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Integrated Modelling of In-Bag Fertilizer Handling Process and Forklift Needs to Reduce Waste in Sales Warehouses of PT Petrokimia Gresik

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***Abstract*— PT. Petrokimia Gresik is one of the most outstanding fertilizer manufacturers with 5 sales warehouses. The Company organizes its distribution system to ensure adequate distribution to the right target. To plan the process of handling in-bag fertilizer, resources such as contract workers, forklifts, and trucks are needed. However, there are numerous wastes associated with the handling process, which is shown by forklift idle time due to the bagging, handling, and loading processes. Therefore, this research identifies the waste that occurs using the Value Stream Mapping (VSM) method with the 5 why's tool. This research also uses simulation to analyze and validate the recommendations. Data obtained through questionnaires showed that waste occurs due to waiting time by 28.2% and unnecessary motion by 22.7%. The described Process Activity Mapping (PAM) tools show that fertilizer delivery has cycle times of 9030 seconds, with value-added activities of 66%. The analysis of 5 why's tools shows that the low handling speed causes waste at the bagging and loading processes and the unnecessary motion of forklift-3. The recommendations according to the future state Value Stream Mapping (VSM) are adding the contract worker in the bagging process, removing forklift-3, and adding the contract worker in the loading process. Therefore, the value-added activity increases to 75.8% and accelerates the delivery cycle time to 7733 seconds. The validation results using the simulation shows that forklift-3 can be eliminated because it has a low utilization value of 16.4%, merging the activity of sewing services of 3% with a decrease in transfer time from 7.9 hours to 2.9 hours for one delivery cycle. In conclusion, the removal of all forklift-3 in 5 sales warehouse results shows that the company can save rental costs by Rp.4,772,376,000/year.**

***Keywords*—waste, value stream, 5 why's, simulation, utilization.**

I. INTRODUCTION

PT PETROKIMIA GRESIK is one of the outstanding fertilizer manufacturers in Indonesia due to its ability to produce various types of fertilizers and chemicals. It is a holding company located on a landmass of more than 450 Ha at Gresik Regency and managed by PT Pupuk Indonesia (Persero) [1]. This company consists of 27 production units, water treatment plant, port facilities, warehousing, research & development, consulting services, engineering, and fabrication department. At PT Petrokimia Gresik, fertilizer needs to be maintained with timely distribution to avoid scarcity. Therefore, the company's Sales Warehouse's good distribution strategies needed to be maintained to send the fertilizers to the right channels. PT Petrokimia Gresik has 5 sales warehouses near the production unit with forklifts and contract workers assigned to the fertilizer loading process. However, there is waste in the fertilizer handling process associated with forklift idle time during each process in the Sales Warehouses. Therefore, all resources need to be serviced by third parties to optimize the time, cost, and quality of each lean process to eliminate errors [2][3].

Value stream mapping (VSM) is one of the extremely powerful lean tools used to combine various material processing steps with information flow and other important related data [4]. This means that by creating a stream mapping system, the activity of adding values that helps in identifying the waste production process is determined. One of the methods used to determine the root cause of the problem is using the 5-Whys approach [5]. This study utilized the discrete event simulation method to validate the recommended process of handling the in-bag fertilizers in 5 sales warehouses. The simulation method was emulated from a real system to observe the characteristics of real systems, carry out evaluations and comparisons with a recommendation system [6]. It also helps in reviewing the calculation of rental prices to provide some discounts. The use of appropriate resources to minimize the waiting time of trucks is the Key Performance Indicator of this research.

II. METHOD

Primary and secondary data were obtained through discussions and interviews with experts on the bagging, handling, and loading processes at the sales warehouse [7]. The various steps in this study are shown in Figure 1.

III. RESULT AND DISCUSSION

Based on the data processing on interviews carried out on experts, waste in Sales Warehouses occurred in the bagging, handling, and loading processes. The current state Value Stream Mapping (VSM) is arranged as shown in Figure 2, with the cycle time of delivering the fertilizer obtained from the bagging to the loading processes at 9030 seconds with 7130 seconds value-added activity. Table 1 shows the waste identification process, which is calculated to get a 28.2%

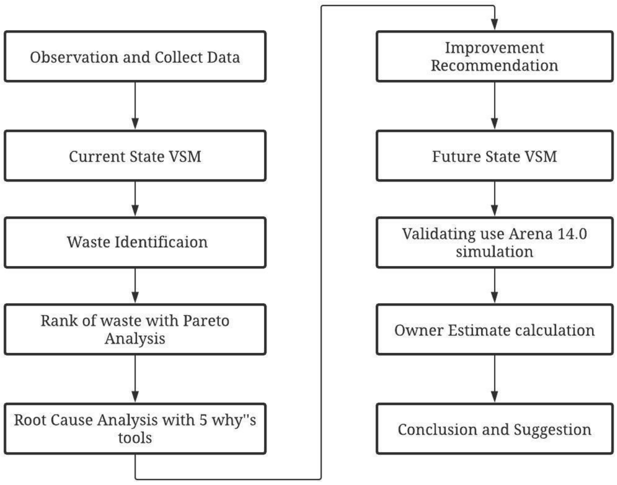

Figure 1. Research Methodology Scheme.

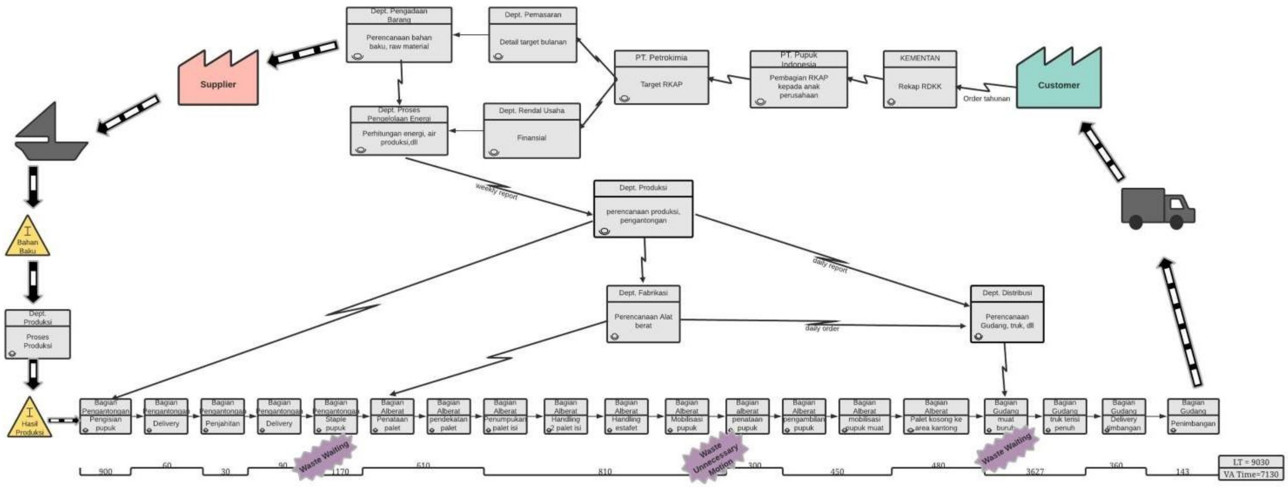

Figure 2. Current State Value Stream Mapping.

Table 1.
Waste Identification

No	Location	Type of Waste	Activity	Type of activity
1	Bagging Process	Waiting	Waiting for in-bag fertilizer (batch) in the pallet	Non-value-added
2	Handling Process	Unnecessary Motion	The low workload of forklift-3 due to the staple and stack fertilizer on the pallet	Non Value Added
3	Loading Process	Waiting	Waiting for the truck to load the fertilizer	Value Added

waste waiting time, 22.7% unnecessary motion based on the VALSAT matrix. The Process Activity Mapping (PAM) tool is suitable for analyzing this waste [8].

After identifying the time wasted in the sales warehouse, the 5 why's tools were used to analyze the root cause for recommendation and improvement, as shown in Table 2 [9].

After implementing the recommended strategy, the changes that occur can reduce the cycling time of fertilizer delivery from 9030 seconds to 7733 seconds. Merging the forklift-3 and forklift-2 tends to decrease the non-value-added activity while increasing the value-added and parallel activities. Figure 3 compares the results after implementing the enhancement method.

Figure 4 shows the future Value Stream Mapping (VSM) after comparing the overall activity [10]. The next step is validating this recommendation using discrete event simulation. Three recommendations based on future state Value Stream Mapping (VSM) were used for validation with simulation method. Therefore, the best choice is comprised of another alternative used to carry out the activities [11]. First, a conceptual model flow needs to be drawn to guide the process into the software. Secondly, the time between arrival data for each process needs to be adequately distributed using the Process Activity Mapping (PAM) [12]. The time distribution is shown in Table 3.

By implementing the time distribution strategy to the flow and bagging processes using simulation [13], the entity arrival of the bin hopper machine value obtained is 1.93e+004 + ANINT(1.3e+004 * BETA(1.45, 0.774)). This conceptual model creates the existing condition with resources [5] such as 4 labor in 1 bagging machine, 4 forklifts to handling fertilizer, and 2 labor for the loading process. With this existing condition, the resource utilization value and waiting time have no error while running [14], followed by the recommendation model by adding 2 labor in the bagging process, after removing the forklift-3 during the

Table 2.
Root Cause and Recommendation

No.	Waste	Root Cause Analysis	Recommendation
1	Waiting to transfer the in-bag fertilizer (batch) into the pallets through labor	Limited Labor	Adding labor to minimize the queue during the bagging process
2	The low workload of forklift-3 because it staples and stacks the fertilizer on the pallet	Low Activity	Merge activity to another forklift
3	Waiting for the loading fertilizer to fill the truck through labor	Limited labor	Adding the labor to minimize the queue during the loading process

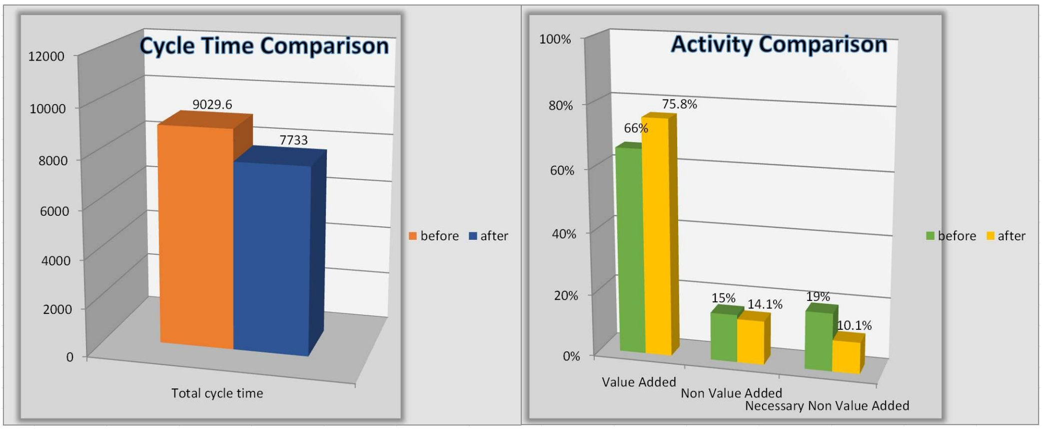

Figure 3. Comparison before and after improvement.

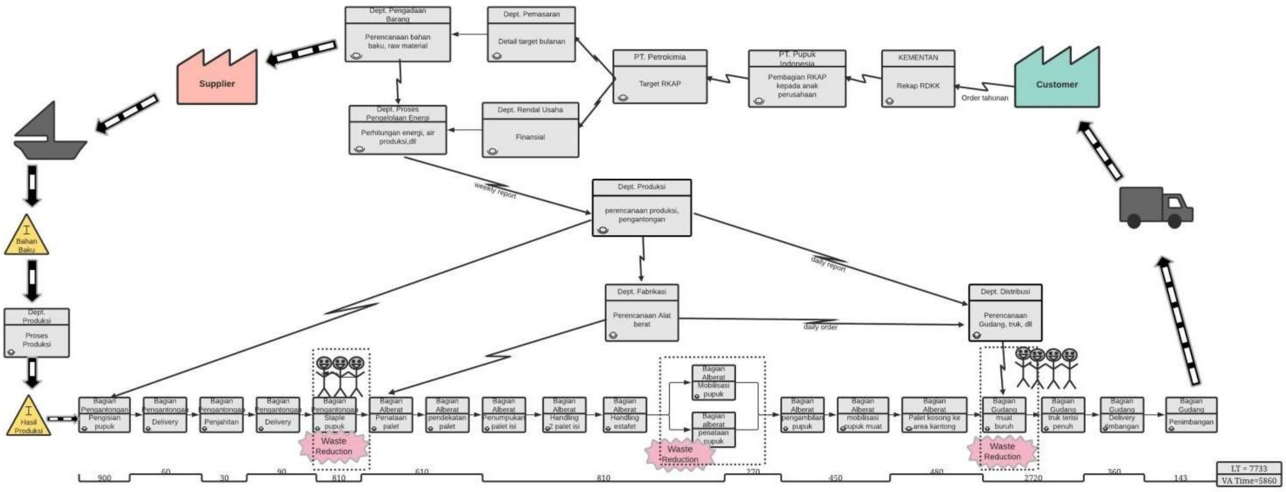

Figure 4. Future State Value Stream Mapping.

loading process based on the future Value Stream Mapping (VSM).

After simulating the model, it was validated with 16 replications with the results of the t-test with P-value above 0.5 [15]. The comparison result of Key Performance Indicator (resource utilization and waiting time for truck) is shown in Table 4 and Table 5. To develop scenario 2, the adding labor was analyzed at the bagging & loading process due to the low use of sewing labor in the existing model. Therefore, the loading labor was merged in scenario 2 for optimal results.

Although Scenario 2 has longer waiting time than scenario 1, the recommendation is to implement scenario 2. One of the reason is that there is no labor added to this scenario, it just merge the activity at sewing process to packaging process because the labor has low utilization.

The advantage of choosing the scenario 2 is due to the numerous waiting times in the scenario 1. Furthermore, no additional labor was added to this scenario because the activities were merged from the sewing to the packaging process due to its low utilization and ability to accommodate the output loading processes.

IV. CONCLUSION

The research conclusions are as follows:

1. The value stream mapping (VSM) tools, the waste waiting, and unnecessary motion time were determined.
2. The 5 why's tools were used to determine the waste caused by limited labor and low forklift workload.
3. Through the simulation, forklift-3 was eliminated and its activity is merged with forklift-2 for its continuous use in sales warehouses.
4. The simulation process also merged the activity of sewing services with the fertilizer labor packaging process. Therefore, the labor in the sewing process was combined with loading activity at the output area.

Table 3.
Time Distribution of Various Activites

No	Activity	Distribution	Square Error
1	Fill In Fertilizer Bag	TRIA(89, 90, 91.3)	0.045246
2	Delivery to shewing machine by the conveyor	60 second	
3	Shew the Bag	(NORM(31.8, 3.47))	0.024599
4	Deliver to stapling labor	90 second	-
5	Stapling by labor to pallet	(2.33e+003 + 21 * BETA(0.336, 0.587))	0.119736
6	Setup and stack the empty pallet	25.5 + (21 * BETA(0.417, 0.709))	0.096721
7	Setup 4 empty pallet to take the fertilizer's bag	TRIA(34, 35, 36.2)	0.271972
8	Fully stack the first and second pallets with fertilizer	16 + (WEIB(8.8, 4.7))	0.426809
9	Transfer from bagging to the docking area	21 + (11 * BETA(0.349, 0.404))	0.032468
10	Take the second pallet from the docking to staple area	17.2 + (14 * BETA(1.3, 1.1))	0.200952
11	Mobilize the staple area	TRIA(23.5, 24, 24.6)	0.209303
12	Stack the staple area	29 + (ERLA(2.56, 4))	0.309982
13	Take the second pallet to the staple area	TRIA(17.5, 18, 18.6)	0.248357
14	Handle the second pallet to the loading area	26 + (9 * BETA(0.159, 0.329))	0.025445
15	Delivery the second pallet empty to the bagging area	2.6 + (469 * BETA(1.02, 0.0563))	0.015295
16	Load the fertilizer until it fills the truck	340 second	-
17	Truck to weighbridge	345 + 17 * BETA(1.09, 0.785)	0.170673
18	Weigh the Process	142 + LOGN(6.23, 5.96)	0.216447

Table 4.
Resource Utilization

No	Resource	existing	Scenario 1 (VSM)	Scenario 2
1	Forklift S1	48.50%	48.30%	47.50%
2	Forklift S2	36.10%	51.50%	50.70%
3	Forklift S3	16.40%	0.00%	0.00%
4	Forklift S4	55.00%	54.70%	57.50%
5	Loading Labor 1	81.50%	40.50%	42.60%
6	Loading Labor 2	81.50%	40.50%	42.60%
7	Loading Labor 3	0.00%	40.50%	42.60%
8	Loading Labor 4	0.00%	40.50%	42.60%
9	Staple Labor 1	63.90%	41.80%	62.50%
10	Staple Labor 2	63.90%	41.80%	62.50%
11	Staple Labor 3	63.90%	41.80%	62.50%
12	Staple Labor 4	63.90%	41.80%	62.50%
13	Staple Labor 5	0.00%	41.80%	0.00%
14	Staple Labor 6	0.00%	41.80%	0.00%
15	Fill in Labor 1	49.20%	48.30%	49.90%
16	Fill in Labor 2	49.20%	48.30%	49.90%
17	Sewing Labor 1	3.50%	3.40%	0.00%
18	Sewing Labor 2	3.50%	3.40%	0.00%

Table 5.
Waiting Time of Truck

KPI	Existing	Scenario 1 (VSM)	Scenario 2
Waiting Time	7.14 hour	2.18 hour	2.9 hour

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REFERENCES

[1]. A. Kadir, "Transportation: Role and its Effects in National Economic Growth," Jurnal Perencanaan & Pembangunan Wilayah, Vol. 1, No. 3, pp. 120-131, 2006.

[2]. J. Jokar Arsanjani, A. Zipf, P. Mooney, and M. Helbich, "An Introduction to OpenStreetMap in Geographic Information Science: Experiences, Research, and Applications," in OpenStreetMap in GIScience: Experiences, Research, and Applications, J. Jokar Arsanjani, A. Zipf, P. Mooney, and M. Helbich, Eds. Cham: Springer International Publishing, 2015, pp. 1–15.

[3]. D. J. Bowersox, D. J. Closs, and M. B. Cooper, Supply Chain Logistics Management, 4th ed. New York: McGraw-Hill, 2013.

[4]. M. W. Dobson, "VGI as a Compilation Tool for Navigation Map Databases," in Crowdsourcing Geographic Knowledge, Dordrecht: Springer Netherlands, 2013, pp. 307–327.

[5]. C.-L. Huang, M.-C. Chen, and C.-J. Wang, "Credit Scoring with a Data Mining Approach based on Support Vector Machines," Expert Syst. Appl., vol. 33, no. 4, pp. 847–856, Nov. 2007.

[6]. Yuli Dwi A., Puryani, and Vertha Fuji Rizky, "Material Handling Efficiency (Forklift) for Minimizing Cost by using Simulation" , Jurnal Teknik Industri dan Informasi, Vol. 5, No. 1, pp. 1–14, Apr. 2016.

[7]. Alfa Yohan.W.E, "Production Process Improvement with Lean Manufacturing Approach in Sugar Factory", Thesis, Institut Teknologi Sepuluh Nopember Surabaya, 2015.

[8]. Vivy Brillian P, "Lean Thinking Implementation for Waste Reduction in Sugar Production Process in PT PG Rajawali Krebet Baru", Thesis, Institut Sepuluh Nopember Surabaya, 2018.

[9]. M. Cardos, E. Babiloni, M. E. Palmer, and J. M. Albarracin, "Effects on Undershoots and Lost Sales on the Cycle Service Level for Periodic and Continuous Review Policies," in 2009 International Conference on Computers & Industrial Engineering, 2009, pp. 819–824.

[10]. D. J. Bowersox, D. J. Closs, and M. B. Cooper, Supply Chain Logistics Management, 4th ed. New York: McGraw-Hill, 2013.

[11]. J. Olhager and D. I. Prajogo, "The Impact of Manufacturing and Supply Chain Improvement Initiatives: A Survey Comparing Make-to-order and Make-to-stock Firms," Omega, vol. 40, no. 2, pp. 159–165, Apr. 2012.

[12]. J. Han and M. Kamber, Data Mining: Concepts and Techniques, 3rd ed. Burlington, MA: Elsevier, 2011.

[13]. Astri Kurnia, “Simulation of Loading System Process Improvement by Considering Investment Cost”, Thesis, Institut Teknologi Sepuluh Nopember Surabaya, 2015.
[14]. L. Palen, R. Soden, T. J. Anderson, and M. Barrenechea, “Success & Scale in a Data-Producing Organization,” in Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI ’15, 2015, pp. 4113–4122.
[15]. Al Fattah, “Changing Workload Analysis based on Value Added, Non-Value Added, and Necessary Added for Overhaul Activities and Their Impacts on Quality, Cost and Time Aspects,” Thesis, Institut Teknologi Sepuluh Nopember, 2018