Integration of Lean Manufacturing and Group Technology Layout to increase production speed in the Manufacture of Furniture

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Abstract. PT. ABC is a wood processing company which manufacture household appliances such as chair, table, wagon, shelf, and cloth en hanger using rubber wood as the base material. Based on the results of observations made on the company, it was known that the production process in the company still having many non-value added activities such as delay and long distance transportation activities, causing longer lead time of the production process. From the problems that exist in the company, lean manufacturing approach is used to reduce non value added activities by using Value Stream Mapping to identify activities which are value added and which are the non-value added then to reduce non-value added activities 5W and 1H principles is used. After non-value added activities have been reduced, followed by Group Technology Layout approach to design three alternative layouts with the purpose of minimize the distance between station. This study aims to eliminate non-value added activities through simplification of the production process and redesign of the layout to reduce production time. The results of this study concluded that using this method the manufacturing lead time is decreased from the beginning of 19237.4 seconds to 14340.3 seconds. In addition, process cycle efficiency also increased by 34.15% and the completion of the process also increased by 20 units or by 25.64%.

Keywords: Facility Layout, Lean Manufacturing, Group Technology Layout, Value Stream Mapping

1. Introduction
The importance of export activities in an effort to increase the country's foreign exchange causes the importance of efforts needed to create work productivity and reliable product quality. Increased productivity is important because the quality of service of a company has a very important role in maintaining a smooth business [1]. One of the leading exports in Indonesia from the manufacturing industry is furniture. But for business development, in the long run, the company always faces the challenge of high levels of competition in furniture sales in the global market. [2]

Manufacturing companies are companies that need a process with a considerable amount of material usage. In an effort to increase productivity, companies must know activities that can increase value added (goods and / services) and eliminate (waste), therefore a lean approach is needed [3]. Lean Manufacturing distinguishes which adds value, by eliminating other things that have no added value [4]
The design of production facilities is one of the factors that greatly influence the performance of a company. This is due to poor layout of the facility which will cause a pattern of unfavorable material flow and the movement of materials, products, information, equipment, and labor to be relatively high which causes delays product completion and increase production costs [5].

Group Technology Layout methods classify products that are not identical based on processing steps, forms, machines, or equipment used, etc. [6]. The GT principle is to realize problems that have in common by grouping problems based on similarity in order to obtain a single solution for a group of problems so that it can save time and effort [7-8].

In recent years the level of productivity at this company decreased significantly. From the preliminary study conducted on this company, it can be seen that the state of production still has weaknesses in the flow of production and the arrangement of laying work stations. Based on the layout of the company which can be seen in Figure 1, So far the location of the workstations at PT. ABC is irregular and has a long distance between stations which results in production that is not optimal.

![Figure 1. Initial Layout](image)

This study tries to solve the problem by integrating the Lean Manufacturing approach which aims to reduce non-value added activity and with Group Technology Layout as a method to improve the location of production facilities on the production floor of PT. ABC in order to increase production and reduce lead times so that it has an impact on increasing the productivity of the company.

2. Research Method
Research begins with a review and collection of data. Data collected from company documents is production volume, and description of the production process, conducting direct observations and direct interviews in the field. The dependent variable in this research design is the proposed production floor layout which has a minimum material handling displacement.

Data processing in this research uses the following steps:
1. Current State Map [9-10]
   a. Value Stream Manager
   b. SIPOC Diagram
   c. Standard Time Calculation
   d. Waste Identification
e. Map Creation for Each Process Category Throughout the Value Stream
f. Overall Factory Process Chart
g. Process Cycle Efficiency Calculation
h. Process Added Mapping Analysis

2. Improvement using Lean Manufacturing and Relayout [11-12]
   a. Initial Layout
   b. Distance Calculation
   c. Transportation Frequency Calculation
   d. Moment of Displacement
   e. Alternative Layout construction using ROC method (Group Technology Layout)
   f. Proposed Process Activity Mapping
   g. Future State Map

3. Result and Discussion

3.1. Deciding Value Stream Manager
In this research, the selected value stream manager is the production manager.

3.2. Product Choosing
In this research, the selected product is wooden chair because it got the highest production volume.

3.3. SIPOC Diagram (Supplier-Input-Process-Output-Customer)
Sipoc Diagram (Supplier-Input-Process-Output-Customer) of wooden chair production process can be seen in Figure 2.

3.4. Calculation of Standard Time
The example of standard time calculation for WC 1 is as follow [13]:

\[
\text{Standard Time} = \text{Normal Time} \times \frac{100\%}{100\% - \text{Allowance}\%} = 12.6 \times \frac{100\%}{100\% - 16\%} = 15.0 \text{ seconds}
\]  

3.5. Waste Identification with Process Added Mapping
Process Activity Mapping (PAM) in identifying necessary activities of non value added and non value Added for company, conducted direct observation [10].
Through process activity mapping obtained the number of operation process, transportation, inspection, storage and delay along with its time can be seen in Table 1.

| Symbol       | Amount | Time (sec) | Percentage (%) |
|--------------|--------|------------|----------------|
| Operation    | 8      | 11054,4    | 57,46          |
| Transportation | 10    | 4688,9     | 24,37          |
| Inspection   | 2      | 1333,1     | 6,93           |
| Delay        | 4      | 2161,0     | 11,23          |

3.6. **Map Creation for Each Process Category Throughout the Value Stream**

Mapmaking for each process category along the value stream uses the standard time data of each process plus other data such as processing time, and the number of operators. A preliminary process category map for tapping as shown in Figure 3 is obtained.

![Figure 3. Map of Tapping Category](image)

3.7. **Forming the Overall Factory Flow Chart**

Each process along the value stream is combined with material flow and information flow so that it becomes a single flow in the factory. After all, information is obtained, thus the current state map can be formed by placing all material and information flows into the folder. Current state map of wooden chair products can be seen in Figure 4.

![Figure 4. Current State Map of Wooden Chair Product](image)
3.8. Calculating Process Cycle Efficiency

The calculation of process cycle efficiency is as follows [14]:

\[
\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Total Production (year)}} = \frac{12387.5}{19237.4} = 64.39\% 
\]

(2)

\[
\text{Average Finishing Time} = \frac{\text{Amount of Work Days}}{\text{Total Production (year)}} = \frac{19500}{250} = 78 \text{ units/day} 
\]

(3)

3.9. Improvement using Lean Manufacturing

Activities included in NVA and can be improved can be seen in Table 2.

| Table 2. Imporvable Non-Value Added Activity |
|---------------------------------------------|
| Number | Activity Name                                      |
| A      | The raw material is carried to the tapping station |
| B      | Stacking the results of the tapping before being transported |
| C      | The wood from the impacting is carried to the cutting station |
| D      | Wood measuring 40 cm is carried to the finger joint station |
| E      | Wood is brought to the drilling station |
| F      | Piling up all the drilling parts |
| G      | Brought to the sanding station |
| H      | Accumulate sanding results |
| I      | Brought to the painting station |
| J      | Piling up dry parts |
| K      | Taken to the packing station |

Activity included above will be analyzed using 5W and 1H method.

3.10. Improvement Using Group Technology Layout

The results of grouping machines using the Rank Order Clustering method can be seen in Figure 5 [11].

![Figure 5. Machine Grouping](image)

Based on the results of the grouping above, it can be seen that there are several components that are not colored, because that the machine used in the construction of the component already exists in another group. This can be overcome by dividing more than one machine into the group of machines that are formed. The results of the improvement of machine grouping can be seen in Table 3.
Table 3. Grouping Correction

| Group | Component | Machine |
|-------|-----------|---------|
| I     | C2,C3,C4,A4,A1,A2,A3,A5,A6,C1,B2 | XIII(3), I(2), II(2), IX(3), X(2), XI(2), XII(1), VII(5), III(1), VI(1), IV(1), V(1) |
| II    | D1,D2,D3,D4,E1,E2,E3,B1,B2,B3,B4 | XIII(2), I(2), II(2), IX(2), X(1), XI(1), XII(1), III(1), VI(4), IV(1), V(1), VIII(2) |

3.11. Alternative Layout Construction
After grouping machines, 3 types of alternative layouts are designed which will then be selected based on the moment of displacement and line efficiency rate [12].

The chosen layout is the second alternative with the lowest moment of displacement 831051.9 meter/month and line efficiency rate 82.77% [13]. The chosen alternative can be seen in Figure 6.

Figure 6. Chosen Layout

3.12. Proposed Process Activity Mapping
Through the proposed Process Activity Mapping (PAM), the number of operations, transportation, delays, and inspections can be seen as shown in Table 4.

Table 4. Proposed PAM Recapitulation

| Symbol | Amount | Time (sec) | Percentage (%) |
|--------|--------|------------|----------------|
| Operation | 8 | 11054.4 | 77.09 |
| Transportation | 10 | 1952.8 | 13.62 |
| Inspection | 2 | 1333.1 | 9.29 |
| Delay | 0 | 0 | 0.00 |

3.13. Future State Map Depiction
Future State Map of wooden chair production can be seen in Figure 7.
3.14. Calculating Improved Process Cycle Efficiency

The calculation of improved process cycle efficiency is as follows:

\[
\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Manufacturing Lead Time}} = \frac{12387.5}{14340.3} = 86.38\% \quad (4)
\]

\[
\text{Production Improvement} = \frac{\text{Initial Lead Time} - \text{Proposed Lead Time}}{\text{Initial Lead Time}} = \frac{19237.4 - 12387.5}{19237.4} \times \text{Average Finishing Time} = 0.2546 \times 78 \text{ units/day} = 20 \text{ units} \quad (5)
\]

After repaired using the lean manufacturing method, increase in production of 20 units to 98 units / day.

4. Conclusion

Based on the results of the analysis using the lean manufacturing approach, delay or non-value added activities that occur in the production process affect the productivity of the company. It can be seen that after improvements with the lean manufacturing method and layout redesign with the Group Technology Layout method there is a change in the manufacturing lead time from the beginning of 19237.4 seconds to 14340.3 seconds. Improvements using the Lean Manufacturing and Group Technology Layout approaches also increased the process cycle efficiency by 34.15% and increased production per day by 20 units.

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