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APPLICATION AND DESIGN OF PRODUCTION ROOM LAYOUT WITH 5S – ARC METHOD TO REDUCE WASTE (CASE STUDY ON RUBBER INDUSTRY PRODUCTION)

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ABSTRACT

This study aims to get good production facility layout recommendations to reduce material handling distance in the company. This is intended so that the production process can run optimally. This study examined the rubber processing industry located in Bogor patent where the production process in this industry still uses simple methods. This causes a significant amount of waste in the production system in the industry. Therefore, this study discussed the redesign of the production room layout by using ARC proximity (Activity Relation Chart), which is a method to see the level of intimacy between activities in the production process. It also examines the work culture in industrial production using the 5S method. The results of this study show that there is a reduction in the distance and time of movement of goods in the production process with 2 alternative layout proposals contained in this scientific research.

Keywords*: Industrial Production, Production Layout, Relation Chart.*

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1. Introduction

CV MA Mekar Rubber is a CV engaged in the rubber industry whose main products are compound rubber and crumb rubber which are the main raw materials in the manufacture of shoe sole rubber, car tires, car variation rubber, and much more. Process production is still carried out using a simple method where the entire production process at the compound rubber plant and crumb rubber production process flow is still ineffective and efficient because there is still a lot of waste in the production process. Therefore, planning and controlling production process activities also need to be planned so that they can reduce production costs to increase the company's profit margins (Vinod *et al.*, 2014; Blais *et al.*, 2023). With work culture planning, the layout of goods with a good production flow and work culture can make a great contribution to optimizing production process activities to reduce the company's production costs. Using space and work culture more efficiently and effectively, companies can use the 5S method because it can reduce existing waste (Kardkhar *et al.* 2007;

Rostika, 2022). The purpose of this study is to obtain a proposal for a good layout of production facilities to reduce the distance of material handling in the company so that the production process can run optimally.

A production process is a form of activity that is most important in the implementation of production in an enterprise, this is because the production process is a method or way in which the activity of adding benefits or creating benefits is carried out (Noerpratomo, 2018). With this research, it is hoped that it can make an effective and efficient production process so that it can have an impact on the production process in the company.

At this time, the layout condition of the production facility experienced several obstacles in the distance of moving the flow of goods that were less efficient and there was still a lot of waste contained in the production process. Therefore, replanning the layout of production needs to be carried out to be able to control the production process more effectively and efficiently (Shariff *et al.*, 2022). The layout of this factory includes planning and setting the layout of machinery, equipment, material flow, and work culture in each work division. Meanwhile, according to Nurcahyo *et al.*, (2019), 5S comes from Japanese words, namely Seiri, Seiton, Seiso, Seiketsu, and Shitsuke (selection, arrangement, cleaning, stabilization, habituation). It requires determination and persistence to carry out 5S continuously, it must be done by all members of the organization and led directly by the highest leadership in the organization (Tahir *et al.*, 2015; Utari *et al.*, 2020), about designing the layout of production facilities on CV Primaset Advertising (refer Figure 1).

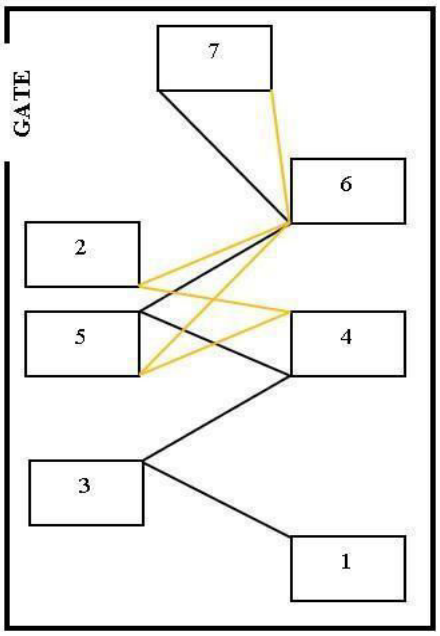


Figure 1. First Layout.

Figure 2 shows the initial layout of the mesh 30 and mesh 40 production sites where there is an inefficient flow of goods at the production site and the physical condition of the field at the sorting place for raw materials for inner tubes is very messy where used tires are stacked without using shelves and the workers do not clean up the garbage after sorting. This makes a lot of raw materials splattered. It can be seen in Figure 3 that in the chopping machine area, there are still many traces of raw material where there is some unused waste that is still there in the chopping machine area.

Figure 2. Physical condition of the field at the sorting place.

Figure 3. Chopping machine area.

2. Methodology

This research was conducted at its production plant located in Karang Asem Timur Village, Citereup District, Bogor Regency. The first step in this study was to conduct the observations on the mesh 30 and mesh 40 production plant areas, in order to identify problems in the field. Based on the observations, an Activity Process Chart on existing production patterns was generated and followed by a literature study on predetermined problems (Malim *et al.*, 2019). The next step is to collect layout data in the factory using the Activity Relation Chart (ARC) approach. This is by providing alternative layouts for new production facilities that can increase material flow and help increase the utilization of space in the plant by looking at the degree of proximity between existing divisions (Mohd Nordin *et al.*, 2022). So that in making alternative layouts on production plans that are more efficient and effective by using the Activity Relation Chart (ARC) method approach with this method we can see the degree of closeness between existing production processes. The Activity Relation chart (ARC) method is a material flow method that can be measured qualitatively using a benchmark for the degree

of closeness of the relationship between one facility (department) and another. Values that lower the degree of relationship are recorded at once for the underlying reasons in an Activity Relationship Chart (Sofyan & Cahyana, 2017). By using this method, it will be able to take advantage of the existing area and the movement of goods will also be effective.

Furthermore, on improving the environment and work culture, the method that will be applied is the 5S method. A 5S method is a basic approach to regulating the work environment, which in essence seeks to eliminate waste to create an effective work environment. Therefore, the 5S method is also important in arranging the layout of industrial production rooms on a rubber A broad definition of 5S according to Wahyudi *et al.*, (2022), is to utilize the workplace (which includes equipment, 17 documents, buildings, and spaces) to train the habits of workers to improve work discipline starting with Seiri (sorting), Seiton (arrangement), Seiso (cleaning), Seiketsu (stabilization), Shitsuke (habituation). Seiton (neat) that is, all items must be placed following a predetermined position so that when using the goods are ready when they want to be used. Seiso (clean) is an activity to clean goods, equipment, and work areas after completion of work so that the goods and workplace remain in good condition. Seiketsu (care) is an activity to maintain personal hygiene, tools, goods, and workplace after work and comply with the previous three stages. Shitsuke (Diligent) is an activity of instilling discipline in the person of each worker in applying the 5S method. This method will be very effective if the workers comply with all regulations and follow the directions in the 5S method to create comfort and safety as well as time efficiency at work.

3. Results and Discussion

The proposed planning of the layout of the production facility starts from obtaining the results of the analysis of the material flow in the form of a 30 & 40 mesh production plant. The process flow map is summarized in Figure 4, where the figure depicts the existing production process. As in Figure 4, there is a group from the 30&40 mesh production plant where there are 2 groups of 2 different raw materials. The first raw material is the outer tire raw material which is directly brought to the place of the chopping machine to be chopped into a smaller shape and the raw material for the inner tire raw material is sorted for sorting dry and non-wet inner tubes which aims not to stick to the crusher machine so that it does not interfere when the machine is running, then the two raw material grooves meet on the crusher machine where the raw materials are both refined to be finer than before. After the completion of the crusher machine, the semi-finished goods are placed in a semi-finished warehouse after which the semi-finished goods are taken to the open mill machine to be smoothed to a smoother one.

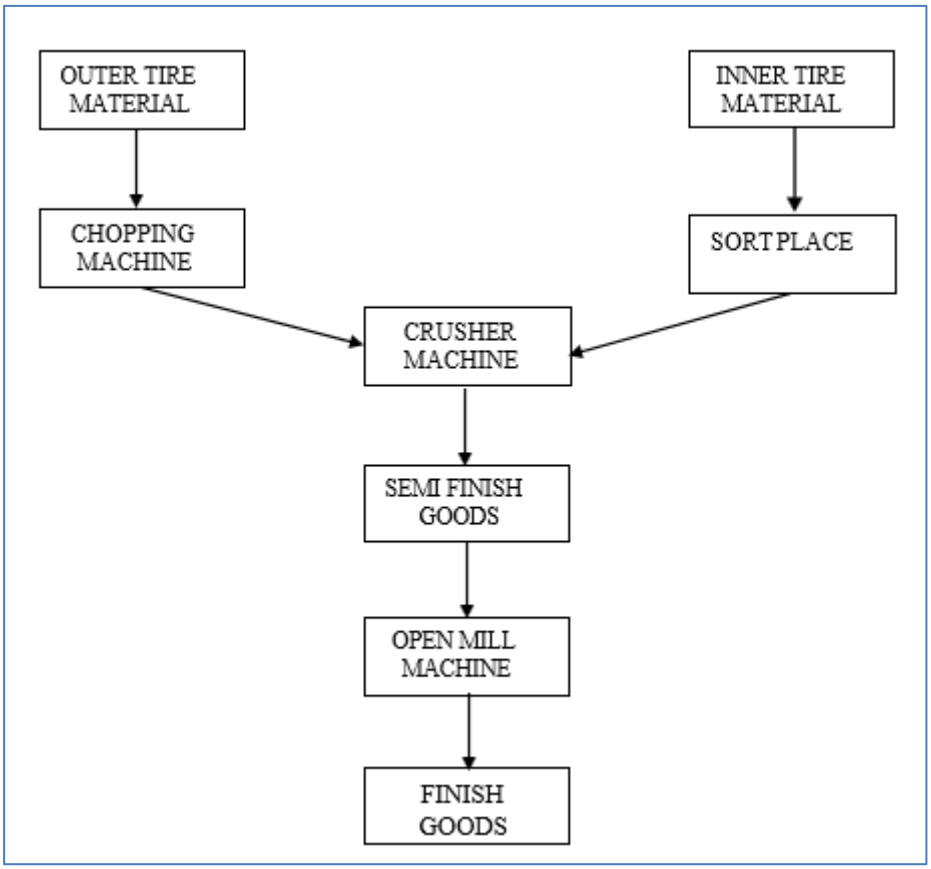
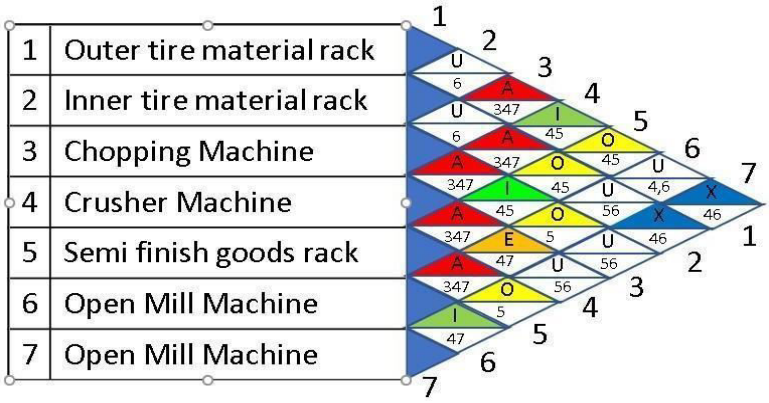


Figure 4. Production Process.

Mesh 40 products are finer than mesh 30 products for the main raw materials for making rubber shoe soles or tires that are just existing in production places where the layout or placement of goods and tools at the production site is not fully good and also the way the raw materials are transferred is located a little far between 1 place to another place where the stage of moving goods still uses the manual method, namely by using human labor where it takes a long time and a lot of labor so that it is not efficient and effective in the flow of production flows in factories. The next stage in this study is to analyze the activities contained in the production site using Activity Relationship Chard (ARC) (refer Figure 5) which is a basis for making alternative new layouts by considering modifications and practical



limitations.

Figure 5. Art Relation Chart.

The activities are coded as per described in Table 1, followed by the description of its importance as described in Table 2.

Table 1. Activities Relation Chart at the production area.

Code	Description
1	Information flow
2	Degree of supervision
3	Order flow
4	Material flow
5	Function
6	Not related
7	Interrelated facilities
8	Noisy, dirty, dust
9	Safety

Table 2. Activities Relation Chart at production Area.

Closeness Color	Description	Code
	ABSOLUTELY IMPORTANT	A
	VERY IMPORTANT	E
	IMPORTANT	I
	ORDINARY	O
	UNIMPORTANT	U
	UNDESIRABLE	X

From Figure 5, the degree of closeness between the processes is summarized in Table 3. It can be seen that the degree of closeness between activities in the table worksheet results in 2 alternative new layout designs that would be able to reduce the distance between goods movement and activities; and in the end to make the process or flow of activities more effective and efficient based on the ARC diagram.

Table 3. Worksheet for degree of closeness.

No	Activities	Degree Of Close					
		A	**E**	**I**	**O**	**U**	**X**
1	Outer tire raw material rack	3			4	2,6	7
2	Inner tire raw material rack	4				1,3,6	7
3	Chopping machine	1,4			5	7,2	
4	Crusher Machine	2,3,5		6	1	7	
5	Semi-finished goods rack	4,6			3		
6	Open mill machine	5		4	7	1,2	
7	Finished goods material rack				6	3,4	1,2

From Table 3, the proposed layout plan 1 is generated as per Figure 6.

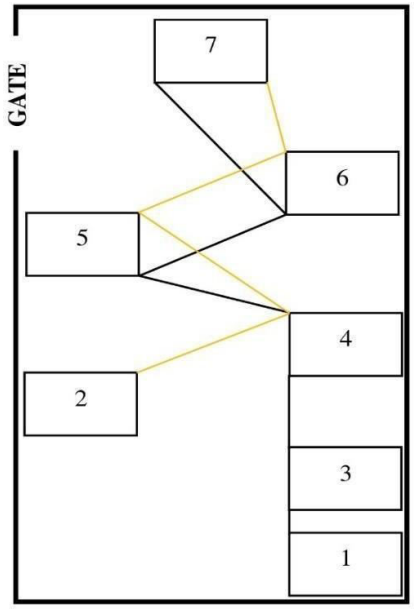


Figure 6. Proposed Alternative Layout 1.

In the proposed alternative layout 1 improvements, there are several changes to some production machine tools without changing and redesigning the production room which can reduce and cut the distance and time of moving goods.

- As stated in the layout image above the position where the warehouse raw material (Inner tube) (2) is to be moved closer to the crusher machine (4) because in the ARC table the two have a very important relationship.
- As shown in the alternative layout figure 1 chopping machine (3) moved close to the raw material warehouse (outer tire) (1) because the chopping machine (3) has a very important degree of proximity in the ARC table because it is the next groove of the processing of raw material (outer tire) (1).
- As stated in the layout above, the position of the semi-finished material storage area (5) is exchanged for the position of the inner tire raw material warehouse (2) because so that there is no reverse flow so that the flow of goods to the open mill machine (6) is closer and can cut the distance of moving goods so that the distance of moving goods is reduced.

  In the second alternative layout proposal (in Figure 7), namely the layout design of the space between the machine and the storage warehouse is still the same as the first alternative layout but in the second alternative layout, it is coupled with redesigning the shape of the production place by adding a gate or additional entrance as in the layout picture above, but the CV must to invest in creating a new gate for loading and unloading raw materials because it greatly saves time and costs for workers to move materials raw that you want to use in the storage warehouse so that it can greatly cut time in the production process.

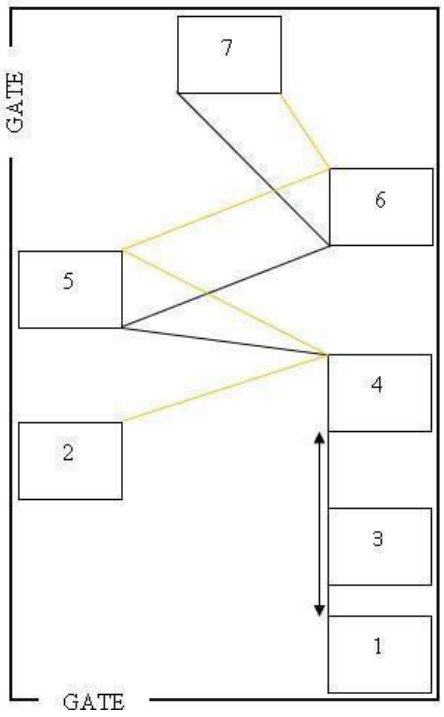


Figure 7. Proposed Alternative Layout 2.

3.1 Analysis of Distance and Time Calculations

The analysis was done on the effect of the alternative layouts in terms of the distance and time. Table 4 shows a comparison of distances in the first layout planning alternative, which was found to cut the distance of goods movement activities at production facilities. The improvement in terms of distance and time cut are calculated based on percentage as described in the following:

$$Effective\ Percentage\ Distance = \frac{Previous\ Distance - Distance\ After}{Previous\ Distance} x100\ \% \quad (1)$$

$$= \frac{5,7}{102,3} x100\ \% = 5,57\ \% = \frac{5,7}{102,3} x100\ \% = 5,57\ \%$$

Table 4. Distance table (M) Alternative Layout 1.

No	Move		Distance		Time (Per 300kg)	
	From	To	Before	After	Before	After
1	1	3	8,4	4	11	4
2	3	4	9,2	5,4	12	7
3	4	5	9,6	10	12,5	13
4	5	6	13,7	11,6	18	15
5	6	7	15,4	15,4	20	20
6	2	4	6	7,2	8	9,5
7	Gate	1	35	35	45.5	45,5
8	Gate	2	5	8	18	20
9	Total		102,3	96.6	145	134

The following calculation of the percentage of trimming the material displacement time is as follows:

$$Percentage\ Effective\ Time = \frac{Previous\ Time - Time\ After}{Previous\ Distance} x100\ \% \quad (2)$$

$$= \frac{11}{145} x100\ \% = 7,58\%$$

It can be seen that there is the effectiveness of trimming the material displacement distance in the first alternative layout by 5.03%. And there is effectiveness in cutting the displacement time by 7.58% compared to before.

Based on Table 5, there is a comparison of distances in the alternative layout role, the second is that there is a distance cut in the activity of moving goods in production facilities by:

$$Effective\ Percentage\ Distance = \frac{Previous\ Distance - Distance\ After}{Previous\ Distance} x100\ \% \quad (3)$$

$$= \frac{42,7}{102,3} x100\ \% = 41,73\%$$

The following is the percentage of trimming the material displacement time as follows:

$$Percentage\ Effective\ Time = \frac{Previous\ Time - Time\ After}{Previous\ Distance} x100\ \% \quad (4)$$

$$= \frac{46,5}{145} x100\ \% = 32,06\% = \frac{46,5}{145} x100\ \% = 32,06\%$$

So, there is the effectiveness of trimming the material displacement distance in the second alternative layout by 51.50%. And there was a 32.06% reduction in material transfer time from before.

Table 5. Distance (m) and Time (M) Table in Alternative Layout 2

No	Move		Distance (m)		Time (S) (per 300kg)	
	From	To	Before	After	Before	After
1	1	3	8,4	3	11	4
2	3	4	9,2	5,4	12	7
3	4	5	9,6	10	12,5	13
4	5	6	13,7	11,6	18	15
5	6	7	15,4	15,4	20	20
6	2	4	6	7,2	8	9,5
7	Gate	1	35	4	45.5	15
8	Gate	2	5	3	18	15
9	Total		102,3	59,6	145	98.5

3.2 Designing The 5S Method

A 5S method is a basic approach to regulating the work environment, which in essence seeks to eliminate waste to create an effective work environment. Based on the results of the audit method 5S can be given proposals for improvements to create a safe and comfortable working area (Sukmana, 2022; Candrianto & Ningsih, 2021). The 5S method is an important aspect to support comfort and work efficiency, on the other hand, the production space that we researched has not fully applied the 5S method, this method has the function of reducing the erosion of the movement of goods or a wider one in the sense that this method if applied will be very efficient in the movement of goods from trucks to goods racks and also from finished goods racks to trucks for delivery. The 5S method is also very important for a more structured layout.

The following is a proposal to improve work culture and the workplace in accordance with the 5S principle.

- Seiri (Concise) design is by selecting and eliminating unused or useless goods in the factory production area such as removing some pallets and used wood that has been damaged and unused at the production site to be removed or disposed of so that in the

production area there are no useless goods so that the goods in the production area are only used goods or those used in the production process.

- Seiton Planning (Neat) is by placing all goods in accordance with a predetermined place and especially in the outer tire raw material warehouse and the inner tire raw material warehouse is given a regional line as needed so that the raw materials of both are not splattered where and tidied up according to the predetermined area.
- Seiso (Clean) planning is by briefing and socializing employees to clean the work area after completion of work so that the production area remains clean after the production activities are completed.
- Seiketsu (Nurse) planning is "constantly and repeatedly nurturing seiri, seiton, seiso both personally and in relation to work." The purpose of seiketsu is: Maintain the environment in good condition. Keeping work tools ready to use and maintaining the quality of work results.
- Shitsuke's (diligent) planning is the last step, which is self-awareness of work ethics: (1) Discipline towards standards, (2) Mutual respect, (3) Shame of committing violations, and (4) Happy to make improvements.

4. Conclusion and Recommendation

From the results of the study, we recommend 2 alternative layouts, the first alternative layout can streamline distance by 5.03% compared to before while a time efficiency of 7.58% compared to before while alternative layout 2 can streamline distance by 41.73% while displacement time efficiency is 32.06%. So, it can be concluded that alternative layout 2 is more effective and efficient than alternative layout 1, but companies must make long-term investments to create an entry gate for the process of loading and unloading raw material goods for a production process that is more effective and efficient than before and improves a good work culture in accordance with the 5S concept. It is hoped that in the next research, a more in-depth study can be carried out with various approaches to analyze the number of production costs that will have an impact on the efficient use of labor and production equipment.

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Author Contribution

Author1 prepared the literature review and oversaw the article writing. Author2 wrote the research methodology and performed fieldwork. Author3 conducted the statistical analysis and interpreted the results.

Conflict of Interest

The authors have no conflicts of interest to declare.

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