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Factory Layout Planning Using Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) Method

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ABSTRACT

Kahuripan Food Lembang which is one of the SMEs (Small and Medium Industries) has invested in the food security sector of West Java. It is unfortunate that from the amount of potential owned by this industry, it does not have a factory layout according to The Indonesian Food and Drug Authority (BPOM) standards, thus hampering the production process. The method used in this research is a qualitative method with data collection techniques in the form of interviews, documentation, and observation. After obtaining the method to be used, then the layout is made with the selected method, namely the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) methods. Based on the results of the analysis and evaluation of the activity relationship of each department needed, it shows that the layout made can help streamline production and logistics activities because it has a flow of activities that have been adjusted to the degree of relationship as a basis for consideration and has been adjusted to the actual size needed.

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1. INTRODUCTION

In the industrial world, the problem of industrial layout or the placement of industrial facilities and production equipment is one that plays an important role in increasing the productivity of a company (Ali, B ., Jaweed, S. , & Fahad, M.., 2015; De Carlo, et.al, 2013) Factory layout is defined as a process of arranging factory buildings to support the smooth production process. Material handling distance in the production area affects production lines and processing time (Fitri., 2022). According to research conducted by Tongur (Tongur., 2020), poor layout of facilities for production in industrial areas often causes problems such as large losses in production costs, disrupting the production process, increasing production waiting time, and reducing productivity (Dongre, A. , & Mohite, N. Y, 2015). Therefore, a good facility layout can provide convenience in the production process, can also minimize the production process, minimize the transfer of goods, maintain flexibility, maintain the turnover of goods, minimize capital, reduce the use of space, maximize worker efficiency, and also provide safety for workers (Yuliarty & Widiarto, 2014; Flessas, M., 2015). The most significant challenges in facility layout design are complexity, dynamics, randomness, simultaneity, high cost lack of integration and standardized procedures, and safety (Zúñiga et al., 2020). In general, to plan a layout that can be by placing departments that have strong relationships in close proximity (Puspita et al., 2015). One industry that is very important to plan the layout of its factory is the Dairy Processing Industry, especially maintaining its sanitation.

The Dairy Processing Industry in Indonesia is one of the priority aspects stipulated in Presidential Regulation No.28 of 2008 concerning National Industrial Policy. Based on data from the Central Statistics Agency (BPS) in 2020-2022, milk production in Indonesia experienced a positive trend. Where production results continue to increase, until finally in 2022 the total milk production produced reaches up to 968,980.14 tons. However, it cannot be denied that the existence of the milk processing industry in Indonesia today has positive and negative sides.

One of the milk processing industries is Kahuripan Food Lembang, which is one of the SMEs (Small and Medium Industries) in Indonesia. This industry has invested in the West Java food security sector with a total investment of Rp 2.6 billion. However, from the great potential of this industry, it is unfortunate that this industry does not have a factory layout that is not in accordance with the standards as can be seen in Figure 1.

Figure 1. Kahuripan Foods Lembang Factory Layout Condition

This is because there is a change of location that takes a long time, but production must continue. The existence of conditions like this, causes disrupted production and logistics activities such as the joining of storage and production warehouses. This means that the layout of the factory facilities has not been standardized by The Indonesian Food and Drug Authority (BPOM) and is not in accordance with the provisions in the Decree of the Head of the Food and Drug Administration of the Republic of Indonesia Number: HK.00.05.4.3870.

Based on these problems, Kahuripan Foods Lembang needs a factory layout that complies with BPOM standards so that this factory can optimize the flow of materials, people and information throughout the factory by strategically placing production areas, warehouses and storage areas so that it will streamline production time and can avoid work piles that will have a positive impact on increasing work productivity and maximizing the potential of this industry. Factory layout planning using ARC (Activity Relationship Chart) and ARD (Activity Relationship Diagram) approach. The purpose of this research is to provide solutions to increase production effectiveness and productivity through factory layout planning that has not been maximized.

The use of ARC and ARD methods is based on several previous studies that show that ARC and ARD methods can be an effective way to design factory layouts. For example, Arda et al. (Arda et al., 2022) conducted at the facility by PT. Kindo Ritel Prima (Pointbreak Store). Where from the proposal given based on ARC analysis, there is a space savings of 3.64 m2 (from 50.14 m2 to 46.5 m2), which can be used to open new spaces, such as adding new shelves., and Dedy et al. (Dedy et al., 2017) in the home industry UD. Tahu Goreng SKY Tebing Tinggi. The use of this method in the industry has created a positive impact, especially in terms of effectiveness and efficiency of movement. Where the movement to a better workstation layout such as the soaking station is closer to the raw material raw materials and the grinding station, the frying station is closer to the cutting station. Space space for employees at the boiling station, the filtering and flavoring stations, pressing stations and cutting stations becomes wider.

2. METHODS

The method used in this research is a qualitative method with data collection techniques in the form of interviews, documentation, and observation. In the observation process, researchers conducted direct interviews with company owners regarding the problems experienced and conducted documentation on the layout of the room and the production process. Based on the results of observations and interviews that have been conducted, researchers get hypothesis results in the form of the importance of layout for the production flow, especially for cleanliness, smoothness, and productivity. Then the researchers conducted further analysis of the methods that will be used to solve the problems of Kahuripan Foods Lembang as shown in Figure 2.

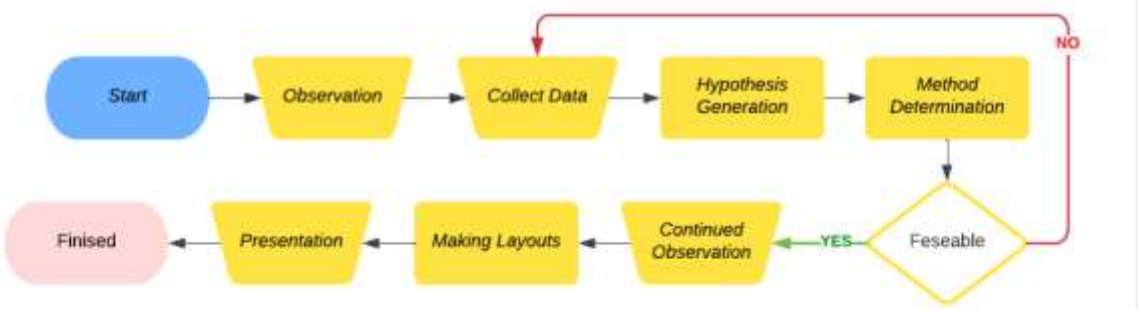

Figure 2. *Research Flowchart*

After obtaining the method to be used, researchers made layouts with the selected method, namely the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) methods using primary data derived from observations made and secondary data in the form of literature reviews from previous research journals regarding ARC and ARD. Layout creation is done with five steps, namely:

1. Identify the actual size and space required and make an Initial layout with a certain scale.
2. Analyze the relationship between rooms using the ARC method. ARC is used to analyze the level of relationship or activity linkage from one room to another (Muther, 1955). In describing the degree of closeness of the relationship between all ARC activities using symbols A, E, I, O, U and X, namely:
    a. **A** : Absolutely necessary i.e. the relationship is absolute
    b. **E** : Especially important, namely the relationship is very important
    c. **I** : Important is the relationship is quite important
    d. **O** : Ordinary which is mediocre
    e. **U** : Undesirable is a relationship that is not desired
    f. **X** : Highly undesirable relationship
3. Analyze the flow and departmental relationships in the new layout based on the departmental linkages that can be seen in the previous step using the ARD method.
4. Evaluate the ARD that has been made previously.
5. Create a detailed layout with a certain scale.

3. RESULTS AND DISCUSSION

The situation analysis is based on the results of observing the conditions of the partners that have been visited, namely Kahuripan Foods Lembang, which is located at Pasir Handap no. 34, Pagerwangi Village, Lembang. Based on the observation results, this SMEs (Small and Medium Industry) still have many obstacles, especially in the logistics sector such as warehousing, inventory, procurement, and distribution. The following is an explanation of the obstacles experienced by Kahuripan Foods Lembang, with the hypothesis obtained shown in table 1.

Table 1. Observation Results

Sector/Field	Situation Analysis	Problem Identification and Formulation	Hypothesis
Warehouse	The storage place and production place are still in the same place in the form of a garage	Kahuripan Foods Lembang still has supporting equipment in the form of a shelf in its warehouse and production site. While supporting tools in the field still rely on storage in the form of freezers with a capacity of 500 liters in each branch. The actual processed ingredients do not enter the storage room because they will be processed directly, only other additional ingredients such as salt, sugar, etc. enter the storage room. Even so, Kahuripan Foods Lembang applies the First In First Out (FIFO) method following the Standard Operating Procedure from The	There is a need for re-planning and maximization of space related to the layout of facilities at Kahuripan Foods Lembang.

		Indonesian Food and Drug Authority (BPOM).	
Inventory	Kahuripan Foods Lembang implements a zero inventory strategy with a make to order policy.	Kahuripan Foods Lembang implements a zero inventory strategy because each distributor of processed ingredients has a different schedule, so it does not have a large stock of only about 20% of the total amount stored. The production system used is make to order because Kahuripan Foods Lembang uses a factory system that already has a market for the distribution of sales goods. The difficulty experienced in the inventory field is in the physical condition section which does not match the data inputted on the computer or manually.	Reassessment of stock-taking activities, with suggestions from the team using the DMAIC method
Procurement	So far Kahuripan Foods Lembang has received offers from suppliers who visit the factory directly. There are no specific criteria for ingredient procurement suppliers, but the milk itself is obtained from the KPSBU cooperative.	Kahuripan Foods Lembang also has difficulties related to the increasing price of milk because it only has one supplier and this has become a provision from the local government, supplier eligibility, and lack of human resources.	There needs to be SOPs related to sourcing and purchasing activities themselves. Where the policy to identify suppliers to check the eligibility of raw materials from suppliers
Distribution	The distribution network of this industrial production has reached outside Java Island including Banjarmasin and Bali. For the distribution process within the island of Java will use paxel if the production to be sent amounts to 5 kg - 10 kg, but if the amount will be sent more will use logistics trains. For distribution outside Java such as Banjarmasin will be sent using aircraft cargo. While to Bali will use the bus.	The distribution constraints experienced by Kahuripan Foods Lembang are in the shipping packaging that can maintain the freshness of the production, because in some cases this industry has experienced problems when shipping UHT milk which has a chemical reaction so that the milk components are curled and separated with water.	It is necessary to choose a distribution mode that is in accordance with the characteristics of dairy products such as a car with a cooling system.

The results of the observation show that the most important thing from all factory activities, especially SMEs (Small and Medium Industry) is from the internal itself. This is seen from how the industry is able to produce quality products. The internal environment is a reflection of the strengths or weaknesses of a company organization and can reflect management's ability to manage the company (Lofian & Riyoko, 2014). Internal factors that can affect the performance of MSMEs include human resource factors, financial factors, production factors, and marketing factors. The results of the study state that good internal factors such as human resource aspects, financial aspects, technical and operational aspects, and market and marketing aspects will help MSME owners to achieve growth in sales, capital, profits, and markets (Siagian et al., 2019). The flow of production activities at Kahuripan Foods Lembang can be seen in the figure below.

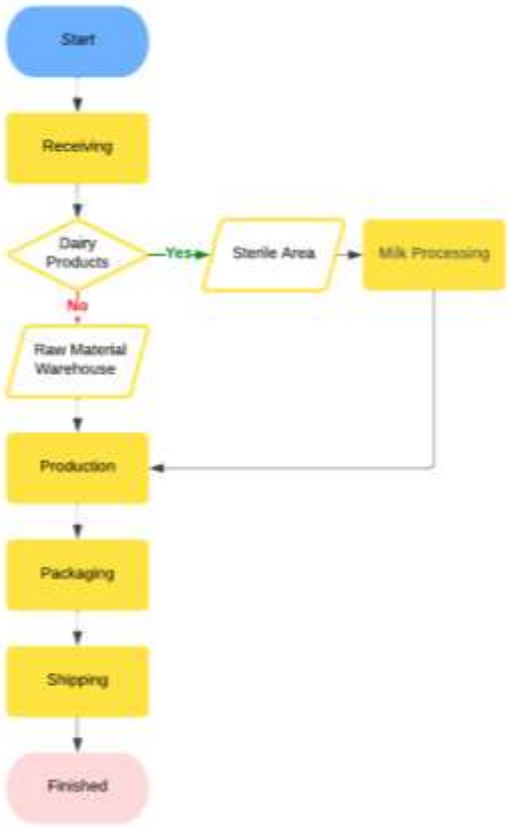

Figure 3. Activity Flowchart of Kahuripan Foods Lembang

Based on the flowchart, there are many activities to finally produce a product, starting from receiving to shipping. The length of this process requires a clear flow in the process, be it from the relationship or relationship between rooms to be effective or from the relationship between the tools used. However, this requirement has not been implemented by Kahuripan Food Lembang for the reasons previously mentioned and as stated by the founder of this industry regarding the current layout, namely.

- "We just moved here, if the old place has BPOM standards, there is a production site, there is storage of goods, a place and packing. because the old place was small and then it was located on the side of the road and in a residential area so we looked for a bigger place. because if the factory has an Environmental Impact Analysis (AMDAL) permit, if it is in a residential area it cannot, if it is remote so for waste disposal everything is safe. We happen to be neighbors with cattle breeders, so we can collaborate lah. When we moved here we started again from 0, now we are still using the garage because the construction of the hall and product area is in process."
- "The difficulty now is in the place, because I just moved. I want to follow the old one, so there is a flow, production flow, storage flow, because it is also risky if it is combined, it's complicated. So like this, just now the goods arrive, they have to be produced immediately, because they can't be supplied anymore. that's the problem at the place, you have to build a new one."
- "We also have Standard Operating Procedure (SOP), our SOPs are quite heavy, because the CAPA desk, as it is called for the BPOM system, has up to 3 procedures, so from the place, like the indentation can't be triangular, so it has to turn so that dirt doesn't slip on the edge, from the floor too. actually this is still a garage but the floor has started to follow the factory, but not all. However, the layout itself is not yet in

accordance with the BPOM because we have just moved and the limitations of the funds as well."

Therefore, the right solution is needed so that these SMEs can be more effective, efficient, and can increase their productivity in producing their products. The application of the method used by the team uses six steps as follows.

3.1. Identify Actual Size and Required Space and Create Initial Layout

Observation results provide the actual size of the industry and department required. As a result of the arrangement and assessment, it was found that there would be eight departments with a total area of approximately 116 m2.

No.	Department	Length (m)	Width (m)	Area (m2)
1	Receiving, Packing, Shipping	2.5	7.25	18.125
2	Sterile Area	3	7.25	21.75
3	Finished Material Warehouse	6.5	4	26
4	Raw Material Warehouse	2	2	4
5	Tool Warehouse	2	2	4
6	Production Area	2	2	4
7	Toilet	7	5	35
8	Office (Home)	2.5	1.5	3.75

Table 2. Required size of the department

Based on the table above, an overview can be given regarding the shape of the room that will be used through the initial layout with a scale of 1: 100 in the figure below.

Figure 4. Initial Layout

3.2. Activity Relationship Chart (ARC)

The next step is to arrange the degree of relationship between rooms indicated by letter symbols and the reasons indicated by number symbols with the Activity Relationship Chart (ARC) method (Jamalludin, A. Fuzi, H. Ramadhan, 2020; Andy, Dwiky Alamsyah. Suhartini, 2021). ARC is an activity between each section that illustrates the importance of proximity between rooms/workstations. In other words, ARC is a map that is prepared to determine the level of relationship between activities that occur in each area with other areas in pairs. ARC is used to analyze the level of relationship or activity linkage from one room to another (Rosyidi, 2018). The results of the preparation of the degree of relationship between rooms using the Activity Relationship Chart (ARC) can be seen in the figure below.

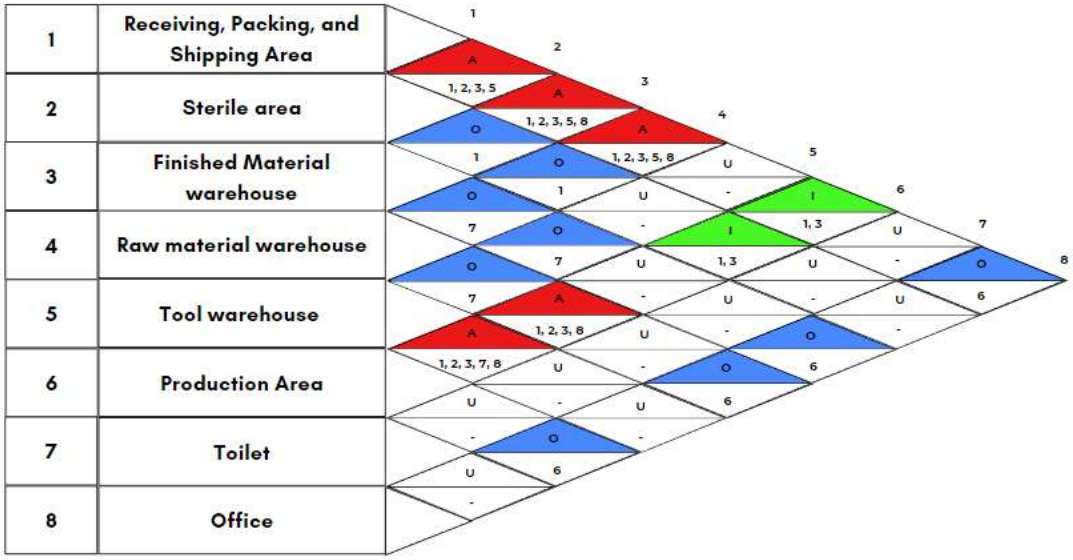

Figure 5. Activity Relationship Chart (ARC)

To see the reasons for determining the degree of relationship in this ARC method, the codes and reasons can be seen in the table below.

Table 3. Activity Relationship Chart (ARC) Codes and Reasons

Kode	Alasan
1	Process flow sequence
2	Degree of staffing relationship
3	Facilitate the transfer of materials
4	Noise, dust, vibration, odour, etc.
5	Uses the same space
6	Ease of supervision
7	Using the same tools
8	Using the same personnel

The next step, from the results of the ARC analysis above, is to make a recap of the degree of relationship between rooms. The results can be seen in the table below.

Table 4. Recap of the Degree of Relationship between Rooms

No	Department	Degree of Attraction					
		A	E	I	O	U	X
1	Receiving, Packing, Shipping	2,4,3		6	9	5,7	8
2	Sterile Area	1		6	3,4	5,7,9	8
3	Finished Material Warehouse	1			2,4,5,6	6,7	8
4	Raw Material Warehouse	1,6			2,3,5,6	7	8
5	Tool Warehouse	6			3,4	1,2,7,9	8
6	Production Area	4,5		1,2	9	3,7	8
7	Toilet					1,2,3,4,5,6,8,9	
8	Office (Home)				1,3,4,6	2,5,7	8

3.3. Activity Relationship Diagram (ARD)

After analyzing the ARC method, the results will be represented in the ARD method. Activity Relationship Diagram (ARD) is a diagram of the relationship between activities (department/machine) based on the priority level of proximity, so that the minimum handling cost is expected. The basis for making ARD is TSP, so the first priority in TSP must be located closer and then followed by the next priority. The area on the ARD is assumed to be the same, then the revision is adjusted based on the line ARD and the area is in accordance with the area of each activity that is reduced to a certain scale. ARD is in the form of blocks connected to one another, describing production areas that have a relationship with one another based on the level of importance of each area that is brought closer (Alamsyah et al., 2021). The degree of relationship using lines in this method can be seen in the figure below.

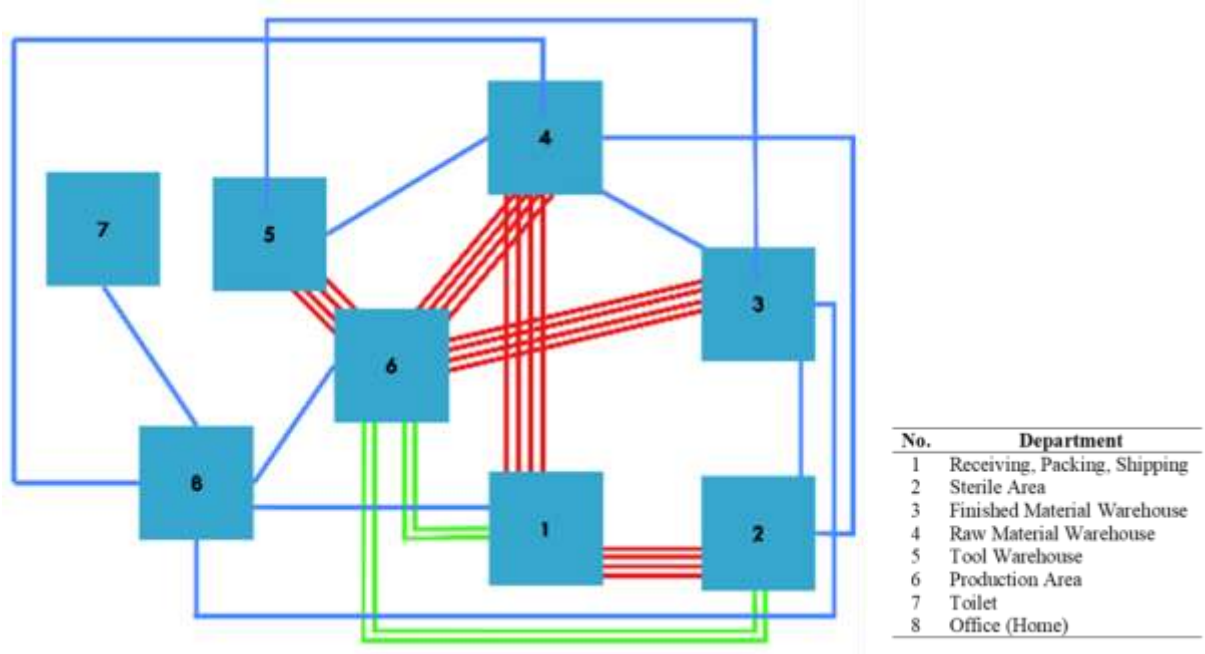

Figure 6. Activity Relationship Diagram (ARD)

Derajat hubungan menggunakan garis pada metode ini dapat dilihat pada tabel dibawah ini.

Table 5. Description of Line Degree

Value	Description	Line Code	Colour Code
A	Absolutely need to brought closer		Red
E	Important to be close		Orange
I	Important to keep close		Green
O	Quite ordinary		Blue
U	Unimportant		No colour
X	Unwanted proximity		Brown

In the ARD that has been made above, it can be seen that there is a lot of accumulation of activities on the right side of the picture, so an analysis of the ARD has been made to streamline the activity path in this warehouse. However, the ARD that has been made previously needs to be evaluated, so that the degree relationship between rooms is more organized and in accordance with the proximity between rooms based on the degree of relationship that has been made.

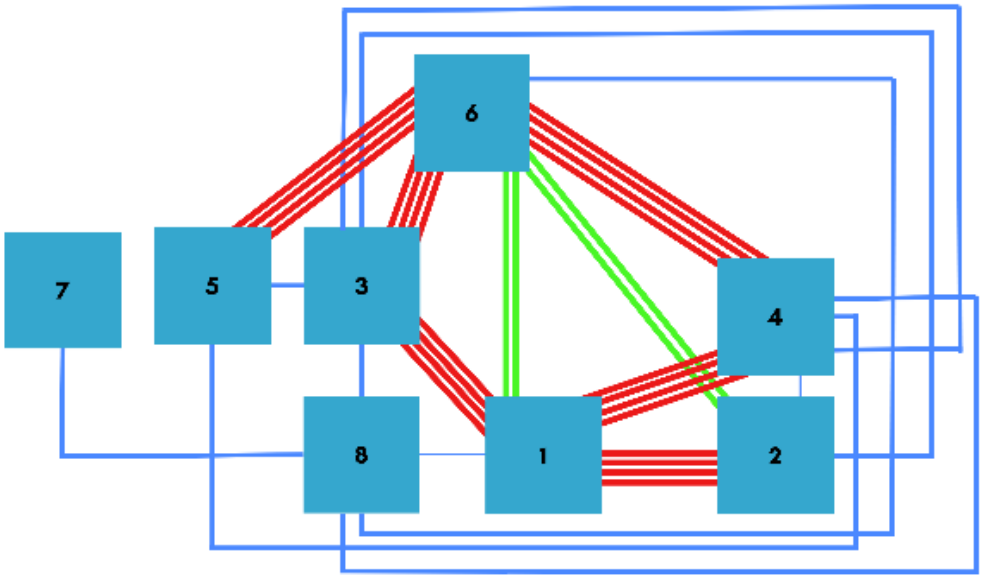

Figure 7. Activity Relationship Diagram (ARD) Analysis Evaluation

3.4. Detailed Layout

The factory production conditions have a buildup of activities such as receiving, shipping, packaging, raw material storage, finished material storage, and equipment storage carried out in the production department(Patel, K., & Chotai, N., 2011) . So that activities are not carried out effectively. The accumulation of activities in one room will also cause less sanitation for the products produced. As a result, products can be reduced in quality. This will not only affect the customers, but will also affect the industry. Where the industry may lose the trust of customers. This can be seen in the picture below, which shows the accumulation of activities in one room.

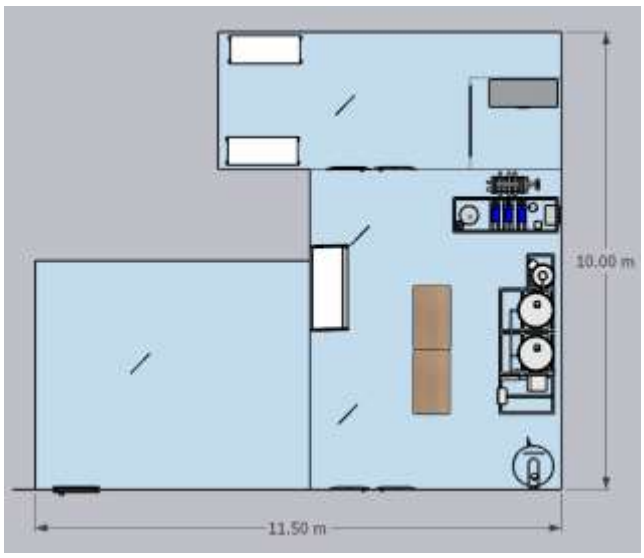

Figure 8. Top View of Detailed Layout of Warehouse Before re-layout planning

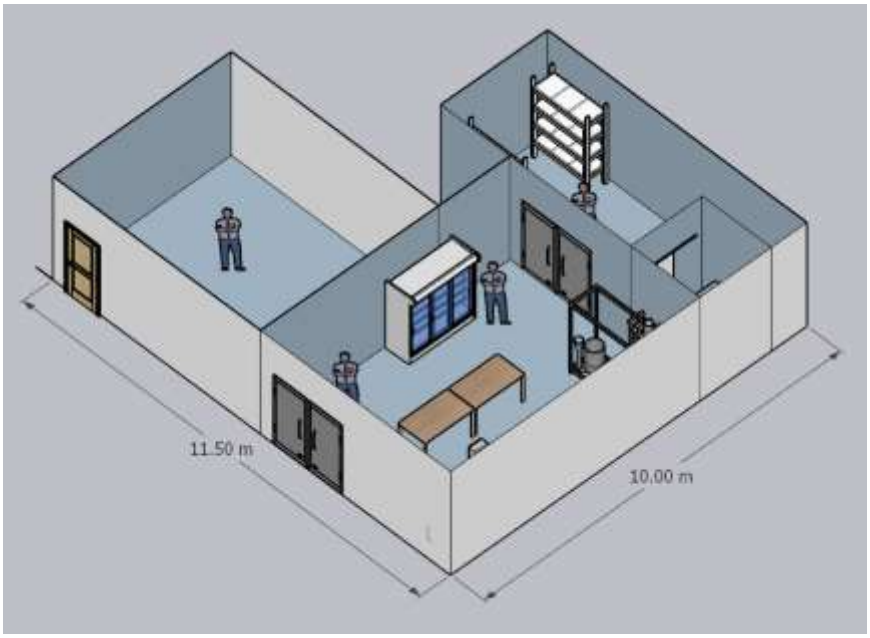

Figure 9. Overall Warehouse Detailed Layout Before re-layout planning

Then the following is a detailed layout after ARC and ARD analysis. With additional departments that are important to support the continuity of production so that production activities can take place efficiently. As can be seen in the picture as well, there is a clear flow of activities with each other. Here u-flow is used with consideration of the size of the industry that is not too large. U-flow flow also has benefits, including based on research conducted by Yuliana et al (Kusuma et al., 2017):

1. Save overall space because if receiving and shipping are side by side, the room can be used flexibly, especially if these activities are scheduled to take place at different times of the working day.
2. Personnel and equipment can be used in a flexible way, reducing the need for overall resources, thus minimizing costs.
3. As the main access to the building is only one place, security is easier to manage.

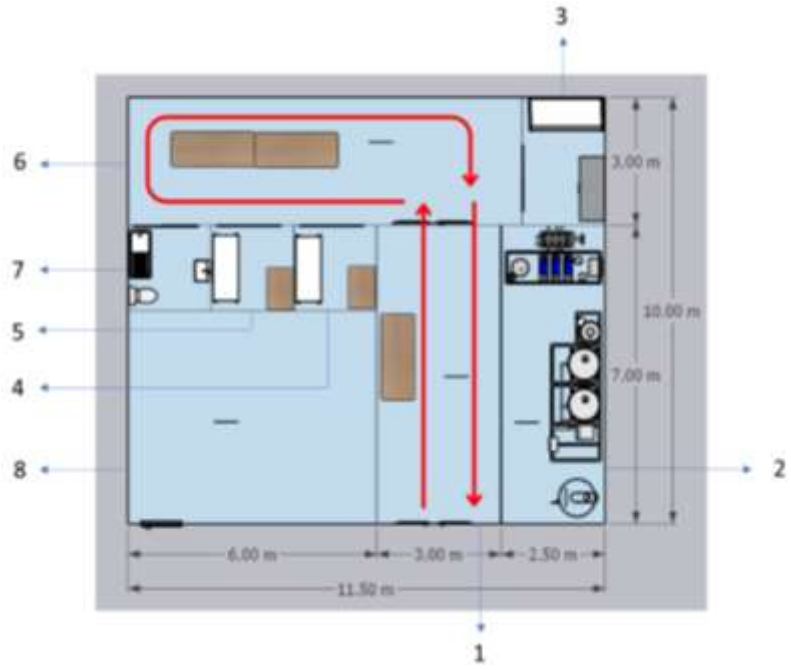

Figure 10. Top view and movement flow of the Detailed Layout Warehouse after the re-layout planning

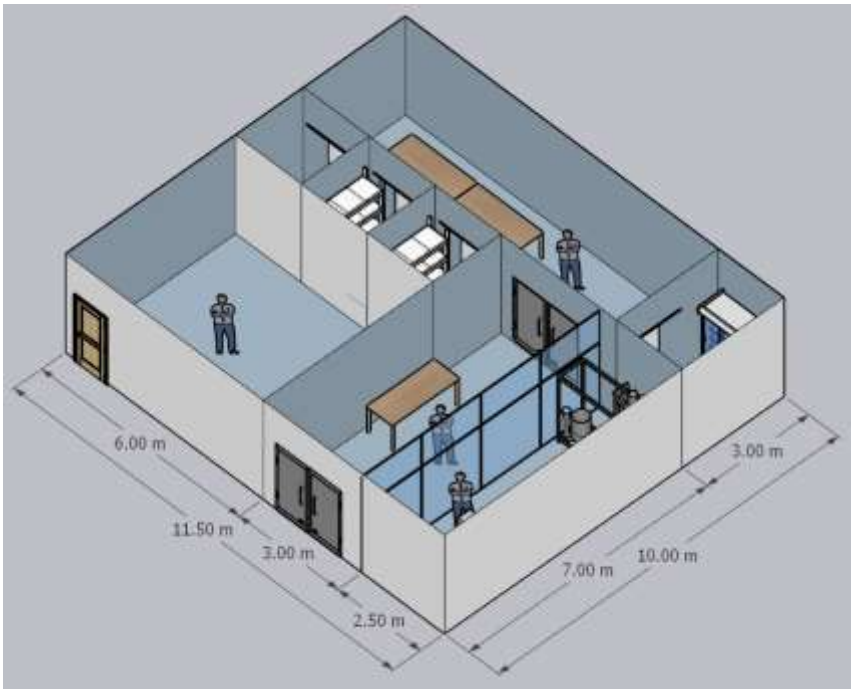

Figure 11. Overall Warehouse Detailed Layout After re-layout planning

But in the course of this industry, despite the new layout plan, there must be discipline by employees to be able to maintain the effectiveness and efficiency of the flow of activities. Among them, according to Tiara (Tiara et al., 2020), it is necessary to apply 5s (seiri, seiton, seiso, seiketsu, shitsuke). The explanation of 5s is as follows (Tanuwijaya et al., 2015):

1. Seiri / concise is organizing and sorting. Distinguish the necessary from the unnecessary, make firm decisions and apply stratification management to dispose of the unnecessary.

2. Seiton/Tidy is storing items in the right place or in the right layout so that they can be used in a pinch. can be utilized at a moment's notice. This is useful for eliminating the search process. If everything is kept in its place, the workplace becomes tidy.
3. Seiso / Clean is cleaning items from dirt or the workplace from unnecessary items. items that are not needed.
4. Seiketsu / Care is maintaining items or workplaces to be organized, neat and clean, including on personal aspects and in relation to pollution / factory waste.
5. Shitsuke/Rajin is the ability to do things the right way as a habit.

4. CONCLUSION

The level of effectiveness of production and logistics at Kahuripan Foods Lembang is disrupted due to a change of location which can be seen from the statement of the owner of this industry. Based on the results of the analysis and evaluation of the activity relationship of each department needed with Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD), this re-layout can help streamline production and logistics activities because it has a flow of activities that have been adjusted to the degree of relationship as a basis for consideration and has been adjusted to the actual size needed. So it can be concluded that this layout will greatly help Kahuripan Foods Lembang to streamline production and logistics. However, it is hoped that there will be further steps to maintain this layout, including applying the 5s (seiri, seiton, seiso, seiketsu, shitsuke).

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