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Facility Layout Design Through Integration of Lean Manufacturing Method and CORELAP Algorithm in Concrete Factory

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Abstract. The company observed was a company engaged in the manufacture of concrete by producing various types of products used for building construction. At the beginning of the establishment, the factory only produced ready-made concrete. Around 2009 the company began producing concrete poles so that the casting station was in a vacuum and backtracking of material flow occurred and transportation waste occurred. The problem that occurs is the long distance in the batching department with the casting station and creates the presence of backtracking. In addition, there are non-value added activities that occur in the waiting process (delay) and the distance of the material that moves away in the production process. Based on these problems required layout design, then a combined approach for lean manufacturing to reduce activities that do not add value and help with layout improvements using the CORELAP algorithm. The method used to solve this problem is to integrate lean manufacturing methods and CORELAP algorithms. This study aims to obtain the layout design of concrete plant facilities through simplification of the production process to increase the company's production capacity. Obtained process cycle efficiency improvements on the results of the lean manufacturing method approach and increased production capacity per day.

1. Introduction

Facility design is a basic principle in the arrangement the layout of production facilities and work areas that utilize work areas to place machines or other production support facilities and facilitate the movement of materials so that they obtain good, safe and comfortable production processes and working conditions so that they can support efforts to achieve the company's basic objectives [1]

Plant layout and material handling are planning and integration of flow of components of a product to get the most effective and economical interrelation between workers, equipment and material handling, beginning from the reception, through manufacturing, to the delivery of finished products [2].

Companies observed are companies engaged in the manufacture of concrete by producing various types of products used for building construction. At the beginning of the establishment of the factory only produced concrete ready mix. Around the year 2009, the company started to produce the concrete pillar of a stake so that the casting station in place of the empty land and material flow movement occurs backtracking and happens waste of transportation. Backtracking material flow occurred in the batching plant department with the casting department. The production floor of PT. X has a waste of transportation problem that is a long distance in batching plant department with casting station and cause backtracking which can be shown in the initial layout of the production floor this company in figure 1

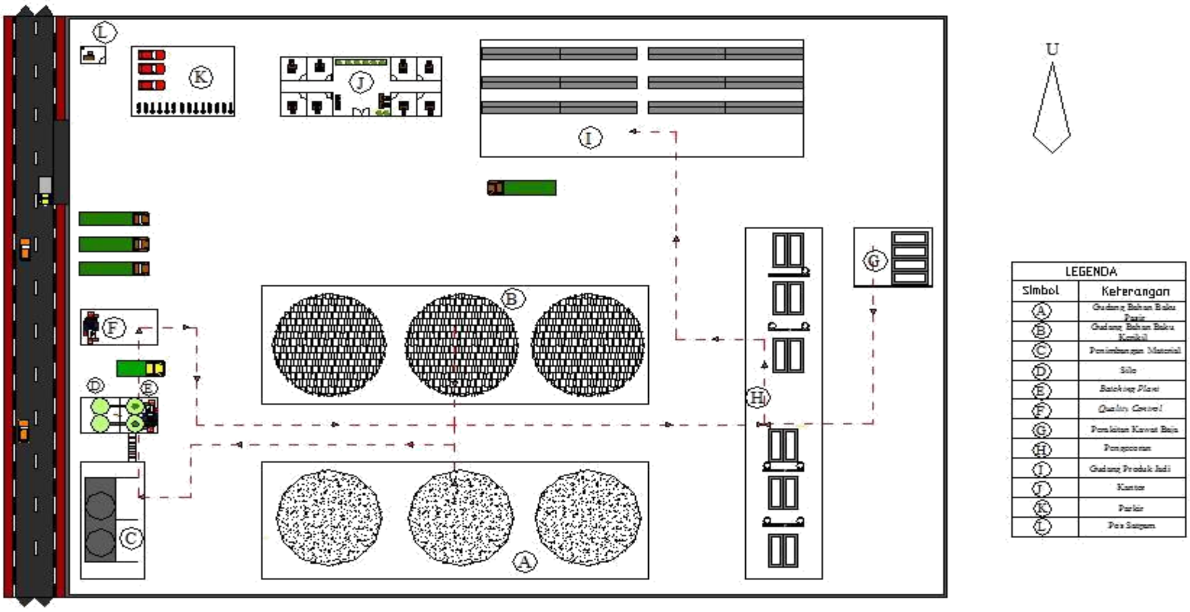

Figure 1. Initial Layout.

The distance of material transfer process will affect the company's production capacity. The more moving material distance, the longer it will take to move the material. This will cause the time to complete a product becomes longer and production result capacity is not maximal. Non-value added activity in the production floor at this factory is the delay process and long distance transportation.

Solving this problem is carried out integration between lean manufacturing and CORELAP algorithm to reduce non-value added so as to increase the efficiency of the production process.

The CORELAP (Computerized Relationship Layout Planning) algorithm uses the proximity relationship rating stated in Total Closing Rating (TCR) in selecting workstation placement. A department's TCR is the number of values of the department's relationship/closeness to other departments [4].

2. Research Method

The steps of this research process consist of collecting, presenting and processing data and analysis and interpretation of initial layout, production flow, activity detail, production volume, lead time and moving distance.

Anaylis and data processing in this research uses the following steps:

Analysis of Current State Map [5, 6]

- Value Stream Manager
- SIPOC Diagram
- Standard Time Calculation
- Waste Identification
- Map Creation for Each Process Category Throughout the Value Stream
- Overall Factory Process Chart
- Process Cycle Efficiency Calculation
- Process Added Mapping Analysis

Improvement using Lean Manufacturing and Relayout [7,8]

- Initial Layout
- Distance Calculation
- Transportation Frequency Calculation
- Moment of Displacement
- Alternative Layout construction using CORELAP Algorithm
- Proposed Process Activity Mapping
- Future State Map

3. Result and Discussion

3.1. Constructing Current State Map

The steps of forming the current state map are as follows:
The source of information for SIPOC Diagam is Production Manager. SIPOC Diagram of Concrete Production can be seen in Table 2.

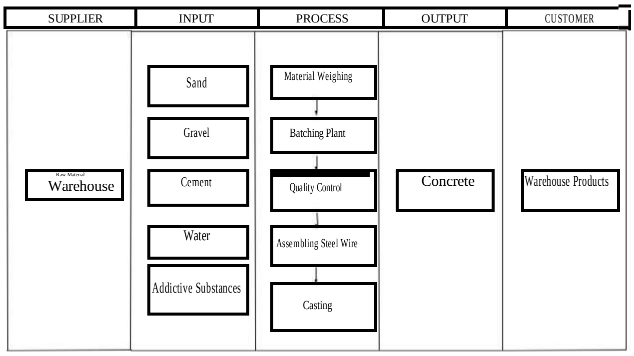

Figure 2. SIPOC Diagram of Concrete Production

The example of standard time calculation for WC 1 is as follow:[9]

$$\text{Standard Time} = \text{Normal Time} \times \frac{100\%}{100\% - \text{All}\ \%} = 741{,}22 \times \frac{100\%}{100\% - 16\%} = 596{,}52 \text{ seconds} \quad (1)$$

The recapitulation of standard time calculation can be seen in Table 1.

Table 1. Standard Time Recapitulation

WC	Normal Time (sec)	Allowance (%)	Standard Time (sec)
I	741,22	16	882.40
II	1157,71	15	1362.01
III	237,57	17	286.23
IV	2919,64	19	3604.49
V	28210,69	17	33988.79

The amount, time and presentation of activity mapping of concrete can be seen in Table 2.

Table 2. Process Added Mapping Recapitulation

Symbol	Amount	Time (sec)	Percentage (%)
Operation	13	31875,5	82,18
Transportation	6	3212,5	13,39
Inspection	1	230,3	0,59
Delay	3	1490,7	3,84

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. Each process along the value stream is combined with material flow and information flow so that it becomes a single flow in the factory [11]. 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 concrete products can be seen in Figure 3.

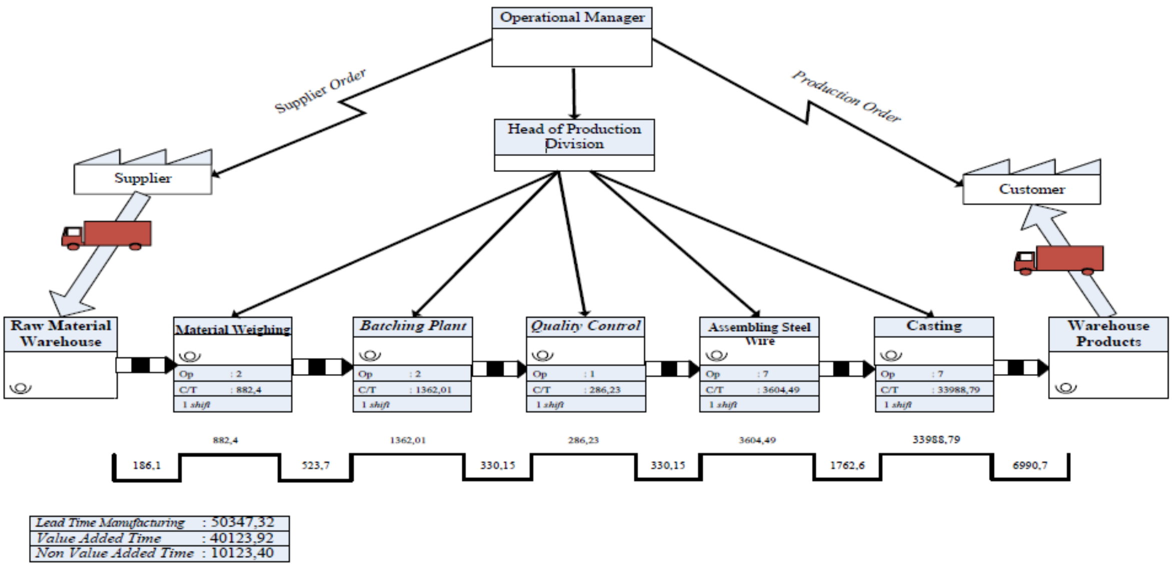

Figure 3. Current State Map of Concrete Product

Based on Figure 7 it can be seen that the results of the calculation of the processing lead time are 50347.32 seconds. The calculation of process cycle efficiency is as follows:[10]

$$\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Manufacturing Lead Time}} = \frac{40123{,}92}{50347{,}32} = 79{,}6\ \% \tag{2}$$

$$\text{Average Finishing Time} = \frac{\text{Total Production (year)}}{\text{Amount of Work Days}} = \frac{10852}{312} = 34{,}78 \approx 35 \text{ units/day} \tag{3}$$

3.2. Application of The CORELAP Algorithm

The CORELAP algorithm calculation uses the proximity relationship expressed with Total Closeness Rating (TCR) as the basis for calculating the selection of workstation placement. The principle of CORELAP Algorithm analysis is to determine the largest layout score, which shows that the relationship between departments is better. This TCR calculation is based on qualitative data of Activity Relationship Chart. The Activity Relationship Chart data is then converted into numerical form with a base rating of TCR values.[11]

Table 3. Base rating of TCR values

Code	TCR Value
A: Absolutely must be nearby	5
E: Very important to be nearby	4
I: Important	3
O: Does not matter	2
U: No need to be nearby	1
X: Not expected to be nearby	0

The Activity Relationship Chart for concrete production is shown in Figure 4.

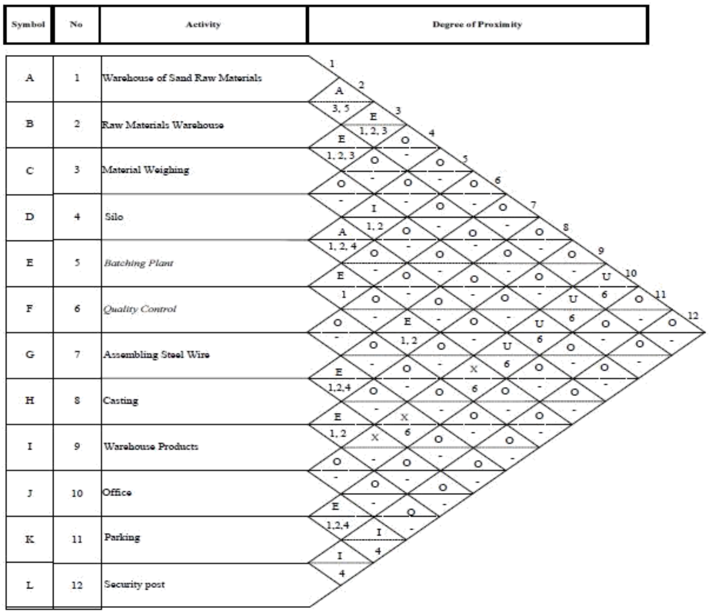

Figure 4. Activity Relationship Chart

After all workstations are placed, the iteration stops. The final shape of the layout design using the CORELAP algorithm is as follows.

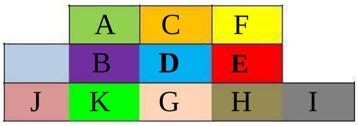

Figure 5. CORELAP Algorithm Result

Here is a proposed layout based on lean manufacturing method and CORELAP algorithm can be seen in Figure 6.

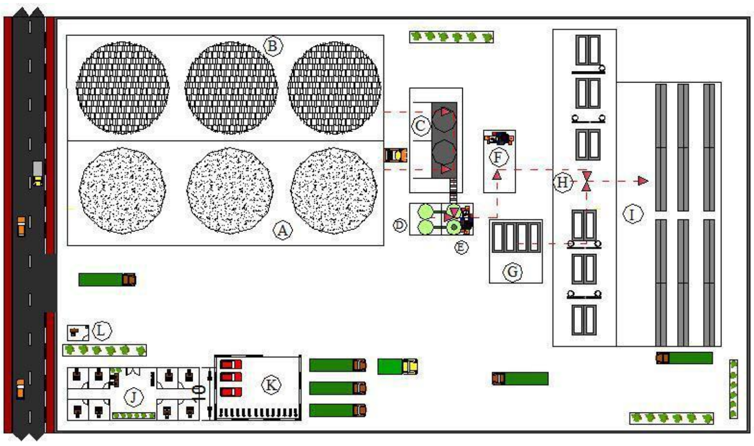

Figure 6. Proposed Layout based on CORELAP Algorithm

3.3. FVSM Construction (Future Value Stream Mapping)

Future Value Stream Mapping (FVSM) is an improvement of proposed conditions that occur from raw materials brought to material weighing. Improvements to the NNVA group, although not prioritized, are eliminated, as much as possible reduced or eliminated whereas non-value added activities (NVAs) must be prioritized for removal [12, 13].

Based on the analysis of 5W and 1H in waste that occurs on the production floor [14], the corrective action that must be taken to reduce the waste is to eliminate the delaying activity and improve the layout to reduce the displacement distance. Repair of layout on the production floor can minimize transportation time by reducing the distance between processes through the application of the CORELAP algorithm.F

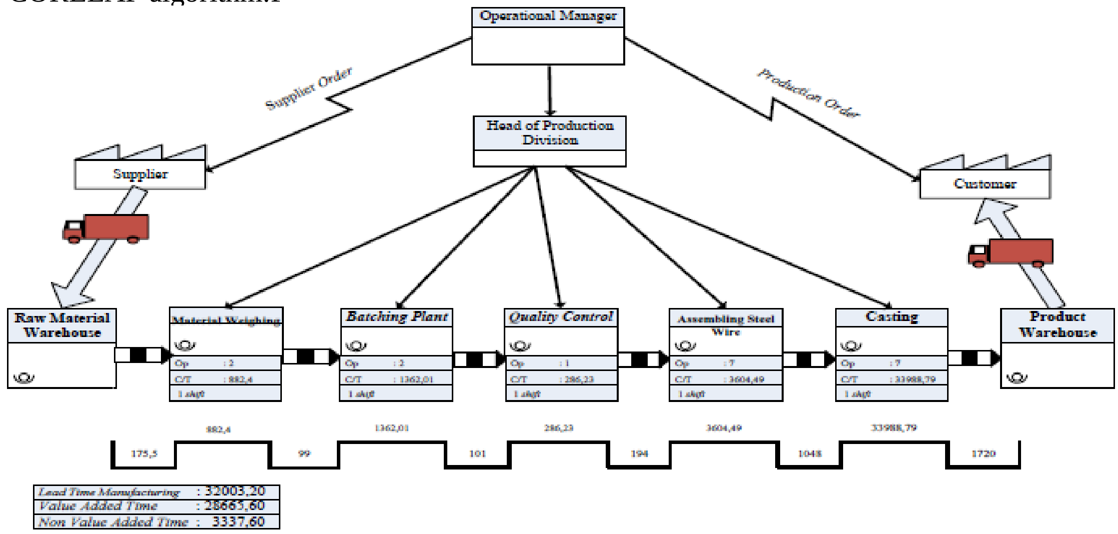

Figure 7. Proposed Future State Map

Based on Figure 7 it can be seen that the results of the calculation of the processing lead time are 32003,20 seconds. The calculation of process cycle efficiency is as follows:

$$\text{Process Cycle Efficiency} = \frac{\text{Value Added Time}}{\text{Manufacturing Lead Time}} = \frac{28665,60}{32003,20} = 90\ \% \quad (4)$$

$$\text{Average Finishing Time} = \frac{\text{Total Production (year)}}{\text{Amount of Work Days}} = \frac{10852}{312} = 34,78 \approx 35 \text{ units/day} \quad (5)$$

$$\text{Production Improvement} = \frac{\text{Initial Lead Time-Proposed Lead Time}}{\text{Innitial Lead Time}} = \frac{50347,32-32003,20}{50347,32} \text{ x Average Finish Time}$$

$$= 0,3643 \text{ x } 35 \text{ units/day} = 13 \text{ units} \quad (6)$$

It was found that the increase of production after using lean manufacturing method was 13 units, so the average speed of completion per day increased to 48 units/day

4. Conclusion

There are activities that are not value-added activities (non-value added) in the production process. Activities that are not worth adding are the delay, transportation, and activities that do not affect the production process. Non-value added activities in concrete production process have an amount of time of 10123.40 seconds. Proposed layout by integrating lean manufacturing method and obtained Activity Relation Chart as input CORELAP algorithm, then the distance of batching plant station with foundry station to 30 meters. Simplification of the production process by lean manufacturing through current state map with actual Process Cycle Efficiency of 79,6% and performed improvement action with lean manufacturing based on the integration of CORELAP algorithm and future state map with process cycle efficiency to 90%. Increased productivity with the actual manufacturing lead time of 50347,32 sec with the average production of 35 units / day and manufacturing lead time of 32003.20 seconds with an average production of 48 units/day after improvement by Lean method Manufacturing with a yield increase for production per day of 13 units/day.

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