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Optimizing Layout for Material Handling Cost Reduction Using Blocplan and FlexSim: A Case Study in Screen Printing Production

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ABSTRACT

Small-scale screen printing businesses often face challenges related to limited production space and high material handling costs, which reduce production efficiency. This research aims to design an efficient facility layout and reduce material handling costs at Usaha Sablon XYZ by using the Systematic Layout Planning (SLP) method combined with the BLOCPLAN algorithm and FlexSim. The methodology involves direct observation, interviews, initial layout measurements, and analysis using tools such as Activity Relationship Chart (ARC), Form to Chart (FTC), and Operation Process Chart (OPC). The proposed layouts produce two alternatives, with Layout Proposal 2 showing the best efficiency, reducing total material handling cost from Rp 11.999.965 to Rp 7.734.185,65 a cost reduction of 35.55%. The results indicate that BLOCPLAN and Flexsim was effective within the context of this case study in generating layout alternatives that reduce material handling cost.

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I. INTRODUCTION

In the era of creative industries, the T-shirt screen printing business has grown over time and is now attracting considerable interest from the public [1]. T-shirt screen printing products are no longer viewed as a necessity, but also as a medium of expression and lifestyle. As public interest in screen-printed T-shirts increases, demand for high-quality products with fast turnaround times has also increased. This development has prompted screen printing businesses to find ways to improve production efficiency in order to meet the needs of an increasingly competitive market.

On the other hand, the T-shirt screen printing production process itself involves various activities that require the transfer of materials, such as T-shirts, ink, screens, and other equipment, between production sections. This transfer often takes a considerable amount of time and money, especially material handling costs, which are an important part of overall operating costs. Material handling costs are often considered “hidden costs” because they are not visible in production cost reports, but they have a major impact on business profitability. Material transfer, or material handling, is an activity that plays a crucial role in the production process and is closely related to the layout of industrial facilities to ensure an efficient workflow [2]. In recent years, layout optimization has increasingly incorporated artificial intelligence (AI)-based approaches to improve material flow efficiency and space utilization. [3] demonstrated that AI-driven analysis can enhance warehouse layout design by quantitatively optimizing handling routes and storage positions. This technological advancement shows potential for future integration in small-scale manufacturing systems such as T-shirt screen printing production. In addition to the importance of material handling in production activities, recent research emphasizes that facility layout design should be directly driven by the efficiency of these material movements. [4] proposed a material handling-driven approach to layout design, demonstrating that optimizing the flow of materials within a workspace can significantly reduce handling distances and overall operational costs. This perspective aligns with the objective of this study, which aims to minimize material transfer distance through systematic layout planning. Various approaches to facility layout design have been developed in the manufacturing industry [5], [6] Various approaches to facility layout design have been developed in the manufacturing industry[5]. Provided a comprehensive review of both problem types, showing how modern layout optimization increasingly integrates simulation and algorithmic approaches — a perspective that underpins the methodological direction of this study. providing a comprehensive literature review on facility layout planning and highlighting methods such as mathematical optimization, expert knowledge, and specialized software—which support the diversity of approaches mentioned above. However, these methods have not been widely applied specifically in the small-scale T-shirt printing industry. Most screen printing businesses in Indonesia use conventional layouts, which do not optimize material flow and transfer processes between work stations. In fact, an optimal facility layout can help improve time and cost efficiency in the production process. Therefore, an approach tailored to the characteristics of the small-scale t-shirt screen printing industry is needed to improve production efficiency. One potential method to help overcome this facility layout problem is the BLOCPLAN algorithm, which is designed to propose facility layouts based on material flow requirements and can help optimize material movement routes. With this algorithm, it is hoped that the distance of material movement in screen printing production can be minimized, thereby reducing handling costs and increasing overall efficiency.

The BLOCPLAN algorithm can generate proposed layouts to minimize material movement distances in each production flow. Previous research shows that the BLOCPLAN algorithm has been successfully applied in various industries to improve facility layout efficiency by reducing distance and material handling. For example, a study conducted on Rizki Bakery, a small business in *Bontang*, applied BLOCPLAN to the small business bakery industry and successfully reduced material transfer distance by 3.79 [7].

The study shows that the BLOCPLAN algorithm has the potential to help optimize facility layout, particularly by reducing material transfer distances, which can have a significant impact on cost efficiency. BLOCPLAN-90 utilizes algorithms that focus on repair or replacement processes and construction methods to systematically solve layout problems [8]. Therefore, this study uses the BLOCPLAN algorithm by adjusting it to the characteristics of T-shirt screen printing production in small-scale businesses. The application of this method is also expected to be a practical solution for small-scale screen printing industries in facing increasingly complex production challenges with limited production space and evolving market demands.

This study intentionally restricts its analytical scope to material handling cost (MHC) as the primary performance indicator of layout efficiency. Other operational dimensions such as ergonomics, service time, safety risks associated with material movement, workstation bottlenecks, and machine utilization are acknowledged as relevant but remain outside the boundaries of the present investigation. These aspects are recognized as potential extensions that may enhance the comprehensiveness of layout evaluation in future research.

II. Research Method

This study uses a descriptive quantitative approach that aims to analyze the layout of production facilities at XYZ Screen Printing Business and design a more efficient layout proposal. A quantitative approach was chosen because it allows researchers to measure and analyze data objectively, such as material transfer distances, activity frequencies, and material handling costs incurred during the production process. A similar approach has also been used in previous studies related to layout design to improve production process efficiency [9]. The descriptive method is used to provide a systematic and factual description of the existing layout conditions in the field as a basis for decision making in the design of a new layout [10]. Conducted a similar study integrating the Systematic Layout Planning (SLP) method with FlexSim simulation to evaluate workshop layout performance [11]. Their findings demonstrate that combining layout planning techniques with simulation tools can produce more accurate and realistic assessments of production efficiency, supporting the methodological framework of this research.

This study was conducted at the XYZ Screen Printing Business located in Jejalenjaya, North Tambun, Bekasi. The research focused on the layout of production facilities, particularly the flow of materials such as T-shirts, ink, and screen printing equipment. Improper layout arrangements are known to cause longer material transfer distances, increased material handling costs, and ultimately reduced work productivity, as has been proven in previous studies [12].

The data used in this study consists of primary and secondary data. Primary data was obtained through direct observation of the production process in the field, interviews with business owners and operators to identify obstacles in the existing layout, and measurement of facility dimensions to map actual conditions [10]. Meanwhile, secondary data was obtained from literature, previous research journals, and relevant company documents to support the analysis and layout design [13].

Data analysis was conducted systematically. First, Material Handling Activity (MHA) was calculated to determine the intensity of material movement based on distance traveled and frequency of movement. This approach was also used in previous studies as a basis for analyzing the efficiency of material flow in production layouts [9]. In the context of layout design, AMH is used to calculate the total workload of movement based on the frequency and distance of material movement. Next, a From-To Chart (FTC) is compiled to record and analyze the frequency and direction of material movement between departments. The data obtained will be converted into a graph to facilitate the visualization of the intensity of material movement.

The next step, the Activity Relationship Chart (ARC), is a visual tool used to illustrate the level of interdependence between pairs of production activities or departments [2]. Activity relationship charts are generally expressed in qualitative assessments and are often based on subjective considerations [14]. The technique of planning and analyzing the relationship between activities using the Activity The technique of planning and analyzing the relationship between activities using the Activity Relationship Chart will connect each department or facility area and record the reason codes within the company environment[15], [16]. The proximity value is determined based on the following relationship levels [17]:

A = Highly required, must be close.
E = Very important, needs to be close.
I = Important, should be close.
O = No problem, proximity can be anywhere.
U = Does not require geographical proximity.
X = Proximity is not desirable.

The results of this analysis form the basis for alternative layout planning using the BLOCPLAN algorithm. The relationship ratings used in the ARC, FTC, and OPC were determined based on the production process sequence and the required proximity between activities, supported by insights obtained from operator and owner interviews. As these methods inherently involve qualitative judgement, the assessment reflects observed operational needs rather than numerical weighting.

The BLOCPLAN algorithm is a system for designing facility layouts developed by Donaghey and Pire in the Department of Industrial Engineering, University of Houston. This program is designed to create and evaluate various types of layouts based on the input data provided [7]. Alternative layouts in BLOCPLAN are selected based on three main criteria: R-score, Adj-score, and product movement. The integration of the Systematic Layout Planning (SLP) approach with computational algorithms such as BLOCPLAN has been proven effective in optimizing facility layouts for various manufacturing industries. [18] successfully applied this combination in a garment industry case, resulting in a more efficient production flow and reduced material handling distances. This supports the methodological framework used in the present study. The main objective of BLOCPLAN is to optimize the layout by minimizing the distance between facilities or maximizing the proximity of relationships between facilities [19]. After the layout alternatives are generated with the highest score, the next step is simulation with FlexSim. In line with this, [20] combined the Systematic Layout Planning (SLP) method with lean manufacturing principles to redesign a steel processing facility layout. Their research highlights how structured layout planning can effectively eliminate waste and streamline material flow, supporting the efficiency goals pursued in this study.

The BLOCPLAN layout generation was carried out using the standard default parameter settings of the software, and the selection of alternatives was based on the R-score, adjacency score, and flow suitability values produced by the program. This configuration enables replication without requiring customized parameter adjustment.

FlexSim is object-based simulation software used to visually model and analyze manufacturing systems [21]. FlexSim enables the creation of production facility layout models to identify potential bottlenecks and evaluate layout improvement alternatives more accurately. With this simulation, productivity analysis can be performed with minimal risk and investment, while providing realistic visualizations of real-world operational conditions. This is used to validate manual calculations using the Euclidea Distance measurement method and to evaluate layout efficiency realistically, including the influence of physical obstacles in the field.

The baseline measurements were verified through direct observation during regular operating conditions to ensure that the initial layout representation reflected actual workflow conditions.

Data collection was carried out through direct observation conducted during regular operating hours to capture actual production conditions. The observed workflow and material movement patterns were validated through interviews with operators and the business owner, followed by cross-checking against the documented process sequence. These steps were applied to ensure that the input data used for layout analysis and MHC calculation accurately reflected real operational conditions.

III. Result And Discussion

A. Existing Layout and Production Activities

XYZ Screen Printing Business has a limited production area with 12 main work stations, including screen printing tables, printing machines, raw material storage rooms, packing rooms, and design computers. The existing layout is arranged conventionally without scientific method-based planning, resulting in long material transfer distances, backtracking, and inefficient work flow. Fig. 1 shows the existing layout plan for XYZ Screen Printing Business.

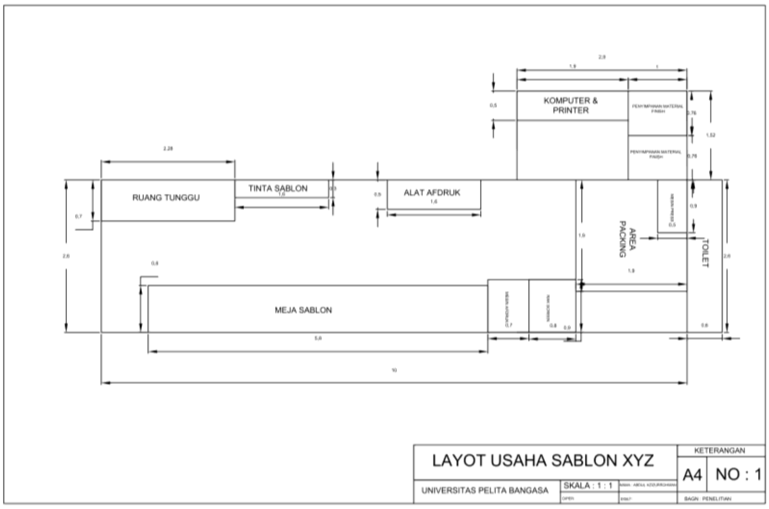


Fig. 1. Initial layout for the XYZ screen printing business

The monthly material handling cost can be determined by knowing the data on monthly labor costs (because the means of transport is human), the frequency of material handling, the total number of workers, and the total distance of material handling. The monthly labor cost is known to be Rp 4.000.000. In an 8-hour workday, material handling is carried out for 6 hours (MHC factor 6/8 or 0.75), so the monthly material handling cost per worker is Rp 3.000.000. With a total of 4 workers, the monthly material handling cost incurred by the XYZ screen printing business is Rp 12.000.000. Meanwhile, the MHC/meter is Rp 40.466, as determined from the following equation:

$$\text{MHC/M} = \frac{\text{Total MHC per month}}{\text{Total Distance}}$$

$$= \frac{\text{Rp } 12.000.000,-}{296{,}54}$$

$$= \text{Rp } 40{,}466,-$$

Table 1 details the names of the work stations and their initial codes. There are 12 main work points, with a total area of all facilities of 16,956 (square meters).

TABLE 1.
WORKSTATION AND INITIALS

No	Workstation	Initials
1	Waiting room	A
2	Screen printing ink	B
3	Tools afdruk	C
4	Computers & printers	D
5	Finish material storage	E
6	Raw material storage	F
7	Packaging area	G
8	Toilet	H
9	Press machine	I
10	Screen rack	J
11	Machine Afdruk	K
12	Screen printing table	L

Based on direct observation of production activities, data on the distance between work points was obtained, as listed in Table 2, This table also reflects the activities and intensity of movement between departments or work stations.

TABLE 2.
INITIAL MATERIALS HANDLING COSTS

From	To	Distance	Freq*	Freq X Distance **	Total MHC(Rp)
D	C	3,98	4	15,92	644.218,72
C	J	5,19	4	20,76	840.074,16
J	H	4,11	4	16,44	665.261,04
H	K	3,60	4	14,4	582.710,40
F	L	6,35	4	25,4	1.027.836,40
K	L	3,25	4	13	526.058,00
B	L	2,14	48	102,72	4.156.667,52
L	G	5,49	6	32,94	1.332.950,04
G	I	0,86	6	5,16	208.804,56
I	G	0,86	48	41,28	1.670.436,48
G	E	2,13	4	8,52	344.770,32
		37,96		296,54	11.999.787,64

* Frequency
** Frequency x Distance

The baseline condition of the existing facility layout was established using quantitative information obtained through field observation. The production area consists of 12 workstations with a total facility area of approximately 16.956 m², and the material flow between stations was quantified based on distance and movement frequency recorded in the Material Handling Cost (MHC) tables. These baseline measurements were validated through direct observation of actual operator movement patterns and workflow sequences.

B. SLP data processing

The Activity Relationship Chart (ARC) is an analytical tool used to map the relationships between activities based on their proximity or priority in the production process. In this study, the ARC helps identify activities or production areas that need to be placed close together to minimize material handling time and costs. The following Activity Relationship Chart (ARC) illustrates the relationships between activities in the production process based on the proximity levels that have been analyzed.

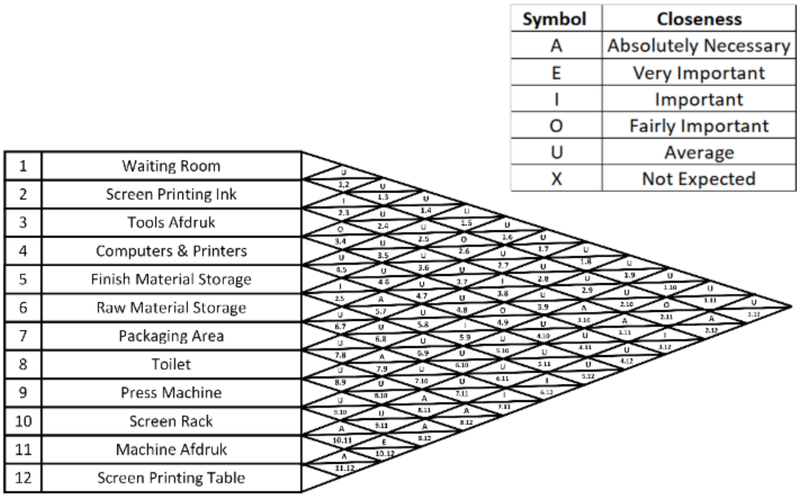
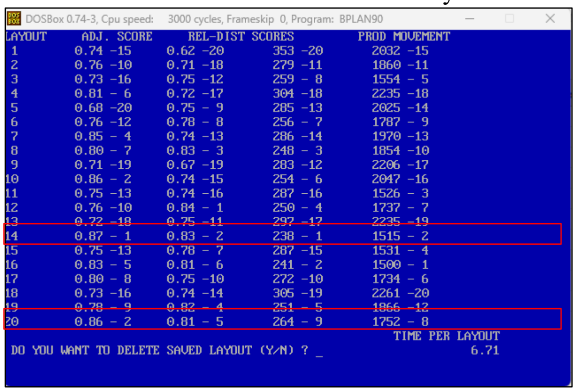


Fig. 2. Activity Relationship Chart (ARC)

At this stage, the proposed layout planning is carried out using BLOCPLAN software to produce more optimal facility layout alternatives. This method was chosen because BLOCPLAN is capable of visualizing the relationships between areas based on the Activity Relationship Chart (ARC). This process aims to design a layout that can minimize material transfer distances, improve process flow efficiency, and accommodate workspace requirements in accordance with the characteristics of the activities at the XYZ screen printing business. The results of this planning will be one of the alternatives evaluated to determine the best layout.



DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Program: BPLAN90

LAYOUT	ADJ. SCORE	REL-DIST SCORES		PROD MOVEMENT
1	0.74 -15	0.62 -20	353 -20	2032 -15
2	0.76 -10	0.71 -18	279 -11	1860 -11
3	0.73 -16	0.75 -12	259 - 8	1554 - 5
4	0.81 - 6	0.72 -17	304 -18	2235 -18
5	0.68 -20	0.75 - 9	285 -13	2025 -14
6	0.76 -12	0.78 - 8	256 - 7	1787 - 9
7	0.85 - 4	0.74 -13	286 -14	1970 -13
8	0.80 - 7	0.83 - 3	248 - 3	1854 -10
9	0.71 -19	0.67 -19	283 -12	2206 -17
10	0.86 - 2	0.74 -15	254 - 6	2047 -16
11	0.75 -13	0.74 -16	287 -16	1526 - 3
12	0.76 -10	0.84 - 1	250 - 4	1737 - 7
13	0.72 -18	0.75 -11	297 -17	2235 -19
14	0.87 - 1	0.83 - 2	238 - 1	1515 - 2
15	0.75 -13	0.78 - 7	287 -15	1531 - 4
16	0.83 - 5	0.81 - 6	241 - 2	1500 - 1
17	0.80 - 8	0.75 -10	272 -10	1734 - 6
18	0.73 -16	0.74 -14	305 -19	2261 -20
19	0.78 - 9	0.82 - 4	251 - 5	1866 -12
20	0.86 - 2	0.81 - 5	264 - 9	1752 - 8

TIME PER LAYOUT
DO YOU WANT TO DELETE SAVED LAYOUT (Y/N) ? _ 6.71

Fig. 2. BLOCPLAN layout generation results.

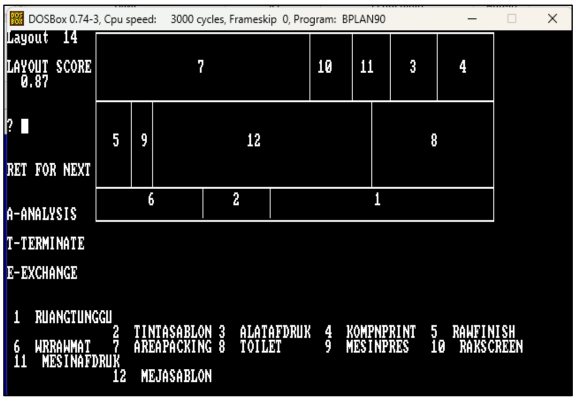


Fig. 3. Alternative layout number 14 BLOCPLAN.

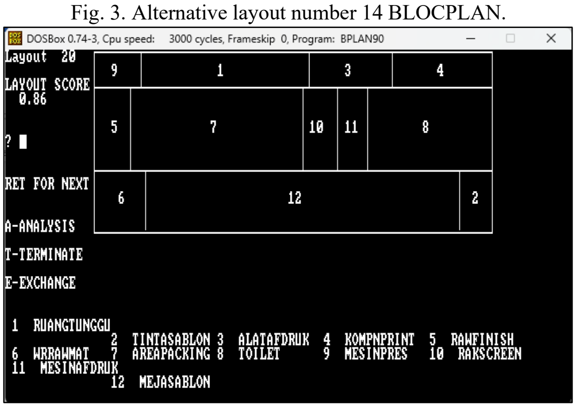


Fig. 4. Alternative layout number 20 BLOCPLAN

C. Proposed Layout 1

Proposed layout 1 is a preliminary design generated from the 14th alternative in the BLOCPLAN software. This alternative has the highest efficiency score based on the area relationship (ARC) algorithm and total material transfer distance.

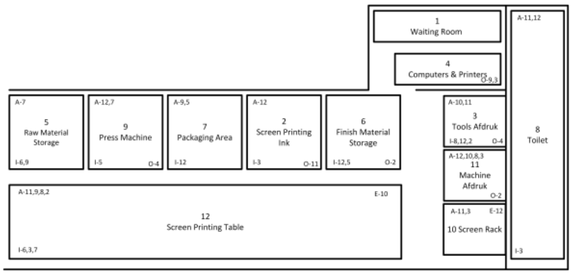


Fig. 5. Activity Relationship Diagram (ARD)

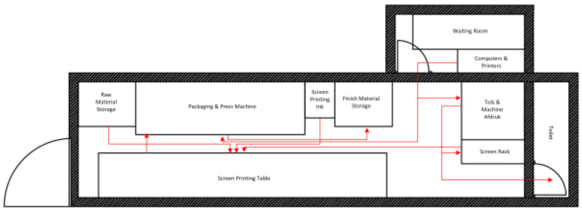


Fig. 6. Activity Area Diagram (AAD)

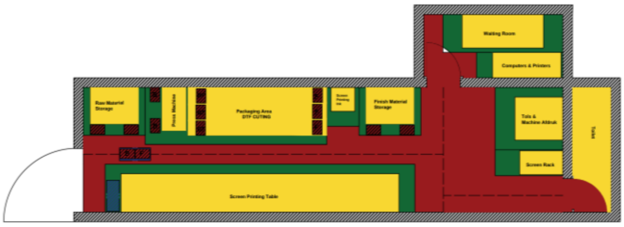


Fig. 7. Proposed layout 1

D. Proposed Layout 2

Proposed layout 2 is the result of developing alternative 20 in the generation process using BLOCPLAN. Although the efficiency score of this alternative is lower than alternative 14, after being adjusted to the actual conditions of the building and physical obstacles, this layout has proven to be more realistic and applicable for implementation in the field.

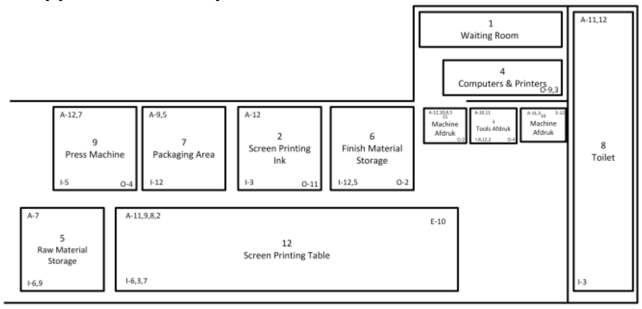


Fig. 8. Activity Relationship Diagram (ARD) Proposed 2

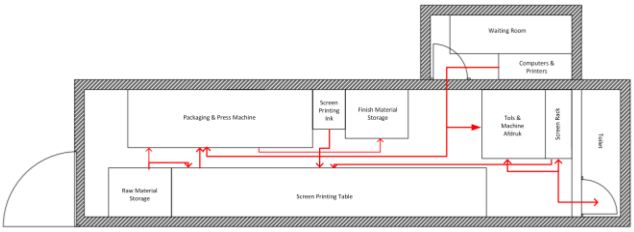


Fig. 9. Activity Area Diagram (AAD) Proposed 2

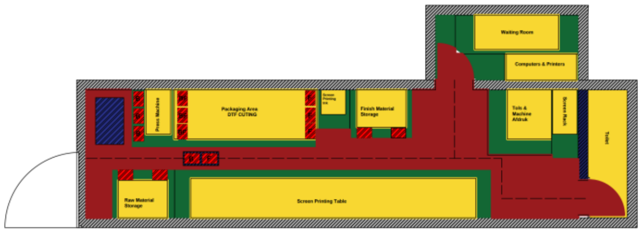


Fig. 10. Proposed Layout 2

Layout Description	
Color/Symbol	**Explanation**
	Tools / Machines
	Movement allowance
	Line / Repair allowance
	Temporary Material Storage
	Temporary Material Storage Table
	Are Storage Tables
B	Before Process
BF	Before Completion
F	Process Completed

Fig. 11. Description of proposed layouts 1&2

This layout considers the position of doors, walls, and operator movement flow to be more optimal and avoid obstacles. As a result, the production process flow becomes more linear and does not repeat (backtracking), even though the algorithmic score is lower in BLOCPLAN. Manual calculations show that the MHC for Proposed Layout 2 is Rp 7.379.056,03, which is lower than Proposed Layout 1 and the initial layout. Considering efficiency and ease of implementation, this layout is a strong candidate for recommendation.

E. Proposed Layout Efficiency Analysis (MHC Manual)

The first analysis was conducted on the material handling cost (MHC) efficiency of each layout. MHC is one of the main indicators in layout evaluation, as it is directly related to material transfer distance, activity intensity, and operational costs [22]. In this calculation, a manual method was used with a straight-line approach between work stations (Euclidean distance) multiplied by the frequency of movement and the cost per meter based on labor wage assumptions.

The following presents the detailed Material Handling Cost (MHC) calculation for proposed layout 1. This calculation is based on the total distance between work stations traveled by materials, the frequency of movement in one production cycle, and a cost per meter of Rp 40.466,00, which has been calculated.

TABLE 3.
MHC MANUAL PROPOSAL 1

Process	From	To	Distance	Transportation	Freq	Freq X Distance	MHC/meter (Rp)	Total MHC (Rp)
Screen Printing	D	C	1,14	Human	4	4,56	40.466,00	184.524,96
	C	J	0,92	Human	4	3,68	40.466,00	148.914,88
	J	H	1,08	Human	4	4,32	40.466,00	174.813,12
	H	K	1,277	Human	4	5,108	40.466,00	206.700,33
Screen Printing Preparation	F	L	1,12	Human	4	4,48	40.466,00	181.287,68
Screen Capture	K	L	6,03	Human	4	24,12	40.466,00	976.039,92
Painting	B	L	2,6	Human	48	124,8	40.466,00	5.050.156,80
Curring	L	G	2,32	Human	6	13,92	40.466,00	563.286,72
Press	G	I	0,43	Human	6	2,58	40.466,00	104.402,28
Packaging	I	G	0,43	Human	48	20,64	40.466,00	835.218,24
Finish Storage	G	E	1,499	Human	4	5,996	40.466,00	242.634,14
			18,846			**214,204**		**Rp 8.667.979,06**

After adjusting the layout based on BLOCPLAN alternative no. 20 and considering the actual condition of the building, proposed layout 2 was obtained. This layout results in a more linear process flow and avoids physical obstacles such as walls and narrow paths. The following is a detailed calculation of Material Handling Costs (MHC) in the proposed layout 2, which can be seen in Table *4* below.

TABLE 4.
MHC MANUAL PROPOSAL 2

Process	From	To	Distance	Transportation	Freq	Freq X Distance	MHC/meter (Rp)	Total MHC (Rp)
Screen printing	D	C	0,99	Human	4	3,96	40.466,00	160.245,36
	C	J	0,72	Human	4	2,88	40.466,00	116.542,08
	J	H	1,21	Human	4	4,84	40.466,00	195.855,44
	H	K	1,799	Human	4	7,196	40.466,00	291.193,34
screen printing preparation	F	L	1,274	Human	4	5,096	40.466,00	206.214,74
Screen capture	K	L	4,32	Human	4	17,28	40.466,00	699.252,48
Painting	B	L	1,95	Human	48	93,6	40.466,00	3.787.617,60
Curring	L	G	2,62	Human	6	15,72	40.466,00	636.125,52
Press	G	I	0,49	Human	6	2,94	40.466,00	118.970,04
packaging	I	G	0,56	Human	48	26,88	40.466,00	1.087.726,08
Finish storage	G	E	0,49	Human	4	1,96	40.466,00	79.313,36
			16,423			**182,352**		**7.379.056,03**

Compared to Proposed Layout 1, Proposed Layout 2 has a shorter total distance and a straighter workflow, resulting in higher cost efficiency. These details support the initial decision that Proposed Layout 2 is more feasible as a new layout solution, both in terms of MHC efficiency and suitability for the existing production facility conditions.

TABLE 5.
COMPARISON OF TOTAL MHC BETWEEN LAYOUTS

Layout	Total MHC(Rp)	Difference from Beginning (Rp)	Efficiency (%)
Initial Layout	11.999.788,00	-	-
Proposed Layout 1	8.667.979,06	3.331.808,94	27,77%
Proposed Layout 2	7.379.056,03	4.620.731,97	38,51%

Based on a comparison of manual MHC calculations for the three layouts, it can be concluded that layout proposal 2 has the highest material handling cost efficiency, with savings of Rp 4.620.731,97 or 38.52% compared to the initial layout. Thus, layout proposal 2 is a strong candidate to be considered as a new operational implementation layout. Final validation of the feasibility of implementation will be carried out through material flow simulation using FlexSim software in the next subsection. This study does not include an assessment of implementation costs such as equipment relocation, transition downtime, or spatial modification, as the analysis is limited to operational efficiency based on material handling cost reduction.

F. Simulation with FlexSim

To obtain more realistic and accurate results, FlexSim simulation software is used. FlexSim enables interactive visualization of the proposed layout that has been designed, so that it can be determined whether the layout is truly efficient and feasible for implementation in the field. Similar studies have also applied FlexSim simulation to validate the efficiency of layouts designed using the SLP method. [23]

optimized the layout of a food warehouse through SLP and FlexSim integration, showing that simulation-based analysis provides more realistic evaluations of material flow and space utilization. This reinforces the use of FlexSim in the present study as a reliable validation tool for layout performance. In addition, FlexSim also serves as a validation tool for manual MHC calculations. By taking into account the actual routes that operators must take to avoid physical obstacles, this simulation is able to reveal significant differences in distance or cost compared to theoretical calculations. After performing MHC calculations using two approaches, namely the manual method (Euclidean distance) and simulation using FlexSim, the results are as shown in the table below. The FlexSim simulation followed the same process sequence and movement structure used in the manual MHC calculations, and was intended to validate actual travel paths rather than evaluate throughput or production capacity. The simulation was run under normal operating assumptions to reflect realistic operator routing.

TABLE 6.
COMPARISON OF MHC MANUAL VS. FLEXSIM

Process	From	To	Distance	Freq	Total Manual Distance (m)	Total FlexSim Distance (m)	Difference (m)
Screen printing	D	C	0,99	4	3,96	17,36	-13,40
	C	J	0,72	4	2,88	3,84	-0,96
	J	H	1,21	4	4,84	13,068	-8,23
	H	K	1,799	4	7,196	13,48	-6,28
screen printing preparation	F	L	1,274	4	5,096	5,12	-0,02
Screen capture	K	L	4,32	4	17,28	15,16	2,12
Painting	B	L	1,95	48	93,6	74,88	18,72
Curring	L	G	2,62	6	15,72	17,76	-2,04
Press	G	I	0,49	6	2,94	3,3	-0,36
packaging	I	G	0,56	48	26,88	24,96	1,92
Finish storage	G	E	0,49	4	1,96	2,2	-0,24
			16,423		182,352	191,128	-8,78
MHC / m					**Rp**		**40.466,00**
MHC Manual					**Rp**		**7.379.056,03**
FlexSim					**Rp**		**7.734.185,65**
Difference between Manual MHC and FlexSim					**Rp**		**355.129,62**

Note: Negative values in the difference column indicate that the distance in FlexSim is longer than the manual calculation

Based on the table above, it can be seen that the total material handling distance obtained from the FlexSim simulation is 191,128 meters, while the manual method produces 182.35 meters, a difference of 8.78 meters or about 4.6% greater. This difference reflects real-world conditions where operators must turn around to avoid physical obstacles that are not taken into account in the manual method.

Several activities that have a significant impact on MHC differences:

a. Screen printing (D-C-J-H-K).
   The total difference reaches -28,872 meters, due to the many obstacles and turning distances in the printing area.
b. Painting (B-L).
   Although the distance is slightly shorter in FlexSim, its high frequency (48x/day) has a significant impact on the total MHC.

To clarify the differences between the manual and simulation approaches, the following is a visual comparison between:

a. Manual calculation (Euclidean Distance).
   Using straight lines between work stations, without considering physical obstacles.
b. FlexSim Simulation (Real Path).
   Using the operator's actual path, considering the position of equipment, walls, and realistic routes with the help of a path network.

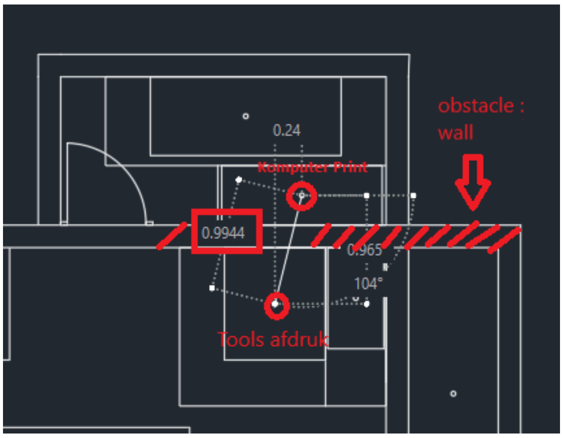


Fig. 12. Manual transfer path D– C.

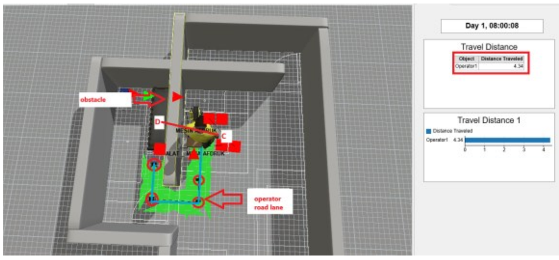


Fig. 13. FlexSim D–C transfer line.

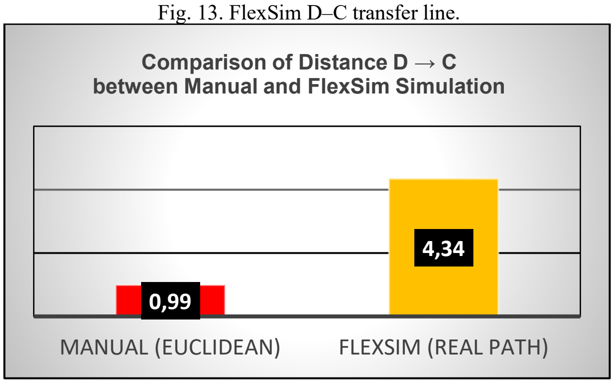


Fig. 14. Comparison chart of FlexSim and manual distances.

Based on the simulation and visualization results, it can be concluded that the use of FlexSim provides a more realistic picture of material handling activities in production facilities. One significant example occurred in the transfer from station D to C, where the manual method recorded a distance of only 0.99 meters, while the FlexSim simulation results showed an actual distance of 4.34 meters.

G. Implementation of Kaizen in the Proposed Layout

Kaizen is a continuous improvement approach that aims to reduce waste in the production process. In this study, Kaizen was implemented by adding a buffer table, which is a temporary storage table that functions as a “stopover” for materials between the raw material collection area and the main screen printing table.

Simulated Production Process:

The production scheme analyzed is the flow of Raw Material > Buffer Table (temporary) > Screen Printing Table, with the following assumptions:

a. Screen printing table capacity: 8 pcs.

b. Maximum operator pickup capacity: 12 pcs.

Without a buffer system, when the operator takes 12 (pcs) of material while the screen printing table can only process 8 (pcs), the remaining 4 (pcs) must be returned or their retrieval postponed. This increases the frequency of trips to the raw material area and prolongs the process time.

The simulation was conducted using FlexSim for two conditions:

1. Without Kaizen.
   a. Direct process from Raw Material > Screen Printing Table.
   b. Details in Fig. 15. System simulation without kaizen. Simulation of a system without kaizen.
2. With Kaizen: there is a buffer table between the flow lines. Details in Fig. 16. System simulation with kaizen.Simulation of a system with kaizen.

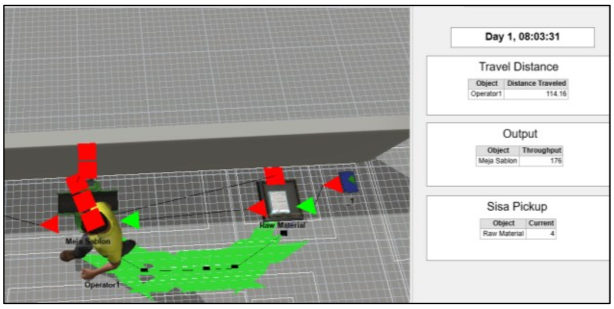


Fig. 15. System simulation without kaizen.

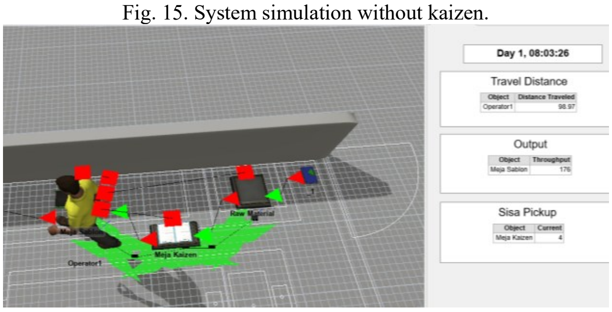


Fig. 16. System simulation with kaizen.

Simulation data shows that the Kaizen system produces a lower total distance traveled compared to the non-Kaizen system, especially in large-scale production schemes.

TABLE 7.
KAIZEN VS NON-KAIZEN + DISTANCE DIFFERENCE

Kaizen				Distance Difference	Non Kaizen			
Production Scheme	**Travel**	**Total Distance**	**Residual Value of Pickup**		**Production Scheme**	**Travel**	**Total Distance**	**Residual Value of Pickup**
1Lusin / 12pcs	1	3,37	4	**0,01**	1Lusin / 12pcs	1	3,36	4
2Lusin / 24pcs	3	11,64	0	**-2,21**	2Lusin / 24pcs	3	13,85	0
3Lusin/ 36pcs	4	17,12	4	**-2,08**	3Lusin/ 36pcs	4	19,2	4
5Lusin / 60pcs	6	30,81	4	**-4,31**	5Lusin / 60pcs	6	35,12	4
10Lusin / 120pcs	15	66,26	0	**-10,91**	10Lusin / 120pcs	15	77,17	0
15Lusin / 180pcs	21	98,97	4	**-15,19**	15Lusin / 180pcs	21	114,16	4
30Lusin / 360pcs	45	202,81	0	**-32,67**	30Lusin / 360pcs	45	235,48	0
50Lusin / 600pcs	75	339,37	0	**-54,42**	50Lusin / 600pcs	75	393,79	0

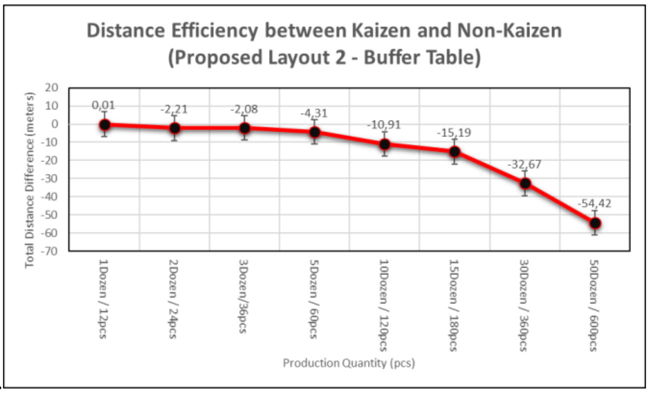


Fig. 17. Kaizen vs. non-kaizen distance difference.

According to [24], buffers placed near workstations are often categorized as part of the work area (in-process area), so their distance is not taken into account in facility layout analysis. [25] also state that if the product size is small, the effect of buffers on material handling costs is insignificant. However, in this study, the authors still explicitly calculate the buffer distance as a conservative approach. This is to demonstrate that system efficiency remains evident even when all distances are calculated fairly. Based on the simulation results and analysis conducted, the implementation of Kaizen through the addition of buffer tables in the proposed layout has been proven to have a positive impact on production system efficiency. The addition of buffers can significantly reduce the total distance traveled by operators, especially in large-scale production.

H. Comparison of Effectiveness

Through the application of the Systematic Layout Planning (SLP) method and the BLOCPLAN algorithm, two alternative layout proposals were produced. Proposed layout 2 is the most effective alternative because it has better facility placement based on proximity analysis (ARC) and Form to Chart (FTC) calculation results. This layout successfully reduced the MHC value from Rp 11.999.965 to Rp 7.947.867, or an efficiency equivalent of 33.74%. Furthermore, to optimize the layout results, a continuous improvement approach was implemented through Kaizen, namely by adding a buffer table on the process line from raw materials to the screen printing table. The buffer serves as a transit point for leftover materials (e.g., 4 pcs from 1 dozen) so that they do not need to be returned to the raw material area. This strategy has been proven to reduce operator movement distance, reduce travel frequency, and increase efficiency, especially at high production volumes. To clarify the quantitative comparison of effectiveness between layouts, Table 8 below presents manual MHC data and FlexSim simulation results for each layout alternative.

TABLE 8.
COMPARISON OF EFFECTIVENESS BETWEEN LAYOUTS

MHC	Total MHC (Rp)	Proposed 1 (Rp)	Efficiency 1 (%)	Proposed 2 (Rp)	Efficiency 2 (%)
Early MHC	11.999.788,00	-	-	-	-
Manual	-	8.667.979,06	27,77%	7.379.056,03	38,51%
FlexSim	-	10.414.265,01	13%	7.734.185,65	35,55%

Considering the simulation results, the Systematic Layout Planning (SLP) approach, and the application of Kaizen, proposed layout 2 with the addition of a buffer table is considered the most effective layout alternative to implement. In addition to significantly reducing material handling costs, this system also simplifies process flow and supports long-term efficiency sustainability. The calculation of Material Handling Cost (MHC) in this study is based on monthly operational assumptions derived from labor wage rates and active handling hours, therefore the reported 35.55% reduction reflects monthly efficiency under normal operating conditions.

Although Proposal 2 presents a lower algorithmic score in BLOCPLAN compared to Proposal 1, its selection was based not solely on material handling cost reduction but also on qualitative criteria related to practical implementation. These include compatibility with physical facility constraints, elimination of backtracking, operator accessibility, alignment with door and wall positions, and reduced interference with equipment. The following table summarizes these qualitative considerations.

TABLE 9.
TABLE SUMMARIZE THESE QUALITATIVE CONSIDERATIONS

Criterion	Proposal 1	Proposal 2
Fit with physical room layout	Partially fits	Fits well
Backtracking in material flow	Still present	Eliminated
Doors, walls, and access paths considered	Limited	Fully considered
Operator movement convenience	Moderate	Easy and unobstructed
Ease of real implementation	Requires major adjustment	Realistically implementable

Based on these qualitative criteria, Proposal 2 demonstrates superior feasibility and operational suitability, supporting its selection as the recommended layout despite its lower computational score.

IV. Conclusion

The layout of existing facilities at the XYZ screen printing business causes several forms of waste, such as excessive material movement, backtracking, and inefficient placement of tools and work stations. This leads to increased material handling costs (MHC) and hinders the smooth flow of production as a whole. This conclusion reflects the defined scope of the study, in which layout performance was evaluated solely based on material handling cost. Other operational factors were not included and are recommended for exploration in future research. The facility layout was designed using the Systematic Layout Planning (SLP) method with the BLOCPLAN algorithm, which produced two layout alternatives. Of the two alternatives, layout proposal 2 proved to be the most optimal because it was able to significantly reduce material handling costs (MHC) from Rp 11.999.965 to Rp 7.734.185,65—resulting in an efficiency of 35.55% based on the FlexSim simulation validation results. The efficiency value represents monthly cost reduction based on the applied calculation assumptions. This figure does not include the potential for additional efficiency if continuous improvement concepts such as adding buffer tables (kaizen) are implemented.

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