LAYOUT PLANNING FOR FABRICATION VESSEL AND TANK MANUFACTURING

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Engineering Program in Engineering Management

The Regional Centre for Manufacturing Systems Engineering

Faculty of Engineering

Chulalongkorn University

Academic Year 2009

การออกแบบผังโรงงานสำหรับผลิตถัง

นาย ชัชชัย สบายยิ่ง

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต

สาขาวิชาการจัดการทางวิศวกรรม ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต

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ปีการศึกษา 2552

ชัชชัย สบายยิ่ง : การออกแบบผังโรงงานสำหรับผลิตถัง. (LAYOUT PLANNING FOR FABRICATION VESSEL AND TANK MANUFACTURING) อาจารย์ที่ปรึกษาวิทยานิพนธ์หลัก : รศ. ดร. ปารเมศ ชุติมา, 82 หน้า.

การวิจัยนี้มุ่งเน้นการศึกษา วิเคราะห์ และการปรับปรุงผังโรงงานของโรงงาน ตัวอย่างที่ทำการประกอบเหล็ก เพื่อที่จะลดเวลาในการผลิต ลดค่าจ้างคนงาน และลดการขนย้ายวัสดุภายในโรงงาน การวิจัยครั้งนี้ใช้ความรู้ทางวิศวกรรมอุตสาหกรรมและวิศวกรรมการจัดการในการวิจัยครั้งนี้อาทิเช่นการวางผังโรงงาน การศึกษาการทำงาน การวัดการทำงาน เป็นต้น

ภายหลังการศึกษาผังโรงงานในปัจจุบันพบว่าเป็นผังโรงงานที่มีปัญหา และมีพื้นที่ที่จำกัด เนื่องจากการวกไปวนมาของเส้นทางการไหลของวัสดุภายในโรงงาน พื้นที่ที่จำกัดการวางตำแหน่งของแผนกต่างๆที่ไม่เหมาะสม ทั้งหมดนี้ก่อให้เกิดการอุดตันของการไหลของวัสดุ การใช้เวลาในการผลิต เค ลื่นย้ายวัสดุที่มาก และอันตรายระหว่างการทำงาน ซึ่งปัญหาและข้อมูลที่กล่าวไปแล้วข้างต้นจะเป็นข้อมูลพื้นฐานในการวิจัยและพัฒนาผังโรงงานต่อไป

วิธีในการพัฒนาคือการจัดตำแหน่งใหม่ของแผนกต่างๆและเครื่องจักร ภายในพื้นที่โรงงานปัจจุบัน พร้อมทั้งมีการวัดเวลาในการผลิตด้วย ภายหลังการปรับปรุงแล้ว มีผังโรงงานที่ได้ออกแบบเป็น 4 ตัวเลือก คือ 1. ผังโรงงานที่จัดวางตามลักษณะของการทำงาน 2. ผังโรงงานที่จัดวางตามลักษณะอยู่กับที่ 3. ผังโรงงานที่จัดวางตามขั้นตอนการผลิต หลังจากการวิเคราะห์ ผังโรงงานแบบ และ 4. ผังโรงงานที่จัดวางตามลักษณะของการทำงานรวมกับผังโรงงานที่จัดวางตามขั้นตอนการผลิต หลังจากการวิเคราะห์ ผังโรงงานแบบสุดท้ายให้ผลออกมาดีที่สุดเมื่อเปรียบเทียบกับผังโรงงานสามแบบแรก กิจกรรมที่ไม่จำเป็นในการทำงานได้ถูกตัดทิ้งไป การไหลของวัสดุถูกจัดให้ง่ายขึ้น ผลที่ตามมาคือการลดของเวลาในการผลิตลงเหลือ 14% ค่าแรงคนงานลดลงเหลือ 14% พื้นที่ในการผลิตเพิ่มขึ้น 26% และของเสียได้คัดแยกออกไปจากพื้นที่ทำงานทั้งหมด ยิ่งไปกว่านั้น ผังโรงงานใหม่ยังช่วยลดโอกาสในการเกิดอุบัติเหตุในการทำงานซึ่งปัจจุบันยังคงเป็นศูนย์

ภาควิชา ศูนย์ระดับภูมิภาคทางวิศกรรมระบบการผลิต ลายมือชื่อนิสิต ....

สาขาวิชา การจัดการทางวิศวกรรม ลายมือชื่อ อ .ที่ปรึกษาวิทยานิพนธ์หลัก...................

#4971605321 : MAJOR ENGINEERING MANAGEMENT

KEY WORD: Plant layout design improvement/ Material Flow/Tank fabrication

CHATCHAI SABAIYING : LAYOUT PLANNING FOR FABRICATION VESSEL AND TANK MANUFACTURING. THESIS ADVISOR : ASSOCIATE PROFESSOR PARAMES CHUTIMA, Ph.D., 82 pp.

This research aims to study, analyze, and improve the plant layout of the case study factory, i.e. a steel fabrication company, in order to reduce the production time, labour cost, and safety level. This research is also based on industrial engineering and engineering management knowledge such as plant layout, work-study, and work measurement.

After studying the existing plant layout, it is found that it is a poor plant with limited space. Because of complicated material flow, limited space, unsuitable location of departments, this result in the bottleneck, excessive use of time in production and transportation, high risk of accident within the factory. All the problems are the bases for analyzing and defining the way of improvement.

The method of improvement is to relocate the department, and machine along with the measurement of the production time in the new location area. After improvement, there are 4 alternatives plant layouts, which are process layout design, product layout design, fixed layout design, and combination layout design. After analyzing, the combination layout design gives the best result compared to existing design and other 3 alternatives. The unnecessary activities is eliminated, the material flow is smoothed out. Those reduce the production time to 14%, labour cost to 14% compared to existing plant layout which result in increasing the productivity. Space area increases 26% and all raw materials are in place properly. Moreover, the new design also reduce the risk of having the accident while running the production with currently equal to zero.

The regional Centre for Manufacturing Systems Engineering Student's Signature………

Field of Study Engineering Management Advisor's Signature…………..................

Academic Year: 2009

Acknowledgement

The author would like to thank to Associate Professor Dr. Parames Chutima, my thesis advisor, for his valuable suggestions through my thesis.

Also, thank you to Professor Dr. Sirchan Thongprasert and Associate Professor Jeerapat Ngaoprasertwong for being the members of the examination committee and for every valuable suggestion.

Many thanks for the people in the factory, who gives me lots of information in order to use in this research, without them it will be a lot more difficulties in doing this thesis.

Thanks for all my friends and colleagues for sharing good time in class and for support and good opinion in doing the thesis.

Finally, this thesis will not succeed without support from my family. Their support, encouragement, and understanding is very valuable for me in doing this thesis.

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CHAPTER I
INTRODUCTION

1.1 Background of the Research

In the metal manufacturing business, quality and price have taken a major role in today's competitive domestic. In order to survive and stay competitive in the business, manufacturers have to improve their capability and performance and do so continuously. As a basic to achieve such advantages, any company needs to become more responsive, customized and be able to meet the increasingly demanding customer requirements.

Currently, economic in Thailand has been in crisis due to many factors such as, unstable government, high price of oil. As a result of these problems, many products are increasing the price rapidly. Many companies are suffering about these factors. On the other hand, companies still have to sustain a quality with the competitive price in order to survive in the market especially in manufacturing firms which mainly make customized products and services.

The study in this thesis will describe how can we design and implement the new tools concept that can increase the working space area, reduce cost and enhance the company competitiveness where the improvement of the efficiency can be done by using the engineering knowledge such as quality control, work and time study, plant layout, etc.

In fact, plant layout can be used to improve the productivity since the good layout can lead to the full utilization of the space, machine, material, and workforce. From that result the company can produce the high quality product with the right delivery time, increase space utilization and can reduce the ineffective movement of material handling and work in process.

1.2 Company Background

Charoen Vivat Rungreung Engineering Corporation was officially established in1988, started from family business. The company operates as the construction firm that fabricates all metal work and operates as a make-to-order manufacturing unit. The company's product ranges have many varieties of the products produced form the construction of the steel sheet such as chemical tank holder, power vessel, etc. The characteristic of the manufacturing is combination layout which are process layout mix with fixed layout.

Later in 1998, the company has invested new machines such as bending machine, cutting machine, rolling machines, buffing machine in order to open a new market in stainless steel fabrication especially for chemical tank holder and vessel. The company products are varied depending on customer requirement.

In 2005, the company has relocated from Samutprakarn plant to Chonburi which nearby Amata Nakorn Industrial District. The size of new factory is two times bigger than an old plant. Even though the company has moved to new location which has a space available bigger than the old place, without awareness of plant layout design, the company has many problems such as complicated workflow, bad material handling, high workforce needed, bottleneck, and delay. As a result, the project of plant layout will be used to design the existing plant layout of the Charoen Vivat Rungreung Corporation in order to have a fully utilized design layout of new plant.

1.3 The procedure of manufacturing the product

For vessels and tank fabrication, the production process consists of cutting, bending, assembling, welding, smoothing, cleaning, buffing, and testing. There are 30 workers in the production process. Some of them are expertise in each process, but some of them are only helper and has no any expertise. The ratio below (Fig 1.1) shows the number of skilled workers and non skilled workers.

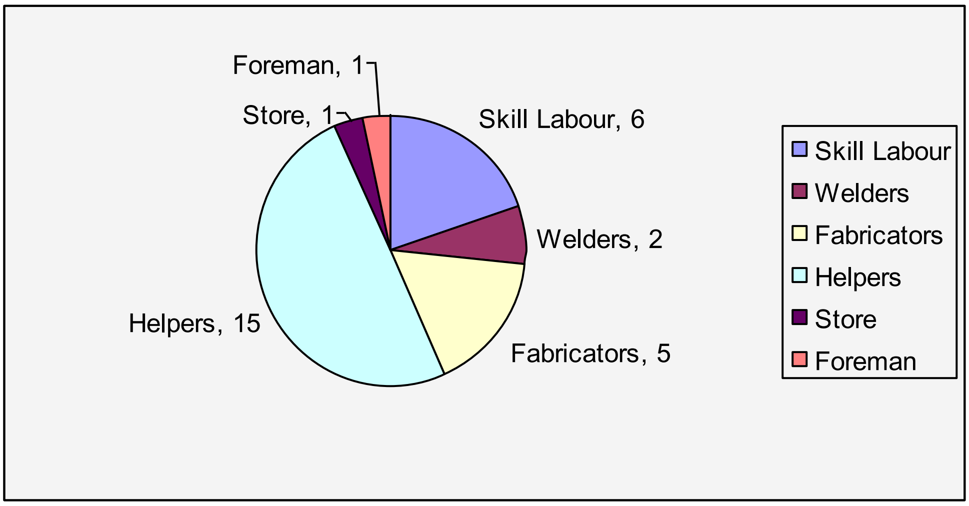


Figure 1.1 : The number of workers

In each production line, every process is playing an important role. The following are the descriptions for each production processes.

Cutting : The cutting process is the first step to fabricate vessel and tank. Metal sheet will be cut by size according to layout from designer. This process need to be very precise because cutting the wrong size can effect to the wrong specification from customer.

Rolling : Rolling is the process that curve a flat sheet from cutting section to make a shape as by drawing. Radius of curve has to synchronize with the cutting size otherwise the size will not be in the right shape.

Assembling : The assembly process is the process that joints the parts that have been prepare separately such as, flanges, nozzles, manholes and so on by using welding machine (only spot). After all the parts are jointed together it will be transferred to the welding section.

Welding : This process is required a skilled workers in welding because vessels or tanks need to be seal 100% to avoid leakage. Some vessels or tanks have to be welded more than 3 layers due to high pressure or very dangerous chemical.

Smoothing : After the welding process the product will pass though the smoothing process. The reason to do this process is to smooth the surface from welding.

Coloring or buffing : Coloring process is for the Carbon steel products which requires to coat with the primer in order to make final finishing adhered to the product. After that, coloring will be painted on products. On the other hand, buffing process is for the Stainless steel products. This process takes a very long time to complete it because the procedure has many steps to be followed. The advantage of this process is that the product will be very shine like a mirror. Mostly, this product is likely to be used in Powder industrial such as, powder detergent.

Testing : Before deliver finish products to customer, testing is a final process to check any leakage all around products. There are two testing type that can be tested, one is air test and another is Hydro test (water test).

1.4 Currently situation of company

Currently, the company has limitation of working capacity, and especially the availability of working space that effect the limitation of overhead crane which is indicate the route of material flow, the area of the existing plant is approximately only 640 square meters. Consequently some manufacturing project has to finish half of a project and deliver the product out of the factory area and then start the other half of the project. In some case, some of the project, the product is too large for the company to make. It is not because of the ability to produce but because of the limitation of workspace and the limitation of the overhead crane that reflect to the type of the machine that is not be able to locate in the plant. The flow of the work is also another obstacle that company has been facing for a long time, since there is no plant layout study before locating the machine mainly because of the limitation of the space in workplace

1.5 Statement of Problem

Since Charoen Vivat Rungreung Corporation has already moved to a bigger place, some unexpected problems have been occurring into the company. So the company would like to design a new plant layout in an existing plant location in order to have a good designed plant and to increase the capacity and capability of working. Moreover, from producing the relatively large product, the company needs to use the overhead crane to transfer the product between processes. From that reason the company needs to concern the use of the overhead crane because the position of the overhead crane will be mainly indicate the route of the workflow.

The following are the factors that occur during production process that causes in over cost in production.

1. Inefficient organize storage area

Figure 1.2 : Factory storage

In figure 1.2, it is obvious that the storage area is under the messy and untidy condition. In the daily inbound operation, the steel plate and pipe are disorderly placed on the factory floor. As a result, inconvenience and difficulties have been generated for the employees to pick the materials which waste a time in production. After a while, all these materials will become dusty, dirty and the worst are rusty. These can be result in waste of materials.

2. Inefficient space utilization

Figure 1.3 : Working area

Due to the untidy condition (Fig 1.3), the space in the factory is unable to be effectively and efficiency utilized. Some useful space is taken up by the unnecessary component. The distance from one section to another is not well organized and cause in waste of time.

3. In efficient raw material utilization

Figure 1.4: Raw materials

Since the company is a make-to-order manufacturer and the raw materials order quantity is approximately set in accordance to the customer specifications. It is unnecessary for the company to hold the inventory. However, due to the fact of the customers frequently changing the demands after the raw materials being delivered, excessive steel bars unavoidably turned up in the factory as time to move on. Currently, raw materials are disorderly piled up as shown in Fig 1.4, a great deal of bottom material such as metal sheet or steel bars could not be used due to the difficulties of moving out. These raw materials are the heart of cost saving. What the worse is that some raw materials become obsolete due to the customer changing requirements on material type, which directly makes the loss on the Company's investment. Moreover, having raw materials or scraps all over the floor can cause an accident to workers and large amount of factory useful space being occupied by them.

4. In efficient employees

Most of the projects which were over cost in production are from human factor. Each year, the company has to spend lots of money on labour cost for overtime working and double charge for working on weekend/holiday. In the past, many projects were complete just about on time or delay because when the due date was coming, extra cost in overtime and holiday has been spent on employees in order to avoid customers complain. Another serious problem is identified as a potential safety hazard. In the historical injury and accident record of company, employees were injured due to production phase. Because of no safety policy for the factory has been ever established after inquiring the managers and employees. No formal safety operating procedure and rule have been formulated to follow.

1.6 Research objectives

The objective of this research is to improve a layout of fabricating vessel/tank manufacturing which will be resulted in increase a working area, reduce a labour cost, increase working safety level, increase the utilization of the material handling, all of these are directly effect from the design of the plant.

1.7 Scope of the research

The research concerns with designing the new layout to improve an existing plant in vessel and tank fabricating area by using quantitative analysis, such as flow time and material handling route and distance, and qualitative analysis such as the relationship between facilities. Additionally, it will only be applied to one product/product type. The research is also limited in that we will not investigate individual machines improvement potential or look into the design of the products to improve the production.

1.8 Expected Benefit

1. The fully utilized design layout of an existing factory
2. Increase the safety level
3. Effective material handling
4. Reduction of production cost

1.9 Research Methodologies

1. Study and research a related topic of this thesis
2. Collect all available background information
3. Analyze and summarize the problems to the new design
4. Implement the layout and evaluate the performance
5. Collect the result and compare with previous result after the improvement
6. Make conclusion and recommendations
7. Write up thesis and submit thesis

CHAPTER II
THEORETICAL CONSIDERATION AND LITERATURE SURVEYS

2.1 Theoretical consideration

Productivity is related to the concept of efficiency. It is a method use to measure how well an organization can convert its input resources to goods and services or simply just a ratio of input and output. Every industry aims for higher productivity rate because as the production increases it will soon follow the rate of increase in terms of profits. There are several ways on how to improve productivity. One of which that is being considered is having an efficient plant layout.

Every infrastructure requires having a layout. A layout is consisted of the detailed plan of the structure being constructed or reconstructed. It emphasizes the arrangements and proper positions of the basic elements of the plan. A layout serves as a guideline for the builders as well as the owners of the establishments to visualize the physical appearance of the infrastructure. A layout also includes the proper allocations of space and equipments that will be use within the production of the plant. It is a very importance aspect within the manufacturing cycle.

Plants should have an ideal layout in order to improve their productivity means. A properly laid out plant ensures a smooth rapid movement of materials and employees. However, plants layouts are dynamic in concept because it tends to adapt several changes regarding the need for improvement of the industry.

2.2 Production and Productivity

The difference between production and productivity is often neglected. These two economic terms are entirely different from each other. Production is all about the total amount of goods and services being produced while productivity refers to the efficiency of production. A manufacturing enterprise should always strive for higher productivity rate; a higher productivity means producing more within the given input resources or producing a given quantity with a lesser input resources. However, increase productivity should not be confused with an increase production because an increase production can be attained by increasing input resources while productivity will remain the same. Either way, productivity can be improved by the efficient use of input resources but at the same time the production may stay the same.

Productivity is important not only in manufacturing but also in the country itself. A higher productivity means a greater opportunity for prosperity. It also leads to a lot of benefits such as it decreases the cost of production which results to a domino effect that also decreases the cost of the product therefore it would become more affordable and available to the public. It tends to lower the production cost and it increase production as it increase the profits of the company. It promotes social and economic progress. It alleviates poverty. It improves working conditions of the workers as it increases their wages. Lastly it advocates exporting companies to compete more in foreign markets. The following benefits are possible with a proper management of productivity.

2.3 An Efficient Plant Layout

One of the aspects that can affect the productivity of an industry is the plant layout. The plant layout involves the planning path each component part of the product is to be followed within the plant. It also includes the proper coordination of each parts so that the process of manufacturing will be carried out in the most economical and practical manner. A plant layout is composed of a detailed plan of the infrastructure – the sketches, drawings that are carefully scaled on order to achieve the real visualization of the plan that is going to be implemented.

The main objective of the having a plant layout is to provide an overall satisfaction to all concerned. Meaning, it should enhance the productivity of the industry more. Hence, other objectives includes the prevention of accidents, promotion of the job satisfactory, reduction of productions delay and manufacturing time, simplification in control of production, avoid necessary capital investment, help effective utilization of employees, machine and services and lastly increase in productivity.

The need for a plant layout depends on the industry itself. The layout of each plant differs from the nature of the industry. The necessity for planning a layout may be due several reasons like a change in product design new which may have to be also a change in manufacturing operations or the sequencing of the processes. It can also be because of a relocation of existing departments or addition of new departments. This is the more usual reason why an industry asks for plant layout. This also includes renovations of the former establishments in the plants for improvement causes. Finally is the need for setting up a new plant. Maybe for further expansion or addition of a new product is utilize by the industry that is why they needed a plant layout for it.

Hence, a well-planned layout is always to be considered to ensure the efficient control over the various production processes.

2.4 Type of plant layout

Layouts may differ according to the category of the business or units. These categories may be manufacturing units, traders and service establishments. In case of manufacturing units, there are four types of layouts considered: the product layout, process layout, fixed position layout and the combination layout.

The product or line layout ensures that each product follows an assembly line where different operations are being done in a sequential manner. Normally, materials are being fed into the machines and the other processes follow in order. Example of which is the paper industry.

The process layout or the functional layout is a type of layout that groups together equipments or workstations that are similar in task. Within this layout, the partly finished products may move from process to process and each batch may follow different routine. Industries engage in handicrafts products usually use this kind of process.

In fixed position layout, the major product is usually being fixed or produce in a fixed location, as it names implies. This is mostly use by large scale entrepreneur like ship yards. All of their production is done in one place which tends to be their work center.

In combined layout, this may be the combination of both or even all of them. Industries involving fabrications of parts may use this method. They can engage with the combination of product layout and process layout.

2.5 Factor influencing a Plant Layout

There are several factors that can affect the layout of the plant and it would be advisable for every entrepreneur to consider these factors to minimize hazards during the plant construction.

First, take note of the nature and size of the building. Determine if the area allocated is sufficient for the activity of the company. Make sure to consider proper ventilation within the space.

Second, know the nature of the product. A uniform product requires a product layout while a custom-made product is more appropriate to process layout. The production process is also similar to this wherein the product layout is more considerable among assembly-line industry while process layout on the other hand is more desirable by intermittent manufacturing.

Third, the equipments to be used, usually general purpose machines are arranged as per process layout and special purpose machine are arranged according to product layout.

Fourth, the repairs and maintenance, negative circumstances should always be considered since it is cannot be avoided, every equipment in the factory should be arranged in an adequate position so that by the time that necessary repairs are needed there should be an allocated space for them to be moved and repaired.

Fifth factor is the human needs. The plant layouts should also be meant not only for the equipment but also to the needs of the employees. There should also be enough facilities for them like sport room, canteen, toilets and lockers that are only meant to comply with their needs.

Finally, the last factor that influences the plant layout is the plant environment. The light, heat, noise, ventilation and other aspects should be duly considered. This part is somehow a prerequisite among plant layouts to minimize accidents in the plant especially if the plant is engage in production of hazardous materials. Adequate safety and precautions are also be made.

2.6 Theory of collecting data that is used in improving plant layout

2.6.1 Manual material handling

Manual material handling is one of the most common activities in manufacturing companies, especially at smaller companies. The concept includes every situation when an employee manually handles goods or work pieces before or after an operation accordingly it do not contemplate the manual element in the operation per se. Manual material handling is a necessary element in the production process and appears irrespective of whether the task is mechanized or manual.

Manual material handling often does not appertain to the activities that are being noticed unless there is a direct connection to the process. A significant part of the manual material handling is therefore unnecessary or physically demanding tasks that lead to expenses for the company e.g. re-loading among different load carriers, up and down picking of work pieces from buffer stocks, manual material transport between different production stations and manual managing of material/pieces at arrival and delivery.

2.6.2 Material handling equipment

Material handling equipment is, like the name implies, the equipment needed to handle the material at issue. Tompkins (1996) classifies the material handling equipment into four different categories:

1. Containers and unitizing equipment.
2. Material transport equipment.
3. Storage and retrieval equipment.
4. Automatic data collection and communication equipment.

2.6.3 Material handling system equation

The material handling equation system equation (Figure 2.1) is a tool that can assist the work of developing alternative material handling system design. The question what deals with what type of materials that is to be moved. Where and when deals with time and place. How and when are concerned the material handling methods. Together these questions give the material handling system equation: Materials + Moves + Methods = Recommended system. The important thing is that for each of these questions one asks oneself why? Why is this amount stored? Why is the material stored in this location? Why is the material moved in this way? Etc. Tompkins et al (2003).

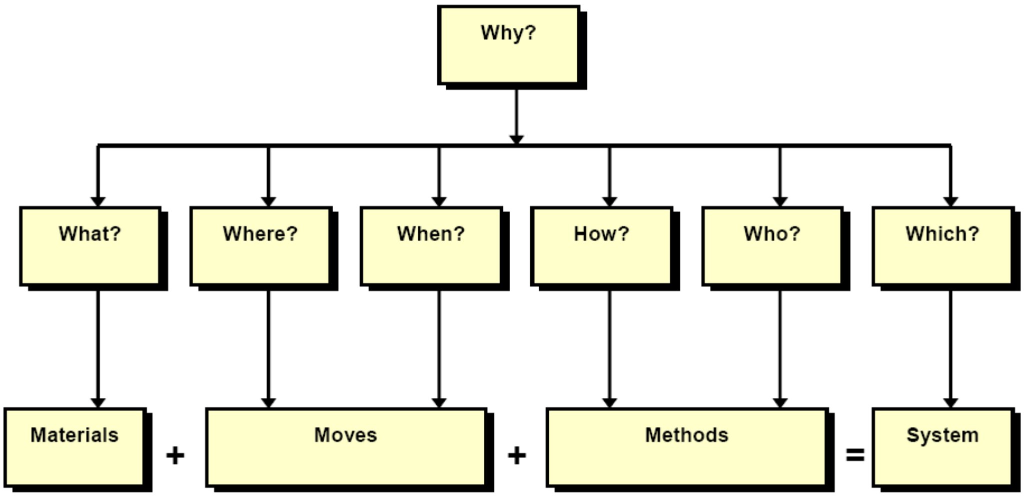


Figure 2.1 : Material handling equation

2.6.4 Flow process chart

A flow process chart traces the movement of material through every step of a process. It uses the standardised process chart symbols shown in Figure 2.2. It can be used when observing a process, in order to visualise it in an understandable way and to get an accurate description of it. It can be used to find improvement opportunities in every step of a process.

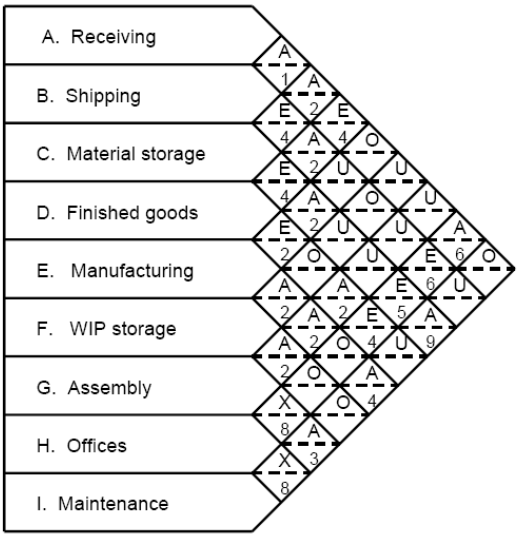
Symbol	Meaning
○	Operation
⇨	Transportation
□	Inspection
D	Delay
▽	Storage

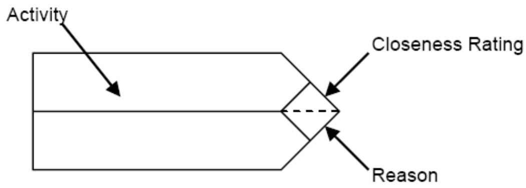
Symbol	Description	Operation time	Department	Total time	Distance	Total distance
○ ⇨ □ D ▽						
○ ⇨ □ D ▽						
○ ⇨ □ D ▽						
			Total			

Figure 2.2 : Flow process chart

2.6.5 Relationship chart

Relationship values may be used when measuring qualitative flow closeness. The value and the reason behind the value can be recorded in a so-called relationship chart (Fig 2.3). The relationship chart shows which activities that have a relationship to each other. Each cell is split so it shows the importance of the closeness and this can be supported with one or several reasons. Relationship chart is the best way to integrate supporting activities in the process investigated.





Value	Closeness rating
A	Absolute necessary
E	Especially important
I	Important
O	Ordinary closeness OK
U	Unimportant
X	Undesirable

Figure 2.3 : Relationship chart

The closeness values are rated according a vowel scale that can be seen in figure 3.5. If the facility planner is unfamiliar with this method it can result in over assigning of A ratings. Muther (1974) suggests a range of frequency of rating occurrences for each vowel. A should be presented about 2 to 5% in a relationship chart, 3 to 10% for E, 5 to 15% for I, and 10 to 25% for O. In most projects almost half of the boxes checked with a U. This is a reason why this closeness is not marked in the relationship diagram. The frequency of X depends on what project that is investigated.

2.7 Improvement technique

Appling the correct technique into the implementation stage will facilitate the procedure and enhance the final results of improvement. At the factory, 5S's technique is commonly and widely used across the world and regarded as a most effective and efficient technique to improve the physical condition.

2.7.1 Concept of 5S's

5S's practices, originating and being developed from Japan companies, is a useful tool to improve both work and life. To apply this technique properly, thus, first to understand the meaning and implication of 5S's is a must. The word used to interpret the 5S's may vary from place to place, but the fundamental principles are exactly same. Hirano (1995), one representative 5 S's researcher, who contributed a great deal of literatures in this field, interpresting the 5S's as Organizaiton, Orderliness, Cleanliness, Standardized Cleanup and Discipline. He further explained its implication in detail as well. 5S Practice relate to corporate health and survive and is the foundation for improvement.

1. Organizaiton

The concept of Organization is clear identifying what is necessary and what is unnecessary. In another word, sort out the things to be kept and throw out the unnecessary things. Sometime, it is difficult to decide whether or not the target is still necessary. Hirano's suggestion is "When is doubt, throw it out." This is because useless things may result in future errors and problems.

2. Orderliness

The meaning of Orderliness is keep things in an organizing way so that every one can use and find them easily. This is important for everyone in the workplace to keep how things are kept in their mind.

3. Cleanliness

Cleanliness implies that the floors are swept and things are keep in order. It helps find the problems concealing under the dirty, dust and debris and make the improvement of workplace or machines through clean state.

4. Standardized Cleanup

Standardized Cleanup means maintain the previous three steps: Organization, Orderliness, and Cleanliness. Maintenance can also be improved by preventing the dirt from occurring.

5. Discipline

Discipline means keeping following the standardized procedure. Without Discipline or maintaining 5S conditions, 5S campaign will stop soon. The best way of maintaining 5S is that managers or 5S formulators set themselves as the pioneers to maintain the 5S.

2.7.2 Concept of Safety operation

The safety rule must be formulated and delivered to the employees as well, In addition, training on safety rule is required to not only the new operator, but also sophisticated staffs. In order to ensure the safety rule take action, at the same time, some mandate measures must be taken. For example, fine or penalty is applied to the workers who violate the safety rule during the operations and the responsibilities are traced back to the supervisor if accident happened. Following is the safety rule being schemed for the company.

- Helmut must be worn during the stock movement.
- Inflammable goods and smoking are strictly prohibited in the stock area.
- Without permission, no employees can change the configurations of storage equipments.
- No people are permitted to stand under the raw materials during its movement.
- The machine and handling equipments must be inspected periodically.
- During the operations, at least two staffs are required.
- Safety warning signs must be post up at the visible place.
- New employees must be trained before operating.
- Report the unsafe conditions to the supervisor as soon as possible.
- Conduct safety examination periodically.

2.8 Example of plant layout improvement

The review was performed in the following databases: Yiangkamolsing (1998) wrote a thesis about an application of genetic algorithms in plant layout design. The author classified the facility layout into 2 classes, quantitative data and qualitative data. The author used genetic algorithms to search for a good facility layout and to improve the searching speed. Amarase (2001) wrote a thesis about the warehouse design for plastic resins trading company. The author wrote about the designing a new warehouse for Polymer Marking and Trading Co.,LTD, the plastic reading company to cover 1000 tons per month sales expectation. The theories of warehouse design, characteristics of each plastic resin type, and the existing warehouse are studied. Then the material handling equipment and material-handling employees are designed. And the result, the warehouse can cover the expected sales amount. Tantrakool (2000) wrote a thesis about studying the problems in a motorcycle part manufacturing factory in Thailand. The purpose of the study is to improve the productivity in the same factory. Form the of the study, the problems of low productivity are from factory planning and layout, production processes, and storage areas. After that the problems were defined and analyzed. The location was relocated, and then the productivity was increased afterward. Charojrochkul (1999) wrote a thesis about improving material handling routing in a warehouse in an automotive parts industry and improving transportation operation within the company. The problems are analyzed and improved. The results are the new warehouse design, the reduction of material handling, and the results are the new warehouse design, the reduction of material handling, and the reduction of transportation route. Kamonpatana (2001) wrote a thesis about improving plant layout of a plastic utensil processing ling. Before improvement, the company had meandering route of material flow, high number of work in process and finished goods that results in excessive use of workforce, time, and transportation. After improvement, by using plant layout design, the unnecessary activities were eliminated that results in the reduction of transportation, time, and cost. Tompkins (1996) wrote a book that concern with the facilities planning including development of material handling and layout, function of manufacturing operations, and quantitative and quantitative facilities planning.Philips (1997) wrote a book that concern with the analysis of the requirement of manufacturing plant layout, material handling, relationship of activities, and alternative layout configuration.

Heragu (1997) wrote a book that concern with the approach to the facility. Lee (1997) wrote a book that concern with facility and workplace design. The book emphasizes on practicing the industrial engineer to the facility planning. The facility design, workstation design, and space planning are explained in this book. Cedarleaf (1996) wrote a book that concern with the analysis of process flow, planning a new plant including, designing, new layout, drawing. Francis (1974) wrote a book that concern with facility layout by using analytical approach. The book covers the problem of layout and location planning with a different type of location type and using analytical model to solve. Gerald R. Aase, John R. Olson, and Marc J. Schniederjans (2002) have studied the impact on labour productivity in working in U-shaped assembly line layout. The decision to move straight-time assembly systems to U-shaped assembly lines systems constitutes a major layout design change and investment for assembly operations. U-shaped assembly systems offer several benefits over traditional straight-line layout in the aspect of lean manufacturing and just-in-time philosophies, also including an improvement in layout productivity. The purpose of this research is to empirically confirm that U-shaped assembly line improve labour productivity. Results indicate that labour productivity will improve significantly under certain conditions when switching from a straight-line layout to a U-shaped layout but not in all cases. The research also reveals some limitations of such a layout change when factors such as the number of tasks and cycle times are varied. Hwang (2004) has studied, analysed and adapted heuristic transporters routing model for manufacturing facility design. Given fixed facility layout and predetermined material flow paths, this study determines the minimum number of transporters required to transfer material within a give manufacturing facility with minimal handling effort. The manufacturing facility design problem is particularly complex and involves the sub-problem such as design of the material network and the transporters routing problem, which provides the fleet size and the routing of each transporters over the flow network. The problem is formulated as an integer problem. The heuristic and integrated vehicle routing model are used to solve the problem. Also the heuristic solution program and several tests is applied along with an industrial example to indicate the effectiveness of this method. Yang Brent, and Tu (2003) has studied the layout design for flexible manufacturing systems considering single-loop directional flow patterns. In the study, in order to achieve high productivity in a flexible manufacturing system (FMS), an efficient layout arrangement and material flow path design are important things to concern due to the large percentage of product cost that is related to material handling. The layout problem has departments with fixed shapers and pick-up/drop-off points. It is an open-field type layout with single-loop directed flow path. A two-step heuristic is proposed to solve the problem. It first solves a traditional block with directed-loop flow path to minimize material handling cost by using a combined space-filling curve and simulated annealing algorithm. The second step of the proposed methodology uses the resulting flow sequence and relative positioning information from the first step as input to solve the detailed FMS layout. This includes the coordinates and orientation of each FMS cell. This detailed FMS layout problem is formulated and solved as a mixed integer program. Empirical illustrations show promising results for the proposed methodology in solving real-world type problems. Balakrishnan, Chen, Conway, and Lau (2002) have studied a hybrid genetic algorithm for the dynamic plant layout problem. The dynamic plant layout problem (DPLP) deals with the layout of multi-period layout plans. Although an optimal solution method based on dynamic programming is available, it is not practical for large DPLPs. It has recently been show that heuristics based on genetic algorithms can solve large DPLPs. In this research, the use of genetic algorithms are extended and improved by creating a hybrid genetic algorithm. A computational study is carried out to compare the proposed algorithm with the existing genetic algorithms and a recent simulated annealing algorithm. The studies show that the proposed algorithm is effective. Thus it may be useful in solving the larger problems. Pelinescu, and Wang (2002) have studied about the multi-objective optimal fixture layout. The study concerned about a major issue in fixture layout design to determined and evaluate the acceptable fixture designs based on multiple quality criteria and to select an optimal fixture with appropriate trade-offs among multiple performance requirement. The performance objectives considered are related to the fundamental requirement of kinematics localization and total fixturing (form-closure). Three performance objectives are defined as the work piece localization accuracy and the norm and dispersion of the locator contact forces. The study focuses on multi-criteria optimal design with a hierarchical approach. An efficient interchange algorithm is extended and used for different practical cases, leading to proper trade-0ff strategies for performing fixture synthesis. Examples are given to illustrate empirical observation with respect to the proposed approach and its effectiveness. Bai, Chen, Bin and Hu (2004) have introduced the concept of the PLE (Product layout Feature), including descriptions of GDEs (Geometric Datum Element) and engineering symbols, as well as the method of how to define them, and provided a solution to the problem of PLF modeling. As a result of the solution, collaborative design activities among multi-teams from different disciplines can be consistently carried out on PLF models in the PDM environment. It resolves the tough problem of consistently maintaining a product scheme to prevent defects the arising from inconsistent general design data or incorrect versions of the layout scheme existing within the schemes of downstream design. By using the principles of the given method and utilizing pervious research project, a prototype system is developed to support collaborative design based on the PLF mode in complicated product design. Mir, and Imam (2001) have studied a hybrid optimization for the layout design of unequal-area facilities. Simulated annealing is used to optimise a randomly generated initial placement on an "extended plane" considering the unequal-area facilities enclosed in magnified envelope blocks. An analytical method is then applied to obtain the optimum placement of each envelope block in the direction of steepest descent. Stepwise reduction of the sizes of the envelope blocks allows controlled convergence in a multi-phase optimization process. The presented test problems include two large size benchmark problems of 50 and 100 facilities of unequal areas. The results indicate that although the computational cost is relatively quite high, the technique is a significant improvement over previously published techniques for unequal-area facilities and can yield solution of the same quality as obtained by PLANOPT, a general-purpose layout optimization program based on pseudo-exhaustive search. Korves. and Loftus (2000) have studied Designing an immersive virtual reality interface for layout planning This study discusses the reasons why manufacturing layout planning is considered to be an appropriate new area of virtual reality (VR) utilization; develops a framework for a VR-based layout planning tool and reports on a study comparing the use of immersive VR to a monitor-based system for detecting layout flaws. The evaluation of the proposed framework has been conducted in a study/ which did not have provision for an interactive alteration of the layout. The aim of the study was to compare an immersive system and a monitor-based VR system for workplace analysis. Participants were asked to investigate a workplace environment. Which included three serious layout design flaws (tool arrangement, visibility, and tool location) and give their assessment about potential improvement. Lin, and sharp (1999) have studied about quantitative and qualitative indices for the plant layout evaluation problem. The authors found that in the past two decades, the researchers used to develop simulation models or mathematical programming models to estimate the performance measures of a production system which may of may not include the considerations of layout design, rather than develop indices specifically for evaluating a layout alternative. These models usually ask for very detailed information. Most of them involve oversimplifying assumptions and request overwhelming computational efforts such that they cannot be manipulated with ease in practice. The limitations and deficiencies of previous indices and performance measures include: parameters hard to obtain; inappropriate detailed data requirement; much effort to obtain little accuracy improvements; data available after operations start; no generic approach and no clear validation provided. To overcome these deficiencies. The generic approaches for developing quantitative and qualitative indices are provided and new indices for the flow criterion group and environment criterion group are presented. The parameters of each index are easier to obtain and do not require much effort on data collection. The validations of each quantitative index with examples are also provided. The generic approaches also allow the users to revise the indices according to the specific case considered. Schmidt-Traub, Koster, Holtkotter, and Nipper (1998) have studied about conceptual plant layout. The study of layout is involves the spatial arrangement of equipment within the steel structure of building of a plant and considers the inter-connections through pipes and ducts as well as walks and vehicle transportation. An optimal layout has to ensure operability, adequate safety and an economic design. Therefore, it is influenced by a whole range of factors such as process needs, maintenance, operational requirements, safety considerations and the available site. The resulting parameters differ significantly and compete with one another. Moreover, The conventional sequential workflow of layout and detail engineering does not allow improvements of the layout at a late state of the project. Today commercial CAD-systems are sued as design tools for plant layout and detail engineering, but they do not support planning and optimization of the layout. These decisions still need to be made by experienced senior engineers and designers. Ziai, and Sule (1989) have studies about computerized materials handling and facility layout design. We are proposing a systematic approach to the design of materials handling (HM) system that includes an algorithm to select the most suitable equipment. Initially, a conveyor system is proposed while determining its association cost. to seek improvement of the system in terms of cost and equipment utilization. The possibility of supplementing of replacing the conveyor with one or more forklift trucks (trucks) will be investigates. The final MH system configuration will consist of conveyors and trucks so that total system optimization will be achieved. The literature on MH design is very limited and often this problem is not directly coupled with the layout problem. The model proposed uses the results of a tentatively designed layout and two important characteristics of the materials. namely size and weight. Facility in this paper refers to a manufacturing plant with low to medium production volume in a process-oriented environment. Facility layout and materials handling are two highly interdependent problems. the location of departments. the corresponding distances and production rates distances the cost of MH. On the other hand, MH costs between departments. influence the departmental arrangements. An iterative process is developed between the layout design and MH selection problems. Yeh (2000) presents a customer focused approach to effective planning of make-to-order production, in which production activities are driven by customer orders and all products are made to customers' specifications. The approach plans, schedules and co-ordinates production activities are based on the needs of individual customer orders. In particular, an integrated bill of material and routing data structure is used to effectively organize production data in response to product specifications of customer orders. It facilitates the creation of production jobs with varying routings and material requirements. A job-oriented finite capacity scheduling system is used to effectively accommodate specific needs of individual customer orders. It allows for realistic setting of delivery dates and negotiation of order changes. Key features of the approach presented show its effectiveness in planning multi-item customer orders and multi-level products. Yeh (2005) addresses the need for effectively coordinating production jobs of varying routings on the shop floor, which cannot be met by existing scheduling techniques or shop dispatching practice. It provides manufacturing practitioners with a structured approach for managing shop floor operations. Specific features of the approach are presented and illustrated with a numerical example. It enables production jobs to be run in the best possible way at individual work centre. Various options of implementing the approach in practical applications are discussed. Taj (2005) offers a practical and easy to use assessment tool to help manufacturing managers to make their manufacturing operations more productive. A spreadsheet based assessment tool is used to evaluate nine key areas of manufacturing. Sorlano-Meler and Forrester (2002) focused on clarifying the concepts of lean manufacturing and what it comprises. The authors also commence with a review of the lean production literature and, specifically, existing models that identify the variables and component elements of lean production firms. Rawabdeh (2005) aims to investigate the waste in a job shop environment and proposes an assessment method aimed at helping companies to identify root causes of waste. The simplicity of the matrix and the comprehensiveness of the questionnaire contribute to the achievement of accurate results in identifying the root causes of waste. Kumar and Harns (2004) reported learning and application of a few significant techniques to improve basic business practices in a company, with manufactures large volume, high quality optical thin film coatings. The study demonstrates measurable results realized through use of process mapping tools, kaizen blitz activities, formalized and documented work instructions and work measurement tools. Houghton and Protougal (2001) presented an analytic framework for processing planning in industries where fixed batch sizes are common. The overall optimum-processing plan is shown to be located on an envelope between the optimum JIT plan and the optimum level plan. These concepts provide the framework for understanding the overall optimum plan, and the framework leads to an efficient heuristic. The approach is practical, illustrated by a case study from the food industry, which shows the place of overall optimum planning within the company's planning system and its implications for company performance. Buxey (2005) reported on the ramifications for production planning when monthly sales exhibit predictable seasonal highs and low. The literature first acknowledged and dealt with the problem 50 years ago. Nevertheless, there is neither evidence that industry has adopted any of the mathematical techniques that were subsequently developed, nor a convincing explanation as to why not. Hence this research sets out to discover the methods manufacturers use to cope with seasonal demand, and how germane the published algorithms really are. In doing this research, forty-two case studies were complied by interviewing senior managers and then conducting plant tours. Nonetheless, no prior assumptions were made and the list of questions covered the gamut of production planning. The main finding is that manufacturers select a straightforward production strategy, right from the outset, so the fundamental cost-balancing format is not relevant. The majority pick a chase strategy, since most organizations subscribe to a just in time ethos. Whenever a different strategy is preferred the rationale spring from skilled labour considerations of binding facilities constraints. Chorafas (1974) defined the term warehousing as both the physical processes of materials handling and keeping and the methodology underlying this process. In a short word, it is the storage and retrieval of goods. He also concluded that organization aspects, the mechanical equipment for materials handling the racks and other media for materials storage and the building necessary to protect the goods form wind, rain, and sun. On the basic of warehousing concept, he categorized all warehouse activities into six major functions, transfer, receiving, storage, handling, expediting, and packing, all the which are interpreted as follows according to his notes. Choragas (1974) also offered his arguments on this aspect. He pointed out that warehousing methodology concerns the orderly execution of physical storage and retrieval activities and the processing of information needed about the goods stored. He further noted that the warehousing methodology should focus on correct evaluation, identification, classification, and quantification of the goods to be stored and retrieved as well as on the ways and means of handling information. Firth (1988) noted that warehouse efficiency and accuracy are largely a function of the control system used to direct and track activity. To improve the warehouse operation efficiency, therefore, understanding the constitution of the typical warehouse operational activities and its sequences as well as carefully formulating the operating policy are essential. Furthermore, great attentions should also be drawn to the status of information in the operation. Hirano (1995), one representative 5S's researcher, who contributed a great deal of literatures in this field, interpreted the 5S's researcher, who contributed a great deal of literatures in this field, interpreted the 5S's as Organization, Orderliness, Cleanliness, Standardized Cleanup and Discipline. He further explained its implication in detail as well. He also noted, 5S Practice relate to corporate health and survive and is the foundation for improvement. O'hEocha (2000) researched the influence of company culture and employees' attitude on use of 5S in his case study as the human facet is the key factor in 5-S implementation. This related to another important issue: Working Culture. Whether the employees are willing to change their working attitude will directly determine the success of 5-S implementation. According to Hofstede (2001) who groups the culture differences into five categories: power distance, uncertain avoidance, individualism and collectivism, masculinity and femininity, long term and short term orientation based on the IBM data set. Thai employees show their strong loyalty to their managers and the top managers incline to solve problem by the help from the technology and prefer to the long term perspective.

CHAPTER III
METHODOLOGY AND CURRENT PLANT LAYOUT

3.1 Overview of methodology

This chapter will discuss in the methodology of designing new plant layout and the current plant layout that is being used. The current plant layout will be studied and analyzed the flow of work and the characteristic of work, in order to use as an example and to develop the new plant layout. For the methodology, the detail of how to research and collect the data will be described and discussed in this chapter.

According to the research procedure in chapter 1, the methodology can be developed as a model procedure to support companies in optimizing their processes and designing effective plant layouts and material handling systems. It is a universal procedure that can be used by manufacturing companies as well as service companies. It has a broad field of application and can be used to help develop a new layout for the whole facility from scratch or to improve an existing layout or to aid in task like revising specific part of the plant and locating new machines. The model also provides step-by-step guidance, which facilitates the work of designing plant layouts and material handling systems. The model can be used sequentially to develop first a block layout and then a detailed layout for each department in the facility.

Before making a layout, whether it is a new layout or a redesign of an existing one, it is essential to know what the objective of the facility is, what products or services to make and the detail of them. The next step is to figure out the quantity or level of activity needed. Then should the routing, that is, how to make the product be specified, which parts should be made and which parts should be bought. For the products that will be produced in-house should it be decided how the product is to be produced. The required processes need to be identified and the best processes needs to be selected by selecting the operations and their sequences that will best produce the required quantity in optimum operating time.

In case of an existing production each concerned process needs to be investigated to see if they are performed in the best possible way. To get an accurate description of the processes, flow process charts should be used, to trace the movement of material through each step of the process. It can be used whenever the full detailed steps of the sequence of flow are wanted, to help identify and eliminate waste. The alternative processes should be evaluated, and a selection of which processes to use made. Routing together with time is the strongest factors that decide how many employees that are needed and what machines and equipment to acquire. The right layout type can be identified using this information and apply it in a volume-variety diagram. Mostly it is necessary to know what supporting service the product needs.

In this step the preferred layout has been chosen and it is time to implement it. The one who has been most involved in the layout procedure and has time and the ability should be the one who implement the layout. Before implementation of the selected layout one has to remember to inform and motivate the workers for the coming changes. This to avoid possible resistance such as: uncertainty, fear of loosing job, and personal conflicts.

When the facility stand in front of a change, is it important to determine what it is that has to be moved or changed. It has also to be planned were everything is to be moved during reconstruction. Rebuilding, repainting, and new equipment such as overhead cranes is examples of what can be necessary to do. The planner should also take advantage of this time and also improve the facility in e.g. improving the safety.
During the Do-stage is all machines, equipment, and storages are moved to their planned locations. If it is an extensive change in the facility layout for the company external contractors may be hired for this project. On the other hand, it can be enough with the existing personnel if it is only a minor restructuring. Finally, the planner has to check so nothing is missed and the implementation it completely done.

Once the layout is implemented, changing conditions and requirements makes it necessary to make periodically audits, to ascertain the need for modifications and revisions.

3.2 Present plant layout

The company production facility has been expanding during the past years. This has happened in several steps and the philosophy has been very similar to: Where can we free space for this workstation? This has led to many short-term solutions, which in turn has affected the material flow in the facility. The present layout, with the different departments marked is presented in Figure 3.1.

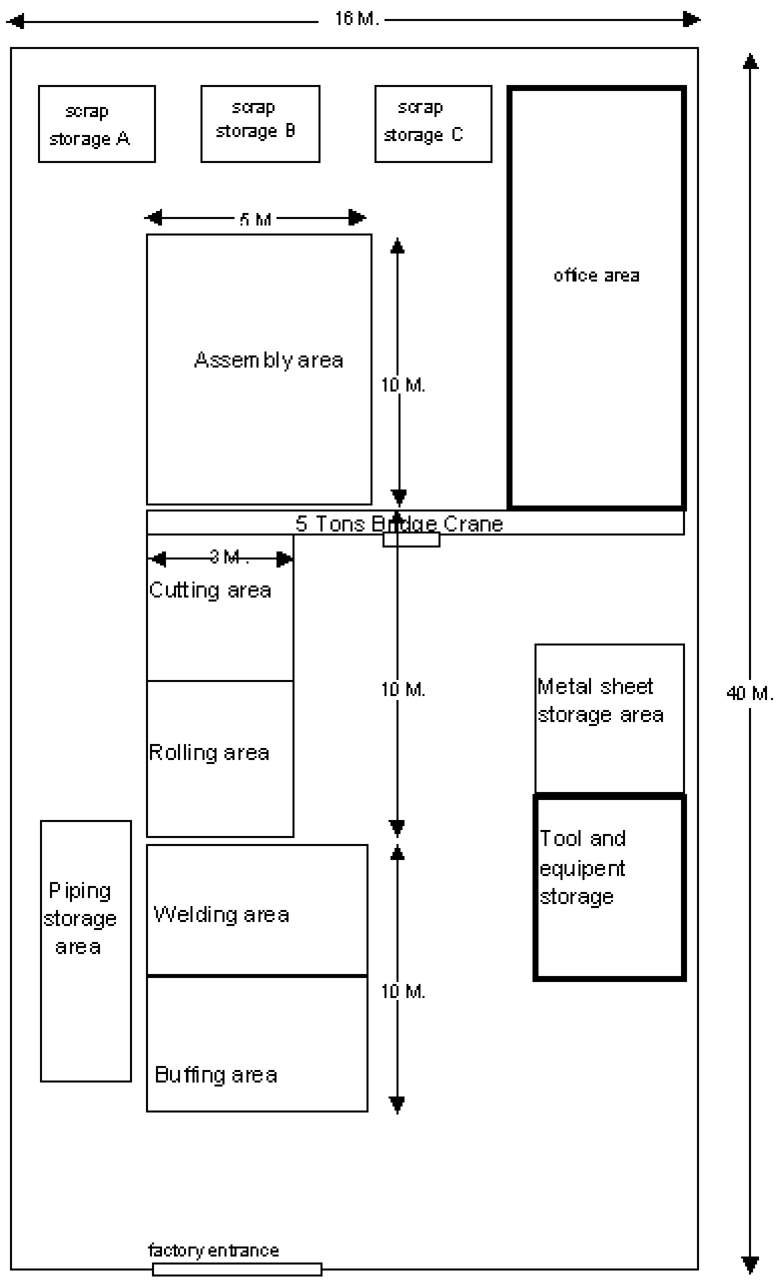


Figure 3.1: Present plant layout

The company has divided six-working area for highly customized products and three storages area. In assembly area, each team works approximate 5-6 workers. It is common that the different teams have to borrow workers from each other if one team has a lot to do. The locations of these teams are, like the storages, spread over the facility (Fig 3.2). There are no clear boundaries for each assembly workstation within the departments. The workers may work with separate substation, but are sharing areas for tools and inventories.

Figure 3.2: Storage area (scraps)

The company has some departments with preparatory work and subassembly, to increase the throughput of the finished product. They have a production department for cutting and rolling sheet metal. These two processes are sharing the same space area which has all scrap spread over on the floor. These do not consume very much space and are often integrated with the storage areas.

3.3 Products type and quantity

C.V.R. Company is producing steel tanks. The purpose with this product is to store raw materials to be produced or store the finished goods to be packed for finished goods such as, powder detergent, shampoo detergent, etc. The product can be categorized into 2 main types: non pressure tank and high pressure tank. Non pressure tanks require regular standard of welding which only one layer will be applied on welding line. On the other hand, high pressure tanks are more complicated and require an advance skill on construction process. Each welding line has to be welded more than one layer in order to prevent the leakage when applied high pressure into the product.

The quantity of the product usually depends on the customer demand. Each project has a different quantity of the product and different specification. For the past 4 years the company had made mostly 4 types of steel tanks, which has a minor different in specification. The types of steel tanks are high pressure tank with single leg (HP-SL 1000-1-12), high pressure tank with twin legs (HP-DL 1000-2-12), low pressure tank with single leg (LP-SL 11-1-12) and low pressure tank with twin let (LP-DL 11-2-12).

The annual sales data from 2005-2008 with forecast for 2009 for these models is presented in Table 3.1. The models that are investigated are similar when it comes to required material, but have different characteristics as finished products.

Table 3.1: Quantity of steel tanks in year 2005 – 2009

Model	Vol. / year 2005	Vol. / year 2006	Vol. / year 2007	Vol. / year 2008	Forecast 2009
HP-SL 1000-1-12	22	31	35	19	15
HP-DL 1000-2-12	28	25	12	16	12
LP-SL 11-1-12	-	16	24	20	18
LP-DL 11-2-12	39	40	36	28	26
Total	89	112	107	83	71

From the historical data, the capacity of the company can be estimated. However, as the company acquired the job from bidding process, it also depends on the price that company offered. Some of the year the company did not use full capacity of work. The company will increase the overtime work when higher of quantity is needed. From having the limited period of time for making product, usually the time allow of 1 set of steel tank is approximately 17 days started from the date of signing contract.

As shown, the demand for this type of steel tank has been relatively stable for the last years. The decrease of demand in the forecast related to factor of world wide economic crisis and unstable political but is according to the purchasing manager a reliable forecast and the demand is believed to remain around this figure in the future if nothing out of the ordinary happens. Therefore are 71 steel tank per year used in the following calculations.

3.4 Flow of material

The following chart in Fig 3.3 represents the company's originally material flow from raw material to finished products. The material flow can be described as in the flow process chart shown in next section.

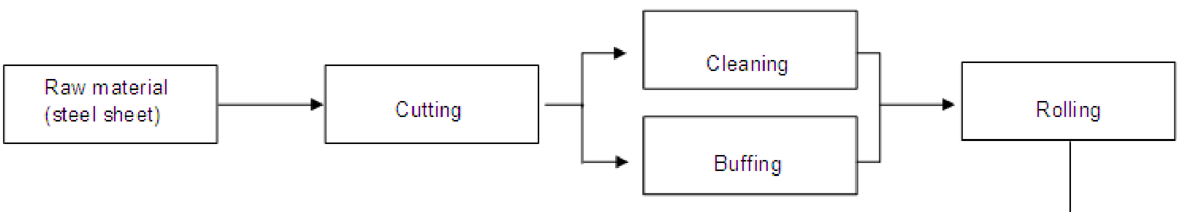


Figure 3.3: Flow of material

3.4.1 Flow diagram

Flow diagram shows the route and the direction of the material in the plant layout, it is easy to see where the process is going. This also shows the location of the department, which helps to identify the position of each department whether it is located in the suitable place or not.

By looking at the flow diagram (Fig 3.4), it can be shown that the current plant layout has quite a complex of material flow especially in machining area and assembly area. Some area should not be closed to each other especially between welding area and buffing area.

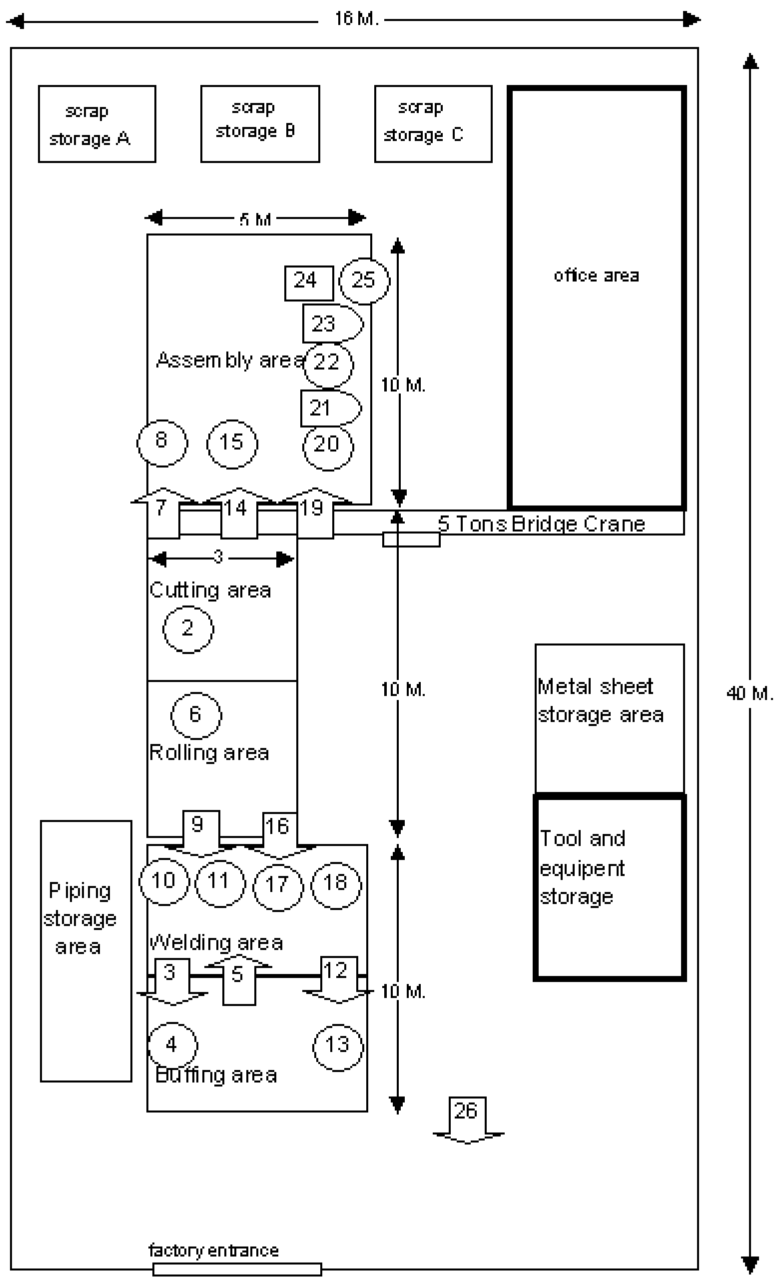


Figure 3.4: Flow diagram

3.4.2 Flow process chart

The flow process chart (Table 3.2) will show all the activities in the process of manufacturing the steel tank. The data of this chart will contain the measurement of time consuming in each activity and also distance of the product movement. From the studying of the flow process chart, we can clearly see more on the performance of each activity, also the non value-added can be identified and improved.

Table 3.2: flow process chart of existing plant

	○ ⇨ □ D ▽	Description	Time/1 set of vessel	Department	Total time	Distance	Total distance
1	⇨	Deliver stainless steel sheet to cutting area	15 minutes	Stock area	15 minutes	12 meters	12 meters
2	○	Cut stainless steel sheet by designing shape	4 hours	Cutting department	4 hours 15 minutes		
3	⇨	Deliver to the buffing area	15 minutes	Cutting department	4 hours 30 minutes	15 meters	27 meters
4	○	Cleaning and buffing process	24 hours	Buffing department	28 hours 30 minutes		
5	⇨	Deliver the steel sheets to pre-constuct for rolling	10 minutes	Buffing department	28 hours 40 minutes	10 meters	37 meters
6	○	Apply rolling process for a required shape	3 hours	Rolling department	31 hours 40 minutes		
7	⇨	Deliver to assembly area	15 minutes	Rolling department	31 hours 55 minutes	15 meters	52 meters
8	○	Pre-construct each steel sheet into a vessel shape	14 hours	Assembly area	45 hours 55 minutes		
9	⇨	Deliver to welding area	15 minutes	Assembly area	46 hours 10 minutes	18 meters	70 meters
10	○	Internal welding	6 hours	Welding department	52 hours 10 minutes		
11	○	External welding	5 hours	Welding department	57 hours 10 minutes		
12	⇨	Deliver back to buffing area	5 minutes	Welding department	57 hours 15 minutes	5 meters	75 meters
13	○	Internal buffing and cleaning	16 hours	Buffing department	73 hours 15 minutes		
14	⇨	Deliver back to assembly area	20 minutes	Buffing department	73 hours 35 minutes	45 meters	120 meters
15	○	Apply top side cover to tank	3 hours	Assembly area	76 hours 35 minutes		
16	⇨	Deliver back to welding area	15 minutes	Assembly area	76 hours 50 minutes	18 meters	138 meters
17	○	Welding top side of the vessle	2 hours	Welding department	78 hours 50 minutes		
18	○	Finish detail work (closing man hole,drill hole,nozzle)	8 hours	Welding department	86 hours 50 minutes		
19	⇨	Deliver to assembly area for coloring some steel part	15 minutes	Welding department	87 hours 05 minutes	40 meters	178 meters
20	○	Apply the first layer painting	2 hours	Assembly area	89 hours 05 minutes		
21	D	wait for the paint to dry	3 hours	Assembly area	92 hours 05 minutes		
22	○	Apply the final layer	2 hours	Assembly area	94 hours 05 minutes		
23	D	Wait for the final paint to dry	6 hours	Assembly area	100 hours 05 minutes		
24	□	Inspect vessel pressure test (leak test)	24 hours	Assembly area	124 hours 05 minutes		
25	○	Final cleaing inside and outside	4 hours	Assembly area	128 hours 05 minutes		
26	⇨	Trasfer product to the truck	25 minutes		128 hours 30 minutes	50 meters	228 meters

3.4.3 Calculation output data sheet

The following table will show the output of the relevant data from calculating the waiting time of the existing plant (Table 3.3).

Table 3.3 Calculation output of the existing plant layout

NO.	PROCESS AREA	1	2	3	4	TIME USAGE	IDLE TIME
1	CUTTING	4	8	12	16	4H	
2	BUFFING	28	32	36	40	24H	
3	ROLLING	31	35	39	43	3H	
4	ASSEMBLY	45	49	59	63	14H	6H
5	WELDING	56	60	70	74	11H	
6	BUFFING	72	76	88	94	16H	2H
7	ASSEMBLY	75	79	91	95	3H	
8	WELDING	85	89	101	105	10H	
9	ASSEMBLY	126	130	167	171	41H	25H
	TOTAL					126H	33H

By looking at Table 3.3, it shows the running time for each process which produce 4 vessels at the time. Since some area such as welding area and buffing area can only fabricate 2 products at the time, there are some bottleneck occur in some area. According to existing plant layout, assembly area has enough space to produce only 2 vessels at the same time. Unfortunately, the space area which close to assembly area has to share with some scraps such as unused metal sheet. The bottleneck occurs in assembly area when 3rd and 4th vessel parts from rolling area are waiting to be assembled in assembly area which take about 6 hours of waiting time to be assembled. As the result, the waiting time to produce 4 vessels is 33 hours. The total time to produce 4 vessels for existing layout is approximately 163 hours 35 minutes.

From the data in output, it shows the relevant data of the existing plant layout. Each of data will be explained in the follow paragraph.

From looking at the flow process chart of the existing plant layout, time of producing a vessel consumes approximately 128 hours 30 minutes. However, these data is calculated from only the first piece of vessel that passes through all the process. When running 4 pieces of the vessel, the delay time caused from the bottleneck will be occurred. Then it is not sufficient to this data to analyze.

Overall idle time shows how long and how many times that waiting has happened. The calculation form Table 3.3 shows that how many times the waiting time has happened in the system. For the existing plant layout ht average waiting time for each wait is 1980 minutes or 33 hours and it happened for 4 times.

3.4.4 Cycle time of the product

Usually company will be given the period of time to make the product. Mostly for the steel tank/vessel type, the time given will be approximately 4 weeks for 4 vessels. By having the measurement the cycle time from the calculation sheet, the cycle has found to be approximately 40 hours per piece. However, from time to time the company has found some difficulty in finishing the project within a given period. This problem is overcome by adding the overtime work, which adding more expense to the company.

3.4.5 Distance of moving the material handling

The distance of using the material handling, not include when the material handling is not occupied, is 228 meters from the beginning of the production until the end of the production.

The distance will be measured at the centre of the working area and in only 2 dimensions which is back and forth, the distance of going up, down, left and right will be neglected in order to make the measurement easier.

The bridge crane is the main material's handling tool. The figure 3.5 Below shows the company's bridge crane. Its working area covers the whole factory and in the daily operation, it shoulders the main responsibility of moving the raw material such as steel plate. The crane's capacity is limited to 5 tons and it has been working in good condition since it was installed.

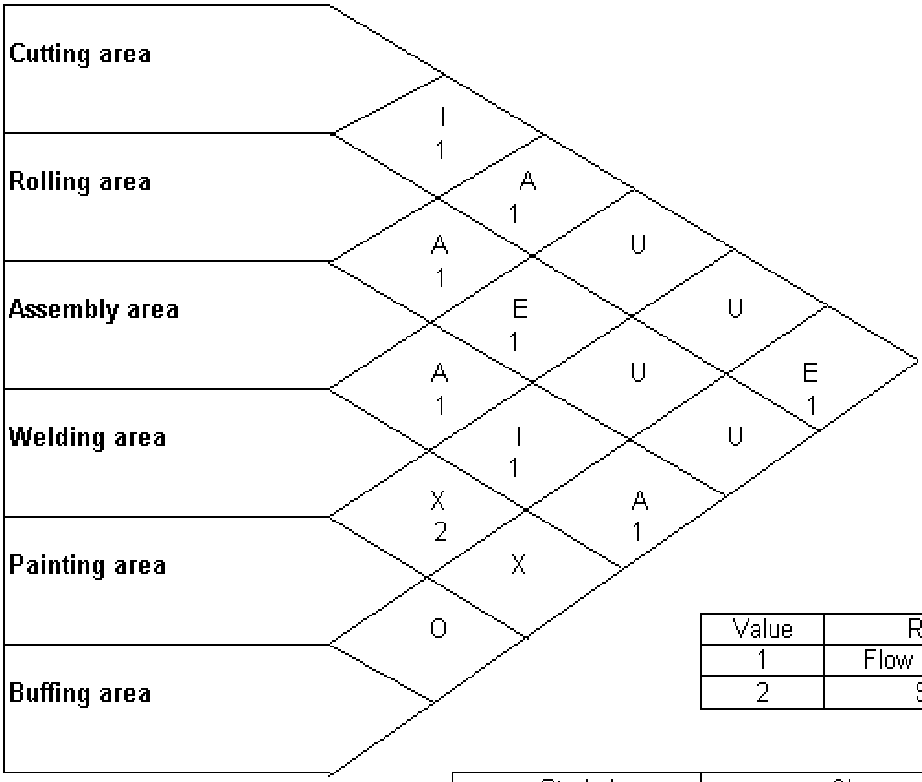
Figure 3.5 : Bridge crane

3.5 Relationship chart

Relationship values may be used when measuring qualitative flow closeness. The value and the reason behind the value can be recorded in a so-called relationship chart. The relationship chart shows which activities that have a relationship to each other. Each cell is split so it shows the importance of the closeness and this can be supported with one or several reasons. Relationship chart is according to Muther (1974) the best way to integrate supporting activities in the process investigated.

The most closeness of each department will be categorized in to 6 alphabets, which indicates the proper relationship between each department. The closeness values are rated according a vowel scale that can be seen in figure 3.5. If the facility planner is unfamiliar with this method it can result in over assigning of A ratings. Muther (1974) suggests a range of frequency of rating occurrences for each vowel. A should be presented about 2 to 5% in a relationship chart, 3 to 10% for E, 5 to 15% for I, and 10 to 25% for O. In most projects almost half of the boxes checked with a U. The frequency of X depends on what project that is investigated.

From observation of the working characteristic, the relationship between each department is shown in the following figure 3.6.



Value	Reason
1	Flow of Material
2	Safety

Stmbol	Closeness
A	Absolutely necessary
E	Especially important
I	Important
O	Ordinary
U	Unimportant
X	Undesirable

Figure 3.6: Closeness Relationship chart

By looking the closeness relationship chart, the most important factor to be concerned is the location between welding area and buffing area. These two departments can cause the electric tool damaged, which the company always used to have before. The reaction between the dust from buffing and the electronic circuit inside welding machine can be short circuit the tool. Another concerned in the relationship will be the flow of the process, because the better position of the department located along with the flow will mean the more effective work.

3.6 Worker capacity

The worker capacity is the quite the most import factor of production system. Having most of activities depend on the capacity of worker along with the worker's equipment. This aspect will be concerned in the part of production performance. In each department there are numbers of worker running each operation. Each operation requires different number of worker. The following table will show the amount of worker in each department in the producing of steel tank/vessel (Table 3.4).

Table 3.4: Number of workers in existing plant

Operation	Number of workers
Assembly	8
Welding	6
Buffing	5
Paiting	4
Rolling	3
Cutting	3
Storing	1

The capacity of the welding equipment will be equal to the number in welding area, assembly area, and cutting area which are 6 units of welding equipment. The welding equipment consists of one electric generating box and one welding device. At each one welding activity will need welding equipment at each point. Painting equipment will have the same concern as the welding equipment.

The standard payment to the worker is 250 Baht per day for 8 working hours. From the amount 30 workers, the company needs to pay 7,500 Baht per day. By using 17 days to finish 1 tank, the labour cost will be 127,500 Baht.

3.7 The problem in the existing plant

By looking at the process of the existing plant, main problem of the company is the complicated of material handling route, especially in the assembly and welding department since product need to go back and forth twice between these two department. And the space in assembly departments can produce only 2 pieces in the area (include painting , testing and storage). Also another area space between each department is quite small. From the measurement, the space for a worker, including the equipment both assembly and welding, to work at the left side and right side of the product is approximately 1 meter. Then the space area will be the problem when the workers are working at the same time (Figure 3.7).

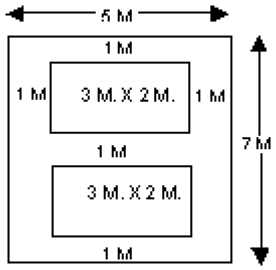


Figure 3.7: Assembly space area

The problem in detail is after inside and outside welding the product needs to move to buffing department to receive the buffing process of the welding line of the product, then transfer again to the assembly department to get the final detail painting process of carbon steel part. Having product transferred back and forth between two processes, this increases the material handling work. It also, most of the time, cause the idle time from the waiting another department available. At this point of process, it can be said that it is the bottleneck of the flow. If the company can increase the space for these two areas and relocate these two departments the company can increase the capacity of the work and make the work flow move better.

Currently, the capacity of each department can be use only 60% of area available because of all there are unused raw materials all over the floor especially the scrap of steel plates. The space area in the factory is occupied by metal plate around. It is obvious that there was no proper layout setup for the factory at the very beginning to arrange the raw materials. No appropriate storage area and aisle layout were taken into account at that time. Two racks were just placed in the warehouse and no considerations were given to the prospective raw materials. As the different raw materials came into the factory and no appropriate layout existed, the employees had no ideas of where placed on any vacant space. As time went on, after the usable horizontal space was totally consumed, the steel plate were placed around on the floor accordingly, which resulted in inefficient warehouse space utilization.

Also the position of the department located is one of the problems of the existing plant. The buffing area which located nearby welding area can cause the damage of welding machines. Since there is lots of dust around the air due to buffing process, the dust will flow in the air and stick on the welding machine circuit board. As a result, the dust of buffing will become a good conductor on the board to short a circuit.

Another problem is the limitation of the storage area. In the existing plant layout the space of the storage area, same area as an assembly area, is not quite enough to keep the finish product and to perform the final painting or testing process. Maximum number of the product that can be kept in this area is 2 pieces of tank include assembly process. By having this problem, the company has to deliver the product to the customer in order to have the space to keep the incoming of finished product. Many times that the finished product can not deliver out because the customer is not ready to receive the product, this leads to the non continuous work flow. The workers need to stop working until the finished product is delivered out to the customer.

Currently, at the full capacity of worker, the company uses 30 workers because adding more workers does not increase the capacity of work because of the limitation of the space. Only working on overtime or holiday will help to increase the capacity of work. Even though working an extra time can help the work finish on time, but the company has to pay an extra to employees due to extra time of working which cost 1.5 times per hour from usual payment.

Since there were some accidents occurred before, the management and employees still did not pay sufficient attention on the potential accident. From the accident record of year 2008, there was accidents' report 22 times in that yeAR. Most of the cases were from the workers did not wear a safety helmet and hit directly to bridge crane's anchor. In fact, the helmet has not been used while workers were in operation and no individual commitment and relevant policy has ever been established. Therefore, the workers have no safety operating procedure to follow, no safety rule to obey and no safety training to receive.

CHAPTER IV
IMPROVEMENT DESIGN AND DESIGN EVALUATION

4.1 New Plant layout design and design evaluation

From the analyzing the information of existing plant layout, we can see many aspects, which are problem and obstruct the efficiency of the working. All these information will be used as a guideline to improve and design the new plant layout in an existing place.

4.1.1 Identification area of improvement

1. Material flow diagram

By looking at the flow of the process, this shows the ineffective layout of the existing plant. There are many back and forth transferring between assembly area and welding area and between buffing process and painting process, which consume a lot of material handling usage.

Also the cutting and rolling area, located between the welding area and assembly area, which obstruct the flow of the process. The workers have to transfer the product from welding area to assembly area through the cutting/rolling process by using the railway. This sometimes cause the work to be stopped because the size of the product and the space is not available to operate

2. Stock of work in process and finished good

From the limitation of the working area, the space can store work in process only 2 pieces of tank. The problem in this area is when the operation of the department is finished but is not able to transfer to the next operation because of there is no room to store the work in process. For example, the operation between welding department and assembly department, when the work in process of welding department is finished at the same time there is work in process in testing at assembly department which take 24 hours to be inspected, this causes the work in process from welding department not be able to transfer to assembly area. This also causes the idle to worker.

Also when the product is finished, the space to keep the finish product is available for only 4 pieces of tank, which is sometime cause by insufficient space because assembly area can hold only 4 pieces of tank included production process. When the storage is sharing with assembly area is full, the workflow need to be stop until the finish product is delivered to the customer. This also causes the idle to the worker. However, transferring the product to the factory yard when the space of keeping product is nearly full can solve this problem but it will cause of dirt and result in redo the cleaning process before delivery to customer.

3. Improper work place

From the observation, the buffing area is not clearly designed and separated to another process. From the existing plant layout, there is no proper design of buffing area. The buffing area is operating next to the welding, which is a problem can cause of damage welding machines. By working this way, there is a chance of damaging machine occur from the buffing dust react to the welding machine's circuit which conduct the electric to short the circuit. Also there is no room to prevent the duct from the buffing that might pollute the working environment.

4. Improper raw material storage layout

It is obvious that there was no proper layout setup for the factory at the very beginning to arrange the raw materials. No appropriate storage area and aisle layout were taken into account at that time. Two racks were just placed in the factory and no considerations were given to the prospective raw materials. As the different raw materials came into the factory and no appropriate layout existed, the employees had no ideas of where to store them to avoid the inconveniences. Due to this situation, the raw materials were placed on any vacant space. As time went on, after the usable horizontal space was totally consumed, the steel plates were stacked accordingly, which resulted in inefficient layout space utilization.

4.1.2 Design of new plant layout

Before designing the new plant layout, company needs to have an idea of the capacity that company would like to have; therefore the quantity of the work needs to be concerned.

Even though the economic in Thailand is decreasing due to unstable government, but for the construction work is quite stable or increasing a little bit especially with the company that service to oversea customers. The company is forecasting the quantity of the product to be a little bit higher than the last year. Also the company is expecting to win more bidding of the available job due to having a new effective plant layout.

Since the factory has a constraint for the limitation of space area, the executive board's commits to design of new plant layout into an existing capacity which using full capacity of space area in order to expand some core production process area such as, assembly area.

4.1.3 Available area

According to the land that company has in existing area, which is 40 meters in length and 16 meters in width (Fig 4.1). From the problem that has been discussed in previous section, the new design of plant layout will be designed starting from analyzing the availability of space area, the capacity desired, and the location of the department.

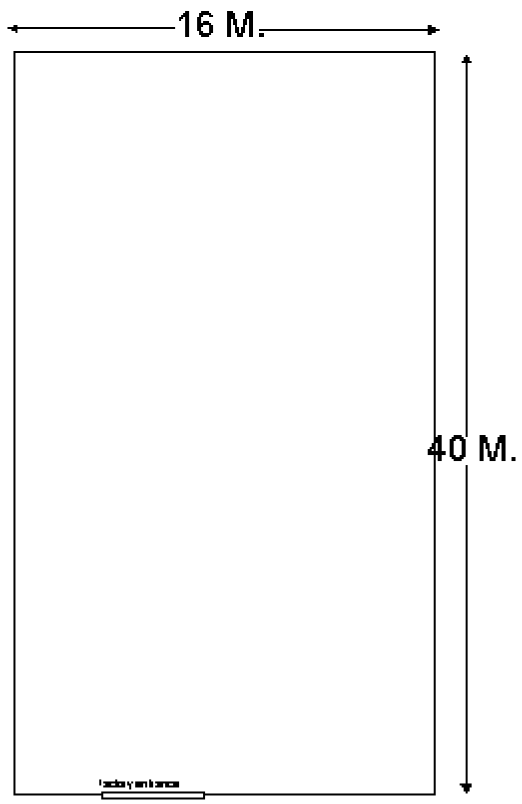


Figure 4.1: Plant layout area

4.1.4 Criteria and limitation of the layout improvement

There are many limitation and criteria in improving an existing plant layout, first the limitation of increasing the heavy machines and cranes. From the executive team's decision, there will not be the budget in increasing the machine like cutting machine or rolling machine, and cranes. The budget will be only enough for increasing of some equipment, for example the welding equipment, buffing equipment.

Fortunately, the main product that the company produces mostly concerned with the capacity of the worker, having the same amount of machine and crane will not effect the improvement or increasing the increasing the area of the existing layout design. However adding more the workers will consequently affect the amount of welding equipment and buffing equipment. From this reason the utilization of the worker and the welding equipment will be mostly concerned.

Also the welding equipment will be placed in the rolling area, assembly area, and welding area. For example, if the number of the worker in welding department is 10 then the number of welding equipment will be 10 also. This mean that increasing the capacity in welding area, assembly area or rolling area the number of welding equipment will be increased along with the number of worker in those particular areas.

Other criteria that will be concerned in the improvement will be a location of the department and the safety in working area. This criterion will follow the analysis of closeness relationship.

4.1.5 Alternative of designing new plant layout

There are many alternatives to design the layout, according to chapter 2; there are 3 types of layout, which are:

1. Process layout
2. Product layout
3. Fixed position layout

In this project, all types of layout will be used and evaluated the best result given to the company. New design of the layout will base on process layout, product layout , fixed layout and combination layout (process and product layout) and then the result will be both evaluated and compared which one give the better result. Each alternative will be described as the follow.

4.2 Layout of new plant design (process layout)

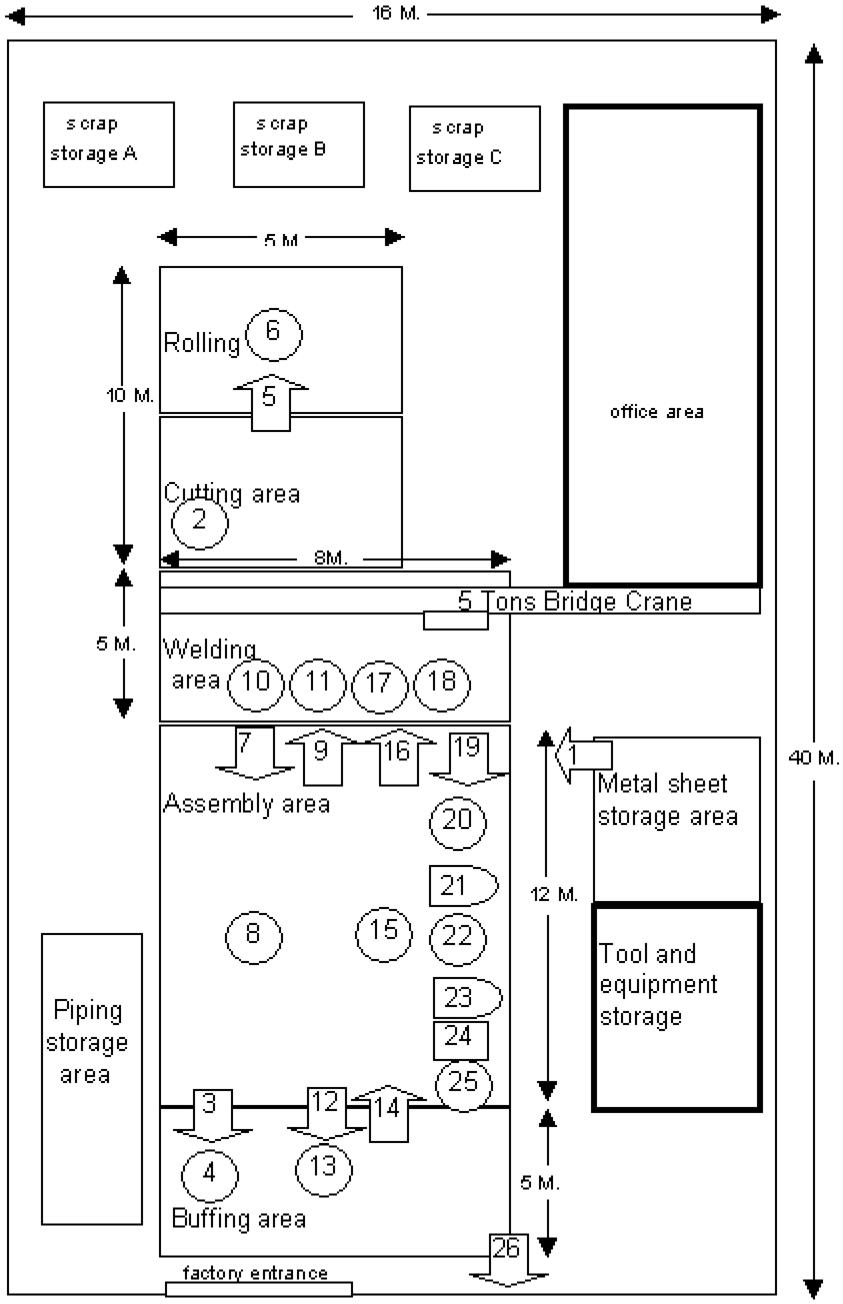


Figure 4.2: New plant design layout (process layout)

In this design, the design will be mostly based on existing layout except the size of each department is expanded due to eliminating of some scraps and some areas are relocated such as, assembly area is moved to center of factory area in order to reduce the transportation distance. Moreover, the differences between this new design and existing design area new location of welding area and buffing area which are located apart from each other for the safety purpose. The following figure (Fig 4.2) is the new plant design according to the design based on process layout.

According to Figure 4.3, the assembly area is increased the size from 5 meter in width and 7 meters in length to 8 meters in width and 12 meters in length by eliminating all scraps and unused materials to storage or garbage. The advantage of increasing the size is the capacity of fabrication the vessel. There are 4 vessels available to assembly at the same time due to the area size is increased. Moreover, the workers have enough space to work at the same time by having 2 meters free space in each vessel.

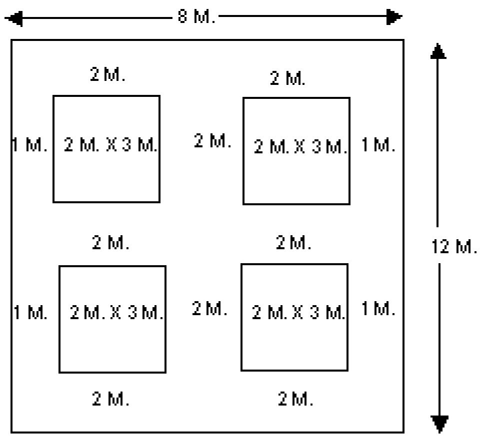


Figure 4.3: Available area of Assembly department

Flow diagram of this design shows the direction and route of material flow. There are still some of back and forth within the flow. But the distance of the flow is shorter compared to the existing plant.

In this type of design the equipment, machine and operation will group together as a department. The capacity will be the keep originally capacity except the storage area can store up to 4 vessels. In this design, the department will be divided into 7 areas and each operation will be grouped together, which are:

1. Raw material receiving area
2. Cutting area
3. Rolling area
4. Welding area
5. Buffing area
6. Assembly area

In fact, bridge crane from the existing layout will be directed the route of material handling from raw material to each process and end up to truck or finished good storage.

The following figure (Fig 4.4) will be the space in welding department and buffing department of the new plant design. According to the design, the area can operate the product 2 vessels. The size of the vessel, which is 2 meters in width and 3 meters in length. From the measurement of suitable working space, 1 meters of a worker including the equipment, the space between each piece vessel is 2 meters which allow 2 workers working at the position for different vessel.

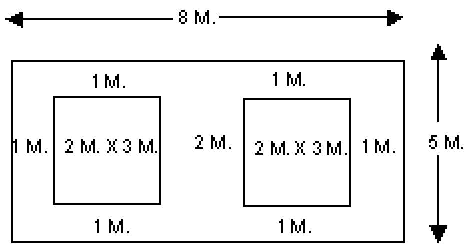


Figure 4.4: The space of welding and buffing area

The disadvantage of this design is the welding area and buffing area can store only 2 vessels at the time. As a result, there area some bottleneck between buffing area and welding area due to the limitation of factory area.

4.2.1 Flow process chart

Flow process chart of the new plant layout shows all the activities, time consuming, and also distance of material flow (Table 4.1).

Table 4.1 : flow process chart of process layout of modify existing plant

	○ ⇨ □ D ▽	Description	Time/1 set of vessel	Department	Total time	Distance	Total distance
1	⇨	Deliver stainless steel sheet to cutting area	10 minutes	Stock area	10 minutes	12 meters	12 meters
2	○	Cut stainless steel sheet by designing shape	4 hours	Cutting department	4 hours 10 minutes		
3	⇨	Deliver to the buffing area	15 minutes	Cutting department	4 hours 25 minutes	22 meters	34 meters
4	○	Cleaning and buffing process	24 hours	Buffing department	28 hours 25 minutes		
5	⇨	Deliver the steel sheets to pre-constuct for rolling	20 minutes	Buffing department	28 hours 45 minutes	30 meters	64 meters
6	○	Apply rolling process for a required shape	3 hours	Rolling department	31 hours 45 minutes		
7	⇨	Deliver to assembly area	15 minutes	Rolling department	30 hours	24 meters	88 meters
8	○	Pre-construct each steel sheet into a vessel shape	14 hours	Assembly area	44 hours		
9	⇨	Deliver to welding area	5 minutes	Assembly area	44 hours 5 minutes	8 meters	96 meters
10	○	Internal welding	6 hours	Welding department	50 hours 5 minutes		
11	○	External welding	5 hours	Welding department	55 hours 5 minutes		
12	⇨	Deliver back to buffing area	5 minutes	Welding department	55 hours 10 minutes	8 meters	104 meters
13	○	Internal buffing and cleaning	16 hours	Buffing department	71 hours 10 minutes		
14	⇨	Deliver back to assembly area	5 minutes	Buffing department	71 hours 15 minutes	8 meters	112 meters
15	○	Apply top side cover to tank	3 hours	Assembly area	74 hours 15 minutes		
16	⇨	Deliver back to welding area	5 minutes	Assembly area	74 hours 20 minutes	8 meters	120 meters
17	○	Welding top side of the vessle	2 hours	Welding department	76 hours 20 minutes		
18	○	Finish detail work (closing man hole,drill hole,nozzle)	8 hours	Welding department	84 hours 20 minutes		
19	⇨	Deliver to assembly area for coloring some steel part	5 minutes	Welding department	84 hours 25 minutes	8 meters	128 meters
20	○	Apply the first layer painting	2 hours	Assembly area	86 hours 25 minutes		
21	D	wait for the paint to dry	3 hours	Assembly area	89 hours 25 minutes		
22	○	Apply the final layer	2 hours	Assembly area	91 hours 25 minutes		
23	D	Wait for the final paint to dry	6 hours	Assembly area	97 hours 25 minutes		
24	□	Inspect vessel pressure test (leak test)	24 hours	Assembly area	121 hours 25 minutes		
25	○	Final cleaing inside and outside	4 hours	Assembly area	125 hours 25 minutes		
26	⇨	Trasfer product to the truck	10 minutes		125 hours 35 minutes	12 meters	140 meters

4.2.2 Calculation output data sheet

The following table will show the output of the relevant data from calculating the waiting time of the process layout (Table 4.2).

Table 4.2 Calculation output of the process layout

NO.	PROCESS AREA	1	2	3	4	TIME USAGE	IDLE TIME
1	CUTTING	4	8	12	16	4H	
2	BUFFING	28	32	36	40	24H	
3	ROLLING	31	35	39	43	3H	
4	ASSEMBLY	45	49	59	63	14H	6H
5	WELDING	56	60	70	74	11H	
6	BUFFING	72	76	88	92	16H	2H
7	ASSEMBLY	75	79	91	95	3H	
8	WELDING	85	89	101	105	10H	
9	ASSEMBLY	126	130	167	171	41H	25H
	TOTAL					126H	33H

By looking at Table 4.2, it shows the running time for each process which produce 4 vessels at the time. Since some area such as welding area and buffing area can only fabricate 2 products at the time, there are some bottleneck occur in some area. According to new design of process plant layout, assembly area has enough space to produce 4 vessels at the same time. The bottleneck occurs in rolling area and assembling area when 3rd and 4th vessel parts from assembly area are waiting to be fabricated which take about 6 hours of waiting time. As the result, the total waiting time to produce 4 vessels is 33 hours. The total time to produce 4 vessels for process layout is approximately 162 hours.

From looking at the flow process chart of the process layout plant of 1 vessel is 7655 minutes or approximately 16 days by using 30 working hours per day (8 hour per day).

In order to produce 4 vessels at the time, there will be some bottleneck in welding area, assembly area and buffing area. The problem occur when the all four vessels are in assembly area and prepare for transferring to buffing area which can only store 2 vessels. The third and forth vessels have to wait for 2 hours to be buffed. The overall waiting time is 33 hours or approximately 4 days. As the result, the total number of making 4 vessels are 20 days.

The distance of using the material handling, not include when the material handling is not occupied is 140 meters from the beginning of the production until the end of the production. It is 88 meters shorter than existing plant, the reduction mostly causes from the relocation of assembly area.

From designing the new layout, the number of worker will be still the same as original number which is 30 workers since the size of each area is still the same.

4.2.3 Improvement in new process layout

By moving the assembly area to the center of production, the overall production time and the distance of material handling is reducing significantly compared to existing plant layout.

Another benefit of design a new process layout is about closeness relationship. The buffing area and welding area are apart from each other to avoid any damages.

4.3 Designed of the layout based on product layout

4.3.1 Layout of new plant design (product layout)

The following figure (Fig 4.5) is the new layout design according to the design based on product layout.

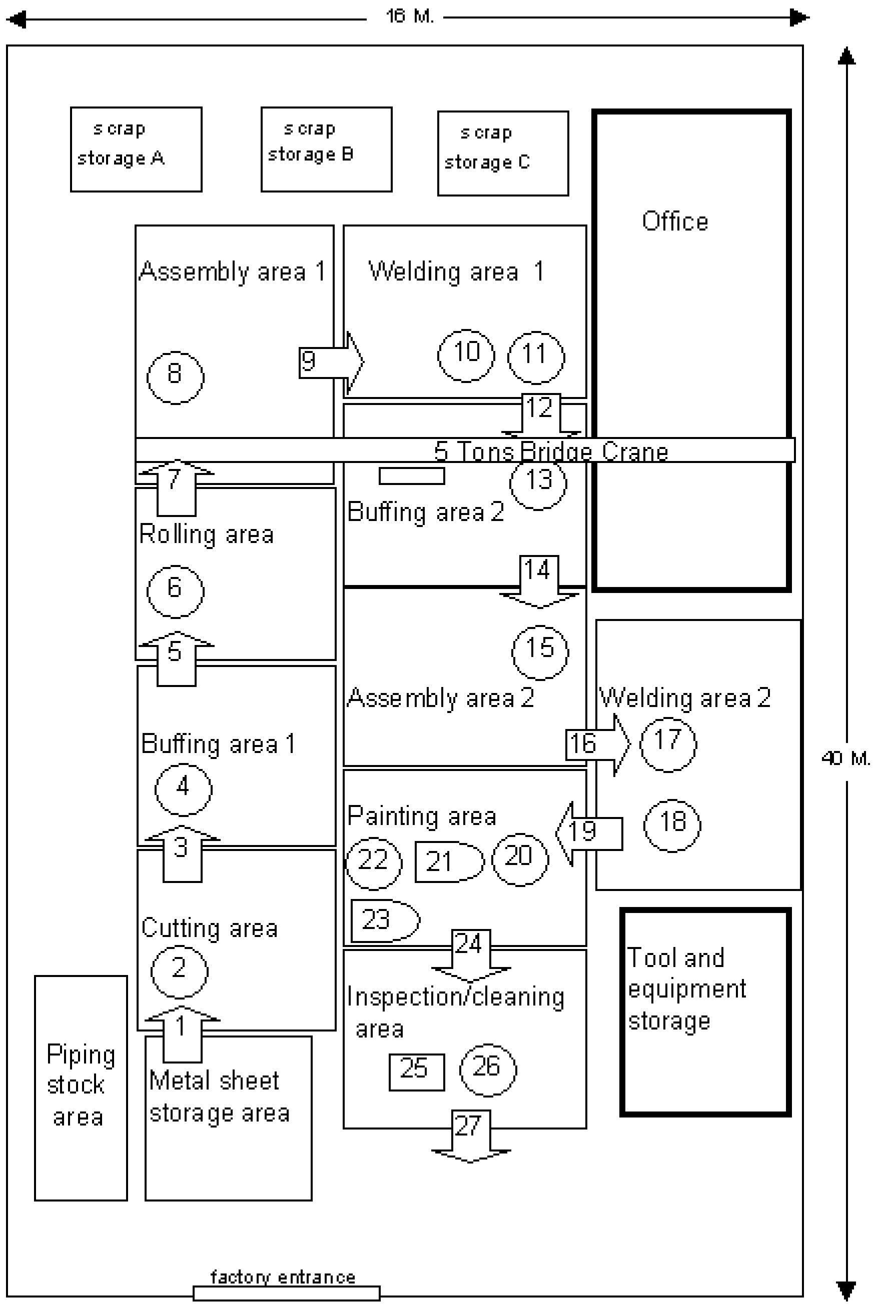


Figure 4.5: New plant design layout (product layout)

In this layout design the operation and the department will be located following the flow of the material. The design of the layout will be designed followed by the sequence of the material flow. The space of each department will be reduced in capacity compared to the existing plant.

The area of assembly 1 area will be reduced in size (Fig 4.6) in order to fit all the area in the factory layout.

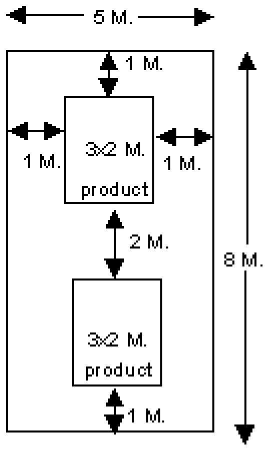


Figure 4.6: The space of assembly area

In the new layout design, the layout will be divided into 10 departments. Each department is located according to the flow and the process required of the production. The buffing process will be broken down into 2 departments, the assembly process will be broken down 2 departments and also the welding process which broken down into 2 departments. Moreover, the painting department is isolated from the assembly department. These will be make the flow of the process run faster and also avoiding the back and forth movement of the material flow.

Since the limitation of factory's space, the closeness relationship cannot meet the requirement. The buffing department is located close to welding department due to the route of the process.

4.3.2 Flow process chart

Flow process chart of the new plant layout shows all the activities, time consuming, and also distance of material flow (Table 4.3).

Table 4.3 : flow process chart of product layout of modify existing plant

	○ ⇨ □ D ▽	Description	Time/1 set of vessel	Department	Total time	Distance	Total distance
1	⇨	Deliver stainless steel sheet to cutting area	5 minutes	Stock area	5 minutes	8 meters	8 meters
2	○	Cut stainless steel sheet by designing shape	4 hours	Cutting department	4 hours 10 minutes		
3	⇨	Deliver to the buffing area	15 minutes	Cutting department	4 hours 25 minutes	8 meters	16 meters
4	○	Cleaning and buffing process	24 hours	Buffing department	28 hours 25 minutes		
5	⇨	Deliver the steel sheets to pre-constuct for rolling	20 minutes	Buffing department	28 hours 45 minutes	8 meters	24 meters
6	○	Apply rolling process for a required shape	3 hours	Rolling department	31 hours 45 minutes		
7	⇨	Deliver to assembly area	15 minutes	Rolling department	32 hours	8 meters	32 meters
8	○	Pre-construct each steel sheet into a vessel shape	14 hours	Assembly area	46 hours		
9	⇨	Deliver to welding area	10 minutes	Assembly area	46 hours 10 minutes	6 meters	40 meters
10	○	Internal welding	6 hours	Welding department	52 hours 10 minutes		
11	○	External welding	5 hours	Welding department	57 hours 10 minutes		
12	⇨	Deliver back to buffing area	5 minutes	Welding department	57 hours 15minutes	8 meters	48 meters
13	○	Internal buffing and cleaning	16 hours	Buffing department	73 hours 15 minutes		
14	⇨	Deliver back to assembly area	5 minutes	Buffing department	73 hours 20 minutes	8 meters	56 meters
15	○	Apply top side cover to tank	3 hours	Assembly area	76 hours 20 minutes		
16	⇨	Deliver back to welding area	5 minutes	Assembly area	76 hours 25 minutes	8 meters	64 meters
17	○	Welding top side of the vessle	2 hours	Welding department	78 hours 25 minutes		
18	○	Finish detail work (closing man hole,drill hole,nozzle)	8 hours	Welding department	86 hours 25 minutes		
19	⇨	Deliver to painting area for coloring some steel part	5 minutes	Welding department	86 hours 30 minutes	8 meters	72 meters
20	○	Apply the first layer painting	2 hours	Painting area	88 hours 30 minutes		
21	D	wait for the paint to dry	3 hours	Painting area	91 hours 30 minutes		
22	○	Apply the final layer	2 hours	Painting area	93 hours 30 minutes		
23	D	Wait for the final paint to dry	6 hours	Painting area	99 hours 30 minutes		
24	⇨	Deliver to inspection area for hydro test	5 minutes	Painting area	99 hours 35 minutes	8 meters	80 meters
25	□	Inspect vessel pressure test (leak test)	24 hours	Inspection area	123 hours 35 minutes		
27	○	Final cleaing inside and outside	4 hours	Cleaning and stock area	127 hours 35 minutes		
28	⇨	Trasfer product to the truck	5 minutes		127 hours 40 minutes	6 meters	86 meters

4.3.3 Calculation output data sheet

The following table will show the output of the relevant data from calculating the waiting time of the product layout (Table 4.4).

Table 4.4 Calculation output of the product plant layout

NO.	PROCESS AREA	1	2	3	4	TIME USAGE	IDLE TIME
1	CUTTING	4	8	12	16	4H	
2	BUFF 1	28	32	36	40	24H	
3	ROLLING	31	35	39	43	3H	
4	ASSEMBLY & WELDING	56	60	81	85	25H	17H
5	BUFF 2	72	46	97	101	16H	
6	ASSEMBLY & WELDING	85	89	110	114	13H	
7	PAINTING	98	102	123	127	13H	
8	INSPECTION	122	126	147	151	24H	
		126	130	151	155	4H	
	TOTAL					126H	17H

By looking at Table 4.4, it shows the running time for each process which produce 4 vessels at the time. Since some area such as assembly1 & 2 area and buffing area can only fabricate 2 products at the time, there are some bottleneck occur in that area. According to product plant layout, assembly area has enough space to produce only 2 vessels at the same time. The bottleneck occurs in assembly area when 3rd and 4th vessel parts from rolling area are waiting to be assembled in assembly area which take about 6 hours of waiting time to be assembled. Additionally, buffing area and inspection area are taking lead time for vessels to be produced approximately 14 hours of waiting time. As the result, the waiting time to produce 4 vessels is 20 hours. The total time to produce 4 vessels for existing layout is approximately 149 hours 10 minutes or 19 days.

From looking at the flow process chart of the product layout plant of 1 vessel is 7660 minutes or approximately 16 days by using 30 working hours per day (8 hour per day).

In order to produce 4 vessels at the time, product layout gives the amount of idle time which is 20 hours. The waiting time occur in assembly 1 area and buffing area which take about 8 hours, another waiting time occur when the product from painting area is transferring to inspection area. It takes about 12 hours to wait for the next process.

The distance of using the material handling, not include when the material handling is not occupied is 86 meters from the beginning of the production until the end of the production. It is 142 meters shorter than existing plant, and 54 meters shorter than new process layout.

From designing the new product layout, the number of worker will be still the same as original number which is 30 workers.

4.3.4 Improvement in new product layout

By having a smooth flow, the problem of back and forth motion is eliminated. Compared to the previous designs, the product design gives the advantage of eliminating the improper flow, which is back and forth motion between welding and assembly area. Especially, concern with the size of the product, the product made by the company is quite large which is not suitable to move in a complex route. It consumes lots of time to move back and forth and also disturb the work in process activities.

However, there is still disadvantages in product layout design which are the lack of finished product's stock area. This means the company must transfer the finished product straight to the truck or place it outdoor. Additionally, the welding area is still nearby buffing area, due to closeness relationship. However, adding yellow curtain between each department can solve this problem.

4.4 Designed of the layout based on combination layout (product and process)

4.4.1 Layout of new plant design (combination layout)

In this design, the design will be mostly based on product layout except only some area is combined which are assembling area and welding area. The following figure (Fig 4.7) is the new plant design according to the product layout mixes with process layout.

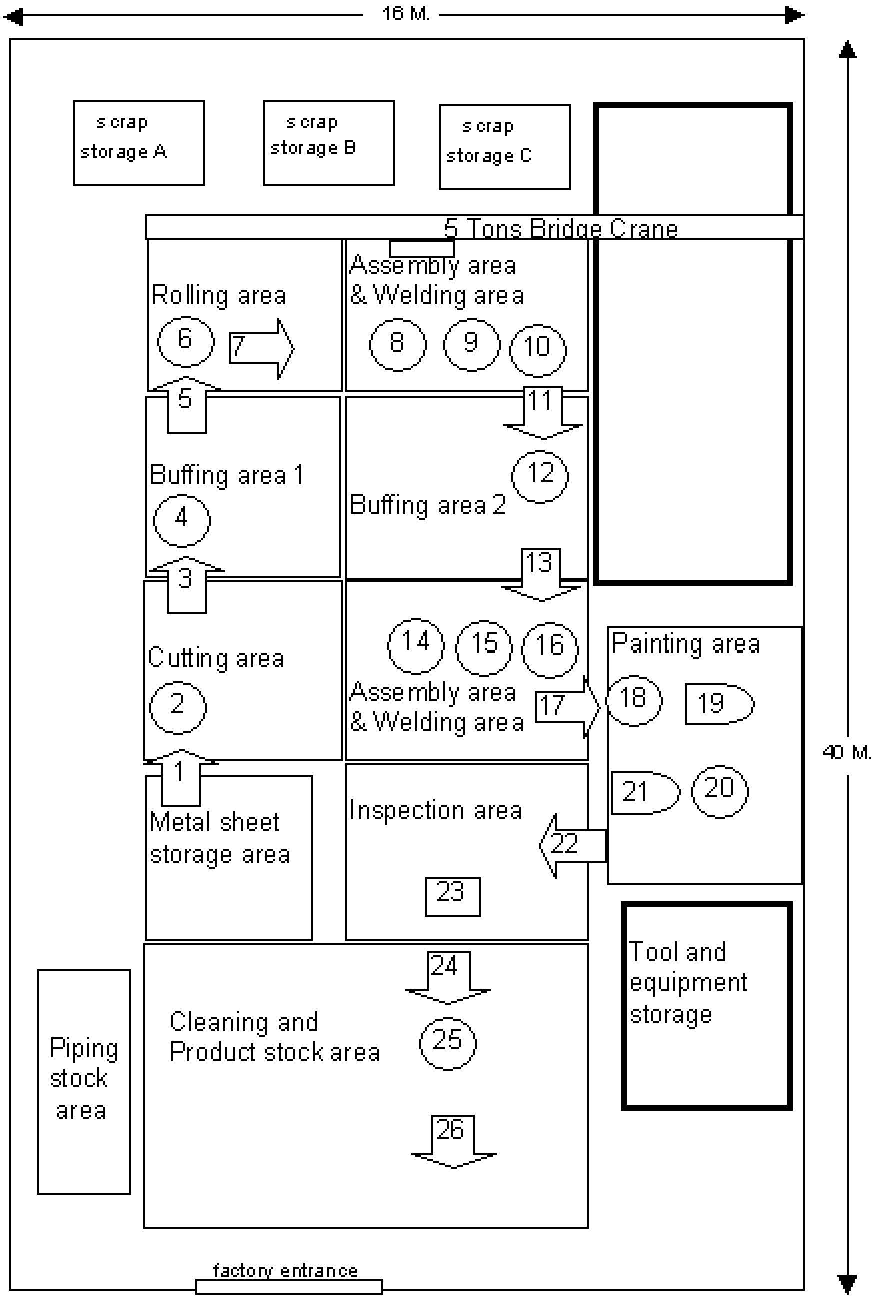


Figure 4.7: New plant design layout (combination layout)

4.4.2 Flow process chart

From looking at the flow process chart (Table 4.5) of the combination layout plant of 1 vessel is 7650 minutes or approximately 16 days by using 30 working hours per day (8 hour per day).

In order to produce 4 vessels at the time, product layout gives the amount of idle time which is 17 hours 2 days. The waiting time occur in only assembly & welding 1 area which takes about 17 hours. As a result, the total time of producing 4 vessels is 18 days.

The distance of using the material handling, not include when the material handling is not occupied is 80 meters from the beginning of the production until the end of the production. It is 148 meters shorter than existing plant, 30 meters shorter than improvement process layout and 6 meters shorter than product layout.

From designing the new layout, the number of worker will be still the same as product layout number which is 30 workers.

TABLE 4.5: flow process chart of combination layout of modify existing plant

	○ ⇨ □ D ▽	Description	Time/1 set of vessel	Department	Total time	Distance	Total distance
1	⇨	Deliver stainless steel sheet to cutting area	5 minutes	Stock area	5 minutes	8 meters	8 meters
2	○	Cut stainless steel sheet by designing shape	4 hours	Cutting department	4 hours 5 minutes		
3	⇨	Deliver to the buffing area	15 minutes	Cutting department	4 hours 20 minutes	8 meters	16 meters
4	○	Cleaning and buffing process	24 hours	Buffing department	28 hours 20 minutes		
5	⇨	Deliver the steel sheets to pre-constuct for rolling	20 minutes	Buffing department	28 hours 40 minutes	8 meters	24 meters
6	○	Apply rolling process for a required shape	3 hours	Rolling department	31 hours 40 minutes		
7	⇨	Deliver to assembly area	15 minutes	Rolling department	31 hours 55 minutes	6 meters	30 meters
8	○	Pre-construct each steel sheet into a vessel shape	14 hours	Assembly area	45 hours 55 minutes		
9	○	Internal welding	6 hours	Welding department	51 hours 55 minutes		
10	○	External welding	5 hours	Welding department	56 hours 55 minutes		
11	⇨	Deliver back to buffing area	5 minutes	Welding department	57 hours	8 meters	38 meters
12	○	Internal buffing and cleaning	16 hours	Buffing department	73 hours		
13	⇨	Deliver back to assembly area	5 minutes	Buffing department	73 hours 5 minutes	8 meters	46 meters
14	○	Apply top side cover to tank	3 hours	Assembly area	76 hours 5 minutes		
15	○	Welding top side of the vessle	2 hours	Welding department	78 hours 5 minutes		
16	○	Finish detail work (closing man hole,drill hole,nozzle)	8 hours	Welding department	86 hours 5 minutes		
17	⇨	Deliver to painting area for coloring some steel part	5 minutes	Welding department	86 hours 10 minutes	10 meters	56 meters
18	○	Apply the first layer painting	2 hours	Painting area	88 hours 10 minutes		
19	D	wait for the paint to dry	3 hours	Painting area	91 hours 10 minutes		
20	○	Apply the final layer	2 hours	Painting area	93 hours 10 minutes		
21	D	Wait for the final paint to dry	6 hours	Painting area	99 hours 10 minutes		
22	⇨	Deliver to inspection area for hydro test	5 minutes	Painting area	99 hours 15 minutes	10 meters	66 meters
23	□	Inspect vessel pressure test (leak test)	24 hours	Inspection area	123 hours 15 minutes		
24	⇨	Deliver to cleaning and stock area for final cleaning	5 minutes	Inspection area	123 hours 20 minutes	8 meters	74 meters
25	○	Final cleaing inside and outside	4 hours	Cleaning and stock area	127 hours 20 minutes		
26	⇨	Trasfer product to the truck	10 minutes		127 hours 30 minutes	6 meters	80 meters

4.4.3 Calculation output data sheet

The following table will show the output of the relevant data from calculating the waiting time of the existing plant (Table 4.6).

Table 4.6 Calculation output of the combination plant layout

NO.	PROCESS AREA	1	2	3	4	TIME USAGE	IDEL
1	CUTTING	4	8	12	16	4H	
2	BUFF 1	28	32	36	40	24H	
3	ROLLING	31	35	39	43	3H	
4	ASSEMBLY & WELDING	56	60	81	85	25H	17H
5	BUFF 2	72	46	97	101	16H	
6	ASSEMBLY & WELDING	85	89	110	114	13H	
7	PAINTING	98	102	123	127	13H	
8	INSPECTION	122	126	147	151	24H	
		126	130	151	155	4H	
	TOTAL					126H	17H

4.4.3 Improvement in new combination layout

By combining assembly department and welding department, eliminated the problem of lacking finished goods storage. Also having a smooth flow, the problem of back and forth motion is eliminated. Compared to the previous designs, the combination design gives the advantage of reducing the material handling route, which is between welding and assembly area. The investment of new welding machine can be also eliminated.

On the other hand, there is still disadvantages in combination layout design which are the closeness relationship occur in welding area and buffing area. Moreover, there is no free space for aisle for officers to walk through office.

4.5 Designed of the layout based on fixed layout

4.5.1 Layout of new plant design (fixed layout)

The following figure (Fig 4.8) is the new layout design according to the design based on product layout. For this design, all the process except cutting and rolling will be consisted in one area (assembly 1 area).

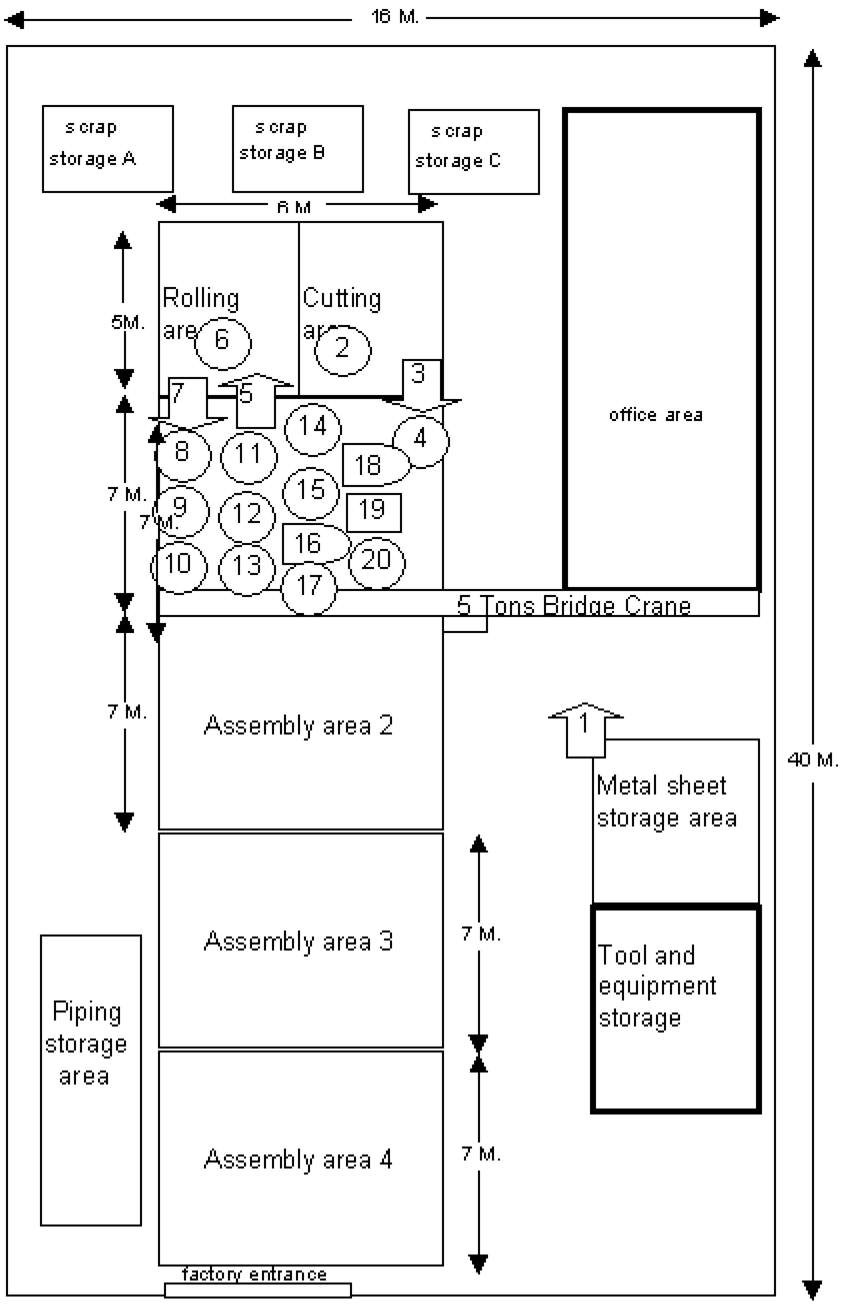


Figure 4.8: New plant design layout (fixed layout)

The following figure (Fig 4.9) shows the space of assembly area which include all the department in one area such as, welding department, buffing department, painting department and testing department. According to the design, each assembly area can produce only 1 product. The size of the vessel, which is 2 meters in width and 3 meters in length. From the measurement of suitable working space for this kind of layout, 2 meters of a worker including the equipment which allow 2 workers working at the position for different task.

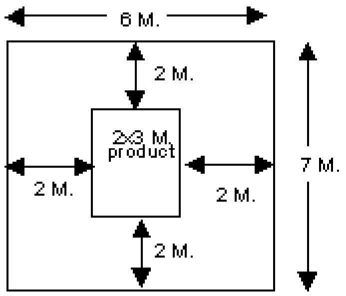


Figure 4.9: The space of assembly area

4.5.2 Flow process chart

From looking at the flow process chart (Table 4.7) of the fixed layout plant of 1 vessel is 7590 minutes or approximately 16 days by using 30 working hours per day (8 hour per day). Most of the workers have to work at the same area because of fixed layout design. In case, of producing 4 vessels at the same time, the company have to increase labour force by double up workers in buffing department, welding department and assembly department since all these departments are combined in one assembly area and each assembly area needs to have skilled workers in each process. As a result, fabricators, welders and buffer require 2 more workers in each area in order to fulfill the time of operation. The total workers that included skilled and non-skilled workers are 36 workers. Table 4.7 shows the amount of workers that require for fixed layout to produce 4 vessels at the same time.

Table 4.7: Workers number in fixed layout

Operation	Number of workers
Assembly	10
Welding	8
Buffing	7
Paiting	4
Rolling	3
Cutting	3
Storing	1

The distance of using the material handling, not include when the material handling is not occupied is 30 meters from the beginning of the production until the end of the production. It is 198 meters shorter than existing plant, 80 meters shorter than improvement process layout, 56 meters shorter than product layout and 50 meters shorter than combination layout.

From designing the new layout, the number of worker will be totally 36 workers.

TABLE 4.8: flow process chart of fixed layout of modify existing plant

	○ ⇨ □ D ▽	Description	Time/1 set of vessel	Department	Total time	Distance	Total distance
1	⇨	Deliver stainless steel sheet to cutting area	10 minutes	Stock area	10 minutes	16 meters	16 meters
2	○	Cut stainless steel sheet by designing shape	4 hours	Cutting department	4 hours 10 minutes		
3	⇨	Deliver to the buffing area	5 minutes	Cutting department	4 hours 15 minutes	7 meters	23 meters
4	○	Cleaning and buffing process	24 hours	Buffing department	28 hours 15 minutes		
5	⇨	Deliver the steel sheets to pre-constuct for rolling	5 minutes	Buffing department	28 hours 20 minutes	8 meters	24 meters
6	○	Apply rolling process for a required shape	3 hours	Rolling department	31 hours 20 minutes		
7	⇨	Deliver to assembly area	5 minutes	Rolling department	31 hours 25 minutes	8 meters	30 meters
8	○	Pre-construct each steel sheet into a vessel shape	14 hours	Assembly area	45 hours 25 minutes		
9	○	Internal welding	6 hours	Welding department	51 hours 25 minutes		
10	○	External welding	5 hours	Welding department	56 hours 25 minutes		
11	○	Internal buffing and cleaning	16 hours	Buffing department	72 hours 25 minutes		
12	○	Apply top side cover to tank	3 hours	Assembly area	75 hours 25 minutes		
13	○	Welding top side of the vessle	2 hours	Welding department	77 hours 25 minutes		
14	○	Finish detail work (closing man hole,drill hole,nozzle)	8 hours	Welding department	85 hours 25 minutes		
15	○	Apply the first layer painting	2 hours	Painting area	87 hours 25 minutes		
16	D	wait for the paint to dry	3 hours	Painting area	90 hours 25 minutes		
17	○	Apply the final layer	2 hours	Painting area	92 hours 25 minutes		
18	D	Wait for the final paint to dry	6 hours	Painting area	98 hours 25 minutes		
19	□	Inspect vessel pressure test (leak test)	24 hours	Inspection area	122 hours 25 minutes		
20	○	Final cleaing inside and outside	4 hours	Cleaning and stock area	126 hours 25 minutes		

4.5.3 Calculation output data sheet

The following table will show the output of the relevant data from calculating the waiting time of the fixed layout (Table 4.9).

Table 4.9 Calculation output of the fixed layout

NO.	PROCESS AREA	1	2	3	4	TIME USAGE	IDLE TIME
1	CUTTING	4	8	12	16	4H	
2	BUFFING	28	32	36	40	24H	
3	ROLLING	31	35	39	43	3H	
4	ASSEMBLY	126	130	134	136	95H	
	- WELDING						
	- BUFFING						
	- PAINTING						
	- TESTING						
	TOTAL					126H	

In order to produce 4 vessels at the time, fixed layout gives a good result which there is no waiting in all process. As a result, the total time of producing 4 vessels is approximately 136 hours or 17 days by using 36 workers.

4.6 The relevant data conclusion of each designed plant layout

In order to compare the performance of each layout easily, this table will show the relevant data of each plant layout. It obviously shows that the product layout design gives the best result.

Having estimate the time and the distance from process chart, it shows the detail of how the process is working. In this experiment the batch of 4 vessels will be the quantity to run the flow time. All the significant results will be shown in the following table (Table 4.10).

Table 4.10 : Significant result data

Decription	Existing plant layout	Process layout	Product layout	Mixed layout	Fixed layout
Overall time for running 1 vessel	17 days	16 days	16 days	16 days	16 days
Waiting time for running 4 vessels	33 hours	33 hours	20 hours	17 hours	-
Overall time for running 4 vessels	21 days	20 days	19 days	18 days	17 days
Overall distance to be used	228 meters	110 meters	86 meters	80 meters	30 meters

Conclusion, by the result, it shows that each plant layout gives a different result. Each of the result will be concluded in the following chapter.

The labour costs for each design layout will be shown in the following table in order to compare the different labour cost (Table 4.11).

Table 4.11 : Labour cost

Types of layout	Labout cost for the production of 4 pontoons (Baht)	Labout cost for the production of 1 pontoon (Baht)
Existing plant layout	157,500.00	39,375.00
Process layout	150,000.00	37,500.00
Product layout	142,500.00	35,625.00
Mixed layout	135,000.00	33,750.00
Fixed layout	153,000.00	38,250.00

This shows that the combination layout design plant gives the best result in less labour cost for running the production.

4.7 Factory improvement system

In order to achieve an objective goal and to improve factory's system, 5s activities are aiming to improve the physical condition. Thus, the implementation action contains both the 5s activities and application of the new factory design.

1. Organization

According to the 5s implementation, the first stage is called "organization" which means keeping the necessary things and removing the unnecessary ones. Following this concept, the first step is sorting out the useful raw materials and getting rid of useless components.

The Red-Tag technique is recommenced to deal with the organization process. It is easy and clear for employees to identify the unnecessary things by labeling.

a. Launch the Red-Tag project

The 5S promotion panel established on the threshold of the campaign is also responsible to launch the red-tag project for the sake of avoiding extra personnel. The movement is supposed to last for one and a half months

b. Identify Red-Tag targets

The red-tag items must be clearly bearing in mind before and during the project. In this case, the raw materials within the factory are the red-tag targets.

c. Set Red-Tag criteria

Most of the items in factory need the red-tag.

d. Make the Red-Tag

Knowing the items to be tagged, the Red-Tag is made accordingly. The content includes the items name, quantity, disposal method and reasons. Thus, the red tag used in this case is described in the figure 4.10 below

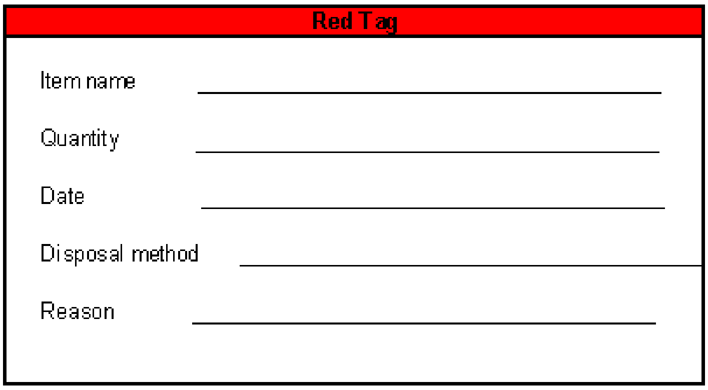


Figure 4.10: Red-Tag

e. Attach the Red-Tag

After making the red-tag, they are then attached on the items falling in the red-tag criteria. Figure 4.11 below shows an example.

Figure 4.11: Attachment of red-tag

f. Evaluate the Red-Tag

Finally, the red-tag items are evaluated, and then are divided into two groups, retained stock and dead stock in light of service value. For the dead stock such as the rusting piece of metal sheet, they are disposed without hesitate. For the retained items, they will be still kept at the separated place within the warehouse for a period of time.

2. Implement safety and security plan

Since the danger of materials and equipment movement, the safety policy is directly implemented after organization action. The operators are trained with the safe operating procedure by their superiors. Safety rule is also imparted to the factory staffs. Some dangerous point must have a warning sign such as, bridge crane. Additionally, all the workers who operate inside the factory must wear helmet without any excuse (figure 4.12)

Figure 4.12: Safety warning and equipment

3. Moving out all items

On the completion of the organization and safety and security plan implementation, all items within the factory, including useful raw materials and useless items, area moved out. This aims to spare the space for storage equipments installation and cleaning activity. For this purpose, all of the utilizable raw materials are primarily sorted out from the useless components, and then are moved and gathered in a certain area where is out of warehouse. Afterwards, the remaining items are divided into retained stock and dead stock, and then are removed to the separated area (figure 4.13).

Figure 4.13: Dead stock

4. Cleanliness

This step regards to the 5S's third stage, "Cleanliness", which refers to thoroughly sweep the floor. After all useful and unnecessary components are moved away, the floor of the present factory is swept.

5. Orderliness

This is the 5S's second stage, "Orderliness", which implies to make things in order so that everybody can easily use and find them. Regularly, it should be done before the cleanliness step. As indicated the 5S introduction model, the signboard strategy is suggested to implement the orderliness. For this reason, signboard strategy is employed to guide the implementation of this stage.

a. Determine location
b. Prepare location
c. Indicate locations and items name

6. Moving back the raw material

After the storage equipments and signboard are ready for action, the useful steel plate are moved back onto the storage equipments where they deserve in the light of tag marked on the equipment body. Before movement, they are required different color printing to distinguish different material type (figure 4.14).

Figure 4.14: Type of piping

7. Identify the each working area

After all the materials are placed in proper way, each department must clearly identify individually. Since the factory has a big space without any identify the area, each department can later on occupied another department. To eliminate the problem, underlining in each area will be the solution of this problem (figure 4.15).

Figure 4.15 : Underlying each department

8. Standardized cleanup organization

The previous step might be regards as the final stage of the implementation campaign, but the fact proved it is not. The organization, orderliness and cleaning activities are repeated regularly every day. The training is keep moving on for both current and new employees. All of these activities are trying to maintain the 5S campaign.

CHAPTER V
CONCLUSION AND RECOMMENDATION

Having designed the different plant layouts, the performance of each plant layout, including existing layout, has been measured in order to evaluate which plant layout gives the best efficiency to produce the work. The result from running the flow chart is discussed in the following.

5.1 Reduction of production time

After designing the new layouts, the performance of each layout will be evaluated by using the flow chart diagram. Flow chart diagram helps on evaluating the production time; it shows the detail of how long each the work in process takes and production. The waiting time of the work in process also finds out from this chart.

5.1.1 Overall time of production

This data show how long the batch of 4 vessels is finished. Fixed layout design gives the shorter time to finish the work in 17 days by using 36 workers, which is 19 % of the existing plant layout. In comparison, combination layout design uses about 18 days or 14 % of the existing plant to finish 4 vessels by using 30 workers. The reason that combination layout design and fixed layout design give the best result because of it has a better material flow compared to existing plant layout which still have the back and forth motion of material flow and less material flow compared to product layout

5.1.2 Overall waiting time

Over all waiting time is the time that work in process waiting for the operation and the time that work in process wait to transfer to the next operation. The data show that existing layout gives the highest average waiting time, because the limitation of the space in each process. The fixed layout design gives the best shortest average waiting time, which does not have any bottleneck in every process of production.

5.1.3 Overall labour cost

The labour cost has been measured in order to evaluate how much the company needs to pay for the labour cost in order to produce 4 vessels. The combination layout design gives the least labour cost, comparing with fixed layout design or existing plant layout design, mostly due to the shorter production time and least of workforce. The labour cost has been reduced 14% from the existing plant or 12 % lesser than fixed layout design. As a result, combination layout design is the best choice for plant layout design in labour cost's case by reducing about 14% of original layout.

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5.2 Improve flow of material

In the existing layout and process layout where the flow of material is quite complicated, there are many back and forth motion between welding department and assembly department. This makes the difficulty to the workers to work effectively. By rearrange and adding department in combination layout, it makes the flow of material run more simple direction.

5.3 Improve factory physical condition

The physical condition of the factory after the implementation is significantly improved. This is the result of removing the messy situation and proper warehouse layout. Since the untidy condition is removed, unnecessary things are eliminated and useful raw materials are fully and quickly used. Additionally, all of storage equipments and raw materials are systemically arranged at their due positions, which facilitate the operations. Moreover, the storage area is cleaner and neater, which directly improve the working environment (Fig 5.1).

Figure 5.1 : Before and after space area

Due to the removal of the unnecessary components, on the other hand, not only is the inventory amount within the warehouse reduced, but also the expenditure on keeping dead stock and other unneeded items is eliminated, which directly decreases the total inventory holding cost. It is estimated that around 200,000 Baht on dead stock holding has been saved. Moreover, the company is able to make money from selling the dead stock as scraps. For this reason, 100,000 Baht from the dead stock sale is expected. In fact, the company has spent about 500,000 Baht per month for ordering raw materials to produce vessels. After the improvement, the company only spend 400,000 per month for raw materials which save cost about 20% from the original payment.

With implementation of the 5s technique, several improvements are achieved. The factory physical condition is significantly improved. Inventory is reduced. Space utilization is increased. Each department is easier and faster, which reduces the production lead time and machine and employees idle times. Raw materials are under good management and control. Factory safety and security is well guaranteed.

5.4 Improving space utilization

The table 5.1 below shows how much space is used by each area before and after the implementation campaign.

Table 5.1: Space utilization before and after implementation

	Storage (Square meter)	Working area (Square meter)	Stock Piling Square meter	Total Space Used (Square meter)
Before	16	115	80	211
After	30	256	0	286

Observed from table 5.1, before the improving efforts, only 16 m″ and 115 m″ are respectively consumed by storage area and working area. A large amount of space, 80 m″, is occupied by the raw materials piling.

After the implementation, a large proportion of space is covered by storage equipments and working areas. Thus, storage area totally takes up 30 m″ and working area accounts for 256 m″ by eliminating all scraps and fully used space effectively.

Based on the comparison above, it can be concluded that all usable space within the new factory has been efficiently utilized. Firstly, space of storage and working area has been significant expanded to 26%. Secondly, the stock pilling is removed, so no space is wasted or improperly used. As a result, free space has turned up.

5.5 Improving safety level

The table 5.2 below shows the number of employees who injured during the working time. In year 2008, there were 16 accidents happened which 15 cases were only not serious cases such as, skin burned from welding process. Moreover 6 cases were reported from workers who have a serious injury during the working period. All 4 cases were from workers had a head injury from hitting at the bridge crane. After the improvement, there is no record of any injury happen in year 2009.

Table 5.2: Injury record of year 2007 and 2008

INJURY RECORD/ YEAR	INJURY (ABLE TO WORK)	INJURY (UNABLE TO WORK)	TOTAL
2007	15	4	19
2008	16	6	22

5.6 Suggestions for further study

Having done all the improvement, even the result of improvement the plant layout of the factory is successful which obviously show that the combination layout design give the best performance by looking at the production time, production cost, material handling utilization.

Those are the reasons that the combination layout design will be chosen to be the best layout in this research. However, all of this work need to take period of time which can cause the opportunity lost for the company. Also the cost to improve the layout can be high even though the crane is used from the existing layout. Moreover, the support from executive team is very important to push the project to be successful. Without the full support from the executive team the project might not be finish. Another aspect is the worker commitment, the worker morale is also important to make the production to be effective; having the very good plant will be useless if the workers are not working with the full ability. All the people in organization need to understand the change of the new environment and the possible problems that can occur in the new plant layout. The availability of the worker is also one major point that company needs to be focus on, shortage of worker resource will directly effect to the product capability. Shortage of the worker resource will also effect to the utilization of the welding equipment. Fortunately, from the past many years, the company has a good relationship with many group of worker, so the availability of the worker is not quite a big problem to the company. All of these aspects need to be concerned in order to make the entire project to fully successful. Furthermore, in order to achieve even better performance, however, each department should be continuously improved. For this reason, it is recommended that 5s should be maintained or continuously improved.

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BIOGRAPHY

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