Redesigning the Production Floor Layout for Operational Efficiency Improvement
(Case Study at PT.XYZ)

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ABSTRACT
PT. XYZ is a manufacturing company that produces brown food-grade wrapping paper, commonly used for packaging rice and dry food items. Inappropriate material storage distribution in the factory causes issues during the manufacturing process. All materials are placed based only on approximations; no thought is given to the capacity in allocating storage spaces on the production floor.This study aims to reallocate storage areas for raw materials, work-in-process products, and finished goods, as well as to redesign the layout of storage zones across the production floor. The objective is to improve operational efficiency by optimizing material flow and minimizing the total travel distance of goods. Proposed layout based on proximity relationships is produced using the Systematic Layout Planning (SLP) approach. Two different suggested layouts come out of this investigation. Both suggested designs can maximize utility and allow the best inventory capacity. Proposed layout I produces a travel distance of 78,229.9 meters or a decrease of 10.23% from the initial layout, while proposed layout II produces a travel distance of 62,695.98 meters or a decrease of 28.06% from the initial layout. The backtracking that occurs decreases with the initial conditions, namely in proposed layout I and proposed layout II by 12.65% and 11.87% of the total distance. In this case, proposed layout II is recommended because it has the largest decrease in total distance of goods movement, and has the smallest percentage of backtracking.

Keywords: *facility layout, systematic layout planning, backtracking, material flow*

1. INTRODUCTION

Numerous factors must be taken into account in order to reach the intended level of productivity in the production process. The layout of the facilities utilized during the production process is one of them. Products made from brown rice paper (also known as laminated oil paper) are manufactured by PT. XYZ. Standard rectangular rice paper is the product kind that is produced. The corporation has not yet taken into account the placement of existing machinery or the flow of materials. The factory's capacity has not been taken into account while allocating storage spaces, and the placement and organization of the commodities are solely based on estimates. Because of this, on some days when output is high, inventory cannot be accommodated by the current storage capacity. Additionally, the factory's condition becomes irregular because the area allocated is insufficient to hold the current inventory.

Currently, roll paper raw materials are frequently positioned in unsuitable locations in vacant spaces on the manufacturing floor. This is due to the fact that the available storage space is insufficient to hold the roll paper supply when it reaches the maximum inventory level. Similar situations occur where roll paper is made and finished products are stored. However, there are a number of storage spaces with sizable capacities that are hardly ever used. As a result, the distribution of each material storage space requires recalculation. Additionally, semi-finished and final goods are moved back and forth (backtracking) in a number of processes. Semi-finished products are in the form of large pieces of laminated paper, while finished products are in the form of rice paper bags stored in pallets. Backtracking increases the distance and moment of transfer materials, diminishing production efficiency (Siregar et al., 2018). Reducing backtracking can enhance forward production flow and cut down on the needless distance that components must travel, which can result in a major reduction in cycle time, as well as an improvement in machine utilization and overall system throughput (Navaei & ElMaraghy, 2021). Backtracking in both materials results in waste, particularly when it comes to the distance traveled, which increases, indicating a less efficient material flow.

These problems indicate that the current production facility layout is not optimal, resulting in inefficiency in material flow and space utilization. A good layout arrangement makes the flow of materials on the production floor smooth and quick, which cuts down on the cost of shipping and idle time of man and machines (Mansur et al., 2021). Therefore, a comprehensive redesign of the production facility layout is needed to improve the company's operational efficiency.

2. RESEARCH METHODS

This study used direct observation at PT. XYZ to identify the challenges encountered and to gather both primary and secondary data and employs the Systematic Layout Planning (SLP). Systematic layout planning (SLP) places two high-frequency, logically related regions close together in a plant's workplace (Singh & Yilma, 2013a). The goal is to create a layout that reduces the distance for transporting materials, considering the proximity relationships between rooms, and is consistent with the production flow (Muther & Hales, 2015). SLP consists of three stages of analysis, namely material flow identification, ARC analysis, and area requirements analysis.

3. RESULT AND DISCUSSIONS

3.1. Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD)

Based on quantitative and qualitative factors associated with material flow, the operational manager of the organization, who is considered an expert, decides how close together the facilities should be. The ARC relies on the assessments of professionals who determine the interrelations between each pair of departments inside the plant (Dweiri, 1999). An activity relationship diagram is created, illustrating proximity and relationships visually (Singh & Yilma, 2013b). Figure 1 below is an ARC on the production floor. ARD is a diagram that describes the relationship between activities with the activity linkage approach presented in Figure 2. ARD is a further development of ARC.

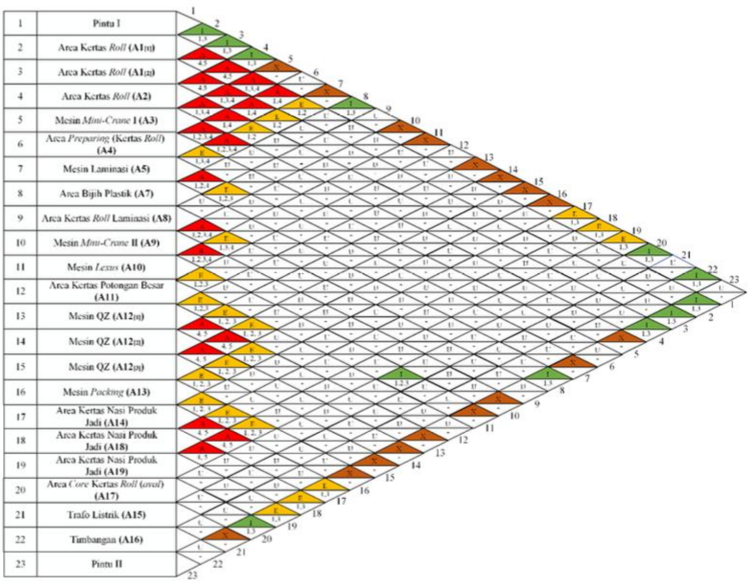


Figure 1 Activity Relationship Chart at PT. XYZ

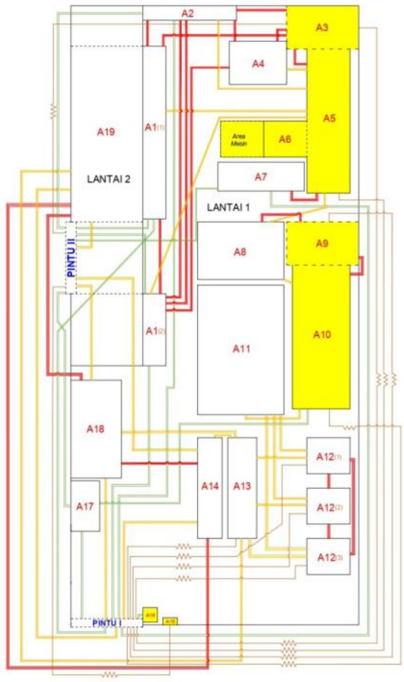


Figure 2 Activity Relationship Diagram

PT. XYZ has a production floor area of 860 m^2. The placement of products on the production floor area will be rearranged without changing the location of most of the production machines, except for the QZ machine and the packing machine which can be moved if necessary. In rearranging, it is necessary to calculate the area required (space requirement) in order to accommodate existing inventory. Table 1 below is a table of raw material storage area requirements.

Table 1. Raw material storage space requirements

Facility	Product Type	Area per Unit	Qty.	Unit	Total Area Req.	Info
Raw material storage area	Roll paper	0,64	67	stack	42,88	1 stack high = 4 rolls
	Plastic ore	1,21	5	stack	6,05	1 pallet = 40 bags
Raw material preparation area	Roll paper	0,896	16	roll	14,336	-

Facility	Product Type	Area per Unit	Qty.	Unit	Total Area Req.	Info
Semi-finished goods storage area	Laminated roll paper	0,896	5	roll	4,48	-
	Large-cut paper	1,21	21	pallet	25,41	-
Core (aval) storage area	Paper core	0,0064	486	core	3,1104	-
Finished product storage area	Greaseproof food wrapping paper	1,21	77	pallet	93,17	1 pallet = 15 bags finished goods
QZ Machine	Production machine	7,5	3	unit	22,5	-
Packing Machine		14	1	unit	14	-

The dimensions of the aisle are also considered when calculating these areas. Aisles are crucial in facilitating the movement of supplies, staff, and industrial equipment between locations (Tompkins et al., 2010). The aisle requirement calculation is based on the theory of (Tompkins et al., 2010), and considers the movement space for operators, forklifts, and hand pallets (hand-lifting).

3.2. Develop Alternative Proposed Layouts

The suggested alternative layouts are developed using the activity relationship chart (ARC) of every current site/department in addition to the operation process chart (OPC). The design of the suggested layout also takes into account the space constraints closely connected to the capacity and functionality of any storage site. Two other suggested layouts that were created are below.

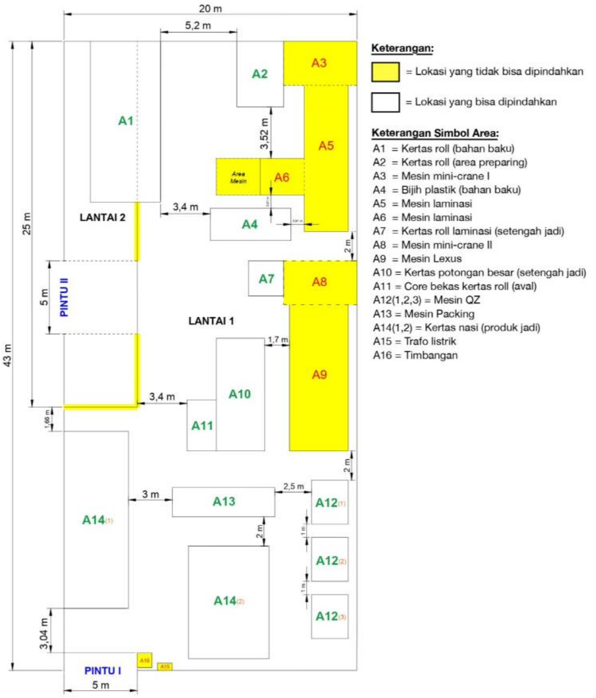


Figure 3 Proposed Layout Alternative I

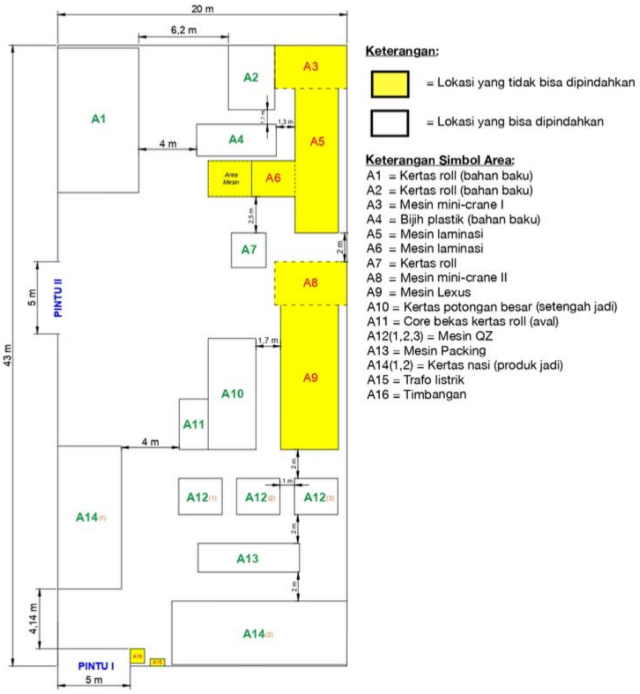
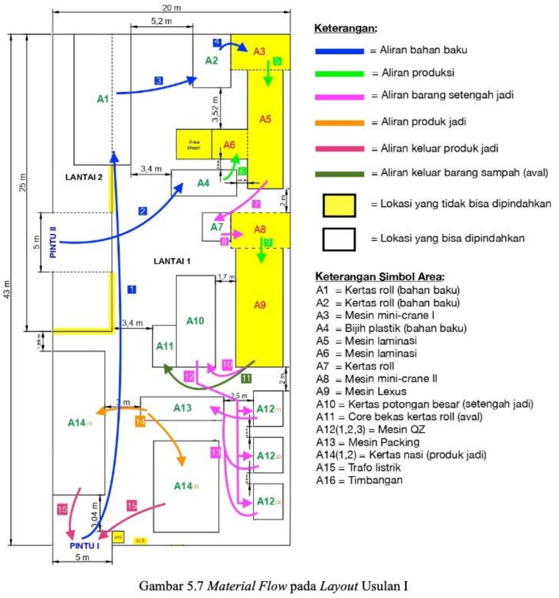


Figure 4 Proposed Layout Alternative II

Figure 3 depicts a change in location in various distinct locations, which begins by modifying the size of each area based on the storage area requirements given by the highest inventory data. This size modification is intended to ensure that the present capacity is sufficient to accommodate the biggest inventory ever recorded. The storage area size was determined based on space requirements and allowances, as shown in Table 1, while all machines remained the same. Since the second level serves no storage purpose, its location is eliminated in the suggested arrangement II. Furthermore, Figure 4 shows that the plan still contains empty space, and the second floor is not used at all in the initial situation, implying that the existence of the second floor is wasteful for the organization. The following diagram depicts the material flow in one of the two proposed layout variations.



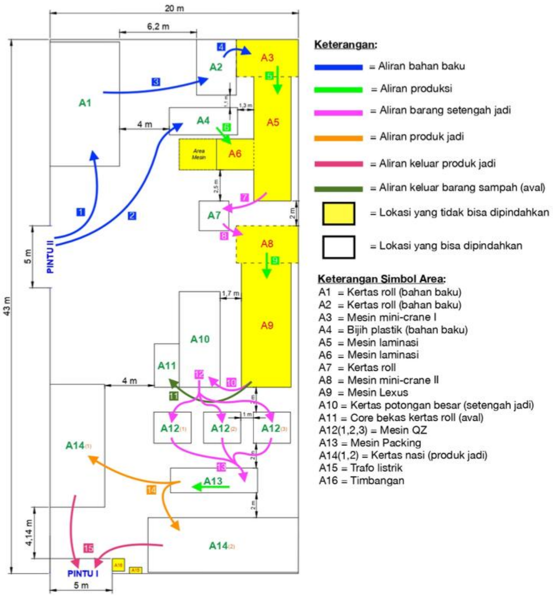


Figure 5 Material Flow in Proposed Layout Alternative 1 **Figure 6** Material Flow in Proposed Layout Alternative II

Utility calculations were conducted on both suggested designs. The calculations were conducted based on the highest initial inventory condition data, and simulation results are presented in tables 2 and table 3 below:

Table 2. Utilization of Proposed Layout I

Location	Product Type	Unit	Capacity	Inventory	Utilization
A1	Roll paper (raw material)	roll	268	268	100%
A4	Roll paper (raw materials in the preparing area)	roll	16	16	100%
A7	Plastic ore (raw material)	bags	400	396	99%
A8	Laminated paper rolls (semi-finished products)	roll	6	5	83,33%
A11	Large-cut paper (semi-finished products)	pallet	21	21	100%
A17	Used paper roll cores (scrap)	core	1093	486	44,46%
A14 (1)	Greaseproof food wrapping paper (finished goods)	bags	675	1154	96,17%
A14 (2)			525		
Minimum Utility					44,46%
Maximum Utility					100%

Table 3. Utilization of Proposed Layout II

Location	Product Type	Unit	Capacity	Inventory	Utilization
A1	Roll paper (raw material)	roll	280	268	95,71%
A4	Roll paper (raw materials in the preparing area)	roll	16	16	100%
A7	Plastic ore (raw material)	bags	400	396	99%
A8	Laminated paper rolls (semi-finished products)	roll	6	5	83,33%
A11	Large-cut paper (semi-finished products)	pallet	21	21	100%

Location	Product Type	Unit	Capacity	Inventory	Utilization
A17	Used paper roll cores (scrap)	core	1093	486	44,46%
A14 (1)	Greaseproof food wrapping paper (finished goods)	bags	540	1154	96,17%
A14 (2)			660		
Minumum Utility					44,46%
Maximum Utility					100%

3.3 Determine the Overall Distance of Material Transportation and the Backtracking Percentage of the Proposed Layout

According to (Heragu, 2016), the distance between locations can be calculated using several methods, one of which is the rectilinear method. For each alternative factory layout, the total material handling distance was calculated using this method. The process of determining the center point coordinates for each facility is carried out using AutoCAD 2023 software.

Determining the distance between each location is closely related to material flow. In the proposed layout, all goods are moved by considering the closest distance to the destination location by considering the existing inventory, then the total distance of the goods movement is calculated. The calculation of the total distance is simulated using data on the frequency of goods movement when inventory reaches the highest number. The following is the total distance of material movement in the proposed layouts I and II:

Table 4. Total Material Travel Distance in Both Alternative Layouts

Proposed Layout I				Proposed Layout II			
From-To	Distance (m)	Freq.	Total Distance (m)	From-To	Distance (m)	Freq.	Total Distance (m)
Pintu I-A1	39,1	440	17.204,00	Pintu II-A1	15,1	440	6.644,00
Pintu II-A4	17,73	74	1.312,02	Piintu II-A4	23,27	74	1.721,98
A1-A2	12,56	347	4.358,32	A1-A2	13,56	347	4.705,32
A2-A3	4,84	496	2.400,64	A2-A3	4,84	496	2.400,64
A4-A6	5,42	2.016	10.926,72	A4-A6	5,22	2.016	10.523,52
A5-A7	12,3	498	6.125,40	A5-A7	10,9	498	5.428,20
A7-A8	4	492	1.968,00	A7-A8	6,6	492	3.247,20
A9-A10	6,5	600	3.900,00	A9-A10	6,5	600	3.900,00
A9-A11	11,25	108	1.215,00	A9-A11	11,25	108	1.215,00
A10-A12(1)	13,45	224	3.012,80	A10-A12(1)	9,27	224	2.076,48
A10-A12(2)	17,35	210	3.643,50	A10-A12(2)	8,93	210	1.875,30
A10-A12(3)	21,25	162	3.442,50	A10-A12(3)	12,93	162	2.094,66
A12(1)-A13	7,25	224	1.624,00	A12(1)-A13	7,55	224	1.691,20
A12(2)-A13	11,15	210	2.341,50	A12(2)-A13	4,95	210	1.039,50
A12(3)-A13	15,05	162	2.438,10	A12(3)-A13	8,95	162	1.449,90
A13-A14(1)	9,91	169	1.674,79	A13-A14(1)	13,77	169	2.327,13
A13-A14(2)	7,2	339	2.440,80	A13-A14(2)	5,94	339	2.013,66
A14(1)-Pintu I	10,59	219	2.319,21	A14(1)-Pintu I	10,59	219	2.319,21
A14(2)-Pintu II	13,4	439	5.882,60	A14(2)-Pintu I	13,72	439	6.023,08
Total Travel Distance			78.229,90	Total Travel Distance			62.695,98

A comparison was then made between the initial layout and the proposed layout utilization to determine whether the rearrangement of storage locations had an impact on improving storage utilization in the factory. The following is a comparison of the initial and proposed layout utilization:

Table 6. Total Material Travel Distance in Proposed Layout I

Types of Material Storage	Initial Layout Utilization	Proposed Layout I Utilization	Proposed Layout II Utilization
Roll paper (raw material)	100,00%	100,00%	95,71%
Roll paper (raw materials in the preparing area)	100,00%	100,00%	100,00%
Plastic ore (raw material)	99,00%	99,00%	99,00%
Laminated paper rolls (semi-finished products)	19,23%	83,33%	83,33%
Large-cut paper (semi-finished products)	47,73%	100,00%	100,00%
Used paper roll cores (scrap)	44,46%	44,46%	44,46%
Greaseproof food wrapping paper (finished goods)	106,13%	96,17%	96,17%

Table 6 shows a comparison of utilities in each storage area. In the proposed layouts I and II, it can be seen that there is an increase in utility with the same percentage in all storage areas except in the paper roll storage area. This increase in utility occurs because of the change in capacity that occurs. This change in capacity is caused by a change in layout, where the area of storage in the proposed layout is adjusted to the area needed to store the highest inventory. Thus, the existing inventory can be placed in the designated area, so that no inventory is placed outside the designated area (fixed). After that, a comparison of the material travel distance between the initial layout, proposed layouts 1 and 2 is carried out, which is shown in the following table.

Table 7. Total Travel Distance Comparison

Distance	Initial Layout	Proposed Layout I	Proposed Layout II
Total Material Travel Distance (meters)	87.147,73	78.229,90	62.695,98
Reduction	-	↓ **-10,23%**	↓ **-28,06%**
Total Backtracking Distance (meters)	16.438,10	9.894,60	7.442,13
Backtracking Percentage (%)	18,86%	12,65%	11,87%

The reduction in distance in each proposed layout is due to the changes in material handling routes, which were redesigned by considering the shortest travel paths and the activity relationship chart (ARC) in the proposed layouts. These modifications also contributed to a decrease in backtracking movements in both proposed layouts.

4. CONCLUSIONS

In both proposed layouts I and II, the maximum utility was 100% and the minimum utility was 44.46%. Meanwhile, in the initial layout, the maximum utility produced was 100% and the minimum utility was 19.23%, thus indicating an increase in utility in the minimum storage utility. The calculation of the distance of goods movement was carried out after knowing the relationship between proximity, backtracking, and material flow that had been adjusted in both proposed layouts. In proposed layout I, the total distance of goods movement was 78,229.9 meters or down 10.23% from the initial layout condition of 87,147.73 meters. Meanwhile, the total distance of goods movement in proposed layout II was 62,695.98 meters or down 28.06% from the initial condition. Likewise with the backtracking that occurred in both the initial layout and the proposed layout. In proposed layout I, the total distance of backtracking that occurred was reduced to 9,894.6 meters or equivalent to 12.65% of the total distance traveled. Meanwhile, in the proposed layout II, the backtracking distance is only 7,442.13 meters or equivalent to 11.87% of the total distance traveled. This shows that the backtracking of both proposed layouts has decreased from the initial condition, which is 18.86% of the total distance. Thus, the proposed layout II has the smallest distance and backtracking percentage compared to the proposed layout I. By considering the capacity, utility, distance, material flow, and backtracking that occurs, the proposed layout recommended to the company is the proposed layout II. It is expected that the implementation of this redesigned layout will contribute to improved operational efficiency by minimizing material handling distances and optimizing storage area utilization.

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