LAYOUT DESIGN FOR IMPROVING SPACE IN FACTORY

BY

PATHAPOL SURIYANUMPAPONG
RATTAPOL POLRAT

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF ENGINEERING IN INDUSTRIAL ENGINEERING AND DIGITAL MANAGEMENT SYSTEMS (INTERNATIONAL PROGRAM)
SCHOOL OF ENGINEERING
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
ACADEMIC YEAR 2020

SCHOOL OF ENGINEERING

KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG

PROJECT CERTIFICATE

Project Title	Layout Design for Improving Space in Factory
Student Name	Mr. Pathapol Suriyanumpapong ID. 60011248
	Mr. Rattapol Polrat ID. 60011265
Degree	Bachelor of Engineering in Industrial Engineering and Digital Management Systems (International Program)
Project Advisor	Signed: ______________________________
	(Asst.Prof.Dr. Chaowalit Hamontree)

Project Title	Layout Design for Improving Space in Factory	
Student Name	Mr. Pathapol Suriyanumpapong	ID. 60011248
	Mr. Rattapol Polrat	ID. 60011265
Degree	Bachelor of Engineering in Industrial Engineering & Digital Management System (International Program)	
Project Advisor	Asst.Prof. Dr. Chaowalit Hamontree.	
Academic Years	2020	

ABSTRACT

The facilities layout problem is an integral part of facilities planning that aims to systematically arrange and locate all production units within a facility with an objective of improving the production operations of a company. The work reported in this paper aims to study and improve the facility layout of a manufacturing company using Muther's systematic layout planning procedure (SLP) for increased productivity and space utilization.

In this case study, the existing layout is studied and the amount of equipment identified. Data on the production processes is investigated and flow analysis conducted. An activity relationship chart is formed, studied and new layout alternatives developed. A multi-criteria decision making tool is then proposed and used to evaluate the developed alternatives which are compared with the existing layout. The SLP method derives an improved layout that improves flow of materials, utilizes space effectively, and is flexible.

ACKNOWLEDGEMENTS

It is always a pleasure to remind the fine people in KMITL for their sincere guidance:

1. The research could not have been complete without the participant and assistance of Asst. Prof. Dr. Chaowalit Hamontree, a person who is an adviser and who provides assistance to make research work more accessible and more successful.
2. I want to thank you, Ms. Suvida Osathanon and Mr. Kanit Chuayphikroh. My lovely friend, who always support me.
3. Thank my family for giving encouragement, enthusiasm, and invaluable assistance to me.

Without all this, I might not be able to complete this research properly.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS/ABBREVIATIONS

Symbols/Abbreviations	Terms
SLP	Systematic Layout Planning

CHAPTER 1
INTRODUCTION

1.1 Statement of the Problems

Nowadays, businesses in the machinery manufacturing or repairing industry, both domestically produced and imported from abroad, are quite competitive. In terms of reducing delivery time. Reduce production costs, increase productivity and maximize the use of limited resources. Therefore, the design and layout of the plant is an important part of the management of the production area of the industrial plant. Because the flat area of the plant is the main area of operation and is integral to determining the efficiency of the plant. The company provides suitable positioning for machinery and equipment, as well as space arrangements for departments and production supports to empower production systems and create competitive advantages, reducing production costs directly or indirectly. This makes it more convenient and safer to operate and satisfy employees as well. According to researchers at Sahamit Metal Industry Company, an industrial facility in machinery manufacturing, as a result, researchers are aware of problems from both entrepreneurs and employees, so researchers are interested in improving and solving problems. According to the company's initial problems

Delay caused by there is a lot of machine space in the factory. Causing the work of the workers to be interrupted, such as canceling forklift because they cannot enter the factory. In 2016 to 2019 factory increase the new 5 machines. Therefore, reducing the area in the factory.

Forklifts cannot enter the factory area**,** due to the factory floor being crowded, Forklift could not come in and lift things. Therefore, having to switch to using Crane to move the Product Causing a delay from transportation.

Need more space to operate, in the factory, there are 2 machines that require more space are milling machines and boring machines. The increased space is 31.07 square meters and 39.71 square meters, respectively.

As a for this problem, the preliminary analysis concluded that the design and planning of the new plant will solve problems that arise by applying academic principles to help determine the correct and appropriate improvement of the production flow, such as process layout, multi-product process chart, and Systematic Layout Planning (SLP) is used to carefully plan plants in each area, then evaluate them with quantitative qualitative evaluation methods and analyze the return on investment in alternative planning for decision making, etc. It can be used as a guide to factories with similar work characteristics or similar production patterns.

1.2 Objectives

1. To study the flow of raw materials in the production process of the current plant layout for define the relationship in the development of a new plant layout.
2. To apply systematic layout planning to help to improve the plant layout.
3. To reduce material flow distance or time and set the space for process paths and departments to be organized.
4. To improve the resource utilizations and space efficiency.

1.3 Research Scopes

1. This case is collected data from the case study such as the shape and size of the work area.
2. The period for study is October 2020 to January 2021.

1.4 Report Outline

The rest of this report is organized as follows:

Chapter 2 reviews and method the systematic layout planning (SLP)

Chapter 3 describes the design and implementation of SLP in factory

Chapter 4 demonstrates how the SLP performs in the project layout testing

Chapter 5 closes the report, reviewing the work undertaken and draws conclusions about key parts of the work that was undertaken. Finally, future work is discussed with particular focus on create the production schedules, manage the scrap and security. All of these will help make the plant layout more efficient.

CHAPTER 2

THEORY AND SYSTAMATIC LAYOUT PLANNING REVIEW

This chapter discusses the concepts and theories related to the management system used to improve plant layout, systematic layout planning principles (SLP) (section 2.2) and related research. Finally, section 2.4 summarizes the chapter.

2.1 Plant Layout

Plant layout means the disposition of the various facilities (equipment's, material, manpower etc.) within the areas of the site selected. Plant layout begins with the design of the factory building and goes up to the location and movement of work. All the facilities like equipment, raw material, machinery, tools, fixtures, workers etc. are given a proper place.

2.1.1 Definition

Fred E. Meyers (2005) defined the plant layout as "plant layout, physical management within the plant, which involves machinery and equipment, workstations, people, space to place and store materials in production, raw material transport routes and equipment for material handling."

Somsak Trisat (2005) defined the plant layout as "Plant layout is planned to place tools, machinery, workers, equipment, raw materials, facilities, convenience and support in the production of the plant in the right position or area to ensure that the production operation is safe, economical and efficient."

Somphatsorn and Thanat (2008) defined the plant planning as "plant scheduling is an activity involving the determination of positioning or allocation of space for inputs such as machine positioning, workstations, workers, tools, storage areas, etc. to ensure that production operations are economical, safe and efficient."

Plant planning is very important in determining the position of people, machinery, materials, and production supports to be in the right position. Form the right production system Reduce wastes, continuous material flow shorter production time causes production systems to be resilient, resulting in lower production costs.

2.1.2 Type of plant layout

Plant layout is generally divided into 4 types: 1. Product Layout 2. Process Layout/Functional Layout 3. Fixed Location Layout 4. Combination Layout/Hybrid Layout.

2.1.2.1 Product Layout

It is the use of machinery and equipment used in the production process to be arranged in order of process, from the beginning of feeding raw materials into the production line from the first process and continuing to get the product out continuously. To reduce the transport of raw materials and try to use as much production space as possible. This layout is used in car assembly plants. As shown in Figure 2.1.

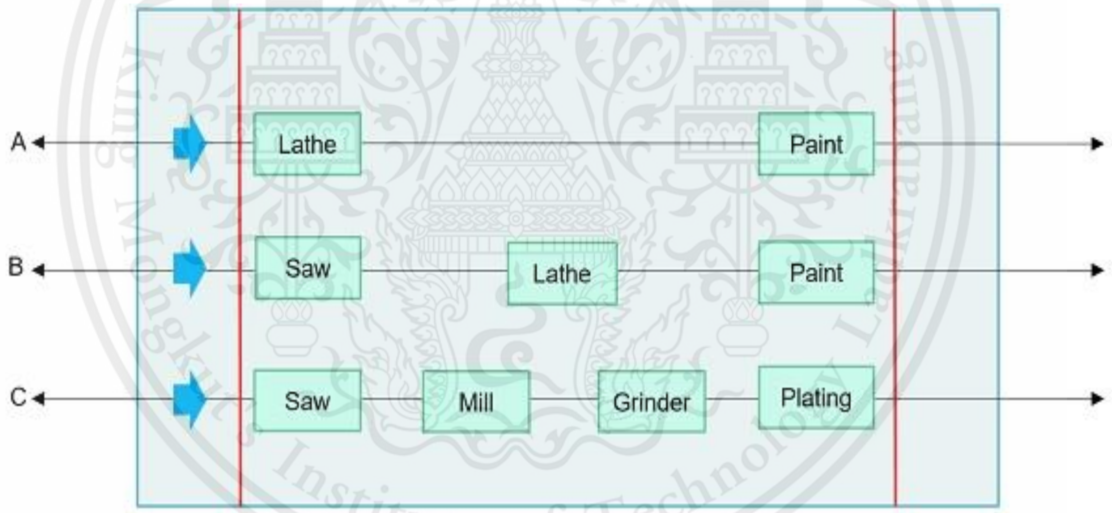


Figure 2.1: Example of product layout

Advantages of planning by product type

1. The cost of moving work between stations is low due to the short distance between departments.

2. Reduce work in process (WIP) because there will be no waiting in the production line.

3. Easy operation control and easy bugs.

4. The production line is balanced, making it possible to produce large quantities.

Disadvantages of scheduling by product type

1. Renovation or change is difficult, it is quite costly when changing products.

2. When a machine is broken or crashes, the production line will be disrupted altogether.

3. Investment in machinery and production equipment is quite high.

4. If there is a lack of raw materials or unsalted delivery, there will be an impact on the entire production system.

5. If waste occurs If it cannot be checked quickly, there will be a lot of losses due to the large production in each time unit.

2.1.2.2 Process Layout/Functional Layout

It is the placement of machines or workstations that are similar in appearance or have the same functions in one group. This type of layout can be seen as functional layout. As shown in Figure 2.2.

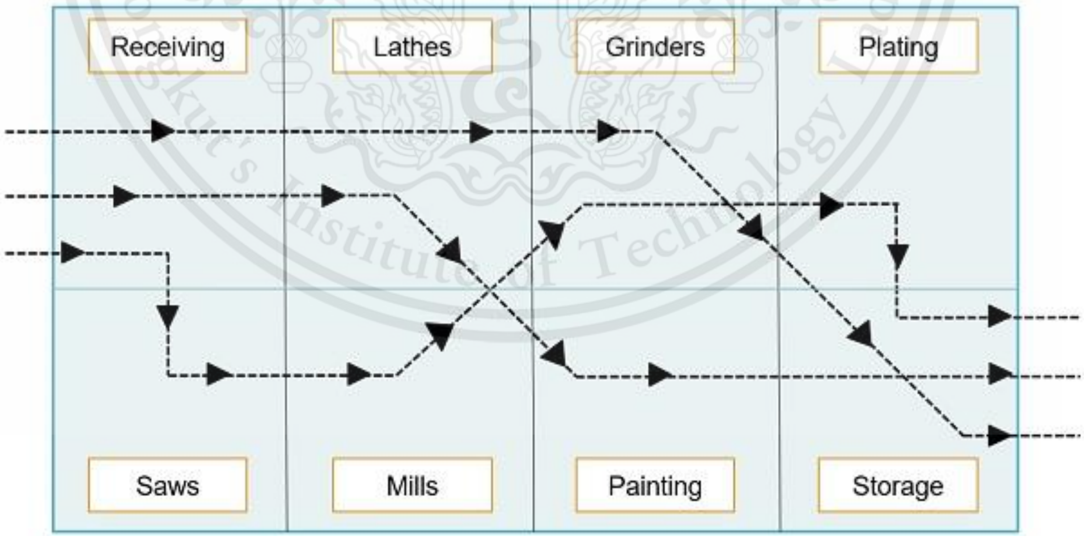


Figure 2.2: Examples of process layout/Functional layout

Advantages of process layout/Functional layout

1. Produce a lot of products because the production line is not specific.

2. Employees will have specific expertise according to the procedure.

3. Flexible, can produce many kinds of products.

4. Save investment, investment because machines can also be used for other tasks.

Disadvantages of process layout/Functional layout

1. There is a lot of waiting work during the production process (WIP).

2. A lot of planning space is used as each department must be prepared for storage raw materials and walking and unloading routes.

3. The production cost per unit is high because it is characterized by low-precision work.

4. Production time is not full due to loss in preparatory work. Prepare machines for frequent production according to the product.

5. Planning and controlling production will be difficult due to the wide range of products, machinery, raw materials and deliveries.

2.1.2.3 Fixed Layout

This kind of scheduling applies to products of relatively large sizes. It is inconvenient to move products such as the construction of aircraft buildings. Construction of dams, marine vessels, etc. After production is completed, most products are in place or if they are moved, it will be quite laborious. Therefore, it is necessary to make the products to be produced in place and to produce sub-parts as the characteristics of the external parts, which are assembled by moving. machine Labor, Equipment, Raw Materials Energy and method of accessing the product as shown in Figure 2.3 (Somsak Trisat, 2005).

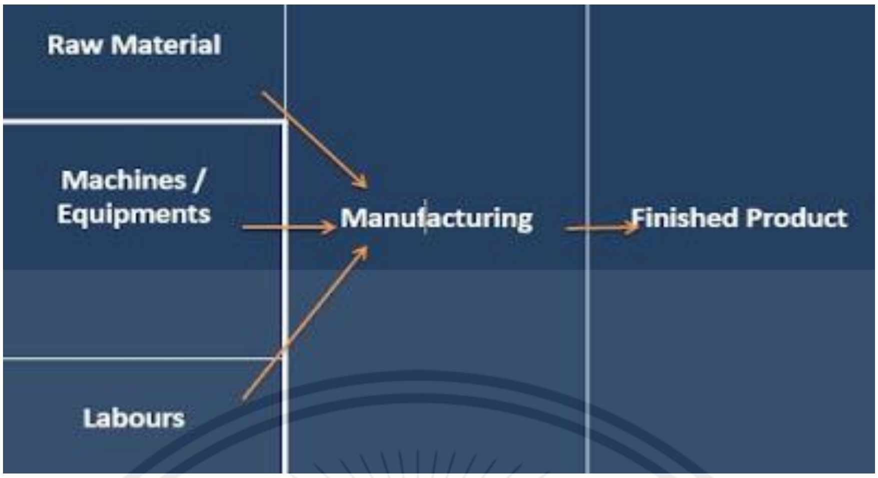


Figure 2.3: Examples of fixed layout

Advantages of fixed layout

1. High flexibility, conforms to a wide range of changes such as product design changes. Many products, etc.

2. Low planning investment.

Disadvantages of fixed layout

1. Suitable for producing very small quantities of work and spending quite a lot of time, will not be able to take jobs or produce large quantities of work.

2.1.2.4 Combination Layout/Hybrid Layout

It is a layout by segmentation in each section, called a cell, also called a cellular layout, in which each cell has a group of production processes, which can be arranged according to the layout, according to the production process or the layout according to the product type, depending on the production model as shown in Figure 2.4.

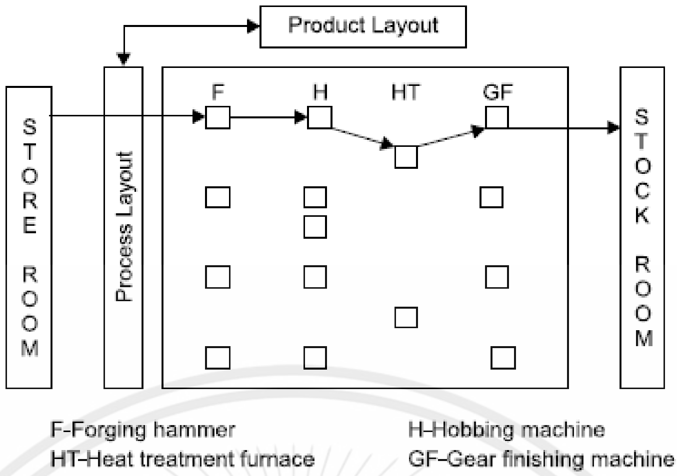


Figure 2.4: Example of combination layout/hybrid layout

Advantages of combination layout/hybrid layout

1. It is a good determination between consideration in terms of cost and flexibility.
2. The rate produced is fast.
3. Promote group work, which is motivation to work.

Disadvantages of combination layout/hybrid layout

1. There may be high factory scheduling costs. In the event of a production change.
2. May require a lot of machinery and equipment.
3. May cause low utilization of machinery and equipment.

2.2 Systematic Layout Planning

The concept of Muther (Systematic Layout Planning: SLP), or systematic plant layout, was developed by Richard Muther in 1973 as a management method for plant planning, consisting of phases, patterns of procedures and the formulation of individual elements and areas related to plant planning proportionately and appropriately, as shown in Figure 2.5 and 9 steps how to do it.

1. Explore the basics of P,Q,R,S,T plants and activities

2. Plant chart analysis from product – quantity (P-Q Chart)
3. Product flow analysis
4. Activity Relationship Diagram in Facility Layout
5. Create a relationship diagram
6. Calculate the require space
7. Detailed factory layout design
8. Analyzing the results of the alternative plant layout
9. Choose the most suitable factory layout

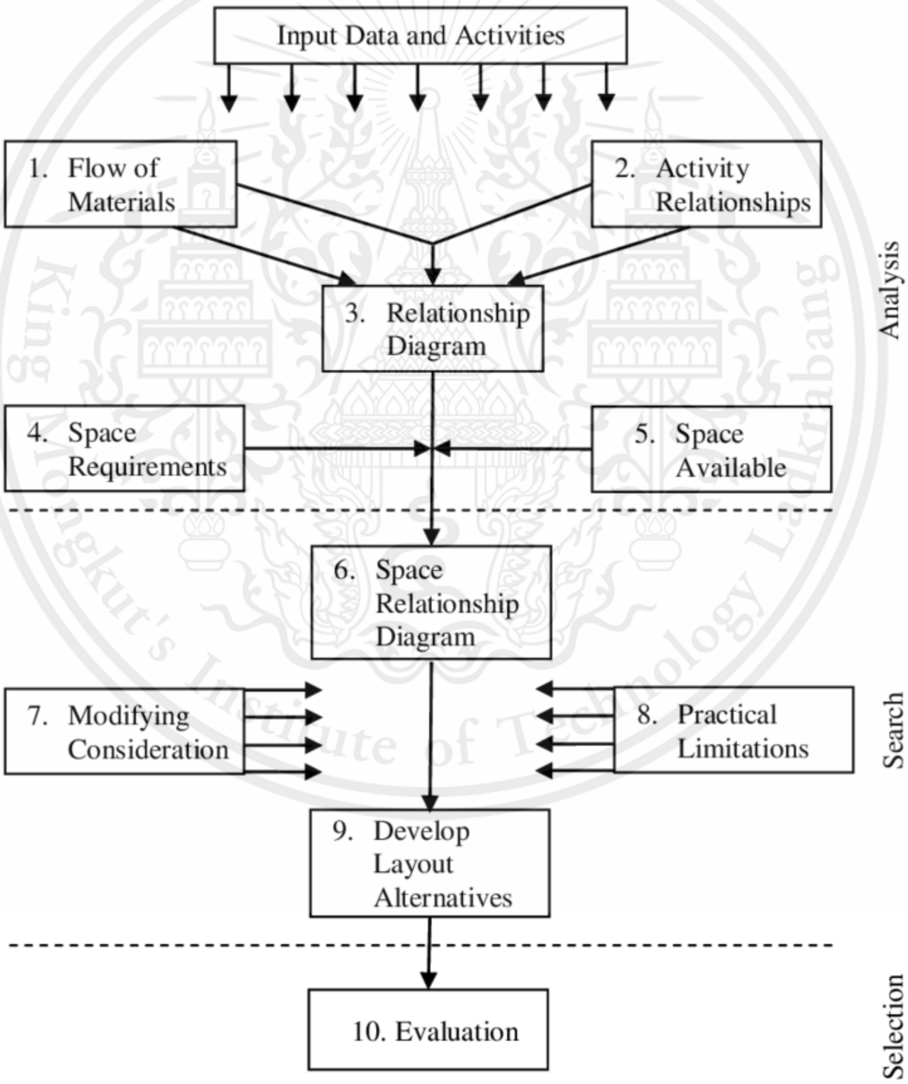


Figure 2.5: Practical plan of systematic layout planning

2.2.1 Explore the basics of P, Q, R, S, T plants and activities

The basic data survey of the plant P, Q, R, S, T and its activities is to explore the basic data of the plant that must be used in the design of the plant layout, namely the product(P). Quantity(Q) Production Flow(R) Production support(S) and time(T) as well as departments or activities included in the current plant layout. These basics are important preliminary steps for starting plant planning as shown in Figure 2.5.

P (Product) is a product or service type; it is important to know what to produce now or in the future. This does not just mean the finished goods, but the parts that are produced.

Q (Quantity) is the manufactured quantity of an item or product of each type can be charged in the form of the item's value or number of pieces or weight, for example. What must be considered for the quantity produced is the waste generated during production and the changing market demand. Therefore, information about the production volume in the design of the plant layout is necessary for both short-term and long-term predictions.

R (Route/production flow) is analyzed in order of economical production flow. That is to say, the production is first analyzed and designed to see which parts should be manufactured and which stages of production should be done first. Then you will get an economical production sequence that is a factor in the layout of the plant to be designed.

S (Production Support) This is a production support, which is essential in order to ensure efficient production. Production support typically requires more space than production units, so it is also indispensable. Letter

T (Time) Depending on the behavior, the letter T is directly related to P, Q, R, S because it allows the size of machine and person space to be set.

2.2.2 Plant chart analysis from product – quantity (P-Q Chart)

Analyzing the plant chart from the Product – Quantity chart (P-Q Chart). Product (P) – Quantity (Q) analysis generally apply the following principles

1. Group by product type, material or require list

2. Distributes or counts the quantities of each product, material, or line grouped in product analysis – quantity. For product counts, it is typically counted as a quantity or weight unit rather than in paramedics. The choice depends on the nature of the product. The quantitative measures that are used for storage jobs usually contain only 2 or 3 units of measure. As shown in Figure 2.6.

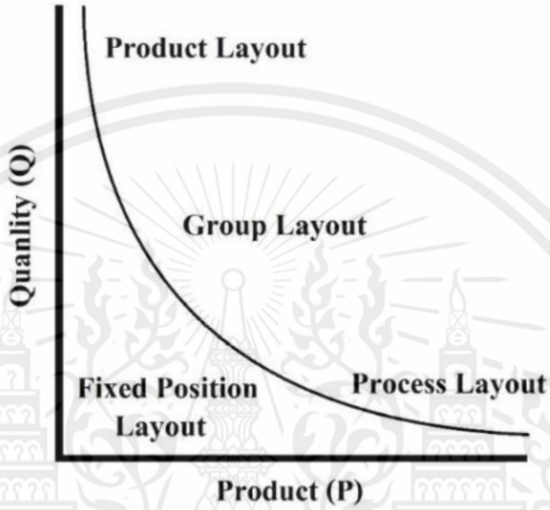


Figure 2.6: The chart shows product relations (P) and quantity (Q)

The importance of a product chart – Quantity is a chart that shows the basic relationship of a product (P) and the quantity (Q). The characteristics of the chart curves can suggest which type of plant the current or future product is in and therefore select the planning type according to the plant layout type.

2.2.3 Product flow analysis

Analyzing the flow of products is that analyzing the flow of raw materials in the production process is at the heart of plant planning, that is, the movement of raw materials is an important part of the process, especially when the raw materials are high in volume. Large or heavy or costly due to high transportation compared to operating costs (Somsak Trisat, 2005).

To analyze the flow of raw materials, there are several ways to analyze the flow of raw materials. The important point is how do we know which method to choose to suit each plant? Product charts – Quantities can be used as guides, namely, differences by product quantity and product type, which come from the product chart arc – the quantity (P-Q Chart) can tell which method to use to analyze the raw material flow details as shown in Figure 2.7.

2.2.3.1 Operation Process Chart

Is a chart that shows the flow of the product. It can help to analyze the current flow method. The structure of the production flow chart consists of vertical flow lines and horizontal material lines (Niebel & Andris,2003).

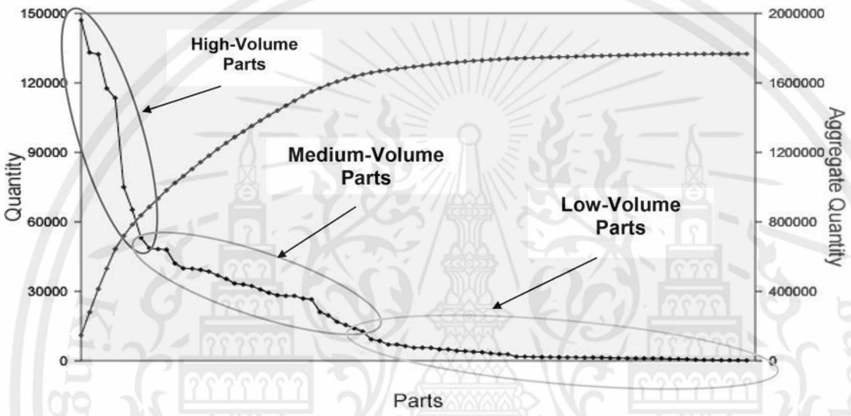


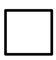
Figure 2.7: Showing relationship between product (P) and quantity (Q)

 = Operation refers to the operation on a work on piece when the characteristics or properties of the workpiece are changed.

 = transportation refers to moving an object from one point to another, except for moving while in the production stage.

 = Inspection refers to the activity of quality comparison of the workpiece. The quantity of material to ensure the appearance of the workpiece.

 = Delays refer to job delays due to obstacles preventing them from carrying out the next operational procedures.

 = Storage or rest refers to the permanent storage of a piece of work that can be used if needed with a disbursement, which should have orders or books from the relevant parties linked together. Vertical flow lines and horizontal material lines.

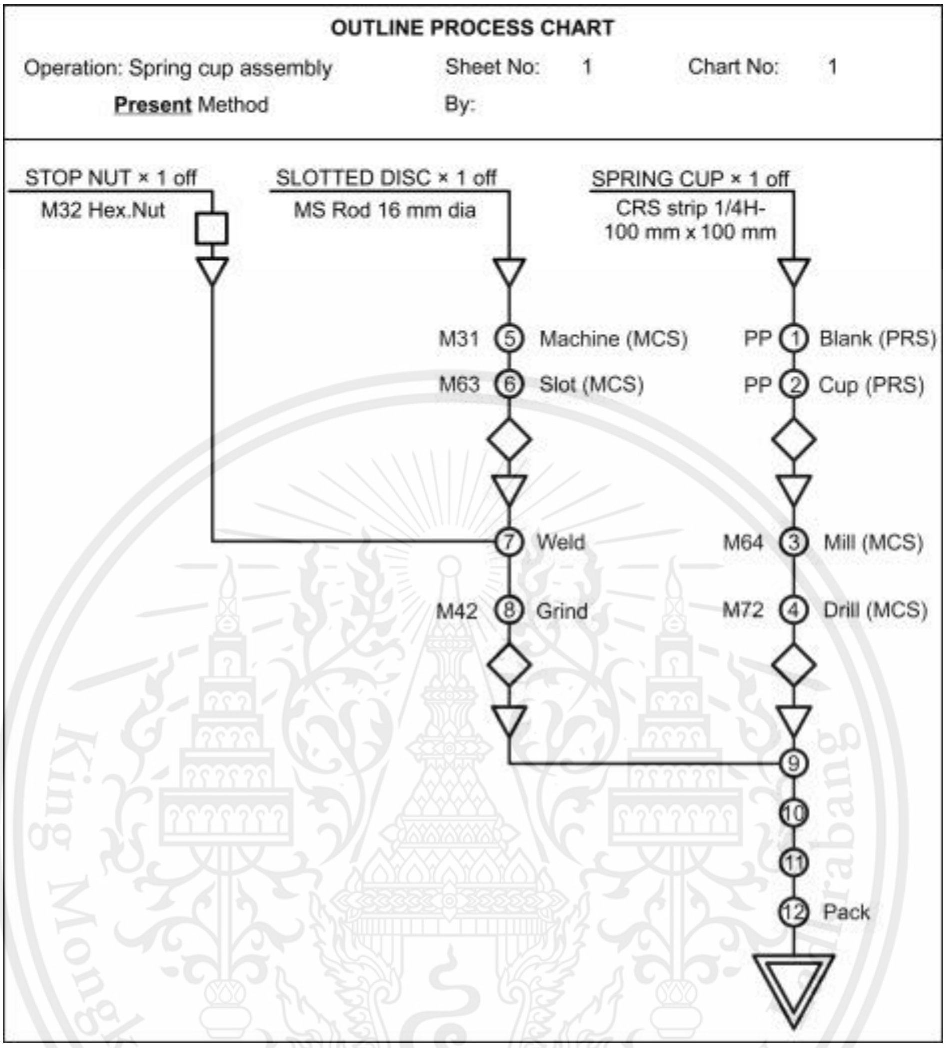


Figure 2.8: Operation Process Chart

The production process chart is a chart that is suitable for studying the main workflows. For products that are currently being manufactured or redesigned products to learn if there is a way to improve or change the production flow and reduce the production flow. This chart is considered an important starting point to acquire a good factory layout. Whether it is a factory that produces a lot of products of its kind or just a few. This is because it is a study to reduce the production process as shown in Figure 2.8.

2.2.3.1 Flow Process Chart

Is a chart written to record the working procedures or procedures for processing raw materials until they are products. The detailed records of every step of the work as shown in Figure 2.9 (Somsak Trisat, 2005). The route flow map specifies a non-valuation process: movement, temporary inventory, production route flow and so on. Waiting is very important because it allows the analyst to know which parts should be improved or reduced (Niebel & Freivalds,2003). This map contains more details that need to be studied than those of the route chart, and to make it easier, the flow should be studied after the production flow chart has been updated. Then study and revise the process flow chart. When both charts are updated successfully, they can be used as a guide to the layout of the plant in this production line. There are 5 action symbols according to ASME standards

○ = Operation refers to the operation on a work on piece when the characteristics or properties of the workpiece are changed.

⇨ = transportation refers to moving an object from one point to another, except for moving while in the production stage.

▽ = Inspection refers to the activity of quality comparison of the workpiece. The quantity of material to ensure the appearance of the workpiece.

D = Delays refer to job delays due to obstacles preventing them from carrying out the next operational procedures.

□ = Storage or rest refers to the permanent storage of a piece of work that can be used if needed with a disbursement, which should have orders or books from the relevant parties linked together. Vertical flow lines and horizontal material lines.

The flows of production can be divided into two as following

1. The Man Type is a chart that records only one person's workflow. That moves through the steps.

2. Material Type is a chart that records only the processing process or procedures that the raw material must go through or be processed in the processing of the raw material until it becomes a product.

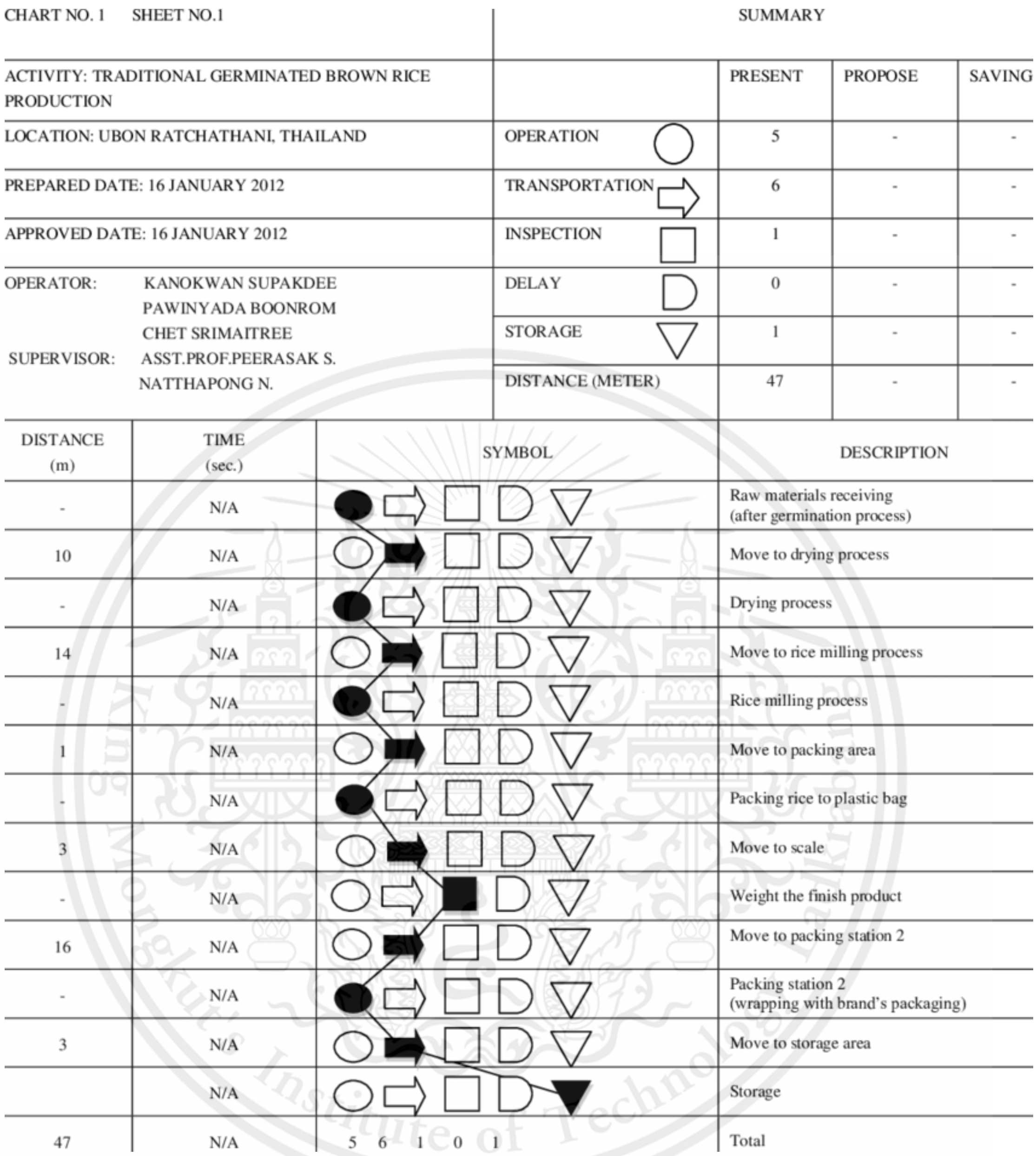


CHART NO. 1 SHEET NO.1	SUMMARY			
ACTIVITY: TRADITIONAL GERMINATED BROWN RICE PRODUCTION		PRESENT	PROPOSE	SAVING
LOCATION: UBON RATCHATHANI, THAILAND	OPERATION	5	-	-
PREPARED DATE: 16 JANUARY 2012	TRANSPORTATION	6	-	-
APPROVED DATE: 16 JANUARY 2012	INSPECTION	1	-	-
OPERATOR: KANOKWAN SUPAKDEE, PAWINYADA BOONROM, CHET SRIMAITREE	DELAY	0	-	-
SUPERVISOR: ASST.PROF.PEERASAK S., NATTHAPONG N.	STORAGE	1	-	-
	DISTANCE (METER)	47	-	-

DISTANCE (m)	TIME (sec.)	SYMBOL	DESCRIPTION
-	N/A		Raw materials receiving (after germination process)
10	N/A		Move to drying process
-	N/A		Drying process
14	N/A		Move to rice milling process
-	N/A		Rice milling process
1	N/A		Move to packing area
-	N/A		Packing rice to plastic bag
3	N/A		Move to scale
-	N/A		Weight the finish product
16	N/A		Move to packing station 2
-	N/A		Packing station 2 (wrapping with brand's packaging)
3	N/A		Move to storage area
	N/A		Storage
47	N/A	5 6 1 0 1	Total

Figure 2.9: Flow Process Chart

2.2.3.2 Multi-Product Process Chart

It is a chart that shows which products or parts have gone through. Make it known which processes are more or less tasked by dragging lines in the table from parts to processes as shown in Figure 2.10 (Prachuap Klomjit, 2012).

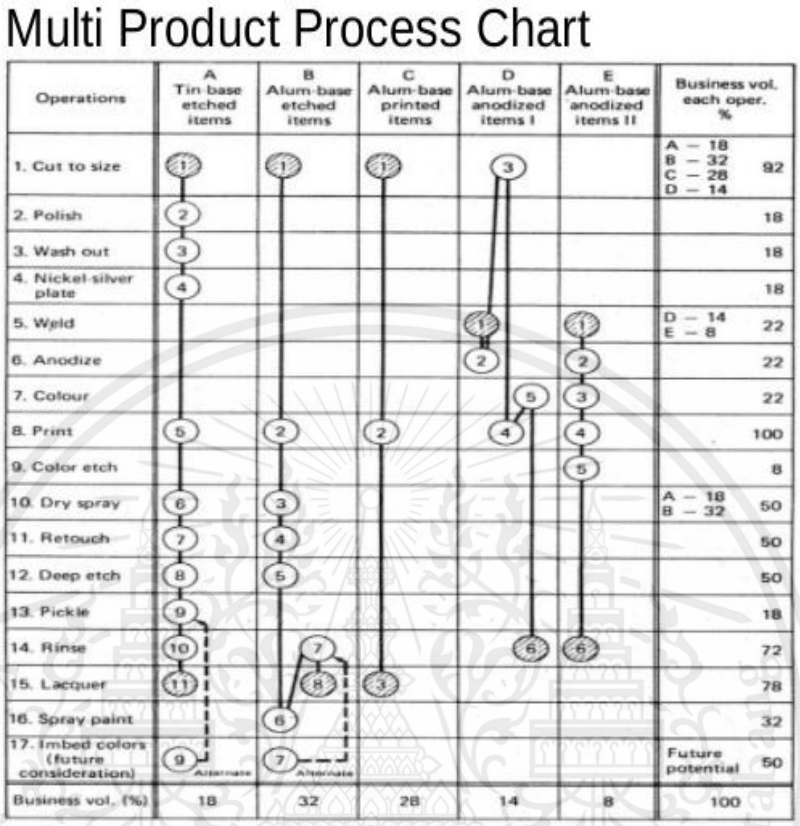


Figure 2.10: Multi product process chart

2.2.3.3 From-to Chart

As the number of types of goods available or shining increases, it is difficult to analyze the flow of each piece. This is in relation to the cost of moving the product between departments, which is associated with the cost of moving the product between departments. The amount of transport may be measured by the number of trips. The number of ballets or weights, depending on the item type or handling cost. These quantities are summarized in numbers and then put into a from to chart, as shown in Figure 2.11, which shows that the departments that should be close together are the departments that have a lot of flows (Prachuap Klomjit, 2012).

To Departments

From Departments	A	B	C	D	E	F	G
A		23	12	35	65	16	95
B			37	45	80	40	80
C				18	50	12	67
D					119	63	60
E						49	30
F							79
G							

Figure 2.11: From to Chart

A flow diagram is a work-related plan that is already displayed in the process flow tree. Flow of production and flow diagrams are usually used in parallel (Somsak, 2005).

How to create a flow diagram

1. Find a plan that needs to be studied that details the location of the machine and the area where the various characteristics are worked, as shown in the flow map of the production process.

2. Write the positions where the activities are performed in the plan, with the symbols and numbers used exactly as defined in the route flow map.

3. Write a line showing the employee's movement path or material in the plan.

4. If the reverse motion repeats the same path, show it with another separate path.

This flow diagram may be written in 3D to illustrate different levels of working conditions.

2.2.4 Activity Relationship Diagram in Facility Layout

The Relationships chart represents the relationships of each activity. Which activities are very correlated, they score high priority points. On the other side, any activity that is less correlated scores low priority. This chart is more practically appropriate than other methods and is a useful tool for plant scheduling, and also a good way to collect production support or for planning office events and service areas with very little material flow.

The Relationship chart tells you the importance of a relationship by defining a score to show the relationship level between activities.

The relationship level values used to analyze the relationships of these activities are divided into six levels: A, E, I, O, U, and X.

A: Absolutely Necessary: It is the most complete relationship level and is the activity partner that must be next to each other or closest to each other, it is said that there is the greatest level of relationship.

E: Especially Improvement: It is a special relationship level but less than a level A relationship or has a large level of relationship.

I: Important: It is the complete relationship level that is important, but less than the E level or the relationship level.

O: Ordinary: Is a simple relationship level, less than a Tier I relationship, or has a low relationship level.

U: Unimportant: It is a level of unimportant relationship, with minimal or virtually no level of relationship, or freedom for each other.

In practice, the level of relationship between the parties is done in different ways. as follows

1. Chart placer must know better about the operation of the activity partner. It will give you the relationship level.

2. Use the flow as a guide to provide a level of relationship to ask for feedback from individuals involved in the operation of the parties, as well as collect information about the need for space.

3. Use a questionnaire to send to the relevant person to help provide feedback on the relationship level, then summarize and decide on the relationship level again.

Relationship charts can help us find relationships. Especially in agencies where there is a lot of activity, it is not possible to calculate relationships. For guidelines for scoring relationships, who are not familiar with scoring using the A, E, I, O, U, and X codes are most likely to go to A to prevent A-level scores from being assigned for each pair of excessive activities. The scoring principle is as shown in Figure 2.12.

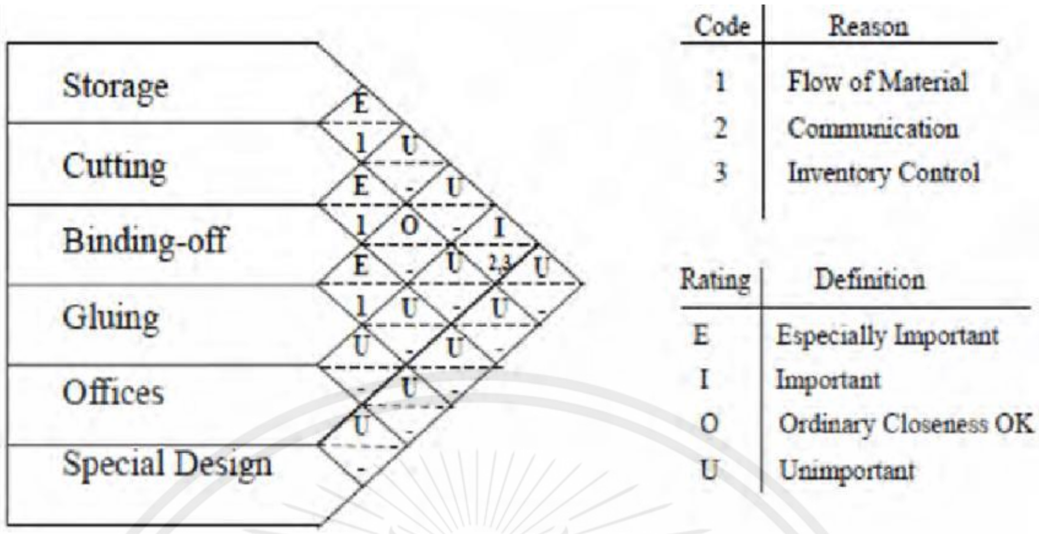


Figure 2.12: Example of create a relationship chart

2.2.5 Create a relationship diagram

Writing an activity relationship diagram (as shown in Figure 2.15) is a relationship diagram technique that can be written in several ways, but the steps are typically performed by using data from the relationship map to write a diagram to give a clearer picture. Key principles of writing a diagram are:

1. Simple and easy-to-write symbols are required to represent activities.

2. Must demonstrate the degree of correlation between activities or point out the flow intensity of the material.

The symbols for writing diagrams (as shown in Figures 2.13 and 2.14) are as follows:

1. Symbols for each activity type.

2. Numbers or letters are used to specify for the activity.

3. The number of lines is used as a code instead of the intensity of the flow or the relationship level.

4. Using color as code may replace either relationship level or flow intensity.

5. Use different colors instead of individual activities.

Symbols and meanings	Symbols used to identify activities and areas
○ = Operation	○ = Forming area and changing properties
⇨ = transportation	○ = Assembly work
▽ = Inspection	⇨ = Area activities associated with the transportation
D = Delays	▽ = Activities/Inventory Areas
□ = Storage	D = Temporary or storage area
	□ = Production Support Activities/Areas
	⇧ = Office Space

Figure 2.13: Symbol used to compose a relationship diagram

Code	Score	Line	Level of relationship	Color code
A	4	////	Perfect important	Red
E	3	///	Special important	Yellow
I	2	//	Important	Green
O	1	/	Normal	Blue
U	0		Insignificant	White
X	-1	≶	Not required	Brown
XX	-2,-3,-4,…	≶ ≶	Not very required	Black

Figure 2.14: Code used to compose a relationship diagram

Summary of how to write an activity association diagram

1. The activity name must be specified and numbered in the diagram using code, which varies by activity type.

2. Write a diagram of an activity with a level A (4 lines) relationship as the first diagram.

3. Then write the E-level relationship diagram (3 lines) as the second chart, where the length of the line is twice that of the A-level relationship.

4. Then write a Level I relationship diagram (2 lines).

5. Diagram the Level I relationship, then write an O-level relationship diagram (1 line). Link between activities by 4 times the length of the 4 lines in the A-level relationship, and then diagram the relationships.

6. Check When writing the final diagram and copying it, it is used as a basis for plant scheduling as well as factory layout adjustments, taking into account the considerations and practical limitations.

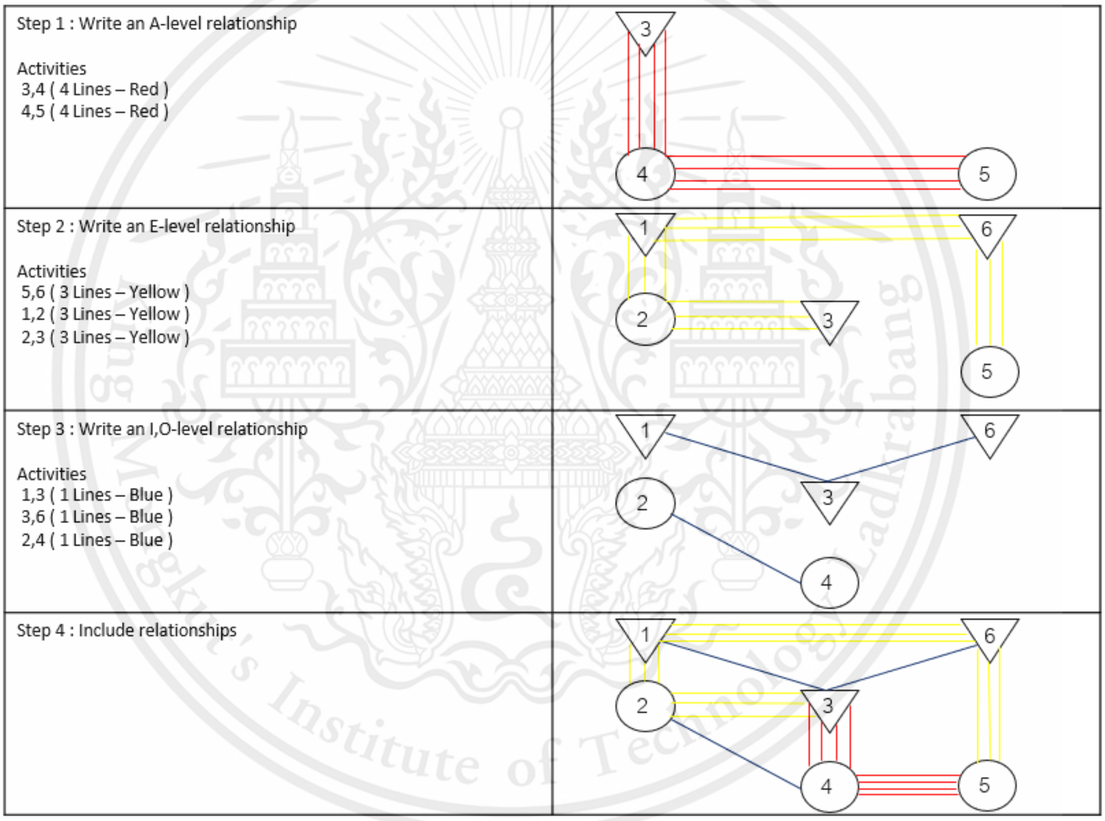


Figure 2.15: Example of writing a relationship diagram written into the framework of the plant layout area

2.2.6 Calculate the require space

Calculating the space required is very important in planning the plant layout, which determines the space according to the departments required.

There are five basic ways to find the space you need:

1. How to find space from work centers

2. How to convert values

3. How to find space from rough factory planning

4. How to find out from standard space

5. How to find out the space from proportions and predictions Therefore, in consideration of the meat, it is important to take into account the space that can be obtained.

The areas to consider included in the plant layout are as follows:

1. Space for material archives

2. Space for warehouse

3. Space for corridors, conveyors, cargo materials

4. Space for material handling equipment

5. Space for tool room

6. Space at the pick-up and drop-off department

7. Space for maintenance department

8. Space for other production supports, etc. how to calculate the desired area. This can typically be done by separating activities or sub-areas of the main area, or by combining the area of each activity into an entire area.

2.2.6.1 A way to find space from a work center, considering that a work center consists of machines and equipment and space required for work. A workplace where the amount of space you want to multiply with the number of machines. This method is suitable for plant planning according to the production process.

2.2.6.2 The space conversion method for converting space must know the important elements of the space currently available and how to convert it to the desired space, but this is a good way to estimate it for future plant expansion studies and a method that can be used. Only if:

1. When the project needs to be done urgently.

2. When the nature of the work in various activities or areas is complex or distributed, which is not required, the fine calculations are not required.

3. When it is the space required for rough plant planning in step 1 for choosing a location, and location.

4. For the elements of the data to be calculated, such as product data (P) or quantity (Q), typically.

2.2.6.3 This method of roughly determining the area of the plant is considered only for critical areas or where special supervision of operations and administration is required.

2.2.6.4 The method of obtaining standard space is to find the space required by the standard size specified by the manual, such as the different types of machines that have standard size guides.

2.2.6.5 The method of proportional and prognosis is done by creating a proportion of the area, which can be square meters per unit produced (or unit worked). For example, square meters per hour, the work of people per year.

2.2.7 Detailed factory layout design

Detailed factory layout design This gives a clearer view of the plant layout, such as the opening/closing distance. Position of operation, placement position Walking routes, etc. In practice, detailed planning procedures often go parallel to planning by department, as they will see more details of the shortcomings. Nowadays, computer systems are used to make it easier and faster. There are three detailed planning methods as following.

2.2.7.1 Drawing

For this method, the planner must initially prepare a layout drawn according to the scale and determine which machines are placed in the complete area. Then consult with the relevant parties for comments and suggestions and re-draft the plant layout. That is it, you will get a good factory layout. Using drawings or writing plant plan to help plan the plant is the most popular preliminary method. If you want to get a clearer picture, you can create models. Sometimes plant layouts use drawings or plan writing, it is the only way to do it.

2.2.7.2 Template

Creating a template is done using a cardboard sheet, if it is good and clearly visible, it is better to use paper with a color instead of a machine. Each machine should be replaced with one color. Cut and place on a sheet of cardboard on the factory floor, which is scaled to a smaller size. To locate and distance the machine, you can measure it from the simulated image sheet because it has been scaled. Currently, various formats can be used from computer programs.

2.2.7.3 Model

The industrial plant layout of all countries today is commonly used to create mannequins because it is convenient to move mannequins that are tools and machines when they need to improve or change the factory layout. Nowadays, 3D renderings can also be used from computer programs.

2.2.8 Analyzing the results of the alternative plant layout

Analysis of alternative plant layouts is an analysis of the results of differentials in each plant layout, such as shorter material transport distances. Increased operating area. The cost of resuming the plant layout and calculating the payback period of each plant layout, for example, will be an important factor in deciding which plant layout is appropriate.

2.3 Related Research

Chanaying Kamol Singh, Chalermchon Waisayadamrong and Wanchai Rattanawong (2002) This research is an improvement of the plant layout by applying systematic layout planning (SLP) from the process of data collection, products, production volume, production process and route. Walking Process flow analysis and route flow tree Chart analysis shows relationships Diagramming Show the relationship to the factory layout between the different departments that are related to the design of the plant layout for the mold pump factory, cut the electronic circuit boards. Considering the distance of moving materials to work from the plant layout before the re-layout and the plant layout after the re-layout, the material handling was found to have a reduced distance. As a result, the overall system time is reduced and the overall efficiency of the plant layout increases. This method can also be applied to other factories.

Anat Wattanasangsut, Taratat kaolim, Sombat Teaksap and Chusak Pornsingh (2005) Due to unplanned production problems. High production cost per component required to produce a lot of overtime. Lost time transporting raw materials to await production. This research has studied the systematic layout planning (SLP) in conjunction with the Multi-Product Process Chart to solve problems found in textile companies' production departments and want to improve production management more efficiently. The researchers collected data and analyzed them using these principles to design three new plant layouts, conducted three planning experiments, and collected performance assessment data, and economics analysis to select plant layouts that reduced the maximum production cost. The results showed that the third new plant layout had the shortest material handling distance of 1,642.12 meters, which is 22.23 percent less than the old plant plan. Ease of transportation, quality control Utilization of operational space, material storage, and ease of supervision of the operation of the planning score. The original chart was 2.42 points, and the night was returned every as soon as 3 months and the annual cost of production was estimated to be 187,652.85 baht.

Sutthipong Promsuwan and Chana Yingkamolsingh (2007) Conducted a study on education. Optimize factory scheduling Case Study K Furniture Co., Ltd. Intended to study the original plant layout and improve the plant layout to be efficient in production and analysis of production. Comparing before and after improvements, studies have shown that the reasons for high production costs and frequent accidents are due to the lack of systematic plant scheduling. This causes a loss of time to move. As a result, excessive overtime resulted in fatigue and frequent accidents during overtime. The studier analyzed and found solutions. It was found that the plant can be arranged in a U-type way, which allows continuous production and reduces production time, and has an additional 612 square meters of space in each tribute. This reduced moving distance by 212 meters and reduced moving time by 1.7 minutes, resulting in a decrease in the total production process from 112.2 minutes to 99.5 minutes, or an 11.32% reduction in production time. The study was used to reduce overtime from

5 p.m. to 10 p.m. Instead, add overtime on Sundays. To reduce employee fatigue and reduce labor costs by 17.49%.

Sompasorn Euareemit and Thanat Mokkamornkul (2008) Renovation of plant layout is Streamline up existing processes This research will improve the plant layout using ready-made garment factories as a case study. The objective of this research is to improve the plant layout and re-position the machines to help increase productivity. The method used in the research is to store the time spent on production and the time it takes to produce it. It is used to move and reduce waiting time during production, then process data with a simulation program called Arena and simulate four plant scheduling scenarios: 1. Current plant layout. 2. Factory layout according to machine type 3. Plant layout according to the product type, which uses the same number of machines as the number of machines used at each stage of the current plant layout, and 4. As a result of the simulation, the plant layout according to the machine type is more suitable for deployment than other plant layouts, as it can reduce the time it takes to move. 30.16% reduced waiting time 71.15% and 3.27% more production than the current plant layout, and according to sales per machine cost used by each plant layout, plant scheduling by machine type increases profitability the most. Therefore, it is concluded that the plant planning according to the machine type is suitable for application to this plant. To improve product production efficiency and help to produce products on time.

Nitaya Bumrungrad (2009) This research aims to redesign the plant layout. Expand future production capacity using systematic layout planning (SLP) in conjunction with analyzing material flow relationships in the production process and evaluating production line efficiency to select the right plant layout. The result of the analysis of the relationship of the work department and the flow of materials in the production line, this time the appropriate alternative plant layout is the 3rd type of plant layout that uses a total area of plant scheduling of 1,650 square meters. The shortest total process moving distance is 24,840 meters per month and the minimum cost of moving materials in the production process is 1,210,950 baht per month. The results showed that from the original prototype plant layout, by designing and planning the plant to expand its production capacity from 10 megawatts per annum, the production line will increase its labor efficiency from 46.54% to 66.75%, and the unemployment time incurred on the production line has decreased from 53.46% to 33.25%.

Lertpong Sekjaisue and Ruphuwan Chandara (2012) This research aims to improve the layout of car accessories companies by systematically designing plant layouts to ensure higher material flow in the sesame process. According to the company's schematic study, the samples showed that the inefficient conditions and flow paths of the material resulted in long material movement distances between agencies, high unloading costs, and many flow route intersections. This increases the chances of an accident. This study was conducted by collecting relevant data. Material flow analysis, relationship analysis between activities Analysis of the desired area and composition analysis with company officials the study will focus on plant planning by department and detailed plant planning in some parts. The results of the study concluded that the company's chart of samples had improved. The total distance used to transport materials between units can be reduced from 5,448 meters to 4,309 meters, which is a 20.91% decrease in the proportion of the flow route, reduced from 24 points to 10 points, a 58.33% decrease in the proportion, and 8 points of reverse flow from 8 points to 0 points.

Glitterdao Samanpan and Nantachai Kantanananta (2013) This research aims to present guidelines for improving the plant layout for the hard disk drive production process in the Clean Room section by applying the principle of systematic layout planning (SLP), a plant planning process that focuses on the level of relationship between stations, to reduce distance and reduce material handling time. Therefore, there is a capacity imbalance between Phase 1 and Phase 2. This results in the transport of many materials to cross-phase production. In addition, some unruly workstations are placed very far apart. This allows for a long material unloading distance between stations. In this research, two revised plant layouts were proposed when evaluating the efficiency of the new plant layout that compared the results before and after the renovation. It was found that the new plant layout type 1 and type 2 can reduce the average material handling distance of various working times. The two revised plant layouts are more efficient than the current plant layout, but the second new plant layout reduces working hours and workers' wages to transport materials and total usage areas more than the new plant plan 1. Therefore, the second new plant layout is the best choice at the same time as more production lines are moved. Therefore, those involved should consider the positive and negative effects of each option as well as the value of the investment to make decisions on plant layout improvements.

2.4 Chapter Summary

In Chapter 1 we proposed a way to improve the plant layout with SLP. This chapter explains about Plant Layout (section 2.1) and the whole process of Systematic Layout Planning (section 2.2), where Related Research (section 2.3) will be used to support this method used in the project.

The next chapter presents details in conducting research, which uses the SLP system to design a new plant layout in order to have a more efficient factory layout and reduce problems in the factory.

CHAPTER 3
METHODOLOGY

3.1 Introduction

This chapter details the research operations from the data collection of the current plant layout, products, production processes, historical average net profit. Machinery and equipment are analyzed according to the operational procedures, divided into 9 stages as follows in section 3.2.

3.2 Design Methodology

This company has enough building and repair space to call it a factory, so systematic layout planning (SLP) is a reasonable alternative to renovating this plant. This is because a factory that has all the information systematic layout planning (SLP) needs. The 9-step process that we have planned is as follows:

3.2.1 Explore the basics of P, Q, R, S, T plants and activities

3.2.1.1 Interviewing of business owners and employees

To learn more about the problem conditions that arise in conventional production line processes and equipment used in production. To use the obtained data to analyze to develop the process flow in the production line and to select the appropriate factory layout solution.

3.2.1.2 Measuring the area of the factory and all the machines

To use the data obtained to study problem areas of process flow on a production line.

3.2.2 Plant chart analysis from product – quantity (P-Q Chart)

Plot the number of products and quality on a graph to find the type of layout to create.

3.2.3 Product flow analysis

Use the machine information used to create 5 types of products to create a Multi-Product Process Chart to know the direction of product flow.

3.2.4 Analyze and create activity relation charts

Creating a relationship chart to find the best plant layout in this factory requires the longest time of day to create a product (3.2.4.1) to bring up a relationship or set up code (3.2.4.2) to make it easier to view relationships chart.

3.2.4.1 The longest time of day to create a product.

Using data on the number of days in the production of all 5 products to create Relationship charts of the machines in the factory.

3.2.4.2 Code

To define the meaning of the characters into a code to describe the relationship of the machine in the factory and the code used is 6 characters as shown in table 3.1.

Table 3.1: Code used to compose relationship diagrams

Level	Meaning
A	Most relevant
E	Very relevant
I	Medium Relative
O	Less relevant
U	Least relevant
X	Should not be around each other.

3.2.5 Create a relationship diagram of the activity

In creating relationship diagrams, relationship diagrams are designed to create layouts that are more efficient than current ones, which use color coding (3.2.5.1) to separate the flow of each relationship. To make it easier to look at the plant layout relationships, use the symbol (3.2.5.2) to indicate what zones each area is responsible for in the layout.

3.2.5.1 Color coding

To define the meaning of the relationship, the machine is color to describe the relationship of the product flow in the factory in a simple and easy way. Colors are divided into meanings as shown in Table 3.2.

Table 3.2: Color code used to compose relationship diagrams

Meaning	Color
Most relevant	
Very relevant	
Medium relative	
Less relevant	
Least relevant	
Should not be around each other.	

3.2.5.2 Symbol

Only one set of standard symbols is recorded in the chart. There are five symbols shown in Table 3.3. It can cover actions or events that appear in general while working in a factory. The symbols used for this record are convenient. And it saves a lot of time in identifying the events that occur in sequence in the operation.

Table 3.3: Symbols used to compose relationship diagrams

Symbols	Meaning
○	Processing and changing areas/assembly
⇨	Pick-up or transport activities
▽	Inventory Activities
D	Temporary or placing area
□	Areas for inspection and testing

3.2.6 Calculate the require space

To divide the area into zones for easy calculation of the area is required from the relationship chart. Can divide zones according to the type of machines or machines that are close to each other. Which will define the zones according to Table 3.4.

Table 3.4: The code used to write the definition of the zone area

Number	Meaning
R1	Receiving department
R2	Cutting department
R3	Leath department
R4	Milling department
R5	Drilling department
R6	Assembly department
R7	Welding department
R8	Painting department
R9	Thermal department
R10	Boring department

3.2.7 Detailed factory layout design

Placing area zones into a factory plan according to the established relationship chart. Based on the actual area of the factory to calculate a new factory layout for solving problems within the factory.

3.2.8 Analyzing the results of the alternative plant layout

Calculation of economic data from factory model improvement There are 6 economic data items used in selecting factory model. In which all 6 items will be obtained Compare in the table to find the best layout, all six of which have ฟs follows.

3.2.8.1 Increase productivity

Productivity increased as a percentage of the reduced plant transport distances.

Equation 3.1: Calculate the increase productivity

$$\left[\left(\left(\frac{1}{Current\ Area}\right).Area\ of\ the\ new\ layout\right)-1\right].100 \qquad \text{Eq. 3.1}$$

3.2.8.2 Calculate labor costs saved through shorter material transport distances

Equation 3.2: Calculate a saving transportation labor cost

$$Cost\ of\ loading\ time.Percent\ of\ Increase\ Productivity \qquad \text{Eq. 3.2}$$

3.2.8.3 Revenue

3.2.8.3.1 Average cost of a new layout (bath/months)

Equation 3.3: Calculate the average cost of a new layout

$$Average\ cost\ of\ a\ new\ layout = Average\ cost.reduced\ area\ percentage \qquad \text{Eq. 3.3}$$

3.2.8.3.2 Increase in income (bath/months)

Equation 3.4: Calculate increase in income

$$Average\ Cost\ of\ a\ new\ layout - Average\ cost \qquad \text{Eq. 3.4}$$

3.2.8.4 Days of maintenance

The total average days that spent to improving the layout.

3.2.8.5 Cost for maintenance areas

The contractor's average total cost used to renovate the layout.

3.2.8.6 Payback period (months)

Equation 3.5: Calculate the payback period

$$\frac{Cost\ for\ maintenance\ areas}{Maintenance\ costs\ from\ reduce\ transportation + Increase\ revenue}$$

Eq. 3.5

3.2.9 Summary the most suitable factory layout

Show how to use SLP in factories, find economic data. To calculate the best form of this plant.

3.3 Interesting Problems

The main purpose of this chapter is to implement SLP in the factory to create a factory layout with the least transportation time required and to increase the area in the factory to reduce the problems associated with the plant space.

3.4 Proposed Solution

Begin by gathering basic factory data, factory size, factory machine size, and the five products that took the longest time to build a plant, and then use SLP to start managing the plant layout.

3.5 Summary

This chapter describes how SLP works in a factory. The SLP is divided into nine steps in the subsection of Section 3.2, which are:

- Explore the basics of P, Q, R, S, T plants and activities
- Plant chart analysis from product – quantity (P-Q Chart)
- Product flow analysis
- Analyze and create activity relation charts
- Create a relationship diagram of the activity
- Calculate the desired space
- Detailed factory layout design
- Analyzing the results of the alternative plant layout
- Summary the most suitable factory layout

Which all 9 steps indicate everything in the factory. Which can be used to arrange the data to create a new plant plan and compare it with the current factory layout. To find out which plant layout is better, using economic data to help calculate the best plant layout.

CHAPTER 4
EXPERIMENTAL RESULT

4.1 Introduction

This chapter details the research operations from the data collection of the current plant layout, products, production processes, historical average net profit. Machinery and equipment are analyzed according to the operational procedures, divided into 9 stages as follows in section 4.2.

4.2 Testing Summary

4.2.1 Explore the production problems of the current plant layout

Survey the problem by asking the factory owner. Then, the information that summarizes 3 important issues is summarized:

4.2.1.1 Delay

Caused by there is a lot of machine space in the factory. Causing the work of the workers to be interrupted, such as canceling forklift because they cannot enter the factory. In 2016 to 2019 factory increase the new 4 machines Therefore reducing the area in the factory.

4.2.1.2 Forklifts cannot enter the factory area

Due to the factory floor being crowded, Forklift could not come in and lift things. Therefore, having to switch to using Crane to move the Product Causing a delay from transportation.

4.2.1.3 Need more space to operate

In the factory, there are 2 machines that require more space are milling machines and boring machines. The increased space is 31.07 square meters and 39.71 square meters, respectively.

4.2.2 Collection of basic plant data

This topic is the collection of information in order to be used for plant scheduling and flow analysis, namely the current plant layout, the number of departments, the usage area of each department, as well as the machinery and operating equipment of each department. The result of the data collection are as follows:

4.2.2.1 Current factory layout information

The method of collecting data is used by drawing a factory plan and measuring the actual area size as shown in Figure 3.1 to make it easier to see the area of each department, thus using color as an indicator of the department and displaying the area boundaries in a timely view of each department as shown in Table 3.1.

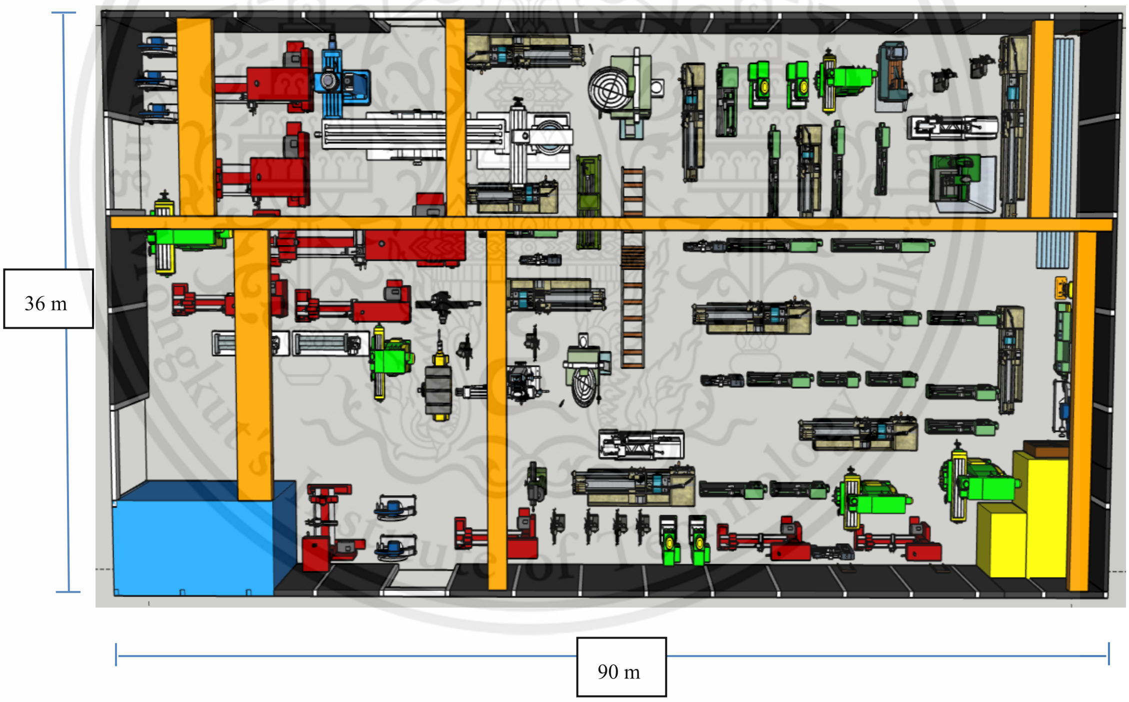


Figure 4.1: Current Plant Layout

4.2.2.2 Information on the departments and operating areas of each department

Collect operational area data for each department using the measurement method from the actual flat area as shown in Table 4.1.

Table 4.1: Operational Areas of Departments

Department	Area (m^2)
R1. Receiving department	36 m^2
R2. Cutting department	120 m^2
R3. Leath department	969 m^2
R4. Milling department	867.5 m^2
R5. Drilling department	256 m^2
R6. Assembly department	16 m^2
R7. Welding department	24 m^2
R8. Painting department	16 m^2
R9. Thermal department	16 m^2
R10. Boring department	16 m^2

4.2.2.3 Information on machinery and equipment of each department

Collect the space requirements of each department with measurements of the size, width, length of machinery and equipment. It allows for space for the use of the machines and equipment to make it easier to operate and to be more safe as in table 4.2.

Table 4.2: Operational Areas of Departments

Department	Machines	Require area (Wide x Length)
R1. Receiving department	-	(6 m x 6 m)
R2. Cutting department	Cutting machine 1	(2 m x 3.3 m)
	Cutting machine 2	(2 m x 3.3 m)
	Cutting machine 3	(2 m x 3.3 m)
	Cutting machine 4	(2 m x 3.3 m)
	Cutting machine 5	(2 m x 3.3 m)
	Cutting machine 6	(2 m x 3.3 m)
R3. Leath department	Vertical lathe 1	(4.5 m x 6 m)
	Vertical lathe 2	(5 m x 5 m)
	Horizontal lathe 1	(3 m x 10.5 m)

	Horizontal lathe 2	(3 m x 6 m)
	Horizontal lathe 3	(1.5 m x 4 m)
	Horizontal lathe 4	(1.5 m x 5 m)
	Horizontal lathe 5	(1.6 m x 3 m)
	Horizontal lathe 6	(2.5 m x 12 m)
	Horizontal lathe 7	(3 m x 5.4 m)
	Horizontal lathe 8	(3 m x 12 m)
	Horizontal lathe 9	(1.5 m x 3.6 m)
	Horizontal lathe 10	(1.5 m x 4.5 m)
	Horizontal lathe 11	(1.5 m x 4.5 m)
	Horizontal lathe 12	(1.5 m x 6 m)
	Horizontal lathe 13	(2 m x 7.8 m)
	Horizontal lathe 14	(2 m x 7.8 m)
	Horizontal lathe 15	(1.5 m x 4.8 m)
	Horizontal lathe 16	(1.5 m x 6.4 m)
	Horizontal lathe 17	(1 m x 3.6 m)
	Horizontal lathe 18	(1 m x 3 m)
	Horizontal lathe 19	(1 m x 7.5 m)
	Horizontal lathe 20	(1 m x 2.1 m)
	Horizontal lathe 21	(1.8 m x 5.4 m)
	Horizontal lathe 22	(1.5 m x 4.5 m)
	Horizontal lathe 23	(1.5 m x 2.7 m)
	Horizontal lathe 24	(2.4 m x 12 m)
	Horizontal lathe 25	(1.5 m x 6 m)
	Horizontal lathe 26	(1 m x 6 m)
	Horizontal lathe 27	(1.5 m x 14 m)
	Horizontal lathe 28	(1.5 m x 8.1 m)
	Horizontal lathe 29	(2.4 m x 5 m)
	Horizontal lathe 30	(3.6 m x 6 m)
	Horizontal lathe 31	(1.5 m x 4 m)
	Horizontal lathe 32	(1.5 m x 4 m)

	Horizontal lathe 33	(1.5 m x 6 m)
	Horizontal lathe 34	(1.5 m x 3.2 m)
	Horizontal lathe 35	(4.5 m x 6 m)
	Horizontal lathe 36	(1.5 m x 8 m)
R4. Milling department	Milling machine 1	(4.5 m x 13.5 m)
	Milling machine 2	(5.2 m x 17.2 m)
	Milling machine 3	(12 m x 18 m)
	Milling machine 4	(3 m x 15.8 m)
	Milling machine 5	(4.5 m x 13.5 m)
	Milling machine 6	(4.2 m x 10.5 m)
	Milling machine 7	(4 m x 12.3 m)
	Milling machine 8	(1.6 m x 8 m)
	Milling machine 9	(1.5 m x 1.6 m)
	Milling machine 10	(3.6 m x 8.4 m)
	Milling machine 11	(1.2 m x 3 m)
	Milling machine 12	(1.5 m x 3 m)
	Milling machine 13	(2.7 m x 3.6 m)
	Milling machine 14	(1.4 m x 2.2 m)
	Milling machine 15	(1.6 m x 3 m)
	Milling machine 16	(2.4 m x 4.2 m)
	Milling machine 17	(1.4 m x 2.2 m)
	Milling machine 18	(2.5 m x 6 m)
	Milling machine 19	(1.5 m x 4.5 m)
	Milling machine 20	(1.2 m x 1.5 m)
	Milling machine 21	(2 m x 3 m)
	Milling machine 22	(2 m x 3 m)
	Milling machine 23	(0.7 m x 2 m)
	Milling machine 24	(0.7 m x 2 m)
	Milling machine 25	(3.6 m x 8.5 m)
	Milling machine 26	(3.2 m x 6.2 m)

	Milling machine 27	(2.9 m x 8.3 m)
R5. Drilling department	Drilling machine 1 Drilling machine 2 Drilling machine 3 Drilling machine 4 Drilling machine 5 Drilling machine 6	(3.6 m x 4.8 m) (3 m x 6 m) (3 m x 4 m) (3 m x 5.4 m) (4.2 m x 7.2 m) (3.6 m x 3.6 m)
R6. Assembly department	-	(4 m x 4 m)
R7. Welding department	-	(4 m x 6 m)
R8. Painting department	-	(4 m x 4 m)
R9. Thermal department	Thermal machine 1 Thermal machine 2	(3.1 m x 5.2 m) (3.1 m x 5.2 m)
R10. Boring department	Boring machine 1	(1.8 m x 7.5 m)

4.2.3 Explore the 5 most ordered products

Explore product ordering data between 2016 and 2019 by selecting the products that are the factory's main product and have the highest number of orders:

4.2.3.1 Column Arm Electrode

Figure 4.2: Column Arm Electrode

4.2.3.2 Trommel

Figure 4.3: Trommel

4.2.3.3 Piston Rod

Figure 4.4: Piston Rod

4.2.3.4 Mud Filter Drum

Figure 4.5: Mud Filter Drum

4.2.3.5 Suction Box Corrugate Shteet

Figure 4.6: Suction Box Corrugate Shteet

4.2.4 Consider plant layout from product – quantity (P-Q Chart)

From considering the product type and production volume data, the chart of analysis of the suitability of the plant layout is considered. Shown as shown in Figure 3.7.

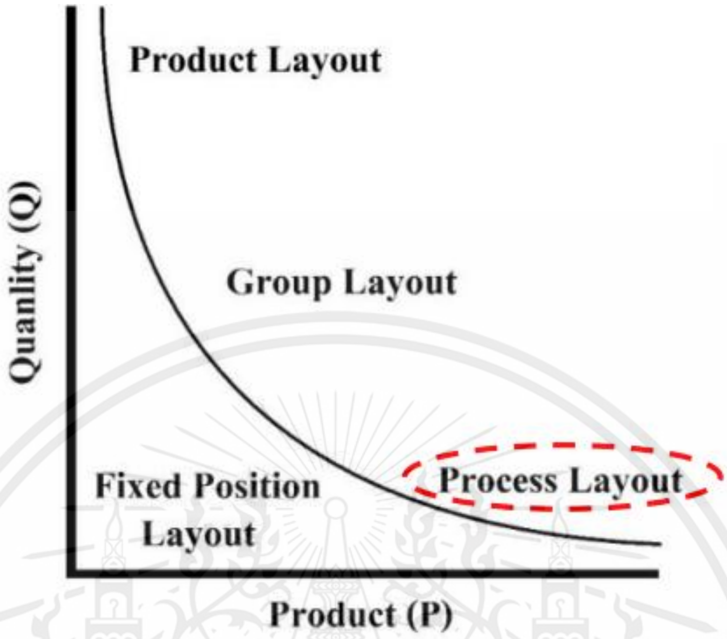


Figure 4.7: Analysis of plant layout suitability

From Figure 4.7, it can be concluded that process layout should be best suited because there are a variety of product types but low production quantity per type.

4.2.5 Multi product Process Chart

Analyze the flow of materials by classifying each product's parts, and then studying the production process and process of each of the five products, as shown in Table 4.3.

Table 4.3: Multi Product Process Chart

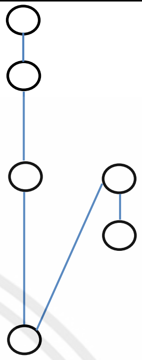
Product 1 (Column Arm Electrode)	
Department	Part 1
R1. Receiving department	
R2. Cutting department	
R3. Leath department	
R4. Milling department	
R5. Drilling department	
R6. Assembly department	
R7. Welding department	
R8. Painting department	
R9. Thermal department	
R10. Boring department	

Table 4.3: Multi Product Process Chart (continued)

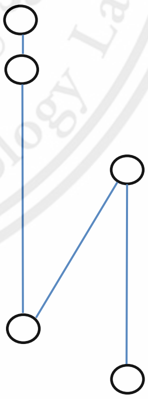
Product 2 (Trommel)	
Department	Part 1
R1. Receiving department	
R2. Cutting department	
R3. Leath department	
R4. Milling department	
R5. Drilling department	
R6. Assembly department	
R7. Welding department	
R8. Painting department	
R9. Thermal department	
R10. Boring department	

Table 4.3: Multi Product Process Chart (continued)

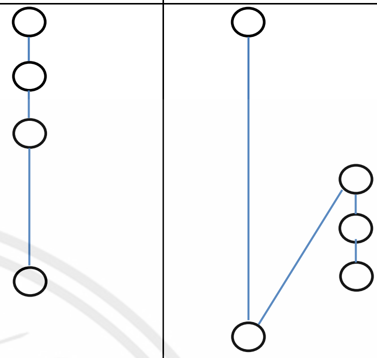
Product 3 (Piston Rod)	
Department	Part 1
R1. Receiving department	○
R2. Cutting department	
R3. Leath department	○
R4. Milling department	
R5. Drilling department	
R6. Assembly department	
R7. Welding department	
R8. Painting department	
R9. Thermal department	
R10. Boring department	

Table 4.3: Multi Product Process Chart (continued)

Product 4 (Mud Filter Drum)	
Department	Part 1
R1. Receiving department	○
R2. Cutting department	○
R3. Leath department	
R4. Milling department	○
R5. Drilling department	
R6. Assembly department	○
R7. Welding department	
R8. Painting department	
R9. Thermal department	
R10. Boring department	

Table 4.3: Multi Product Process Chart (continued)

Product 5 (Suction Box Corrugate Shteet)		
Department	Part 1	Part 2
R1. Receiving department		
R2. Cutting department		
R3. Leath department		
R4. Milling department		
R5. Drilling department		
R6. Assembly department		
R7. Welding department		
R8. Painting department		
R9. Thermal department		
R10. Boring department		



4.2.6 Analyze department relationships using the relationship tree and relationship diagram

Analyze departmental relationships using the relationship chart and relationship diagram by determining the amount of time it takes to layout each product and determine the level of relationship on each machine based on the longest layout laying period according to Table 3.5.

Table 4.4: Relationship level determination criteria

Product	Duration to set layout (Days)
Suction Box Corrugate Shteet	180 days
Mud Filter Drum	90 days
Column Arm Electrode	39 days
Trommel	36 days
Piston Rod	27 days

From Table 4.4, the longest time of the Corrugate Shteet box is 180 days, which the researchers will make the most of the department's relationship in this product and the importance of the department in products with less layout days, respectively.

Import the data in Table 4.4 to analyze relationships each department has to each other. Determine the relationship level, as in table 4.5.

Table 4.5: The relationship of each department to each other

Department relations	Product	Relationship level
R1-R2	Suction Box Corrugate Shteet,	A

	Mud Filter Drum, Column Arm Electrode, Trommel	
R2-R3	Suction Box Corrugate Shteet	A
R3-R4	Suction Box Corrugate Shteet	A
R4-R5	Suction Box Corrugate Shteet	A
R5-R7	Suction Box Corrugate Shteet	A
R2-R4	Mud Filter Drum, Column Arm Electrode	E
R4-R7	Mud Filter Drum, Column Arm Electrode	E
R2-R7	Trommel	I
R4-R6	Trommel	I
R1-R3	Piston Rod	I
All	Others	U

Create relationship charts by taking data in tables 4.4 and 4.5 into consideration, to determine the relationship level of each department and for the integrity of the relationship chart. As shown in Figure 4.8.

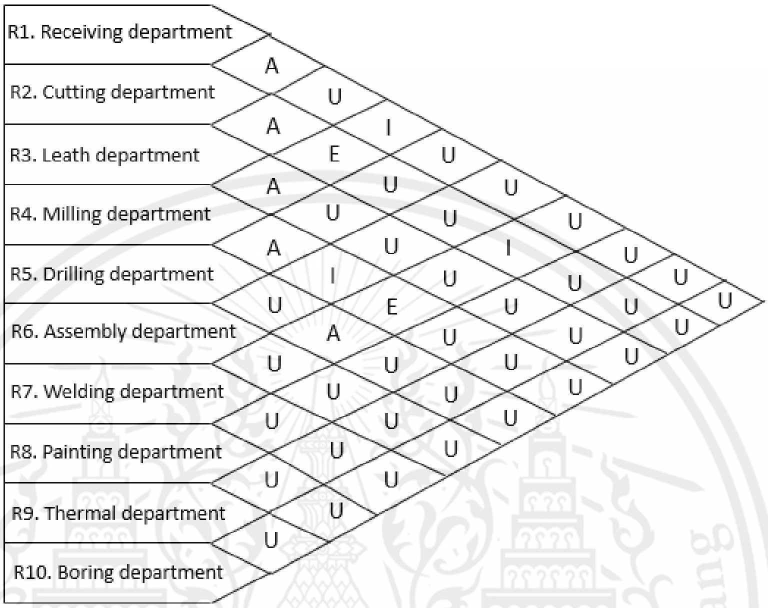


Figure 4.8: Relationship Chart

To write a relationship diagram, the number of lines used to connect and what of each relationship level must be defined, as in table 4.6, and set a symbol to tell what activity will occur in that department, as shown in Table 4.7.

Table 4.6: Code used to compose relationship diagrams

Level	Meaning	Color
A	Most relevant	
E	Very relevant	
I	Medium relative	
O	Less relevant	
U	Least relevant	
X	Should not be around each other.	

Table 4.7: Symbols used to compose relationship diagrams

Symbols	Meaning
○	Processing and changing areas/assembly
⇨	Pick-up or transport activities
▽	Inventory activities
D	Temporary or placing area
□	Areas for inspection and testing

Then, use the code information used to compose the relationship diagram in Table 4.6, the symbol used to compose the relationship diagram in Table 4.7, and the Relationship chart in Figure 4.8.

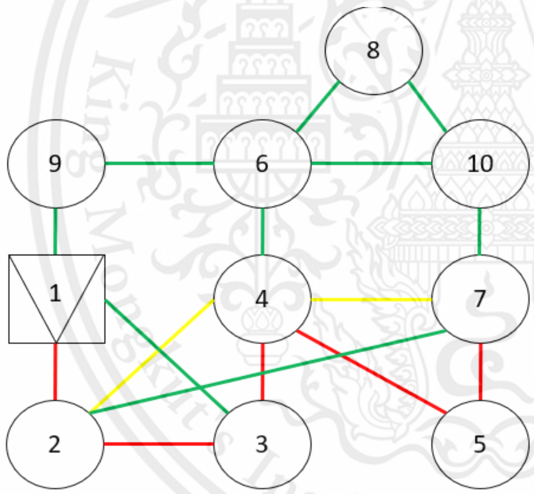


Figure 4.9: Relationship Diagram

Number	Meaning
1	Receiving department
2	Cutting department
3	Leath department
4	Milling department
5	Drilling department
6	Assembly department
7	Welding department
8	Painting department
9	Thermal department
10	Boring department

4.2.7 Consider the limitations and design of alternative plant layouts

Detailed design of the current layout the researchers used the method of drawing plant plan according to the actual size in SketchUp 3D program to create alternative plant layouts as shown in Figure 4.10.

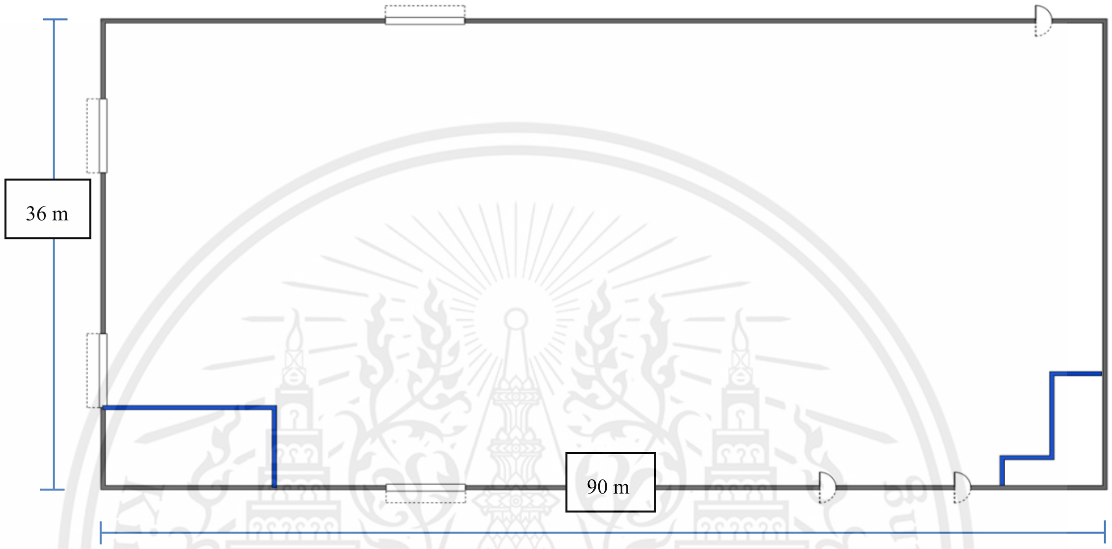


Figure 4.10: The current layout

Then, by analyzing diagrams and relationship charts, there are many alternative layouts that can be designed, but when the production process constraints are considered, including the order of production process, the size of the area, the need for sharing equipment, hygiene, safety. And by cooperating in the joint planning of the plant of the factory owner. Department heads and operators can summarize the results of three alternative plant layouts with details of the improvement to the layout and plan of the three alternative plant layouts as follows:

4.2.7.1 The first alternative plant layout as show in Figure 3.14

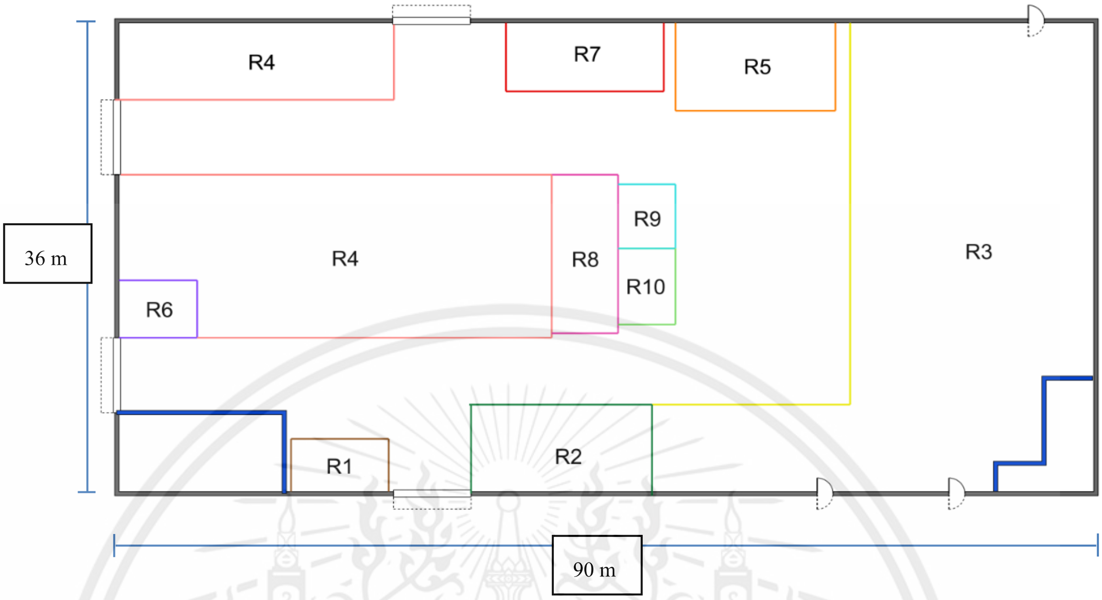


Figure 4.11: The first alternative plant layout

Information on the area of each department after the first plant layout is revised is shown in Table 4.8.

Table 4.8: Operational areas of various departments after the first plant layout are revised

Department	Area (m^2)
R1. Receiving department	36 m^2
R2. Cutting department	72 m^2
R3. Leath department	969 m^2
R4. Milling department	867.5 m^2
R5. Drilling department	226.72 m^2
R6. Assembly department	16 m^2
R7. Welding department	24 m^2
R8. Painting department	16 m^2
R9. Thermal department	16 m^2
R10. Boring department	16 m^2

Details of the renovation of the first alternative plant layout are as follows:

1. Move the same machines into the same area and divide the area of the turning department into 2 areas on the left side of the factory.

2. Second floor extension at the top of the storage department.

3. Remove the material moving rails from the factory area.

4.2.7.2 The second alternative plant layout as show in Figure 3.15

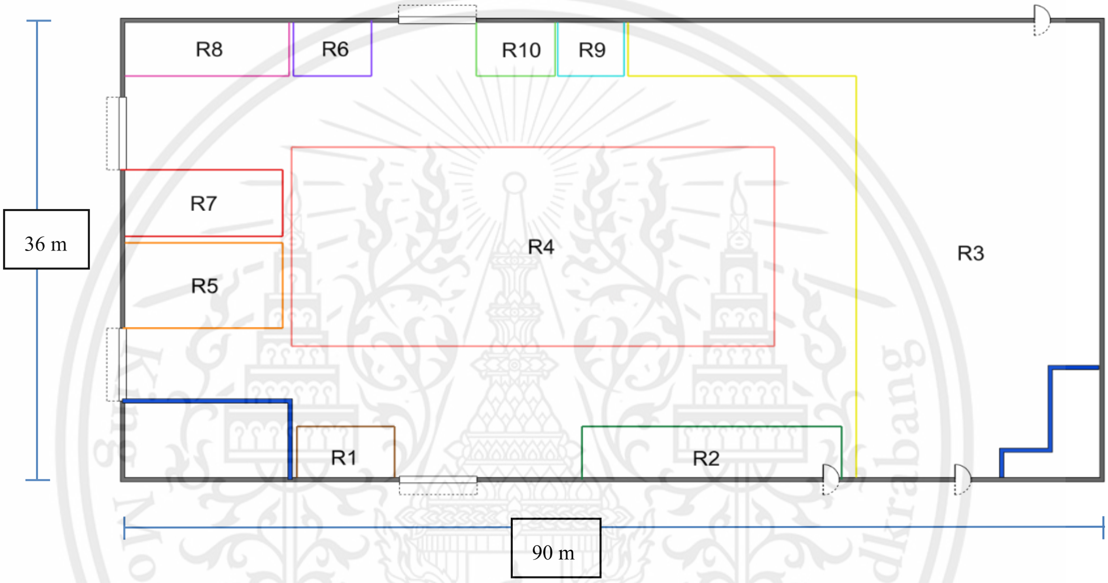


Figure 4.12: The second alternative plant layout

Information on the area of each department after the second plant layout are revised is shown in Table 4.9.

Table 4.9: Operational areas of various departments after the second plant layout is revised

Department	Area (m^2)
R1. Receiving department	36 m^2
R2. Cutting department	72 m^2
R3. Leath department	969 m^2
R4. Milling department	867.5 m^2
R5. Drilling department	226.72 m^2

R6. Assembly department	16 m^2
R7. Welding department	24 m^2
R8. Painting department	16 m^2
R9. Thermal department	16 m^2
R10. Boring department	16 m^2

Details of the renovation of the second alternative plant layout are as follows:

1. Move the same type of machinery into the same area.
2. Second floor extension at the top of the storage department.
3. Remove the material moving rails from the factory area.

4.2.7.3 The third alternative plant layout as show in Figure 3.16

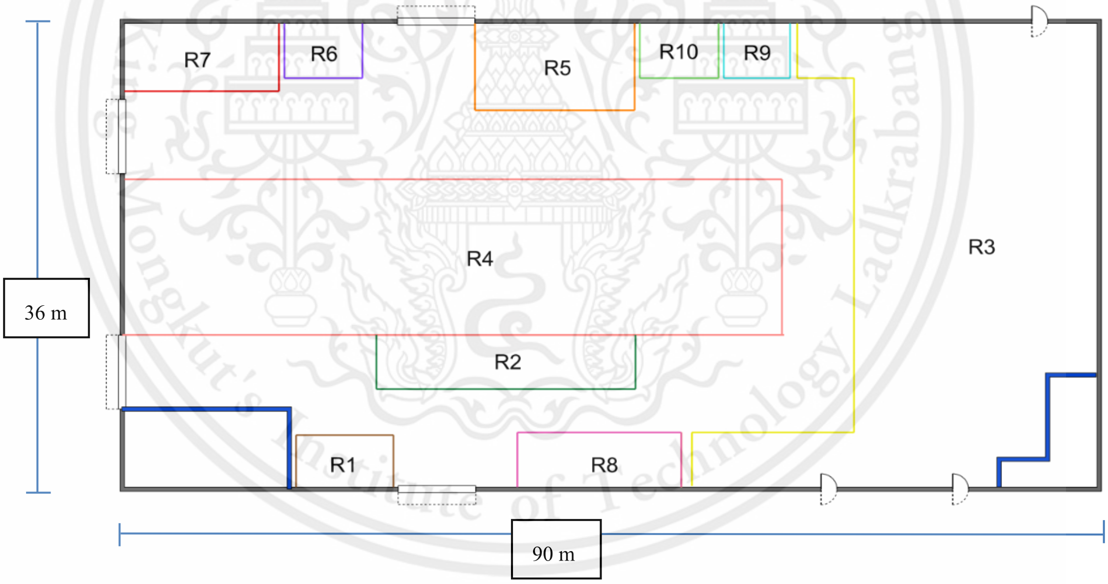


Figure 4.13: The third alternative plant layout

Information on the area of each department after the third plant layout are revised is shown in Table 4.10.

Table 4.10: Operational areas of various departments after the third plant layout is revised

Department	Area (m^2)
R1. Receiving department	36 m^2
R2. Cutting department	72 m^2
R3. Leath department	969 m^2
R4. Milling department	867.5 m^2
R5. Drilling department	226.72 m^2
R6. Assembly department	16 m^2
R7. Welding department	24 m^2
R8. Painting department	16 m^2
R9. Thermal department	16 m^2
R10. Boring department	16 m^2

Details of the renovation of the third alternative plant layout are as follows:

1. Move the same type of machinery into the same area.
2. Second floor extension at the top of the storage department.
3. Remove the material moving rails from the factory area.

From the layout of the three detailed alternative plants, the area of each department has changed from the layout. The current plant, which shows the area size of each department, is compared to the current plant layout in Table 4.11.

Table 4.11: Comparison of area size data of each department changed to the current plant layout

Department	Layout			
	The current layout	First layout	Second layout	Third layout
R1. Receiving department	36	36	36	36
R2. Cutting department	72	72	72	72

R3. Leath department	969	969	969	969
R4. Milling department	867.5	867.5	867.5	867.5
R5. Drilling department	226.72	226.72	226.72	226.72
R6. Assembly department	16	16	16	16
R7. Welding department	24	24	24	24
R8. Painting department	16	16	16	16
R9. Thermal department	16	16	16	16
R10. Boring department	16	16	16	16

From Table 4.11, Can see that the three new area sizes have the same space for each department. Each department requires all existing machines except cutting and drilling departments that reduce the size of the area because four unusable machines are transported from the factory area.

4.2.8 Analysis of the results of the alternative plant layout

Analyzing the transport distance of the combined materials of the three alternative plant layouts to compare with the total material transport distance of the current plant layout. Considering the distance of transporting the material multiplied by the number of times the transport is taken, then put the value in the From-away chart and aggregate the total distance. Details of the material handling distance of each plant chart in Table 4.12 – 4.15 and the comparison of the total distance of each chart in Table 4.16.

Table 4.12: Total material transport distance after improvement of first layout

From-To	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total distance
R1	-	6.5	32	8	62	17	77	25	62	32	321.5
R2	6.5	-	0	5.9	39	37	46	4	33	12	183.4
R3	32	0	-	36	0	53	21	22	14	14	192
R4	8	5.9	36	-	19	0	7	0	20	19	114.9
R5	62	39	0	19	-	82	0	13	11	20	246
R6	17	37	53	0	82	-	73	37	58	42	399
R7	77	46	21	7	0	73	-	41	10	39	314
R8	25	4	22	0	13	37	41	-	0	0	142
R9	62	33	14	20	11	58	10	0	-	0	208
R10	32	12	14	19	20	42	39	0	0	-	178
Total distance	321.5	183.4	192	114.9	246	399	314	142	208	178	**2298.8**

Table 4.13: Total material transport distance after improvement of second layout

From-To	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total distance
R1	-	7	41	7	16	80	66	66	103	42	428
R2	7	-	0	9	43	77	93	93	53	64	439
R3	41	0	-	7	58	34	50	50	0	18	258
R4	7	9	7	-	0	6	0	15	6	6	56
R5	16	43	58	0	-	34	0	23	58	47	279
R6	80	77	34	6	34	-	15	0	29	9	284
R7	66	93	50	0	0	15	-	8	40	32	304
R8	66	93	50	15	23	0	8	-	34	26	315
R9	103	53	0	6	58	29	40	34	-	0	323
R10	42	64	18	6	47	9	32	26	0	-	244
Total distance	428	439	258	56	279	284	304	315	323	244	**2930**

Table 4.14: Total material transport distance after improvement of third layout

From-To	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total distance
R1	-	4	56	8	100	87	69	10	90	95	519
R2	4	-	26	0	67	98	70	4	61	66	396
R3	56	26	-	6	39	76	80	0	0	20	303
R4	8	0	6	-	6	9	7	8	10	10	64
R5	100	67	39	6	-	9	38	71	23	0	353
R6	87	98	76	9	9	-	0	104	56	51	490
R7	69	70	80	7	38	0	-	87	75	71	497
R8	10	4	0	8	71	104	87	-	56	60	400
R9	90	61	0	10	23	56	75	56	-	0	371
R10	95	66	20	10	0	51	71	60	0	-	373
Total distance	519	396	303	64	353	490	497	400	371	373	**3766**

Table 4.15: Total material transport distance of the current layout

From-To	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Total distance
R1	-	1	45	69.5	58.5	11	64.5	43.5	14	11	318
R2	1	-	38	68.5	68.5	18	63.5	43.5	19	10	330
R3	45	38	-	64.5	64.5	48	39.5	39.5	61	54	454
R4	69.5	68.5	64.5	-	37	78.5	4	8	78.5	66.5	475
R5	58.5	68.5	64.5	37	-	68.5	31.5	31.5	82.5	67.5	510
R6	11	18	48	78.5	68.5	-	73.5	53.5	1	24	376
R7	64.5	63.5	39.5	4	31.5	73.5	-	20	76.5	62.5	435.5
R8	43.5	43.5	39.5	8	31.5	53.5	20	-	52.5	42.5	334.5
R9	14	19	61	78.5	82.5	1	76.5	52.5	-	13	398
R10	11	10	54	66.5	67.5	24	62.5	42.5	13	-	351
Total distance	318	330	454	475	510	376	435.5	334.5	398	351	**3982**

Table 4.16: Comparison of distance data of each alternative plant layout

Comparative factors	Alternative factory layout			
	The current layout	First layout	Second layout	Third layout
Comparison of the transport distance of the material (meters)	**3982**	**2298.8**	**2930**	**3766**

From Table 4.16, the first alternative plant layout has the shortest material transport distance of 2298.8 meters. This data is then used for economics analysis and other evaluations to further select the most suitable plant layout.

4.2.9 Economic Analysis

This step is an analysis of the payback period of the alternative plant layout. The comparison of material transport distance in Table 4.15 is analyzed for the reduced transport distance of the three alternative plant layouts compared to the material transport distance of the current plant layout. Shown in Table 4.17.

Table 4.17: Reduced distance of alternative plant layout

Alternative factory layout	Calculation method	Reduced distance (%)
Layout 1	[((1/3982)*2298.8)-1]*100	42%
Layout 2	[((1/3982)*2930)-1]*100	26%
Layout 3	[((1/3982)*3766)-1]*100	5%

From Table 4.17, it is concluded that the three alternative plant layouts can reduce the transportation distance within the factory, 42%, 26% and 5% respectively.

In the process of working All operational employees are both workers in accordance with their main duties and sent in. With a total of 27 employees at the operational level, the average labor cost per person is 1,111 Baht, labor cost 30000 baht/day, it is found that the unloading time is 16.76% of the total working time, representing a lost cost of 5,028 baht/day. 42 % 26% and 5%, respectively, based on the introduction of phase data. The shorter material transportation of alternative plant layouts calculates the labor cost savings from the shorter transportation distance compared to the current plant layout. Display and how it is calculated in Table 4.18

Table 4.18: Results and methods for calculating labor costs saved from shorter material transportation distances

Alternative factory layout	Calculation method	Save cost per day (Baht)	Save cost per month (Baht)
Layout 1	5028*42%	2,111	57,017
Layout 2	5028*26%	1,307	35,296
Layout 3	5028*5%	251	6,787

From the transport distance, the shorter material of the alternative plant layout compared to the current plant layout. Therefore, the researchers expect can shorten production time significantly If the assumption is that the transportation of materials inside the plant is shortened, it will help to produce more work. Therefore, the researchers assumed that the three plant layouts increased by 42%, 26% and 5%, respectively, thus increasing output estimates and increasing sales by 42%, 26% and 5%, respectively.

At present, the factory has an average sale of 2,250,000 baht/month, net profit is 21% of sales, that is, 1,859,504 baht/month, so it is expected that sales and net profit of the plant layout are expected. All three options are increased by displaying and calculating methods in Table 4.19.

Table 4.19: Results and methods for calculating sales of alternative plant layouts

Alternative factory layout	Calculation method	Alternative plant layout sales (Baht/Month)	Net profit 21% of sales (Baht/Month)

Layout 1	2,250,000*42%	3,195,000	2,640,495
Layout 2	2,250,000*26%	2,835,000	2,342,975
Layout 3	2,250,000*5%	2,362,500	1,952,479

Therefore, when comparing the net profit of the three alternative plant layouts compared to the net profit of the current plant layout, we have increased the revenue value as shown in Table 4.20.

Table 4.20: Increased revenue of alternative plant layouts

Alternative factory layout	Calculation method	Increased revenue (Baht/Month)
Layout 1	2,640,495-1,859,504	780,991
Layout 2	2,342,975-1,859,504	483,471
Layout 3	1,952,476-1,859,504	92,972

To improve the plant layout, there will be wages to improve. Wage data on the refurbishment of the plant, including the cost of re-planning and forecasting the number of days of planning improvements considered, are based on the average valuation and the number of days of the charting of the three contractors as follows:

Valuation details and the number of days to update the layout of the three contractors.

First Contractor

Layout 1 cost for maintenance areas 880,000 Bath duration 25 days

Layout 2 cost for maintenance areas 1,005,000 Bath duration 27 days

Layout 3 cost for maintenance areas 1,125,000 Bath duration 30 days

Second Contractor

Layout 1 cost for maintenance areas 890,000 Bath duration 27 days

Layout 2 cost for maintenance areas 1,070,000 Bath duration 29 days

Layout 3 cost for maintenance areas 1,220,000 Bath duration 32 days

Third Contractor

Layout 1 cost for maintenance areas 950,000 Bath duration 29 days

Layout 2 cost for maintenance areas 1,150,000 Bath duration 32 days

Layout 3 cost for maintenance areas 1,350,000 Bath duration 45 days

Then, the various data calculated for the payback period will be shown in detail from the plant layout adjustments in Table 4.21 and how to calculate the payback period as shown in Equation 3.1.

Table 4.21: Details of economic data from plant layout improvements

Economics Information \ Alternative factory layout	Layout 1	Layout 2	Layout 3
1. Cost for maintenance areas	907,000 Bath	1,075,000 Bath	1,232,000 Bath
2. Days of maintenance	27 Days	30 Days	36 Days
3. Cost saving from shorter material transportation distances (Baht/month)	57,017 Bath	35,296 Bath	6,787 Bath
4. Increased productivity	42%	26%	5%
5. Increase in revenue (Baht/month)	780,991 Bath	483,471 Bath	92,972 Bath
6. Payback period (months)	1 Month	2 Months	12 Months

Equation 4.1

Payback period = (Cost for maintenance areas) / (Cost saving from shorter material transportation distances + Increase in revenue)

Example 4.1 The payback period of layout 1 is equal to:

Payback period = (907,000) / (57,017 + 780,991) = 1.07 or about 1 month.

4.3 Evaluation

The testing described in section 4.2 show that SLP can create a plant layout capable of draw in up the potential of the factory area. Therefore, in this section we will evaluate, implement, and discuss factory issues to improve the plant layout. It is based on the data that has been calculated.

4.4 Testing and Evaluation Summary

This chapter describes the whole process of SLP in the factory. The chapter begins with explore the production problems of the current plant layout (section 4.2.1), then collection of basic plant data (section 4.2.2) and explore the 5 most ordered products (section 4.2.3). Collect all the information you need to consider plant layout on the product type and quantity chart (section 4.2.4) and create a Multi-Product Process Chart (section 4.2.5) to understand the flow in the factory products. Once the product flow is obtained, it is possible to analyze department relationships using the relationship tree and relationship diagram (section 4.2.6) to find out what kind of diagram the factory can provide by creating 3 diagrams. All three diagrams of plants need to be carefully considered the limitations and design of alternative plant layouts (section 4.2.7) when we get all three types of plant layouts, we use analysis of the results of the alternative plant layout (section 4.2.8), giving us the information of each. How much space then bring each type to compare with current plant layout to Economic Analysis (section 4.2.9) how much the percentage of area of that plan was reduced. Which when we get the reduced area percentage, we can calculate calculating labor costs saved from shorter material transportation distances, calculating sales of alternative plant layouts and increased in income of alternative plant layouts. We can use all the information to find the payback period of each plant layout.

CHAPTER 5
CONCLUSION

5.1 Introduction

In this Chapter, we first summarize the work described in this report (section 5.2). According to the theory of systematic plant planning (SLP), the result is to design the plant layout based on the data obtained from the operation. Let us summarize the comparison of the current plant layout with the new plant layout, the result summary in (section 5.3) and finally in section 5.4 we discuss future work.

5.2 Summary

The summary of each chapter

Chapter 1 introduced the problem in Sahamit Metal Industry Company and objective of the project.

Chapter 2 reviews and method the systematic layout planning (SLP).

Chapter 3 describes the design and implementation of SLP in factory.

Chapter 4 demonstrates how the SLP performs in the project layout test.

Chapter 5 presented a series of tests that demonstrate the results of the SLP of the three alternative plant layouts and conclude which alternative plant layout should be the most suitable.

5.3 Conclusions

The aim of this project was to design and factory model to suit the production line of Sahamit Metal Industry Company. By exploring the problems in production of Sahamit Metal Industry Company. Therefore, the researchers were able to summarize the problem as follows: There is delay, need more space to operate, lack of operating space and raw material placement area and then analyzing the flow of all 5 products are Column Arm Electrode, Trommel, Piston Rod, Mud Filter Drum and Suction Box Corrugate Sheet.

For designing and planning plants to suit the production line of Sahamit Metal Industry Company by used the systematic layout planning (SLP). It can design three alternative plant layouts. The first alternative plant layout has a transportation distance of 2298.8 meters, representing a reduced distance from the current plant layout of 42%, with a saving transportation labor cost of 57,017 baht/month and the current increase in income is 780,991 bath/month and the payback period is 1 month. The second alternative plant layout has a transportation distance of 2,930 meters, representing a reduced distance from the current plant layout of 26%, with a saving transportation labor cost of 35,296 baht/month, the current increase in income is 483,471 bath/month and the payback period is 2 months, and the third alternative plant layout has a transportation distance of 3,766 meters, representing a reduced distance from the current plant layout of 5%, with a saving transportation labor cost of 6,787 baht/month, the current increase in income is 92,972 bath/month and the payback period is 12 months.

According to the results, the plant selected first alternative plant layout as the factory model that best suits the production line of Sahamit Metal Industry Company.

5.4 Key Points

According to the study of the appropriate guidelines for plant planning. Considering the flow process in the production line. After implementing the plant layout improvements to help increase productivity and process flow, the following key points.

5.4.1 Create the production schedules

The plant layout should perform sequencing and production schedules to maximize resource efficiency and reduce waiting in the production process.

5.4.2 Manage the scrap

The plant layout should clearly separate the type and storage of unused steels with used steel. This includes keeping the remaining scraps for convenience, speed and no obstruction of operation.

5.4.3 Security

1. Fire extinguishers should be installed in areas that are convenient to use and always check the condition and train the use of fire extinguishers with all employees.
2. The factory should supply the mask or PPE for the employees wearing in welding time. To prevent the danger of sparks from occurring.
3. Supervisors should provide annual health check-ups to employees to reduce health costs with employees.

REFERENCES

Chana Yiangkamonsing: Case study on the improvement of the mold factory layout for the circuit board. electronics. Accessed on May 20, 2015. Accessed from: https://searchlib.utcc.ac.th/library/onlinethesis/259366.pdf

Somsak Trisat. (2005). Design (and plant layout. 10th edition Bangkok: Technology Promotion Association (Thai Japanese)

Somphatsorn Euaareemit, Thanat Mokkhamakul (2008). "Improvement of factory layout using a scenario model: a case study of a garment factory." Academic of the National Operational Research Annual (2008)

Suthipong Promsuwan, Chana Yiangkamonsing. (2007). Study on the enhancement of factory layout, a case study of K Furniture Co., Ltd." in Proceedings of the 2nd UTCC Graduate Research Conference 2007, 1185-1192. Bangkok: University of the Thai Chamber of Commerce Press

Lertpong Sekchaisue, Riphuwan Chantarasa (2012). "Improving the car accessory assembly company layout with principles of systematic plant layout design." Industrial Engineering Year 2012. 601-607.

Waewdao Samanphan, Nantachai Kantananánth (2013). "Improvement of factory layout to balance production capacity. By problem modeling in the hard disk drive industry. " KKU ENGINEERING JOURNAL, 40 (April-June): 173-178.

Vimlin Sukthomaya. (2012). Plant layout. Accessed on 20 May. Accessed from: http://blog.bru.ac.th/wp-content/uploads/bp-attachments/6776/เอกสารประกอบการสอนรวมเล่ม-ดร.อุดมพงษ์2561.pdf

Anat Wattanasangsut, Tharatat Kaolim, Sombat Teekasap, Chusak Pornsing. (2005). "Management of the Couple A Garment factory production plan." In the industrial engineering network conference Year 2005. 978-985.

Nittaya Bumrungrad (2009). Design and layout of the thin film amorphous silicon solar panel factory with a capacity of 10 MW per year, a case study of the prototype plant for solar cell production of NSTDA. On 10 May. Accessed from: http://libdoc.dpu.ac.th/mtext/article/431917.pdf

Nittaya Ngamphakt. Selection of layouts and computer simulation for cellular plant layout design. Accessed on May 1 0 , 2 0 1 5 . Accessed from: https://mim12natthapon.blogspot.com/2017/10/blog-post_28.html?m=1

Prachuap Klomchit. (2012). Industrial plant design. Bangkok: Se-Education.

Fred E. Meyers, Metthew P. Stephens. (2005). Manufacturing facilities design and material Handling (Vol. 3rd edition). United States of America: Pearson Prentice Hall

Niebel, B. W., &Freivalds, A. (2003). Methods Standards and work design (11 Ed.). New York: McGraw-Hill.

APPENDICES

APPENDIX A

SELECTED LAYOUT

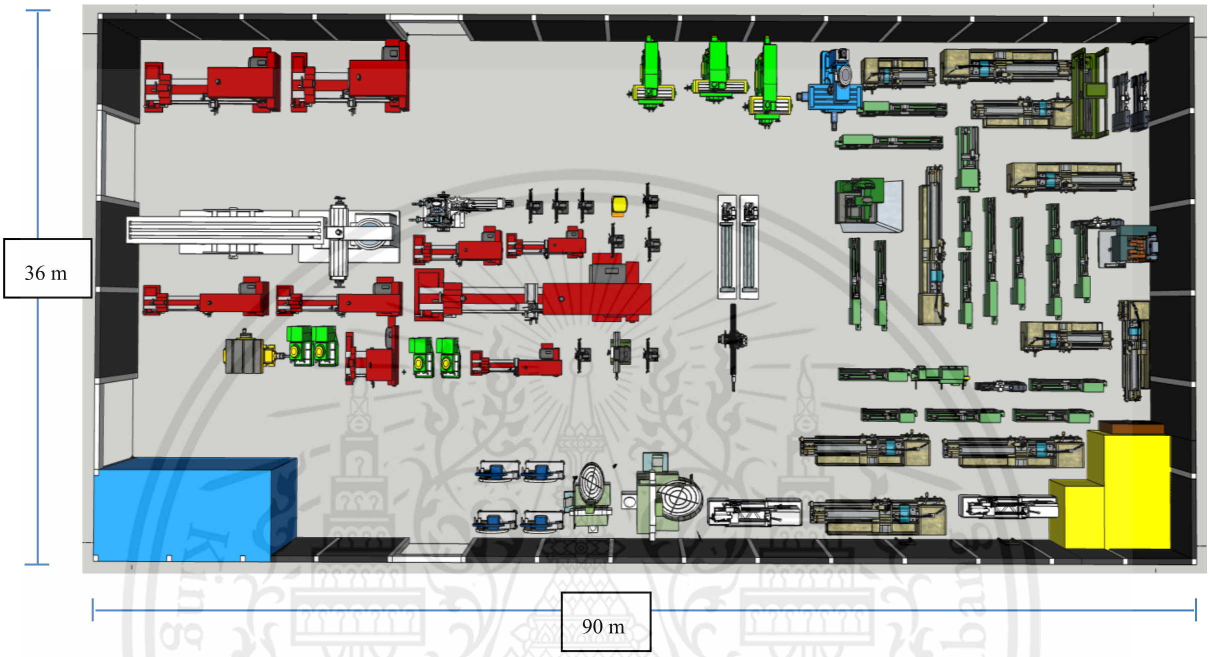


Figure 6.1: Show the first alternative layout or the best suitable layout for Sahamit Metal Industry Company

APPENDIX B
FIGURES OF AREAS IN SAHAMIT METAL INDUSTRY COMPANY

Figure 6.2: Outside the factory of Sahamit Metal Industry Company

Figure 6.3: Inside the factory of Sahamit Metal Industry Company

Figure 6.4: Entrance Gate 1 of Sahamit Metal Industry Company

Figure 6.5: Entrance Gate 2 of Sahamit Metal Industry Company

Figure 6.6: Entrance Gate 3 of Sahamit Metal Industry Company

Figure 6.7: Entrance Gate 4 of Sahamit Metal Industry Company

Figure 6.8: Crane in factory of Sahamit Metal Industry Company

Figure 6.9: Office department