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# A Study off Efficient Spatial Design by Apllying Systematic Layout Design: A Structured Literature Review

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**Abstract:- Establishing the factory's layout is one of the issues that both large and small businesses in the industry face frequently, if not always. In order to meet customer demand, every corporation aspires to boost production targets. As a result, optimizing the facility's layout and design is crucial to raising business productivity. In the past several years, a lot of research has been done on facility layout planning and optimization, and many techniques are used for production setup and layout design. But in the end, creativity and experience truly do matter. This study will go over how the company used the systematic layout planning (SLP) method to develop its layout. The SLP method is a production facility layout technique that analyzes material flows, creates multiple diagrams, generates alternative designs, and concludes with a design evaluation in order to solve production flow issues. This approach serves as a comprehensive manual for creating a methodical layout, beginning with the steps of material flow analysis, design, and assessment.**

***Keywords:-*** *Layout Design.*

## I. INTRODUCTION

The production layout, or the setup of facilities used to make sure that the production process is carried out effectively and efficiently, is a part of the production process. This is done to help the company achieve it's goals, which include generating the greatest profits and establishing and preserving the company's survival. The layout will also have an impact on the company's competitiveness since, with well-planned layouts, manufacturing processes can be more efficient and are bolstered by quality labor and facilities, making the business competitive in terms of both the number and quality of items produced. To ensure that the company's goals are met, effective operational plans for execution are therefore required. These plans include controlling the production of goods in terms of quantity, quality, price, time, cost, and a specific location in accordance with what customers want. Based on the previous events, it can be inferred that an ideal layout for production facilities or the organization of the production area are good solutions in the implementation of production. A company's layout, additionally referred to as its plant layout, greatly affects how effectively operations run and how much is produced [1].

The procedures for setting up factory facilities to facilitate a productive manufacturing procedure are known as facility layout design or factory layout. The concept will make an effort to make use of the space for the installation of equipment or other production-supporting facilities, effective material flow, temporary and permanent material storage, worker staff, and other uses [2]. A more optimal layout may produce greater results (output) with the same or possibly lower production costs, shorter production times, or less time spent working for production machines. Facility layout design is the process of setting production facilities in the most effective places to support the efficient operation of the production process [3]. Layout, in the words for Slack, Jones, and Johnson, is the process of reorganizing the resources whose transformations are placed next to one other and the responsibilities given to those transformation resources [4]. "A mechanism for structuring a company's physical facilities to obtain a successful and effective flow system" which Muther & Webster describe as "factory layout" [5]. Facility layout planning was described as "procedures for arranging factory facilities to support smooth production" by Sritomo Wignjosoebroto [6].

An efficient and organized company of all production facilities and labor within the factory qualifies as a good factory layout. In addition to machinery, the factory facilities here include storage facilities, maintenance bays, and additional service spaces as well as locations for receiving and shipping items. Also, it is critical to consider the comfort and safety that workers have while they're doing their jobs. Therefore, an effective industrial design features interconnected work zones to optimize material production at a reasonable cost. The productivity and efficiency of the workforce are directly correlated with the factory's layout. This is easiest to comprehend as [7]:

- Production operations will be more cost-effective if a material's flow is well-designed.
- An effective machine array is built on material flow patterns.
- By using the proper method of transportation, material handling will transform the static material flow pattern to a dynamic one.
- The effective operation of numerous interrelated production processes can be guaranteed by arranging facilities around material flow patterns.
- Production costs are decreased by efficient operations.

- More revenue will come from lower production costs.

➢ *There are 4 Main Types of Factory Layouts,Namely:*

- *Layout by Product*

When there is an important amount of production and the items produced share the same features, it is extremely helpful to arrange machinery and equipment according tothe products. This is how equipment and machinery are set up to offer a constant flow of materials in the form of a straight line. The setup of machinery and equipment is based onthe order in which products are produced.

- *Layout by Process*

Process layout refers to a type of layout arrangement where tools that are similar or serve the same purpose are grouped together ina segment. A mower, for illustration, is set up on the cutting area. Therefore, every division or area has a single sort of process. This kind works well for non-standard manufacturing processes, such as those used by businesses that manufacture a wide range of special goods or a single fundamental product in multiple variations.

- *Fixed Position Layout*

Is a setup in which tools and machinery are positioned fixedly because the item they are working on cannot be moved. Typically, it is employed for finished goods with substantialdimensions; shipping is one such instance.

- *Group Technology Layout*

It's an arrangement where equipment andmachines are grouped not by the final product but by the components they work on. In order for the work done in one department on parts or parts whose procedure is almost the same.

Because layout effects a company's competitiveness in terms of capacity, procedures, flexibility, and cost as well as the standard of the work environment, it has many strategic implications [4]. An efficient layout must be able to assist businesses in implementing techniques that boost production processes, maximize time efficiency, and cut expenses. The layout design of a manufacturing firm has a big impact on its success. This helps to increase the productivity and economy of the production process. According to studies, a well-designed layout can save plant running expenses by as much as 30% [8]. It takes observation and early preparation to get a nice layout. Understanding the tight relationship between workstations is one of them. Among other things, layout design is required for material flow patterns in order to generate linked production processes efficiently, conserve production space, and offer workers comfort, convenience, and safety while carrying out the production process. The production process may take longer if the layout is irregular [9].

Unequal material flow from a poorly designed layout leads to a lot of back-and-forth movement and transportation, which lowers efficiency. A plan must be properly planned and designed in order to assist the attainment of production goals in order for a production firm tosucceed in accordance with its objectives andinstructions. Planning the layout of production facilities is one of the plans that needs to be takeninto account. This is significant because abusiness's operations will be impacted in the future if it fails to consider how best to arrange and locate its production and business spaces. The planning can involve determining the most effective way to distribute and position spaces, machines, and work and production equipment, as well as how best to arrange the facilities to suit thecompany's operations [10].

Many articles were subjected to a systematic reviewfor this investigation. The Systematic LayoutPlanning approach of layout design is the foundation for the analysis that was conducted. Reviewing several publications that have been compiled into ananalysis for the benefit of future researchers can be done through a literature review, which can be utilized to carry out research operations. In order tobe used for future research, this study intends to offer layout design methodologies and identify a new production area layout design connected to optimization using the Systematic Layout Planning approach.

## II. RESEARCH METHODS

Systematic Layout Planning (SLP) is a systematic and organized factory layout plan. SLP is made up of detailed instructions for organizing facility layouts that may be used for workflow analysis and design, as well as information on industrial and other facilities. SLP is frequently used to address a wide range of issues, such as those pertaining to manufacturing, shipping, warehousing, auxiliary services, and office operations (office layout). [6].

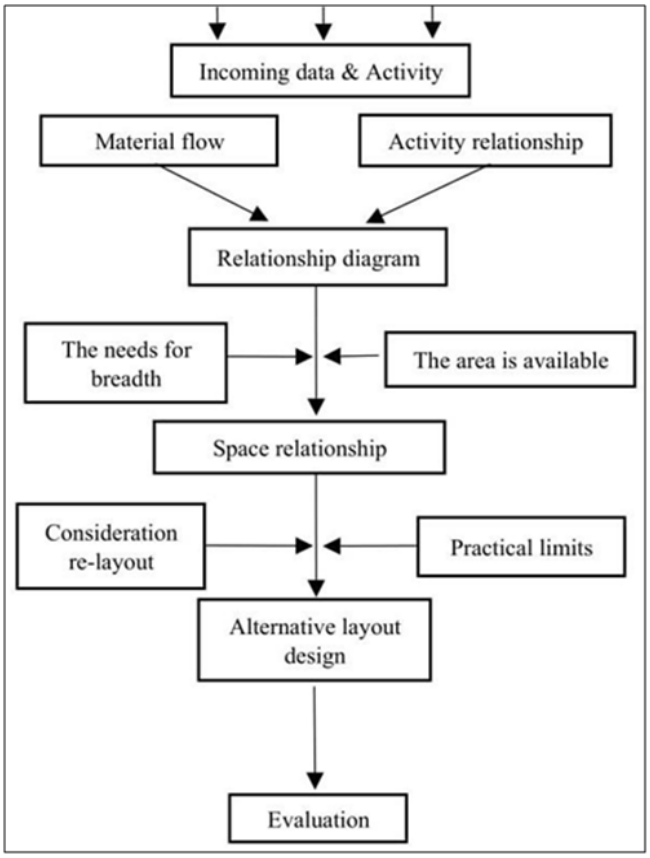


Fig 1 SLP Method

➢ *The Steps to Improve the Layout using the SLP Procedure are as follows [11]:*

Richard Muther developed Systematic LayoutPlanning (SLP), a methodical and structured approach to layout planning, in 1973. This SLP stage is frequently used to address a wide range of issues, such as those involving assembly, transportation, storage, production, office work, and supporting services. Businesses can improve production efficiency and streamline production flow by utilizing the Systematic Layout Planning (SLP) method for measuring and developing facility layouts. Obviously, businesses that use this will benefit from it. [1].

- The Activity Relationship Chart computation determines machine proximity by utilizing the degree of activity relationship, which is frequently stated in qualitative evaluations and is frequently dependent on personal preferences. The evaluation is based on the actual field conditions that were observed.
- Activity Relationship Diagram (ARD) Therefore, the position of each department will be ascertained using the data acquired, namely through the use of an instrument known as the Activity Relationship Diagram (ARD). The information gathered from the ARC is first entered into a worksheet to create this ARD..
- Blocplan Analysis computes the real-distance value for any pair of workstations or machines that have a direct working sequence.

- *In Addition, there are also Procedures in Designing with the SLP Method are [12]:*

✓ Perform initial data collection
✓ Determining the material flow
✓ Define activity relationships
✓ Diagram activity relationships
✓ Make the amount of space required
✓ Customizing available rooms
✓ Diagram the relationship between workstations
✓ Make modifications and limitations in creating alternative layouts
✓ Make practical considerations in creating alternative layouts
✓ Creation of alternative layouts
✓ Evaluate and select alternative layouts

The five key components of SLP's basis are material (what is produced), quantity (transaction volume), process (sequence of transformation), services required (staff or supplier support), and time (when output is required). The following justifies the selection of this approach: The benefits of SLP over alternative techniques allow more than one alternative solution to come up and SLP has a more detailed procedure for arranging layouts based on the order of the proces.

[12]. Making an Activity Relationship Diagram (ARD), which will be used to pinpoint each cell's location, comes after making an Activity Relationship Chart (ARC) [11]. Activity linkage maps provide the information used to prepare ARDs. The link between operational activities and activity locations is planned using this diagram as a guide [9]. Therefore, the position of each department will be ascertained using the data acquired, namely through the use of an instrument known as the Activity Relationship Diagram (ARD). The information gathered from the ARC is first input into a worksheet in order to create this ARD. The next stage is to plan the proposal layout after gathering information from the Activity Relationship Diagram and Activity Relationship Chart. The suggested or revised layout is applied in a way that takes into account the land's characteristics and the structures of the buildings that are currently in place [13]. The layout is then chosen following the determination of the suggested layout. The impacted employees, managers, and supervisors must all approve the chosen arrangement. After that, the finished layout is made. Time and money are desperately needed to move the machine and all of its supporting infrastructure, such as power grids, wind, sewage lines, lighting, and other equipment [11].

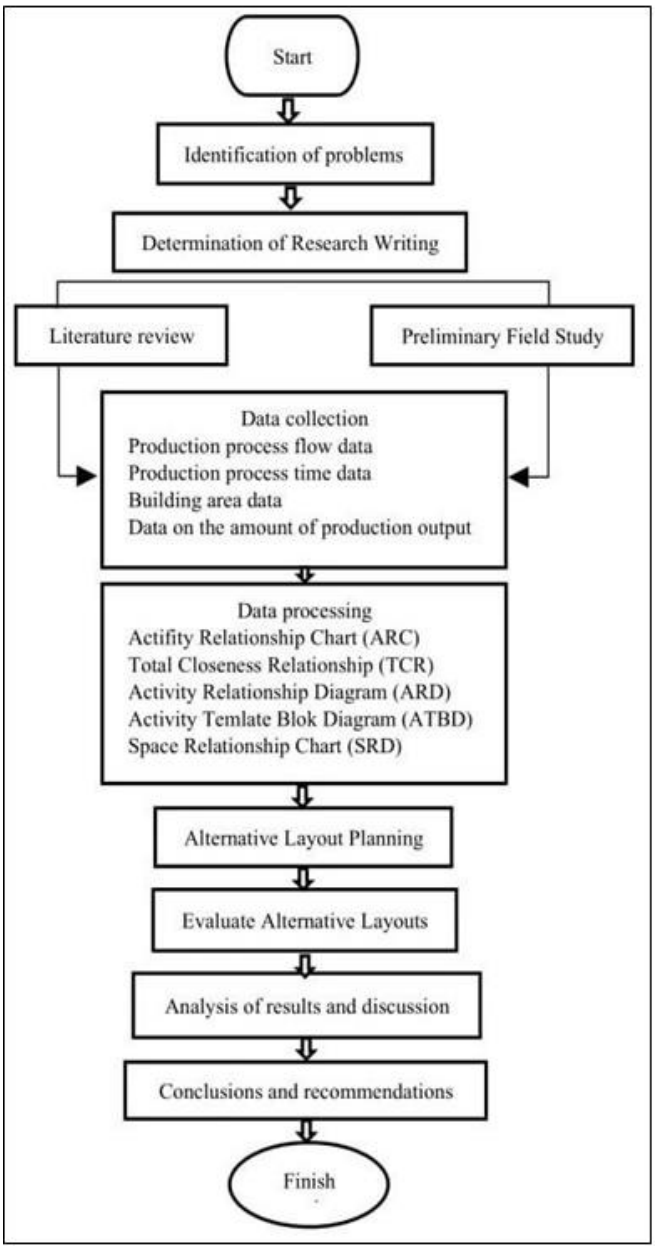

Fig 2 Research Flow Diagram

## III. RESULTS AND DISCUSSION

➢ *Stages of Systematic Layout Planning*

Processing the initial data layout based on the findings of direct observation is what needs to be done in the first stage [13]. Additionally, data processing and calculation are done on the original data, which is either from the current state or from a previous state before the change. Next, the layout modifications are calculated. To ascertain the impact of modifications to the workstation / machine cell and machine details, the outcomes of the two computations are compared [11]. In addition, information on the order in which the manufacturing process's activities are performed can be used to create an activity relationship chart. These pairs of data will be joined to ascertain the degree of linkage between each activity. The factors vary depending on the institution or department.

➢ *Determining Issues and Establishing Research Objectives*

Finding the issues is the first step. Determine which materials are moved between workstations. Information that is used to calculate the transfer of materials between workstations and the conversion of raw materials into final goods. According to Purnomo, the goal of facility layout design is to efficiently organize and coordinate physical facilities in order to meet production capacity and quality requirements in the most cost-effective manner. To be more specific, some of thegoals of creating the facility's layout are as follows[14]:

- Use the spaces that are already there.
- There is a higher utilization of people,equipment, and production facilities.
- Reducing the amount of production materials.
- Cut down on wait times as well as confusionand traffic.
- Provide assurances to employees on comfort, security, and safety.
- Simplify the production procedure.
- A decrease in semi-finished stock.
- Make specific modifications to the supervisiontasks.

Following an understanding of the rationale behind the facility's layout design, proceed with material transfer activities. These activities incur expenses and have an impact on the production cost structure, so planning, supervising, controlling, and repairing are essential to achieving the goals of the material transfer activities themselves, which include:

- Expand Your Production Capability This increase in production capacity can be accomplished by raising the amount of work produced per man-hour, improving the efficiency of the machinery, or performing material transfer activities. All of these activities incur expenses and have an impact on the structure of production costs, thus they must be carried out.
- Cutting Down on Waste Material transfer activities need to be mindful of the following in order to accomplish this purpose. Ensuring appropriate oversight of the inventory's entry andexit, preventing damage to materials during the transfer, and adapting to unique circumstances are all necessary when relocating materials that differ in kind.
- By offering safer and more comfortable working environments, lowering operator and worker tiredness, raising operator comfort levels, and motivating employees to work harder, good material removal will be able to achieve this goal. Boost the distribution of materials The goals of material handling operations in this instance are to improve material transfer lines, decrease the likelihood of product damage during the material transfer and shipping process, and improve the location and arrangement of storage facilities. enhance the effectiveness of receiving and delivering commodities.
- This cost reduction can be attained through raising productivity, using available space more wisely, and lowering inventory expenses.

➢ *Gathering and Handling Data*

Data gathering comes next, when the problem has been identified and study goals have been established. A primary data source is one that provides the data collector with data directly. That is, by employing techniques like documenting, interviewing, and observation. On the other hand, secondary data comes from reading, analyzing, and comprehending other media that comes from books, papers, and other literary works [1]. The sections on planning and job safety provide further supporting information [11]. Next, a quantitative analysis of the collected data will be conducted [2]. Maps or diagrams are frequently used in the following ways to examine quantitative measurements for each transfer of material between departments or operational activities: [10].

- A map of the process flow.
- From the chart.
- Relationship chart of activities.

➢ *Following that, the Data will be Processed using a Number of Quantitative Approach Techniques, such as the Following [2]:*

- *Using Activity Relationship Charts to Process Data*

Data about the order of the manufacturing process's activities is needed to create an Activity Relation Chart (ARC), which will be connected in pairs to show how closely related the various activities are to one another. The relationship is examined from a number of angles, such as connections within organizations, flows of materials, tools used, people, information, and environmental interactions [9]. In order to obtain the most optimal degree of proximity relationship from each department, each current department will determine its level of closeness utilizing the Activity Relationship Chart table [2]. The degree of activity relationship, which is frequently represented in qualitative judgments and is typically based on subjective considerations, is the basis for the Activity Relationship Chart's calculation of machine proximity. The evaluation is based on actual field circumstances observed during observation [11].

Data on the order of the production process's activities can be used to create an activity connection chart. These pairs of activities will be connected to ascertain thedegree of connectivity between them. Every institution or department has its own subjectiveconsiderations [12]. When creating an Activity Relationship Chart (ARC), it is necessary to take into account various factors, including thefollowing [13]:

- ✓ Material flow is the reason behind the stronginteraction between work operations.
- ✓ Data flow is the reason behind the proximitylink between work operations.
- ✓ The material loading and unloading area.
- ✓ Material type varying amongst warehouses.

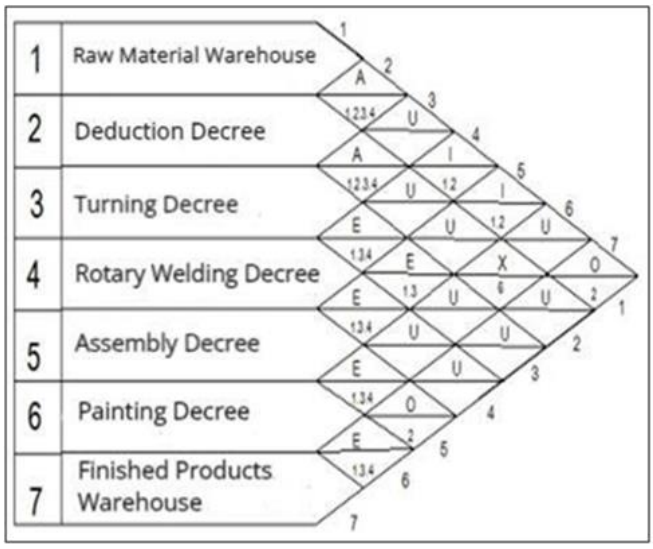


Fig 3 Example of Activity Map Relationship Chart

- *It is Clear from the Image above that:*

- ✓ Symbol A: The absolute must be near Symbol E: It's critical to move it closer. Symbol I: Significant nearby activities
- ✓ Symbol O: Activity relationship's proximity symbol U: Geographic connection is not required Symbol X: Continuous, unwanted activity.

- *The Activity Relationship Chart (ARC) Table is used to calculate the Total Closeness Ratio (TCR).*

The quantity and values derived from the degree level of activity relationships created inthe preceding stage will be executed in this step. Additionally, following the data extraction from the TCR computation, the data will be transformed into a worksheet (Worksheet), which contains the data in a worksheet format.

This will then serve as the foundation for choosing the Activity Relationship Diagram (ARD), which is the following step [2].

Tabel 1 Worksheet Activity Relationship Chart

| No | Degrees | | | | | |
|---|---|---|---|---|---|---|
| | **A** | **E** | **I** | **O** | **U** | **X** |
| 1 | 2 | 8 | 4.5 | 1 | 3.6 | - |
| 2 | 1.3 | - | - | 4 | 5.7 | 6 |
| 3 | 2 | 4.5 | - | - | 1.6.7 | - |
| 4 | - | 3.5 | 1 | - | 2.6.7 | - |
| 5 | - | 3.4.6 | 1 | 7 | 2 | - |
| 6 | - | 5.7 | - | - | 1.3.4 | 2 |
| 7 | - | 6 | - | 1,5 | 2.3.4 | - |

- *Activity Relationship Diagram (ARD) Creation*

The process of turning data from the Total Closeness Ratio into a diagram, known as an Activity Relationship Diagram or rail diagram for short, is the first stage in creating a diagram that will be used to locate each department that is now in place [2]. The data from the Activity Relationship Chart was used to produce this diagram. The planning of the connection between operational operations and the site of testing activities is based on this diagram [9]. Material movement and the degree of activity interaction between workstations can be more clearly visualized using ARD. InARD, letter, line, and color codes are used to indicate the degree of proximity between facilities [14].

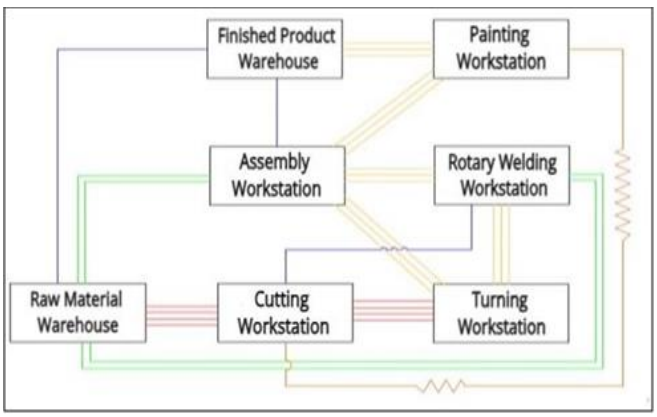


Fig 4 Example of the Activity Relationship Diagram for Proposal 1

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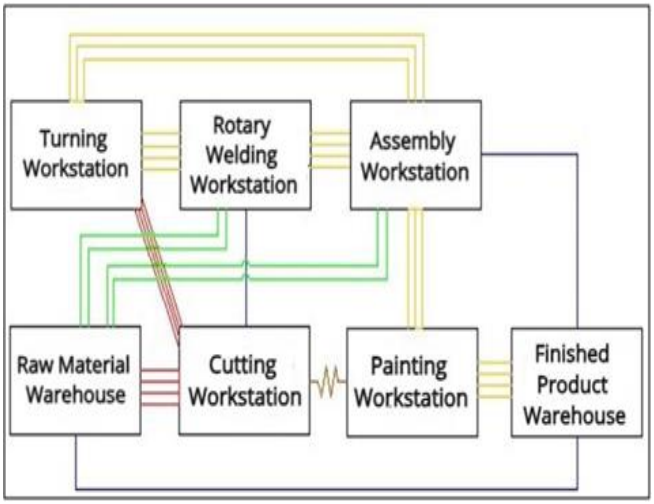

Fig 5 Example of Proposal 2 Activity Relationship Diagram

According to the above figure, which shows how the Activity Relationship Diagram (ARD proposal 1) results have addressed the initial layout's flaws—for example, by placing the painting workstation next to the finished product warehouse and the turning workstation next to the cutting work station and rotary welding—the distance of material movement can be reduced[14].

- *The ATBD, or Compiling Activity Template Block Diagram*

The name of the facility area, the degree code of adhesion, and the rationale for its proximity will all be included in block diagrams that are created during the preparation stage. Additionally, the facility area has been pushed closer at this point in accordance with the relationships between the activities that take place between the existing facilities.

- *Space Relationship Diagram (SRD) Creation*

The initial step in the layout design process is called the Space Relationship Diagram (SRD), which combines data from the Activity Relationship Diagram with floor area needs data to describe the space required for each facility and the location of each facility position that was found to be related in the previous stage. Later, all of the data will be arranged in a systematic manner in the Pace Relationship Diagram (SRD). In addition, information pertaining to each operational facility will be processed alongside the outcomes of data processing at the Activity Relationship Diagram phase to provide outcomes in the shape of a Space Relationship Diagram (SRD). In this instance, the required area and data from the Activity Relationship Diagram will be combined, and the lines connecting the various degrees of relationships between the current facility areas will be provided [2].

➢ *Layout Alternative Planning*

This stage of the design process involves all of the data from the analysis of the relationships and linkages between each facility that was processed in the stage before in accordance with the steps of the method used. It also takes into account any modifications that have been made with regard to practical limitations, and there are a number of alternate layouts that will be an option. When choosing other layouts, it is important to take into account how the product quality, redesign expenses, operator comfort, and other environmental aspects will affect the final result. To determine expenses incurred or ongoing due to warehouse activities, such as material transfer distance calculations and utilities, an initial layout analysis is required, material transfer frequency to material movement cost calculations (OMH), and finally to suggested layout planning and comparisons for improved operational cost efficiency and effectiveness. Using a drafting or sketching methodology, alternative designs for production area layouts will thereafter be created in compliance with the processes in the Systematic Layout Planning procedure. The application of the redesign or planned layout is modified to take into account the site's characteristics and the building's current structure. An example of an alternate layout outcome that will be shown at the evaluation stage is as follows.

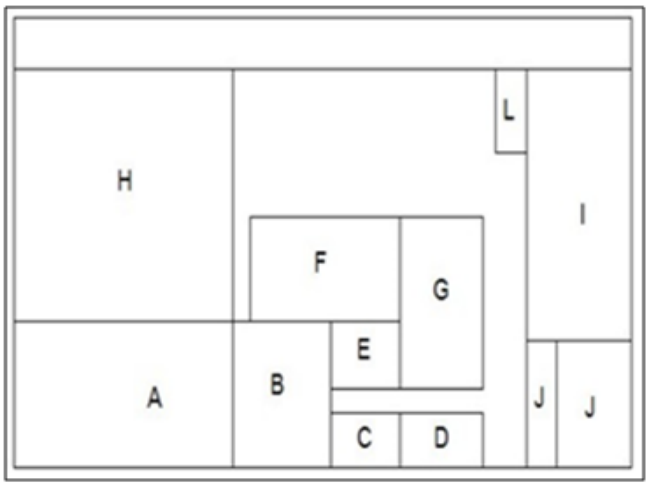

Fig 6 Proposed Layout 1

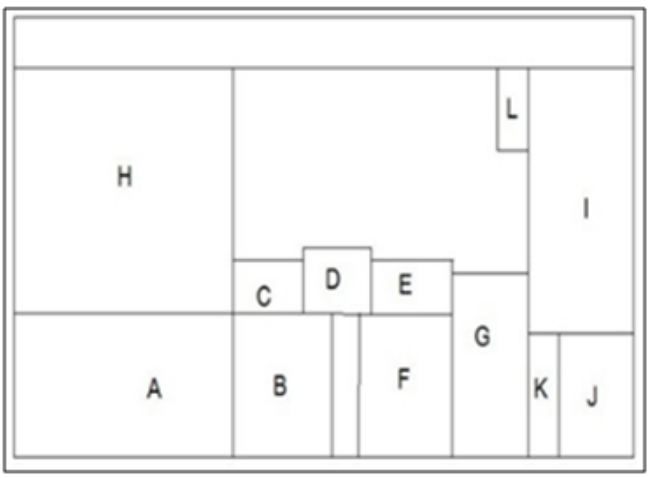

Fig 7 Proposed Layout 2

The next step after receiving the proposed plan is to calculate the distance between the activity area and the proposal's layout.

Table 2 Distances between Activity Areas Proposed Layout 1

| No | Dept | Distance(m) | Time Tomove (second) |
|---|---|---|---|
| 1 | A-B | 20.5 | 61.5 |
| 2 | B-C | 15.4 | 30.8 |
| 3 | C-D | 10.2 | 20.4 |
| 4 | C-E | 8.1 | 16.2 |
| 5 | D-E | 18.3 | 36.6 |
| 6 | E-F | 13.5 | 27 |
| 7 | F-G | 18.6 | 37.2 |

Table 3 Distances between Activity Areas Proposed Layout 2

| No | Dept | Distance(m) | Time to move (second) |
|---|---|---|---|
| 1 | A-B | 20.5 | 61.5 |
| 2 | B-C | 15.4 | 30.8 |
| 3 | C-D | 9.7 | 19.4 |
| 4 | C-E | 19.1 | 38.2 |
| 5 | D-E | 10.4 | 20.8 |
| 6 | E-F | 10.4 | 20.8 |
| 7 | F-G | 17 | 34 |

In order to achieve optimal efficiency, thedistance and time of movement for each of thetwo computed alternative layouts will be assessed together with the degree of efficiencyfor both the displacement distance and thematerial handling cost. Tables 8 and 9 below show the findings of material handling costs and distance transfer for each alternative plan.

Table 4 OMH Per Month Layout Proposal 1

| No | From | To | Transport Equipment | Freq/ Month | Distance/ Month (m) | OMH/meter | Total OMH/month |
|---|---|---|---|---|---|---|---|
| 1 | A B | | Hoist | 44 | 902 | Rp 946.72 | Rp 853.941 |
| 2 | B C | | Trolly | 264 | 4.065,6 | Rp 43.45 | Rp 176.650 |
| 3 | C D | | Trolly | 220 | 2.244 | Rp 43.45 | Rp 97.501 |
| 4 | D E | | Trolly | 220 | 1.782 | Rp 43.45 | Rp 77.427 |
| 5 | E E | | Trolly | 220 | 4.092 | Rp 43.45 | Rp 174.929 |
| 6 | F F | | Trolly | 220 | 2.970 | Rp 43.45 | Rp 129.046 |
| 7 | G G | | Trolly | 220 | 4.092 | Rp 43.45 | Rp 177.797 |
| Total | | | | 1.408 | 20.081,6 | Rp 1.207 | Rp 1.687.295 |

According to the table above, Rp 1,687,295 is the total cost of material handling in the suggested configuration 1 for a single month.

Table 5 OMH Per Month Layout Proposal 2

| No | From | To | Transport Equipment | Freq/ Month | Distance/ Month (m) | OMH/meter | Total OMH/month |
|---|---|---|---|---|---|---|---|
| 1 | A B | | Hoist | 44 | 902 | Rp 946.72 | Rp 853.941 |
| 2 | B C | | Trolly | 264 | 4.065,6 | Rp 43.45 | Rp 176.650 |
| 3 | C D | | Trolly | 220 | 2.134 | Rp 43.45 | Rp 92.722 |
| 4 | D E | | Trolly | 220 | 4.202 | Rp 43.45 | Rp 182.576 |
| 5 | E E | | Trolly | 220 | 2.288 | Rp 43.45 | Rp 99.413 |
| 6 | F F | | Trolly | 220 | 2.288 | Rp 43.45 | Rp 99.413 |
| 7 | G G | | Trolly | 220 | 2.904 | Rp 43.45 | Rp 126.178 |
| Total | | | | 1.408 | 18.783,6 | Rp 1.207 | Rp 1.630.896 |

According to the data above, the total cost of material handling in the second proposed planin a single month is Rp 1,630,896.

➢ *Evaluation Stages*

The complete layout alternative that was created will be assessed at this point in the review process. The comparative method is usedfor evaluation, and its purpose is to determine which alternative is the most efficient in terms of material handling, production output, and expenses incurred.

Below is a comparison table comparing the original layout, proposal layout I, and proposal layout 2, based on the calculations that were done on the suggested layout.

Table 6 Comparative Examples of InitialLayout and Proposed Layout

| Comparison | Initial Layout | Proposal 1 | Proposal 2 |
|---|---|---|---|
| Total DisplacementDistance | 32934 | 20081.6 | 18783.6 |
| Total OMH/Mounth(Rp) | Rp. 2.424.579,- | Rp 1.687.295,- | Rp 1.630.896,- |
| Cost Efficiency | - | 30% | 32% |

According to the above table, the proposed layout 2 has the lowest total distance and material transfer cost. With a total material handling distance of 18783.6 m and a total OHM per month of Rp. 1,630,896, it outperforms the original configuration interms of cost efficiency by 32%.

## IV. CONCLUSION

The production facility layout technique known as "Systematic Layout Planning" analyzes material flow, creates multiple diagrams, generates alternative designs, and concludes with design review in order to solve production flow issues. Based on the previous discussion, it can be stated that layout planning utilizing the Systematic Layout Planning approach may be used to plan layouts that are clear, succinct, and create a comfortable work environment for employees, all of which will increase the company's ability to produce goods efficiently.

Utilizing the resulting Systematic Layout Planning process, the layout design has taken into account available space, departmental relationships, material flow, and space needs in order to minimize the amount of distance created in the suggested layout and lower material handling expenses. Consequently, a company's layout can be redesigned utilizing the Systematic Layout Planning method's layout design as a guide.

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