Redesign Layout of Production Facilities Using Systematic Layout Planning and ARC Methods at UMKM Bill Bakerykoe

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ABSTRACT

Bill Bakerykoe is one of the UMKM operating in the food sector in Kudus, with the main production being Donat and Roti Manis. Based on observations, UMKM do not yet have a good work area arrangement. In carrying out bread production activities, using the current layout of production facilities, it was found that the arrangement of the work areas was not in accordance with the sequence of the production process flow from the initial process to the final process. Thus, there was repetition in passing through production areas that should not have been time to pass. The work stations observed were from the location of the raw material warehouse, production machines, to the product packaging area. This research aims to provide proposals for the layout of new production facilities that is appropriate and more efficient, and can eliminate repetitive activities that can waste a lot of time, by minimizing the total production distance. The research method used is Systematic Layout Planning (SLP) which starts from preparing a production route sheet, production process map, creating an ARC (Activity Relationship Chart), redesigning the layout, stages of analyzing the results, then conclusions and suggestions. The results of the research were changes to the layout of 7 work areas including the raw material area 1 (A), the leftover materials area (C), the equipment warehouse area (D), the dough molding area (F), the dough frying area (G), the Donut WIP (J), and equipment washing area (O). As for the comparison of the total production distance in the initial layout and the improved layout, the results showed that the new layout can reduce the total production distance by 16.4 meters.

1. INTRODUCTION

Usaha Mikro Kecil Menengah (UMKM) are not only seen from the quality of the products they produce. However, UMKM that are able to implement good product quality standards, appropriate production layout, appropriate production equipment, and skilled employees will also be taken into consideration [1]. Basically, UMKM partners need to manage the layout of the area where products are produced so that they are effective and efficient in cutting all forms of waste, such as repetitive activities, which can waste a lot of production time [2]. Production layout, in this case can be interpreted as a procedure for arranging factory/company facilities, by utilizing the area (space), to support the smooth production process, as well as supporting the placement of facilities or equipment used and needed in production activities [3, 4].

UMKM Bill Bakerykoe is one of the UMKM that operates in the food sector, with its main production being donuts and sweet bread. This UMKM distributes bread to almost all Kudus Regency. UMKM Bill Bakerykoe is located at Dalangan RT 04/ RW 05, Barongan, Kudus Regency, Central Java Province. UMKM Bill Bakerykoe produces several types of bread, including donut and sweet bread. The amount of bread produced at UMKM Bill Bakerykoe in one production range is between 200-3000 pieces, with a ratio of 45% for donut and 55% for sweet bread. Equipment used in bread production activities includes mixer machines, dough developing machines, ovens and stoves. In order for this bread to compete in the culinary world, UMKM Bill Bakerykoe must maintain the quality of

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the products produced. Quality assurance and quality will increase if the work environment has good conditions [5]. A neat work environment makes employees and consumers feel comfortable [6, 7]. Apart from that, employees can work more efficiently so that production capacity will increase [8].

The bread production process activities in UMKM begin with weighing ingredients, mixing ingredients, rolling and cutting bread dough, developing bread dough, baking, cooling and packing. The number of workers at UMKM Bill Bakerykoe is currently 3 workers. The area of the UMKM which functions as a production floor and also as a warehouse for the UMKM Bill Bakerykoe is 33 m^2. The layout of facilities at UMKM Bill Bakerykoe currently does not follow any specific rules in the placement of equipment and machines used for the production process and does not pay attention to the flow of the production process. This results in limited space for workers to move, as well as repetition of activities which results in a total waste of movement distance and time, and the production process is inefficient [9, 10].

Therefore, it is necessary to redesign (relayout) the layout of production facilities at UMKM Bill Bakerykoe so that production process activities can run in accordance with the production process flow. One method that can be used to solve facility layout problems is the Systematic Layout Planning (SLP) method. Systematic Layout Planning will provide solutions to layout design problems involving various types of problems such as production, warehousing, transportation and other activities [11, 12, 13]. Systematic Layout Planning is a method in the layout design system that takes into account the close relationship of each department based on material flow in the production process [14]. This design has the advantage that it is the result of proposed improvements in the form of a layout that is in accordance with actual conditions.

In previous research, Panrelli [15] used the SLP method to redesign facility layouts to increase production process productivity by minimizing the distance between work stations and material movement distance by considering material flow, and the research results showed that the proposed layout using the Rectilinear SLP method could resulting in a total reduction in material movement distance of 42.91% compared to the initial layout. Khofiyah [16], used the SLP method to evaluate facility layout to improve performance efficiency, and research showed that after carrying out an evaluation by moving the finishgoods warehouse area and the pet cutting area, the result was an increase in work efficiency of 53%. Wahyudi [17], used the SLP method to redesign the layout of PT Lambang Jaya's facilities using the Systematic Layout Planning (SLP) method, and research shows that the proposed layout using the SLP method can result in a reduction in the total material movement distance of 48.21% compared to with the initial layout.

On the other hand, so that the layout of production facilities is more optimal, policies are needed regarding the optimal distance from one facility to another, how long the production time takes and how long the transfer time from one facility to the next. To find out this, the ARC (Activity Relationship Chart) qualitative method was used. This qualitative method was chosen because it plays a role in connecting activities in pairs so that all activities will know the level of relationship between flows (flow of materials, equipment, people, information, etc.) and the relationship between processes. Thus, this research will combine two methods, namely the SLP and ARC methods simultaneously, in order to provide a better layout of production facilities and become a solution in creating a more effective and efficient production process, so as to eliminate the process of repeating activities and minimizing the total distance displacement when production activities are carried out.

2. THE PURPOSED RESEARCH

The purposed of this research is to provide proposals for the layout of new production facilities to create a more effective and efficient production process, so as to eliminate the process of repeating activities and minimize the total distance moved when production activities for donuts and sweet bread are carried out.

3. METHODS

In this research, the author used 2 methods simultaneously, including:

3.1. Systematic Layout Planning (SLP) Method

The stages used to design the layout of factory facilities are in accordance with the Systematic Layout Planning (SLP) approach. SLP according to Purnomo [18], consists of three stages. The first stage is the analysis stage, starting from material flow analysis, activity analysis, activity relationship diagrams, consideration of space requirements and available space. The second stage is the research stage, starting from planning room relationship diagrams to designing alternative layouts. Meanwhile, the third stage is the selection process by evaluating alternative layouts that have been designed. The data required for layout planning using the SLP method is product design data, process design and production schedule design.

1. Determination of Production Capacity

In fulfilling production orders received by the company, it must be known whether they can be fulfilled according to the capabilities of the company's installed production capacity. If there is an excess of production orders, it can be done through overtime or sub-contracting by transferring it to another company. In determining production capacity, use data on products that are frequently ordered and produced in large quantities (reference products) within 3 months of research.

2. Determining the Distance Between Production Facilities in the Initial Layout

In the initial layout, the distance between work stations can be determined by determining the center between the work stations. Next is calculating the distance using a rectilinear distance system, namely the distance measured between the center of one work station and the center of another work station. Look for the center point for each work station, namely 0 of x and y. The reason for using this method is the flow path/transportation route that the material and semi-finished products pass through. The formula used is as follows:

$$\boldsymbol{d_{ij} = x_i - x_j + y_i - y_j} \quad (1)$$

di mana: x_i = x coordinate at the center of facility i

y_i = y coordinate at the center of facility i

d_{ij}= distance between the centers of facilities i and j

3. Determination of Initial Layout Performance

Starting from calculating the distance between work stations above, it can be seen that the initial layout performance is the total material handling distance (D).

$$\boldsymbol{D = \sum^{n}_{j=1} d_j} \quad (2)$$

di mana: D = total material handling distance

d_j = material handling distance for each work station

n = many work stations

4. Determination of Selected or Accepted Proposal Layout Alternatives

In determining the selected layout alternative, it is obtained from the results of calculating the minimum distance.

$$\boldsymbol{D_{jk} = D_{ja} - D_{ju}} \quad (3)$$

$$\boldsymbol{Min\ DJK = \sum D_{jk}}$$

di mana: D_{jk} = the difference in distance for each work station

D_{ja} = initial layout material handling distance

D_{ju} = material handling distance proposed layout

DJK = selected material handling distance is selected

3.2. Activity Relationship Chart (ARC) Method

Activity Relationship Chart (ARC) is a technique for planning the layout of facilities or departments based on the degree of activity relationship of each facility/department [19]. ARC is qualitative, using letter codes to indicate the degree of activity relationship and also number codes to explain the reasons for determining the choice of letter code. The letters A (Absolutely Necessary): Red, E (Especially Necessary): Orange, I (Important): Green, O (Ordinary): Blue, U (Unimportant): White, X (indesirable): Brown represented by color at the top, while the number code defines the reason for choosing the letter. The criteria for relationships between ARC facilities can be seen in Table 1.

Table 1. Criteria for Relationships between Facilities

No	Reason
1	Use of the same room
2	Using the same workforce
3	Using the same notes
4	High level of employee coordination
5	The relationship between using worksheets
6	Similarity of work processes
7	Interrelationship of work process sequences
8	Interrelation of material flows
9	Simultaneous use of work equipment
10	Discomfort when close together (unpleasant odor, dirty, noisy, etc.)

4. RESULTS AND DISCUSSION

UMKM Bill Bakerykoe is an UMKM that produces food, namely donuts and sweet bread. UMKM Bill Bakerykoe's production layout shows that there are several work areas that should be close together, but in reality, these work areas are far from each other, and vice versa. The layout existing UMKM Bill Bakerykoe can be seen in Figure 1.

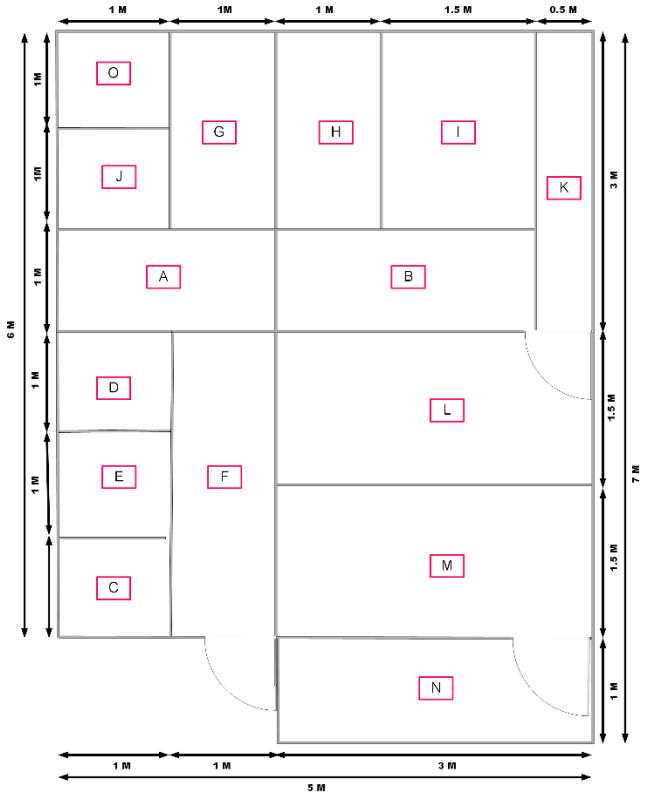

Figure 1. Layout Existing UMKM Bill Bakerykoe

In figure 1, we know, there are 15 work stations available for bread production activities which include:

A. Raw Material 1

This area is an area where the main raw materials for making donuts and sweet bread are stored and taken. The main raw materials in question include various flours, potatoes, granulated sugar and eggs.

B. Raw Material 2

This area is an area where supporting raw materials are stored and retrieved, such as various jams for bread fillings, mesis, sprinkled sugar, margarine, etc.

C. Leftover Materials

This area is a place to store used supporting materials. This means that when the ingredients are used, there are leftovers and they need to be put in the refrigerator so they don't spoil, for example like jam.

D. Equipment Warehouse

This area stores various production equipment such as basins, frying pans, spatulas, bowls, spoons, forks, etc.

E. Material Mixing

In this area there is a mixer machine which is used to mix the main ingredients, which will later turn into bread dough.

F. Dough Molding

In this area, there is a long table that is used to mold bread dough, before being put into the dough developing machine.

G. Dough Frying (for donuts)

This area is only used when producing donuts. Where, the dough that has been developed will be fried.

H. Dough Improvement

In this area, there is a developing machine, to develop dough that has been molded or shaped.

I. Dough Roasting (for sweet bread)

This area is only used when producing sweet bread. Where, after the sweet bread dough goes through the dough development stage, the dough is ready to be baked, using an oven machine.

J. WIP Donuts

This area is used for semi-finished donut products. In other words, this area is used to decorate the donut cake, with the addition of sprinkles, powdered sugar, etc., so that it looks attractive and is ready to be packaged.

K. WIP Sweet Bread

This area is used for sweet breads that are not yet ready for sale. Because you need to add jam. So, this area is used to add jam to sweet bread before packaging.

L. Packaging

This area is used to package donuts and sweet bread products.

M. Finished Good Warehouse

This area is used to place donuts and sweet bread products that have been packaged and ready to be sold.

N. Product display

This area is used as a place for taking orders, sales, and samples of products produced.

O. Equipment Washing

An area used to wash dirty equipment after use in production activities.

4.1. Distance Between Work Stations

In this case, calculations are needed to determine the value of the distance between one work station and another work station. The distance between work stations is the distance required for the material to be moved. To determine the size of the distance in layout design, first determine the euclidean distance, namely the distance measured straight between the center of one facility and the center of another facility. The formula used in measuring Euclidean distance is:

$$d_{ij} = [(x_i - x_j)^2 + (y_i - y_j)^2]^{1/2} \quad (4)$$

Dimana : x_i = x coordinate at the center of facility i

x_j = x coordinate at the center of facility j

y_i = y coordinate at the center of facility i

y_j = y coordinate at the center of facility j

d_{ij} = distance between the centers of facilities i and j

The x and y coordinate values at the center of facilities i and j are obtained from the matrix image below, with the aim of making it easier to determine the distance of movement through the coordinate points of each work station. The matrix in Figure 2 is a matrix of work station layouts according to existing conditions.

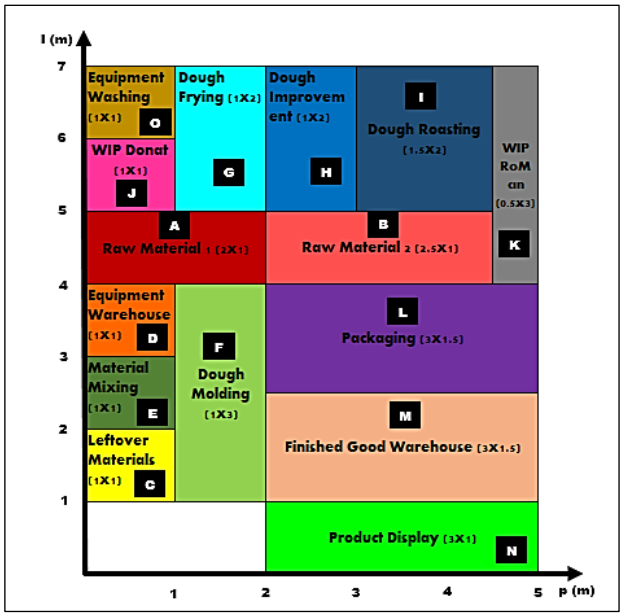

Figure 2. Workstation Layout Matrix (**Existing**)

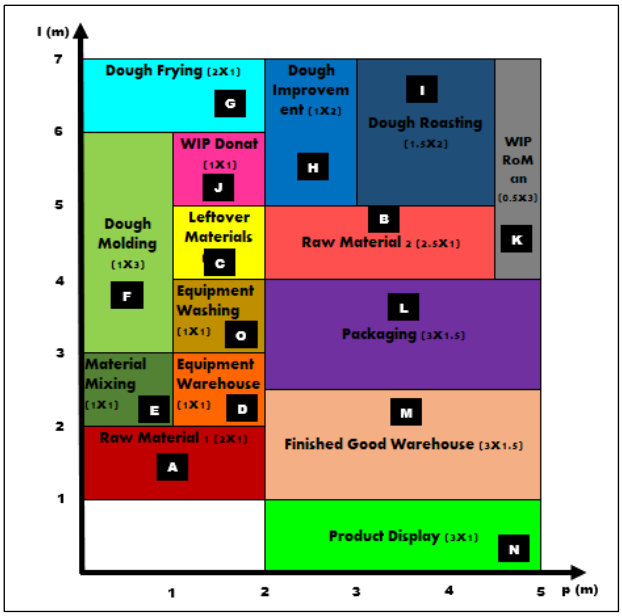

Figure 3. Workstation Layout Matrix (**New**)

Meanwhile, Figure 3 shows the results of the work station matrix layout after making changes to 7 work station areas including the raw material area 1 (A), the leftover materials area (C), the equipment warehouse area (D), the dough molding area (F), the dough frying area (G), the Donut WIP (J), and equipment washing area (O).

4.2. Close Relationships Between Facilities

The close relationship between facilities at UMKM Bill Bakerykoe can be determined using the Activity Relationship Chart (ARC) method. Proximity relationships between facilities, symbolized in letter and color codes. Each of these letter and color codes has a priority level of closeness relationship that varies from absolute to unexpected, which can be seen in Figure 4., below:

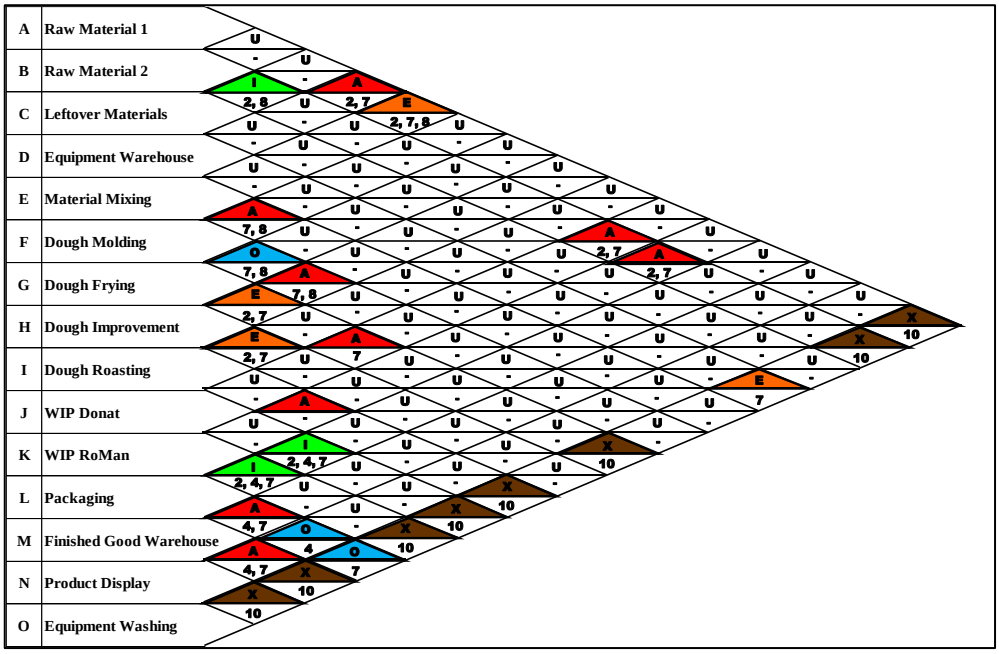

Figure 4. Activity Relationship Chart

4.3. Result Analysis

Redesigning the layout of existing facilities at MSME Bill Bakerykoe is a solution, especially in resolving problems involving the movement of material flows, labor and meeting production needs.

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The recommended layout alternative to choose is according to Figure 3. Work Station Layout Matrix (New), on the previous page. The preparation of the proposed layout was based on an analysis of the activity relationships of each department, namely the Activity Relationship Chart and the shortest distance was obtained. Apart from that, these results are strengthened based on the calculation of the distance between work stations from the proposed layout which can be seen in Table 2., for the process of making Donuts and Table 3., for the process of making Sweet Bread below.

Table 2. Comparison of the Results of Distance Values Between Work Stations between the Initial Layout and the Proposed Layout of Donut Product

From the Workstation	To the Workstation	Distances (m)	
		Existing Layout	*Proposed Layout*
D	A	1,1	1,1
A	E	2,1	1,1
E	F	1,0	2,0
F	H	3,6	2,5
H	G	1,0	1,6
G	J	1,1	1,1
B	J	2,9	2,0
B	C	4,1	1,8
J	L	3,8	3,0
L	M	1,5	1,5
M	N	1,3	1,3
L	O	4,4	2,0
O	D	3,0	1,0
TOTAL		30,9	22,0

Table 3. Comparison Results of Distance Values Between Work Stations between the Initial Layout and the Proposed Layout of Sweet Bread Product

From the Workstation	To the Workstation	Distances (m)	
		Existing Layout	*Proposed Layout*
D	A	1,1	1,1
A	E	2,1	1,1
E	F	1,0	2,0
F	H	3,6	2,5
H	I	1,0	1,3
I	K	1,1	1,1
B	K	1,8	1,8
B	C	4,1	1,8
K	L	2,6	2,6
L	M	1,5	1,5
M	N	1,3	1,3
L	O	4,4	2,0
O	D	3,0	1,0
TOTAL		28,6	21,0

In Table 2 above, it is known that there is a shortening of the transfer distance between the existing layout and the proposed layout for making Donut products, which occurs when the distance from work station A (Raw Material 1) to work station E (Material Mixing) is initially 2.1 m becomes 1.1 m. Then, from work station F (Dough Molding) to work station H (Dough Frying) there is also a shortening of the distance, from 3.6 m to 2.5 m. Then, from work station J (WIP Donuts) to work station L (Packaging), from 3.8 m to 3 m. Also, there is a shortening of the distance from work station O (Equipment Washing) to work station D (Equipment Warehouse) from 3 m to 1 m.

Meanwhile, in Table 3 above, it is known that there has been a shortening of the transfer distance between the existing layout and the proposed layout for making Sweet Bread products, which occurred in the distance transfer from work station A (Raw Material 1) to work station E (Material Mixing) which was originally 2.1 m becomes 1.1 m. Apart from that, the distance between work stations is also shortened when moving from work station F (Dough Molding) to work station H (Dough Frying) there is also a shortening of the distance, from 3.6 m to 2.5 m. Also, there is a shortening of the distance from work station O (Equipment Washing) to work station D (Equipment Warehouse), from 3 m to 1 m.

So, from these two tables, conclusions can be drawn by comparing the results of the total distance moved from each Donut and Sweet Bread production process based on the existing layout with the proposed layout. The result is that there is a reduction in the total distance of 16.4 m.

Below in Figure 5, is the donut production process flow before the work station layout was updated, so that the donut production process flow looks complicated and messy. Meanwhile, Figure 6 shows the donut production process flow after the work station layout has been updated, which looks more sequential and neat.

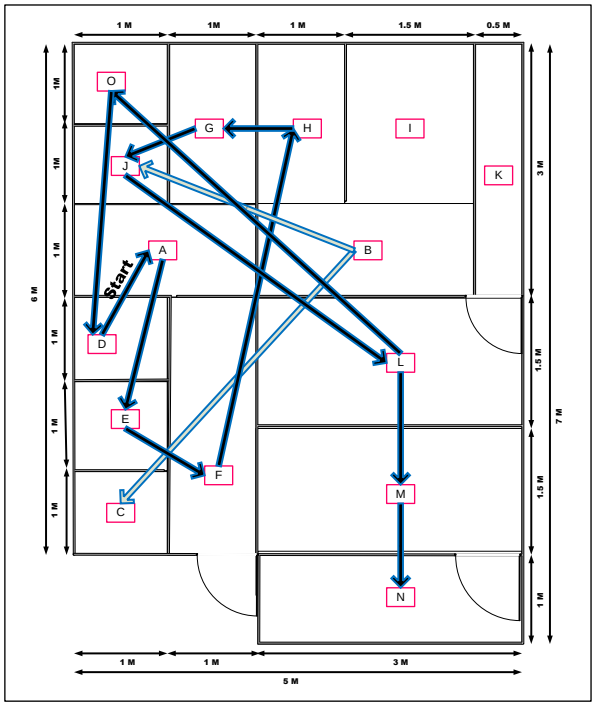

Figure 5. Donut Production Process Flow Based on Existing Layout

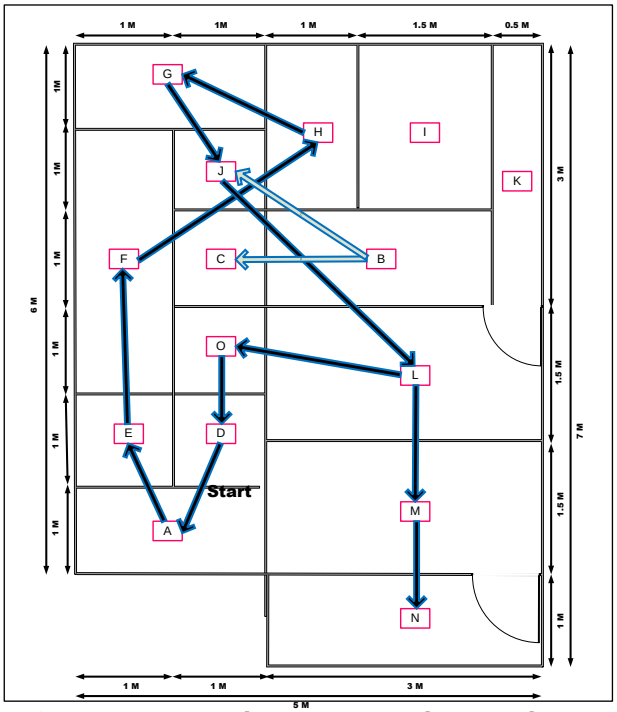

Figure 6. Donut Production Process Flow Based on the Proposed (New) Layout

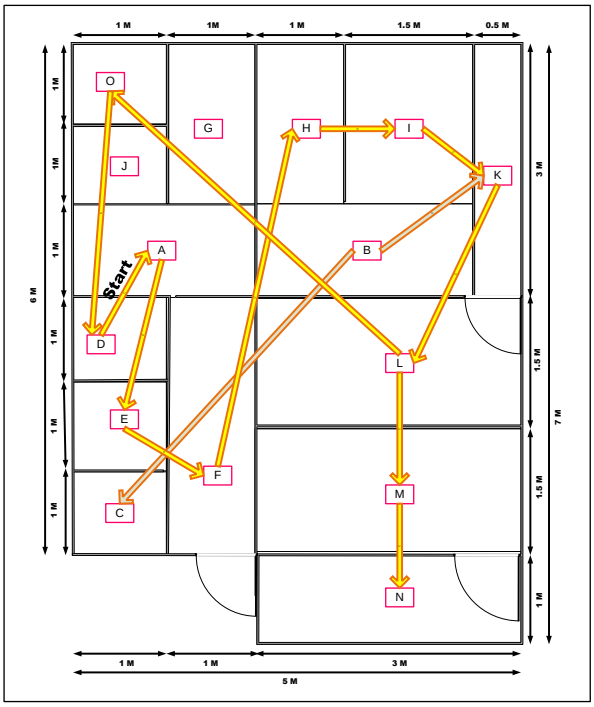

Figure 7. Sweet Bread Production Process Flow Based on Existing Layout

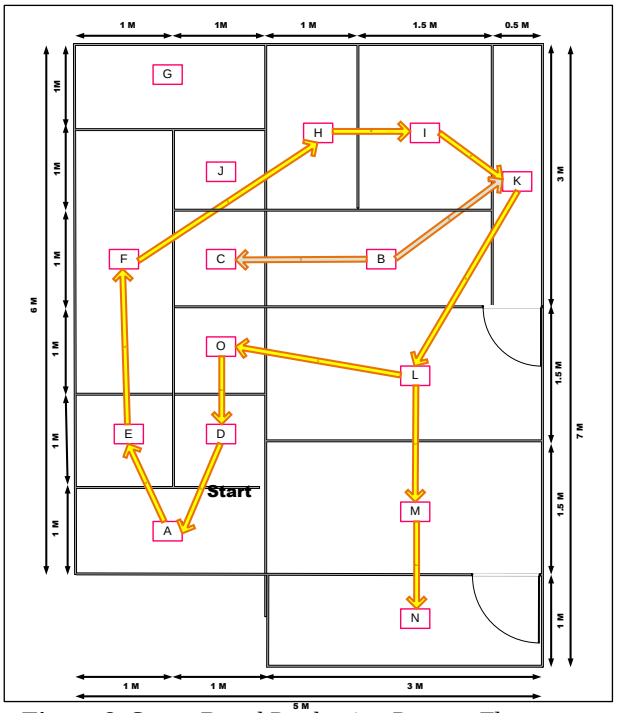

Figure 8. Sweet Bread Production Process Flow Based on the Proposed (New) Layout

The following above Figure 7., is the sweet bread production process flow before the work station layout was updated, so that the sweet bread production process flow looks complicated and messy. Meanwhile, Figure 8 shows the flow of the sweet bread production process after the work station layout has been updated, which looks more sequential and neat.

5. CONCLUSION

Based on research and discussion of the redesign of the facility layout carried out at UMKM Bill Bakerykoe, it can be concluded that:

1) Based on the resulting redesign of the production layout, changes were obtained at 7 work station locations, including: the raw material area 1 (A), the leftover materials area (C), the equipment warehouse area (D), the dough molding area (F), the dough frying area (G), the Donut WIP (J), and equipment washing area (O).
2) Based on the calculation results of the total movement distance between work stations in accordance with the sequence of production steps, both donut production and sweet bread production, namely 30.9 m and 28.6 m respectively. After changes to the layout, the total movement distance between work stations for donut production became 22 m, and sweet bread production became 21 m. So, by comparing the total production distance in the initial layout and the improved layout, the results show that the new layout can reduce the total production distance by 16.4 meters.

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