



Analysis of Facility Layout Design to Improve Production Efficiency Using the Systematic Layout Planning (SLP) Method: A Case Study at CV. XYZ

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ABSTRACT

The increasing complexity of manufacturing systems requires companies to continuously improve production efficiency through effective facility layout design. CV. XYZ, a manufacturer of 10-ton wooden drums, experiences inefficiencies caused by long material handling distances, backtracking movements, and high operational costs resulting from its existing production layout. This study aims to optimize the facility layout using the Systematic Layout Planning (SLP) method integrated with BLOCPLAN software to identify the most efficient layout alternative. Primary data were collected through direct observation, time studies, interviews with production personnel, and documentation of workstation dimensions and production flow. The proposed layouts were evaluated using Activity Relationship Chart (ARC), Activity Relationship Diagram (ARD), material handling distance, travel time, and material handling cost (OMH). The results indicate that the SLP-based layout reduced material travel distance by 38%, travel time by 38%, and material handling cost by 25%, while the BLOCPLAN layout achieved reductions of 35%, 35%, and 20%, respectively. Compared with the algorithm-generated layout, the manually developed SLP layout provided superior operational efficiency while maintaining existing production constraints. The novelty of this research lies in the quantitative comparison between manual SLP and algorithm-based BLOCPLAN layouts for a complex wooden drum manufacturing process involving 31 production stages. The findings provide practical guidance for improving facility layout efficiency in wood-based manufacturing industries.

1. INTRODUCTION

The development of the manufacturing industry requires companies to improve effectiveness, efficiency, and occupational safety to maintain competitiveness amid increasingly intense global competition (Nasihardani et al., 2024). CV XYZ, as a manufacturer of wooden drums made from wood-based materials, faces operational challenges in the form of long and unstructured process flows. Wooden drums used as cable-winding containers are produced through 31 stages involving storage, cutting, forming, inspection, and material handling activities (Fajaruddin et al., 2025). The irregularity of the layout in

this series of processes leads to wasted time, increased material handling costs, and a higher risk of occupational accidents (Marti-Puig et al., 2024). CV XYZ is a company focused on the production of wood-based containers and has been operating for more than four years. During this period, the company has successfully built a reputation as a manufacturer of high-quality wooden containers with innovative designs and functions. Its products are used across various sectors, including the cable, wire, logistics, and manufacturing industries (Marti-Puig et al., 2024).

Research findings by (Khofiyah et al., 2023) show that optimizing facility layout through the Systematic Layout Planning (SLP) approach resulted in significant



improvements in material flow efficiency. The total material handling distance was reduced by 229.5 meters, which directly led to a reduction in material handling costs (OMH) of IDR 2,243,570.52 per product. This efficiency represents a cost reduction of approximately 54.69% compared to the initial layout condition, demonstrating that layout redesign can enhance operational effectiveness while lowering process costs. Findings by (Nasihardani et al., 2024) identified the shortest material handling distances accompanied by alternative layout designs. SLP has also been applied in small and medium-sized laundry enterprises to improve productivity and customer satisfaction (Khofiyah et al., 2024). Research by (Hernawati Suryatman et al., 2024) focused on improving machine layout in an engineering company producing specialized off-road products for the mining sector.

Meanwhile, (Yulia & Cahyana, 2022) examined facility relay layout using the Systematic Layout Planning and Blocplan methods to minimize material handling distances. Numerous studies indicate that inefficient facility layouts can reduce productivity, disrupt material flow, and affect product quality. Therefore, the objective of this research is directed toward optimizing material flow, reducing transfer distances, shortening cycle time, and minimizing occupational accident risks at CV XYZ. This optimization is necessary to meet operational efficiency demands and support improvements in company productivity. Systematic Layout Planning (SLP) was selected as the main approach because it provides a systematic method for arranging layouts based on activity relationships, space requirements, and material flow patterns (Hasan Bisri & Cahyana, 2023). Previous studies have proven that SLP is capable of reducing waste, improving process flow, and increasing work efficiency across various manufacturing sectors (Roca-Limache et al., 2025). However, most prior research has focused on automotive, metal, and textile industries, while the application of SLP in wood-based industries with high process complexity—such as wooden drum production—has received limited attention.

Previous studies consistently demonstrate that the Systematic Layout Planning (SLP) method effectively improves production performance by reducing material handling distance, minimizing transportation waste, and increasing operational efficiency across various manufacturing sectors. However, most previous studies primarily focused on evaluating a single layout alternative without comparing manually designed layouts with computer-assisted optimization approaches such as BLOCPLAN. Furthermore, studies involving wooden drum manufacturing, characterized by relatively complex production sequences and multiple material handling activities, remain very limited. Therefore, a research gap

still exists regarding the comparative performance of manually developed SLP layouts and algorithm-generated BLOCPLAN layouts under identical production conditions. Evaluating both approaches is essential to determine whether computerized optimization consistently produces superior layouts or whether manual planning based on engineering judgment can provide better practical solutions. This creates a significant research gap and calls for a more adaptive approach.

Accordingly, this study proposes an integrated SLP–BLOCPLAN approach to redesign the facility layout of a wooden drum manufacturing process consisting of 31 production stages. Unlike previous studies, this research quantitatively compares two alternative layouts based on material travel distance, travel time, and material handling cost while considering implementation feasibility within existing production constraints. Blocplan provides an iterative algorithm capable of generating multiple layout alternatives, calculating efficiency values (R-scores), and simulating the impact of layout changes on operational performance (Darunanto et al., 2023). The advantages of Blocplan in reducing material transfer distances, lowering handling costs, and improving activity proximity have been demonstrated in several studies (Halim et al., 2024). The SLP–Blocplan combination offers a more robust approach for quantitatively and qualitatively evaluating and validating layout alternatives (Salins et al., 2024).

The contribution of this research lies in the development of an integrated SLP–Blocplan framework specifically designed to map and optimize the 31 stages of the wooden drum production process at CV XYZ, which has not been comprehensively examined in previous studies. This approach not only provides structural layout improvements but also supports enhancements in occupational safety, material flow efficiency, and waste reduction. Consequently, this research makes a significant contribution to the development of facility layout studies in wood-based industries as well as manufacturing systems with complex process flows. Figure 1.1 illustrates the conceptual framework of this study. The existing facility layout affects production efficiency through material flow patterns, workstation relationships, transportation distance, and material handling costs. The proposed framework integrates the Systematic Layout Planning (SLP) method with ARC, ARD, and BLOCPLAN to generate alternative layouts. These alternatives are evaluated using travel distance, travel time, material handling cost (OMH), and layout efficiency before selecting the most feasible layout for implementation.

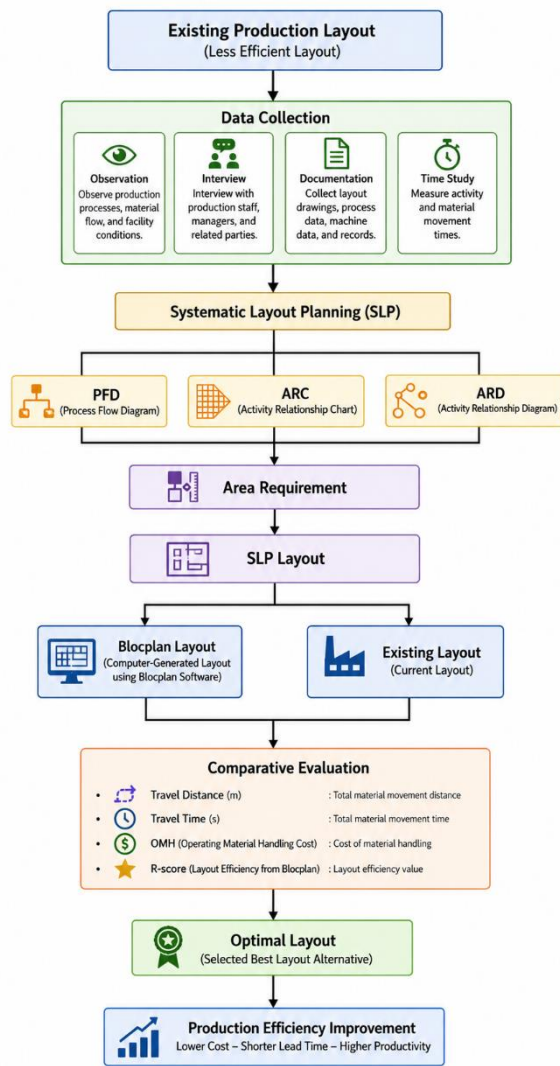


Figure 1.1 Conceptual Framework

2. METHOD

1. Systematic Layout Planning (SLP)

Systematic Layout Planning (SLP) is a structured method for planning factory or industrial facility layouts, involving organized steps to design workflows, production processes, transportation, warehousing, and office spaces (Ali Naqvi et al., 2016). The objective of SLP is to create an efficient layout that reduces waste in time and space while maximizing the flow of materials and information. Accordingly, SLP can increase productivity, reduce costs, improve work quality, and provide a foundation for continuous layout improvement (Febri & Susilawati, 2022). This study employed a quantitative case study approach to redesign the production facility layout at CV. XYZ. The research integrated the Systematic Layout Planning (SLP) method with BLOCPLAN software to evaluate alternative facility layouts based on operational efficiency indicators, including travel distance, travel time, material handling cost, and layout efficiency (R-score). Primary data were collected through four techniques. First,

direct observation was conducted to identify production activities, workflow patterns, and material movement. Second, a time study was performed to measure material transfer time between workstations. Third, semi-structured interviews were conducted with the production manager and engineering personnel to determine workstation relationships and operational constraints. Finally, documentation was used to collect production layout drawings, workstation dimensions, production capacity, and material handling information. The study was conducted under several assumptions. Production volume, product specifications, machine capacity, and the number of operators remained constant during the observation period. In addition, no building expansion was considered, and the production sequence remained unchanged throughout the layout redesign process. The proposed layouts were developed within several operational constraints. Existing building dimensions were maintained, utility locations were fixed, operator safety access was preserved, and material flow followed the original production sequence.

2. Blocplan

Blocplan is a supporting tool used in facility layout improvement by utilizing a hybrid algorithm to optimize the layout redesign process. Its primary benefit lies in minimizing the distance between workstations, which in turn can enhance operational efficiency. In addition, Blocplan functions to develop and strengthen the correlations among workstations, thereby making the production flow more integrated and effective (Kustriyanto et al., 2016). Blocplan analysis is applied to each pair of machines or workstations with sequential process flows by calculating the rel-distance value (Heragu, 2008). The calculation results are then aggregated to update the rel-distance score. The proximity value can be determined using the following equation:

$$\text{Proximity Value} = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{dijRij} \quad (1)$$

Meanwhile, the R-score value is obtained using the following equation:

$$\text{R-score} = \frac{\sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{RijDij}}{\sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{Rij}} \quad (2)$$

After that, Blocplan calculates the upper and lower bounds and then determines the normalized rel-distance value, referred to as the R-score, as shown in the following equation:

$$\text{R-score} = 1 - \frac{(\text{nilai jarak relatif} - \text{batas bawah})}{(\text{batas atas} - \text{batas bawah})} \quad (3)$$

The R-score value obtained from Blocplan calculations is considered optimal when it approaches 1, while values closer to 0 indicate less optimal results ($0 < \text{R-score} < 1$). The validated ARC served as the primary input for BLOCPLAN software. Several alternative layouts were automatically generated and evaluated based on adjacency

score, R-score, material handling distance, travel time, and material handling cost. The layout with the highest operational efficiency and implementation feasibility was selected as the recommended design. In its software-based

$$\text{OMH/meter} = \frac{\text{Gaji tenaga kerja material handling per tahun}}{\text{Jarak Total}} \quad (1)$$

application, Blocplan requires input data in the form of qualitative information arranged in an Activity Relationship Chart. The degree of relationship between machines is determined by the user; however, the standard values commonly used in Blocplan data processing are as follows:

- Symbol A = 10
- Symbol E = 5
- Symbol I = 2
- Symbol O = 1
- Symbol U = 0
- Symbol X = -10

The Activity Relationship Chart (ARC) was developed through discussions involving the production manager, engineering supervisor, and researchers. To minimize subjectivity, the assigned closeness ratings were validated using direct production flow observations and operational requirements before constructing the Activity Relationship Diagram (ARD).

Tabel 1.1 Layout Evaluation Criteria

Indicator	Unit	Objective
Material Travel Distance	m	Minimize
Travel Time	s	Minimize
Material Handling Cost (OMH)	IDR/day	Minimize
R-score	0–1	Maximize

3. Material Handling and Material Handling Costs

Material handling is the process of handling materials that involves the use of appropriate equipment and methods. In facility design, planning the material handling system is crucial, particularly in relation to layout design. Therefore, facility layout design and material handling design must always be integrated. Material handling cost refers to the costs incurred from managing materials that move from one department to another or from one machine to another. Material handling cost (cost of material movement) consists of wages for personnel who handle materials, investment costs of various material handling equipment used, and other inseparable costs that are included in production costs for processing the finished products.

Material handling costs are calculated using the transfer distance and the cost of movement per meter. The magnitude of these costs is influenced by material flow and the layout used. Once the material movement activities are identified, the OMH (Material Handling Cost) can be

calculated. The mode of transportation and the equipment used in handling activities significantly affect the material handling costs incurred. The cost (OMH) per meter of movement consists of two types, namely:

Manual material handling (human labor), using the following formula:

Material handling using trolley equipment, using the following formula:

$$\text{OMH/meter} = \frac{\text{Biaya alat material handling per tahun}}{\text{Jarak Total}} \quad (2)$$

For the Total Material Handling Cost, the following formula is used:

$$\text{Total OMH} = \text{OMH/meter} \times \text{Jarak tempuh} \quad (3)$$

3. RESULT AND DISCUSSION

CV XYZ is a company that focuses on the wood-based container manufacturing industry. Its products are widely used across various sectors, including the cable, wire, logistics, and manufacturing industries. The main product of CV XYZ is the wooden drum, a wooden container used for cable winding with a capacity of 10 tons. The wooden drum production process consists of 31 stages, which include storage, inspection, forming, and material handling activities. The following is the production process layout for wooden drum manufacturing.

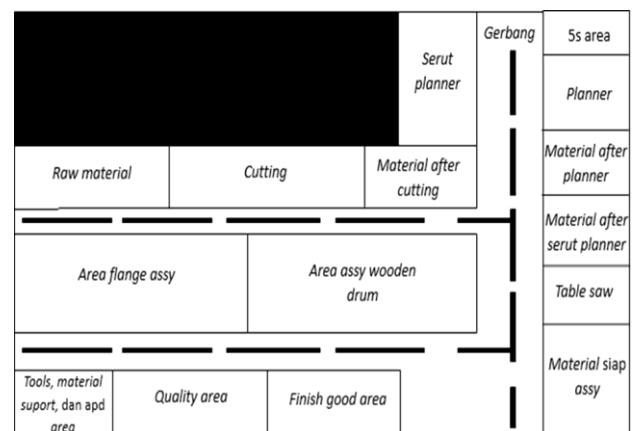


Figure 1.2 Wooden Drum Production Layout

The production process area has an approximate size of 95.4 m². Information regarding the total area is provided, while detailed dimensions of each workstation are presented more clearly in the table below.

Table 1.2 Production Area Dimensions

Workstation	Code	Length (m)	Width (m)	Area (m ²)
Raw material	A	4.1	2.3	9.4
Cuting	B	5.3	2.3	12.9
Materialaftercuting	C	2.7	2.3	6.3
Serut planner	D	2,6	2.2	5.9

Material after serut planner	E	2.4	1.5	3.6
Planner	F	2.4	1.4	3.4
Material after planner	G	2.4	1.3	3.1
Table saw	H	2.4	1.2	2.9
Material siap assy	I	2.4	3.2	7.7
Flange assy	J	6.1	2.1	12.8
Assy wooden drum	K	6.3	2.1	13.2
Finish good area	L	4	1.4	5.6
Quality area	M	3.7	1.4	5.1
Tool, materials suport dan apd area	N	2.5	1.4	3.5
Total area				95.4

The relationships among workstations can be analyzed in greater detail through the presented arc diagram. This diagram provides a visual representation of the workflow and the interconnections between one workstation and another, making it easier to understand task distribution, production process flow, and potential efficiencies that can be optimized within the existing work system. The identification of proximity factors among facilities was conducted through discussions with the engineering team and the production manager. The arc diagram can be seen in Figure 1.3 below.

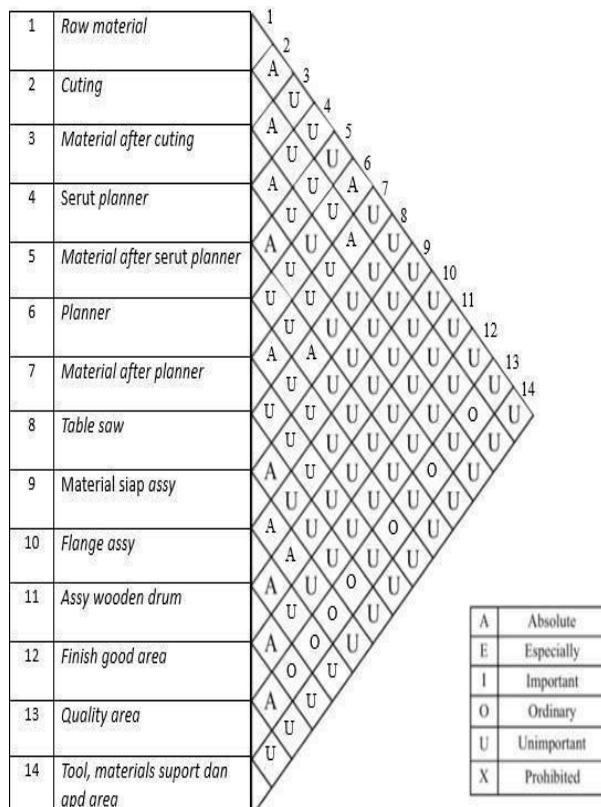


Figure 1.3 ARC Diagram

After designing the ARC diagram and determining the degree of closeness between workstations, the next stage is the preparation of the ARD diagram. The ARD diagram can be seen in Figure 1.4 below.

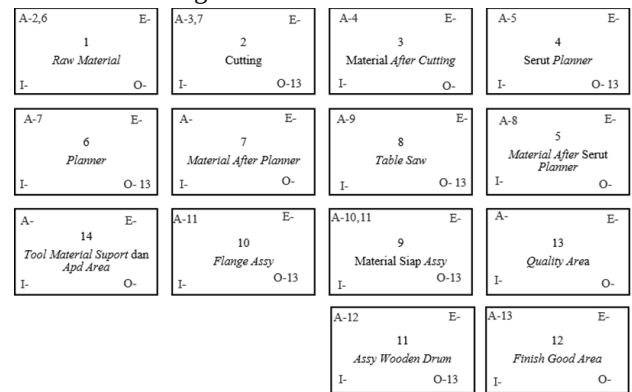


Figure 1.4 ARD Diagram

Based on the results of the SLP method analysis above, a layout design adjusted to the actual conditions of the production area was obtained. The proposed layout is presented as follows:

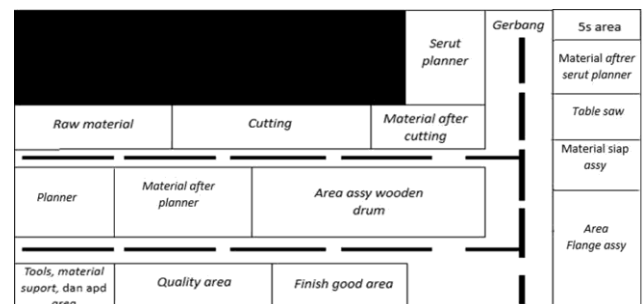


Figure 1.5 Proposed Layout Using the SLP Method

The data collected in the previous stage were subsequently analyzed and processed using the Blocplan approach to obtain outputs relevant to the focus and objectives of this study. Based on the results of the analysis using the Blocplan method, a layout recommendation considered the most optimal was obtained. This layout was selected because it meets the criteria of material flow efficiency, appropriate proximity between workstations according to their level of importance, and a minimal number of unnecessary material movements.

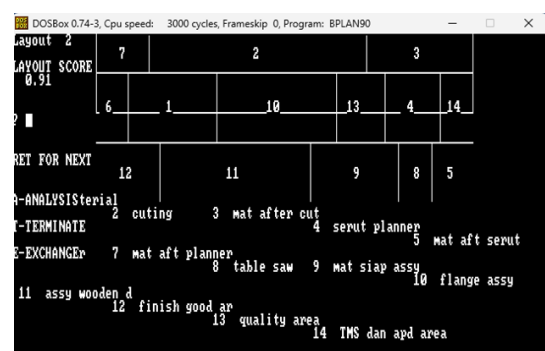


Figure 1.6 Proposed Layout Using Blocplan Software

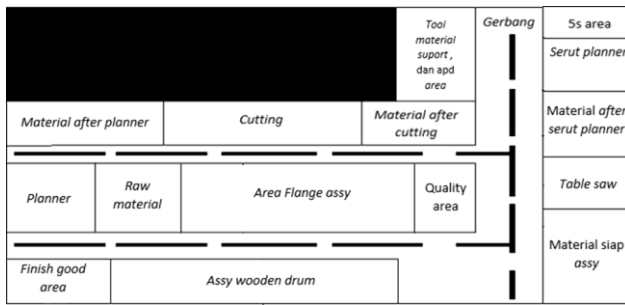


Figure 1.7 Proposed Layout Using Blocplan Software

The analysis of the collected data was structured to support the achievement of the research objectives, based on the methods described in the previous chapter. The main focus of the analysis is facility layout efficiency. The discussion is directed toward interpreting the analysis results, examining their relationship with the underlying theories, and assessing their suitability with actual conditions in the field. For the initial layout data, with a material travel distance of 59.6 meters, a material transfer time of 62.6 seconds, and a material handling cost of IDR 1,669,335 per day, the following results were obtained:

Layout	OMH/Day		Reduction Difference		Percentage Reduction			
	Initial	Proposed	Travel Distance	Travel Time	OMH	Travel Distance	Travel Time	OMH
Proposal 1	Rp1.669.335	Rp1.248.711	22,5	23,64	Rp420.624	38%	38%	25%
Proposal 2	Rp1.669.335	Rp1.342.326	21,1	22,17	Rp327.009	35%	35%	20%

4. CONCLUSION

Based on the results of the research on facility layout design using the Systematic Layout Planning (SLP) method and Blocplan software, the resulting layout designs can be summarized as follows:

1. Among the proposed alternatives, the SLP-based layout demonstrated the highest operational efficiency by reducing material travel distance by 38%, travel time by 38%, and material handling cost by 25%. These improvements indicate that systematic workstation arrangement significantly enhances material flow and minimizes transportation waste.
2. Based on the results of this study, integrating the Systematic Layout Planning (SLP) method with BLOCPLAN software provides an effective framework for optimizing facility layouts in complex manufacturing environments. Among the proposed alternatives, the SLP-based layout demonstrated the highest operational efficiency by reducing material travel distance by 38%, travel time by 38%, and material handling cost by 25%. These improvements indicate that systematic workstation arrangement significantly enhances material flow and minimizes transportation waste.
3. The scientific contribution of this research lies in the comparative evaluation of manually developed SLP

layouts and algorithm-generated BLOCPLAN layouts under identical production conditions. Unlike previous studies focusing solely on layout redesign, this research demonstrates that engineering judgment combined with systematic planning can outperform computerized optimization when implementation feasibility is considered.

4. From an industrial perspective, the proposed layout offers a practical solution for improving production efficiency without requiring major facility expansion or significant investment. Nevertheless, the study is limited to a single case company and primarily evaluates operational efficiency. Future research is recommended to incorporate discrete-event simulation, ergonomic analysis, digital factory concepts, and comprehensive economic feasibility assessment to further validate facility layout optimization strategies.

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