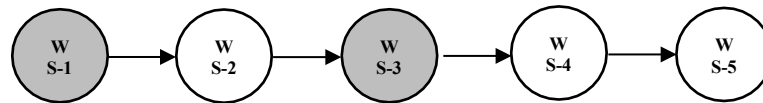


Figure 4. Work stations

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-1, WS-3, and WS-4 bottlenecks because all three have the highest bottlenecks, which produce 400 kg / 75 Minutes and 72.73 Minutes, and 64.69 Minutes. In WS-1, there is only one sub-process, namely the milling machine process. Meanwhile, the WS-2 only focuses on the press machine sub-process. Meanwhile, WS-4 has six sub-processes, in which the sub-processes of cutting and drying bottleneck values are 64.69 Minutes and 64.00 Minutes. The two bottlenecks WS-1 and WS-3, can be eliminated by replacing the old press and grinder with a new one. An investment feasibility analysis must precede the purchase of these two machines.

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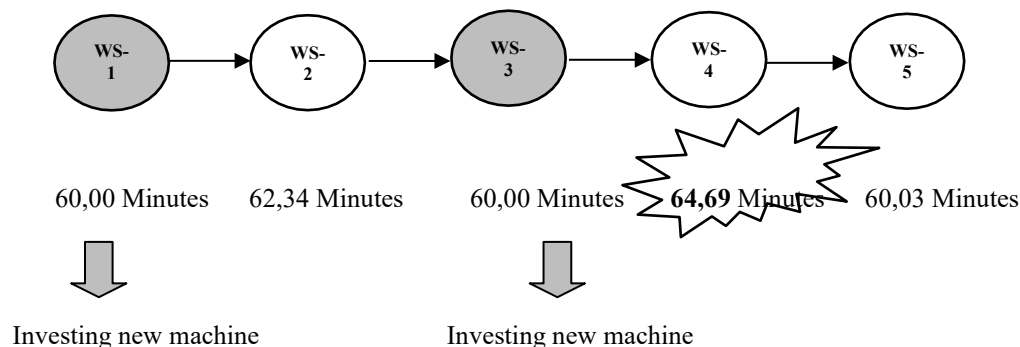


Figure 5. Production Process Time Diagram After Machine Investment

The VSM approach identifies processes or sub-processes that do not or have less added value. Before discarding or eliminating processes that do not have added value, the following Figure 6 is the actual condition based on observations of the current state validated by FGD. This paper identified the biggest bottleneck in the pelleting process on the cutting and drying sub-process with bottlenecks of 64.69 minutes and 64.00 minutes.

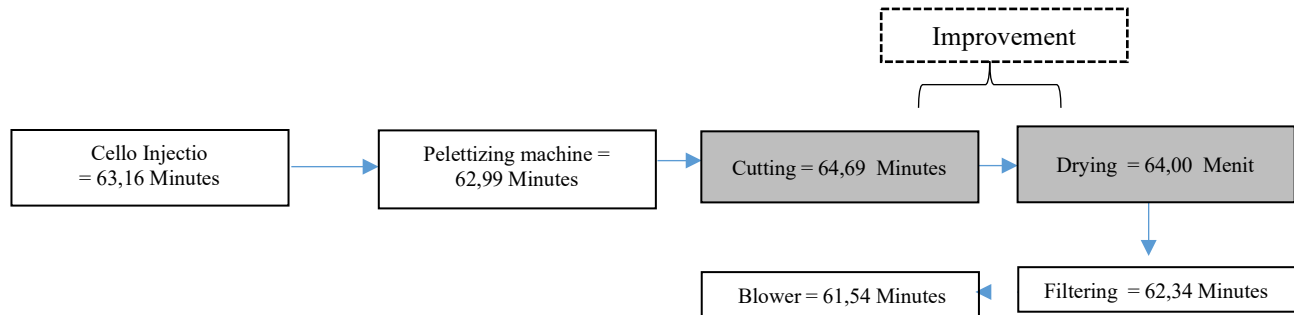


Figure 6. Pellet Process (WS-4) After Investment in Crusher and Press Machines

The following is the Current State of the pelleting process to identify sub-processes that have less added value (Figure 7).

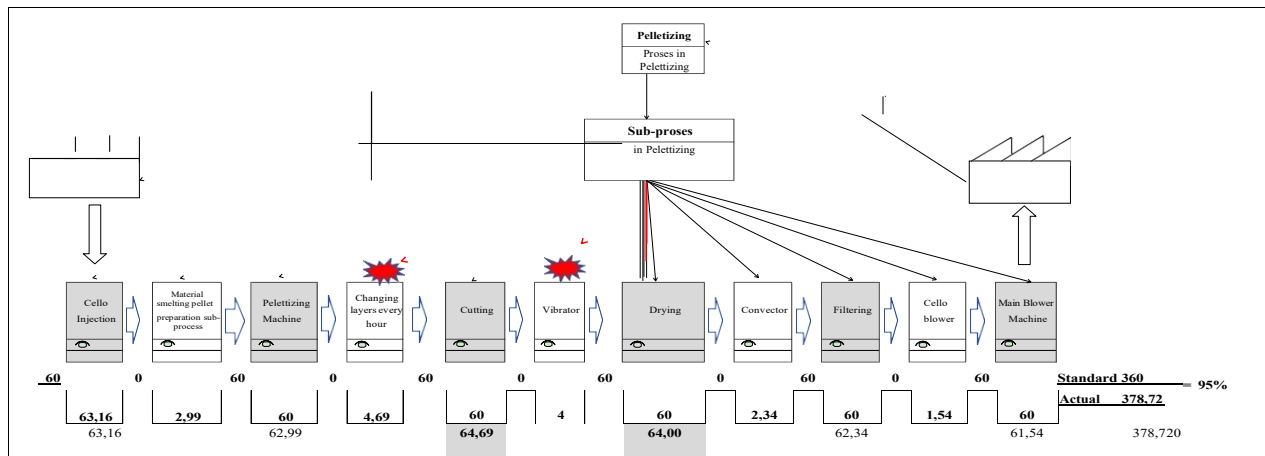


Figure 7. Process Stream Mapping Before Improvement

From the picture above, the repaired sub-process is the Cutting Machine Sub-Process which has a time value of 64.69 minutes to produce 400 kg. The bottleneck value of 64.69 comes from the sum of the cutting sub-processing time of 60 minutes with the hourly cleaning time of 4.69 minutes, so $64.69 = 60 + 4.69$ minutes. The layer cleaning process every hour of 4.69 minutes, replacing the layer with a new one every 4 hours to reduce the time by 2.69 minutes from 4.69 to 2 minutes. Meanwhile, in the drying sub-process, which has a bottleneck of 64.00 minutes, it comes from the length of the drying process, then it is corrected by increasing the temperature of the vibrator to reduce the bottleneck from 64 minutes to 62 minutes. The result was only 95% before the improvement. It rose to 96%, as shown by the Future State after the improvement in figure 8 below:

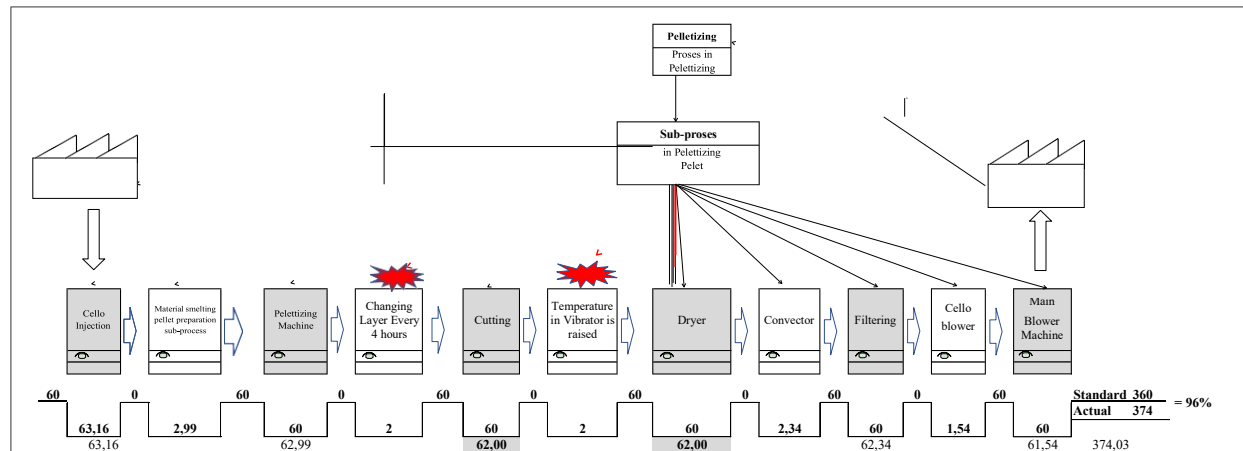


Figure 8. Value Stream Mapping After Improvement (Future State)

After eliminating processes that do not have added value in the Pellet Machine Process (WS-4), namely cutting and drying processes, the achievement value against the ideal time is 96%, increasing 95%. Although the value of 1% is only 2 minutes, this has a vast impact on the balance of production in the Pellet Machine Process and on the overall process, which changes the bottleneck time from 75.00 minutes to 64.69 Minutes in the pellet machine process. The improvement is focused again on the cutting sub-process. And drying, which finally became 63.13 minutes, because the cello sub-process injection became the biggest bottleneck in the pelleting process.

5.1 Numerical Results

1. Identified the biggest bottleneck in the pelleting process on the cutting and drying sub-process with bottlenecks of 64.69 minutes and 64.00 minutes.
2. After eliminating processes that do not have added value in the Pellet Machine Process (WS-4), namely cutting and drying processes, the achievement value against the ideal time is 96%, increasing 95%.
3. Although the value of 1% is only 2 minutes, this has a vast impact on the balance of production in the Pellet Machine Process and on the overall process, which changes the bottleneck time from 75.00 minutes to 64.69 Minutes in the pellet machine process.
4. The improvement is focused again on the cutting sub-process. And drying, which finally became 63.13 minutes, because the cello sub-process injection became the biggest bottleneck in the pelleting process.

6. Conclusion

Based on the description of the research analysis, the most unbalanced points in the plastic recycling production line at PT PAM are Crusher Process Machines and Press Machines, which have bottleneck values of 75 and 72.73 Minutes in producing 400 kg. The inability of the Crusher and Press Machine based on the Focus Group Discussion (FGD), experts, financial assessment, and field observations, investment in replacement was made to reduce potential losses so that the most significant bottleneck lies in the pelletizing process with a bottleneck of 64.69 minutes. The focus of improvement in this study is to reduce the non-value-added sub-process in the Pelletizing Process with the VSM approach to reduce the time of 64.69 minutes.

This research applied the VSM approach to the workflow of several sub-processes of the WS-4 Pellet Process. Sub-processes that have less added value are sub-cutting with 64.69 minutes and 64.00 to produce 400 kg. By replacing the layer with a new one every 4 hours, reduce the time by 64.69 minutes to 62 minutes in the sub-cutting process. Meanwhile, in the drying sub-process, improvement comes from the length of the drying process, then it is corrected by increasing the temperature of the vibrator to reduce the bottleneck from 64 minutes to 62 minutes.

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