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Redesign of Wallet Production Facility Layout Using ARC and Simulation at Fanri Collection

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Abstract

The development of technology at this time causes competition in the accessories and fashion industry. This situation has caused an increase in the number of requests for products at Fanri Collection, a producer of leather craft accessories. To survive and win the competition, companies need to increase productivity. One way of resolving the issue is by designing the layout and production facilities to minimize the distance of material handling in the production process. This research aims to design layout and production facilities on wallet products with the Discrete Event Simulation (DES) method using FlexSim 21.0 software and Activity Relationship Chart (ARC) to analyze the amount of output and get a proposed facility layout. Based on the simulation results, in producing 200 units of wallets, the initial total material handling distance is 20.667 meters with a cycle time of 1 day, 5 hours, and 3 minutes. After making improvements with ARC, the total material handling distance is reduced to 17.475 meters with a cycle time of 1 day, 4 hours, and 48 minutes. Thus, the improvement can minimize material handling distance by 3.192 meters and reduce cycle time by about 15 minutes.

Keywords: facility layout; activity relationship chart; material handling; simulation.

Introduction

Every industrial company must be able to compete and improve the quality of its products and production processes. Apart from production quality, it is also necessary to increase and maintain the sustainability of production in an effort to grow profits (Oktini *et al.*, 2023). Quality improvements can be made through improvements to the product, for example, for food products so they are drier and more durable (Fitriyanti, 2023), and also at the production site/layout. In industries, layout is essential in increasing production capacity, which concerns the efficiency of time, place, and cost.

Layout design is a way to improve the company's operational activities, including the proper placement of machines in the production process, the placement of desks in the office, as well as service centers in hospitals or supermarkets (Rauan *et al.*, 2019). The efficient design of facility layouts can minimize or reduce material handling costs (Faiz *et al*., 2019; Kholifah & Suhartini, 2021). Efficiency improvements and cost reduction also underlie the importance of redesigning layout planning (Mebrat *et al*., 2020), not only in normal conditions but also in the pandemic era (Oktalia *et al*., 2021).

Fanri Collection is an SME that produces leather handicrafts through wallets, bags, key chains, etc. This SME has a vital role in empowering its workers, the majority of whom are people with disabilities or defined as someone with a different ability to carry out activities than others. The type of production used in Fanri Collection is make-to-stock and make-to-order, where this company will produce products directly to be used as inventory without waiting for consumers but also accept orders according to consumer desires.

Furthermore, there are several challenges in running a business, such as when moving production goods, some operators use wheelchair assistance. However, due to improper layout arrangements, wheelchair user operators have limited space for movement. Thus, they have to transfer production goods to other operators manually before they arrive at the destination machine, which takes a significant amount of time.

Figure 1. *Fanri Collection Production House*

Moreover, the storage warehouse can no longer accommodate semi-finished goods, resulting in the remaining items being placed in the vicinity of the production environment, leading to a buildup of goods and causing congestion in the goods transfer routes. Consequently, this condition has impeded the achievement of production targets as the completion time deviates from the planned schedule due to inadequate layout arrangements. Therefore, reassessing the company's layout and facilities is necessary to address these issues. There are several methods for designing production facility layouts. A systematic and organized approach is employed to generate layouts that align with production flow and minimize transfer distances, namely Systematic Layout Planning (SLP) (Kholifah & Suhartini, 2021; Naufalah *et al*., 2023; Ramadhan *et al*., 2021; Suhardi *et al*., 2019). The SLP method can be supplemented with various diagrams, including the Activity Relationship Chart (ARC), Activity Relationship Diagram (ARD), and several software options. Simulation is required to comprehensively visualize production flow within the production area and provide multiple scenarios to reduce material handling in facility layout redesign (Dewa *et al*., 2018; Faiz *et al*., 2019). Discrete Event Simulation (DES) can be employed in discrete event problems (Rizqi & Aulia, 2019). This study aims to evaluate the initial layout of the wallet production facility at Fanri Collection using Flexsim software, design a proposed layout using the ARC method, and compare material handling costs between the initial and proposed layouts.

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Method

The research was conducted at Fanri Collection, Jalan Kaliurang Km. 13.5, Besi, Sukoharjo, Ngaglik, Sleman, DIY. This SME operates in the fashion industry, with several product lines, including bags, belts, and wallets. The study focused on the production process of wallets made from raw cowhide and stingray leather materials.

The variables examined in the research pertained to the design of facility layouts aimed at minimizing material handling during the production process. Data were collected over three months, from July 2022 to September 2022. Primary data collected through direct observation and interviews encompassed the initial layout, production process sequence, machine processing times, and distances between machines. Meanwhile, secondary data were obtained from literature studies and company documents, including the company profile, product drawings, and specifications.

The initial production layout data, production process sequence, machine processing times, and distances between machines were then processed using Flexsim 21.0 software employing discrete event simulation (DES) methodology. Flexsim is discrete simulation software used to model and simulate different systems from several different industries. Flexsim software is a 3-D computer technology that is a simulation technique, artificial intelligence technology, and data handling technique. FlexSim is suitable for use in manufacturing production, storage and shipping, transportation systems, and other fields (Zhu *et al*., 2014). The stages of modeling and simulation using FlexSim software are surveying the system, collecting data from the system, building a model, building a simulation model, model validation, simulation and running, and analyzing the output of the simulation results.

The ARC method is applied to evaluate the initial layout results by determining the degree of interdepartmental relationship proximity, thus reducing material handling costs. If there are two machines or facilities that have a strong connection, then they need to be placed close to each other. Likewise, if there is no need for connection, then there is no need to be close. The value of the closeness relationship is determined based on the degree of closeness as follows:

A = Absolutely Necessary, adjacent.
E = Very Important, adjacent.
I = Important, side by side.
O = Normal, proximity anywhere is not a problem.
U = No need for any geographical connection.
X = It is not desirable that the activities close together.

Results and Discussion

The collected data is used to depict the factory layout, as illustrated in Figure 2. The discussion will be divided into several parts, namely initial model building, factory layout design, experimental design, and proposed layout.

Initial Model Building

The model is constructed using Flexsim software based on the station arrangement resembling the factory layout and following the wallet production flow. The wallet production flow is then translated into a conceptual model represented by a flowchart, as shown in Figure 3.

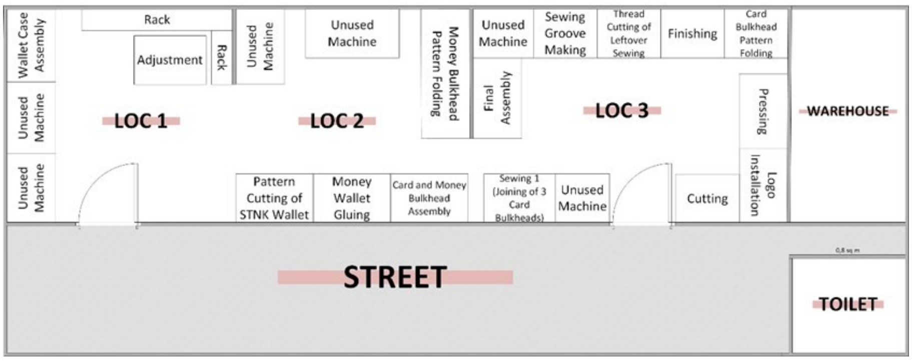

Figure 2. *Initial Production Layout of Fanri Collection*

The production process of making cow leather wallets at Fanri Collection starts with the arrival of cow leather and opaque paper. The raw materials for cow leather and opaque paper come in the form of large and long sheets. The cow leather will then be cut into wallet-sized pieces (24 cm x 10 cm). These pieces of leather will be used to make card bulkheads, money bulkheads, and wallet cases. To make the card bulkheads, the leather pieces will be pressed first. After that, fold the leather pieces according to the pattern of the card bulkhead and make a stitching groove to facilitate the sewing process. In the sewing process, three pieces of leather will join together to form one card partition. The last process is finishing by cutting the remaining sewing thread on the card bulkhead.

To make the money bulkhead, the first process is to fold the leather pieces according to the pattern of the money bulkhead. The next step is gluing the leather pieces together. The final process of making the money bulkhead is to adjust the money bulkhead according to the pattern by cutting off unnecessary parts of the leather. The leather pieces that are glued to the money bulkhead are used to glue the money bulkhead and card bulkhead into one part (card and money bulkhead).

Processing for the opaque paper will start with cutting the opaque paper according to the STNK (vehicle registration) bulkhead pattern; the result is the STNK bulkhead. The STNK bulkhead will be used to make a wallet case. To make the wallet case, the leather pieces will be combined with the STNK bulkhead. Next is the process of combining the wallet case with the card and money bulkhead parts to form a wallet. After that, the finishing process of the wallet is carried out and continued with the installation of the logo on the wallet, and finally, it will be stored in the finished warehouse and sold to customers. Then, the model is subsequently constructed by applying the process flow depicted in Figure 3 with the simulation of the production of 200 wallet units in Flexim software according to the initial layout conditions. Figures 4 and 5 illustrate the simulation and outcome as well.

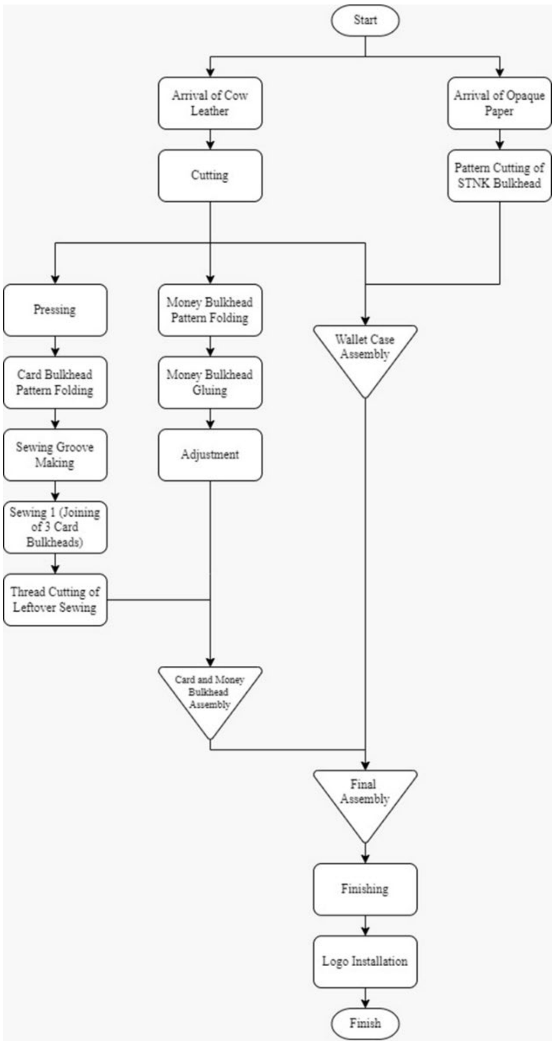

Figure 3. *Conceptual Model of Wallet Production Process*

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According to the simulation results, the total material handling amounted to 20,667 meters, indicating that the workers have traveled a total distance of 20,667 meters while producing 200 wallet units. The workers at the cutting station accounted for the highest movement, covering a distance of up to 5,948.63 meters due to the necessity for them to transport the cut leather pieces to three different workstations. Meanwhile, workers at the wallet tongue assembly and STNK pattern cutting stations also undertook considerable movement, with total distances traveled of 2,110.93 and 1,676.73 meters, respectively. The simulation results indicate that producing 200 wallet units requires a total time of 43,285.97 seconds, equivalent to 12.02 hours or approximately one day, 5 hours, and 3 minutes, considering a working day of 7 hours.

Figure 4. *Initial Model*

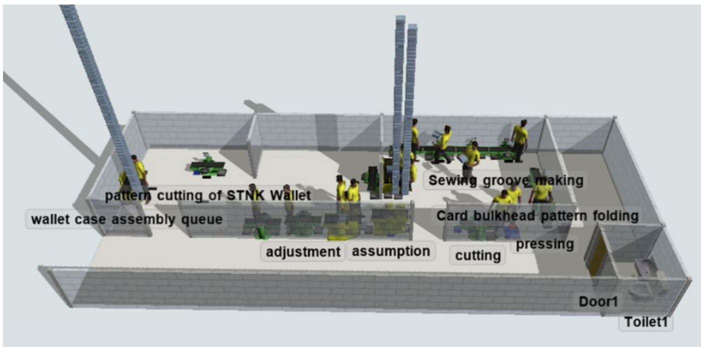

Figure 5. *Simulation Model Run*

Factory Layout Design

In designing the layout, an analysis of activity relationships is required to determine the degree of proximity between existing departments. There are quantitative aspects in analyzing the flow of materials used and qualitative elements in assessing these relationship degrees. These qualitative aspects can be demonstrated using an Activity Relationship Chart (ARC). Figure 6 illustrates the proximity of relationships between the existing departments at Fanri Collection. In the ARC diagram model (Figure 6), each location is assigned a number and color with its significance to indicate the relationships between locations. Table 1 explains the meaning of the colors and numbers in Figure 6. Meanwhile, Table 2 elucidates the rationale behind assigning numbers to each relationship between locations in Figure 6.

Experimental Design

An experimental design was conducted to improve suboptimal performance based on the analysis of simulation results from the initial model. This proposed model was constructed considering several points, including:

1. Workstation relocations were implemented by adjusting the degree of proximity between workstations previously established in the Activity Relationship Chart (ARC).

2. Workstation layouts were rearranged without altering the overall area for workstation usage and movement space.
3. The cutting station remained unchanged, as its current location was deemed appropriate.
4. No relocations were made for stations utilizing sewing machines (assembly stations).

A new workstation layout was then designed utilizing the identified inter-location relationships (Figure 6), as illustrated in Figure 7. Subsequently, the new design was incorporated into the Flexsim model for experimentation.

Table 1. Color Description on ARC

No	Color	Description	Code
1	Red	Absolutely Very Important	A
2	Yellow	Very Important	E
3	Green	Important	I
4	Blue	Moderate	O
5	White	Not Important	U
6	Brown	Not Desirable	X

Table 2. Reason Code Description on ARC

Reason Code	Description
1	Ease of Supervision
2	Ease of Coordination
3	Smooth Flow of Materials
4	Mutual Support Function
5	Interrelated Facilities
6	No Functional Relationship
7	Dust/Dirty/Safety

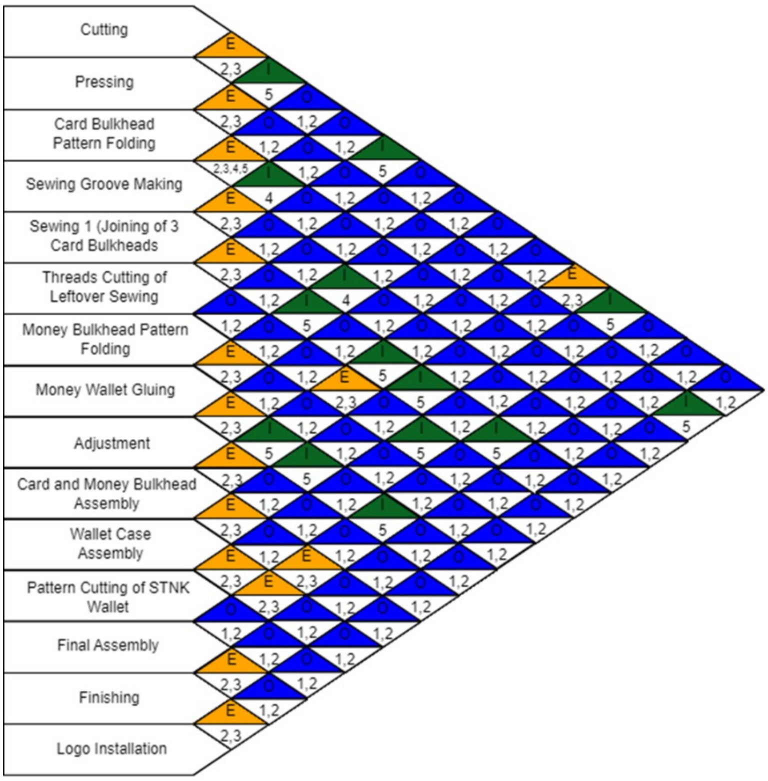

Figure 6. *Activity Relationship Chart*

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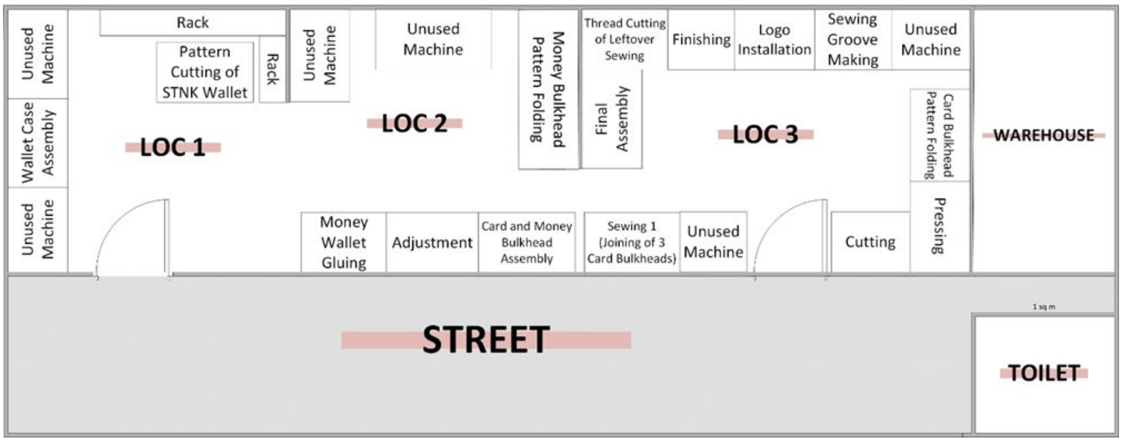

Figure 7. *Proposed Layout*

A comparison between the initial facility layout and the proposed layout was obtained after carrying out model construction and simulations on the Fanri Collection, which can be seen in Table 3. There are 12 comparisons. The experiment results with the new layout design show that the material handling value obtained was 17,475 meters, with a total cycle time of 1 day, 4 hours, and 48 minutes. Compared to the initial layout's simulation results, the new layout design resulted in approximately 15 minutes faster processing time, depicted in Table 4. Based on the comparison data in Table 4, the results show that there is a reduction in material handling distance of 3,192 meters. This will provide several benefits, including saving material handling costs (Oktalia *et al*., 2021) and material transfer time (Suhardi *et al*., 2021) to increase overall manufacturing cycle efficiency (Waseem *et al*., 2021). Savings on material handling costs are expected to increase production and ultimately increase profits (Oktini *et al*., 2023).

This article makes improvements in increasing the production process by improving the layout. Companies can compete with other companies if they can make continuous improvements. Improvements can be made in the production process or the product (Oktini *et al*., 2023). Research related to the production process in manufacturing is more widely carried out because it has a direct impact on efficiency and costs.

There is a limitation in this article, where the discussion does not use a comparison of material handling costs, so it is unknown how much material handling costs can be reduced. If possible, it is necessary to add comparisons for material handling costs in further research. The results in the field show that Fanri Collection sometimes does not pay much attention to where the work is carried out, especially for work without the help of machines or large tools, which has the potential to cause production to run sub-optimally. It is necessary to provide a basic understanding of the importance of production facility layout in achieving optimal production.

Table 3. Comparison of Initial and Proposed Layout

NO.	Initial Layout	Proposed Layout
1.	The wallet tongue assembly process is in location 1.	The wallet tongue assembly process has been moved but is still in the same location.
2.	The setup process is in location 1.	The setup process is moved to location 2.
3.	The process of cutting the STNK wallet pattern is in location 2.	The process of cutting the STNK wallet pattern is moved to location 1.
4.	The process of gluing the money wallet is in location 2.	The process of gluing the money wallet is moved but is still in the same location.

NO.	Initial Layout	Proposed Layout
5.	The process of making sewing grooves is at location 3.	The process of making sewing grooves has been moved but is still in the same location.
6.	The process of cutting the remaining sewing thread is in location 3.	The process of cutting the remaining sewing thread is moved but is still in the same location.
7.	The finishing process is at location 3.	The finishing process is moved but is still in the same location.
8.	The process of folding the card divider pattern is in location 3.	The folding process of the card divider pattern is moved but is still in the same location.
9.	The compression process is in location 3.	The compression process is moved but is still in the same location.
10.	The logo installation process is in location 3.	The logo installation process has been moved but is still in the same location.
11.	The material handling value in producing 200 wallets is 20,667 meters.	The material handling value in producing 200 wallets is 17,475 meters.
12.	The time required to produce 200 wallets in one working day is 43,285.97 minutes (12.02 hours) or around 1 day, 5 hours, and 3 minutes.	The time required to produce 200 wallets in one working day is 42,503.11 minutes (11.8 hours) or around 1 day, 4 hours, and 15 minutes.

Table 4. Comparison Results of Initial and Proposed Layout

	Initial Layout	Proposed Layout
Material Handling	20,667 meters	17,475 meters
Cycle Time (Production of 200 wallets)	1 day, 5 hours, and 3 minutes	1 day, 4 hours, and 48 minutes

Conclusions

The placement of workstations significantly influences production cycle time and material handling for workers. This study aims to recommend a comfortable working environment for SMEs with an organized facility layout to minimize material handling in the production process, particularly for workers with wheelchairs. Proposed facility layouts are formulated using the Activity Relationship Chart (ARC) method. Simulation results with the new design can reduce the cycle time for producing 200 wallet units by up to 15 minutes. Additionally, material handling movements for all workers can be decreased to approximately 3.192 meters. It is necessary to add comparisons for material handling costs in further research.

Fanri Collection needs to consider relocating some workstation layouts according to the suggestions. For the proposed design to be effectively implemented, it is essential to provide basic training on the importance of facility layout in production systems.

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