Design of Lean Manufacturing Integration to Reduce Waste in NBC 001 Production Flow Using VSM and DMAIC Approach

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Abstract— *This research was conducted on NBC 001 products sold by the Nibras brand, engaged in garments. This company sells many products, but the NBC 001 product is the best-selling product because it has sold 12,673 pcs. This study focuses on the waste that occurs in the production process flow. Based on the results of interviews with the warehousing department, it was found that there are 2 (two) types of waste that are the problem, namely defects and the length of production lead time. Then the research was carried out using the lean method, namely a combination of VSM (Value Stream Mapping) and DMAIC (Define-Measure-Analyze-Improve-Control), to get the lean results. This study stated that based on the results of the calculation of DPMO (Defects per Million Opportunities), the defects that occurred were still within the concession provided by the company, namely 5%. And the problem in lead-time production after being calculated and analyzed using VSM (Value Stream Mapping) and DMAIC (Define-Measure-Analyze-Improve-Control) is obtained by combining processes with the same output, namely marker and cutting, adding operators, and adding supermarkets. At work, stations can reduce the value of NVA (Non-Value Added) from 97% to 91% and increase the value of VA (Value Added) from 3% to 9%, then shorten the lead time from 10.4 days to 3 days and speed up the cycle time from 154.5 minutes to 137 minutes.*

Keywords— *Lean, VSM, DMAIC, waste, defect.*

I. INTRODUCTION

Planning regarding the use of materials in the manufacturing industry has a fairly large percentage of total production costs. With more and more companies in Indonesia, they are competing to make products that have high quality but at prices that can attract attention and make consumers satisfied with these products.

Inventory or inventory of raw materials has a fairly important role in the manufacturing industry. Matters concerning the availability of goods must be planned to control the amount of material or raw materials that will be ordered will come or will be stored so that the company can save production costs and get a minimum total cost.

Rochmoeljati, N, and Firmansyah [1-10] entitled Analysis of Waste in Edamame Production Using Lean Manufacturing Methods at PT. Mitrani Dua Tujuh Jember stated that the results obtained from the lean system research are very helpful in identifying waste that occurs in the production process. Where in this study, the largest waste occurs during waste waiting and waste in the storage of raw materials that are not needed (unnecessary waste inventory). This weighting result is obtained after determining each weight using Value Stream

Analysis Tools (VALSAT). And by using this method, they can make reductions and improvements in production.

A study conducted by Hartono, Putro, and Farhan [11-17] entitled Process and Product Performance Analysis With a Six Sigma Methodology Approach (DMAIC) for The Botol Products at PT XYZ stated that in developing its business, a company always strives to improve quality, especially in handling non-standard products that can arise in each production process, and the results of this study state that by using the Define-Measure-Analyze-Improve-Control (DMAIC) method, it is possible to map out which parts should be the main focus of a company to improve quality. Its products.

A study conducted by Astuti & Apriliana [17-22] entitled Application of Value Stream Mapping (VSM) as an Effort to Reduce Procurement Process Delays at PT X states that a company in supporting the smooth running of a production process requires a good procurement process where procurement is an activity to get the goods needed for the production of a product and after mapping with the VSM method the company can reduce waste that occurs at a time to reduce delays in ordering raw materials.

Of all the products sold by PT. Fatahillah Anugerah Nibras, the NBC 001 product, is the most in-demand model by consumers; this is evident from its sales, which have the highest score. This product is a best seller because the model is simple and suitable for all ages. Even during the 2020 pandemic, the demand for this product is still relatively high.

Fig. 1. Product

The following is a comparison table of total sales among the products sold by the Nibras brand. Among the five best-selling products, NBC 001 products occupy the first position with total sales of 12,673.

In planning the procurement of the main raw material, namely cloth, it must be calculated based on the needs of each size and type after that PT. Fatahillah Anugerah Nibras must pre-order fabric manufacturers. When the materials arrive, the cloth materials are handed over to the production department to be processed into finished products.

In the process from incoming materials to finished products, there is still a lot of waste, especially in lead times. And it creates waste in inventory because of the long production time. Then lead time data was obtained for each procurement of raw materials used for NBC 001 products by existing data in the company. In addition, based on interviews with the head of the warehousing section, product defects are also one of the problems faced by the company.

TABLE I. Production Cycle Time for NBC 001

No	Marker (second)	Cutting (second)	Sewing (second)	Finishing (second)
1	1200	1800	4800	2400
2	900	1500	4920	2100
3	1200	1620	4500	1800
4	1020	1680	4680	2280
5	900	1500	3600	2220
6	1080	1200	3600	2160
7	1200	1500	4500	2100
8	1080	1800	4800	2100
9	1020	1800	4800	2100
10	900	1860	4380	2100
Average	1050	1626	4458	2136

The table above shows that the cycle time to make 1 product is 9270 seconds or equivalent to 154.5 minutes.

II. RESEARCH METHODS

In this study, data collection was carried out by observing the making of NBC 001 products at PT. Fatahillah Anugerah Nibras at each work station. This research uses qualitative and quantitative data types obtained directly from the company concerned. The analysis was carried out using a lean manufacturing approach using the DMAIC (Define, Measure, Analyze, Improve, and Control) and VSM (Value Stream Mapping) methods. The following are some steps of data processing:

Production System Analysis

At the stage of production system analysis in research on making NBC 001 products at PT. Fatahillah Nibras carried out the following stages of analysis:
  a. The flow of the production process carried out
  b. Scheduling carried out by the procurement division
  c. Operation cycle time

Integration of DMAIC and VSM Methods

The following are the steps involved in identifying waste for optimizing the manufacturing process for the NBC 001 product at PT. Fatahillah Nibras Award:

a. Define, Measure, Analysis, Improve and Control (DMAIC)

DMAIC is a structured problem-solving method used for quality and process improvement. DMAIC is an implementation of the Six Sigma philosophy. The DMAIC method consists of five main stages, define, measure, analyze, improve, and control.

1. Define

This stage is the initial stage in Six Sigma. Targeting and identifying processes and process bottlenecks will be carried out at this stage. The defined waste stage in this research is integrated with the Value Stream Mapping method.

2. Measure

Several things are done in this stage: measuring cycle time, balance delay, and production efficiency.

3. Analyze

This stage is the stage of analyzing, seeking and finding the root cause of a problem.

4. Improve

At this stage, FMEA (Failure Mode and Effect Analysis) is used to determine the priority of the improvement plan. FMEA is a system of activities that identify and evaluate the potential failure level in a system, product or process, especially at the roots of the product or process function on the factors that affect the product or process. FMEA is a systematic approach that applies a tabular method to develop a thought process used by engineers to identify potential failure modes and their effects (Amin, Syukron, and Muhammad Kholil., 2013).

5. Control

This control or control stage ensures that the improvements made are not effective. This stage is the stage to control the process that has been improved. This control can be done by monitoring the daily production output after balancing the production line.

b. Value Stream Mapping (VSM)

Value stream mapping is a map that summarizes or describes the production process starting from the supply of materials to the production process until the product is in the hands of the customer. Because VSM helps in finding waste in the production process. The following is a description of creating a Value Stream Mapping:

1. Create a Current Value Stream Mapping

Current value stream mapping is needed as the basis for making the proposed state map.

2. Identification of Waste with VSM.

At this stage, material flows are identified during the production process, activities along the value stream, the cycle time of the assembly process, and manpower requirements for each activity and other process data.

3. Analysis of the Root Causes of Waste.

This analysis is carried out using a fishbone diagram to determine the main root causes of waste. Proposed Improvements with Lean Tools, including using Pareto diagrams or fishbone charts.

4. Create a Future State Map

The future state map is obtained from reducing waste in the current state map. However, future state mapping still refers to the initial mapping or current state.

After analyzing and providing recommendations for improvement, the next step is to describe the Future State Map. An expectation of the value stream mapping for future conditions after repairs are made. At this stage, the current

state map will be compared with the future state map regarding the lead time before and after repairs to find out the changes.

III. RESULT

Stage 1 Define

In the define stage, there are several calculations used, namely SIPOC (Supplier-Input-Process-Output-Customer), CTQ (Critical to Quality), cycle time (Cycle Time), and Value Strem Mapping Current Flow. Here are the results of the analysis:

a. SIPOC (Supplier-Input-Process-Output-Customer)

SIPOC analysis is useful for identifying and knowing the supplier of raw materials from input to process and then to output in the form of finished products.

1. Supplier

The raw materials used in the initial steps of making NBC 001 products are obtained from several suppliers from outside the organization who have collaborated with the company and come from suppliers from other work units. Suppliers who come from outside the company are suppliers of tayboo cloth, buttons, and lists. The rest of the suppliers shown in table 4.2 come from other work units.

2. Input

In the manufacture of NBC 001 products, several materials are needed to carry out the production process, such as raw materials and semi-finished goods. The materials used are included as inputs in the production process.

3. Process

The processing stage contains what processes occur to the materials that are entered to produce NBC 001 products. These processes include making patterns, cutting, sewing, and finishing.

4. Output

The output stage contains the results of the processes that have been carried out previously, both in the form of semi-finished materials and finished goods.

5. Customers

Customers of NBC 001 products are people who are interested in and buy NBC 001 products.

b. CTQ (Critical to Quality)

In this CTQ analysis, it was obtained from the results of interviews with workers in the warehousing division who understand the best quality for NBC 001 products; because this division is a division that is directly connected with partners from the company, this division understands the most about customer desires for NBC 001 products.

c. Cycle Time

Cycle time data is the time required to make 1 unit of product per one workstation. This data will be used as the basis for the value-added time of the total production process. In the production process of the NBC 001 product, there are 4 work stations, namely marker, cutting, sewing, and finishing. Making NBC 001 products is already automatic. Therefore, it does not require any further calculations to obtain standard time data. The cycle time to make 1 product is 9270 seconds or 154.5 minutes.

d. Value Stream Mapping Current Flow

After knowing the cycle time for each process, a value stream is created.

Stage II Measure

At this stage, measurements are made to make NBC 001 products. Among them are Pareto Diagrams, DPMO (Defect per Million Opportunities) calculations, Data Uniformity Test, Data Sufficiency Test, Takt Time Calculation, NVA (Non-Value Added) calculation. Here are the results of the analysis:

a. Pareto chart

A Pareto diagram is a diagram that is used to find problems that occur and focus on solving problems. Several defects occurred during the production process of NBC 001 products, including untidy stitches, uneven lists, buttons that were not tight, and untidy cuts.

b. Calculation of DPMO (Defect per Million Opportunities)

At this stage, measurement of sigma value is carried out by calculating DPU, DPO and DPMO as well as Yield on these products. In this stage, it is useful to measure the company's performance and get the following results:

TABLE II. DPMO

Months	Demand (Pcs)	Defect (pcs)	DPU	DPO	DPMO	Yield	Sigma
1	875	40	0,05	0,01	11428,57	73%	3,775814
2	642	31	0,05	0,01	12071,65	73%	3,754841
3	637	30	0,05	0,01	11773,94	74%	3,764427
4	575	27	0,05	0,01	11739,13	74%	3,765561
5	562	28	0,05	0,01	12455,52	73%	3,74278
6	577	24	0,04	0,01	10398,61	77%	3,811646
7	592	29	0,05	0,01	12246,62	73%	3,749303
8	572	25	0,04	0,01	10926,57	76%	3,792911
9	535	27	0,05	0,01	12616,82	73%	3,737807
10	573	26	0,05	0,01	11343,8	75%	3,778655
11	567	27	0,05	0,01	11904,76	74%	3,760189
12	490	20	0,04	0,01	10204,08	78%	3,818758

Based on the table above, the sigma results are obtained with an average of 3.77. If seen from the sigma level conversion above, it is at the 2-sigma level, which means it is average for the Indonesian industry. From the DPU and DPO results, it is stated that the defects that occur are still within the concession limit that the company provides, which is 5% - 7%. Therefore, the calculation is continued with the next waste, namely waste in lead time.

c. Data Uniformity Test

The data uniformity test was conducted to ensure that the data studied were uniform and did not vary. The data uniformity test was carried out by graphing the Upper Control Limit (BKA) and Lower Control Limit (BKB). After the calculation, the result is that the marker, cutting, sewing, and finishing processes are still included in the BKA and BKB areas, so the data is declared uniform.

d. Data Sufficiency Test

This data adequacy test ensures that the data collected is objectively sufficient. In this study, the level of research confidence is 90%, with an accuracy level of 10%. After doing the calculations, it was found that the marker, cutting, sewing, and finishing processes showed that the value of N' of each

process was still smaller than the value of N, so the data was considered sufficient and suitable for further research.

e. Takt Time Calculation

Takt time calculation is intended to be a reference standard for each process's cycle time so it can be analyzed between processes that are more or less than takt time. After calculating, it was found that the takt time was 1152 seconds, so it can be seen that the process is a bottleneck or an obstacle in the process flow.

f. Calculation of NVA (Non-Value Added).

Based on the current state map that has been made, it can be seen that the processing time is 9270 seconds or 154.5 minutes, and the production lead time is 10.4 days.

After calculating the non-value added, it can be seen that in the process of making NBC 001, it has 97% non-value added activity, meaning there are a lot of activities that are not added value in the production process of NBC 001.

Stage III Analyze

At this stage, 2 (two) tools are used, namely Fishbone Diagram and Kaizen Blitz. The results of the analysis are as follows:

1. Fishbone Diagram

An analysis of the things that cause a long production time causes a high percentage of non-value added.

From the results of the fishbone diagram, several conclusions can be drawn, namely,

1. The amount of material that accumulates in each process
2. Raw materials are transported manually
3. Absence of production standards
4. Too many processes

After knowing what factors cause problems that cause the production lead time for making NBC 001, the use of this method is expected to be able to focus on what things need to be fixed in the future state map.

2. Making Kaizen Blitz

After knowing what factors are causing the problems that cause the production lead time for making NBC 001. The use of this method is expected to be able to focus on what things need to be fixed in the future state map. Things to watch out for are:

a. WIP between processes
b. Production flow

Stage IV Improve

The implementation of the improvements can be seen in the future state map; what things at the analysis stage are the dominant factors in the length of the production lead time in the production process of NBC 001 so that the improvement in the production lead time becomes shorter.

The proposed improvements made to change the current state map are as follows:

1. Adding Operators

The addition of operators is implemented because there is a lot of demand, while fewer operators are available in sewing and finishing. Therefore production can be hampered. With the addition of operators, the work will be done faster.

2. Job Merger

Combining jobs must have the same or uniform job characteristics and the same output. So it is calculated that the marker and sewing are done in 1 line. Because this is a combination of 2 processes, the highest cycle time can be taken.

3. Supermarket Use

The use of supermarkets is wrong as a safety stock which consists of 3 supermarkets.

a. The first supermarket is located between the warehouses by combining marker stations with cutting so that the movement distance is not too far.

b. The second supermarket is between the marker and cutting processes with sewing. This is done so that it is easier for the operator at the sewing station to pick up the material according to the type and not have to spend a lot of time looking for the type of pattern.

c. The third supermarket is between the sewing and finishing processes

Delivery of raw materials from warehouse to marker and cutting is changed to every 4 hours or 0.5 days, from marker and cutting to sewing to every 6 hours or 0.75 days, sewing to finishing process is changed to once every 6 hours or 0.75 days and from finishing to warehouse once a day. This is done to control the production flow.

Stage 5 Control

In this research, input is given to companies regarding how to control and supervise the production process of NBC 001, which has a high level of production lead time; the amount of inventory in each process is the main obstacle after measuring, analyzing and improving the production lead time is reduced. Therefore, it is necessary to maintain control so that the fixed production lead time is stable. The things that need to be considered and done by the company are:

1. Operator retraining
2. Better use of time
3. Communicate the things that become obstacles at work

Final Stage Comparison Before and After

At this stage, several comparisons are made, namely the comparison of lead time, cycle time, and production time values

a. Lead Time Value

Based on the previous chapter, it can be concluded that the most dominant waste is inventory waste caused by the length of the production lead time because the current state map shows that the production time is 10.4 days. After repairs with kaizen blitz have been made, the improvements made to the future state map are to combine processes that have the same output, namely the marker and cutting processes, and the use of supermarkets to control production activities.

The decrease in the value of NVA (Non-Value Added) time by 6% from the current state map 97% to 91% on the future state map.

b. Cycle Time

Based on the current state map that has been made, it can be seen that the processing time is 9270 seconds or 154.5 minutes, and the production lead time is 10.4 days. The

following is a comparison of cycle times on the current state map and future state map

TABLE III. Cycle Time Comparison

Process	Current State Map (s)	Future State Map (s)
Marker	1050	1626
Cutting	1626	
Sewing	4458	4458
Finishing	2136	2136
TOTAL	9270	8220

It can be seen from the table that there is a difference in cycle time from before and after repairs, from 9270 seconds or 154.5 minutes to 8220 seconds or 137 minutes.

c. Production Time

To find out more about the comparison of changes that occur, a table is made to make it easier to know the value of the comparison.

TABLE IV. Comparison of NVA and VA

	Production Time (Hari)	Processing Time (Menit)	VA	NVA
Current	10,4	154,5	3%	97%
Future	3	137	9%	91%

IV. CONCLUSION

Conclusion

From the results of data processing and analysis of the problems that have been carried out in the NBC 001 production process, it can be concluded as follows:

1. From the results of calculations using DMAIC and mapping with VSM, in the flow of the production process to make a better NBC 001 product, several changes can be made including combining processes that have the same result, namely the marker process is combined with cutting because these two processes have the same results. same end result, they can be combined to reduce waste in lead time.

2. After calculating using DMAIC, it is known that before the improvement of the NVA (non value added) value in lead time production is 97% and VA (value added) is 3% and after repairing the NVA (non value added) improvement in the lead time production is 91% and VA (value added) is 9%

3. The right proposal based on the results of data analysis calculations as an improvement is to combine processes that have the same output so as to save time, increase the number of operators, and make supermarkets in several work stations to be able to control the production rate.

Suggestion

Suggestions that can be given from the results of this study both for the application of the company and for further research are:

1. To increase the value of VA (value added), it is hoped that the company can apply this method because the results of this analysis can answer problems in the production process of NBC 001 products.

2. This study only discusses one type of product among several products produced by PT. Fatahillah Anugerah Nibras, it is hoped that further research can discuss all types of products produced by the company PT. Fatahillah Nibras Award.

3. It is hoped that further research can discuss other methods that are still related to improvements that are more widespread and of course relevant to future conditions.

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