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IMPROVEMENT OF LAYOUT PRODUCTION FACILITIES FOR A SECONDARY PACKAGING AREA OF A PHARMACEUTICAL COMPANY IN INDONESIA USING THE CORELAP METHOD

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ABSTRACT

This research is for one of the pharmaceutical companies in Indonesia. The company's production area is composed of two parts, namely a Black Area and a Grey Area for processing and packaging. There are four types of packaging in the Secondary Packaging Area. Each type of packaging uses different processes, but there are also some processes that are used by all types of packaging. Based on these observations, the layout of the production area for secondary packaging in the pharmaceutical company is not optimal because the material handling distances are still quite long and there are some similar processes for same packaging type that are not adjacent, so that the production process is inefficient. This study aims to redesign the layout in the area with the Computerized Relationship Layout Planning (CORELAP) method. Data such as the name of the process, the order of the process, and the relationship between processes into the Activity Relationship Chart (ARC), are subsequently processed to obtain the Total Closeness Rating (TCR) values for each process iterated with the CORELAP method. From the calculations, the proposed layout has material handling distances that are shortened by 9.017% compared with the current layout. The same type of packaging processes are located in adjacent positions.

Keywords: ARC; CORELAP; Facility layout planning; Pharmaceutical; Secondary packaging

1. INTRODUCTION

Indonesia has many companies in the pharmaceutical industry; it can be seen from the increase in the total revenue of the pharmaceutical industry which is in parallel with the increase in health budgetary allocations. This increase is encouraged by government regulations in support of public health projects. Another contributing factor is the growth of the middle class who pay more attention to better healthcare products. Increasing the amount of health care spending encourages every pharmaceutical company in Indonesia to continue improving the effectiveness of their production processes in order to increase the output of the company to meet the increase in consumer demand.

The production facilities layout, which is in parallel with the production process, is one of the factors, which affects the performance of a company. The layout of the production facility is a major basis for production efficiency. The machines and other production support facilities in the work area arrangement facilitate the movement of materials handling. The purpose is to obtain a regular flow between materials and working conditions to foster an optimal

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relationship. Production process efficiency will enable the company to operate smoothly, leading to an increase in productivity. These efforts support the ultimate goal of the company, which is to optimize profits.

Purnomo (2004) mentions the layout of a well-designed facility will generally provide a positive contribution in the company's operation process. Eventually, such optimization will lead to the sustainability and success of the company. Often existing firms also redesign their production layouts to improve their operating efficiency. One of the reasons management needs to further improve the performance is to obtain a shorter material handling distance. Generally, the production process becomes more effective and efficient afterwards in order to continuously maintain the viability of the company operations.

This research focuses on a pharmaceutical company whose production area is divided into a Black Area and a Grey Area for processing and packaging. The Black Area is where the process of drugs manufacture takes place, starting from weighing up to the primary packaging process. While the Grey Area is where the process of secondary packaging occurs. The Grey Area or Secondary Packaging Area consists of several processes, namely the assembly of small and large cardboard boxes, packing the drugs into small cardboard boxes, affixing expiry date labeling, weighing small cardboard boxes after they have been charged with medicine, inserting small cardboard boxes into big cardboard boxes, weighing big cardboard boxes, and affixing production number labels.

The problems that are associated with the particular layout relate to the precise placement of the production facilities. An irregular production facility layout impacts the efficient handing of material flows, thereby reducing the production process optimization, especially in the Secondary Packaging Area. After the primary packaging process, intermediate goods accumulate in both the Storage Area as well as in the Secondary Packaging Area, thus leading to problems in material flows and long distance material handling. In the Secondary Packaging Area, there are five types of packaging process groups. There are still some processes within the same type packaging group that have not placed adjacent to each other.

In this research, the authors will evaluate the layout of production facilities in this pharmaceutical company's Secondary Packaging Area by analyzing the total distance of material handling that occurs on the production floor. The Computerized Relationship Layout Planning (CORELAP) method is chosen as the best method to address these material handling issues because it is suitable for the redesign of an existing layout (Kriel, 2010). Furthermore, we will look for a new layout with shorter material handling distances. The problem is analyzed based on the close relationship between departments that are interconnected on the production floor. A proposed layout with more regular material flows and shorter material handling distances are the research objectives.

2. METHODOLOGY

The data collected and used by the authors in this study are the processes' names and their initial layout in the Secondary Packaging Area, the area size, the types of packaging, and the processes that are used for each type of packaging. There are five process groups:

- Packaging Material Storage (PM)
- Coding Line (CL)
- Packaging Line (PL)
- Coding Strip (CS)
- Check Weigher (CW)

In general, the packaging process starts from the Packaging Materials Storage (PM) area with the delivery of the medicine that has been packaged in bottles, strips, and blisters in the adjacent Primary Packaging Area. Simultaneously, the products are moved to the Coding Line (CL) affixing the programming code strip on the box. Furthermore, boxes are distributed to each Packaging Line (PL) to be filled and to affix the Production Coding Strip (CS) After this process is done, the boxes are weighed on a scale at the Check Weigher (CW), and then they are sent to the warehouse as finished material. The packaging process contained in Secondary Packaging Area is divided into four packaging process types.

Based on the degree of closeness or adjacency between the facilities in the Activity Relationship Chart (ARC), then the Total Closeness Rating (TCR) calculation is performed. The TCR calculation is the first stage of determining the CORELAP allocation. Afterwards, the process with the highest TCR is selected as the first one for placement. The next allocation process has an ‘A’ relationship with the first process. If no ‘A” relationship exists, then ‘E’ relationships are selected. If there is more than one process that has the same degree of relationship, then the higher TCR value is selected. Those steps are repeated until all the processes have been selected. The process allocation in this study uses the Western Edge method.The Western Edge method is the first process in getting an allocation from the Activity Relationship Chart in the production area. From the Western Edge method we can obtain information about workflow priority and the degree of closeness or adjacency for each process.

Table 1 Processes Used by Each Packaging Type

No	Process	Packaging Type			
		Type 1	Type 2	Type 3	Type 4
1	Packaging Material Storage	√	√	√	√
2	Coding Line 1	√	√	√	√
3	Coding Line 2	√	√	√	√
4	Coding Line 3	√	√	√	√
5	Packaging Line 1	√			
6	Packaging Line 2A			√	
7	Packaging Line 2B			√	
8	Packaging Line 3		√		
9	Packaging Line 4				√
10	Packaging Line 5				√
11	Packaging Line 6		√		
12	Packaging Line 7				√
13	Packaging Line 8				√
14	Packaging Line 9		√		
15	Packaging Line 10		√		
16	Packaging Line 11		√		
17	Packaging Line 12		√		
18	Coding Strip			√	
19	Check Weigher 1			√	
20	Check Weigher 2		√		√
21	Check Weigher 3		√		√

3. RESULTS

3.1. Process Allocation by CORELAP

TCR and ARC analyses are then used to decide the placement process in the Secondary Packaging Area. The next step is in determining the position of the layout process for proposals through various iterations. Based on data processing methods, Process Number 2 or Coding

Line 1, which has the largest TCR, is selected as the center. The box right next to the process that has been allocated in the vertical/horizontal direction has the full weight in accordance with the closeness value of the location to be determined and with the locations that have been allocated previously. The box right next to the departments has been allocated in a diagonal direction, having a weight of 0.5× closeness value between the location to be determined and the previous location.

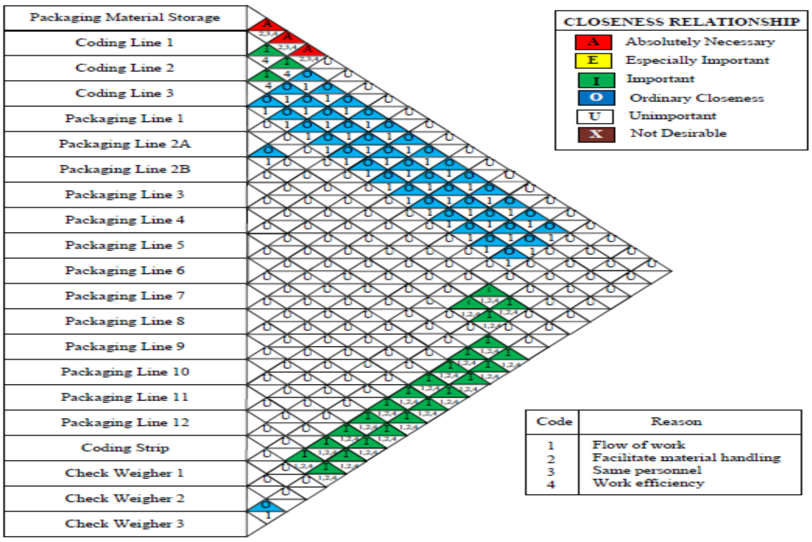

Figure 1 Activity relationship chart of Secondary Packaging Area

No	Process	Relationship between process																					Summary 5	4	3	2	1	0	TCR	Order
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	A	E	I	O	U	X		
1	Packaging Material Storage		A	A	A	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	3	0	0	0	17	0	32	2
2	Coding Line 1	A		I	I	O	O	O	O	O	O	O	O	O	O	O	O	O	U	U	U	U	1	0	2	13	4	0	41	1
3	Coding Line 2	A	I		I	O	O	O	O	O	O	O	O	O	O	O	O	O	U	U	U	U	1	0	2	13	4	0	41	3
4	Coding Line 3	A	I	I		O	O	O	O	O	O	O	O	O	O	O	O	O	U	U	U	U	1	0	2	13	4	0	41	4
5	Packaging Line 1	U	O	O	O		U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	0	0	0	3	17	0	23	21
6	Packaging Line 2A	U	O	O	O	U		O	U	U	U	U	U	U	U	U	U	U	I	I	U	U	0	0	2	4	14	0	28	17
7	Packaging Line 2B	U	O	O	O	U	O		U	U	U	U	U	U	U	U	U	U	I	I	U	U	0	0	2	4	14	0	28	20
8	Packaging Line 3	U	O	O	O	U	U	U		U	U	U	U	U	U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	5
9	Packaging Line 4	U	O	O	O	U	U	U	U		U	U	U	U	U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	13
10	Packaging Line 5	U	O	O	O	U	U	U	U	U		U	U	U	U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	14
11	Packaging Line 6	U	O	O	O	U	U	U	U	U	U		U	U	U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	8
12	Packaging Line 7	U	O	O	O	U	U	U	U	U	U	U		U	U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	15
13	Packaging Line 8	U	O	O	O	U	U	U	U	U	U	U	U		U	U	U	U	U	U	I	I	0	0	2	3	15	0	27	16
14	Packaging Line 9	U	O	O	O	U	U	U	U	U	U	U	U	U		U	U	U	U	U	I	I	0	0	2	3	15	0	27	9
15	Packaging Line 10	U	O	O	O	U	U	U	U	U	U	U	U	U	U		U	U	U	U	I	I	0	0	2	3	15	0	27	10
16	Packaging Line 11	U	O	O	O	U	U	U	U	U	U	U	U	U	U	U		U	U	U	I	I	0	0	2	3	15	0	27	11
17	Packaging Line 12	U	O	O	O	U	U	U	U	U	U	U	U	U	U	U	U		U	U	I	I	0	0	2	3	15	0	27	12
18	Coding Strip	U	U	U	U	U	I	I	U	U	U	U	U	U	U	U	U	U		U	U	U	0	0	2	0	18	0	24	18
19	Check Weigher 1	U	U	U	U	U	I	I	U	U	U	U	U	U	U	U	U	U	U		U	U	0	0	2	0	18	0	24	19
20	Check Weigher 2	U	U	U	U	U	U	U	I	I	I	I	I	I	I	I	I	I	U	U		O	0	0	10	1	9	0	41	6
21	Check Weigher 3	U	U	U	U	U	U	U	I	I	I	I	I	I	I	I	I	I	U	U	O		0	0	10	1	9	0	41	7

Figure 2 TCR value calculation of process in the Secondary Packaging Area

Iteration 1 (Figure 3):

Process 2 is a central process. The next process placed is the process that has an 'A' relationship with the Process 2, which is now known as Process 1.

8	7	6
1	2	5
2	3	4

2,5	5	2,5
5	2	5
2,5	5	2,5

Figure 3 Iteration 1

10	9	8	7
1	1	2	6
2	3	4	5

2,5	6,5	5,5	1,5
5	1	2	3
2,5	6,5	5,5	1,5

Figure 4 Iteration 2

If the Process 1 is allocated in:
Locations 1, 3.5, 7 are worth: 5
Locations 2, 4, 6, 8 are worth: 0.5×5 = 2.5
Then Process 1 is placed at Location 1 because it has the greatest value and located on the most western side.

Iteration 2 (Figure 4):
The next process to be placed is Process 3 because has a relationship 'E' with Process 2 and a relationship 'A' with Process 1, and it also has a large TCR value.

If Process 3 allocated in:
Location 1 is worth: 5
Location 2 is worth: 0.5×5 = 2.5
Location 3 is worth: 5 + (0.5×3) = 6.5
Location 4 is worth: (0.5×5) + 3 = 5.5
Location 5 is worth: 0.5×3 = 1.5
Location 6 is worth: 3
Location 7 is worth: 0.5×3 = 1.5
Location 8 is worth: (0.5×5) + 3 = 5.5
Location 9 is worth: 5 + (0.5×3) = 6.5
Location 10 is worth 0.5×5 = 2.5

Locations 3 and 9 have the same value. However, since the selection of sites using the Western Edge method is the governing factor, then Process 3 is placed at Location 3. The calculation method used for the next iterations continues so that all processes in the Secondary Packaging Area can be allocated correctly in accordance with the CORELAP method. The result of the last iteration of CORELAP method for this study is:

5	1	2	6	18
16	3	4	17	19
14	8	20	9	7
15	21	11	10	
	13	12		

Figure 5 Result of CORELAP Last Iteration

3.2. Calculation of Material Handling Distance

After making the proposed layout, the next step is to calculate the material handling distance of each packaging type in the Secondary Packaging Area. Distance calculation in this study uses rectilinear distance.

For Type 1, the calculation of the material handling distance is made by summing up the average distance of the Packaging Materials Storage (PM Storage) to the Box Coding Line (CL) and the average distance of the Box Coding Line to the Packaging Line 1 (PL 1). As seen in the PM Process, the CL Storage distance beforehand was 6.80 and then afterwards, the improvement became 9.10. The CL to PL distance beforehand was 37.92 and after improvement it became 37.50. As can be shown in Table 2, the Type 1 material handling distance on the proposed layout becomes greater than the initial layout. The reduced material handling distance has caused Locations 3 and 9 to have the same value. Then, Process 3 is placed at Location 3.

Table 2 Comparison of Packaging Type 1 material handling distance

Process	Distance	
	Initial	**Proposed**
PM Storage to CL	6.80	9.10
CL to PL 1	37.92	37.50
Total	44.72	46.60

As for the material handling distance of Packaging Types 2, 3, and 4, the average distance of material handling is from Packaging Material Storage (PM) to Box Coding Line (CL), and from the Box Coding Line (CL) to the Packaging Line (PL) to the Check Weigher (CW). Especially for Packaging Type 3 the distance from the Packaging Line (PL) to the Coding Strip (CS) is added. For Packaging Type 2, the packaging lines are Packaging Lines 3, 6, 9, 10, 11, and 12. Compared with the initial layout, Packaging Type 2's material handling distance on the proposed layout is reduced as shown in Table 3.

Table 3 Comparison of Packaging Type 2 material handling distance

Process	Distance			
	Initial		**Proposed**	
PM Storage to CL	6.80		9.10	
CL to PL 3	30.82	50.13	18.22	31.54
PL 3 to CW	12.51		4.22	
PM Storage to CL	6.80		9.10	
CL to PL 6	52.58	84.00	38.25	65.46
PL 6 to CW	24.72		18.11	
PM Storage to CL	6.80		9.10	
CL to PL 9	26.44	43.60	24.15	43.48
PL 9 to CW	10.36		10.23	
PM Storage to CL	6.80		9.10	
CL to PL 10	29.59	50.01	26.16	48.38
PL 10 to CW	29.59		13.12	
PM Storage to CL	6.80		9.10	
CL to PL 11	14.88	31.41	22.04	43.30
PL 11 to CW	9.73		12.16	
PM Storage to CL	6.80		9.10	
CL to PL 12	9.94	30.09	30.18	55.50
PL 12 to CW	13.35		16.22	
Average		48.21		47.94

Shown in Table 4, the material handling distance of Packaging Type 3 for the proposed layout is also reduced compared to the initial layout. Packaging Lines 2A and 2B are used in Packaging Type 3.

Table 4 Comparison of Packaging Type 3 material handling distance

Process	**Distance**			
	Initial		**Proposed**	
PM Storage to CL	6.80		9.10	
CL to PL 2A	22.75	44.99	8.24	27.91
CS to PL 2A	10.22		6.20	
PL 2A to CW 1	5.22		4.37	
PM Storage to CL	6.80		9.10	
CL to PL 2B	22.44		14.22	
CS to PL 2B	9.98	44.99	6.32	34.16
PL 2B to CW 1	6.23		4.52	
Average		45.22		31.04

Material handling distance reduction also occurred on the packaging material Type 4 which uses Packaging Lines 4, 5, 7, and 8. As can be seen in Table 5, the material handling distance for Packaging Type 4 on the first layout is 56.26 meters, while the proposed layout is 51.30 meters, thus indicating a reduction of 4.96 meters.

Table 5 Comparison of Packaging Type 4 material handling distance

Process	**Distance**			
	Initial		**Proposed**	
PM Storage to CL	6.80		9.10	
CL to PL 4	31.84	50.18	22.97	45.55
PL 4 to CW	11.54		10.48	
PM Storage to CL	6.80		9.10	
CL to PL 5	37.82	60.38	31.26	56.18
PL 5 to CW	15.76		15.82	
PM Storage to CL	6.80		9.10	
CL to PL 7	36.77	60.32	28.73	48.55
PL 7 to CW	16.75		10.72	
PM Storage to CL	6.80		9.10	
CL to PL 8	33.88	54.15	31.76	54.90
PL 8 to CW	13.47		14.04	
Average		56.26		51.30

4. DISCUSSION

4.1. Layout Analysis based on the Process Closeness Relationship Factor

The closeness process analysis in this study using an Operation Process Chart is subsequently developed into an Activity Relationship Chart (ARC). Based on the ARC, it can be seen that the processes which are essential and important for adjacency are:

- Packaging Material Storage with the Box Coding Line
- Coding Strip with Packaging Lines 2A and 2B
- Check Weigher 1 with Packaging Lines 2A and 2B

- Check Weighers 2 and 3 with the entire packaging line except Packaging Lines 2A and 2B

These processes need to be allocated adjacent to one another due to the sequence of work flow to facilitate the movement of goods, as well as to enhance process efficiency. Besides, the packaging line that is used by the same type of packaging is also placed adjacent to one another in accordance with the results of the calculations in the CORELAP method.

4.2. Analysis based on the Relationship to Other Production Areas

Packaging Materials Storage is the temporary storage of raw materials which are used for secondary packaging, such as boxes, cardboard, and catch covers. Therefore, the Packaging Material Storage area needs to be adjacent to the factory road that connects this area with the Raw Material Warehouse so that the supply of raw material packaging process is facilitated.

Furthermore, Packaging Line 1 has an absolute location in the initial position because the process is directly connected with the production process in the Black Area. In the Black Area for Packaging Type 1, the product is packaged in a bottle by using a machine, then it is passed along a conveyor that is connected to Packaging Line 1. Then, the bottles are directly channelled to the Grey Area for labeling and packing into boxes and cardboard. Additionally, Packaging Line 6's position cannot be moved because it is also directly related to the production engine in the Black Area. For other Packaging Lines and Check Weighers, their position still can be moved because the equipment used is not directly related to the Black Area.

4.3. Comparative Analysis of Initial Layout and Proposed Layout

In the initial layout, there are few barriers to the distribution of products from the Black Area to the Grey Area because the distribution is more often than not focused only on the distribution door near the Packaging Line 6, whereas there are other distribution doors located along Packaging Line 1 within the Coding Strip process. However, due to a lack of space between those two areas, the use of that distribution door is not maximized. Therefore, on the proposed layout, the distance between Packaging Line 1 with its adjacent process area is located next to Packaging Line 8, so that the distribution of the product can be quickly and smoothly accomplished.

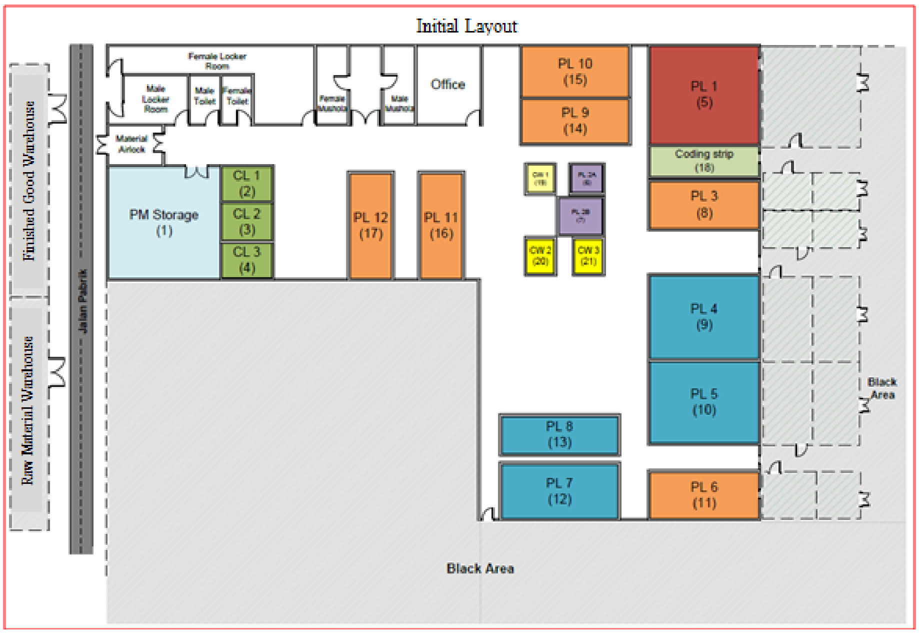

Figure 6 Initial layout of the Secondary Packaging Area

Figure 6 shows the initial layout of the Secondary Packaging Area. Material flow processes from Packaging Line 1 to Packaging Line 3 continue on until Packaging Line 12. It is inefficient because there are too many additional material handling locations. This research indicates that an improvement can be made to minimize material handling distances using the CORELAP Method.

In a step-by-step improvement for the proposed layout, the other processes are placed in accordance with the results of the CORELAP iteration which also is adjusted so that the process used for each type of packaging can be allocated adjacent to each other. For example, Packaging Type 3 that uses Coding Strip, Packaging Line 2A, Packaging Line 2B, and Check Weigher 1 are all placed next to each other in an adjacent position. From the CORELAP calculation method, Packaging Line 11 position is adjacent to Packaging Line 9 and Packaging Line 10 which is also used by Packaging Type 2. The position of Check Weigher 2 and Check Weigher 3 did not change and it remains in the middle of the production area, because both of these processes are needed for almost all types of packaging. Their location must be central and easily accessible by all packaging lines. The packaging line for Packaging Type 4 position was changed, but it is still close by, near the sequence from Packaging Line 4 to Packaging Line 5 and from Packaging Line 7 to Packaging Line 8.

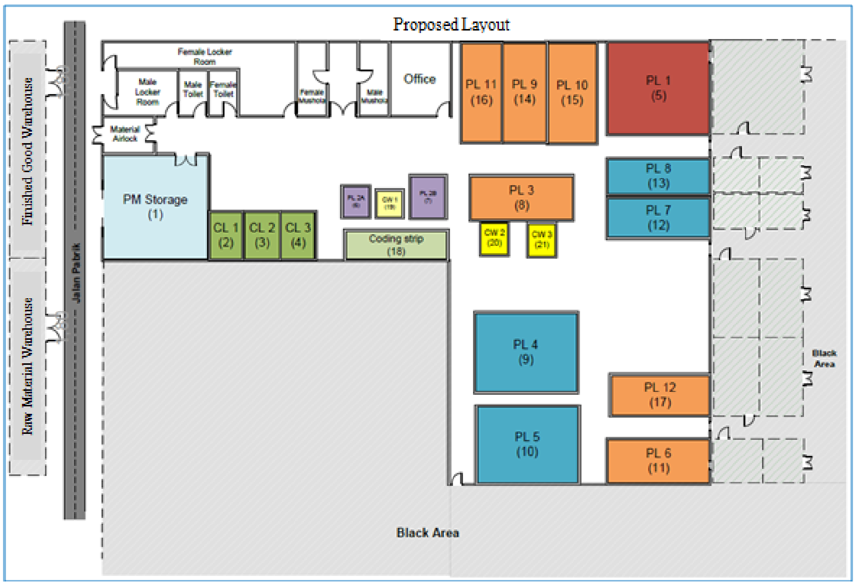

Figure 7 Proposed layout of Secondary Packaging Area

Figure 7 shows the proposed layout of the Secondary Packaging Area after improvement using the CORELAP Method. The sequence of the Packaging Line (PL) starts from PL 1 and then to PL 8 and PL 7, after that from PL 12 and PL 6 then to PL 4 and PL 5, and it is continuous until PL 3.

The four packaging process types located in the Secondary Packaging Area obtained material handling distances as shown in a comparison between the initial layout and proposed layout as summarized in Table 6.

Table 6 Comparison material handling distance between initial layout and proposed layout

Packaging Type	Distance (meter)		Difference (meter)
	Initial	Proposed	
Type 1	44.72	46.60	
Type 2	48.21	47.94	
Type 3	45.22	31.04	
Type 4	56.26	51.30	
	194.41	176.88	17.53

The material handling distance in the initial layout was 194.42 meters, which after improvements in the proposed layout became 176.88 meters with a 17.53-meter reduction. It can be seen in all packaging types that the distances have been reduced. Packaging Type 3's distance has been reduced the most. Comparatively, the distances between all the other packaging types have been reduced on average from 5–10%. Based on these calculations, this reduction factor in material handling distance indicates that the CORELAP Method is suitable for the redesign of an existing layout.

5. CONCLUSION

Based on the research and analysis, it can be shown that the material handling distance of the proposed layout obtained by using the CORELAP method results in a minimum reduction of 17.53 meters or 9.017% in comparison with the material handling distance of the initial layout. In the initial layout, the total material handling distance is 194.41 meters, while the proposed layout is 176.88 meters. By using the CORELAP method, the relationship factor between processes and material handling can be realized by aligning related processes based on the type of packaging so that the production process operates cleanly, smoothly, and efficiently.

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