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Facility Layout Redesign for Tire Vulcanization SMEs Using Systemic Layout Planning and Graphical Methods
(Case Study: IKM Tirta Kencana)

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ABSTRACT

This study aims to redesign the layout of facilities at Tirta Kencana Ban Vulkanisir SME to improve production efficiency. The initial layout had problems in the form of unclear workstation boundaries, which caused workflow disruptions, inefficient operator movements, and the risk of musculoskeletal problems. To overcome these problems, this study applied and compared two methods, namely Systematic Layout Planning (SLP) and the Graphic Method. The research gap was addressed by focusing on the application of SLP in the tire vulcanizing SME sector, which has been rarely studied. The analysis was conducted in several stages, namely data collection, evaluation of the initial layout, and mapping of material movements using the Activity Relationship Diagram (ARD) and From-To Chart (FTC). The dual-method comparison showed that the Graphic Method was the most effective, reducing the total initial material movement distance from 421.5 meters to 349.3 meters, or a reduction of 15.73%. In addition, this new layout improves production flow, space utilization efficiency, and provides practical contributions in the form of reducing unnecessary operator movement, supporting improved ergonomics in the workplace, and minimizing the risk of musculoskeletal problems. Thus, redesigning the layout using the Graphic Method is a strategic solution to improve the operational efficiency and productivity of IKM Tirta Kencana Ban Vulkanisir.

Keywords: *Layout, Systematic Layout Planning, Tire Vulcanization*

Introduction

Factory layout is a crucial aspect in industry that plays a significant role in increasing productivity and operational efficiency. Facility layout is defined as the optimal arrangement of factory facilities to ensure the smooth flow of the production process. The distance of material movement in the production area directly affects the path and cycle time of the process [1]. Therefore, errors in layout design can result in significant and unpredictable losses in the long run [2].

Small and Medium Enterprises (SMEs) are a strategic sector that is a major driver of job creation and economic growth. SMEs have the advantage of flexibility and innovation, even though they often operate with limited resources [3]. One important SME sector is the manufacturing industry. tire retreading, which focuses on the remanufacturing process to extend tire life by resurfacing worn treads. This process is very important from a tire perspective. Environment and operations because it allows tire carcasses to be reused multiple times, contributing to the reduction of solid waste, and increasing resource efficiency[4]

This case study focuses on the Tirta Kencana Tire Retreading Small and Medium Enterprise (SME) in Dumai City, which faces critical layout challenges. The factory is currently experiencing efficiency issues due to a lack of marking and separation of workstation systems, which directly impedes the workflow and movement of operators. The ergonomic impact of this condition is also significant, as it has the potential to trigger musculoskeletal disorders (MSDs)among workers, which disrupts their health and body balance [5].

Although facility layout improvements is a broad field of study, the majority of redesign research on SMEs tends to focus on common manufacturing sectors (e.g., food, furniture, textiles) [6]. There is aresharp research gap because very few studies which specifically discuss redesign layout on SMEs in the automotive tire retreading/recycling sector, especially those that explicitly integrate ergonomics and the risk of MSDsto guide the planning of new layouts[7].

Method Systematic *Layout Planning*(SLP) and hybrid methods have been shown to be effective in layout optimization [8]. However, the application of these methods combined with ergonomic risk assessment, particularly in the context of SMEs operating in unique sectors such as tire retreading, remains an area rarely explored in depth [9].

Based on these research gaps, this study aims to redesign the layout of the Tirta Kencana Ban Retreading IKM facility. Using a systematic approach, this redesign will focus on improving material flow efficiency (minimizing distance and time) and minimizing musculoskeletal risks to workers, which is expected to significantly increase production process productivity.

Research Methods

To address these issues, this study uses a combined approach of Systematic Layout Planning (SLP) and graphical methods. The SLP method is a systematic approach to designing layouts that considers the functional relationships between activities in the work area. This method will help organize the layout based on the functional proximity required between work areas[10]. Meanwhile, the graphical method is used to visualize the proximity of activities (activity relationship chart) and material flow, thereby facilitating the analysis of work flow efficiency[11].

Based on the above description, this study formulates the main problem: how can the layout redesign at IKM Vulkanisir Ban Tirta Kencana improve workflow efficiency, minimize material transfer distances, and optimize the utilization of workspace through the SLP and graphical methods? The purpose of this study is to answer these questions by redesigning the layout.

This study uses a quantitative approach. Data collection was carried out in various ways, including observation, interviews, literature studies, and documentation. The data collected is divided into two types: primary and secondary data[12]. Primary data was obtained directly at the research site and includes information such as workstation dimensions, operational process details, and distances between stations. Meanwhile, secondary data was obtained from sources such as literature and scientific journals related to facility layout design using the SLP method and graphical methods[13].

The method used for this research is SLP, which is one of the methods used to organize workplaces in a factory by utilizing two areas that have high frequency and logical relationships with each other[14]. The computerized relative allocation of facilities technique algorithm is an improvement program that seeks optimal designs by gradually improving the layout[15].

Graph-based methods are construction-type layout algorithms rooted in graph theory. These methods are often used for adjacency-based objectives. The introduction of graph theory as a mathematical tool for solving facility planning problems began in the late 1960s and early 1970s. Graph theory methods share similarities with the SLP method developed by Muther [7].

Systematic Layout Planning (SLP) offers several key advantages for companies. By arranging departments that frequently interact to be in proximity, SLP effectively reduces material handling costs, as travel distances are shorter and transportation time is reduced[16].

In addition, this method also improves production efficiency by eliminating waiting times and bottlenecks, which ultimately speeds up the production process and increases overall productivity. SLP also helps maximize the use of available space, so that no area is wasted and the work environment becomes more organized[16].

In terms of safety, the implementation of SLP improves workplace safety. A well-organised layout minimizes the risk of accidents that may occur due to irregular material movement. Finally, SLP is also highly flexible and easy to adapt, as it can be applied to design new layouts or modify existing ones, making companies better prepared for future changes[17].

This study used the Systematic Layout Planning (SLP) method and the Graph method with the following stages. First, data collection was carried out through observation, interviews with the Tirta Kencana Tire Vulcanisation SME, and measurements of the distances between departments. The validity of this data was reinforced by verifying business licenses. Next, in the data processing stage, an evaluation of the initial layout and measurement of workstation dimensions was conducted as the basis for redesign. Based on this data, a From To Chart (FTC) was created to group the rectilinear distance values between workstations. Subsequently, the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) were used to analyze the proximity relationships between workstations. The next step is to determine the required area size, considering the needs of machinery, equipment, and workers. Then, the Graph method is used to determine the weights and proximity relationships between workstations based on the largest rectilinear distance from the FTC[18]. Finally, a proposed layout from both methods (SLP and Graph) is created for comparison to determine which layout is most optimal for IKM Vulkanisir Ban Tirta Kencana.

The research flowchart for the redesign of the IKM Vulkanisir Ban Tirta Kencana layout can be seen in Figure 1.

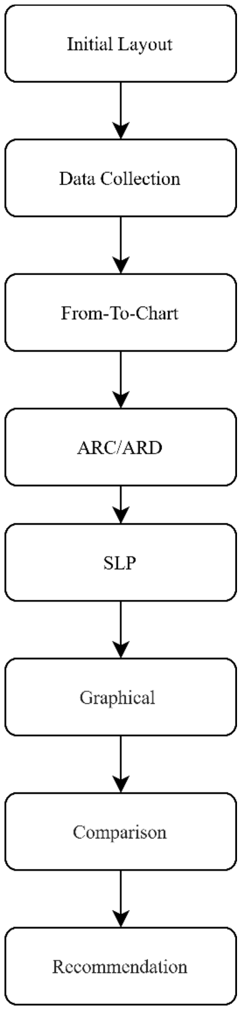

Figure 1. Research Flow Chart

Results and Discussion

Initial Layout of Tirta Kencana Tire Vulcanization IKM

The physical area of IKM Tirta Kencana Vulkanisir Ban stands on 300 m2 of land. In the process of designing the proposed layout, an evaluation was conducted on the initial layout for the Tirta Kencana Tire Vulcanization IKM, which consists of 9 rooms, namely: the peeling area, the cooking area, the compressor area, the finished goods storage area, the coating and lining area, the side door, the tire grinding area, the cashier and administration area, the raw material warehouse, and 1 parking lot.

Workstation Size

Length and width dimensions for each brick-making workstation at IKM Vulkanisir Tirta Kencana Vulkanisir Ban

Table 1. Workstation Size

No	Workstation Name	Size (m)		Area (m^2)
		Length	Width	
1	Peeling Area	2,5	3,5	8,75
2	Cooking Area	2,5	4,10	10,25

3	Compressor Area	7,25	2,5	18,12
4	Finished Goods Storage Area	7,25	3	21,75
5	Repair and Coating Area	3	2,5	7,5
6	Waiting Room	3,5	2,5	8,75
7	Tire Shaving Area	2,5	3	7,5
8	Cashier and Administration Area	3	3	9
9	Material Warehouse	4	3	12
10	Parking Lot	12	9	108
	Total			**211,62**

Production Flow

The production process at IKM Vulkanisir Ban Tirta Kencana consists of several stages, which can be seen in figure 2.

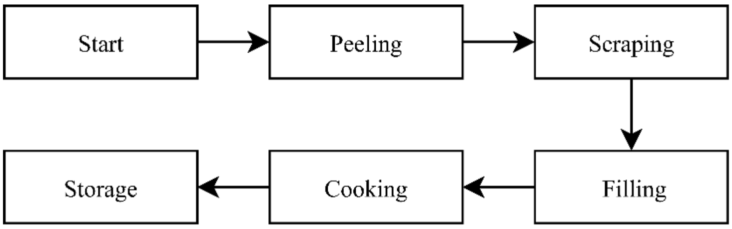

Figure 2. Production flow

Discussion

In this study, data processing was carried out in three stages, namely processing the initial layout data, then designing the proposed layout using the SLP method and the graphical method, and finally analyzing and evaluating the results of the proposed layout design.

Initial Layout Analysis

The process of designing the proposed layout for IKM Tirta Kencana Vulkanisir Ban was carried out first, namely the analysis of the initial layout of IKM Vulkanisir Ban Tirta Kencana. The analysis was conducted on the flow of materials, the distance of material transfer, and the operating time in the production process.

The initial analysis of the tire vulcanization process at the Tirta Kencana Tire Vulcanization SME was conducted using an operational process map. This visual tool serves to facilitate understanding of the material flow and relationships between workstations. As such, this map enables the evaluation of efficiency and the identification of areas requiring improvement. Therefore, the operational process map is an important foundation in efforts to optimize the entire tire vulcanization process[19].

The initial layout analysis at the Tirta Kencana Tire Vulcanization IKM began with calculating the distance between work stations. This calculation uses the rectilinear distance formula, where the coordinates of each workstation are determined from the IKM layout. Subsequently, the distances between workstations are calculated using the Euclidean distance formula[20]. The results of these calculations are organized into a distance matrix to compare the total distance travelled by materials or workers. The objective is to determine whether there is a reduction in total distance. This reduction serves as an important indicator for improving layout efficiency, which ultimately streamlines the production process, saves time and energy, and reduces waste[21]. The IKM layout block for the Tire Vulcanization Plant Tirta Kencana can be seen in Figure 3.

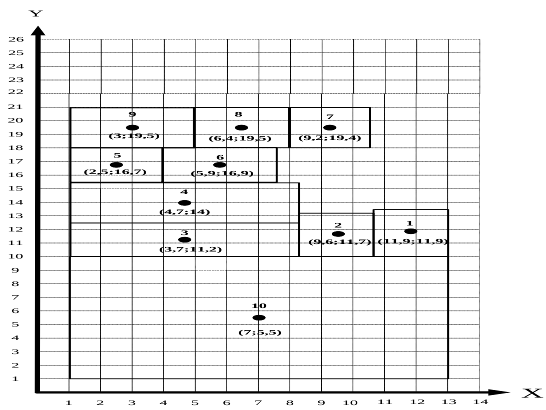

Figure 3. Coordinate Point Layout Block

The coordinate points of the work stations of IKM Vulkanisir Ban Tirta Kencana can be seen in Table 2.

Table 2. Work Station Coordinate Points

No	Workstation Name	Coordinates	
		X	Y
1	Peeling Area	11,9	11,9
2	Cooking Area	9,6	11,7
3	Compressor Area	3,7	11,2
4	Finished Goods Storage Area	4,7	14
5	Repair and Coating Area	2,5	16,7
6	Waiting Room	5,9	16,9
7	Tire Shaving Area	11,1	19,4
8	Cashier and Administration Area	6,4	19,5
9	Material Warehouse	3	19,5
10	Parking Lot	7	5,5

Table 2 is a table of coordinate points for the work stations in the initial layout of the Tirta Kencana Tire Vulcanization IKM. Next, the distance between stations will be calculated. Based on the above coordinate points, the rectilinear distance between work stations can be calculated using Formula 2.1.

1. The rectilinear distance calculation between the peeling area and the cooking area is:
D_{ij} = [(11.9-9.6) + (11.9-11.7)] = 2.5
2. The rectilinear distance calculation between the peeling area and the compressor area is:
D_{ij} = [(11.9-3.7) + (11.9-11.2)] = 8.9
3. The rectilinear distance calculation between the peeling area and the finished goods storage area is:
D_{ij} = [(11.9-4.7) + (11.9-14)] = 9.3

Form to Chart (FTC)

The rectilinear distance calculations between work stations at the Tirta Kencana Tire Vulcanization IKM, based on known distance calculations, will be analyzed using FTC, as shown in Table 3.

Table 3. Table From to Chart

Station	1	2	3	4	5	6	7	8	9	10	Total
1		2,5	8,9	9,3	14,2	11	8,3	13,1	16,5	11,3	95,1
2			6,4	7,2	12,1	8,9	9,2	11	14,4	8,8	78
3				3,8	6,7	7,9	15,6	11	9	9	63
4					4,9	4,1	11,8	7,2	7,2	10,8	49
5						3,6	11,3	6,7	3,3	15,7	40,6
6							7,7	3,1	5,5	12,5	28,8
7								4,8	8,2	18	31
8									3,4	14,6	18
9										18	18
10											

Designing with the SLP Method

Research in the redesign of the layout of the Tirta Kencana Tire Vulcanization IKM used the SLP method, among others. This method is based on the importance of activities between each workstation. The importance of activities will be analyzed using the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD)[22].

Activity Relationship Chart (ARC)

One of the stages in the proposed layout design using the SLP method is to analyze the degree of importance of activities between stations using ARC[23]. The ARC in this study can be seen in Figure 4 and Table 4.

Table 4. Activity Relationship Chart

Value	Proximity	Code	Reason
A	Absolutely Necessary	1	Process Flow
E	Very Important	2	Material Flow
I	Important	3	Information Flow

O	Normal Proximity	4	Worker Movement
U	Not Important	5	Not Process Flow

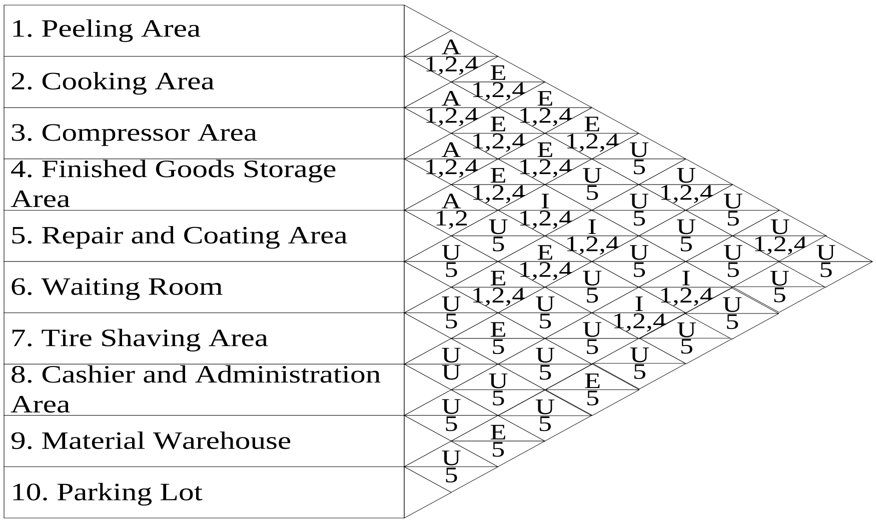

Figure 4. ARC IKM Vulkanisir Ban Tirta Kencana

Activity Relationship Diagram (ARD)

ARD is an activity relationship diagram based on proximity priority. This activity relationship diagram combines two aspects: the degree of activity relationship and material flow[24]. The ARD for the tempeh production process can be seen in Figure 5.

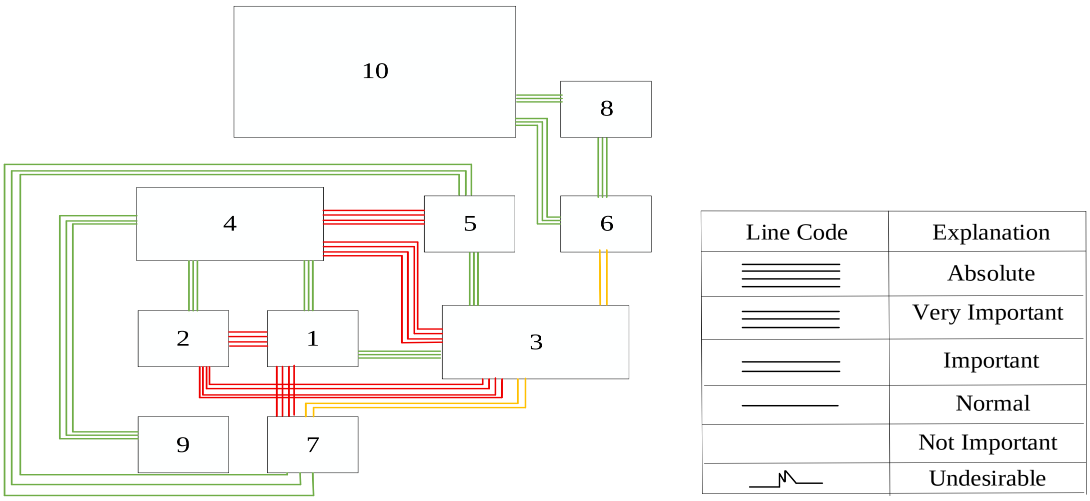

Figure 5. ARD IKM Tirta Kencana Vulkanisir Ban

Determining the Required Area

First, the space requirements will be considered. These calculations are based on the requirements of the machinery, equipment, and personnel. The calculations for the required area can be seen in Table 5 below.

Table 5. Production Area Requirements

No	Department	Amount	Size(m^2)			Area (m^2)	Total Area (m^2)	Relaxation	Area Requirment (m^2)
			P	L	D				
				Stripping Area					
1	Area	1	2,5	3,5		8,75	8,75	-	8,75
				Cooking Area					
2	Area	1	2,5	4,10		10,25	10,25	-	10,25
				Compressor Area					
3	Area	1	7,25	2,5		18,12	18,12	10%	19,93

				Finished Good Storage Area				
4	Area	1	725,3	3	21,75	21,75	-	21,75
				Filling and Coating Area				
5	Area	1	3	2,5	7,5	7,5	10%	8,25
				Waiting Room				
6	Area	1	3,5	2,5	8,75	8,75	-	8,75
				Scraping Area				
7	Area Tempat	1	2,5	3	7,5	7,5	-	7,5
				Cashier and Administration Area				
8	Area	1	3	3	9	9	-	9
				Material Warehouse				
9	Area	1	4	3	12	12	-	12
				Parking Lot				
10	Area	1	12	9	108	108	-	108
				Total (m^2)				212,93

Table 5 shows that the total area required is 121.93 m2 with a 10% allowance, which is used to take into account existing facilities and ease of movement for workers.

Design Using the Graphical Method

The proposed layout design for IKM Vulkanisir Ban Tirta Kencana, which was initially created using the SLP (Systematic Layout Planning) method, will be continued using the Graphical Method. This approach aims to determine the proximity between work stations. In the Graphical Method, weights are assigned to the relationships between stations, and then the stations are connected based on the highest weights[25].

Table 6. Distance Between Work Stations 1, 3, 4, 5, 6, 7, 8, 9, and 10

Station	Weight 4
179	28,3 The best
5710	27,5
157	26
1810	27,3
158	21,4
3910	21,8
379	22,8
3710	26,4
2810	25,2
258	19,3
2510	22,9
169	20,6
1610	24,2
6910	22.1

Based on Table 6, it can be seen that station 2 has the largest weight, which will then be entered into the proximity graph between stations 1, 3, 4, 5, 6, 7, 8, 9, and 10, as shown in Figure 6.

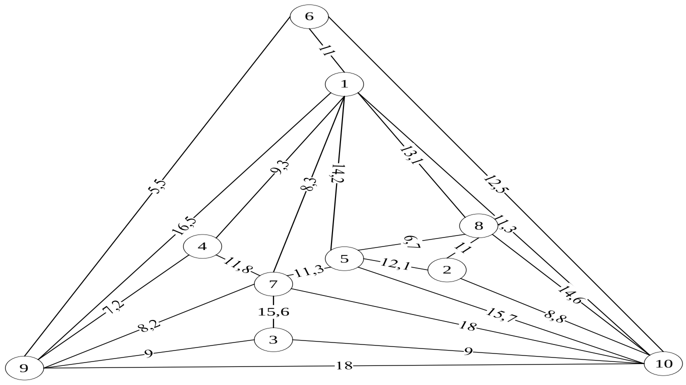

Figure 6. Proximity graph for Stations 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10

Proposed Layout Design

The process of designing a new layout for IKM Vulkanisir Ban Tirta Kencana began with collecting initial data from the entire production flow. This data was then analyzed using the Systematic Layout Planning (SLP) method. The SLP method is very important for identifying and classifying the crucialness of the relationships between work stations[26]. The goal is to optimize the proximity between activities that frequently interact, thereby minimizing movement distances and improving work efficiency. Subsequently, a graph will be used to facilitate the determination of workstation positions based on the calculated relationship weights[27].

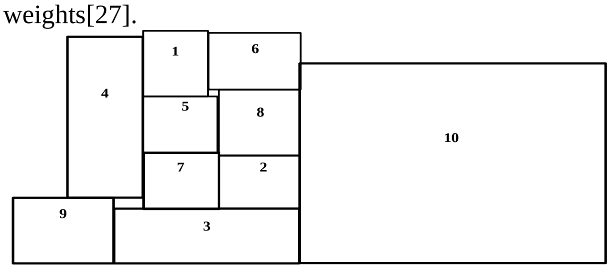

Figure 7. Layout Proposal Using Graphic Methods

Figure 7. Proposed Layout Using the Graphical Method

1. Peeling Area 4. Finished Goods Storage Area 7. Tire Shaving Area
2. Cooking Area 5. Repair and Coating Area 8. Cashier and Administration Area
3. Compressor Area 6. Waiting Room 9. Material Warehouse

Analysis and Evaluation

The steps taken to determine the proposed layout for IKM Vulkanisir Ban Tirta Kencana used two approaches, namely the SLP method and the graphical method. Each of these methods produced a different layout proposal. Next, an analysis was conducted on the layout proposal produced by the SLP method by calculating its coordinates, as shown in Figure 8.

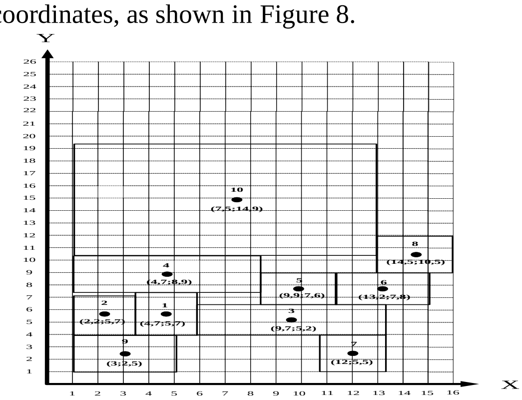

Figure 8. *SLP Method Layout Coordinate Points*

Figure 8 shows the coordinate points of the layout blocks for the work stations in the proposed SLP method layout. These coordinate points can be seen in Table 7 below.

Table 7. SLP Method Work Station Coordinate Points

No	Work Station Name	Coordinates	
		X	Y

1	Peeling Area	4,7	5,7
2	Cooking Area	2,2	5,7
3	Compressor Area	9,7	5,2
4	Finished Goods Storage Area	4,7	8,9
5	Repair and Coating Area	9,9	7,6
6	Waiting Room	13,2	7,8
7	Tire Shaving Area	12	5,5
8	Cashier and Administration Area	14,5	10,5
9	Material Warehouse	3	2,5
10	Parking Lot	7,5	14,9

The table above shows the results of rectilinear distance calculations for the proposed layout using the SLP method. Next, analysis of this proposed layout will continue using the Graph method, in which coordinate points are calculated for the new layout, as shown in Figure 9.

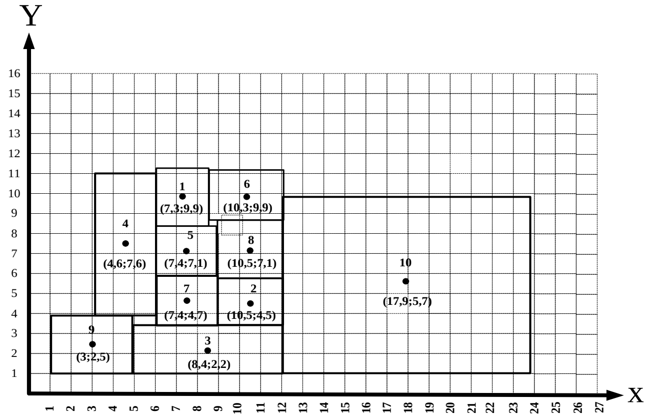

Figure 9. *Graphical Method Layout Coordinate Points*

Figure 9 shows the coordinate points of the layout blocks for the work stations in the proposed graphical method layout. These coordinate points can be seen in Table 8 below.

Table 8. Work Station Coordinate Points in the Graphical Method.

No	Work Station Name	Koordinat	
		X	Y
1	Peeling Area	7,3	9,9
2	Cooking Area	10,5	4,5
3	Compressor Area	8,4	2,2
4	Finished Goods Storage Area	4,6	7,6
5	Repair and Coating Area	7,4	7,1
6	Waiting Room	10,3	9,9
7	Tire Shaving Area	7,4	4,7
8	Cashier and Administration Area	10,5	7,1
9	Material Warehouse	3	2,5
10	Parking Lot	17,9	5,7

Comparison of transfer distances between stations for the initial layout and the proposed layout. A comparison of transfer distances between layouts can be seen in Table 9.

Table 9. Comparison of Transfer Distances Between Layouts

No	Station		Initial Layout	SLP	Graph
	From	To			
1	Peeling Area	2,3,4,5,6,7,8,9,10	95,1	69,9	66,1
2	Cooking Area	3,4,5,6,7,8,9,10	78	82	53,3
3	Compressor Area	4,5,6,7,8,9,10	63	51,4	53,9
4	Finished Goods Storage Area	5,6,7,8,9,10	49	49,7	43,7
5	Repair and Coating Area	6,7,8,9,10	40,6	36,9	32,1

6	Waiting Room	7,8,9,10	28,8	35,8	37,6
7	Tire Shaving Area	8,9,10	31	33,9	23,6
8	Cashier and Administration Area	9,10	18	30,9	20,9
9	Material Warehouse	10	18	16,9	18,1
Total			**421,5**	**407,4**	**349,3**

Table 9 is a comparison table of the distances between stations for the initial layout and the proposed layout. Based on the table, it is known that the distance between workstations in the proposed layout is greater than that in the initial layout, which is 421.5. From the comparison above, it can be seen that the smallest distance between workstations is 407.4 using the SLP method, compared to 349.3 using the graphical method. Therefore, the proposed layout selected for IKM Vulkanisir Ban Tirta Kencana is the proposed layout using the graphical method because it has the smallest distance between workstations. This method is more effective in optimizing the layout of workstations, as it minimizes the distance between workstations, which directly impacts time and labour efficiency in the production process.

Comparative Analysis of Material Transfer Distance Efficiency **Conclusion**

In redesigning the layout of the IKM Tirta Kencana Ban Vulkanisir facility, the Graphical Method has proven to be most effective for minimising material transfer distance. Compared with the Initial Layout (421.5 meters) and the proposed SLP, the application of the Graphical Method resulted total distance reduction of 15.73%, becoming 349.3 meters.

A detailed analysis of the implementation of the proposed layout of the Graphical Method shows benefits vary at each workstation (based on Table 9). In general, the majority of stations are a core part of the production flow (Station 1, 2, 3, 4, 5, and 7) successfully reached a significant reduction in material transfer distance. The largest reduction was seen in the Cooking Area (Station 2) with a decrease of 31.7% (from 78.0 m to 53.3 m) and the Peeling Area (Station 1) with a decrease of 30.5% (from 95.1 m to 66.1 m). Other stations also experienced reductions, such as:

- Compressor Area (Station 3): 14.5%
- Finished Goods Storage Area (Stasiun 4): 10.7%
- Repair and Coating Area (Stasiun 5): 21.0\%
- Tire Shaving Area (Station 7): 23.9%

However, some supporting areas, namely Waiting Room (Station 6), Cashier and Administration Area (Station 8), and Material Warehouse (Station 9), experience slight increase in the material transfer distance. The improvements at Stations 6 and 8 are described as justifiable consequences(justified) because the main focus of layout optimization is to maximise the smoothness and efficiency of the core production process flow.

Collectively, it is the reduction in transfer distances at these major stations that is the main contributor total reduction in material transfer distance by 15.73%, which ultimately strengthens Graphical Method as the most optimal layout solution.

Table 10 *Transfer Distance Comparison Table*

Work Station	Initial Distance (m)	Proposed Distance (m)	Reduction/Increase (%)	Information
1. Peeling Area	95.1	66.1	30.5% reduction	Second largest reduction
2. Cooking Area	78.0	53.3	Reduction of 31.7%	The biggest reduction
3. Compressor Area	63.0	53.9	Reduction of 14.5%	Production Core
4. Finished Goods Storage	49.0	43.7	Reduction of 10.7%	Production Core
5. Repair and Coating	40.6	32.1	21.0% reduction	Production Core
6. Waiting Room	28.8	37.6	Improvement	Supporting area, justified
7. Tire Shaving Area	31.0	23.6	Reduction of 23.9%	Production Core
8. Cashier & Admin.	18.0	20.9	Improvement	Supporting areas, optimization consequences

9. Material Warehouse	18.0	18.1	Slight increase	Support area

Ergonomic Contribution: Reduction of Fatigue and Musculoskeletal Risks

The redesign of the layout of the Tirta Kencana Ban Vulkanisir IKM facility has a dual focus, namely material transfer distance efficiency and improved work ergonomics. The old layout was deemed problematic because of ambiguous workstation boundaries and interrupted workflow, which results in operator movements becoming inefficient and risks causing musculoskeletal complaints. Through the implementation of a new layout based on the Graphical Method, the placement of work stations has been optimized according to logical material flow priorities and the highest proximity weight. As a result, it reduction of unnecessary operator movement and excessive material handling activities. Directly, the success of reducing the total material transfer distance by 15.73% plays a role in mitigating major physical risk factors that causes musculoskeletal disorders in workers, such as non-ideal working posture, repetitive lifting, and static fatigue. Therefore, this proposed layout provides an important practical contribution to support the improvement of ergonomic conditions at IKM Tirta Kencana.

Comparison of Results with Similar SME Case Studies

Results from this research, namely increasing process efficiency through redesigning the facility layout, are in line with other studies about Small and Medium Enterprises (SMEs), which apply quantitative methods. Research on the layout of SMEs, including this case study on the Tirta Kencana Retreading Tires SME, generally uses Method SLP or its derivatives to optimize facility placement.

However, this study provides an important insight. Although SLP is a systematic approach based on functional relationships, Graphical methods are proven to be more effective in the context of Tirta Kencana UKM. The graphical method produces the minimum material transfer distance (349.3 meter), outperforming the SLP results (407.4 meter).

These results show that in the production environment of SMEs, which often has specific and has space limitations, a method that focuses on flow and station proximity (Graphical Method), which is rooted in graph theory, can produce better performance compared to methods that are oriented only on general functional proximity relations (SLP).

Overall, the achievement of distance reduction of 15.73%. confirms the great potential of using structured layout methods. This is consistent with other studies showing that quantitative methods can be effective. Increase productivity and minimize costs *in material handling* in the SME manufacturing sector.

Conceptual Diagram of Layout Comparison

To visualize the layout improvements, a conceptual comparison of three layout scenarios is presented Initial Layout, Proposed SLP, and Proposed Graphics.

Table 11 *Conceptual Diagram of Layout Comparison*

Level	Conceptual Description	Main Benefits
Initial Layout	Workstations are scattered with unclear boundaries, resulting in obstructed workflow, inefficient operator movement, and ergonomic risks.	-
SLP Proposal	Workstation placement based on functional proximity analysis (ARC/ARD) partially reduces transfer distances. It is still less than optimal in minimizing material transfer distances (Total 407.4 m).	Improved functional relationships between areas.
Graphic Proposal (Selected)	Workstation placement based on the highest weighting of rectilinear distance (FTC) and proximity relationship, resulting in the most compact material flow (Total 349.3 m). Optimizing space and reducing operator movement	Highest transfer distance efficiency (15.73% reduction), production flow improvement, and ergonomic contribution.

Conclusion

The objective of this study was to optimize the layout of facilities at the Tirta Kencana Vulcanizing SME, which initially caused process efficiency problems and musculoskeletal risks. Through a comparison between the SLP method and the Graphical Method, it was found that the Graphical Method was the most effective approach for this case study. This method was able to reduce the total material distance from 421.5 meters to 349.3 meters, equivalent to a 15.73% increase in efficiency. Based on these research results, MSMEs in the automotive service sector can use simple structured methods such as SLD and the Graphical Method to improve productivity and safety. Managerially, this new layout reduces bottlenecks and minimizes unnecessary operator movement, contributing to improved ergonomics. Although it only focuses on material movement, this study concludes that the proposed layout is a strategic solution. For future research, it is recommended to integrate cost analysis and perform simulation-based validation (e.g., using FlexSim) for more comprehensive optimization.

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