



Redesign Of Machine Layout Using Systematic Layout Planning Method

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Abstract

Optimizing the production process is one of the things that needs to be considered in a factory. Machines play an important role in the production process because they function as the main tool in the production process. Rearrangement is carried out to obtain the smallest distance in moving raw materials in the production process. By rearranging the machine using the systematic layout planning method. The latest distance value was obtained at 60,865, which was originally 63,905. Therefore, making a machine layout can be done using the proposed layout.

Introduction

The current era of industrial development in Indonesia is very rapid. The ever-increasing population and quality of life encourage technological development to become more advanced (Sales et al., 2023). This has provided a significant increase in the medical equipment industrial sector. The influence of this increase has made medical experts strive to produce better quality medical devices by conducting research in the field of orthopedics, such as research on biomaterials. Biomaterials themselves have two characteristics, namely biofunctionality and biocompatibility. Biofunctionality is the ability of a material to be shaped to suit needs and have good mechanical properties. Meanwhile, biocompatibility is the ability of a material to be accepted by the body (Yang et al., 2017). One of the materials used is bone plate (Ma et al., 2023). The next research obtained was the manufacture of plates and screws which function to help maintain the position of broken bones so that they remain in a normal position. Domestic medical device manufacturers are taking advantage of conditions like this to develop products and increase their production capabilities (Chakravarty, 2022; Maharaj, 2019; Stavropoulos et al., 2020).

This research analyzes the layout of one of the domestic medical device manufacturers, namely PT XYZ, which focuses on the production of plates and screws which have the function of repairing the condition of bones that are wrong or damaged after experiencing an injury. incident or accident. Since its inception until now, PT XYZ has experienced many developments in terms of technology, administration and management. However, as a company that implements continuous improvement, of course there are still many gaps that must be improved, such as work efficiency, production time and work environment. One example of an aspect that needs to be improved is the machine layout which must always be considered (Azizah et al., 2023).

After conducting observations, it was found that the machine layout at PT XYZ had not been updated and was currently still using the old layout. Meanwhile, there are several new

machines that have been used in the production process. These machines are already used in the production process. The placement of these machines is still placed in makeshift locations and does not pay attention to the production process flow (Cilliers & Timmermans, 2014). Apart from that, the old machines used are also affected in their use because they have to adjust to the attachment of the new machines that are already in use.

With cases like this, it is necessary to create a renewable machine layout on the production floor of PT XYZ. It is hoped that after rearranging the production machines, productivity and work efficiency on the production floor will increase. Therefore, I carried out layout design using the Systematic Layout Planning (SLP) method based on journals (Afifah & Ngatilah, 2020; Wiyaratn & Watanapa, 2010).

Systematic Layout Planning (SLP) is used to create a new layout, the calculation process requires stages such as creating ARC, ARD, block layout, creating a proposed layout and determining the comparison with the layout currently used. This method is used to obtain a more efficient production layout and increase production value (Afifah & Ngatilah, 2020). Activity relationship chart (ARC) is a stage used to determine the relationship between groups of activities and create new configurations so as to increase production productivity. Activity Relationship Diagram (ARD) is a stage for obtaining a diagram image regarding the level of importance of relationships between work stations (Apsari & Mahachandra, n.d. 2020).

Methods

Systematic Layout Planning (SLP), introduced by Richard Muller in 1973, is a method designed to optimize the layout of production sites to enhance efficiency and streamline production processes (Utomo et al., 2022). The stages in SLP include creating a Process Flow Chart, an Activity Relationship Chart (ARC), an Activity Relationship Diagram (ARD), calculating area requirements, and developing alternative block layouts (Afifah & Ngatilah, 2020). ARC is used to establish relationships between departments, grouping them based on the importance of their interactions (Apsari & Mahachandra, 2020). The next step, ARD, further clarifies the proximity of departments in the layout, which can lead to more efficient production processes and cost savings (Azizah et al., 2023).

Total Closeness Rating (TCR) is a quantitative measure used in conjunction with the ARC to determine optimal workstation placement by assessing the closeness between departments based on their activity relationships (Setiyawan et al., 2017). The workstation with the highest TCR value becomes the center of the layout, with subsequent workstations arranged based on their proximity ratings (Pradana, 2016). The initial block layout depicts the spatial arrangement of production areas, machines, and workstations, providing a blueprint for efficient facility design (Budianto & Cahyana, 2021). The rectilinear or Manhattan distance formula is often used to calculate the shortest path between workstations, simplifying the analysis of space and proximity in layout planning (Siska & Sabri, 2016). Rectilinear distance measurements can be written into the following equation:

$$d_{ij} = |x_i - x_j| + |y_i - y_j|$$

x and y is the position of the work station

d = distance between x dan y

x_i = coordinates at the center of the workstation regarding the x axis

y_i = coordinates at the center of the workstation regarding the y axis

Results and Discussion

Layout Machine

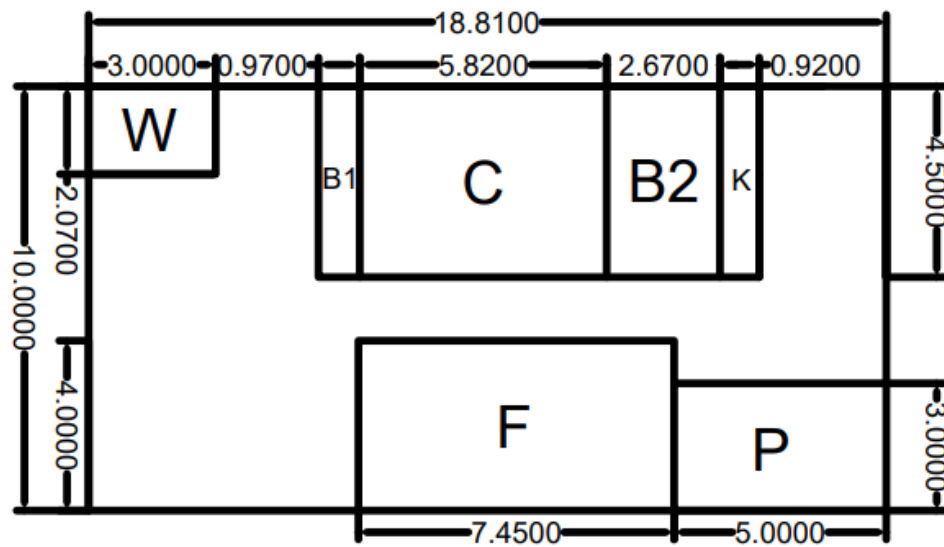


Figure 1. Initial Layout Machine

The initial layout shown in the figure illustrates the spatial arrangement of various workstations and areas on a production floor. Each section, including W, B1, B2, C, K, F, and P, is designated with specific dimensions, reflecting the allocation of space for different operations. For instance, W (likely a workstation) occupies 3.00 x 2.07 m, while C (potentially a central processing area) is the largest section, indicating its importance in the production process. Other sections like B1, B2, and K are positioned adjacent to each other, suggesting a close relationship between these workstations or processes.

This layout is crucial for ensuring efficient workflow and minimizing unnecessary movement between stations. By organizing workstations based on their proximity, as shown in the layout, production efficiency can be improved. The careful allocation of space, as reflected by the dimensions provided, enables optimal use of the production floor while reducing transportation costs and enhancing overall productivity.

Based on the picture above, the production floor area and machine area are known. These dimensions have been summarized in the table below.

Table 1. Production Floor Area

Work Station	Length (m)	width (m)	Dimention (m2)
Wire Cut	3	2.07	6.21
Bubut 1	0.97	4.5	4.365
CNC	5.82	4.5	26.19
Bubut 2	2.67	4.5	12.015
Kikir	0.92	4.5	4.14
Poles	5	3	15
Frais	7.45	4	29.8
Total			97.72

The table provides the dimensions of different workstations on the production floor, showing both the length and width of each station and their corresponding area in square meters. The largest areas are occupied by the Frais workstation, with an area of 29.8 m², and the CNC workstation, with 26.19 m², indicating that these are likely the most critical or space-intensive

operations on the production floor. Smaller workstations like Wire Cut (6.21 m²) and Bubut 1 (4.365 m²) suggest that these tasks require less space, potentially reflecting shorter process times or less machinery involvement.

The total production floor area sums up to 97.72 m², indicating the overall space utilized by these workstations. The arrangement and size of each station are essential for efficient workflow, ensuring that there is adequate room for both machinery and personnel while maintaining close proximity between related operations to optimize movement and reduce production time.

Production Proces Flow

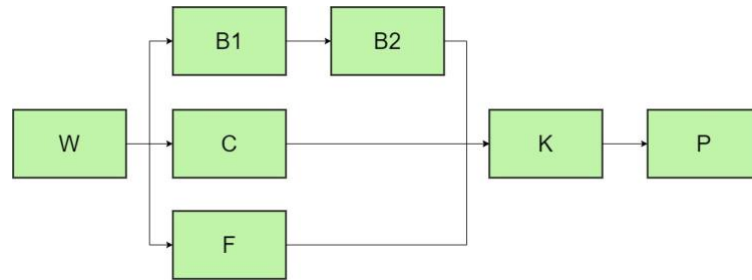


Figure 2. Production Proces Flow

The figure illustrates the production process flow, mapping out the sequence and relationships between various workstations. The flow starts from W (Wire Cut) and proceeds to B1 (Bubut 1), then B2 (Bubut 2), indicating a clear progression of tasks involving material shaping or cutting. From C (CNC), the flow diverges, with operations moving both to F (Frais) and directly towards K (Kikir), which is likely a finishing or fine-tuning process.

The final step leads to P (Poles), signifying the polishing or final treatment before the product is completed. This layout demonstrates a logical and efficient sequence of operations, with minimal backtracking and clear transitions between processes, helping to optimize workflow and minimize delays between production stages.

Activity Relationship Chart

Table 2. Proximity Degree Symbol

Code	Score	Meaning
A	6	Absolute
E	5	Very Important
I	4	Important
O	3	Normal
U	2	Not Important
X	1	Very Not Important

The coding system presented is a ranking method used to evaluate the importance of relationships between different workstations or departments in a production layout. Each letter represents a specific score, indicating the level of importance: A (Absolute) with a score of 6 signifies the highest level of importance, meaning that two departments or workstations must be placed in close proximity to each other. This is followed by E (Very Important) with a score of 5, and I (Important) with a score of 4, reflecting slightly lesser but still significant levels of importance in their spatial relationship.

On the other end of the spectrum, O (Normal) with a score of 3 indicates a neutral relationship where proximity is neither critical nor unimportant, while U (Not Important) and X (Very Not Important) with scores of 2 and 1, respectively, suggest that the placement of these workstations or departments in relation to each other has little to no impact on efficiency. This

system helps in prioritizing the arrangement of workstations based on their operational interdependence, contributing to a more efficient production layout.

Table 3. Workstation Connections

Kode	Connections
1	Side by side
2	One Division
3	Sequential Process
4	Opposite
5	Not Related

The coding system for connections outlines the spatial and operational relationships between workstations or departments in a production layout. Each code represents a different level of connection, which influences how closely or distantly certain processes or stations should be positioned. A code of 1 (Side by Side) signifies that two workstations must be placed directly adjacent to each other to ensure smooth workflow and minimize transportation time between them. 2 (One Division) indicates that the workstations are part of the same division, suggesting they should be placed near each other, but not necessarily adjacent.

A 3 (Sequential Process) indicates that the workstations follow a specific order in the production process, so proximity is important for maintaining process flow. 4 (Opposite) means that the workstations are related but should be placed on opposite sides of the layout, likely to facilitate a clear separation of functions. Lastly, 5 (Not Related) indicates that the workstations or departments have no functional relationship, so their placement in the layout is flexible, and proximity is not required. This system helps guide the spatial arrangement to optimize workflow and process efficiency based on operational dependencies.

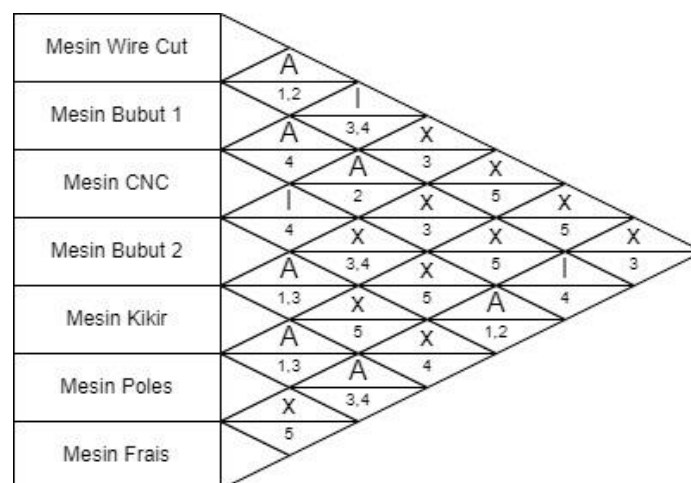


Figure 3. Activity Relationship Chart

Based on the symbol table for the degree of proximity and relationship between work station, an arc is obtained as in Figure 3. You can see the relationship that occurs between each work station

Activity Relationship Diagram

Table 4. Degree of Reaationship

No	Description	Code Line	Code Color
1	Absolute	<u> </u> <u> </u> <u> </u>	Red

2	Very Important		Yellow
3	Important		Green
4	Normal		Blue
5	Not Important		Colorless
6	Very Not Important		Brown

The table provided categorizes different levels of importance using a color-coded system. Each description is assigned a specific color to indicate its priority. For example, Absolute importance is represented by Red, signifying tasks or areas that require immediate attention or are critical to the operation. Very Important tasks are coded in Yellow, while those that are simply Important are shown in Green, indicating a lower but still significant priority.

Lower-priority tasks, such as those labeled Normal and Not Important, are color-coded Blue and Colorless respectively, reflecting their lesser impact on the overall process. Finally, tasks or areas considered Very Not Important are represented by Brown, further emphasizing their minimal relevance. This system helps in visualizing and organizing tasks or departments based on their urgency and relevance, allowing for efficient decision-making and resource allocation.

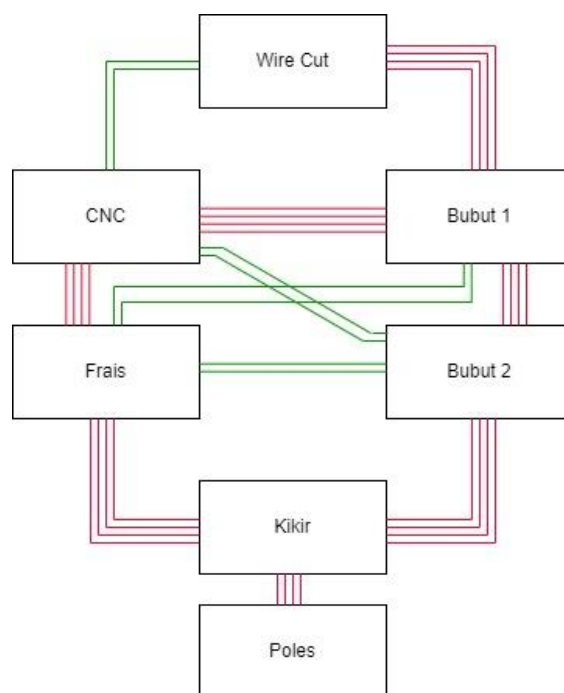


Figure 4. Activity Relationship Diagram

Figure 4 is the result of creating an ARD based on the ARC data in Figure 3 using table 4 as a reference. In Figure 3 there are 2 different relationships. The first is red which means absolute and the second is green which means important. With the ARD book, you can know more clearly the relationship between each work station.

Total Closeness Rating

Table 5. Total Closeness Rating

To--- From	1	2	3	4	5	6	7	TCR
1		A	I	X	X	X	X	14

2	A		A	A	X	X	I	24
3	I	A		I	X	X	A	22
4	X	A	I		A	X	A	24
5	X	X	X	A		A	A	21
6	X	X	X	X	A		X	11
7	X	I	A	A	A	X		24

Table 6. Result Total Closeness Rating

No	Work Station	Score
1	Frais	24
2	Bubut 2	24
3	Bubut 1	24
4	CNC	22
5	Kikir	21
6	Wire Cut	14
7	Poles	11

Based on table 5, you can see the values produced in the TCR calculation and in table 6 they have been sorted from the largest TCR value to the smallest. The largest TCR value is at 3 workstations, namely Frais, Bubut 2 and Bubut 1. The smallest TCR value is at the Poles workstation.

Iterations

Workstation Frais as the center . The workstation that is placed next is the workstation that has the closest relationship with workstation Frais, namely workstation Bubut 2 has a relationship A with workstation Frais.

8	7	6
1	F	5
2	3	4

If workstation Bubut 2 allocation in:

Location 2,4,6,8 has score : $0.5 \times 6 = 3$

Location 1,3,5,7 has score : $0.5 \times 1 = 6$

Iteration result

		W	
	C	B1	
	F	B2	
	P	K	

After 7 iterations, the work station placement was obtained as in the table above. The table above is used as a reference in making the proposed layout.

CORELAP

Input the number of Workstation



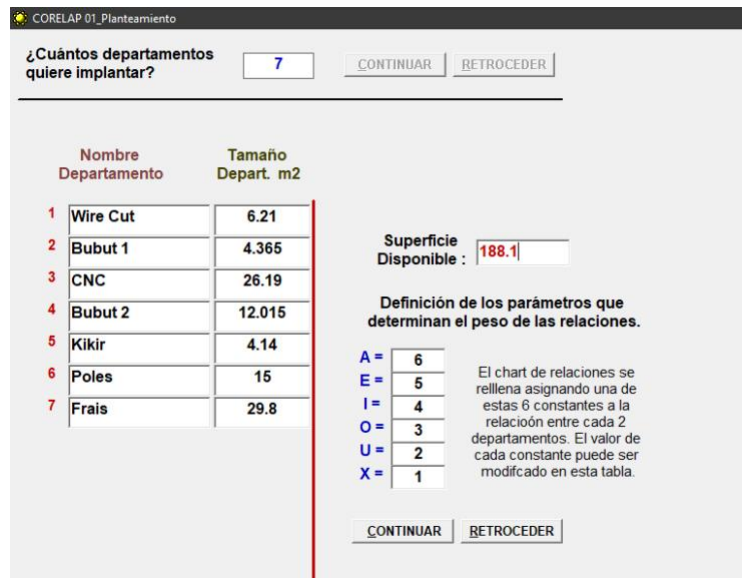
CORELAP 01_Plantamiento

¿Cuántos departamentos quiere implantar?

Figure 5. Input the number if workstation

The first stage is to determine the number of work stations for which the calculation will be carried out

Input name, layout area, proximity value, and available production floor area



CORELAP 01_Plantamiento

¿Cuántos departamentos quiere implantar?

	Nombre Departamento	Tamaño Depart. m2
1	Wire Cut	6.21
2	Bubut 1	4.365
3	CNC	26.19
4	Bubut 2	12.015
5	Kikir	4.14
6	Poles	15
7	Frais	29.8

Superficie Disponible :

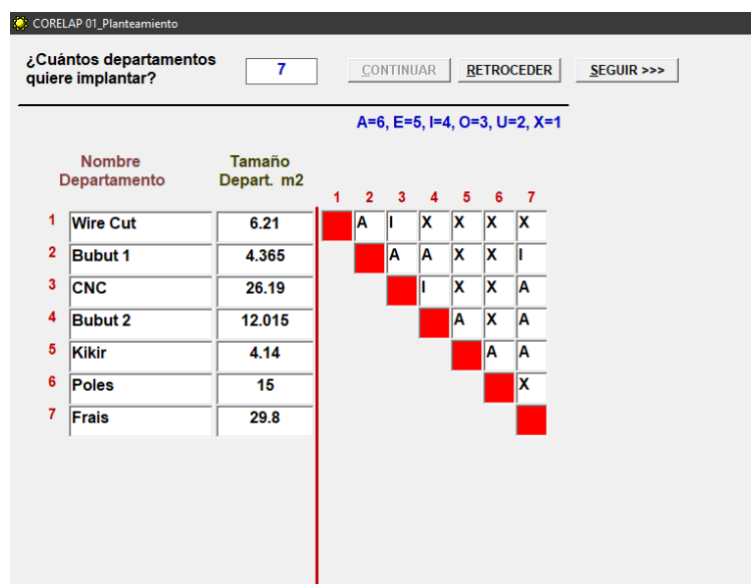
Definición de los parámetros que determinan el peso de las relaciones.

A =	6
E =	5
I =	4
O =	3
U =	2
X =	1

El chart de relaciones se rellena asignando una de estas 6 constantes a la relación entre cada 2 departamentos. El valor de cada constante puede ser modificado en esta tabla.

Figure 6. Input name, layout area, proximity value, and available production floor area

Activity Relationship Diagram



CORELAP 01_Plantamiento

¿Cuántos departamentos quiere implantar?

A=6, E=5, I=4, O=3, U=2, X=1

	Nombre Departamento	Tamaño Depart. m2	1	2	3	4	5	6	7
1	Wire Cut	6.21		A	I	X	X	X	X
2	Bubut 1	4.365			A	A	X	X	I
3	CNC	26.19				I	X	X	A
4	Bubut 2	12.015					A	X	A
5	Kikir	4.14						A	A
6	Poles	15							X
7	Frais	29.8							

Figure 7. Input proximity value

The image above is the process of inputting proximity between work stations in the CORELAP application.

CORELAP 01_Presentación Resultados

ORDENACIÓN DE LOS DEPARTAMENTOS POR IMPORTANCIA

Orden	Nombre	TCR	Superficie m2
1.-	Frais	24	29.8
2.-	Bubut 2	24	12.015
3.-	Bubut 1	24	4.365
4.-	CNC	22	26.19
5.-	Kikir	21	4.14
6.-	Wire Cut	14	6.21
7.-	Poles	11	15

Solución Gráfica

☒ Calcular Iteración

Superficie Requerida < Superficie Disponible

Superficie Requerida: 97.72

Superficie Disponible: 188.1

Figure 8. Value TCR

The image above is the result of the Total Closenes Rating (TCR) value from the data that has been input. It can also be seen that the required production floor area is smaller than the available production floor area.

Layout results

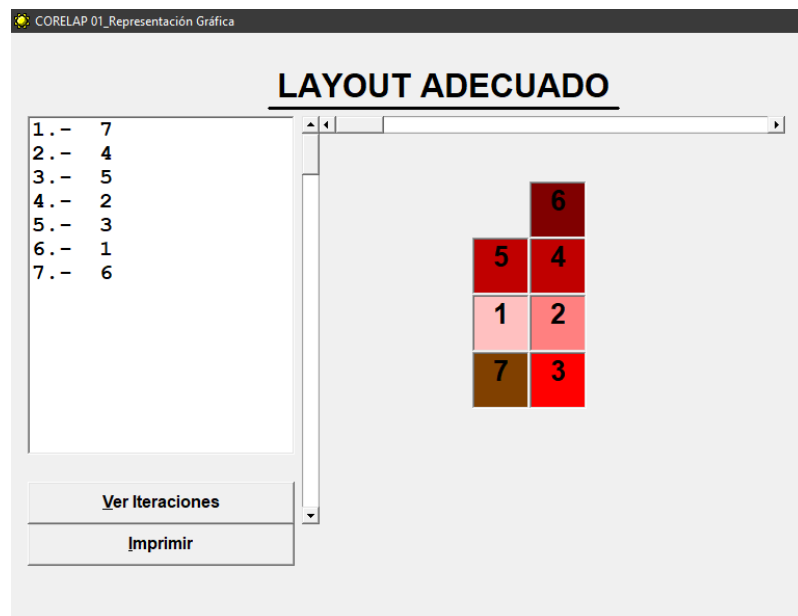


Figure 9. Layout calculation results

Based on calculations using the CORELAP application, there are 4 rows consisting of 7 work stations. In the first row there is 1 work station, namely the Wire Cut machine. In row 2 there are 2 work stations, namely a CNC machine and a lathe 1. In row 3 there are 2 work stations, namely a milling machine and a lathe 2. In row 4 there are 2 work stations, namely a polishing machine and a file machine.

Layout Proposed

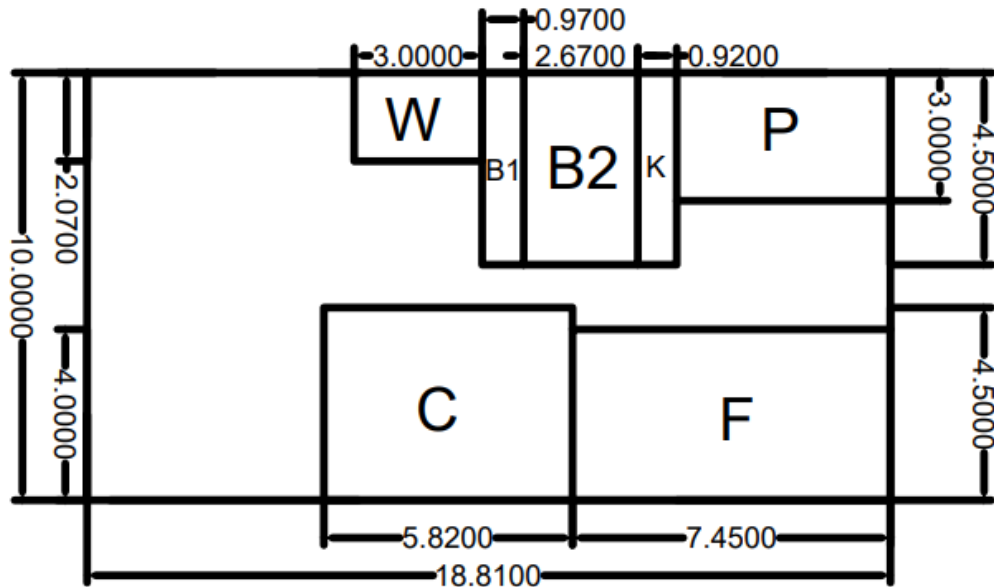


Figure 10. Layout Proposed

Distance between workstation initial layout

Table 7. Distance between workstation initial layout

Workstation		X1 (m)	X2 (m)	Y1 (m)	Y2 (m)	X1-X2 (m)	Y1-Y2 (m)	Result (m)
Wire Cut	Bubut 1	1.5	5.915	8.965	7.5	4.415	1.465	5.88
Bubut 1	Bubut 2	5.915	13.555	7.5	7.5	7.64	0	7.64
Bubut 2	Kikir	13.555	15.35	7.5	7.5	1.795	0	1.795
Kikir	Poles	15.35	16.31	7.5	1.5	0.96	6	6.96
Wire Cut	CNC	1.5	9.31	8.965	7.5	7.81	1.465	9.275
CNC	Kikir	9.31	15.35	7.5	7.5	6.04	0	6.04
Wire Cut	Frais	1.5	10.085	8.965	2	8.585	6.965	15.55
Frais	Kikir	10.085	15.35	2	7.5	5.265	5.5	10.765
Total								63.905

Based on the table above, the distance between work stations in the production process is known. The farthest distance is the distance between the WireCut workstation and the Frais workstation. The shortest distance is the distance between the Bubut 2 workstation and the Kikir workstation. And the total displacement distance is equal to 63.905.

Distance between workstation proposed layout

Table 8. Distance between workstation proposed layout

Workstation		X1 (m)	X2 (m)	Y1 (m)	Y2 (m)	X1-X2 (m)	Y1-Y2 (m)	Result (m)
Wire Cut	Bubut 1	8.36	10.345	8.965	7.5	1.985	1.465	3.45
Bubut 1	Bubut 2	10.345	12.165	7.5	7.5	1.82	0	1.82
Bubut 2	Kikir	12.165	13.96	7.5	7.5	1.795	0	1.795
Kikir	Poles	13.96	16.31	7.5	1.5	2.35	6	8.35

Wire Cut	CNC	8.36	3.45	8.965	2.25	4.91	6.715	11.625
CNC	Kikir	3.45	13.96	2.25	7.5	10.51	5.25	15.76
Wire Cut	Frais	8.36	10.085	8.965	2	1.725	6.965	8.69
Frais	Kikir	10.085	13.96	2	7.5	3.875	5.5	9.375
Total								60.865

Based on the table above, the distance between work stations in the production process is known. The farthest distance is the distance between the WireCut workstation and the CNC workstation. The shortest distance is the distance between the Bubut 1 workstation and the Bubut 2 workstation. And the total displacement distance is equal to 60.865.

Comparison of workstation distances from the initial layout and the proposed layout

Table 9. Comparison of workstation distance from the initial layout and the proposed layout

Workstation		Initial Distance	Proposed Distance	Difference
Wire Cut	Bubut 1	5.88	3.45	2.43
Bubut 1	Bubut 2	7.64	1.82	5.82
Bubut 2	Kikir	1.795	1.795	0
Kikir	Poles	6.96	8.35	-1.39
Wire Cut	CNC	9.275	11.625	-2.35
CNC	Kikir	6.04	15.76	-9.72
Wire Cut	Frais	15.55	8.69	6.86
Frais	Kikir	10.765	9.375	1.39
Total		63.905	60.865	3.04

Based on the table above, the total initial layout distance is 63.905 compared to the total proposed layout distance of 60.865, namely 3.04. therefore it is known that the proposed layout has reduced the displacement distance. This speeds up the production process and makes the production process more optimal.

Conclusion

The creation of a new layout which was carried out using a systematic layout planning method was in accordance with the proper flow, starting from creating ARC, ARD, TCR to Block layout and creating a new layout. Apart from that, calculations were also carried out using the CORELAP application which produced the same proposed layout as calculations using the systematic layout planning method. Therefore, the same proposed layout is created and then the difference in distance between the initial layout and the new layout is calculated. The proposed layout can be accepted if it produces a smaller distance and it can be seen that the new layout distance is 60.865 from the original layout of 63.905. With this difference of 3.04, it is recommended that the new layout be accepted. This aims to make the production process faster and more optimal.

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