CHAPTER 4

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 new 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 welding area and painting area and between cutting process and sand blasting process, which consume a lot of material handling usage.

Also the sand blasting room, located between the painting process and storage area, which obstruct the flow of the process. The workers have to transfer the product from painting area to storage area through the sand blasting room by using the railway. This sometimes causes the work to be stopped because 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 4 pieces of pontoon. 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 painting department, when the work in process of welding department is finished at the same time there is work in process in painting is waiting for the paint to be dry, this causes the work in process from welding department not be able to transfer to painting area. This also causes the idle to the worker.

Also when the product is finished, the space to keep the finish product is available for only 30 pieces of pontoon. This causes the problem when the project of job is more than 30 pieces, which is usually more than 30 pieces. When the storage space 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 finish product to customer at the time when the space of keeping product is nearly full can solve this problem.

3. Improper work place

From the observation, the painting area is not clearly designed and separated to another process. From the existing plant layout, there is no proper design of painting area. The painting area is operating next to the welding, which is a risk to have an accident. By working this way, there is a chance of accident occurs from the spark of welding process react to the wet paint. Also there is no room to prevent the dust from painting that might pollute the working environment.

4.1.2 Design of new plant layout

By having the new available land the company is able to expand the factory area and design the new 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.

Looking at the business environment, Thailand's construction work is now getting better, the government increases the investment in developing the rural area, which effects to the quantity of the product, pontoon, which is used in the rural area. The company is forecasting the quantity of the product to be higher than the last two year, which is approximately double of the past quantity. Also having the new plant layout, the company is expecting to win more bidding of the available job.

From the executive board's decision, the company decides to design of new plant layout into the double size compared to the existing capacity. This means the area of working area will be increase from 2 sets of pontoon in each department to 4 sets of pontoon (8 pieces of pontoon) in each department.

4.1.3 New available area

According to the land that company have in new area, which is 110 meters in length and 65 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 analysing the availability of the new land, the capacity desired, and the location of the department.

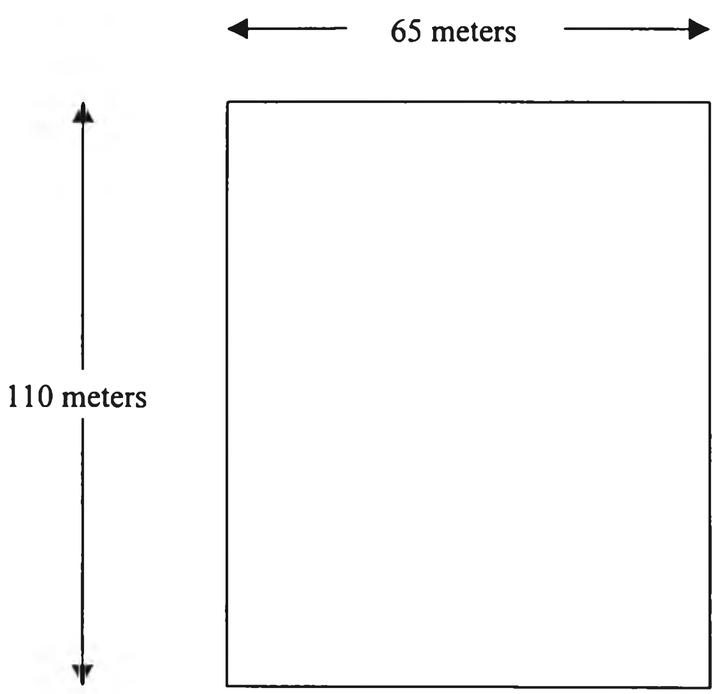

Figure 4.1: New available land for new plant

4.1.4 Criteria and limitation of the layout improvement

There are many limitations and criteria in improving the new plant layout, first the limitation of increasing the machine and cranes. From the executive team's decision, there will not be the budget in increasing the machine like pressing machine or rolling machine, and cranes. The budget will be only enough for increasing of some equipment, for example the welding equipment, painting 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 area of the new layout design. However adding more the workers will consequently affect the amount of welding equipment and painting 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 cutting department, pre-constructing area, and welding department, number of welding equipment will be equal to the number of worker in those departments. For example, if the number of the worker in welding department is 10 then the number of welding equipment will be 10 also. This means that increasing the capacity in welding area, pre-constructing area or cutting 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 the first two alternatives will be used and evaluated the best result given to the company. New design of the layout will base on product layout and process layout and then the result will be both evaluated and compared which one give the better result. Fixed position layout will not be used because the product made from company is not well suitable for that kind of fixed position layout. Each alternative will be described as the follow.

4.2 Design of the layout based on process layout

In this type of design the equipment, machine, and operation will group together as a department. The capacity will be double capacity. In this design, the department will be divided into 8 areas and each operation will be grouped together, which are:

1. Raw material receiving area
2. Cutting area
3. Sand blasting room
4. Pre-construct area
5. Welding area
6. Painting area
7. Final painting area

8. Storage area

The following figure (Fig 4.2) will be the space in each department of the new plant design. According to the design the width of the overhead crane rail will be designed for the space that be able to store the 4 sets of pontoons (8 pieces of pontoon). According to the size of the pontoon, which is 5.4 meters in length and 1.2 meters in width. From the measurement of suitable working space, 0.75 meter of a worker including the equipment, the space between each piece pontoon is 1.5 which is wider than existing plant (1.2 meters between each piece of pontoon) in order to allow 2 workers working at the position for different pontoon, the width of the overhead crane rail, which is the width of the department, will be 25 meters and the length will be 9 meters (according to the standard design of the crane span, which is 6 and 9 meters per span).

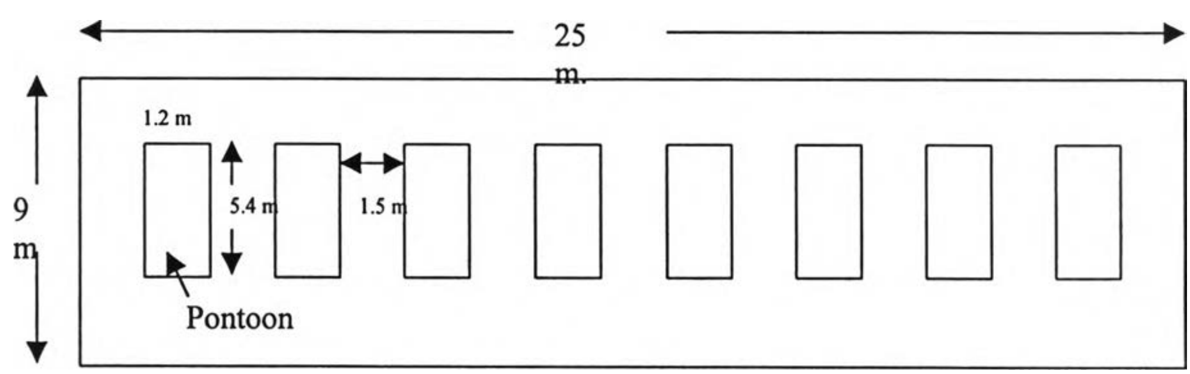

Figure 4.2: The area of each department

Sand Blasting Room

Sand blasting area will be designed as a room right next to the cutting area. The size of the room will be 6 x 8 square meter and the size of cutting area will be 6 x 17 square meter. The material-handling device that used to transfer steel sheet between sand blasting room and cutting area will be designed as a cart and a rail. The steel sheets will be put on the cart and transferred between these two departments. By having the bigger space of sand blasting area, the work can be done 3 pontoons at the same time (Fig 4.3)

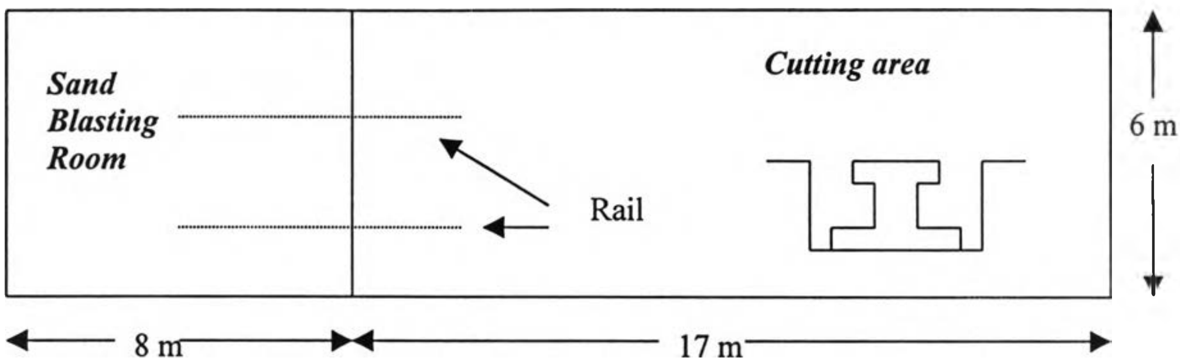

Figure 4.3: The area of Sand Blasting room and Cutting area

4.2.1 Layout of new plant design (process layout)

In this design, the design will be mostly based on existing layout design except only the capacity of the area, which is a double capacity and will be divided into 8 departments.

Moreover, the differences between this new design and existing design are new location of sand blasting area and the addition of final painting area. Sand blasting area is moved closer to the cutting area in order to reduce the transportation distance. And it is also enlarged in order to increase the capacity. The machining area will be cut out since the space of pre-construct area is big enough to locate the pressing machine and rolling machine. Then it is easier to transfer fabricated steel sheet to the pre-construct operation. The following figure (Fig 4.4) is the new plant design according to the design based on process layout.

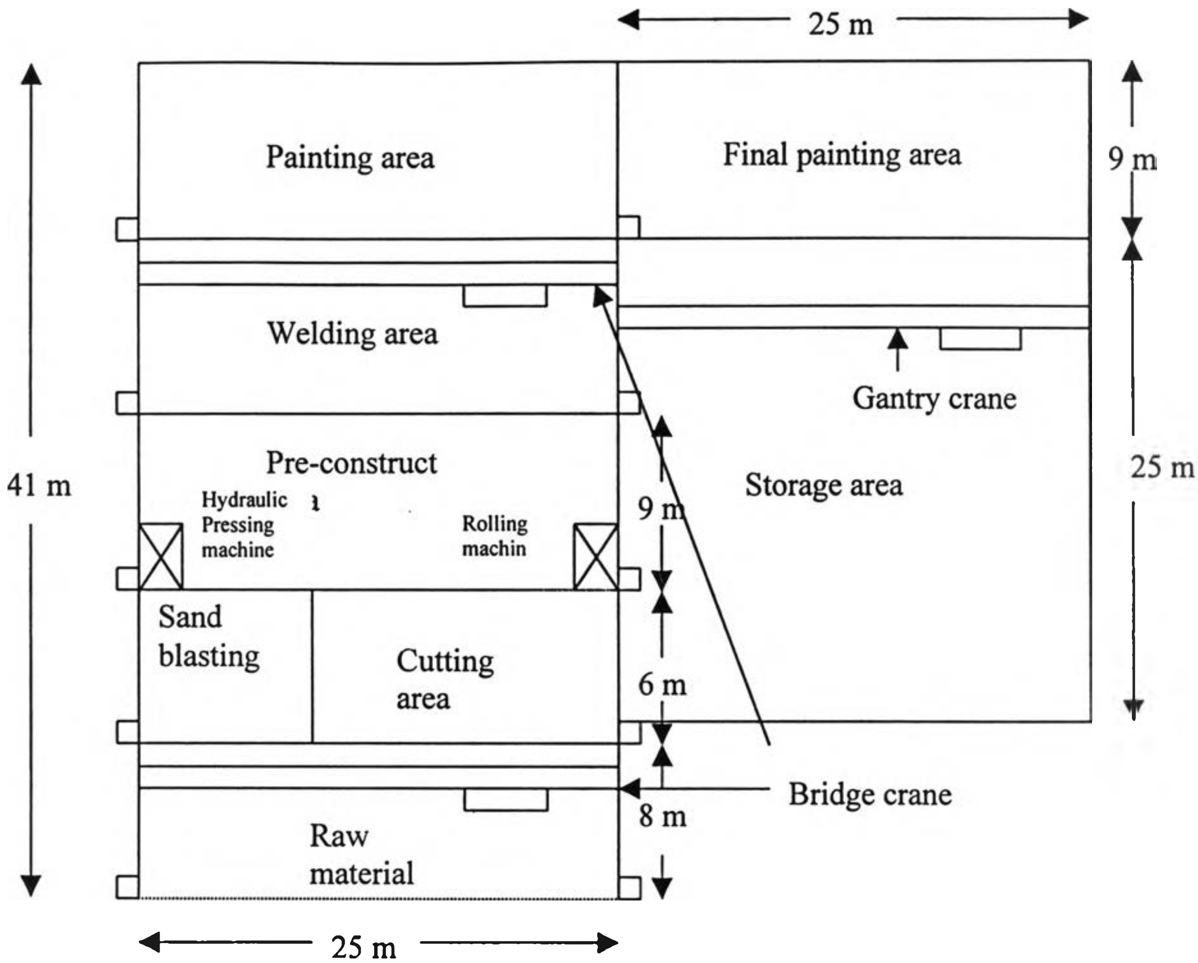

Figure 4.4: New plant design layout (process layout)

Two bridge cranes from the existing plant will be used to move the material from raw material area up to painting area. Also the gantry crane will be used to move the product between final painting area and storage area. The storage area is larger than the existing plant where the product can be stored 60 pieces of pontoon.

4.2.2 Flow process chart

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

Table 4.1: Flow process chart of process layout plant

	○ ⇨ □ D ▽	Description	Time/1set of pontoon	Department	Total time	Distance	Total distance
1	○	Cut 6 pieces of the steel sheet (excluding top part)	4 hours	Cutting department	4 hours		
2	⇨	Deliver to the sand blasting area	10 minutes	Sandblasting Room	4 hours 10 minutes	13 meters	13 meters
3	○	Sand blasting process	4 hours	Sandblasting Room	8 hours 10 minutes		
4	⇨	Deliver to cutting area	10 minutes	Cutting department	8 hours 20 minutes	13 meters	26 meters
5	○	Apply the first layer painting to the steel sheets	1 hour 30 minutes	Cutting department	9 hours 50 minutes		
6	D	Wait for the paint to dry	1 hour	Cutting department	10 hours 50 minutes		
7	⇨	Deliver the steel sheets to pre-construct for machining	30 minutes	Pre-construct department	11 hours 20 minutes	7 meters	33 meters
8	○	Apply pressing process for a required shape	1 hour	Pre-construct department	12 hours 20 minutes		
9	○	Pre-construct each steel sheet into a pontoon shape	1 hour	Pre-construct department	13 hours 20 minutes		
10	⇨	Deliver to Welding area	12 minutes	Welding department	13 hours 32 minutes	9 meters	42 meters
11	○	Inside welding	2 hours	Welding department	15 hours 32 minutes		
12	○	Construct internal structure	8 hours	Welding department	23 hours 32 minutes		
13	○	Inside structure welding	4 hours	Welding department	27 hours 32 minutes		
14	○	Outside welding	2 hours	Welding department	29 hours 32 minutes		
15	○	Internal cleaning and inspecting	2 hours	Welding department	31 hours 32 minutes		
16	⇨	Deliver to painting area	12 minutes	Painting department	31 hours 44 minutes	9 meters	51 meters
17	○	Internal painting	2 hours	Painting department	33 hours 44 minutes		
18	D	Wait for the paint to dry	18 hours	Painting department	51 hours 44 minutes		
19	⇨	Deliver back to welding area	12 minutes	Welding department	51 hours 56 minutes	9 meters	60 meters
20	○	Welding top side of the pontoon	2 hours 30 minutes	Welding department	54 hours 26 minutes		
21	⇨	Deliver to painting area	12 minutes	Painting department	54 hours 38 minutes	9 meters	69 meters
22	○	Finish detail work (closing man hole, drill hole, cleaning)	3 hours	Painting department	57 hours 38 minutes		
23	⇨	Deliver to final painting area	12 minutes	Final painting department	57 hours 50 minutes	25 meters	94 meters
24	○	Paint the 2nd layer	1 hour	Final painting department	58 hours 50 minutes		
25	D	Wait for the paint to dry	8 hours	Final painting department	66 hours 50 minutes		
26	○	Paint the 3rd layer	1 hour	Final painting department	67 hours 50 minutes		
27	⇨	Deliver to storage area	12 minutes	Storage area	68 hours 2 minutes	17 meters	111 meters
28	D	Wait for the paint to dry	24 hours	Storage area	92 hours 2 minutes		
29	⇨	Transfer product to the truck	1 hour		93 hours 2 minutes	13 meters	124 meters

4.2.3 Simulation output

Also having the complicate flow, even more, of material alongside with the large number of queue, running the simulation program help finding the production time.

The following table will show the output of the relevant data from running the simulation of the new process layout plant. The constraint in running simulation program will follow the information in flow process chart.

Table 4.2: Simulation output of the new process layout plant

ARENA Simulation Results
Summary for Replication 1 of 1

Project:New processLayout — Run execution date : 8/15/2004
Analyst:Process Layout — Model revision date: 8/15/2004

Replication ended at time : 28174.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
avgflowtime	10054.	(Insuf)	5590.0	15364.	80
cycletime	285.87	(Insuf)	24.000	3226.6	79
overallidletime	130.26	(Corr)	.00000	4224.6	2616
craneutilization	.2587	(Corr)	.00000	1.0000	.00000

COUNTERS

Identifier	Count	Limit
jobdone	80	Infinite

Simulation run time: 0.00 minutes.
Simulation run complete.

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

From looking at the flow process chart of the process layout plant along with running the simulation program, the replication end time of producing or make span is 28,174 minutes. By constraint of running the program in 24 working hours per day, this shows that the overall production time for producing 80 pontoons is approximately 20 days.

The average flow time in the new process layout plant is 10054 minutes or approximately 7 days.

The cycle time of production is the gap between each finished product, which goes out of the production line. It shows that the cycle time of the product in process layout plant is 285.87 minutes or 4.8 hours

Overall idle time and the numbers of idle times of the process layout plant is 130.26 minutes or 2.2 hours and it happened for 2616 times.

Crane utilization shows how many percent the cranes are used in the production of 80 pontoons. The percentage of using crane is compared to the replication time of producing 80 pontoons. In the process layout plant, the percentage of using cranes is 25.87 of time in producing 80 pontoons.

4.2.4 Flow diagram

Flow diagram of this design (Fig 4.5) 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. However there are still the closeness problem between the painting area and welding area.

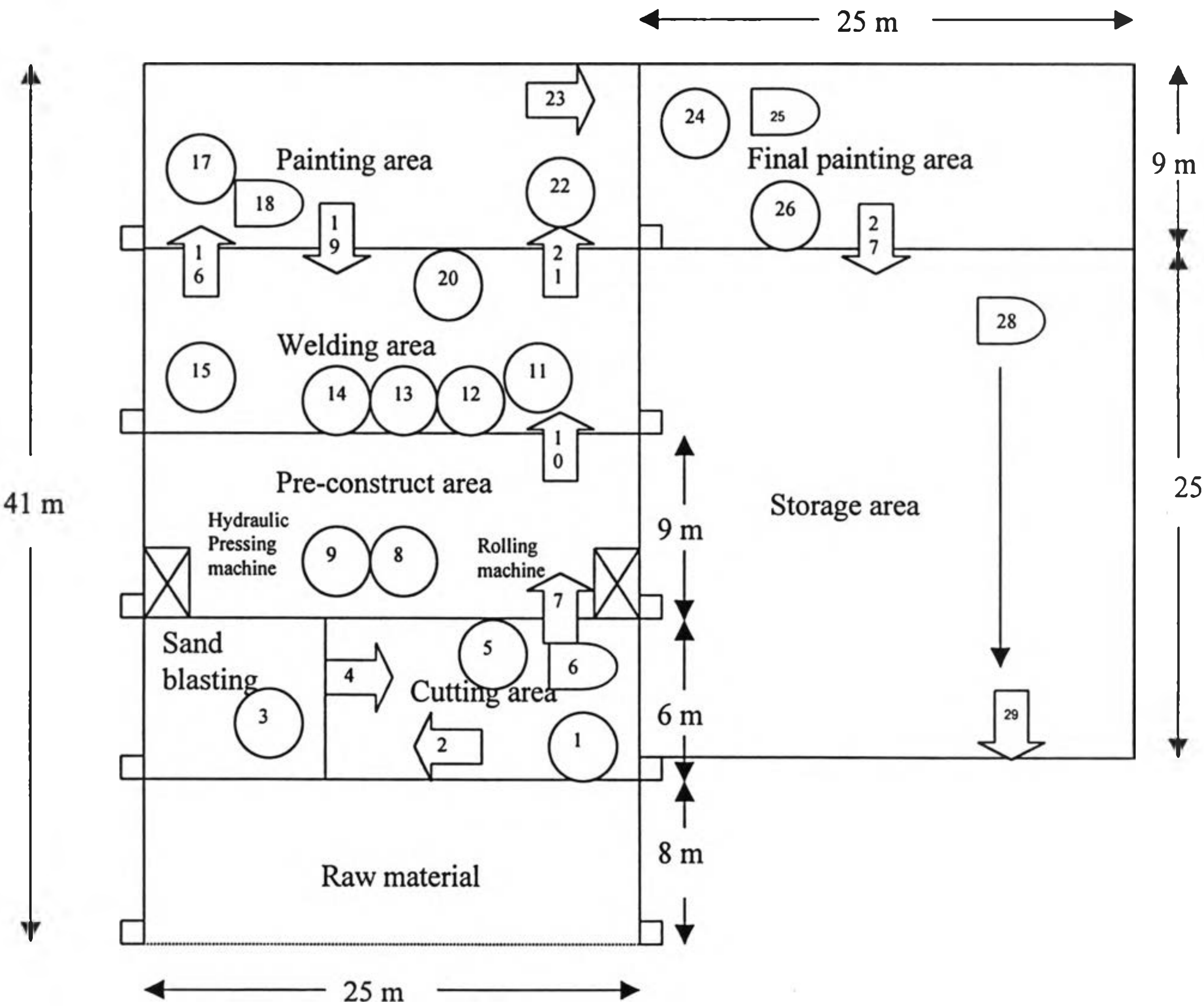

Figure 4.5: Flow diagram of new plant design layout (process layout)

4.2.5 Cycle time of the product

From the simulation program, the cycle time of the product within process layout plant is 4.8 hours for 1 piece of pontoon. This give the better result compared to existing plant layout.

4.2.6 Distance of moving the material handling (crane)

The distance of using the material handling, not include when the material handling is not occupied, is 124 meters from the beginning of the production until the end of the production. It is 11 meters shorter than existing plant, the reduction mostly causes from the relocation of sand blasting area. And the absence of the machining area also reduces the distance of material handling.

4.2.7 Worker capacity

From designing the new capacity of the plant, the number of worker will be increased in order to meet the size of the operation. Following table will be the estimation of number of worker in process design plant layout.

Table 4.3: Estimated number of worker in process design plant layout

Operation	Number of workers
Cleaning	8
Sand Blasting	3
Painting	18
Welding	16
Pre-constructing	20
Cutting	8
Total	73

In painting department where is divided into two departments, painting and final painting the number of worker will be 8 for each department. Other 2 workers will be for first layer painting. The painting equipment will increase along with the number of painting worker.

This also means that the capacity of the welding equipment will be equal to the number of worker in welding area, pre-constructing area, and cutting area, which are 44 units. 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.

With the standard payment rate of 150 per worker per day, the company needs to pay 10950 Baht per day for 73 workers. From using 20 days to finish the project, the company has to pay 219,000 Baht.

4.2.8 Improvement in new process layout plant

By having increased the space in the new process layout design, the overall production time (replication end), average flow time, idle time, and cycle time is reduce significantly compared to existing plant layout. Also the utilization of the crane is also increase that means the cranes are less idle.

However the problem of closeness between welding process and painting process is still the problem, which is quite still not effective to the way of work. The closeness between these two departments may cause the accident to the facility and to the workers. Also the number of welding equipment will be increased along with the increasing of the worker. Also the company needs to invest for the increasing of welding equipment along with the increasing of number of worker and also the factory structure.

With the availability of the space, the process layout design will be slightly modified by separating welding process and painting process away. In the modification welding process and painting process will be separated by having the space of 9 meters, this area can also be used as a temporary inventory area before going to next operation.

4.3 Design of the modified process layout

The following figure (Fig 4.6) will be a layout design of the modified process layout. This design will eliminate the problem of closeness between welding department and painting department by adding buffer area.

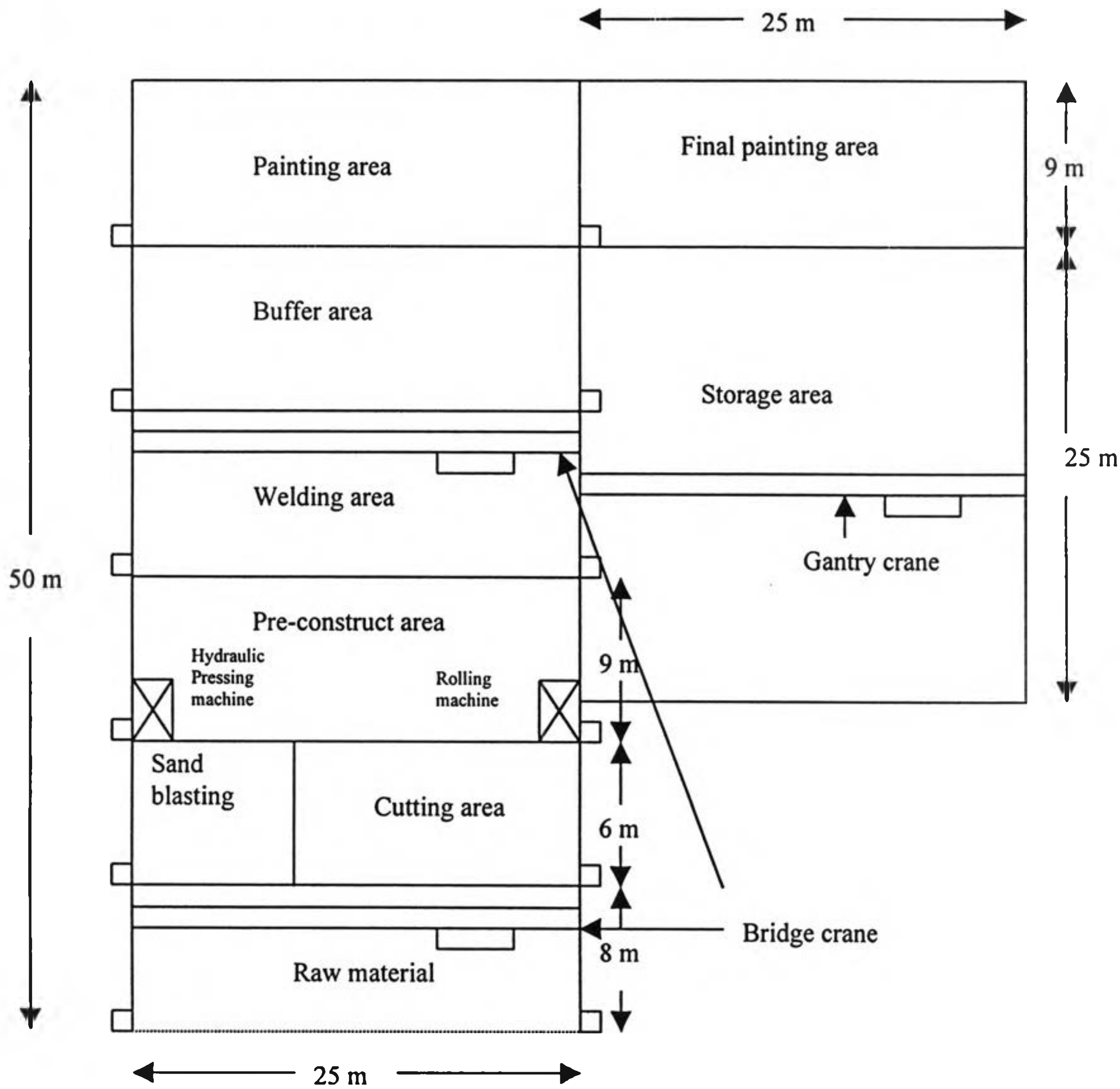

Figure 4.6: Modified process layout

The modified process layout will be mostly the same as the original process layout design, except the addition of buffer area. This will separate welding department and painting department.

4.3.1 Flow process chart

This chart shows all the activities, time consuming, and also distance of material flow of the modified process layout.

Table 4.4: Flow process chart of modified process layout plant

	○ ⇨ □ D ▽	Description	Time/1set of pontoon	Department	Total time	Distance	Total distance
1	○	Cut 6 pieces of the steel sheet (excluding top part)	4 hours	Cutting department	4 hours		
2	⇨	Deliver to the sand blasting area	10 minutes	Sandblasting Room	4 hours 10 minutes	13 meters	13 meters
3	○	Sand blasting process	4 hours	Sandblasting Room	8 hours 10 minutes		
4	⇨	Deliver to cutting area	10 minutes	Cutting department	8 hours 20 minutes	13 meters	26 meters
5	○	Apply the first layer painting to the steel sheets	1 hour 30 minutes	Cutting department	9 hours 50 minutes		
6	D	Wait for the paint to dry	1 hour	Cutting department	10 hours 50 minutes		
7	⇨	Deliver the steel sheets to pre-construct for machining	30 minutes	Pre-construct department	11 hours 20 minutes	7 meters	33 meters
8	○	Apply pressing process for a required shape	1 hour	Pre-construct department	12 hours 20 minutes		
9	○	Pre-construct each steel sheet into a pontoon shape	1 hour	Pre-construct department	13 hours 20 minutes		
10	⇨	Deliver to Welding area	12 minutes	Welding department	13 hours 32 minutes	9 meters	42 meters
11	○	Inside welding	2 hours	Welding department	15 hours 32 minutes		
12	○	Construct internal structure	8 hours	Welding department	23 hours 32 minutes		
13	○	Inside structure welding	4 hours	Welding department	27 hours 32 minutes		
14	○	Outside welding	2 hours	Welding department	29 hours 32 minutes		
15	○	Internal cleaning and inspecting	2 hours	Welding department	31 hours 32 minutes		
16	⇨	Deliver to buffer area	12 minutes	Buffer area	31 hours 44 minutes	9 meters	51 meters
17	⇨	Deliver to painting area	12 minutes	Painting department	31 hours 56 minutes	9 meters	60 meters
18	○	Internal painting	2 hours	Painting department	33 hours 56 minutes		
19	D	Wait for the paint to dry	18 hours	Painting department	51 hours 56 minutes		
20	⇨	Deliver back to buffer area	12 minutes	Buffer area	52 hours 8 minutes	9 meters	69 meters
21	⇨	Deliver back to welding area	12 minutes	Welding department	52 hours 20 minutes	9 meters	78 meters
22	○	Welding top side of the pontoon	2 hours 30 minutes	Welding department	54 hours 50 minutes		
23	⇨	Deliver to buffer area	12 minutes	Buffer area	55 hours 2 minutes	9 meters	87 meters
24	⇨	Deliver to painting area	12 minutes	Painting department	55 hours 14 minutes	9 meters	96 meters
25	○	Finish detail work (closing man hole, drill hole, cleaning)	3 hours	Painting department	58 hours 14 minutes		
26	⇨	Deliver to final painting area	12 minutes	Final painting department	58 hours 26 minutes	25 meters	121 meters
27	○	Paint the 2nd layer	1 hour	Final painting department	59 hours 26 minutes		
28	D	Wait for the paint to dry	8 hours	Final painting department	67 hours 26 minutes		
29	○	Paint the 3rd layer	1 hour	Final painting department	68 hours 26 minutes		
30	⇨	Deliver to storage area	12 minutes	Storage area	68 hours 38 minutes	17 meters	138 meters
31	D	Wait for the paint to dry	24 hours	Storage area	92 hours 38 minutes		
32	⇨	Transfer product to the truck	1 hour		93 hours 38 minutes	13 meters	151 meters

4.3.2 Simulation output

As same as having the complicated flow and the larger number of pontoons in the system running the simulation program help finding the production time.

The following table will show the output of the relevant data from running the simulation of the modified process layout plant. The constraint in running simulation program will follow the information in flow process chart.

Table 4.5: Simulation output of the modified process layout plant

ARENA Simulation Results
Summary for Replication 1 of 1

Project:Modified process Layout — Run execution date : 8/15/2004
Analyst:Modified process Layout — Model revision date: 8/15/2004

Replication ended at time : 27167.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
avgflowtime	9536.8	(Insuf)	6239.3	10848	80
cycletime	264.90	(Insuf)	45.333	655.33	79
overallidletime	111.69	(Corr)	.00000	2065.3	2640
craneutilization	0.3347	(Corr)	.00000	1 .0000	.00000

COUNTERS

Identifier	Count	Limit
jobdone	80	Infinite

Simulation run time: 0.00 minutes.
Simulation run complete.

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

From looking at the flow process chart of the modified process layout plant along with running the simulation program, the replication end time of producing or make span is 27,167 minutes. By constraint of running the program in 24 working hours per day, this shows that the overall production time for producing 80 pontoons is approximately 19 days.

The average flow time in the new process layout plant is 9536.8 minutes or approximately 6.62 days.

The cycle time of production is the gap between each finished product, which goes out of the production line. It shows that the cycle time of the product in process layout plant is 264.90 minutes or 4.4 hours

Overall idle time and the numbers of idle times of the process layout plant is 111.69 minutes or 1.8 hours and it happened for 2640 times.

Crane utilization shows how many percent the cranes are used in the production of 80 pontoons. The percentage of using crane is compared to the replication time of producing 80 pontoons. In the process layout plant, the percentage of using cranes is 33.47 of time in producing 80 pontoons.

4.3.3 Flow diagram

Flow diagram of this design (Fig 4.7) shows the direction and route of material flow. In this modified process layout, the closeness problem between welding area and painting area is overcome, however there are still some of back and forth within the flow. This modification also increases the distance of the flow compared to the process layout design.

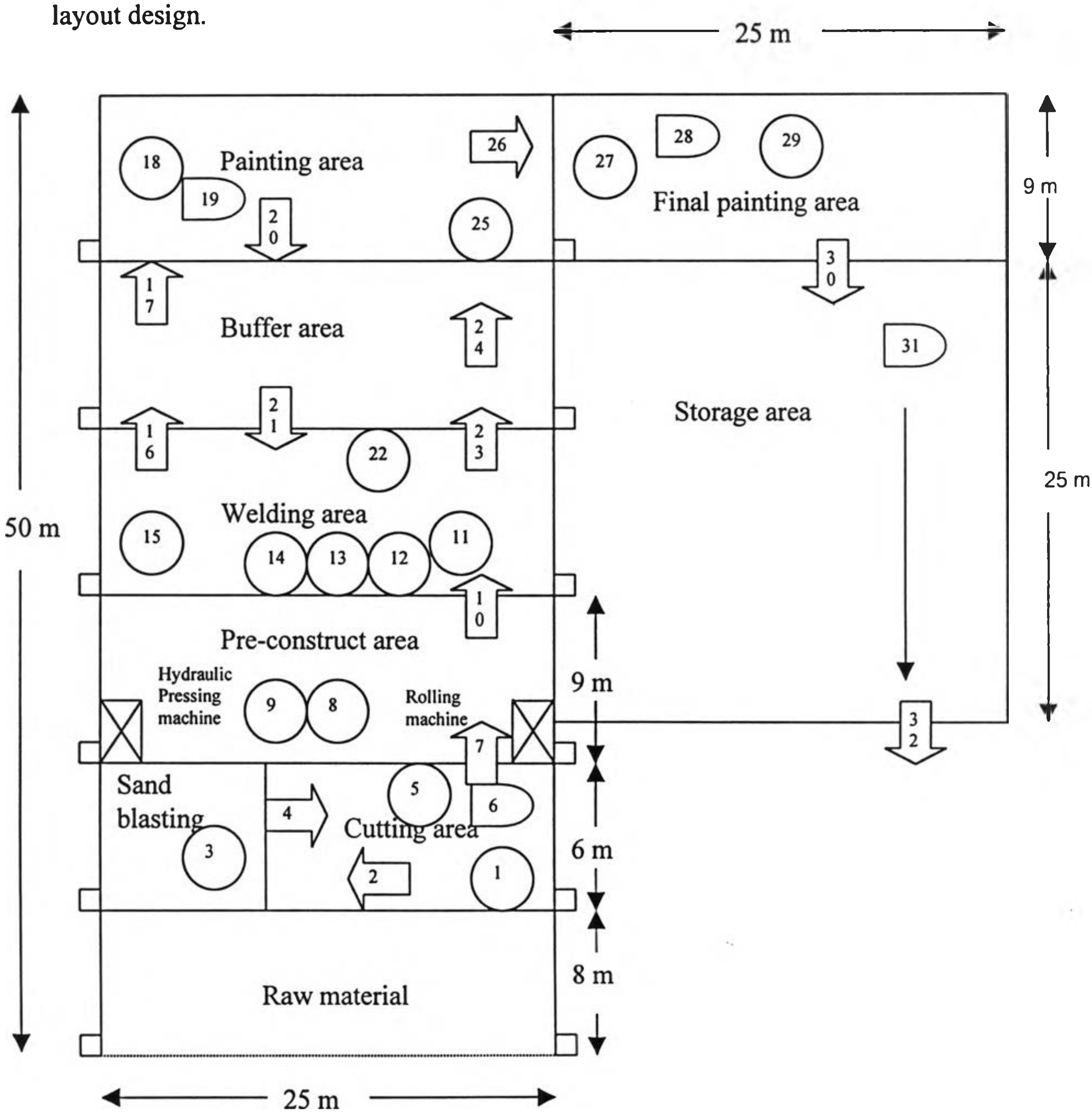

Figure 4.7: Flow diagram of modified process layout

4.3.4 Cycle time of the product

From the simulation program, the cycle time of the product within process layout plant is 4.4 hours for 1 piece of pontoon. This gives the better result compared to existing plant layout and the process design layout.

4.3.5 Distance of moving the material handling (crane)

The distance of using the material handling has increased to 151 meters, since the buffer area is added.

4.3.6 Worker capacity

The amount of workers is the same as the original process layout design. By adding the buffer area will not effect to the number of workers.

Table 4.6: Estimated number of worker in modified process layout

Operation	Number of workers
Cleaning	8
Sand Blasting	3
Painting	18
Welding	16
Pre-constructing	20
Cutting	8
Total	73

In painting department where is divided into two departments, painting and final painting the number of worker will be 8 for each department. Other 2 workers will be for first layer painting. The painting equipment will be increased along with number of painting worker.

The capacity of the welding equipment will be equal to the number of worker in welding area, pre-constructing area, and cutting area, which are 44 units. This is still equal to the previous design.

Without adding the number of worker from the previous design layout, the company has to pay 10,950 Baht per day for 73 workers. But with the slightly shorter production time, which is 19 days, the company has to pay 208,050 Baht.

4.3.7 Improvement in modified process layout plant

By having increased the space in the new process layout design, the overall production time (replication end), average flow time, idle time, and cycle time is reduce significantly compared to both existing plant layout and new process layout plant. Also the utilization of the crane is also increase compared to both previous layouts.

Moreover, the problem of closeness between welding process and painting process is eliminated, which will be safer and more effective to the way of work. Also the investment of factory structure is needed for the increasing of buffer area.

However there are still back and forth motion between welding area, buffer area, and painting area. By looking at two previous designs, it obviously looks like a job shop characteristic. Although it seems like suitable for the company, the complicated flow still exists in within the workflow. By taking the advantage of the large area in new land the product design layout will be used to design to be another alternative layout.

4.4 Design of the layout based on 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 double in capacity compared to the existing plant. Except the storage area and the final painting, which is increased more than a double, in order to store the work in process

The overhead crane from the existing plant will be removed and relocated in the new plant layout in order to save the investment cost.

The space of each department (Fig 4.8) will be double from the existing capacity same as the product layout.

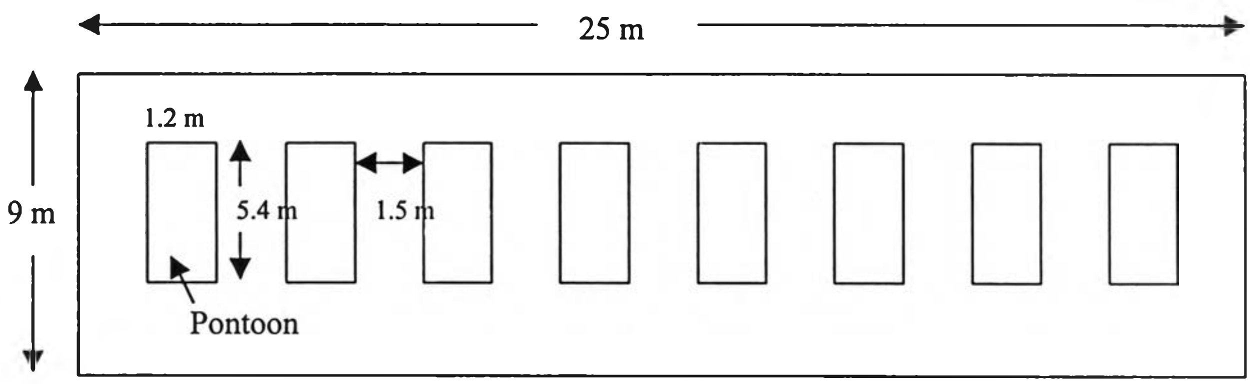

Figure 4.8: The area of each department

Sand blasting room

Sand blasting room will be also increased the capacity and relocated. The design will be the same as the process layout type. Sand blasting room will be located next to the cutting area in order to reduce the material handling usage. Same as the process design, the work can be done 3 pontoons at the same time in the sand blasting room.

4.4.1 Layout of new plant design (product layout)

In the new layout design, the layout will be divided into 13 departments. Each department is located according to the flow and the process required of the production. The painting process will be broken down into 3 departments, also the welding process which broken down into 2 department. These will be making the flow of the process run faster and also avoiding the back and forth movement of the material flow.

The following figure (Fig 4.9) is the new layout design according to the design based on product layout.

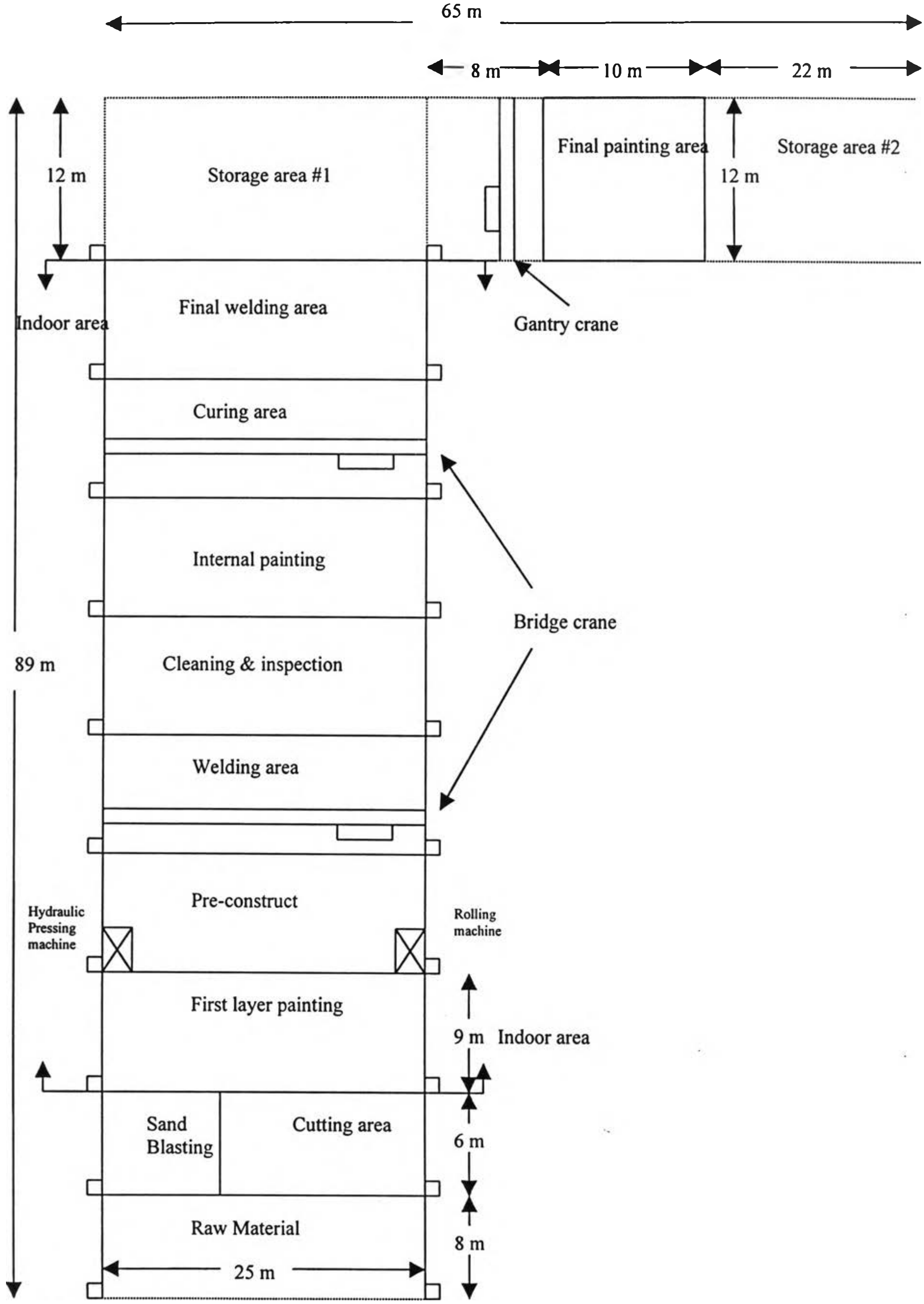

Figure 4.9: New plant design layout (product layout)

From the problem of the closeness between welding area and painting area, the new layout design will be designed to isolate these two processes. By having the Pre-construct area to isolate first layer painting area and welding area and having Cleaning and Inspection area to isolate the welding area and Internal painting area. Also having Curing area to isolate internal painting area and final painting area apart to each other. At the front and the back of first layer painting area and internal painting area, the plastic curtain will be used as a slide window in order to avoid the spreading of the dust to the other areas. All of these will avoid the possible accident of the explosion of the chemical reaction of the welding and painting.

In the storage area number 1, this area will have a bigger area, which is able to store 16 pieces of pontoon. This will act like a buffer storage for the product before transferring to final painting room.

The final painting area will be designed as a room, being able to store 8 pieces of pontoon, since the final painting is quite an intensive of having the pollution from the painting. There will be the ventilation system to decrease the pollution inside the room and also to decrease the curing time of the painting.

For two bridge cranes and a gantry crane from the existing plant, it will be used in the new plant. Bridge cranes will be located at from the raw material receiving area down to storage area #1 and for the gantry crane, it will be located at the right side of the storage area #1 down to storage area #2.

In the storage area number 2, this area will be able to store 40 pieces of pontoons. However, the areas outside storage area number 2 can also be used to keep the finish product in the special case.

4.4.2 Flow process chart

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

Table 4.7: Flow process chart of product layout plant

	○ ⇨ □ D ▽	Description	Time/1set of pontoon	Department	Total time	Distance	Total distance
1	○	Cut 6 pieces of the steel sheet (excluding top part)	4 hours	Cutting department	4 hours		
2	⇨	Deliver to the sand blasting area	10 minutes	Sandblasting Room	4 hours 10 minutes	13 meters	13 meters
3	○	Sand blasting process	4 hours	Sandblasting Room	8 hours 10 minutes		
4	⇨	Deliver to first layer painting area	15 minutes	First layer painting department	8 hours 25 minutes	21 meters	34 meters
5	○	Apply the first layer painting to the steel sheets	1 hour 30 minutes	First layer painting department	9 hours 55 minutes		
6	D	Wait for the paint to dry	1 hour	First layer painting department	10 hours 55 minutes		
7	⇨	Deliver the steel sheets to pre-construct for machining	30 minutes	Pre-construct department	11 hours 25 minutes	9 meters	43 meters
8	○	Apply pressing process for a required shape	1 hour	Pre-construct department	12 hours 25 minutes		
9	○	Pre-construct each steel sheet into a pontoon shape	1 hour	Pre-construct department	13 hours 25 minutes		
10	⇨	Deliver to Welding area	12 minutes	Welding department	13 hours 37 minutes	9 meters	52 meters
11	○	Inside welding	2 hours	Welding department	15 hours 37 minutes		
12	○	Construct internal structure	8 hours	Welding department	23 hours 37 minutes		
13	○	Inside structure welding	4 hours	Welding department	27 hours 37 minutes		
14	○	Outside welding	2 hours	Welding department	29 hours 37 minutes		
15	⇨	Deliver to cleaning and inspection area	12 minutes	Cleaning & Inspection area	29 hours 49 minutes	9 meters	61 meters
16	○	Internal cleaning and inspecting	2 hours	Cleaning & Inspection area	31 hours 49 minutes		
17	⇨	Deliver to Internal painting area	12 minutes	Internal painting department	32 hours 1 minutes	9 meters	70 meters
18	○	Internal painting	2 hours	Internal painting department	34 hours 1 minutes		
19	⇨	Deliver to curing area	12 minutes	Curing area	34 hours 13 minutes	9 meters	79 meters
20	D	Wait for the paint to dry	18 hours	Curing area	52 hours 13 minutes		
21	⇨	Deliver to final welding area	12 minutes	Final welding department	52 hours 25 minutes	9 meters	88 meters
22	○	Welding top side of the pontoon	2 hours 30 minutes	Final welding department	54 hours 55 minutes		
23	⇨	Deliver to storage area #1	12 minutes	Storage area #1	55 hours 7 minutes	10 meters	98 meters
24	○	Finish detail work (closing man hole, drill hole, cleaning)	3 hours	Storage area #1	58 hours 7 minutes		
25	⇨	Deliver to final painting area	12 minutes	Final painting department	58 hours 19 minutes	25 meters	123 meters
26	○	Paint the 2nd layer	1 hour	Final painting department	59 hours 19 minutes		
27	D	Wait for the paint to dry	8 hours	Final painting department	67 hours 19 minutes		
28	○	Paint the 3rd layer	1 hour	Final painting department	68 hours 19 minutes		
29	⇨	Deliver to storage area #2	12 minutes	Storage area #2	68 hours 31 minutes	16 meters	139 meters
30	D	Wait for the paint to dry	24 hours	Storage area #2	92 hours 31 minutes		
31	⇨	Transfer product to the truck	1 hour		93 hours 31 minutes	5 meters	145 meters

4.4.3 Simulation output

As same as having the complicated flow and the larger number of pontoons in the system running the simulation program help finding the production time.

The following table will show the output of the relevant data from running the simulation of the product layout plant. The constraint in running simulation program will follow the information in flow process chart.

Table 4.8: Simulation output of the product layout plant

ARENA Simulation Results
Summary for Replication 1 of 1

Project:Product Layout — Run execution date : 8/15/2004
Analyst:Product Layout — Model revision date: 8/15/2004

Replication ended at time : 20856.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
avgflowtime	7575.9	(Insuf)	6430.6	8038.6	80
overallidletime	51.575	10.833	.00000	1200.0	2960
cycletime	182.59	(Insuf)	18.000	1044.6	79
craneutilization	0.4802	(Corr)	.00000	1 .0000	.00000

COUNTERS

Identifier	Count	Limit
jobdone	80	Infinite

Simulation run time: 0.00 minutes.
Simulation run complete.

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

From looking at the flow process chart of the product layout plant along with running the simulation program like the previous layout, the replication end time of producing or make span is 20,856 minutes. Also by constraint of running the program in 24 working hours per day, this shows that the overall production time for producing 80 pontoons is approximately 14.5 days.

The average flow time in the new process layout plant is 7575.9 minutes or approximately 5.26 days.

The cycle time of production is the gap between each finished product, which goes out of the production line. It shows that the cycle time of the product in process layout plant is 182.59 minutes or 3.04 hours

Overall idle time and the numbers of idle times of the process layout plant are 51.575 minutes or 51 minutes and it happened for 2960 times.

Crane utilization shows how many percent the cranes are used in the production of 80 pontoons. The percentage of using crane is compared to the replication time of producing 80 pontoons. In the process layout plant, the percentage of using cranes is 48.02 of time in producing 80 pontoons

4.4.4 Flow diagram

The flow diagram (Fig 4.10) will show the route and the direction of the material within the new plant design. Looking at flow diagram in the new plant layout (figure 4.10), it shows more simply route compare to the existing plant layout. There is no back and forth flow of the material.

The distance of using material handling is reduced to 127 meters measured from the beginning of the production to the finish of the production.

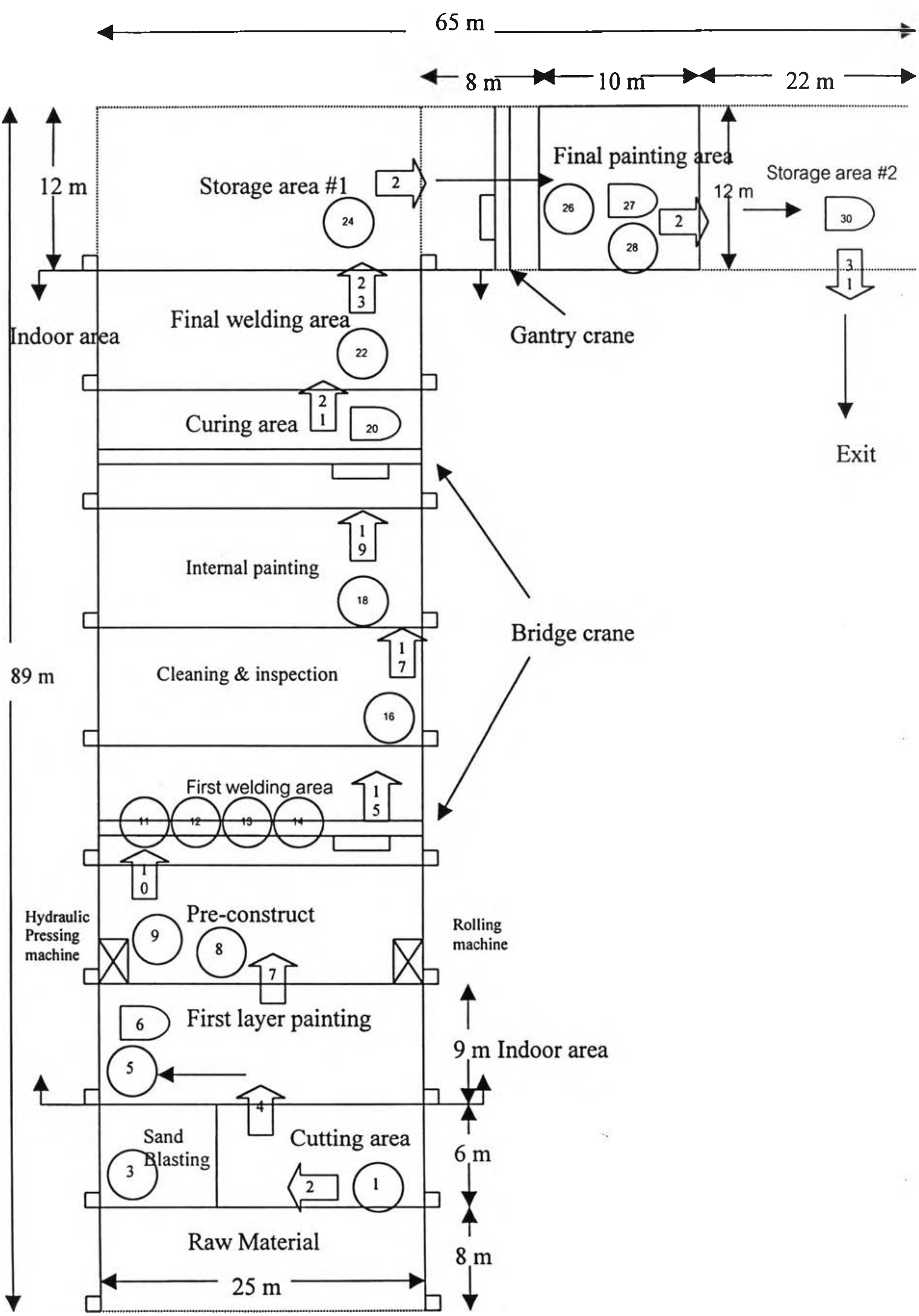

Figure 4.10: New plant design layout (product layout)

4.4.5 Cycle time of the product

From the simulation program, the cycle time of the product within process layout plant is 3.04 hours for 1 piece of pontoon. This gives the best result compared to two previous layouts.

4.4.6 Distance of moving the material handling (crane)

The distance of using the material handling, not include when the material handling is not occupied, is 145 meters from the beginning of the production until the end of the production. It is 10 meters longer than existing plant because of having more departments added into the production line. However this helps to smooth out the material flow.

4.4.7 Worker capacity

From designing the new capacity of the plant, the number of worker will also be increased in order to meet the size of the operation. Following table will be the estimation of number of worker in product design plant layout.

Table 4.9: Estimated number of worker in product design plant layout

Operation	Number of workers
Cleaning	8
Sand Blasting	3
Painting	20
Welding	16
Pre-constructing	20
Cutting	8
Total	75

In the product design plant layout where the departments are divided into small department the worker in each main department will be spread out to each department.

Painting department (20 workers)

- 4 workers in First layer painting
- 8 workers in Internal painting
- 8 worker in Final painting

Welding department (16 workers)

- 8 workers in First welding
- 8 workers in Final welding

The number of painting equipment will be increased along with the number of painting worker. Also the capacity of the welding equipment will be equal to the number of worker in welding area, pre-constructing area, and cutting area which are 44 units. This is still equal to the previous design. The company needs to be concern in this point of investment to cover the increasing of the welding equipment and painting equipment.

Also with the standard payment rate of 150 per worker per day, the company needs to pay 11,250 Baht per day for 75 workers. From using 14.5 days (round up to 15 days) to finish the project, the company has to pay 168,750 Baht.

4.4.8 Improvement in product layout plant

By having increased the space in the product layout design and the additional of the department to smooth out the flow, the overall production time (replication end), average flow time, idle time, and cycle time is reduce mostly compared three previous plant layout, also along with the increasing of utilization of the crane.

The problem of closeness between welding process and painting process is eliminated, which will be safer and more effective to the way of work.

Moreover, the problem of back and forth motion between welding area and painting area is eliminated and there are the departments those separate the welding and painting apart from each other.

Compared to the previous designs, the product layout design gives the advantage of eliminating the improper flow, which is back and forth motion between welding and painting 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; moreover it consumes lots of time to move back and forth and also disturb the work in process activities.

However, there are still disadvantages in product layout design, which are the increasing of the worker that affect to the increasing of the welding equipment and painting equipment. This means the company must be more rely on the worker, also the investment in the increasing the factory capacity and investment in equipment.

4.5 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 run the simulation program in each layout, it shows all the detail of how the process is working. In this experiment the batch of 80 pontoons will be the quantity to run in the simulation program. All the significant results will be shown in the following table.

Table 4.10: Significant result data

Description	Existing plant layout	Process layout	Modified Process layout	Product layout
Overall time for running 80 pontoons	53 days	20 days	19 days	14.5 days
Average flow time	9.03 days	7 days	6.62 days	5.26 days
Cycle time	14.63 hours	4.8 hours	4.4 hours	3.04 hours
Overall idle time (avg, observation)	3.1 hours (2800)	2.2 hours (2616)	1.8 hours (2640)	51 min (2960)
Crane Utilization	12.85%	25.87%	33.47%	48.02%

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: Labour cost

Type of layout	Labour cost for the production of 80 pontoons (Baht)
Existing plant layout	357,750
Process layout	219,000
Modified Process layout	208,050
Product layout	168,750

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

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

4.6 Sensitivity Analysis

By looking at the characteristic of production, which more rely on the capacity of worker than the machine. This analysis will test the effect on the production time when the amount of worker is reduced. In this analysis, the production time from 3 new layout designs will be tested when the amount of worker is reduced by 10%. The result of 3 designs will be compared and analysed in order to find which design gives the shortest production time when the resource, worker, is reduced.

In order to find the production time, simulation will also be used to find the result. The criteria of reduction of the worker will be the reduction in every process. The capacity of the worker will be reduced approximately by 10% in every department according to the worker capacity in previous section. The following table will be the amount of the worker that has been reduced in 3 new design layouts. Note that some of the department, for example in sand blasting area, will not be reduced due to the small number of worker.

Table 4.12: The amount of the worker after the reduction

Operation	Process layout design	Modified process layout design	Product layout design
Cleaning	7	7	7
Sand Blasting	3	3	3
Painting	16	16	18
Welding	14	14	14
Pre-constructing	18	18	18
Cutting	7	7	7
Total	65	65	67

After reducing the capacity of worker, this will surely effect to the production time. This means the production capacity will be reduced and the production time will increase. By running the simulation program same as previous section, the production time will be shown in the following table.

Table 4.13: The result of production running with less 10% of number of worker

Description	Process layout	Modified Process layout	Product layout
Overall time for running 80 pontoons	23 days	22 days	17 days
Average flow time	9.5 days	8 days	6.16 days
Cycle time	6.9 hours	6.2 hours	5.02 hours
Overall idle time (avg, observation)	3.6 hours (2720)	2.9 hours (2780)	1.2 hours (2960)
Crane Utilization	22.45%	30.19%	41.03%

After analyzing the result from running the simulation, this shows that the product layout still gives the shortest time compared to other layout design. This gives more confident in choosing the product layout design to be the best-improved design layout.