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MENINGKATKAN PRODUKTIVITAS INDUSTRI GARMEN MELALUI PENDEKATAN MODIFIED VALUE STREAM MAPPING

ENHANCE PRODUCTIVITY IN THE GARMENT INDUSTRY THROUGH A MODIFIED VALUE STREAM MAPPING APPROACH

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ABSTRACT
The objective of this study is to overcome problems that occur in the garment industry, the company has tried to develop an agile system to increase productivity in this industry. The garment company that focusses on the production of woven bottoms and outerwear, noted that women's woven bottoms products have the highest demand throughout 2022. However, the company was unable to meet Brand demand of 3.5%. Production data shows defects in products, low quality raw materials, and unstable production processes. A modified Value Stream Mapping (VSM) methodology is use to consider all aspects of production. The results of traditional VSM and Value Stream Analysis Tools (VALSAT) analysis include current state and future state, identification of value added and non-value-added elements during the production process, as well as setting priorities to reduce waste in the production process, especially in inventory (19%), defective parts (17%), and transportation (15%). Based on the VALSAT matrix, Process Activity Mapping (33.5%), Supply Chain Response Matrix (21.6%), and Demand Amplification Mapping (15.3%) were obtained. The findings of this research are Pilot Run, which succeeded in becoming an agile and reliable system during the production process. Through the application of the methodology combined with VSM the results have improved compared to the traditional VSM method. This proves that this method is effective in overcoming takt time, cycle time, man power, and value-added ratio. Limitations of this research were also discussed, including that this research only focused on women's woven bottom products only on the production workflow.
***Keywords**: Agile System, Enhance Productivity, Garment Manufacturing, Lean Manufacturing, Value Stream Mapping.*

INTRODUCTION

Industry in Indonesia is developing rapidly after the Covid-19 pandemic, with a focus on meeting domestic and foreign needs. The Ministry of Industry is committed to increasing the productivity of the domestic manufacturing industry with a strategy that includes resources and energy supply. 2020 is an important year for the industry 4.0 sector which emphasizes the internet and innovative technology, as well as creating new business models to increase quality, quantity and competitiveness in the global market.

The Ministry of Industry pays special attention to the Textile and Textile Products (TPT) industry which is experiencing contraction and a decline in exports due to the declining global economic situation. Efforts are made through programs to increase exports, control imports and increase industrial competitiveness. Collaboration between the Ministry and entrepreneurs is carried out to develop industrial human resources, restructure equipment, and subsidize natural gas prices.

To increase productivity and competitiveness, many companies apply the lean production concept which is rooted in the Toyota Production System (TPS). This concept includes Just in Time (JIT), total production maintenance, cellular manufacturing, and reducing machine setup time to reduce waste.

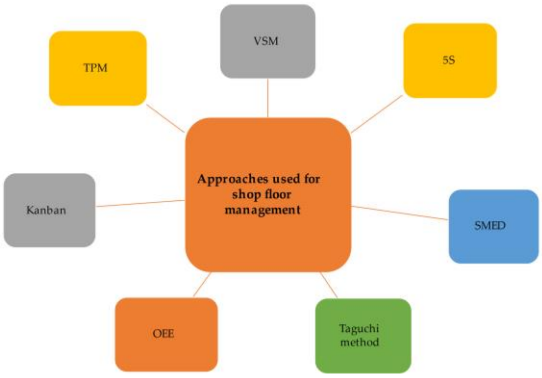

Figure 1. Techniques in Increasing Productivity. (Tripathi et al., 2021)

In **Figure 1** are various techniques that have demonstrated their usefulness in increasing productivity. Value Stream Mapping (VSM) has proven its suitability for more complex production systems. VSM techniques are highly preferred over all other process optimization techniques because other production management techniques can only be applied to eliminate certain types of NVAA (Tripathi et al., 2021), whereas VSM can be implemented to improve any type of production conditions (Byrne et al., 2021). These production conditions indicate the types of problems responsible for lower productivity levels, which can include higher production times, lower quality, excess defective products, higher inventory levels, mismanagement of equipment types, and inefficient labor (Cannas et al., 2018). All these problems can be eliminated simultaneously by using VSM, which is not possible by applying other techniques. VSM is based on lean manufacturing principles, which focus on maximizing production by effectively utilizing available resources (Thomas et al., 2016). VSM also improves production and work planning; therefore, it can reduce production time and focus on maintaining product quality and variety at competitive costs (Seth * & Gupta, 2005).

Industry Level. KPI tree. Smart Production. KPI tree design for lean production systems. Bosch Production System (BPS) execution, holistic approach with CIP Systems. Structure Hierarchy KPI (Ante et al., 2018). Industry Level. KPI tree. Analyze and Planning. A holistic lean production approach to industry 4.0 with targeted analysis must be based on a systematic and methodical planning procedure. Structure Hierarchy KPI (Dillinger et al., 2022). Industry Level. Value Stream Mapping. Productivity, Management System and Waste Recycling. Recycling process with 2 categories, namely with plastic pellets and fuel as the main products, reduction of waste in the process of recycling plastic waste. Several analyzes: categories of plastic waste processing, Value Added Time (PPN) and Non-Value-Added Time (NVAT), as well as processing time per work station. Cause-Effect or Fish bond Method to find root cause analysis (Gustina Amran, 2020). Industry Level. Value Stream Mapping. Productivity, Management System, Waste Recycling, Cost Handling. Implementing Value Stream Mapping that is integrated with the cost approach in the manufacturing industry. Cost Benefit Analysis (Kosasih et al., 2020). Industry Level. Value Stream Mapping. Productivity. On an assembly line heat sink section of a manufacturing unit. Cause-Effect Diagram (Latha et al., 2021). Industry Level. Value Stream Mapping. Management System, Sustainability. Lean manufacturing that focuses on sustainability-oriented applications based on the systematic VMS literature from the triple bottom line point of view. Cause-Effect or Fish bond Method to find root cause analysis (Lee et al., 2021). Industry Level. Value Stream Mapping. Smart Productivity. Manufacturing is located in the UK. The scope of manufacturing is Make to Order; the types of products are repeated. The processes include Mold preparation, mixing, pouring, demolding, assembly, packaging. Cause-Effect or Fish bond Method to find root cause analysis, FMEA (Mudgal et al., 2020). Industry Level. Value Stream Mapping. Logistic in Manufacturing Optimizing the Value Stream on a logistics orientation.

Inconsistencies Data (Muehlbauer et al., 2022). Industry Level. Value Stream Mapping. Data acquisition and processing. Digitizing Value stream mapping on a standardized and measurable basis between data acquisition and processing. Preprocessing Data (Teriete et al., 2022).

Research Objective

The garment industry has the main challenge of increasing productivity and work planning to maintain product quality and variety at competitive costs. In this context, value stream mapping (VSM) is a strategic choice to increase production efficiency. On a production line, each work station has varying cycle times depending on the task, workforce skills, and machine settings. Balancing workloads between these stations is crucial to reduce work in process (WIP) and waiting times, which directly affect production cycle times and costs.

VSM helps visualize Value Added (VA) and Non-Value Added (NVA) times in material and information flows, while takt time ensures the time available for production matches customer demand. With the application of VSM techniques and metrics, including line balancing, multitask operations scanning, and method studies, production and inventory waste can be reduced, which in turn reduces product lead time and WIP inventory while increasing productivity.

This company in the garment industry focuses on the production of Woven Bottoms and Outerwear using a make to order system. Their production process flow includes receiving raw materials, pattern making, cutting, sewing, washing, product finishing, and packaging before storing the finished product in the warehouse. By focusing on value stream mapping, the company aims to increase overall productivity and efficiency in their production processes.

The aim of this research is to create an agile system to maintain increased production in the garment industry through a methodology combined with Value Stream Mapping to increase productivity levels in the garment industry by considering all the facts therein. To achieve the target, initially the values of all production parameters are calculated using traditional methodology. After that, the proposed methodology will be applied for the same output. The robustness and sustainability of the proposed methodology is analyzed based on the improvements obtained by comparing the traditional methodology with the proposed methodology, where the results that will be obtained with the proposed methodology are much better than the results obtained with the traditional methodology or not. **Figure 2** is the framework of the proposed methodology.

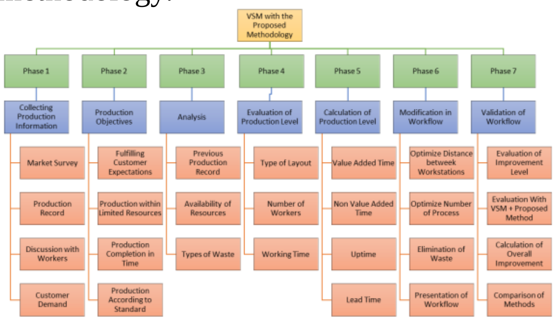

Figure 2. Framework Of The Proposed Methodology

METHOD

Value stream is the series of activities required to produce a product, including information and physical flows. Value stream mapping (Value Stream Mapping) is a tool used to describe the system as a whole and identify the value streams within it. Consists of three main components: Material Flow, Information Flow, and Time Line.

The steps for creating Value Stream Mapping include identifying the production process, detailed explanation in VSM, including the number of operators, using time information to calculate value added time (VA) and non-value-added time (NVA), and creating a time diagram.

Value Stream Mapping helps identify waste in the production process and enables continuous improvement to increase production efficiency. Next, calculate the value-added ratio (VAR), using the following formula:

$$\text{Value Added Ratio} = \frac{\textit{Value added time (process time)}}{\textit{Total process cycle time}} X\ 100\% = \cdots$$

Various parameters are used to analyze production conditions through VSM, which mainly include total cycle time, total uptime, working time, available time, downtime, number of workers, production per day, number of shifts, total change time, total idle time, and non - value added time (NVAT) (Tripathi et al., 2021). Total uptime is measured by calculating the sum of the uptimes of each operation, total idle time is measured by calculating the sum of the cycle times of each operation, and total turnaround. Time has been measured by calculating the amount of change time of each operation. Time has been measured by calculating the amount of WIP time between total idle processes. The modern approach in industry 4.0 transforms traditional production floor management systems into digital management systems. Modern technology currently influences production systems and digital tools, including asset tracking systems, sensors, RFID, and automation (Lugert et al., 2018). Digitalization of production systems with the VSM approach can increase productivity by building a more efficient, sustainable and flexible production system (Lugert et al., 2018). This technology can increase financial profitability by successfully eliminating waste on the production floor. It is critical for shop floor management team members to implement new technologies to maintain higher operational performance within available resources built with advanced tools. Primary production data collected at the beginning consists of important production information collected from the production floor, which is necessary for the next step, namely, drawing a map of the current state of the current methodology.

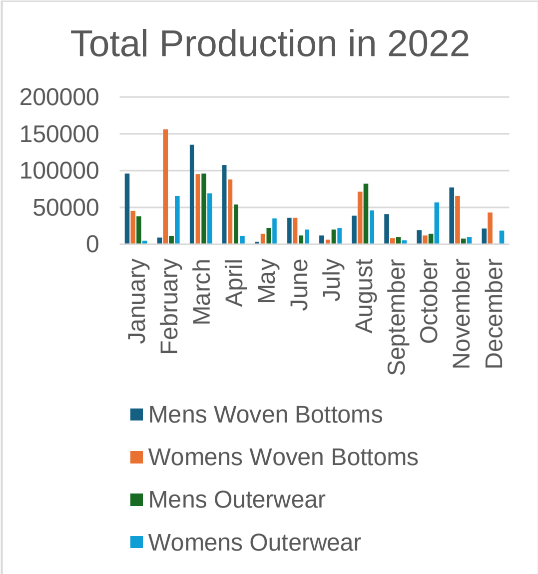

Figure 3. Total Production in 2022

Throughout 2022, The company has succeeded in producing nearly 2 million pcs of garment products, including mens woven bottoms as many as 594,538 pcs, womens woven bottoms of 639,446 pcs, mens outerwear as many as 366,325 pcs, and the last is womens outerwear as many as 361,724 pcs throughout the year. If you add up all these products there are 1,962,033 pcs. In **Figure 3**, it can be concluded that the highest production of womens woven bottoms products was in February, namely 155,940 pcs, then for mens woven bottoms, mens outerwear, and womens outerwear products was in March, namely 135,001 pcs, 96,102 pcs, and respectively. 68,744 pcs. **Figure 3** can also explain that peak productivity in 2022 from this company is in February, March, and April. In these three months, companies must pay more attention to all aspects that can affect production productivity.

In this company, the production system for the womens woven bottoms process adopts the Progressive Bundle System, where each operator is responsible for different garment operations. These systems provide major benefits in improving operator performance as they focus on single or limited operations. Additionally, product consistency can be maintained from one garment to another. The sewing machines required for garment making are placed in a line. The cut material is arranged in bundles. Each operator receives the cut component bundle, opens the bundle, and performs its operations for all parts of the bundle. Once completed, the bundle is moved to the next operator who continues the next operation. Several individuals are involved in the process of sewing one garment. Many export-focused garment manufacturers adopt the progressive bundle system as the main production system. **Figure 4** shows the work flow in this company. The flow starts from the process of receiving orders, then continues with the development sample process, material sourcing. Next is the material order which will then be in-house. At the same time making pattern and grading making, then cutting, sewing and assembling, followed by washing and finishing, and the final flow is the packing process.

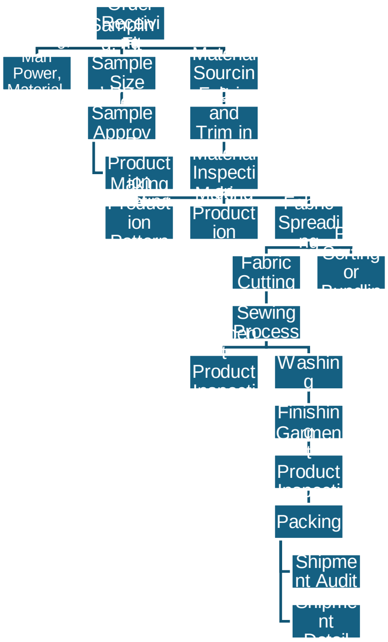

Figure 4. Work flow

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VSM is a visual representation of the company's entire production process and the related elements in it. **Figure 5** is a value stream mapping of current conditions which describes the company's initial situation. In this company, two types of flow have been identified, namely information flow and physical product flow. This information flow is related to interactions between divisions, such as between merchandisers and PPIC, which leads to the communication process. Meanwhile, the physical product flow involves a series of processes in the production of women's woven bottoms products, including procurement of raw materials, then cutting by the cutting division, sewing and assembly, and other stages.

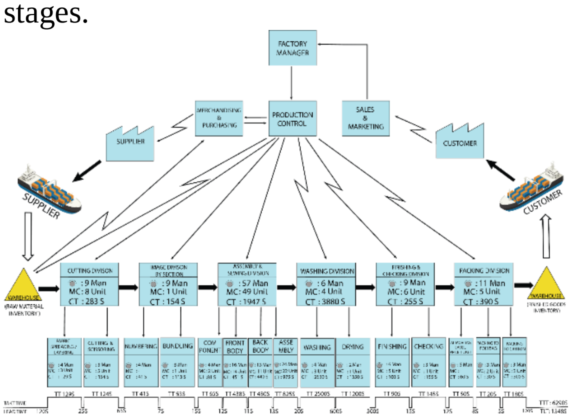

Figure 5. Current State Mapping on Womens Woven Bottoms Products.

n value stream mapping, there are a series of steps which include the process of spreading fabric, cutting with scissors, numbering, grouping, making components, making the front body, making the back body, assembling, finishing and packing. At each stage, there is a number of operators and processing time required, which produces a takt time value which is the average processing time for each stage.

Data collection related to waste is carried out through questionnaires to identify the level of waste in the seven-waste concept. This questionnaire is filled out by experts who have a deep understanding of the situation in the field. The accumulated results from distributing the questionnaire will be summarized in **Table 1** below. The experts involved have filled out a questionnaire containing questions to evaluate the frequency of occurrence of seven types of waste in the field.

Table 1. Recapitulation of Questionnaire Results

Types of Waste	Assessment According to Experts				Total	%	Ranking
	Q1	Q2	Q3	Q4			

Transportation	4	1	3	1	9	15%	3
Waiting	3	2	1	2	8	14%	4
Over Production	2	1	3	2	8	14%	5
Defective Part	3	2	2	3	10	17%	2
Inventory	2	2	2	5	11	19%	1
Movement	2	3	1	1	7	12%	6
Excess Processing	2	1	1	2	6	9%	7

Based on the waste identification results above using a questionnaire, the results obtained for the most dominant type of waste are Inventory with a score of 19%, followed by Defective Parts with a score of 17%, third is Transportation with a score of 15%, and the rest is followed by waste.

Table 2. VALSAT Matrix Conversion Results

Type of Waste	Score	PAM	SCRM	PVF	QFM	DAM	DPA	PS
Transportation	9	81						27
Waiting	8	72	72	8		24	24	
Over Production	8	8	24		8	24	24	
Defective Part	10	10			90			
Inventory	11	33	99	33		99	33	11
Movement	7	63	7					
Excess Processing	6	54		18	6		6	
Total		321	202	59	104	147	87	38
Percentage		33.5%	21.1%	6.2%	10.9%	15.3%	9.1%	4.0%
Ranking		1	2	6	4	3	5	7

Information: (1) PAM: Process Activity Matrix, (2) SCRM: Supply Chain Response Matrix, (3) PVF: Product Variety Funnel, (4) QFM: Quality Filter Mapping, (5) DAM: Demand Amplification Mapping, (6) DPA: Decision Point Analysis, (7) PS: Physical Structure.

The scoring results from identifying waste that occurs become basic data for selecting tools that are relevant to the VALSAT approach by multiplying the average score by the weight value in the VALSAT matrix. The graph of the results of the VALSAT matrix conversion can be seen in **Table 2**. The results of the VALSAT conversion are known to be the highest tool for identifying waste that occurs, where Process Activity Mapping has the largest percentage, namely 33.5%, Supply Chain Response Matrix has a percentage of 21.1% and Demand Amplification Mapping has a percentage. 15.3%.

The process of mapping activities in making this tool requires direct supervision of the process, the activities of each process, distance, time and labor involved. The results are entered into a table where each activity will be combined into five types of activity, including Operation (O), Transportation (T), Inspection (I), Delay (D) and Storage (S). This table shows the proportion of the number of activities and time for each type of activity. By understanding that value added activity (VA) is an operation, value added activity (VAA) will be obtained. Operation and inspection are activities that have added value. Meanwhile, transportation and storage are activities that do not add value but are necessary or necessary non value adding activity (NNVA). Delay is an activity that has no added value or non-value added (NVA). In 1 shift you can produce around 901 pcs, the time calculation is carried out during the production process of women's woven bottoms products.

Table 3. Amount and Proportion of Time for Each Activity

No	Activity	Total	Time (Sec)	Percentage	VA	NNVA	NVA
1	Operation (O)	55	5490	78.1	5490		
2	Transportation (T)	13	619	8.8		619	
3	Inspection (I)	3	300	4.3		300	
4	Storage (S)	1	120	1.7		120	
5	Delay (D)	5	500	7.1			500
Total		**77**	**7029**	**100**	**5490**	**1039**	**500**

In **Table 3** it can be seen that during the production process of women's woven bottoms, the proportion of operational activities that took the most time was 5490 seconds or the equivalent of 1.5 hours with a percentage of 78.1% of the overall time consumption. The second largest proportion of time is transportation activity with a time of 618 seconds or a proportion of 8.8%. Delay activity has a proportion of 7.1% with a total of 500 seconds.

$$\text{Value Added Ratio} = \frac{Value\ added\ time\ (process\ time)}{Total\ process\ cycle\ time}\ X\ 100\% = \cdots$$

$$\text{Value Added Ratio} = \frac{5490}{7029}\ X\ 100\% = 78.1\%$$

Supply Chain Response Matrix (SCRM) is a tool that describes the lead time conditions for each process and the amount of inventory. By using this tool, monitoring of increases or decreases in distribution times and inventory quantities in each area of the supply chain flow can be carried out. With this map, distribution managers can more easily know which areas in the distribution flow make it possible to reduce lead times and inventory levels. SCRM is used to identify waiting time obstacles in the distribution and supply process. This matrix shows the cumulative waiting time of the processes in the supply chain. There are two axes, where the horizontal axis describes the cumulative product waiting time in working days, while the vertical axis indicates the average amount of inventory in working days at a certain point in the supply chain.

To create SCRM, the data required includes data on accumulated use of raw materials, data on production results of women's woven bottoms, and data on delivery of packaged products per week. The following is a summary of SCRM, namely the raw material warehouse receives materials from suppliers with an average lead time of a week. The average daily arrival quantity from 2022 is 395 yards per day, while the average material usage is 1,216 yards per day on a line. Thus, the number of days physical stock is 0.325. In the production area, the average monthly output is 901 units per day on one line, while the average material usage is 1,216 yards per day on one line. This results in a number of days physical stock of 1.35 with an average waiting time of 18 days. The results of the production process that have been packaged are then stored in the finished goods warehouse. The average number of women's woven bottoms that are packaged every day is 750 units per day on one line. If the women's woven bottoms products sent per week are 4,500 units per week, then every day it is 720 units per day. This results in a total day physical stock of 0.96 with an average waiting time of 7 days or 1 week.

Table 4. Defects in the Production of Womens Woven Bottoms in 2022

Month	Production	Defect	Defect Percentage	Defect Cumulative
January	45094	980	2.2	980
February	155940	5586	3.6	6566
March	95451	4778	5.0	11344
April	87753	2963	3.4	14307
May	14068	103	0.7	14410
June	35570	624	1.8	15034
July	6224	97	1.6	15131
August	71154	2889	4.1	18020
September	8137	88	1.1	18108
October	11482	101	0.9	18209
November	65359	2954	4.5	21163
December	43214	1849	4.3	23012
Total	662458	23012	2.8	

Quality filter mapping is used as an evaluation method for types of waste in the form of defective parts. In this research, the defects that occur during the production process in this company mostly include defects in seams, shadow defects, holes in raw materials and finished products, as well as waste because most of these defects can be identified visually through the inspection process at each stage of production. Table 4 shows the percentage of defects occurring in women's woven bottoms products in units throughout 2022. The results of defects each month do not exceed 5% or can be sent as short shipments, in accordance with the womens woven bottoms Brand regulations.

The results of the VSM method, where the physical flow and information flow of products that have been made, can identify problems that occur in the production process of women's woven bottoms at this company. The initial problem was due to delays in the arrival of raw materials and the process of moving them to the production floor. This is because the majority of raw materials are imported or from Nominated Brands, so that when the goods arrive, they are usually in large quantities and cause a buildup in inventory. This buildup makes the WIP process from one division to another unbalanced and less than optimal. Waste actually occurs because not all divisions process using machines so the level of set up or work timings are not the same. There are processes that have to wait before they can be continued to the next process, for example in the cutting division, where inspection and spreading can use automatic machines, but there are also who still use manual, while during the cutting or cutting process, everything is still manual which requires an improvement process on the cutting machine used. And sometimes there are special raw materials that require special processes, so this can result in incompatibilities and less than optimal tools in the cutting process. After that, there are processes that are not valuable, but must be carried out, such as maintaining the sewing machine with its various set ups. The three sewing or assembly processes have 3 initial stages including components, front body, rear body and 1 assembly stage, namely assembling all components. On average, these stages still use manual machines, and a few uses automatic ones, where each machine carries out a different process and of course requires different maintenance too. This can cause waste, namely it can result in defective parts or waiting, because each machine must be run simultaneously, but if one of the machines is not functioning, it can result in queues and cause a lack of productivity on the production floor. This can also cause operator fatigue when carrying out the process, because the machine used is not functioning optimally. So, this can cause waste in defective parts and waiting. The location of the finished goods warehouse which is not spacious enough will also have an impact on transportation, so that when arranging finished goods products with a forklift the movement is very limited. This results in the movement of the forklift being only allowed to the permitted area, however the arrangement is placed manually or using a trolley.

Value Stream Mapping Future State

As a result of improvements based on questionnaires, interviews and brainstorming with certain parties, a future state mapping will be obtained which can be reviewed in **Figure 6**. In practice, this tool is often used by various industrial engineering experts to map all activities in detail in order to eliminate waste, inconsistency and irrationality in the work environment. The goal is to increase performance efficiency by improving quality, speeding up processes, and reducing costs.

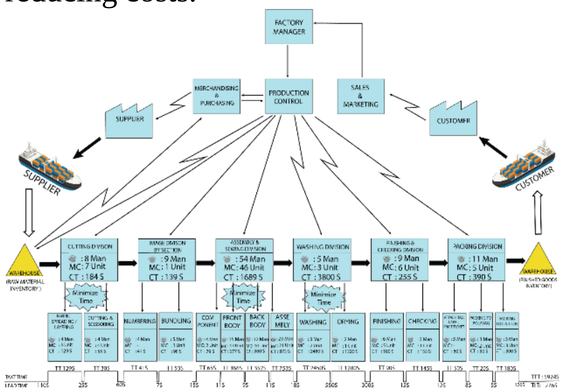

Figure 6. Future State Mapping on Womens Woven Bottoms Products

Pocess activity mapping provides an overview of the physical and information flow, the time required for each activity, the distance traveled, and inventory measurements at each production stage. Identifying activities is made easier by dividing them into five categories, namely operation, transportation, inventory, inspection, and delay. Operation and inspection are considered activities that provide added value. Meanwhile, transportation and inventory are important activities but do not provide added value or non-value-added activity (NVAA). Delays are activities that do not provide added value or non-value added (NVA) and should be avoided to increase efficiency.

Table 5. Amount and Proportion of Time After Repair.

No	Activity	Total	Time (Sec)	Percentage	VA	NNVA	NVA
1	Operation (O)	55	5624	85.6	5490		
2	Transportation (T)	13	523	8.0		619	
3	Inspection (I)	3	300	4.6		300	
4	Storage (S)	1	120	1.8		120	
5	Delay (D)	0	0	0.0			0
Total		**77**	**6567**	**100**	**5490**	**1039**	**0**

The Value-Added Ratio above, it has been proven that there has been an increase, where previously it was 78.1% and after improvements it became 85.6%, see the above **Table 5**. This percentage will increase the company's profitability.

$$\text{Value Added Ratio} = \frac{Value\ added\ time\ (process\ time)}{Total\ process\ cycle\ time} X\ 100\% = \cdots$$

$$\text{Value Added Ratio} = \frac{5624}{6567} X\ 100\% = 85.6\%$$

Based on existing product defect data, the results show that the percentage of waste reaches 2.8% of total production. This waste occurs due to defects in the product, most of which consist of defects in seams, defects in shading, the presence of holes in the finished product, and waste because most of these defects can be immediately identified visually during the inspection process at each stage of production. This situation results in a waste of time because it requires additional evaluation processes for inefficient processes. Therefore, improvements are needed in the work system based on previous analysis, with priority improvements aimed at reducing the percentage of defects from 2.8% to 2% or even eliminating defective products altogether in order to maximize productivity and reduce waste, such as by adding labor and changing during work time.

Based on the results of the questionnaire regarding the seven wastes which have been distributed to parties with a direct interest in the production of women's woven bottoms with a maximum score of 10 and a minimum score of 0. So, the 3 largest wastes were obtained, namely inventory, transportation and defective parts. Inventory, this type of waste gets a score of 11 (19%). This factor is caused by the majority of raw materials being imported or originating from Nominated Brands. Because the volume of goods arriving is usually large, there is a significant buildup in inventory. This accumulation results in an imbalance in the WIP process between one division and another, causing less than optimal efficiency. This situation is a major problem because the Company does not have sufficient warehouse space for storage, which leads to additional costs, decreased work regularity, and overproduction. Transportation, this type of waste was given a score of 10 (17%). This waste occurs due to the process of moving finished goods into the storage warehouse. The limited area of the finished goods warehouse causes restrictions in the use of forklifts for arranging finished products, so that movement is limited. Product arrangement is done manually or by using a trolley. Limited area in the factory causes a high risk of work accidents and results in waste. Defective Part, this type of waste gets a score of 9 (15%). Waste occurs in several divisions, but what needs to be paid attention to is the sewing and assembly division. In the three sewing or assembly processes, there are 3 initial stages, including components, front body, rear body, and one assembly stage for all components. This stage generally uses manual or automatic machines, where each machine carries out different processes and requires different maintenance. This situation can result in waste due to the potential for defective parts due to the dependence of machines running simultaneously. If one of the machines experiences a problem, this can cause queues and reduce productivity on the production floor. Apart from that, this condition can also cause operator fatigue because the machine used is not operating optimally, which in turn can cause waste of defective parts.

The following is an analysis with Root Causes of each waste according to the seven wastes. This is the result of interviews with internal parties who have policies in the Company and improvements to current processes or the future state. Transportation, the main causes are inefficient delivery routes, warehouses that are not well organized, and the transfer of WIP to finished goods warehouses. Waiting, the cause is an imbalance in the work flow resulting from waiting for the next process, inefficient machine settings, and a limited number of workers. Over Production, the causes are processing that is too complicated, unnecessary quality improvements, and differences in production speed in each division. Defective Part, the causes are unstable production processes, lack of employee training, defective raw materials, lack of machine maintenance, different machine set ups. Inventory, the causes are overproduction, imbalance between supply and demand, buildup in WIP. Movement, the cause is inefficient factory layout, lack of adequate planning in work flow which can result in excessive waste of time and labor, operators doing other activities to just rest, and an uncomfortable work area. Excess Processing, the causes involve inefficient factory layout, deficiencies in workflow, equipment that is not ergonomic, and differences in work methods that occur.

RESULT AND DISCUSSION

Implementation of VSM with the Proposed Methodology

In implementing Value Stream Mapping (VSM) according to the proposed methodology during production, all production processes and activities are mapped thoroughly. Next, the parts responsible for the decrease in productivity are identified. In the previous analysis, it was revealed that the processes of cutting raw materials, sewing and assembling, as well as washing were sources of slow production rates or had non-value added.

However, the main source specifically is at the sewing and assembly stages when making women's woven bottoms products which have 4 main stages, namely component sewing, front body, back body and overall assembly. In each process, it is identified as the main process that is problematic during production. Apart from that, it is realized that inappropriate work flow arrangements, excess raw materials, large gaps between processes, inappropriate handling, lack of skills, and irregular placement of equipment are also some other reasons behind the same problem.

All product-related information is gathered from discussions with workers and industry records. For both of this information has been obtained from the previous process and has been generally identified with the root cause. The main information related to the product information that has been collected can produce suitability for the products that will be produced by the Company. This is a very important phase of the production process because it determines the overall activities or processes required to meet customer needs and what products the company can make. Where achieving the desired specifications, achieving standard quality, production using limited resources, production on time, and production within a limited budget are the main goals of the production process, all of which help get the desired results.

After that, the analysis stage helps the production system to recognize the actual conditions of the production floor, where the production process will be carried out. In this phase, previous production records and wastage identification are some of the important factors responsible for production and also help in increasing production levels. **Table 6** shows a general analysis of the current production floor across all sections, which is based on the information that has been collected.

Table 6. Current Production Floor Analysis

No	Factor	Data / Quantity
1	Previous Production Records	901 pcs / day / line
2	Resources Availability	97 workers, Spreading machine, Cutting machine, Sewing machine, Washing machine, Iron machine, Forklift, Trolley
3	Types of Wastes	Inventory, Transportation, Defective Part
4	Lack/Drawbacks	Delays in the arrival and process of moving raw

	materials, WIP transfers, less than optimal auxiliary equipment, machine maintenance, different machine setups, miscommunication, operator fatigue, finished goods piling up, area limitations, less than optimal work flow.

The proposed methodology focuses on the main stages, namely sewing and assembly. This stage is the main one because of the three wastes that have been identified, this stage has all three wastes. The production system is Progressive Bundle System, where each operator is responsible for different garment operations. Therefore, more attention is needed and will be a concern for the parties involved during production.

After the analysis stage, the decision-making stage takes place, which involves production planning. This activity is necessary to achieve the desired productivity. **Table 7** shows the factors discussed. After checking and understanding all production related conditions, all types of waste on the factory floor are eliminated. This helps propose new workflows for future production on the production floor. In analyzing the proposed workflow, parameters are calculated from the analysis of the proposed activities. And to be more effective and efficient during production activities, apart from February, March and April which are the peak demand for products, it is best to carry out a Pilot Run before mass production activities begin.

Pilot run refers to the first small production run of a new garment style or design before starting mass production of womens woven bottoms products. A pilot run is an important step to test the production process, identify potential problems, and ensure that all aspects of production have been checked before entering large-scale production. During the pilot run, manufacturers can test design feasibility, pattern suitability, raw material availability, production processes, and overall production efficiency. It is also possible to evaluate the time and costs required to mass produce womens woven bottoms. Pilot runs provide an opportunity for companies to improve and change production processes as needed before starting production in large quantities. Thus, it is an important step in ensuring that garment production can be carried out efficiently and of high quality before entering the larger production stage.

Table 7. Value of Decision Making in the Sewing and Assembly Process

No	Factors	Data / Quantity
1	Number of Activity	4
2	Type of Layout	Process
3	Number of Workers	58
4	Number of Proceses	47
5	Cycle Time	1614s

Table 7 is the result of the sewing and assembly process after the pilot run. This methodology is applied to analyze each sewing and assembly process. And it is known that the benefits obtained by the company are reducing the number of employees, reducing the number of processes, and reducing the cycle time for making women's woven bottoms products.

Table 8. Amount and Proportion of Time with the Proposed Methodology

No	Activity	Total	Time (Sec)	Percentage	VA	NNVA	NVA
1	Operation (O)	55	5582	86.0	5490		
2	Transportation (T)	10	490	7.5		619	
3	Inspection (I)	3	300	4.6		300	
4	Storage (S)	1	120	1.8		120	
5	Delay (D)	0	0	0.0			0
Total		**77**	**6492**	**100**	**5490**	**1039**	**0**

Table 8 shows that the overall process of operations in making women's woven bottoms products was reduced by 6492 seconds. The percentage of productivity level also increased to 86.0% and only a difference of 0.4% after using the proposed methodology. This is because when producing women's woven bottoms or other products, many still use manual systems or do not use many automatic machines, so the level of productivity is still far from expectations and the level of waste cannot be 100% eliminated.

$$\text{Value Added Ratio} = \frac{Value\ added\ time\ (process\ time)}{Total\ process\ cycle\ time}\ X\ 100\% = \cdots$$

$$\text{Value Added Ratio} = \frac{5582}{6492}\ X\ 100\% = 86.0\%$$

Comparison of Traditional VSM and Proposed Methodology

Validation of the proposed methodology has been carried out. It has now been compared with the results of the proposed methodology for the same measures. During the validation, it has been observed that the implementation of VSM with the proposed methodology in the Company provides effective decisions with a higher level of production improvement compared to the traditional methodology. Different phases are used in the proposed methodology, which helps in identifying accurate production requirements on the production floor. These requirements are met with information collected from several sources for the product and its production according to production conditions. It can be seen in **Table 9** as a comparison of Cycle Time between traditional VSM and VSM with the proposed methodology.

Table 9. Comparison of Cycle time of Traditional VSM and Proposed Methodology

No	Processes	VSM Traditional	VSM with Proposed Methodology
1	Fabric Spreading / Layering	129s	129s
2	Cutting and Scissorring	55s	55s
3	Numbering	41s	41s
4	Bundling	98s	98s
5	Component	79s	62s
6	Front Body	377s	352s
7	Back Body	360s	341s
8	Assembly	873s	859s
9	Washing	2480s	2480s
10	Drying	1320s	1320s
11	Finishing	100s	100s
12	Checking	155s	155s
13	Attach Tag, Label, Price Ticket	60s	60s
14	Packing to Polybag	30s	30s
15	Packing to Carton	300s	300s
	Total	**6457s**	**6382s**

In the presented analysis, it is found that the developed agile system is able to improve production parameters, and this is reflected in the growth achieved by the proposed methodology. Production parameters have been improved with the developed agile system, and this has been proven by the improvements achieved in the parameters. By examining production and analyzing information gathered from many sources, it was found that several activities and processes involved in production were the cause of high production times

Table 10. Improvements in Various Parameters

No	Parameter	Current State	Future State / Traditional Methodology	Proposed Methodology
1	Takt Time	6290s	5924s	5882s
2	Cycle Time	6909s	6457s	6382s
3	Man Power	102 Person	97 Person	94 Person
4	Lead Time	1348s	1276s	1276s
5	Value Added Ratio	78.1	85.6	86.0

Table 10 shows improvements in various parameters between current state, future state or traditional methodology, and proposed methodology. In this case, it is proven that VSM with the developed methodology is quite tolerant in overcoming takt time, cycle time, man power and value-added ratio. However, the lead time cannot be avoided or is still the same as traditional VSM and in this case further research is still needed to reduce the existing lead time.

Recommendations for Improvement Based on Root Cause Analysis

Table 11 is a solution applied to eliminate problems identified in the process of making women's woven bottoms products. This Root Cause Analysis is based on the results of discussions with Company management and also direct surveys on the production floor.

Table 11. Proposed Improvements to Womens Woven Bottoms Products.

No	Waste	Root Cause	Improvement Proposals	Production Process
1	Inventory	Imbalance between supply and demand for women's woven bottoms products, overproduction, buildup of work in process (WIP), large volumes upon arrival of raw	Carrying out production plan rescheduling, better production planning, optimal inventory management, improving logistics	Cutting Division, Packing Division

		materials and impact on less-than-optimal efficiency, limited warehouse space for storage.	systems with the internet of things to monitor inventory and logistics in real-time, optimizing production processes, expanding warehouse capacity, risk and contingency management.	
2	Transportation	Delivery routes are less efficient, warehouses are not well organized, transfer of WIP to the next process, movement of finished goods into limited storage warehouses, limited use of forklifts in certain areas which require arranging products manually or using trolleys, no forklift lanes in the factory area.	Improvement of facilities and infrastructure by using good information technology systems, planning efficient delivery routes, rearranging warehouses, optimizing limited storage areas, evaluating accident risks.	Cutting Division, Washing Division, Packing Division
3	Defective Part	Unstable production processes, lack of employee training, defective raw materials, less than optimal machine maintenance, different machine set ups.	Carrying out regular machine checks including setting up machines to comply with existing SOPs, adjusting machine performance according to standards so that defects do not occur, improving the stability of the production process, training employees, controlling the quality of raw materials, optimal machine maintenance, performance monitoring and analysis data	Cutting Division, Part Drawing Division, Sewing and Assembly Division, Finishing and Checking Division
4	Waiting	Imbalance in work flow resulting in waiting for the next process and inefficient machine settings	It is necessary to improve the efficiency of work flow, better machine organization, it is necessary to evaluate each process to ensure that an adequate number of workers are available for the task and that there is no waiting time.	Sewing and Assembly Division, Washing Division, Finishing and Checking Division, Packing Division
5	Over Production	Overly complicated production processes, unnecessary quality improvements, differences in production speed in each division.	Apply the line balancing method so that there is no excessive WIP between processes of semi-finished products or finished goods, re-evaluate the production process to reduce process complexity and eliminate unnecessary steps, consider whether unnecessary quality improvements can be eliminated or simplified so as not to result in costs additional, and equalize production speed in each division and reduce significant differences.	Cutting Division, Part Drawing Division, Sewing and Assembly Division, Washing Division, Finishing and Checking Division, Packing Division
6	Movement	Lack of adequate planning in work flow, operators carry out other activities to just rest, the work area is less comfortable.	Emphasize start-up work discipline, give workers sufficient rest hours and reduce working hours in hazardous production areas, carry out better planning in work flow to avoid delays and waste of time, and provide more comfortable working conditions for operators to reduce the need to them to rest or do other activities.	Cutting Division, Part Drawing Division, Sewing and Assembly Division, Washing Division, Finishing and Checking Division, Packing Division
7	Excess Processing	Inefficient factory layout, use of equipment that is less ergonomic, and differences in work methods between operators.	Installation of a visual information network about SOPs in each division, revise factory layout, improve work flow, ensure production processes follow a logical and efficient sequence, ergonomic equipment, standardize work methods, improve communication between divisions and teams to minimize unnecessary differences in production approaches.	Cutting Division, Part Drawing Division, Sewing and Assembly Division, Washing Division, Finishing and Checking Division, Packing Division

The aim of this research is to build an agile system to maintain increased production through a methodology combined with VSM in Garment Companies, where this methodology was previously used for automatic production processes, but in this case, it is different in that almost the entire production process is still carried out manually. Therefore, in building an agile system to increase productivity in production processes that are carried out manually, it still needs to be improved or use other methods other than Pilot Run, which is the agile system currently used in this company based on the garment industry.

In this case it can be seen that the proposed methodology helps the industry and management to control the operating conditions in the company by eliminating the difficulties faced in the production system. VSM provides a strategic approach to identifying waste and providing improvement suggestions by monitoring production processes. Management can control activities with real-time monitoring, and this helps in the decision-making phase to improve operational performance using limited resources. Thus, it can be concluded that this VSM is faster, easier and more flexible, and can produce production with minimum waste.

CONCLUSION

Based on data processing and analysis in this research, the author conducted a case study to increase the productivity of the garment manufacturing industry using a modified VSM framework. The following are the conclusions that can be drawn from this research:

1. Based on research results, the types of waste that occur most frequently are Inventory (19%), Defective Parts (17%), and Transportation (15%).
2. The results of converting questionnaire scores into the VALSAT matrix are Process Activity Mapping with a percentage of 33.5%, Supply Chain Response Matrix of 21.6%, and Demand Amplification Mapping of 15.3%.
3. Through the use of mapping tools, process activity mapping reveals that the percentage of transportation activities is 8.8%, which shows the second largest proportion of time. This activity is included in the necessary but non-added value category. After improvements were made to transportation activities, the resulting percentage value became 8%.
4. Based on Quality Filter Mapping of existing defect data, it was revealed that the percentage of waste each year is 2.8% of total production. Therefore, improvement or efficiency efforts are needed to reduce the waste that occurs.
5. The proposed methodology is proven to be slightly superior when compared to the traditional methodology with VSM on the production floor.
6. Pilot run is an agile system used at the sewing and assembly stage in this company and is proven to test production processes, identify potential problems, and ensure that all aspects of production have been checked before entering large-scale production.
7. The proposed methodology significantly reduces Takt time by 5882 seconds, Cycle time by 6382 seconds, Man power to 94 people, and increases the value-added ratio by 86.0% compared to the traditional VSM methodology, which reduces Takt time by 5924 seconds, Cycle time amounting to 6457 seconds, Man power 97 people, and value-added ratio of 85.6%.

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