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Optimization of Production Process with Re-Planning of Logistic Facility Layout Using Systematic Layout Planning Method (Case Study in the Lubricant Manufacturing Industry)

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ABSTRACT

This research investigates the optimization of production processes through the redesign of logistics facility layouts. The research was conducted in a lubricant manufacturing industry that commands approximately 30% of Indonesia's lubricant market share. The factory has experienced bottlenecks in material and finished goods movement due to a threefold increase in production capacity, from 50-67 million liters to 176 million liters per year. This condition has led to wasted time and costs, necessitating improvements in material handling. This study aims to quantitatively measure and analyze the impact of facility layout redesign using the Systematic Layout Planning (SLP) method and compare it with block plan software simulation. The research methodology involves data collection, material flow analysis, and proposed layout design. Following the implementation of the proposed SLP layout, there was an efficiency increase of 15.56% in rectilinear distance (reducing to 691.4 m), 12.46% in OMH (reducing to IDR 2,451,421) and 12.31% in moment (reducing to 15744). Meanwhile, the proposed Bloc plan layout demonstrated more significant efficiencies: 51.33% for rectilinear distance (reducing to 398.5 m), 28.17% for OMH (reducing to IDR 2,011,558), and 28.95% for moment (reducing to 12756). Although Bloc plan offers higher efficiency, the SLP method is suggested in this study given the field conditions and available space.

1. Introduction

In the manufacturing industry, facility layout-particularly in warehouses and logistics centres-plays a strategic role in supporting supply chain efficiency. This arrangement involves planning the flow of products, labour, machinery, and material handling processes to ensure optimal utilization of available space [1]. Poor layout design often leads to production bottlenecks, time inefficiencies, and increased material handling costs, which can contribute significantly to total operational expenses [2]. Therefore, facility re-layout is essential as part of continuous improvement initiatives to achieve cost efficiency, improved quality, faster production processes, and enhanced service levels [3]. Productivity is defined as the ratio between output and labour input over a specific period of time [4]. Productivity improvement can be achieved through cost reduction, process acceleration, quality enhancement, and effective resource utilization [5, 6, 7]. Among various improvement strategies, efficient facility layout design remains one of the most widely adopted approaches, as it directly affects the speed and continuity of production processes [1].

This study focuses on a lubricant manufacturing industry with an approximate market share of 30% in Indonesia, which has experienced a significant production increase from 67 million to 176 million liters per year. The production facility is in Marunda-Jakarta while the distribution warehouse is situated 42 km away. This rapid growth has led to decreased logistics efficiency and stagnation in Overall Equipment Effectiveness (OEE).

Previous studies indicate that demand fluctuations can increase work-in-process queues, the waiting times, and reduce machine performance, ultimately leading to OEE stagnation [8, 9]. Empirical evidence further shows that during periods of high demand variability, machines tend to experience lower utilization rates and production times that deviate from takt time, resulting in a significant decline in OEE [21]. This decline is primarily caused by imbalances between production capacity and actual demand, which increase machine idle time and setup frequency, extend queue lengths, and degrade overall system performance. Additionally, inefficient facility layouts contribute to longer material transfer distances and reduced production efficiency [10, 11]. Layout optimization combined with the implementation of Total Productive Maintenance (TPM) has been shown to sustain machine performance and logistics efficiency during demand surges [12, 13, 14].

The current facility layout condition results in non-ergonomic material movement, increased travel distances, and elevated occupational safety risks. Inefficient material handling activities can lead to higher energy consumption, accelerated equipment wear, and increased accident potential. Therefore, minimizing travel distance and material handling costs becomes a strategic priority for achieving competitive logistics efficiency. Systematic Layout Planning (SLP), developed by Muther (1987), offers a comprehensive approach for structured facility layout redesign. SLP analyzes activity relationships, material flows, space requirements, and qualitative factors such as supervision and workplace safety. Several studies have demonstrated that the implementation of SLP can significantly reduce material handling costs and improve productivity [1], [2], [7].

However, the application of SLP in industries with limited space and complex processes remains challenging. This study aims to evaluate the effectiveness of SLP within the specific context of the lubricant manufacturing industry, focusing on measuring the impact of layout redesign on reducing material handling distances and costs. Specifically, this research aims to: (1) develop a facility layout design capable of significantly minimizing material handling travel distances; and (2) design a more efficient production and distribution flow to reduce material handling costs, while considering spatial constraints and opportunities for optimal space utilization. Through a systematic and data-driven approach, this study is expected to provide a foundation for strategic decision-making in optimizing the company's overall logistics system.

2. Method

2.1 Research Design

This study adopts a quantitative research approach with an experimental design, aiming to evaluate the effectiveness of facility layout and distribution route modifications in optimizing material handling processes and reducing downtime that affects Overall Equipment Effectiveness (OEE). The research employs a one-group pretest–post-test design, in which OEE values before and after the implementation of the proposed changes are compared. The research procedure consists of three main stages: (1) collection of historical data related to transporters, downtime, warehouse capacity, and production volume; (2) implementation of trial modifications to distribution routes and warehouse layout; and (3) comparative analysis of OEE values before and after the changes. The effectiveness of the intervention is determined based on the extent of improvement in OEE values following the implementation of the modified system. A significant increase in OEE indicates that the proposed layout and distribution adjustments contribute positively to operational performance.

2.2 Data Analysis

In this study, data analysis is conducted systematically to understand and optimize material flow within the production process, with the objective of improving material handling efficiency. The analysis begins with the identification of material flow using key analytical tools, particularly the Material Flow Diagram. The Material Flow Diagram provides a visual representation of material movement using graphical symbols, such as arrows (indicating direction of movement), circles (representing operations), and straight lines (denoting transfer paths). This visualization facilitates the identification of inefficiencies, excessive movement, and potential bottlenecks within the system. The overall research framework adopted in this study is illustrated in Figure 1, which outlines the sequence of analysis from problem identification to layout optimization and performance evaluation.

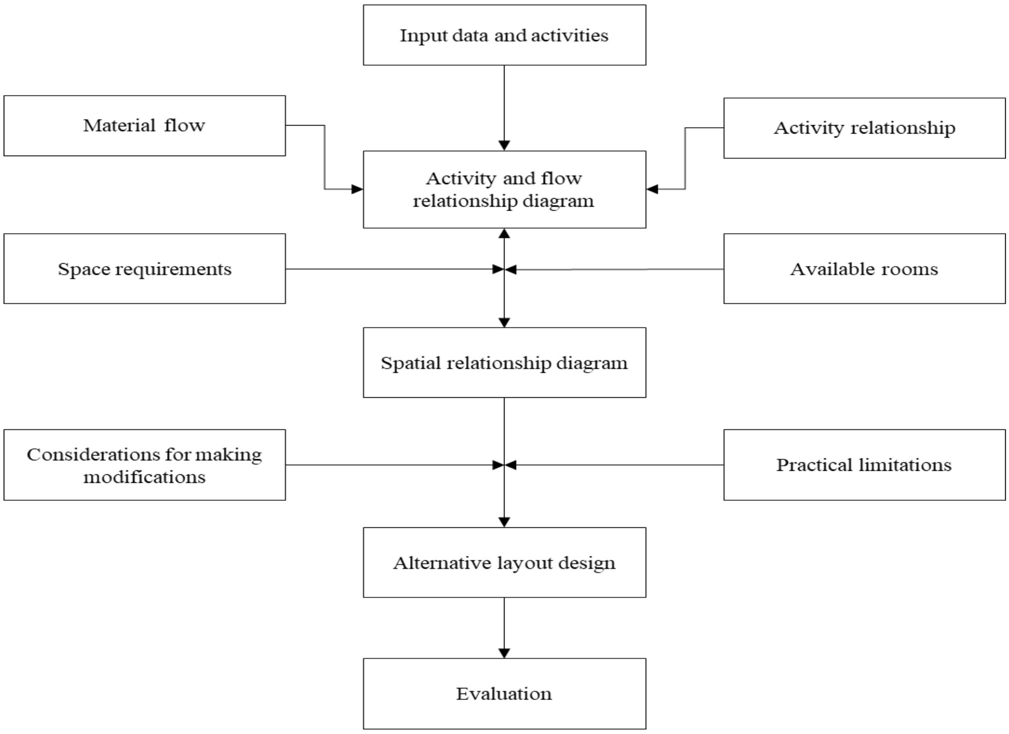

Fig.1. Study framework

In this study, the Systematic Layout Planning (SLP) method, developed by Muther (as cited in Wignjosoebroto, 2009), is employed as the primary approach for facility layout redesign. The SLP method provides a structured framework to analyze activity relationships, material flow, and space requirements in order to achieve an efficient layout configuration. The steps implemented in this study are as follows: (1) Development of Activity Relationship Chart (ARC): The relationships among production activities are mapped using an Activity Relationship Chart (ARC) to identify the degree of functional closeness between work areas. This step helps determine which departments or stations should be located near each other. (2) Preparation of Activity Relationship Worksheet (ARW): The ARC is further detailed into an Activity Relationship Worksheet (ARW), which quantifies the closeness ratings and provides justification for each relationship. This serves as the basis for determining the relative positioning of each functional area. (3) Block Template Development: Based on the ARW, activity blocks are arranged into a visual representation (block template) to illustrate spatial requirements and interrelationships among different work areas. (4) Construction of Activity Relationship Diagram (ARD): The Activity Relationship Diagram (ARD) visualizes the relationships among activities using block representations, indicating the degree of closeness between areas derived from ARC and ARW analyses. (5) Proposed Layout Design: The layout design focuses on key workstations, such as the depalletizer and raw material storage area, with the objective of optimizing production flow and minimizing unnecessary material movement. (6) Development of Alternative Layouts Using Microsoft Visio: Based on the ARD results, several alternative layouts are generated while considering spatial constraints and functional requirements. These layouts are visualized using Microsoft Visio software. (7) Calculation of Material Handling Distance and Cost: The total distance of material movement between work areas is calculated and subsequently converted into material handling cost based on movement frequency and handling intensity. (8) Construction of From-To Chart: A From-To Chart is developed to document the frequency of material movement and associated costs between workstations with logistical relationships. This tool supports quantitative evaluation of layout efficiency. (9) Evaluation and Selection of Layout Alternatives: The alternative layouts are compared based on space utilization efficiency and material handling cost. The layout with the lowest Material Handling Cost (MHC) is selected as the optimal proposed design. (10) Analysis and Discussion of the Proposed Layout: The selected layout is evaluated in terms of space requirements, efficiency of material flow paths, and potential reduction in material handling costs. (11) Conclusion and Recommendations: The final stage summarizes the research findings, provides practical recommendations for the company, and suggests directions for future research on facility layout improvement.

3. Results and Discussion

3.1 Analysis of the Proposed Layout According to SLP

Systematic Layout Planning (SLP) is a method used to plan facility layouts in a structured and systematic manner. The goal is to create an efficient and optimal layout that maximizes space utilization, improves workflow, and reduces production costs.

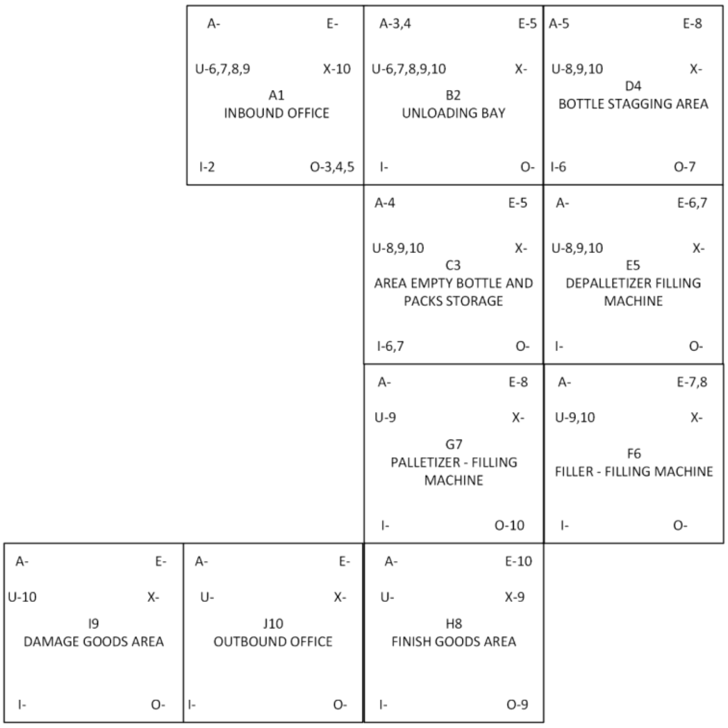

Fig. 2. Block template proposal according to SLP

The proposed SLP layout has slight differences in area B and area D due to changes in position from the initial layout. By following the results of ARC and ARD, the two areas were moved to reduce the distance and the OMH of the proposed layout was recalculated. According to the data listed in Table 1, the moment arising from the proposed SLP layout reached 15744.4 and the largest moment occurred in the Empty Bottle and Packs Storage Area (C) towards the Bottle Stagging Area (I), which was 3514.95. In addition, the smallest moment occurred in the Finish Goods Area (H) towards the damaged goods area (I) at 8.5.

Table 1. OMH calculation of the proposed layout according to SLP

From	To	Conveyance	Cost (IDR)	Frequency	Distance (m)	Moment	Total Cost
Inbound office (A)	Unloading Bay (B)	by Truck	0.00	6.7	87.5	586.25	0.00
Unloading Bay (B)	Area empty bottle storage (C)	Forklift, Trolley & Manual Hand Pallet	161.92	84.3	28.5	2,402.55	389,020.90
Unloading Bay (B)	Bottle staging area (D)	Forklift, Trolley & Manual Hand Pallet	161.92	21.5	37.9	814.85	131,940.51
Area empty bottle storage and packs (C)	Bottle staging area (D)	Forklifts, Trolleys & Manual Hand Pallets	161.92	53.5	65.7	3,514.95	569,140.70
Area empty bottle storage and packs (C)	Depalletizer - filling machine (E)	Forklifts, Trolleys & Manual Hand Pallets	161.92	25.3	130	3,289.00	532,554.88
Area empty bottle storage and packs (C)	Filler - filling machine (F)	Forklifts, Trolleys & Manual Hand Pallets	161.92	1.8	95.9	172.62	27,950.63
Area empty bottle storage and packs (C)	Palletizer - filling machine (G)	Forklifts, Trolleys & Manual Hand Pallets	161.92	4.0	80	320.00	51,814.40

From	To	Conveyance	Cost (IDR)	Frequency	Distance (m)	Moment	Total Cost
Bottle staging area (D)	Depalletizer - filling machine (E)	Forklifts, Trolleys & Manual Hand Pallets	161.92	53.9	53.4	2,878.26	466,047.86
Palletizer - filling machine (G)	Finish goods area (H)	Forklifts, Trolleys & Manual Hand Pallets	161.92	65.6	12.5	820.00	132,774.40
Finish goods area (H)	Damage goods area (I)	Forklifts, Trolleys & Manual Hand Pallets	161.92	0.1	85	8.50	1,376.32
Finish goods area (H)	Outbound office (J)	Forklifts, Trolleys & Manual Hand Pallets	161.92	62.5	15	937.50	151,800.00
Total				**379.2**	**691.4**	**15,744.4**	**2,454,420.60**

From the results of the calculation of the material handling costs for the previously proposed SLP layout, a from to chart was obtained from the proposed systematic layout planning method as shown in Table 2.

Table 2. From-to-chart proposed layout

FROM	TO										TOTAL
	Inbound office	Unloading bay	Empty bottle storage area	Bottle staging area	Depalletizer filling machine	Filler-filling machine	Palletizer filling machine	Finished goods area	Damaged goods area	Outbound office	
Inbound office											0
Unloading bay			389,021	131,941							520,961
Empty bottle storage area				569,141	532,555	27,951	51,814				1,181,461
Bottle staging area											466,048
Depalletizer filling machine											
Filler-filling machine											
Palletizer filling machine								132,774			132,774
Finished goods area									1,376	151,800	153,176
Damaged goods area											
Outbound office											
Total			**389,021**	**701,081**	**532,555**	**27,951**	**51,814**	**132,774**	**1,376**	**151,800**	**2,454,421**

3.2 Analysis of the Proposed Block Plan Layout

Based on the simulation results by producing 20 alternative layouts, the values obtained are as shown in Figure 3.

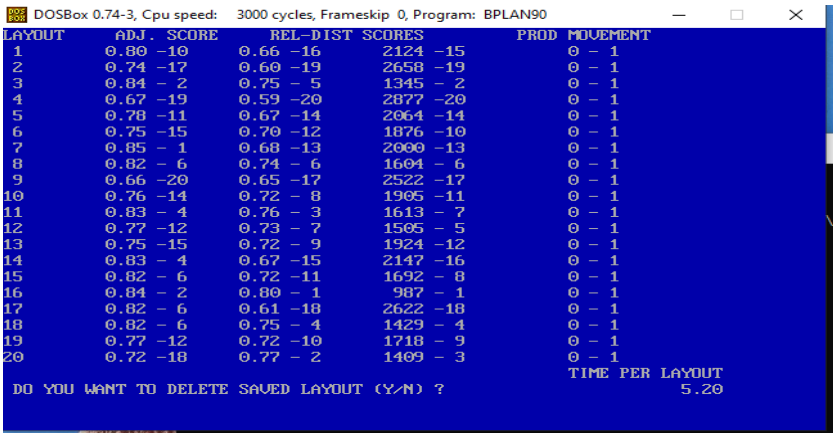

Fig. 3. Score results from 20 alternative block plan layouts

From the data generated by the proposed block plan layout, a recalculation of the OMH from the proposed block plan layout was performed. According to the data listed in Table 3, the moment arising from the proposed block plan layout reached 12756.8 and the largest moment occurred in the Palletizer - Filling Machine (G) area towards the Finish Goods Area (H), which was 3,377.74. In addition, the smallest moment occurred in the Finish Goods Area (H) towards the damaged goods area (I) at 7.25.

Table 3. OMH layout calculation of proposed block plan

From	To	Conveyance	Cost (IDR)	Frequency	Distance (m)	Moment	Total Cost
Inbound office (A)	Unloading bay (B)	by Truck	0.00	6.7	49.8	333.66	0.00
Unloading bay (B)	Empty bottle storage area (C)	Forklift, Trolley & Manual Hand Pallet	161.92	84.3	28.71	2,420.25	391,887.37
Unloading bay (B)	Bottle staging area (D)	Forklift, Trolley & Manual Hand Pallet	16.92	21.5	20.68	444.62	71,992.87
Empty bottle storage and packs area (C)	Bottle staging area (D)	Forklift, Trolley & Manual Hand Pallet	16.92	53.5	37.29	1,995.02	323,032.83
Empty bottle storage and packs area (C)	Depalletizer - filling machine (E)	Forklift, Trolley & Manual Hand Pallet	16.92	25.3	15.27	386.33	62,554.72
Empty bottle storage and packs area (C)	Filler - filling machine (F)	Forklift, Trolley & Manual Hand Pallet	16.92	1.8	23.94	43.09	6,977.46
Empty bottle storage and packs area (C)	Palletizer - filling machine (G)	Forklift, Trolley & Manual Hand Pallet	16.92	4.0	38.09	152.36	24,670.13
Bottle staging area (D)	Depalletizer - filling machine (E)	Forklift, Trolley & Manual Hand Pallet	16.92	53.9	23.3	1,255.87	203,350.47
Palletizer - filling machine (G)	C	Forklift, Trolley & Manual Hand Pallet	16.92	65.6	51.49	3,377.74	546,924.31
Finished goods area (H)	Damaged goods area (I)	Forklift, Trolley & Manual Hand Pallet	16.92	0.1	72.49	7.25	1,173.76
Finished goods area (H)	Outbound Office (J)	Forklift, Troli dan Manual Hand Pallet	161.92	62.5	37.45	2,340.63	378,994.00
Total				**379.2**	**398.5**	**12,756.8**	**2,011,557.91**

After calculations and layout changes were made using the SLP method, the following results were obtained, which can be seen in the recapitulation table (Table 4).

Table 4. Summary of results

Method	Rectilinear distance (m)		Material Handling Cost (IDR)		Moment	
	Result	Difference	Result	Difference	Result	Difference
Original Layout	818,9	-	2.800.474	-	17.955	-
SLP proposed layout	691,4	127,5	2.454.421	346.053	15.744	2211
Proposed block plan layout	398,5	420,4	2.011.558	788.916	12.756	5199

3.3 Efficiency Calculation of Proposed SLP Layout

From the proposed alternative layout that has been made by changing the 2 work area locations in the Unloading Bay (B) and Bottle Stagging Area (D), the next step is to evaluate the results of the SLP method layout design by finding the level of efficiency. In finding the efficiency value in this study, namely by using the total recliner distance between the initial layout of the material handling work area and after the layout changes with the SLP proposal. The total recliner distance of the area that has an activity relationship in the initial layout is 818.9 m while for the SLP proposed layout it is 691.4 m. The formula for calculating the recliner distance efficiency is as follows:

$$Efficiency = \frac{Layout\ original\ distance\ -\ Layout\ proposed\ distance}{Layout\ original\ distance}\ x\ 100\%$$

$$Efficiency = \frac{818{,}9\ -\ 691{,}4}{818{,}9}\ x\ 100\%$$

$$Efficiency =\ 15{,}56\%$$

From the distance efficiency calculation, an efficiency value of 15.56% was obtained. After that, an efficiency calculation was performed in terms of the OMH value between the initial layout and the proposed layout. The total OMH value in relation to activities in the initial layout was IDR. 2,800,474 per day, while for the proposed SLP layout it was IDR. 2,451,421 per day. Therefore, the formula for calculating OMH cost efficiency is as follows:

$$Efficiency = \frac{OMH\ layout\ original\ -\ OMH\ layout\ proposed}{OMH\ layout\ original} x\ 100\%$$

$$Efficiency = \frac{2.800.474 - 2.451.421}{2.800.474} x\ 100\%$$

$$Efficiency = 12{,}46\%$$

From the OMH value efficiency calculation, an efficiency value of 12.46% was obtained. After that, the efficiency calculation was carried out in terms of the moment value between the initial layout and the proposed layout. The total moment value in the activity relationship in the initial layout was 17955, while for the proposed SLP layout it was 15744. The formula for calculating the moment efficiency is as follows:

$$Efficiency = \frac{Moment\ layout\ original\ -\ Momentlayout\ proposed}{Moment\ layout\ original} x\ 100\%$$

$$Efficiency = \frac{17955 - 15744}{17955} x\ 100\%$$

$$Efficiency = 12{,}31\%$$

From the calculation of the moment value efficiency, the moment efficiency value obtained was 12.31%.

3.4 Calculation of Block Plan Layout Efficiency Value

From the proposed alternative layouts created through simulations in the block plan software, the next step is to evaluate the results of the block plan layout design by determining its efficiency level. To find the efficiency value in this block plan, the total reclinear distance between the initial layout of the material handling work area and the one after the simulation with Blocplan is used. The total reclinear distance of the area that has an activity relationship in the initial layout is 818.9 m, while for the proposed block plan layout it is 398.5 m., so the formula for the calculation is as follows:

$$Efficiency = \frac{Layout\ original\ distance\ -\ Layout\ proposed\ distance}{Layout\ original\ distance} x\ 100\%$$

$$Efficiency = \frac{818{,}9\ -\ 398{,}5}{818{,}9} x\ 100\%$$

$$Efficiency = 51{,}33\ \%$$

From the distance efficiency calculation, an efficiency value of 51.33% was obtained. After that, an efficiency calculation was carried out in terms of the OMH value between the initial layout and the proposed layout. The total OMH value in relation to activities in the initial layout was IDR. 2,800,474 per day, while for the proposed block plan layout it was IDR. 2,011,558 per day. Therefore, the formula for calculating efficiency is as follows:

$$Efficiency = \frac{Original\ OMH\ layout - Proposed\ OMH\ layout}{Original\ OMH\ layout} x\ 100\%$$

$$Efficiency = \frac{2.800.474 - 2.011.558}{2.800.474} x\ 100\%$$

$$Efficiency = 28{,}17\ \%$$

The OMH efficiency calculation yielded a value of 28.17%. The efficiency was then calculated in terms of the moment values between the initial layout and the proposed layout. The total moment value in the activity relationship for the initial layout was 17955, while for the proposed block plan layout it was 12756. The formula for calculating the efficiency is as follows:

$$Efficiency = \frac{Oroginal\ momen\ layout - Proposed\ momen\ layout}{Original\ momen\ layout}\ x\ 100\%$$

$$Efficiency = \frac{17955 - 12756}{17955}\ x\ 100\%$$

$$Efficiency = 28{,}95\%$$

From the calculation of the moment value efficiency, the moment efficiency value obtained was 28.95%. In the transition process from the initial layout to the proposed layout, an Occupational Safety and Health risk analysis is a crucial step that cannot be overlooked. The involvement of relevant departments in this process is crucial to ensure that the changes made do not create the potential for detrimental incidents or near misses. One key aspect that must be analyzed is the risk of workplace accidents. Changes in material movement paths or the placement of heavy equipment such as forklifts can significantly impact safety levels in the production area. Material movement paths that are not ergonomically designed or integrated with the workflow can extend travel distances, increase energy consumption, accelerate equipment wear, and increase the risk of workplace accidents due to potential collisions or operational errors.

In addition to safety aspects, employee health is also a crucial consideration in layout redesign. Factors such as ergonomics, lighting, air circulation, and movement space significantly influence work comfort. A work environment designed with ergonomics in mind can improve overall worker morale and operator productivity. However, layout changes made without careful planning also have the potential to disrupt production. Reorganizing equipment, moving machinery, or constructing new areas can lead to production downtime. Therefore, structured technical planning is required to ensure a smooth transition process and minimize disruption to production. Another crucial aspect is the potential for contamination, especially if there are areas that generate dust, dirt, or waste. Proximity between contamination sources and sensitive production areas must be avoided to prevent the spread of particles or materials that could compromise product quality. In this context, mapping production areas based on cleanliness and risk levels is an important preventative measure. Therefore, any layout changes must be accompanied by comprehensive identification and mitigation of OHS risks. This approach not only ensures that efficiency improvements are achieved but also safeguards the safety and well-being of employees, the company's primary asset. The combination of operational efficiency and a commitment to OHS will create a more productive, safe, and sustainable work environment. One of the fundamental principles in facility layout planning is flexibility, namely the layout's ability to adapt to various changes, whether in technology, communication systems, or the dynamics of consumer needs. In the increasingly competitive manufacturing industry, flexibility is a strategic value that enables companies to remain adaptive to market changes. The implementation of the proposed layout using the SLP and block plan approaches in this study is aimed not only at increasing efficiency but also at strengthening the adaptive capacity of the production system. A flexible layout enables manufacturers to anticipate changes in processes, volumes, and product types more efficiently.

First, a layout optimized through a systematic approach such as SLP helps reduce bottlenecks in the production process. By streamlining workflows and logically reorganizing facilities, potential bottlenecks that can slow productivity can be significantly minimized. Second, the new layout also improves material flow, as shorter and more efficient travel distances between processes speed up material movement. This supports a more agile production system that is responsive to changes in volume and product variety. Third, improvements in space utilization, both horizontally and vertically, contribute to increased flexibility, especially in facing future expansions or changes in facility configuration. Optimally utilized space allows for rapid adaptation to changing production and storage needs.

Fourth, layout efficiency also strengthens a company's ability to respond to fluctuations in consumer demand. A well-structured layout better prepares a company to reorganize production lines or introduce new product variants without disrupting the stability of the ongoing process. In the context of this research, although test results indicated that the block plan method provided higher material flow efficiency, the SLP method was chosen because it better suited field conditions and available space constraints. This confirms that in industrial practice, method selection is not solely based on efficiency figures but also considers aspects of flexibility and long-term design sustainability. Flexibility is not only an added value but a primary requirement in designing a robust and adaptive production system. This study compares the results of facility layout optimization using the Systematic Layout Planning (SLP) method and block plan simulation with findings from relevant previous research. This study focuses on material movement distance efficiency, material handling costs (OMH), and movement moments. The initial layout analysis results indicate an OMH of IDR 2,800,474 per day with a rectilinear movement distance of 818.9 meters. The following is a comparison of the efficiencies achieved by the two proposed methods:

1. Proposed SLP Layout
   - Increased rectilinear distance efficiency by 15.56% (to 691.4 m).
   - Increased OMH efficiency by 12.46% (to IDR 2,451,421).
   - Increased moment efficiency by 12.31% (to 15,744).
2. Proposed Block Plan Layout
   - Increased rectilinear distance efficiency by 51.33% (to 398.5 m).
   - Increased OMH efficiency by 28.17% (to Rp 2,011,558).
   - Increased moment efficiency by 28.95% (to Rp 12,756).

Although the calculation results show that the block plan method provides higher efficiency, this study recommends using the Systematic Layout Planning (SLP) method, taking into account field conditions and available space limitations. This choice is not only contextual but also supported by the findings of several previous studies demonstrating the effectiveness of the SLP method in optimizing facility layout and reducing material handling costs. Research [15], for example, successfully reduced material handling costs by 17.305% in the sandal industry through layout improvements [15]. Rahaju and Dewi also demonstrated success in redesigning the layout of a muffler factory using the LMIP 4 method, which significantly reduced material transfer moments [16]. Although the bloc plan method has proven effective, as demonstrated by Firmansyah, who noted a reduction in travel time in the warehouse area, the SLP-based approach still offers advantages in terms of practical implementation in space-constrained environments [17].

Furthermore, research by [18] demonstrated that the application of SLP can reduce material handling costs by up to 10.98% while simultaneously increasing production capacity by 37.5%, demonstrating that this method has a dual impact on operational efficiency [18]. Another study by Susetyo and Ramos also noted a 13.36% reduction in rectilinear distance and a 16% reduction in material handling costs through a combination of the Group Technology approach and the bloc plan algorithm, confirming that the appropriate method will depend heavily on the needs and characteristics of the production space [19]. In a more recent context, Ariq utilized a combination of the SLP method and SimPy simulation, resulting in a 13.9% reduction in material handling costs while providing a more realistic picture of the overall efficiency of the production system [20]. Thus, a comparison between these two methods demonstrates that both SLP and block planning can positively impact manufacturing process efficiency. However, SLP remains the more recommended choice in the context of this research because it is more adaptive to real conditions in the field and is easier to integrate with a participatory approach in redesigning the layout of small and medium industrial facilities.

4. Conclusion

Based on the analysis of the comparison of the proposed layouts using the Systematic Layout Planning (SLP) and block plan methods, several important findings were obtained. In the proposed SLP layout, significant changes occurred in area B (unloading bay) and area D (bottle staging area), as a result of position adjustments based on the ARC and ARD mapping results. The total moment generated from this layout was 15,744.4, with the highest moment of 3,514.95 during the move from the Empty Bottle and Packs Storage Area to the Bottle Stagging Area. Meanwhile, material handling costs were recorded at IDR 2,454,420.60 and a rectilinear displacement distance of 691.4 meters. In contrast, the Bloc plan layout demonstrated more efficient performance, with a total moment of 12,756.8, material handling costs of IDR 2,011,557.91, and a rectilinear distance of only 398.5 meters. Based on the results summary, the proposed bloc plan layout demonstrated a more significant reduction in rectilinear distance, material handling costs, and moments compared to the proposed SLP layout. The proposed bloc plan layout resulted in a rectilinear distance of 398.5 m, material handling costs of IDR 2,011,558, and moments of 12,756. Meanwhile, the proposed SLP layout resulted in a rectilinear distance of 691.4 m, material handling costs of IDR 2,454,421, and moments of 15,744. A comparison of the efficiency between the initial layout and the proposed SLP layout showed an increase in efficiency.

Overall, the proposed block plan layout provided higher efficiency compared to both the SLP and the initial layout. The efficiencies achieved by block plan included a 51.33% reduction in rectilinear displacement distance, a 28.17% reduction in material handling costs, and a 28.95% reduction in moments. Meanwhile, the SLP layout also demonstrated efficiency improvements, though not as significant as the bloc plan, with rectilinear distance efficiency of 15.56%, material handling cost efficiency of 12.46%, and moment efficiency of 12.31%. Therefore, although block plan is quantitatively superior, the choice of layout method still needs to be adjusted to the spatial context, flexibility, and actual field conditions.

For future research, it is recommended that the proposed layout using the block plan method be considered, given its higher efficiency results in terms of reduced travel distance, material handling costs, and moments. However, given the limitations of field conditions and space availability, the SLP approach remains a more realistic option in the context of this study. Further research should also expand the analysis to other factors that can influence layout efficiency, such as ergonomics, occupational safety, and layout flexibility to changing needs in the future. Furthermore, regular layout simulations can be used as a monitoring strategy to identify potential systematic improvements to maintain operational efficiency. Layout changes should also be accompanied by an OHS risk analysis involving relevant departments to minimize the potential for detrimental incidents or near misses from the planning stage.

Declarations

Author contribution.

- Teddy Wahyudi: data collection, data analysis, final report.
- Humiras Hardi Purba: data analysis, interpretation and evaluation.

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