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Systematic Layout Planning to Improve Facility Layout in Small and Medium Food Enterprises

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Abstract

The absence of a structured method for revamping current or introducing new production layouts in small and medium-sized enterprises may hinder the flexibility and competitiveness of the enterprise. This study aimed to assess the existing production layout and offer improvement recommendations for a small and medium-sized food enterprise in East Java, Indonesia. Data was obtained through interviews with the owner and observation at the production site. The research employed systematic layout planning, utilizing activity relationship charts and diagrams. The findings presented two alternative suggestions for the production facility layout, with the study recommending the second alternative based on an evaluation of criteria. The second proposed alternative exhibited a total material handling distance per week of 1,812 and a total material handling cost of 17,961.96 rupiah, lower than the first proposed alternative. The managerial implications of this study pertain to the construction of facilities with a focus on technical and hygiene requirements, the design and layout of buildings and rooms, and the requirements for machinery, equipment, and transportation to ensure product quality and safety.

Keywords: production facility layout, systematic layout planning, activity relationship chart, activity relationship diagram

JEL Classification: D24, L32, L66

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Introduction

The growth of the food and beverage sector in Indonesia has shown a consistent and significant increase over the years. Throughout 2020, the food and beverage industry experienced a modest growth of 1.58%, mainly due to the outbreak of the COVID-19 pandemic. Nevertheless, the Director of the Food, Sea Products and Fisheries Industry of the Ministry of Industry, Supriadi, has projected a 5% growth of the food and beverage industry in 2021. This growth is anticipated to be partly driven by the frozen food sector.

One of the small businesses involved in producing frozen food, the XYZ SME, in Krian-Sidoarjo, East Java, faces challenges with the layout of its production facilities. An Indonesian Food and Drug Supervisory Agency assessment identified several areas in which improvements are necessary, such as the lack of a proper washing area, defective machinery, and an inefficient layout that disrupts the production flow. Systematic layout planning (SLP) is recommended to address these challenges, given the limited production floor space, high material handling costs, and the need for an efficient facility layout to optimize output. The SLP method offers a practical approach to minimizing material handling costs and optimizing facility layout.

The proposed implementation of the manufacturing facility layout at XYZ SME is advantageous for the company. It plays a vital role in driving growth within the food and beverage industry, demonstrating its significance as a major contributor to the national economy. During the second quarter of 2021, the food and beverage industry emerged as the primary contributor to the non-oil and gas processing industry sector, accounting for 38.42% of its output. Therefore, optimizing facility layouts benefits individual businesses and supports the Ministry of Industry's endeavours to strengthen industrial competitiveness and enhance productivity.

Literature Review

The concept of layout pertains to the strategic arrangement of production facilities to optimize efficiency (Wignjosoebroto, 2009) and align with the specific needs of a company, including the positioning of machines in a manufacturing environment, workspaces in an office setting or service centres in establishments such as hospitals and department stores. In creating a practical layout, it is crucial to consider the efficient utilization of material handling equipment, along with a thorough evaluation of capacity and spatial requirements. These considerations depend on the number of employees, machinery, and equipment involved. Moreover, the aesthetic and environmental aspects of the layout should be deliberated, considering factors such as natural lighting, vegetation, and partition design, all of which contribute to enhancing air circulation, reducing noise, and ensuring privacy. In addition, optimizing information flow and managing relocation costs between different work areas are vital elements of proficient layout planning.

Systematic layout planning is widely used to solve production facility layout challenges. Developed by Muther, this method considers various factors, such as the interaction between different facilities and shipping costs, to ensure the optimal layout (Hanggara, 2020; Ojaghi et al., 2015). The process involves several steps, including drawing the material flow, creating an activity relationship diagram, determining the relationship diagram based on product flow, adjusting the required area, creating a spatial relationship diagram, and making modifications. Additionally, the method emphasizes the role of alternative layouts, implementation, and evaluation to achieve an efficient facility layout.

The Activity Relationship Chart (ARC) is a tool utilized in the SLP method to analyze the relationships in material flow within a factory. It helps in grouping activities and assists in the decision-making of which activities should be located closer to each department. The chart utilizes codes to represent the degree of closeness required for each activity (Apple, 1990). For example, the code 'A' signifies that an activity must be located very close, while 'E' and 'I' denote varying importance levels in being nearer to each other. Following the ARC, an Activity Relationship Diagram (ARD) is created, which further visualizes the degree of closeness using different line styles and colour codes. The red colour code shows the degree of closeness A, the orange colour code shows the degree of closeness E, the green colour code shows the degree of closeness I, the blue colour code shows the degree of closeness O, the white colour code (without colour) shows the degree of closeness U and the brown colour code shows the degree X proximity. Each letter code in the diagram is supported by a reason code based on factors such as noise, dust, ease of activity, simultaneous use of machines, and the specific conditions of the research field.

The systematic layout planning (SLP) method resulted in several improvements in various production facilities (Ali Naqvi et al., 2016; Elahi, 2021; Fahad et al., 2017; Flessas et al., 2015; Hanggara, 2020; Khariwal et al., 2021; Le et al., 2019; Maheso et al., 2019; Ojaghi et al., 2015; Suhardi et al., 2019). These improvements include decreased lead time from 6 weeks to 4 weeks, significant energy savings, identification of non-optimal material flow, and removing refrigerators and freezers from the production area. Additionally, the research findings indicate that the use of diesel in factories can be decreased, resulting in fuel cost savings of $209.08 per year and a potential annual reduction of 719.6 kg in carbon footprint. The optimization of factory layout has also contributed to increased layout scores, meeting the requirements of construction managers while guaranteeing preferences for temporary facility connections. Furthermore, gradual layout improvements and layout evaluations have shown potential in resolving issues related to flow between shops and reducing movement within the shop. Material flow efficiency has improved significantly, mainly due to the building of a centralized logistics centre, which has minimized delays in transportation and reduced lead time. Lastly, alternative design proposals for the layout of facilities in the sewing department of a company have been based on transfer distance, material handling costs, and transfer time, leading to the selection of a rail facility layout with integrated training and learning areas.

Methodology

The study employed the systematic layout planning (SLP) technique within a qualitative research framework. This qualitative approach involves a descriptive research methodology to assess objects' conditions naturally. Data collection for this study encompassed interviews, questionnaires, and video recording transcripts, as outlined by Bougie and Sekaran (2016). Elahi (2021) expounded that systematic layout planning serves as a tool for evaluating factory facility layouts by considering inter-activity relationships and material flows. Data gathering involved interviews with the owner and direct observation of the XYZ production site in Krian-Sidoarjo, East Java. The owner was selected as the primary informant due to comprehensive knowledge of business and production processes, factory conditions, machine types and quantities, daily consumer product requests, and machine layout specifics for the production process. Observations were conducted over three months to gain deeper insights into production process challenges.

The process of research encompasses multiple sequential phases. Initially, it involves identifying, examining, and visualizing the interconnection of various material flows. Subsequently, it entails determining and documenting the spatial criteria for each resource within the factory facility configuration. Following this, the activity relationship charts (ARC) and activity relationship diagram (ARD) graphs are essential for assessing the extant material flow associations. Table 1 contains the ARC reason code as the authors' basis for creating a degree of closeness in this research.

Meanwhile, the literature review section explains the proximity code in ARC in this study. In addition, it involves outlining the configuration of novel spatial interconnections based on resource prerequisites and limitations. Subsequently, a comprehensive evaluation of each new layout option is conducted, considering pertinent criteria to ascertain the alignment of the layout enhancements with the anticipated outcomes. Ultimately, the optimal layout alternative for the production facilities is selected.

Table 1. The Reason Code on Activity Relationship Charts

Code	Explanation
1	Information flow
2	Workflow sequence
3	It uses the same space
4	It makes it easier to move goods
5	Mutual support functions
6	Using the same equipment
7	Not related
8	Noisy, dirty, dust
9	Hot air
10	Risk of work accidents

Results and Discussion

XYZ is an SME that operates in the frozen food industry and produces several types of meatballs. The XYZ SME failed to make adequate preparations and plans for the initial layout of production facilities, resulting in the unplanned placement of production tools and machines in an open area. The factory area is segmented into four workstations, a break room, and another room. Upon conducting direct observations at the XYZ factory, the authors documented the production process in a comprehensive flow chart, outlining all activities from raw material acquisition to packaging. The flow process chart depicts the sequence of activities starting from production and includes both productive and unproductive activities. The product manufacturing flow outlined in this study originates from the raw material warehouse, with raw materials being transferred to the meat mill and dough mill before reaching the product moulding workstation. Subsequently, the product undergoes moulding, boiling, cooling, and packaging before being stored in the goods warehouse for freezing. The research also involves material handling movements calculation, determining the number of material units that can be moved between workstations in one operation and the frequency of these movements within a day.

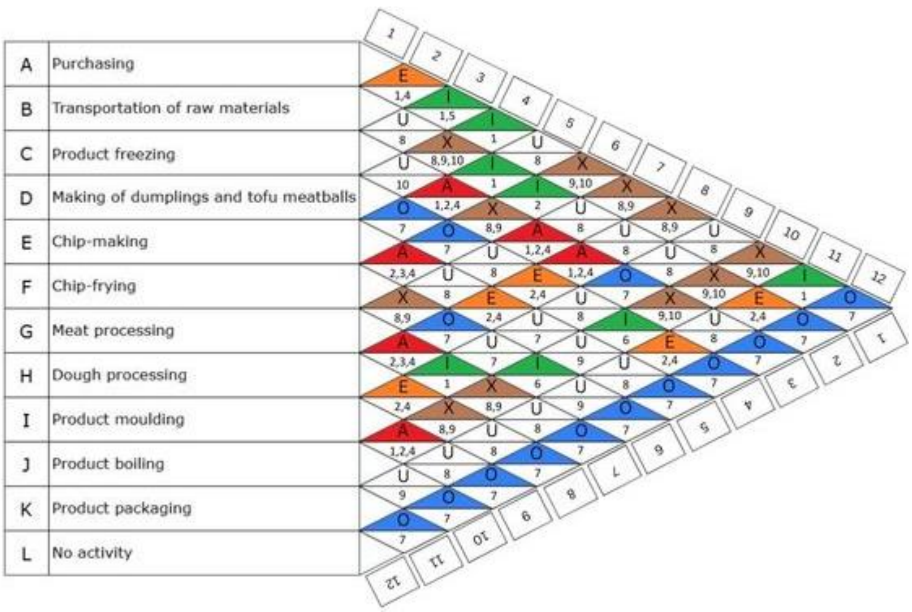

Figure 1. Activity Relationship Chart

The diagram has been adjusted based on the proximity code in ARC. The reading flow follows from column to row. For instance, column 2 and row 1 indicate that the second activity (B) has a degree of closeness E to the first activity (A). The numbers below the code signify the reasons for the closeness between the two activities. The results can be summarized as follows.

The transportation of raw materials has a degree of closeness 'E' to the purchasing, highlighting the importance of these two activities being near. Similarly, product freezing, making of dumplings and tofu meatballs, and product packaging are significant to being near the purchasing. Conversely, chip-making and product moulding do not require proximity to purchasing. Furthermore, activities like chip frying, meat processing, dough processing, and product boiling should not be near purchasing. The product packaging and making of dumplings and tofu meatballs are essential to be near the transportation of raw materials. Activities like chip-making and chips-frying must be near the transportation of raw materials. However, the product freezing process, meat processing, dough processing, and product moulding are not necessarily required to be near the transportation of raw materials. Similar to those above, the relationships between other activities are elucidated by the need for proximity, lack of necessity, or the potential issue of being near each other. This analysis helps comprehend the optimal arrangement and grouping of activities.

Upon the activity relationship chart (ARC) and priority scale table, the activity relationship diagram (ARD) can be developed as a proposed alternative layout (Naganingrum et al., 2013). For the first proposal, the workstation with the highest priority (priority I) has been positioned closer to other prioritized areas, such as the cashier room to the finished goods warehouse. However, certain workstations, such as the dumpling-making and packaging workstations, do not adhere to their required proximity in Proposal I. The second proposal addresses these deficiencies by adjusting each workstation according to its degree of closeness and in alignment with the priority scale table. Furthermore, the facility layout is designed to accommodate material flow in the manufacturing process.

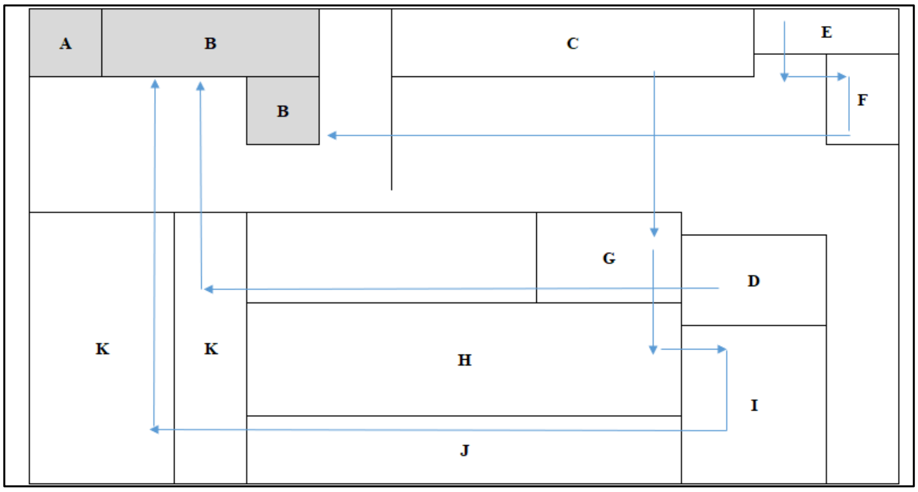

Figure 2. Block Layout of Proposed Alternative I

The next stage in designing alternative layouts is creating a block layout by looking at the spatial relationship diagram. Figure 2 illustrates the block layout for proposed alternative I, conforming to its respective activity relationship diagram. Similarly, Figure 3 depicts the block layout for proposed alternative II following its activity relationship diagram. The purpose of this block layout is to illustrate the layout alongside the production process flow. Non-production areas are represented in grey, while the blue arrow indicates the production process flow, depicting the sequence of production activities.

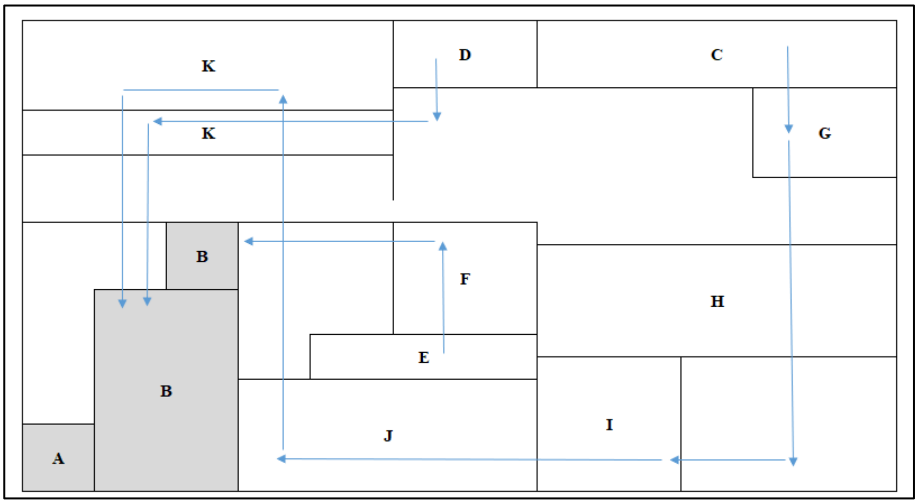

Figure 3. Block Layout of Proposed Alternative II

Upon completion of the block layout, the subsequent phase involves the assessment of the distance between individual stations. Spatial requisites are evaluated based on inventory quantity, labour force size, machinery quantity and dimensions, and daily production levels. A tolerance of 0.75-1 meter is allocated to each side of the machinery, and a 50% allowance is provisioned for each machinery or tool and their corresponding facilities. The material handling expenses for the two alternatives can be quantified and utilized in the layout proposal assessment by determining the path length between stations. The distances between facility sections within the first and second proposed layout alternatives are derived from a rectilinear distance calculation system tailored to the corresponding block layout proposals.

The optimal layout determination involves three sequential stages: initial assessment of material handling path distances for each option, computation of material handling expenses for each option, and evaluation of the two proposed alternatives. The proposed alternative I entails a weekly total material handling distance of 1,875 and a corresponding total material handling cost of 24,885.15 rupiah. On the other hand, the proposed alternative II features a total material handling distance of 1,812 and a weekly total material handling cost of 17,961.96 rupiah. Comparative analysis reveals that the second alternative proposal offers reduced material handling costs over a shorter distance than the first alternative, thus recommending alternative II as the superior choice for the SME. The managerial significance of this study pertains to compliance with the certification requirements of the Indonesian Food and Drug Supervisory Agency. The SME necessitates attention to the aspects related to building design and layout, machinery and equipment, and transportation in processed food production methods. In processed food production, adhering to stringent technical and hygiene standards when constructing buildings and rooms is essential, ensuring that the facilities are designed for easy cleaning, sanitation activities, and maintenance. Furthermore, careful consideration must be given to the layout of the room structure, sanitary facilities, machinery and equipment aspects, and transportation requirements to uphold product quality and safety throughout the production process.

Conclusion

The current layout of production facilities still has rooms that have space and are not used optimally. Meanwhile, some rooms are full of goods and cause work accidents, such as collisions between one employee and another because the room is too full. It causes an imbalance in the layout of production facilities. Based on calculating the distance between facility areas for proposed alternatives I and II, calculating material handling costs for the two proposed alternatives, and evaluating the two proposed layouts, the best-proposed alternative is proposed alternative II. Alternative Proposal II has a total material handling distance per week, and the total material handling costs per week is smaller when compared to the Alternative I proposal, namely the total material handling distance per week is 1,812 with a total material handling cost per week of 17,961.96 rupiah.

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