Redesigning of Crackers Manufacturing using BLOCPLAN Software

Anita Christine Sembiring, Jusra Tampubolon, and Yansen Effendi

***Abstract*—Facility and equipment layout design is always a challenging problem in the industry. Facility layout is a strategic operational decision that can be evaluated based on the efficiency and productivity of the company. This study focuses on a cracker production factory that faces challenges in production efficiency, specifically in terms of material travel distance and space utilization. To address these challenges, the study utilizes ARC as the main foundation, CORELAP with pattern-based approach, and BLOCPLAN with the assistance of BPLAN90 software. The results of the study propose alternative designs for ARC, CORELAP, and BLOCPLAN, with efficiency improvements of 1.5%, 0.01%, and -2.56% respectively compared to the initial layout.**

***Index Terms*—Facility layout, BLOCPLAN, Pattern-based approach, Information software.**

I. Introduction

DESIGNING facility layout and placement of production equipment is a crucial issue in the industrial world that plays a vital role in enhancing a company's productivity. The better the obtained design, the better the product will be in terms of quality and quantity [1].

Facility layout is an operational strategic decision that evaluates the level of efficiency, productivity, and long-term competitiveness of a company. This planning encompasses the size of the facility, machine placement, and material flow to each workstation [2]. The facility layout design system is expected to enable companies to adapt to changes, ranging from planning new processes to adjusting product demand. Even well-established companies need to update their facilities approximately every three to five years [3].

The distance between the *Semprong* Machine and the Steamer is quite far, causing the mold material to dry out before being steamed. This results in uneven steaming and incomplete drying during the sun-drying process, leading to unsatisfactory expansion during frying. The solution could be adjusting the dough's elasticity or fineness before preparation or regulating the drying speed of the dough prior to steaming. Additionally, there is an issue with the cutting area obstructing the entry and exit of the Processing Room, which means adjusting the material travel distance.

An optimal layout was able to achieved by implementing methods/approaches that align with a company's needs, one of which is BLOCPLAN. While designing facility layouts systematically, there was a need to balanced material flow, optimized movement distances, analyzed activity relationships, and other relevant documentation associated with the layout [4]. Some software like BLOCPLAN facilitates was assigned these considerations, and it able to analysis, simulation, and optimization of the layout [5]. Consequently, minimal costs can be achieved. Companies was minimizing capital expenditures by designing layouts that maximize the use of existing infrastructure, thereby reducing the need for additional space or equipment [6].

In this diagram (Fig. 1), the design of a cracker manufacturing plant layout was explored by focusing on critical parameters such as the Optimal Process Chart (OPC), Activity Relationship Chart (ARC), movement distances, and production cycle time. Various elements were adopting a systematic approach including worksheets, block templates, activity allocation diagrams, and activity relationships to design an optimal layout. Through the use of BLOCPLAN, this research aimed to select the optimum warehouse placement, ensuring that the layout design maximizes space utilization, minimizes wasteful movements, and aligns with the organization's strategic objectives [7].

BLOCPLAN operates as a comprehensive software solution that aids in the systematic design, analysis, simulation, and

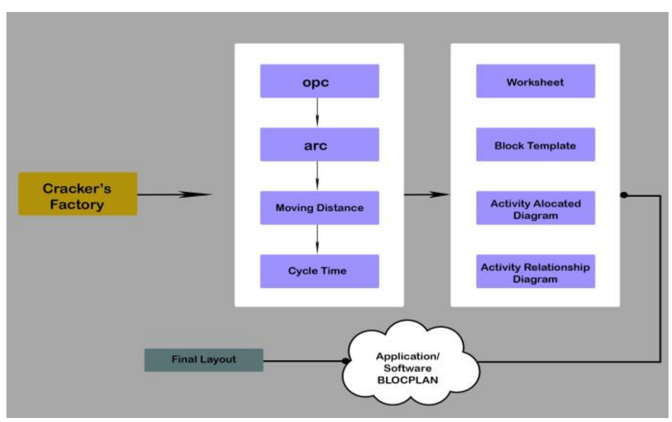

Fig. 1. The facility layout design scheme based on the BLOCPLAN software application

A. C. Sembiring, J. Tampubolon, and Y. Effendi are with Department of Industrial Engineering, Universitas Prima Indonesia, Indonesia (e-mails: anitachristinesembiring@unprimdn.ac.id*, jusrat_tampubolon@yahoo.com, yengseng0123@gmail.com).

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optimization of facility layouts, aligning with a company's specific needs. In the described process of designing a cracker manufacturing plant layout, BLOCPLAN plays a crucial role in achieving an optimal configuration. The software facilitates the consideration of factors such as balanced material flow, optimized movement distances, and analyzed activity relationships, which are essential components in achieving an efficient facility layout. Therefore, an efficient and effective facility layout, enabling the cracker production operations to run optimally to them. If it is necessary, add facility size data alongside the facility names as shown Table 1.

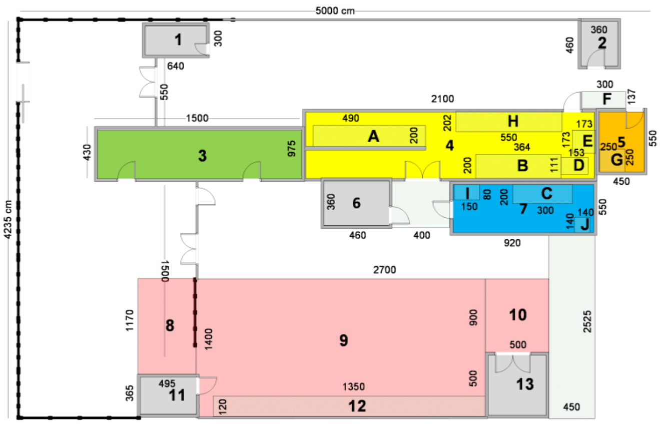


Fig. 2. Initial Layout.

TABLE I
FACILITY DATA

No.	Nama Fasilitas	Kode	Length (m)	Width (m)	Actual Area (m^2)
1	Warehouse 1	1	6.4	3	19.2
2	Warehouse 2	2	4.6	3.6	16.56
3	Office	3	15	4.3	64.5
4	Operation room	4	21	9.75	204.75
5	Dough room	5	5.5	4.5	24.75
6	Warehouse 3	6	4.6	3.6	16.56
7	Processing room	7	9.2	5.5	50.6
8	Field 1	8	11.7	4.95	57.9
9	Field 2	9	15.5	14	217
10	Field 3	10	9	5	45
11	Core	12	13.5	1.2	16.2
12	Warehouse 4	11	4.95	3.65	18.06
13	Warehouse 5	13	5	5	25

After getting the initial layout, an Activity Relationship Chart is carried out to find out which departments are most important to be close to get the optimal layout. The sequence and reasons used in the Activity Relationship Chart (ARC) are as shown in Table 2. The preparation of ARC for the degree of closeness of

TABLE II.
EXAMPLE OF WEIGHT VALUE

SYMBOL DEGREE OF CLOSENESS		Description	Color Code	Weight Value	Closeness Rating
A	Necessary	Absolute	Red	243	1
E	Especially important	Very important	Yellow	81	2
I	Important	Important	Green	27	3
O	Ordinary	Normal	Blue	9	4
U	Unimportant	Not important	White	1	5
X	Undesirable	Not expected	Gray	0	6

work departments can be seen in Fig. 3.

The Crackers Factory, also known as Crackers of *Seng Merah*, is located at Jl. Jenderal Gatot Subroto No. 318. The company is a village-level enterprise based in Binjai Barat, Brahrang. It was initially established in 1970 and has acquired a specific customer base that enjoys the crackers produced at its factory. Based on this, a research study can be conducted with the title Facility Layout Design in Crackers of *Seng Merah* to evaluate the knowledge of production process layout that can be applied at the Crackers *Seng Merah* factory, as there are some customer demands that remain unfulfilled [8].

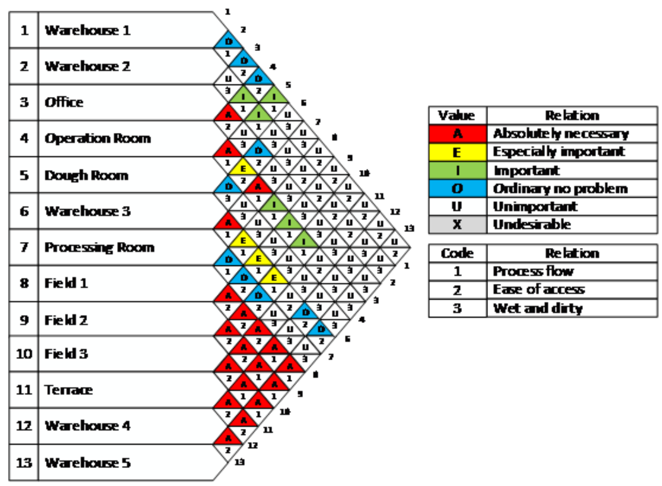


Fig. 3. ARC of Initial Layout.

From the above background, the problem can be formulated as follows: find an effective method to reduce the material travel distance in the layout of the cracker's factory. The purpose of this research is to minimize the material travel distance to obtain a proposed layout that aligns with the production process needs in the cracker's factory.

II. PROCEDURE FOR PAPER SUBMISSION

A. *Activity Relationship Chart (ARC)*

The Activity Relationship Chart (ARC) is a method used to connect various activities in pairs to determine their level of proximity. The relationships between activities can be observed from an organizational, process flow, and working environment perspective [9].

In general, ARC is a method for establishing relationships between related organizations. ARC is always associated with activity arrangement and facility size. The main objective of this method is to determine the proximity of each organization to the facility [10].

The steps to create an Activity Relationship Chart (ARC) include [11]:

- Record the names of facilities and assign numbers to them. If necessary, add facility size data alongside the facility names.
- Flow the numbers from the columns to each outer side of the triangles.

- Assign proximity codes (e.g., code A) and corresponding reasons for the proximity of facilities within the small triangles. Then use code E, and so on. These steps will help in visualizing the relationships and proximity between different facilities in the ARC diagram.

B. *Computerized Relationship Layout Plan (CORELAP)*

The CORELAP technique helps identify the busiest activities in a layout based on their relationships and the highest Total Closeness Rating (TCR) placed in the center of the layout matrix [12]. This method is an algorithm builder that is not highly dependent on the initial layout.

TCR is used for each department and is calculated from systematically ranking the closeness relationships. Department placements are based on. In Table 3, it can be seen the preparation of the Total Closeness Rating based on existing machines.

TABLE III
FACILITY TOTAL CLOSENESS RATING

	1	2	3	4	5	6	7	8	9	10	11	12	13	A	E	I	O	U	X	TCR	Rating
1	-	O	O	O	I	U	U	U	U	U	U	U	U	0	0	1	3	8	0	5	12
2	O	-	U	I	I	U	U	U	U	U	U	U	U	0	0	2	1	9	0	5	13
3	O	U	-	A	U	O	U	U	U	U	U	U	U	1	0	0	2	9	0	12	11
4	O	I	A	-	A	E	A	I	I	I	U	U	U	3	1	4	1	3	0	44	7
5	I	I	U	A	-	O	U	U	U	U	U	U	U	1	0	2	1	8	0	15	10
6	U	U	O	E	O	-	A	E	E	E	U	O	O	1	4	0	4	3	0	34	8
7	U	U	U	A	U	A	-	O	O	O	U	U	U	2	0	0	3	7	0	23	9
8	U	U	U	I	U	E	O	-	A	A	A	A	A	5	1	1	1	4	0	58	2
9	U	U	U	I	U	E	O	A	-	A	A	A	A	5	1	1	1	4	0	58	1
10	U	U	U	I	U	E	O	A	A	-	A	A	A	5	1	1	1	4	0	58	3
11	U	U	U	U	U	U	U	A	A	A	-	A	A	5	0	0	0	7	0	50	6
12	U	U	U	U	U	O	U	A	A	A	A	-	A	5	0	0	1	6	0	51	5
13	U	U	U	U	U	O	U	A	A	A	A	A	-	5	0	0	1	6	0	51	4

TABLE IV
MACHINE TOTAL CLOSENESS RATING

	1	2	3	4	5	6	7	8	9	10	A	E	I	O	U	X	TCR	Rating
1	-	U	U	I	U	U	I	U	U	U	0	0	2	0	7	0	4	8
2	U	-	U	A	O	U	I	U	O	U	1	0	1	2	5	0	14	4
3	U	U	-	E	U	U	I	U	I	U	0	1	2	0	6	0	9	5
4	I	A	E	-	O	I	O	U	I	U	1	1	3	2	2	0	23	1
5	U	O	U	O	-	O	U	O	U	U	0	0	0	4	5	0	4	9
6	U	U	U	I	O	-	A	O	I	U	1	0	2	2	4	0	16	3
7	I	I	I	O	U	A	-	U	U	O	1	0	3	2	3	0	18	2
8	U	U	U	U	O	O	U	-	I	O	0	0	1	3	5	0	5	7
9	U	O	I	I	U	I	U	I	-	U	0	0	4	1	4	0	9	6
10	U	U	U	U	U	U	O	O	U	-	0	0	0	2	7	0	2	10

Placement Ratings, considering the weight of the closeness ranking values. The Placement Rating is the boundary length compared to the number of adjacent square units with TCR. TCR is the calculation of the closeness level of department facilities in the ARC [13]. The steps for using CORELAP, according to Tompkins (2010), are as follows [14]:

- Arrange the ARC data into Form to Chart (FTC) format.
- Create weight values (optional), as shown in example Table 1, and calculate the TCR.
- Rank the TCR from highest to lowest, then place the highest-ranked department in the center of your layout plan using a symbol or code.
- Select the top-ranked department, check if there is an A relationship degree, then place it around the top-ranked department, select E, and so on.
- If the TCR values are the same, select the one with the largest area.
- Departments are chosen based on the Placing Rating, which is the total weight of the closeness rankings entered and to be entered. If they are the same, compare the boundary length or the number of adjacent square units.

C. *Block Layout Overview with CORELAP (BLOCPLAN)*

The BLOCPLAN algorithm is a hybrid facility layout design system used for creating and improving facilities. It was developed by Donaghaye and Pire at the University of Houston. BLOCPLAN is similar to CRAFT in organizing departments, but it uses a linkage map instead of a form-to-chart map. Rows in BLOCPLAN are generated by software and usually consist of two or three rows. The BLOCPLAN algorithm replaces facilities using ARC or FTC data as input for layout improvement [15].

To run the BPLAN90 program and obtain a BLOCPLAN layout, the following data needs to be inputted: the number of facilities and their names, the area of each facility, the Activity Relationship Chart (ARC), and the Total Closeness Rating (TCR) [16]. The explanation of these three values is as follows to determine the selected BLOCPLAN layout:

- R-score: It represents the efficiency value of the resulting layout [17-27].
- Proximity score: It indicates the closeness value of a facility based on the predetermined ARC.
- Rel-dist score or squared-distance score: It is the sum of the total material transfer distance between two facilities.

The proposed facility layout selection is based on the highest R-score. If R-scores are the same, the layout with the highest adjacency value is chosen. If there are still equal proximity scores, the layout with the lowest rel-dist score is selected.

III. DISCOVER & RESULT

A. *Process Flow Diagram*

Before designing the facility layout, it is necessary to diagram as needed, which includes the required information and the distance that can be moved. Based on the process flow diagram, the production facilities for crackers are divided into, Table 2. Facility data and Table 3. Machine Data. For a better understanding, please refer to the initial factory layout (Fig. 2. Initial Layout).

B. *Distance and Delivery Time*

Distance and delivery time refer to the distance and time required to perform a task. These data are obtained through direct observation in the field at each work facility using a stopwatch and estimation.

C. *Activity Relationship Chart (ARC)*

The Activity Relationship Chart (ARC) is a diamond-shaped activity relationship that consists of two parts: the top part represents the degree of relationship between two departments, and the bottom part represents the reasons or factors that measure the degree of relationship.

D. CORELAP Method Calculation

After obtaining the ranking results (rating) from the Total Closeness Rating (TCR) calculation based on ARC with weighting values for closeness: A = 10, E = 5, I = 2, O = 1, U = 0, and X = -10, the allocation of placing each facility according to CORELAP rules can be seen in the pattern below [16].

E. CORELAP Method Calculation

The BLOCPLAN algorithm can iteratively generate layout options until a maximum of 13 iterations (optional) in this research to obtain the best layout according to the BLOCPLAN algorithm. In programming, iteration refers to the repetitive execution of a sequence of algorithmic steps.

From the iterations that shown by Fig. 5. BLOCPLAN Facility Iteration, and Fig. 5. BLOCPLAN Facility Layout 4 for the facilities, it can be seen that Layout 3 has the best relative distance score of 0.87 and is chosen as the alternative layout proposal. From 10 iterations of the machines, it can be observed that Layout 2 has the highest relative distance value of 0.86 and is selected as the proposed alternative layout. In Fig.9. Layout 2 BLOCPLAN for Machine, the image is flipped 180 degrees to align with each facility in Fig. 8. BLOCPLAN Machine Iteration.

F. Proposed Facility Layout Design

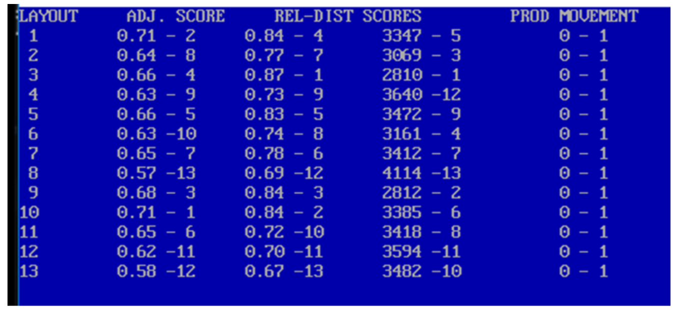
The above image represents the selected layout based on the BLOCPLAN algorithm using the BPLAN90 software with the DOSBOX application. Based on the image below, facility number 3 (office) is a permanent facility located on the left side of the BLOCPLAN layout. The layout change using the BLOCPLAN method shows a complete transformation from the initial layout.

TABLE V
MACHINE DATA

No.	Machine	Code	Length (m)	Width (m)	Actual Area (m^2)
1	Rose Machine	A	4.9	2	9.8
2	*Lontong* Machine	B	3.64	2	7.28
3	Sneaker Machine	C	3	2	6
4	Steamed	D	1.53	1.11	1.69
5	Stove	E	1.73	1.73	2.99
6	Watery Dought	F	3	1.37	4.11
7	Solid Dought	G	2.5	2.5	6.25
8	Grill	H	5.5	2.02	11.11
9	Slicer	I	1.5	0.8	1.2
10	Grinder	J	1.4	1.4	1.96

Based on the understanding of ARC in relation to the changes above, it is known that Warehouse 1 is placed near Warehouse 2, and the Cutting and *Semprong* Printing area is placed near the Steaming area, reducing the production travel distance. The Oven area is relocated for ease of access. Therefore, there is a relocation of facilities and production grouping according to the facility space.

In the CORELAP layout, Warehouse 1 is placed closer to Warehouse 2, the Oven and Stove located in the Operation Room are moved to the Processing Room, and the Thin Dough is relocated to the Dough Room. This means that there is only a slight reduction in material travel distance.



LAYOUT	ADJ. SCORE	REL-DIST SCORES		PROD MOVEMENT
1	0.71 - 2	0.84 - 4	3347 - 5	0 - 1
2	0.64 - 8	0.77 - 7	3069 - 3	0 - 1
3	0.66 - 4	0.87 - 1	2810 - 1	0 - 1
4	0.63 - 9	0.73 - 9	3640 -12	0 - 1
5	0.66 - 5	0.83 - 5	3472 - 9	0 - 1
6	0.63 -10	0.74 - 8	3161 - 4	0 - 1
7	0.65 - 7	0.78 - 6	3412 - 7	0 - 1
8	0.57 -13	0.69 -12	4114 -13	0 - 1
9	0.68 - 3	0.84 - 3	2812 - 2	0 - 1
10	0.71 - 1	0.84 - 2	3385 - 6	0 - 1
11	0.65 - 6	0.72 -10	3418 - 8	0 - 1
12	0.62 -11	0.70 -11	3594 -11	0 - 1
13	0.58 -12	0.67 -13	3482 -10	0 - 1

Fig. 4. Facility Iteration Layout.

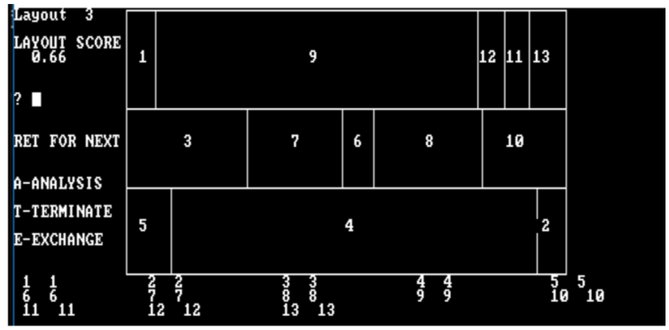


Fig. 5. Layout 4 BLOCPLAN for Facilities.

G. Analysis of Delivery Time

Based on Table 4, the material flow starts from raw material retrieval from Warehouse 1, then continues through the Warehouse 3, 4, and 5. The different showed by Table 8. The Different od Delivery time.

According to the principles of factory layout, the smaller the delivery distance by materials, the better the layout. Based on the differences mentioned above, the layout using the BLOCPLAN method is considered the best proposed layout. To analyze the time, we will use the velocity formula:

$$V = S/t \quad (1)$$

Where V is the velocity in m/minute, S is the distance in meters, and T is the time in minutes. By using the formula above, we can determine the time by utilizing the velocity and distance data.

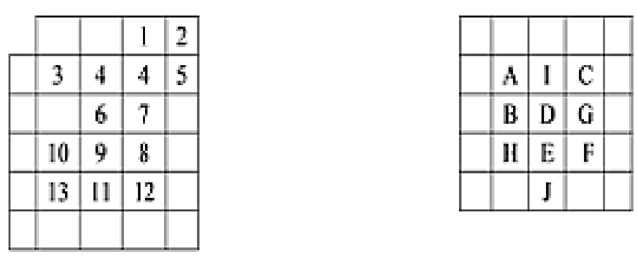


Fig. 6. Facility and Machine Corelap Allocation Pattern

The distance and time data have been obtained from the previous data. To calculate the material movement distance, the formula above can be used and the correct calculation is that the smaller the material movement distance, the shorter the distance, time and energy expended.

LAYOUT	ADJ. SCORE	REL-DIST SCORES		PROD MOVEMENT
1	0.79 - 1	0.81 - 6	186 - 5	0 - 1
2	0.77 - 3	0.86 - 1	174 - 1	0 - 1
3	0.79 - 1	0.69 - 9	205 - 8	0 - 1
4	0.73 - 9	0.84 - 2	187 - 6	0 - 1
5	0.75 - 5	0.76 - 7	209 - 9	0 - 1
6	0.73 - 9	0.68 -10	217 -10	0 - 1
7	0.75 - 5	0.83 - 3	183 - 4	0 - 1
8	0.77 - 3	0.83 - 4	182 - 3	0 - 1
9	0.75 - 5	0.73 - 8	192 - 7	0 - 1
10	0.75 - 5	0.81 - 5	181 - 2	0 - 1

Fig. 7. Machine Iteration BLOCPLAN

The material movement speed produced by the proposed layouts is that proposed layout 1 is 57.06 m/minute, proposed layout 2 is 56.2 m/minute, and proposed layout 3 is 54.75 m/minute. And what was chosen was proposal 3 with a material transfer distance because the shorter the material movement distance, the optimal the distance and time required. Therefore, it can be concluded that in the proposed BLOCPLAN layout, less labor is required for one production compared to the initial layout and other layouts.

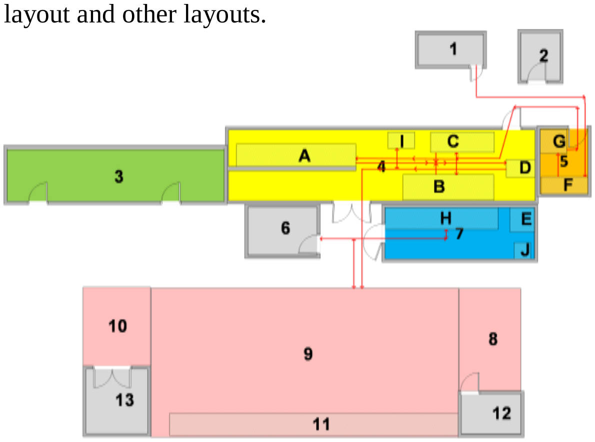


Fig. 8. CORELAP Proposed Layout

IV. Conclusion

Based on the discussion of the required material travel velocities for each proposed facility layout, the efficiencies are 1.5%, 0.01%, and -2.56%. The BLOCPLAN method can be considered successful in significantly reducing material travel distance. However, almost the entire facility and machine layout need to be changed, which implies high relocation costs. If the company wishes to change the layout with lower costs, the ARC or CORELAP methods can be used. If further research is needed, the effectiveness can be assessed with more detailed data.

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