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Implementation of Lean Manufacturing in the Rubber Industry to Support Sustainable Manufacturing by usung Value Stream Mapping Tools

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Abstract:- PT. XYZ processes rubber raw materials from suppliers in the form of slabs to be processed into semi-finished rubber (crumb rubber) to meet customer needs. In its activities there are jobs that do not have added value (non-value added) which can cause inefficiency due to waste. Currently, at the warehouse for receiving raw materials, truck weighing officers have to wait because of the uncertainty of the number of suppliers who come every day, as well as the waiting time for packaging. The purpose of this study is to identify the waste that occurs with the value stream mapping method. Based on the Waste Relationship Matrix, the most dominant waste is in waiting and transportation with a weight of 16% each. In the process cycle efficiency of 63.87%, it means that the process that occurs is still wasteful which does not add value to the customer. From the observations, there are 6 types of waste that occur, namely waiting, transportation, unnecessary motion, overprocessing, inventory, and defects. Several steps that can be taken to minimize waste include strengthening external cooperation, making schedules, and determining weekly delivery targets by suppliers; Addition or change of means of transportation as well as the addition of the number of machine operators; Scheduling product delivery to consumers; Production scheduling according to the number of consumer requests; Stricter sorting of raw material purchases; as well as regular checks on production machines, especially rusty machines.

Keywords:- *Component; Minimalize; Non Valur Added; Value Stream Mapping; Waste.*

I. INTRODUCTION

In the plantation industry sector, Indonesia is the second largest natural rubber producer in the world. South Sumatra is the largest rubber producer in Indonesia with dry rubber production of 0.93 tons (Central Statistics Agency, 2019), indicating that South Sumatra's potential for processing the rubber industry is very large. PT. Z was processes rubber raw materials from farmers in various regions in South Sumatra in the form of slabs into semi-finished rubber (crumb rubber) which is then exported to partner companies. Production is divided into two parts: Production I was processes raw materials into blankets, and Production II processes blankets into crumb rubber. The production process is an important part of the planned output to be produced. In its activities, there are jobs that have added value (value added) and those that do not have added value (non-value added). According to Gaspersz (2012), to create an effective and efficient production process, manufacturing companies have activities that have value added and are not value added or waste. Waste will result in higher use of energy resources, human resources, and time, so the production process becomes inefficient (Hanum et al. 2020) (Pratiwi, Djanggu, and Anggela 2020). Some of the problems that arise during the production process are in the warehouse for receiving raw materials. The truck weighing officers have to wait because they do not know for sure how many bokar supplier cars come every day carrying raw materials from suppliers, and there is no fixed schedule from suppliers. Furthermore, in the process of packaging bale crumb rubber, there is waiting or waiting time due to the lack of operators on the press machine even though there are enough tools available. This study will identify in more detail value added and non value added activities, so that improvements can be made to minimize waste.

II. LITERATURE REVIEW

A. Lean Manufacturing

According to Soekartawi (2010: 220) the notion of work efficiency is an effort to use the smallest input to get the maximum production (SYAM 2020). Lean manufacturing (LM) gives manufacturers a competitive edge by reducing cost and improving productivity and quality (Hartini, Ciptomulyono, and Anityasari 2019). Lean Manufacturing is a philosophy of continuous improvement to eliminate waste (Mohan Prasad et al. 2020). Lean concept is basically a concept of downsizing or efficiency. This concept can also be applied to manufacturing or service companies. The concept of lean thinking was introduced by Toyota's production system in Japan. Lean is run by Taichi Ohno and Sensei Shigeo Shingo where the implementation of this concept is based on 5 main principles, including specify value, which is to determine the value of a product from the consumer's point of view, not from the company's point of view, identify the whole value stream, which is to identify the necessary stages, starting from the process of designing, ordering, and manufacturing products based on the entire value stream to find waste that has no added value (non value adding waste), flow, which is doing activities that create value without interruption, rework process, backflow, waiting activities or the rest of the production, pulled, namely knowing the important activities used to make what consumers want, perfection, which is trying to achieve perfection by eliminating waste (waste) gradually and continuously (M. Wahyu Syawalluddin 2018). This approach

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is oriented towards reducing and eliminating waste that occurs in the production process with the aim that the production system runs effectively and efficiently (Hazmi, Dana, and Supriyanto 2012). Lean manufacturing tools do not consider environmental and societal benefits (Hartini et al. 2018a).

B. Seven Waste

In an effort to eliminate waste, the company must know in advance what types of waste are usually found on the production floor. According to (Gaspersz and Vincent, 2011) in general there are 7 types of waste or commonly referred to as "Seven plus One Type of Waste" found on the production floor, namely (Pratiwi, Djanggu, and Anggela 2020):

1. Overproduction is a type of waste that usually occurs because of the production of a product that exceeds customer demand or produces the product earlier than the schedule that has been made by the company.
2. Waiting Time (Delay) is a type of waste that usually occurs due to the operator's idle time to wait for the product flow from the previous process or waiting to carry out the next process.
3. Transportation is a type of waste associated with an activity or movement around the production floor both material and product movement.
4. Process is a type of waste caused by the existence of a production process that is not in accordance with the procedures that have been made by the company.
5. Motion is a type of waste caused by unnecessary movements and also does not add value to a product or process so that it can extend lead time.
6. Inventory is a type of waste caused by the amount of inventory that is not really needed.
7. Defect is the definition of a product that is defective or does not meet specifications.

C. Value Stream Mapping (VSM)

Value Stream Mapping is a tool that is used as an initial step in the change process to obtain lean manufacturing conditions (DZIKRI ARIJ FIRDAUS 2018). The purpose of VSM is to identify the production process so that materials and information can run without interruption, increase productivity, and assist in implementing the system. Therefore, VSM helps in finding waste in the production process. VSM is a lean method that can reach the process flow with a three-step method, namely describing a current state map that maps the actual flow of information and materials that occur in the process, identifying the root causes of problems that hinder the improvement process, determining what process improvements can be made. carried out in the process flow, and determine plans for implementing improvements into the company's production processes. VSM is created using certain symbols to describe the flow of waiting, storage, decision making, queuing and inspection processes. Value stream mapping consists of a current state map in the form of product value stream configurations using specific icons and terminology to identify waste and areas for improvement or improvement, indicating all important information related to product value streams such as cycle time, inventory levels, lead times and others. which will help to make real improvements (FERNANDO AND NOYA 2014).

D. Waste Relationship Matrix (WRM)

This WRM was adopted from the framework developed by Rawabdeh (2005). WRM is used as an analysis of the criteria for measuring the relationship between waste that occurs. WRM is a matrix that is used to analyze the measurement criteria. WRM is a matrix consisting of rows and columns. Each line shows the effect of a particular waste on the other six wastes. While each column shows the waste that is influenced by other wastes.

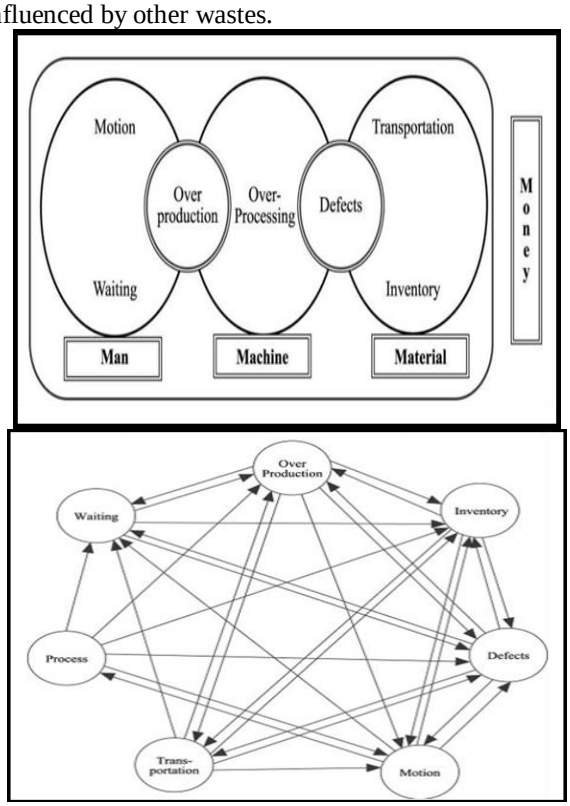

Fig 1. Relationship of the Seven Wastes (Sadiq et al. 2021)

Based on its application in the industrial sector, the expansion of VSM is applied to the automotive industry, followed by the agricultural food industry, the furniture industry, and electronics. Meanwhile, VSM for the processing industry has never been implemented (Hartini et al. 2018b).

III. RESEARCH METHODS

The research steps were carried out through field observations, identifying problems, direct observations on the production floor based on theory seven. The purpose of this research is to identify and minimize waste in the rubber processing production process and to provide suggestions for improving the production process to the company. Data processing starts from waste identification, current value stream mapping, and calculation of waste relationship matrix. The conclusion is made based on the results of data processing and analysis that has been done as well as suggestions for companies and further research.

IV. RESULT AND DISCUSSION

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PT. XYZ processes rubber raw materials from farmers in various regions in South Sumatra in the form of slabs into semi-finished rubber (crumb rubber) which is then exported to partner companies. Production at this PT has two parts, namely production I processing raw materials into blankets, and production II processing blankets into crumb rubber. The production process can be seen in Fig 2.

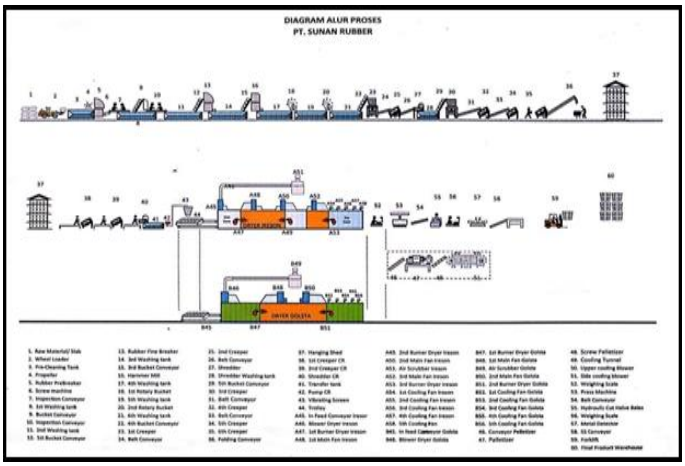

Fig 2. Production Process Flowchart of PT. XYZ Palembang

The process of receiving raw materials is the initial process of crumb rubber production activities. At the receipt of raw materials, workers wait for the suppliers' cars to arrive, with an average of 40-50 cars per day. The raw material received is in the form of rubber slab. In this factory, the raw material scales still use manual scales, totaling 3 scales. Raw materials are received and then placed in the raw material storage area. After that, the initial cleaning and counting process was carried out. The bokar rubber is chopped and cleaned so that it becomes a wet rubber sheet (blanket), then dried by hanging in the air. In production II, the blanket is dry, then crushed to make it smooth and uniform, then washed, and re-drying at a certain time and temperature. Crumb rubber that has been cooked and dried from the trolley to be taken to the weighing machine. The initial weighing process with a weight of 35 kg each, followed by the process of pressing the rubber bales that have been weighed. Then it is carried out with a final inspection according to SN I 06-1903-2000, if there is still dirt then it is immediately taken and separated.

Respondents who will fill out this questionnaire are experts who know the state of production at the PT. XYZ, there are 6 respondents who filled out the WRM questionnaire. This questionnaire serves to identify waste. So that in total there are 186 question items. The questionnaire answer score scale is in the range of 0 to 4. Furthermore, the results of the questionnaire will get a score for each waste relationship. The scores are added up to get the total value of each relationship, then the total value is converted into symbols A, I, U, E, O, X as shown in table 1.

F/T	*Waste*						
	O	I	D	M	T	P	W
O		15	14	12	12	0	13
I	12		11	13	16	0	0
D	11	15		10	10	0	10
M	0	12	10		0	12	10
T	13	13	15	16		0	13
P	13	9	11	11	0		11
W	17	18	18	0	13	0	

Table 1. Skor *Waste Relationship Matrix*

Current state value stream mapping is used to find out an overview of all activities that have added value or not. As the curent state VSM of Crumb Rubber SIR PT. XYZ can be seen in Fig 3.

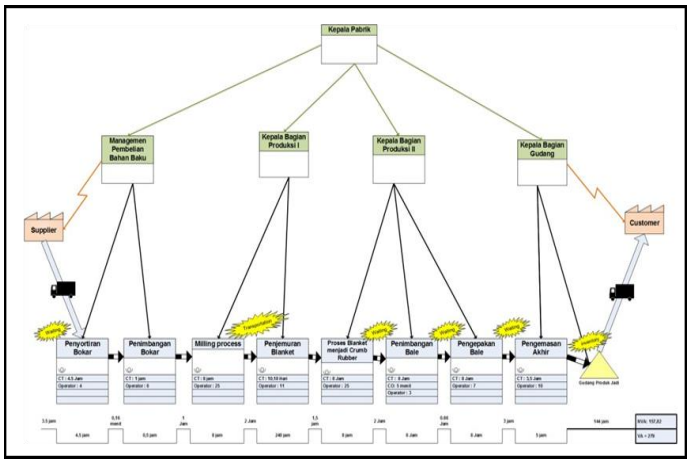

Fig 3. Flowchart of the Production Process of PT. XYZ Palembang

Based on Fig 3 the current state of VSM shows that the value added time owned by PT. XYZ is 157 hours and Non Value Added time is 279 hours, so we get:

$$Process\ Efficiency\ Circle = \frac{279}{436{,}82} x100\%$$
$$= 63{,}87\%$$

From the table, the influence level score of each type of waste is calculated using the conversion values A: 10, E: 8, I: 6, O: 4, U: 2, and X: 0 (Mughni, 2012) whose calculation results are can be seen in the following table.

F/T	O	I	D	M	T	P	W	*Score*	%
O	10	8	8	6	6	0	8	46	15
I	6	10	6	8	8	0	0	38	13
D	6	8	10	6	6	0	6	42	14
M	0	6	6	10	0	6	6	34	11
T	8	8	8	8	10	0	6	48	16
P	8	6	6	6	0	10	6	42	14
W	10	10	10	0	8	0	10	48	16
Score	48	56	54	44	38	16	42	298	100
%	16	19	18	15	13	5	14	100	

Table 2. Waste Matrix Value
Source: Data processed, 2022

From table 5, it is known that waiting and transportation are two types of waste with the most significant proportion in

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the overall value stream in the production process at PT. XYZ, where the percentage value of waiting is 16% and transportation is 16%.

From the results of the research that has been carried out, it is found that there are several causes of waste that occur, namely:

1. Waste waiting

The causes of waste waiting are as follows:

a. The truck weighing officers have to wait because of the uncertainty of the number of bokar supply cars that come per day because there is no fixed schedule.
b. In the bale weighing process, waiting occurs due to the lack of operators on the press machine so that the factory does not take full advantage of the existing facilities.
c. Waiting also occurs in the final packing. This is due to the packed bale crumb rubber piling up on the final packing roller, because there is only one forklift used in the final packing and only one operator.

The recommended steps from this research are to minimize the occurrence of waste waiting at PT. XYZ is:

1. The need to develop extensive cooperation with farmer groups and rubber planters in order to be able to send a large supply of bokar directly to factory warehouses or branch warehouses according to the region so that the selling price is more suitable than being sold to other bokar collectors and the delivery time is relatively longer short so as to prevent waste waiting in the bokar warehouse and milling process.
2. The need for scheduling and determining the target for delivery of bokar every week carried out by each supplier who has collaborated so that there is no waste waiting for car weighing officers and to prevent shortages of raw materials in the bokar warehouse.
3. To minimize waste waiting in the pressing process, the employees are expected to make maximum use of the existing press machine. And also the need for additional forklift operators in the final packing section so that there is no buildup of bale on the final packing rolls and there is no waste waiting in the process.

2. Causes of Waste Transportation

The causes of transportation waste in the crumb rubber production process at PT. XYZ Palembang as follows:

a. The first transportation waste occurs in the transfer of bokar from the sorting place to the bokar storage warehouse, because the distance is quite far, which is about 30 meters, the equipment and wheel loader operators are limited. This makes transportation time and is a Non Value Added (NVA) activity.
b. To minimize waste in this section, it is necessary to add a tool to transport bokar to the raw material storage warehouse with a larger transport capacity so that transportation waste can be reduced.
c. In the process of transferring blankets to the blanket drying room, there is transportation waste in the form of the length of time it takes to transfer blankets because there are several factors such as the limitation of the elevator which only has one lift, causing the transportation process to accumulate on the transfer rail and make the transportation time longer. In addition, another factor that causes waste is the lack of labor in the drying room to take blankets that have been transferred from the milling process. Then the transportation waste is also caused by the distance between the blanket taking place to the drying room which is around 80 meters away, so this makes transportation time more time consuming. So to minimize waste in this process, it is necessary to add more workers in the blanket transportation section to the drying room or replace the equipment to transport the bokar to the raw material storage warehouse with a larger transport capacity such as a forklift, so that the blanket transportation process is more efficient.

3. Causes of Waste Overprocessing

There is an excessive process at PT. XYZ Palembang when checking the metal detector in the packaging process, the initial check is carried out when the bale has been packed and then checked again with the metal detector when the bale has packed the bale with a box in the final storage warehouse. As for minimizing waste in the process, it is necessary to change the work method in checking metal detectors so that the packaging process is more efficient.

4. Causes of Waste Inventory

Waste inventory is caused by excessive production, causing products to accumulate in storage warehouses, and products also deposit in storage warehouses for approximately 1 week before being sent to consumers. To minimize inventory waste, it is necessary to schedule delivery to consumers and make a production schedule according to the number of consumer requests.

5. Causes of Waste Unnecessary Motion

Motion wastage that occurred at PT. XYZ is at the time of moving the bokar from the weighing station to the bokar storage warehouse. This movement is done repeatedly because of the limited carrying capacity of the wheel loader to carry the bokar into the warehouse and the distance it has to travel. Then the wastage of motion also occurred during the transfer of blankets to the drying room, this movement was carried out repeatedly due to the limited capacity of the trolley to transport blankets to the drying room and the distance it had to travel. So it is necessary to add a tool to transport bokar to the raw material storage warehouse with a larger carrying capacity so that unnecessary motion waste is reduced. Then to minimize waste in this process, it is necessary to add more workers in the blanket transportation section to the drying room or replace the equipment to transport blankets to the drying room with a larger carrying capacity such as a forklift, so that the blanket transfer process is more efficient.

6. Causes of Waste Defect

Waste of defects (defective products) at PT. XYZ is rare during production. However, based on historical data from the company, there are several product defects as follows:

Month (kg)	**Prod**	***White Spot***	***Metal Cont***	***Grand Total***	**NC (%)**	***Control Limit (%)***

January	2679320	2590	9590	12180	0.45	1.00
Febuary	2462390	2345	11550	13895	0.56	1.00
March	2722580	105	10815	10920	0.40	1.00
April	2554160		16275	16275	0.64	1.00
Mei	2023980		9730	9730	0.48	1.00
June	2595600		10850	10850	0.42	1.00
July	2266740		9380	9380	0.41	1.00
August	2276260		9345	9345	0.41	1.00
September	2257920		9135	9135	0.40	1.00
October	1925280	175	7105	7280	0.38	1.00
Grand Total	23764230	5215	103775	103775	0,46	1.00

Table 3. Defective Products PT. XYZ, 2021
Source: Data processing, 2022

From the table data and statistics above, it can be seen that defective products are still within control limits with the average NC in January-October 2021 in the range of 0.46% of the total products produced, and does not exceed the maximum limit of 1% in the green industry. It can also be seen that Metal Contamination is the most dominant type of damage with a percentage of 95% and other types of defects, namely white spots with a percentage of 5% of the number of defective products in the January-October period.

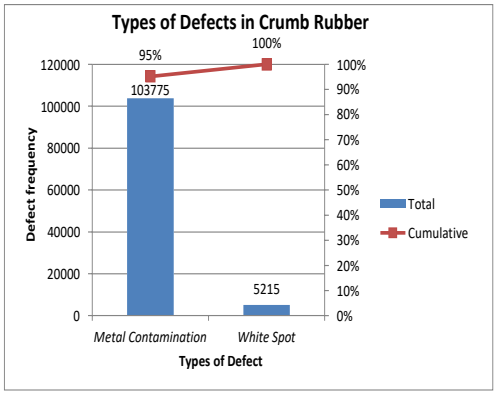

Fig 4. Pareto Diagram Number of Crumb Rubber Product Defects

As for reducing and minimizing waste defect, it is necessary to conduct a stricter sorting of the purchase of raw materials from suppliers with the provisions of the standard raw materials set, then it is necessary to carry out routine checks on machines that have started to rust so that defects, especially on the type of metal contamination can be reduce.

V. CONCLUSION

The conclusions of this study are as follows:

1. There are various types of waste that occur in the production process, including waiting, transportation, unnecessary motion, inventory, and defects. The most dominant waste in the production line at PT. XYZ is waste waiting with a weight of 16% and transportation with a weight of 16%. Based on the data processing that has been carried out, it can be concluded that the percentage of Value Added (VA) is 63.87%, and the percentage of Non Value Added (NVA) is 36.01%, which is still a much larger portion for VA, and obtained in the results VSM is the process cycle efficiency value of 63.87% so that the production process can still be said to be productive and efficient.
2. Waste minimization can be done by strengthening cooperation between PT. XYZ with its suppliers, making schedules and setting targets for delivery of bokar every week by each supplier. Addition or change of means of transportation as well as the addition of the number of machine operators. Scheduling product delivery to consumers, scheduling production according to the number of consumer requests. Tighter sorting of the purchase of raw materials, as well as regular checks on production machines, especially on machines that have started to rust.

REFERENCES

[1]. Dzikri Arij Firdaus. 2018. "IDENTIFIKASI WASTE DENGAN PENDEKATAN VALUE STREAM MAPPING DI BAGIAN SANDING BALIKAN FLOW COATER." *World Development*. Universitas Islam Indonesia. file:///C:/Users/User/Downloads/Skripsi Dzikri Arij Firdaus 13522222.pdf.

[2]. Fernando, Yosua Caesar, and Sunday Noya. 2014. "Optimasi Lini Produksi Dengan Value Stream Mapping Dan Value Stream Analysis Tools." *Jurnal Ilmiah Teknik Industri* 13 (2): 125–33.

[3]. Hanum, Natasya Fadilah, Fakultas Sains, D A N Teknologi, Universitas Islam, Negeri Sultan, and Syarif Kasim. 2020. "Lean Manufacturing Di Ptpn V Sei Galuh."

[4]. Hartini, Sri, Udisubakti Ciptomulyono, and Maria Anityasari. 2019. "Life Cycle - Value Stream Mapping: Evaluating Sustainability Using Lean Manufacturing Tools in the Life Cycle Perspective." *AIP Conference Proceedings* 2114 (June). https://doi.org/10.1063/1.5112428.

[5]. Hartini, Sri, Udisubakti Ciptomulyono, Maria Anityasari, Sriyanto, and Darminto Pudjotomo. 2018a. "Sustainable-Value Stream Mapping to Evaluate Sustainability Performance: Case Study in an Indonesian Furniture Company." *MATEC Web of Conferences* 154: 2017–19. https://doi.org/10.1051/matecconf/201815401055.

[6]. ———. 2018b. "Sustainable-Value Stream Mapping to Evaluate Sustainability Performance: Case Study in an Indonesian Furniture Company." *MATEC Web of Conferences* 154: 1–7. https://doi.org/10.1051/matecconf/201815401055.

[7]. Hazmi, Farah Widyan, Putu Dana, and Hari Supriyanto. 2012. "Penerapan Lean Manufacturing Untuk Mereduksi Waste Di PT ARISU." *Jurnal Teknik Its* 1 (1): F-135-140.

[8]. M. Wahyu Syawalluddin. 2018. "PENDEKATAN LEAN THINKING DENGAN MENGGUNAKAN MENGGGUNAKAN METODE ROOT CAUSE ANALYSIS UNTUK MENGURANGI NON VALUE

ADDED ACTIVITIES." *PASTI* VIII (2): 236–50. https://www.accountingtools.com/articles/2017/5/12/non-value-added-activity.

[9]. Mohan Prasad, M., J.M. Dhiyaneswari, J. Ridzwanul Jamaan, S. Mythreyan, and S.M. Sutharsan. 2020. "A Framework for Lean Manufacturing Implementation in Indian Textile Industry." *Materials Today: Proceedings*, no. xxxx. https://doi.org/10.1016/j.matpr.2020.02.979.

[10]. Pratiwi, Yuni, Noveicalistus H. Djanggu, and Pepy Anggela. 2020. "PENERAPAN LEAN MANUFACTURING UNTUK MEMINIMASI PEMBOROSAN (WASTE) DENGAN MENGGUNAKAN METODE VALUE STREAM MAPPING (VSM) PADA PT . X Yuni Pratiwi." *Jurnal TIN Universitas Tanjungpura* 4 (2): 8–15. https://jurnal.untan.ac.id/index.php/jtinUNTAN/article/view/42196.

[11]. Sadiq, S, M S Amjad, M Z Rafique, S Hussain, U Yasmeen, and M A Khan. 2021. "An Integrated Framework for Lean Manufacturing in Relation with Blue Ocean Manufacturing - A Case Study." *Journal of Cleaner Production* 279. https://doi.org/10.1016/j.jclepro.2020.123790.

[12]. SYAM, SHOFIANA. 2020. "Pengaruh Efektifitas Dan Efisiensi Kerja Terhadap Kinerja Pegawai Pada Kantor Kecamatan Banggae Timur." *Jurnal Ilmu Manajemen Profitability* 4 (2): 128–52. https://doi.org/10.26618/profitability.v4i2.3781.