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Facility Layout Design of Mr. Budi's Tofu Factory Using the HIRARC Method and Blocplan Algorithm

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A B S T R A C T

Occupational health and safety is something that cannot be separated in human resources where occupational health and safety includes preventing accidents due to work, securing materials, carrying out maintenance to improve living standards and increase productivity. At the Mr. Budi tofu factory, employees have not used Personal Protective Equipment in the production process and the unstructured layout causes work accidents on the production floor. This study aims to conduct an OHS assessment at the Pak Budi tofu factory and redesign the facility layout to reduce work accidents so that the production process is more effective and efficient. The methods used in this research are HIRARC and Blocplan Algorithm. The results of the OHS assessment at the Pak Budi tofu factory show 2 activities with a medium risk level and one activity with a low risk level, in the redesign of the facility layout the distance of material movement in the initial layout is 19.2 m and the distance of material movement in the proposed layout is 11.7 meters where there is a difference in the distance of material movement of 7.5 meters, this shows that the proposed layout can be applied to the Pak Budi tofu factory.

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1. INTRODUCTION

Along with technological advances, competition in the industrial world is also increasing so that companies are required to always develop and innovate in various aspects of the industry (Nurwahidah, et al., 2022). The times that occur require all industries to be able to manage people, machines and materials effectively and efficiently. Negligence in managing these components can harm the company in developing its industry. Conditions on the production floor also affect the production process where if a work accident occurs on the production floor, it can increase production operational costs. In this condition, manufacturing companies, especially in Indonesia, need to have the flexibility to make the changes needed in the field of facility layout design or commonly called re-layout (Azima, Arifin, and Afma, 2020).

According to Octaningrum, et al (2022) Occupational health and safety is something that cannot be separated in human resources and

employment. The aim is to create a comfortable and healthy workplace so as to reduce the risk of accidents and occupational diseases as low as possible, improving occupational safety and health is expected to have an impact on reducing the number of work accidents. According to research conducted by Noer, Perdana, and Rahman, (2024) Facility layout design is an important aspect in supporting the smooth production process, especially in manufacturing industries such as tofu factories. A good layout can minimize production time, reduce operating costs, and increase the overall efficiency of the factory. However, often non-optimal arrangements can lead to bottlenecks, high waiting times, and inefficiencies that have a direct impact on productivity and product quality.

Figure 1. Budi's Tofu production floor

Based on Figure 1, it can be seen that there is a lot of water on the production floor and also employees who only use makeshift footwear during the production process. This causes frequent work accidents on the production floor due to slippery floors and also employees who only use makeshift footwear. From the results of direct interviews with employees, it can be seen that some employees have experienced work accidents such as slipping, tripping over tofu containers and blistering hands. This is due to the layout of facilities that do not pay attention to the flow of production and the distance between one station to another station is not based on the degree of relationship or proximity between departments, does not determine the need for space and the needs of work activities and employees who do not use PPE during the production process.

Table 1. Work accident data of Mr. Budi's Tofu factory

Process Stage	Work Accidents	Causes
Tofu Printing	Slipped	There is a lot of water on the production floor
Raw Material Removal	Waist Pain	Transporting raw materials
Boiling	Hand Blisters	Exposed to steam during the boiling process

Work accidents are caused by the layout of facilities that do not pay attention to the flow of production and the distance between one station and another station is not based on the level of relationship or proximity between departments, not determining space requirements and work activity needs and employees who do not use Personal Protective Equipment during the production process.

Research conducted by Hidayanti (2023) stated that the occurrence of work accidents due to work can cause many losses, both economic and non-economic losses. Economic losses can be in the form of medical expenses and losses caused by the cessation of the production process, while non-economic losses are in the form of organizational chaos, employee disability and complaints. Realizing the magnitude of the risk of loss both borne by the company and workers who become victims, it is necessary to prevent work accidents at Pak Budi's tofu factory by reducing unsafe conditions through the notification of personal protective equipment when carrying out the production process and selection station placement by redesigning the facility layout.

Based on the results of interviews and observations made at Pak Budi's tofu factory, it is known that the layout of facilities at Pak Budi's factory is not based on planning but only adjusts to the existing space, this has resulted in several problems. Based on Adiyanto and Clistia's research (2020), regarding the design of facility layouts, one of the problems that arises is that the distance of improper material movement results in a long trajectory of material handling which results in movement back and forth in the production process and the placement of stations that do not consider the

order of the production process causes a waste of time in the production process. In the research of Arbi and Rendra (2022) it is stated that the layout of the facility is considered effective if it is able to minimize production costs, is able to reduce production time and is able to maintain work security and safety. In the research of Prastawa and Negarawan (2020), it is stated that work safety includes preventing accidents, preventing or reducing the occurrence of occupational diseases, preventing or reducing defects due to work, securing materials, construction and carrying out maintenance, all of which lead to an increase in the standard of living and human welfare.

Based on the problems found in the Pak Budi tofu factory, it is necessary to redesign the facility layout. In this research, the methods used are the HIRARC method and the Blocplan Algorithm method. The HIRARC method (hazard identification, risk assessment, and risk control) is a key element in occupational safety and health management that is directly related to efforts to prevent and control hazards. According to OHSAS 18001: 2007 in the implementation of the k3 management system in companies must apply HIRARC, namely establishing, implementing and maintaining to identify hazards, risk control and risk assessment (Zulkarnain, et al., 2023). The Blocplan method is a heuristic algorithm that uses quantitative data and qualitative data, the Blocplan method can observe the exchange of facility layouts based on involvement in the production process (Halim, et al., 2024).

2. LITERATURE REVIEW

HIRARC

HIRARC is a series of processes to identify hazards that can occur in routine or non-routine activities in the company. HIRARC starts from determining the type of work activity which then identifies the source of the hazard so that the risk is obtained, then risk assessment and risk control will be carried out to reduce exposure to hazards contained in each type of work (Ramdhani et al., 2023).

Facility Layout Design

According to Wignjosocbroto, (2009) cited by Naim, et al., 2020. Factory layout or facility layout can be defined as a procedure for organizing factory facilities to support the smooth production process. This arrangement will be useful for the placement area of machines or other supporting facilities. Production facilities, smooth material movement, temporary and permanent material storage, placement of labor personnel, and so on.

Activity Relationship Chart (ARC)

Activity relationship chart is a very useful layout design method, because by using it the designer can find out the proximity relationship of each group of activities or departments that are usually found in each company. The activity relationship chart is similar to the from-to chart in the conventional floor area calculation method, except that in the Activity relationship chart, the distance which is the determining variable is replaced with a qualitative letter or password (Panjaitan and Azizah, 2020).

Blocplan

Blocpan is a heuristic algorithm that combines quantitative and qualitative information. The concept of the blocplan algorithm involves designing a layout by randomly changing the position of existing facilities, then evaluating the results by calculating the adjacency score, r-score and rel-dist score. The data used in the blocplan algorithm can come from quantitative data generated through the Activity Relationship Chart or quantitative data in the form of product flow and the size of the building area (department) that the facility will occupy (Muharni, 2022).

Here are the steps in using the Blocpan method (Sholekhah, et al., 2022): (1) Enter the number of departments, (2) Enter the area name data of each department, (3) Enter the data of the link diagram between activities, (4) Select alternatives by considering adjacency score (proximity value between facilities), r-score (layout efficiency) and rel-dist score (total distance traveled), and (5) Design the proposed layout based on the blocplan results.

3. RESEARCH METHOD

This research begins with making preliminary studies, literature studies, making problem formulations, determining research objectives, followed by data collection obtained from direct interviews with the owner of Pak Budi's tofu

factory, then data processing is carried out using the HIRARC and Blocplan methods, the next stage is to analyze the data processing that has been done, the last one makes conclusions and suggestions. The flowchart of the research stage can be seen in Figure 1.

Explanation of research flowchart:

1. The preliminary study was carried out by identifying data obtained through direct observation and conducting interviews with business owners.
2. Literature study is carried out by looking for theories that support and facilitate in solving problems in research.
3. Identification of problems in this study, namely employees who do not use personal protective equipment during the production process, causing work accidents and station placement that does not match the flow of the production process.
4. The formulation of the problem will be answered through the data that has been collected and will be processed.
5. The research objectives in this study are to conduct an OHS assessment at Pak Budi's tofu factory and redesign the facility layout.
6. Data obtained from interviews with the owner of Pak Budi's tofu factory in the form of a company profile, production process, equipment used in the production process and factory layout.
7. The first stage in HIRARC is to identify hazards, then carry out a risk assessment by finding the relative risk value obtained from multiplying the likelihood and saverty values, finally carrying out risk control of the hazards found.
8. In the process of making blocplan, the first thing to do is to make an Activity Relationship Diagram followed by entering data on the name and area of each department in blocplan, entering data on the relationship diagram between activities that have been obtained from ARC, selecting alternatives by considering adjacency score, r-score, and rel-dist score then blocplan will give a layout proposal based on the data that has been entered.

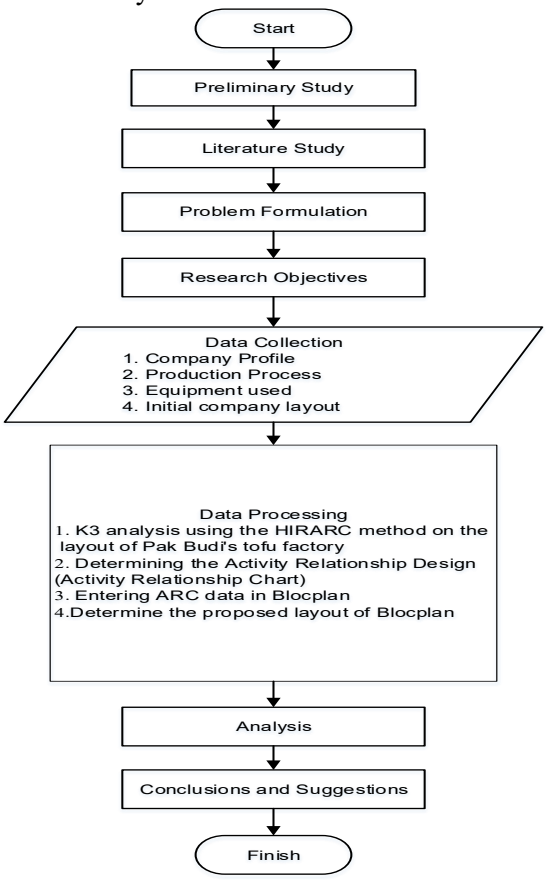

Figure 2. Study framework

4. RESULT AND DISCUSSION

HIRARC Assessment

Hazard identification is carried out based on activities carried out at Pak Budi's tofu factory. From the results of interviews that have been conducted, it can be seen that the activities and risks of work accidents that occur at Pak Budi's tofu factory are as follows:

Table 2. Hazard identification

Work activities	Causes	Risk
Moving soybean raw materials	Does not use tools, where raw materials are transported manually	The waist becomes sore and cramped
Soy bean soaking and tofu molding process	Not wearing PPE properly, many puddles on the floor	Employee slips
Soy bean boiling process	Not wearing PPE properly, the presence of hot steam from steam	Hand blistering from hot steam

Risk Assessment

From the identification of hazards that have been carried out at Pak Budi's tofu factory, it can be seen that the level of risk that exists at Pak Budi's tofu factory is as follows:

Table 3. Risk assessment

Work Activities	Causes	Risk	O	S	Risk value	Risk level
Moving soybean raw materials	Does not use tools, where raw materials are transported manually	The waist becomes sore and cramped	4	2	8	Medium
Soy bean soaking and tofu molding process	Not wearing PPE properly, many puddles on the floor	Employee slips	4	2	8	Medium
Soy bean boiling process	Not wearing PPE properly, the presence of hot steam from steam	Hand blistering from hot steam	3	3	9	High

From the results of the risk assessment, it can be seen that there is 1 job with a high risk level and 2 jobs with a moderate risk level, so it is necessary to carry out risk control to reduce the level of risk of work accidents at Mr. Budi's tofu factory.

Risk Control

To reduce and prevent work accidents, risk control is carried out on each potential hazard as follows:

Table 4. Risk control

Work activities	Causes	Risk control recommendations
Moving soybean raw materials	Does not use tools, where raw materials are transported manually	Using tools such as wheelbarrows to transport raw materials, bringing the storage station and soaking station closer together.
Soy bean soaking and tofu molding process	Not wearing PPE properly, many puddles on the floor	Use PPE such as shoes and redesign the facility layout.
Soy bean boiling process	Not wearing PPE properly, the presence of hot steam from steam	Using PPE in the form of gloves and given warning signs K3 signs

Activity Relationship Diagram

To find out which stations need to be brought closer to Mr. Budi's tofu factory, an Activity Relationship Chart is created.

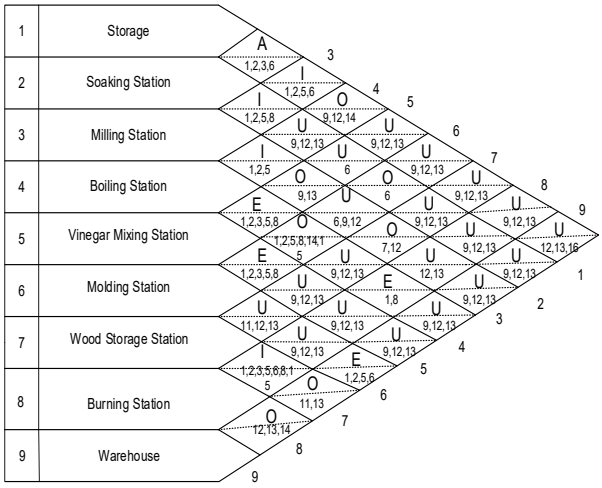

Figure 3. Activity relationship diagram

Table 5. Percentage of proximity relationship

Symbol	Description	Usage threshold
A	Absolutely necessary	0 – 5%
E	Very necessary	3 – 10%
I	Need	5 – 15%
O	Ordinary/No Problem	10 – 25%
U	Not necessary	25 – 60%
X	Not desired	Depends on needs

The worksheet is a summary of the results of the activity relationship chart. Mr Budi's tofu factory worksheet can be seen in table 6.

Table 6. Recapitulation of ARC calculation results

Worksheet						
Departement	A	E	I	O	U	X
Storage	2		1,3		4,5,6,7,8,9	
Soaking	1		3	6	4,5,7,8,9	
Milling			1,2	4,5,6,7	8,9	
Boiling		5,8		2,3,6	1,7,9	
Vinegar blending		4		3,6	1,2,7,8,9	
Molding		9		2,4,5	1,3,7,8,	
Wood storage			8	3,9	1,2,4,5,6	
Burning			7	9	1,2,3,5,6	
Warehouse		6		7,8	1,2,3,4,5	
Sub-Total	2	5	7	18	40	
Total	**72**					

To find out whether the proximity presente is in accordance with the proximity threshold, the following calculation is carried out:

1. Percentage A $= \frac{2}{72} \times 100\% = 2.78\%$
2. Percentage E $= \frac{5}{72} \times 100\% = 6.95\%$
3. Percentage I $= \frac{7}{72} \times 100\% = 9.72\%$
4. Percentage O $= \frac{18}{72} \times 100\% = 25\%$
5. Percentage U $= \frac{40}{72} \times 100\% = 55.55\%$
6. Percentage X $= \frac{0}{72} \times 100\% = 0\%$

From the calculation of the proximity percentage that has been done, it can be seen that the percentage value is in accordance with the proximity threshold, which shows that the proposed layout based on HIRARC is in accordance with the closeness set.

Finding Alternative Layouts Using BLOCPLAN

The blocplan application is used to find alternative layouts based on data that has been obtained from ARC.

1. Enter the department name and department area on the blocplan as shown in Figure 3.

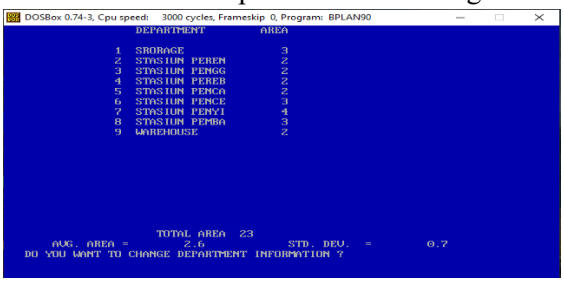

Figure 3. Department name and area

2. Enter the Activity Relationship Chart data according to what has been obtained previously as shown in Figure 4.

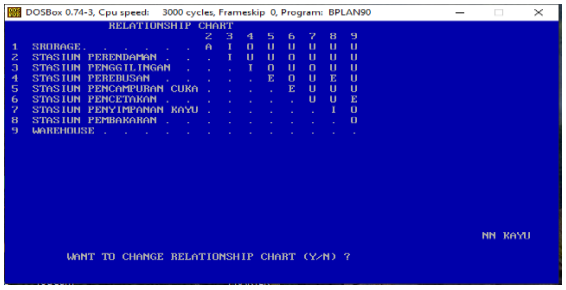

Figure 4. ARC data entry

3. Blocplan will show the score of each alternative.

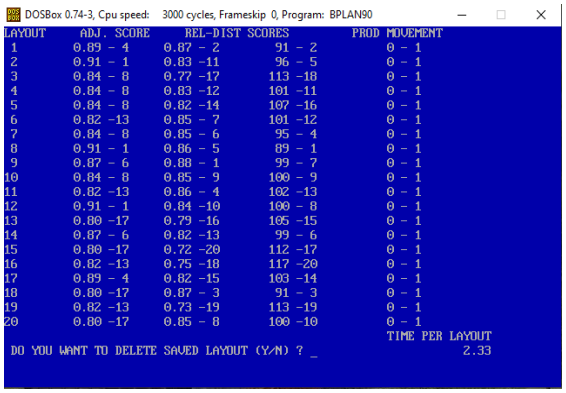

Figure 5. 20 Alternatif layout

4. Alternative 8 was selected out of 20 alternatives, here is the blocplan selected alternative.

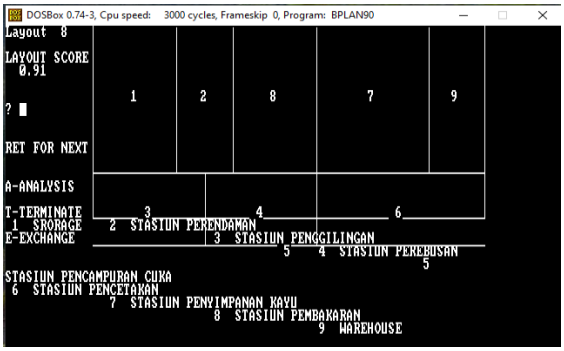

Figure 6. Alternative Layout Display

After knowing the selected alternative, the From To Chart will be calculated to calculate the distance between departments as can be seen in table 9.

Table 7. FTC based on blocplan selected alternative

to \ from	A	B	C	D	E	F	G	H	I	**Total**
A										**0**
B	2									**2**
C		1,5								**1,5**
D			1							**1**
E				1						**1**
F					1					**1**
G						1,2				**1,2**
H										**0**
I					2			2		**4**
Total	**2**	**1,5**	**1**	**1**	**3**	**1,2**	**0**	**2**		

Analysis Forward and Backward:
A – B – C – D – G – H – E – F – I
Forward: 1) 2 + 1,5 + 1 + 1 + 1 + 1,2 + 2 = 9,7
2) 2 + 0 = 2
% Forward = (11,7 : 11,7) x 100% = 100

The forward value is more than 75% and even reaches the maximum value of 100%, the backward value also does not exist, so there is no need to make improvements to the proposed bloc plan.

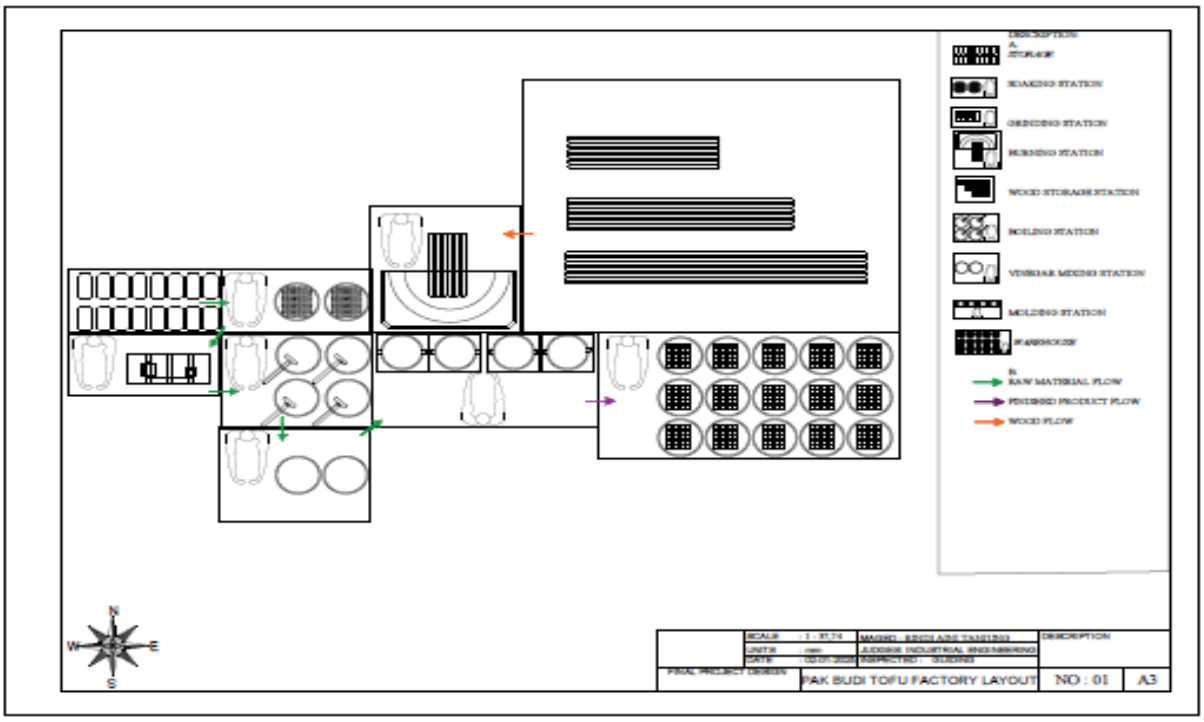

Figure 7. Selected proposed layout

The results of the HIRARC assessment at the Pak Budi tofu factory show 2 activities with moderate risk levels and 1 activity with high risk levels, this indicates the need for risk control at the Pak Budi tofu factory by giving employees an understanding of the importance of personal protective equipment in the production process and improvements to the layout of the Pak Budi tofu factory facilities. One of the risky work activities in the production process is the transfer of raw materials carried out manually where workers transport 50 kg of soybeans from the storage station to the soaking station which is 3 meters away. Recommendations for this problem are that the transportation of raw materials is carried out with tools and a redesign of the layout of Pak Budi's tau factory facilities. The results of improving the layout of facilities can reduce the distance of material movement where before the proposed improvement in the layout of facilities at the Pak Budi tofu factory the total distance of material movement is 19.2 meters, in the proposed layout of facilities the distance of material movement is 11.7 meters this result shows a decrease in distance of 7.5 meters.

5. CONCLUSION

This study aims to assess occupational health and safety using the HIRARC method at Pak Budi's tofu factory. After the assessment, it is known that there are 2 production process activities with moderate risk levels and 1 activity with high risk levels. Risk control recommendations for the activity of moving soybean raw materials and the tofu printing process are to redesign the facility layout, in activities with high risk levels the recommendation for improvement is to use PPE in the production process and give warning signs of K3 signs so that employees are more careful. The next goal is to redesign the layout of facilities at the Pak Budi tofu factory where after redesigning the layout using the blocplan method there is a difference in material transfer distance of 7.5 meters, this shows that the application of facility layout redesign at the Pak Budi tofu factory can be implemented so that the production process is more effective and efficient.

To reduce work accidents and increase productivity at the pak budi tofu factory, it is

better to notify employees about K3 hazards so that employees are more careful at work, and evaluate the facility layout design to ensure the factory operates more optimally. Based on the findings of the research on the redesign of the facility layout at Pak Budi's tofu factory using the HIRARC and Blocplan methods, the research results can be used as a reference to reduce work accidents during the production process and make improvements to the facility layout.

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