CHAPTER IV

METHODOLOGY

In this chapter, the new system is developed based on the required capacity to improve assembly line efficiency and productivity. The solution is done by designing the new workstations, improving some operations, balancing assembly lines, and allocating manpower to the new system. In addition, the new process layouts are designed and proposed in order to be the alternatives for the company to make decision for implementation in the future.

4.1 Design the new system

The general objective of assembly line design is to design the line to be able to produce the products at capacity required and to minimize the idle time across all workstations in the assembly line.

In order to produce the products to meet capacity required, an assembly line is designed based on the required capacity to progressively assemble the products through series of workstations in a uniform time interval called "cycle time". After the required cycle time is determined, all work elements assigned in current workstations are reviewed and some, which their standard time is more than cycle time, will be prioritized to find the ways for operation improvement.

When operation improvements are accomplished, all work elements are assigned into new workstations based on the concept that work elements are assigned in each workstation until sum of the task time is equal to the cycle time, or no other tasks are feasible because of time or sequence restrictions.

After new workstations of all product types are designed, manpower allocation of the new system is determined. In this step, the throughput generated by the current manpower at the specific period will be compared with those done by the new manpower at the same period to determine how the productivity of the new system is improved.

The detail steps to design the new system can be explained as follows:

4.1.1 Product identification

After study the standard time from sub assembly to packing in detail, all DY products can be grouped into 12 product types based on different total assembly time as follows:

Type1: Product DY size 14" assembled with terminal board & leads and inspected for external customer.

Type2: Product DY size 14" assembled with terminal board and inspected for external customer.

Type3: Product DY size 14" assembled with terminal board & leads and inspected for ITC.

Type4: Product DY size 14" assembled with terminal board and inspected for ITC.

Type5: Product DY size 20" assembled with terminal board & leads and inspected for external customer.

Type6: Product DY size 20" assembled with terminal board and inspected for external customer.

Type7: Product DY size 20" assembled with terminal board & leads and inspected for ITC.

Type8: Product DY size 20" assembled with terminal board and inspected for ITC.

Type9: Product DY size 21" assembled with terminal board & leads and inspected for external customer.

Type10: Product DY size 21" assembled with terminal board and inspected for external customer.

Type11: Product DY size 21" assembled with terminal board & leads and inspected for ITC.

Type12: Product DY size 21" assembled with terminal board and inspected for ITC.

Because all product types have different work contents and total task time, their best balancing solutions, which the work elements are assigned into the workstations in order to achieve the highest line efficiency, are possibly different. To improve mix model assembly line efficiency, each product type will be focused to find the best balancing solution in details, and then all workstations will be designed in two assembly lines to meet a variety of product demands and also keep the optimum mix model assembly line efficiency.

4.1.2 Capacity identification

In year 2001, the company demand is approximately 8,000 pieces DY/ day, however, the demands is increasing to approximately 10,000 pieces DY/ day in year 2002. The detail demands of each product type are shown in Appendix F.

The company demands can be viewed based on three criteria; product size, terminal type, and customer in the Table 4.1, 4.2, and 4.3 respectively.

Table 4.1: The company demands classified by product size

Criteria: Product size	Loading proportion
• DY size 14"	42%
• DY size 20"	44%
• DY size 21"	14%

Table 4.2: The company demands classified by terminal type

Criteria: Terminal type	Loading proportion
• DY assembled with terminal board & leads	65%
• DY assembled with terminal board	35%

Table 4.3: The company demands classified by customer

Criteria: Customer	Loading proportion
• DY inspected for internal customer (ITC)	57%
• DY inspected for external customer	43%

To produce DY to meet 10,000 units/ day, cycle time of the assembly lines is determined as follows:

4.1.3 Cycle time determination

According to theory in chapter II, the cycle time of a production line can be determined based on two information, production time per day and required outputs per day as follows:

- Production time of current DY process can be defined based on sections as follows:

Section	Production time (hrs) per day
1. H-coil winding	24 hrs
2. V-coil winding	21 hrs
3. Sub assembly	21 hrs
4. Assembly	21 hrs

- Required outputs per day are 10,000 pieces DY per day.

Then, the required cycle time of DY production lines can be determined by using the following formula and the result is shown in the Figure 4.1.

$$\text{Cycle time} = \frac{\text{Production time per day}}{\text{Required output per day (in units)}}$$

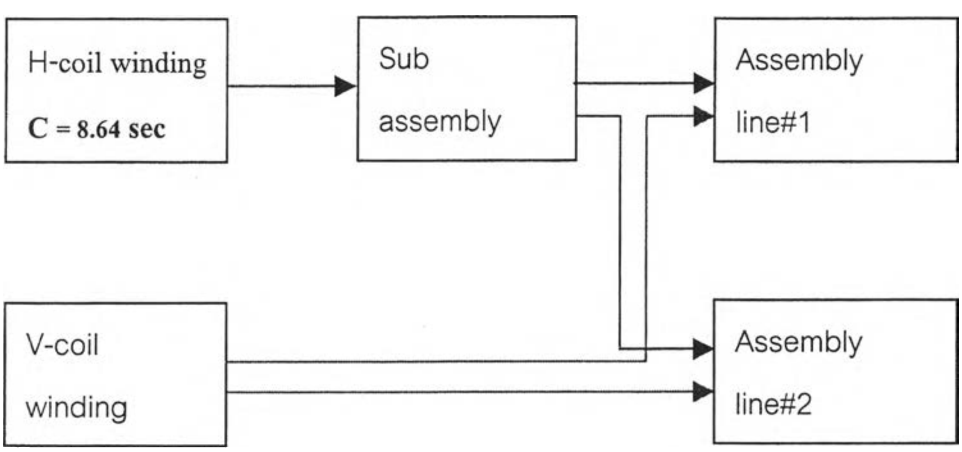


Figure 4.1: Required cycle time of DY production lines

After the required cycle time of each section is determined, the current DY production system is reviewed the possibility to implement the new system.

According to analysis the standard time in detail, the possibility for implementation the new system in h-coil and v-coil winding sections can be briefly summarized as follows:

- **H-coil winding section**

  Three more H-coil winding machines are required to cover increasing demand.

- **V-coil winding section**

  All V-coil winding machines are needed to maximize their utilization to cover increasing demand. Then, production time of all v-coil winding machines are required to change from 21 hrs per day to 24 hrs per day so that v-coil throughput can supply to produce 10,000 piece DY per day.

For assembly processes from subassembly to packing, the operations will be analyzed in details as follows:

4.1.4 Design new workstations

After analyzing the assembly operation in detail, all assembly tasks are firstly identified as the required tasks, and non added value tasks. The required tasks mean the tasks, which are needed to perform so that a finished product DY is completed. In practical, this task type may be real added value task or non added value tasks but needed to do to meet customer requirement such as inspection operation. The real non added value tasks mean wastes occurred due to ineffective work design and layout. These task types are needed to eliminate.

Because the objective of this thesis is to improve productivity and line efficiency of DY process, then all non added value tasks both required tasks and wastes are considered to reduce so that the productivity of DY process is improved. After that, all the rest required tasks are assigned to new workstations based on the required cycle time so that the assembly lines are balanced and their efficiencies are improved. The steps can be explained in details as follows:

4.1.4.1 Operation improvement

In DY assembly process, two main operations are considered to improve which are inspection operation and subassembly operation. For inspection operation, it is actually non added value operation, but required to perform to ensure that the product meets the customer specification. Minimizing inspection time benefits not only reducing unnecessary waste, but also bottleneck problem in the current assembly process.

For subassembly operation, it found that there are many real non added value tasks due to unnecessary movement occurred in the current process. Moreover, if the current operation is remained, its total task time will exceed the required cycle time. Then, its operation is considered to improve. The improvement methods are explained in details as follows:

• Inspection operation

The inspection operation is the bottleneck of the assembly line and inspection time is also fluctuated due to inconsistent DY characteristics. Generally, an inspection operator takes much time to inspect and correct the first DY characteristics to meet acceptable specification. After that, if following DY has the same characteristic as the previous one, the inspection operator will take less time for inspection by learning pattern to correct from the previous DY. The process is repeated until the different DY characteristics provided. As explained in chapter III, the different characteristic DYs are provided to inspection workstation in every 5-6 piece DY. To solve this problem, there are two possible solutions as follows:

1. Improve coil winding operation of all h-coil winding machines and all v-coil winding machine to be able to wind the coils as the same quality. Then, every 5-6 piece DYs, that is the current supply method, can be provided to inspection workstations as the same characteristics.

2. Change supply method by providing the bigger batch of the same characteristic DYs to inspection workstations so that an inspector can use the first DY to be the guideline to inspection all the rest.

After evaluating the possibility to implementation, although the first solution has the possibility to eliminate the problems, but it needs huge analysis and experiment because each machine has it own capability and constraint. Then, the second solution is considered for implementation. The methodology is explained as follows:

1. **Determine DY batch size**

   Because one h-coil tray (60 h-coil pieces) from one h-coil winding machine will be assembled with one v-coil tray (60 v-coil pieces) from one v-coil winding machine to be 30 assembled DY, then, maximum DY batch size which has the same characteristic is 30. Due to limitation of conveyor space, 15 pieces DY are determined as the new batch size to transfer DY to inspection workstations.

2. **Assign operator in cross talk adjustment & hot melt fixing workstation to Allocate DY to inspection workstation**

   In practical, it needs to be realized that providing 15 pieces DY will need some more work elements such as to move each assembled DY to rest area, to arrange DY until the batch is completed, and also to move such batch to the conveyor line. Because standard time of cross talk adjustment & hot melt fixing, which is the operation before inspection, is 10.90 sec./ piece DY, which is less than cycle time approximate 4 sec, then, the operator in this workstation is assigned to allocate and provide DY batch to the inspection workstations.

After implementing the new system, the inspection time of DY inspected for customer reduced from 110 to 99 sec, or approximately 10% time reduction and the inspection time of DY inspected for ITC reduced from 66 to 55 sec, or approximately 16.67% time reduction. However, to achieve required outputs 10,000 pieces DY per day, the tasks are needed to balance as 15.12 sec. Because the inspection time of both DY inspected for customer (99 sec) and ITC (55 sec) exceed the required cycle time, so it is needed to be split and allocate manpower properly so that line efficiency and productivity are improved.

- **Subassembly operation**

Subassembly process is the h-coil preparing process that consists of three main operations; taping h-coil, peeling the h-coil tip off, and checking Air-L. For DY size 14", it is required to perform only two operations, which are taping h-coil, and peeling the h-coil tip off. For DY size 20" and 21", all three operations are required to perform.

After analyze required tasks in Sequence Of Events (SOE), it is found that there are unnecessary movements occurred in the current operation (as see the detail operations in Appendix E). The movement proportion of both DY 14" and 20"&21" can be summarized in Table 4.4 as follows:

Table 4.4: Movement time in sub assembly process.

Task type	Standard time (sec)		% Proportion	
	DY 14"	DY 20"&21"	DY 14"	DY 20"&21"
Setup	1.14	1.14	5%	4%
Value added	16.24	26.36	73%	78%
Movement	**4.87**	**6.09**	**22%**	**18%**
Total	22.24	33.59	100%	100%

After analyzing the current subassembly process, some unnecessary movements are performed because the equipment of each operation is located separately.

A subassembly operator needs to move h-coils into the tray, move the tray to the next required operation and then move the h-coils from the tray to operate in the next required operation. The movement process is repeated until all required operations are completed.

To solve this problem, all equipment in subassembly process is relocated in order to reduce unnecessary movement. Current and improved layouts are shown in the Figure 4.2, and 4.3 as follows:

After implementing the new system, the real non added value movements are eliminated. However, to achieve required outputs 10,000 pieces DY per day, all subassembly operators need to work by using one-piece-flow concept that an operator does all operations in subassembly process. This concept eliminates line-balancing problem and allows all operators to do the tasks without idle or exceeds. Finally, the assembly manpower and their throughput generated by the current and new system is compared to determine how the productivity of the new system is improved in Table 4.5 as follows:

Table 4.5: Comparison of the subassembly manpower and their throughput generated by the current and new system

System	Manpower/ day	Pieces DY / day	Pieces DY/ person
Current system	4 x 3	8,400	700
New system	4 x 3	10,000	833.3

Before re-layout

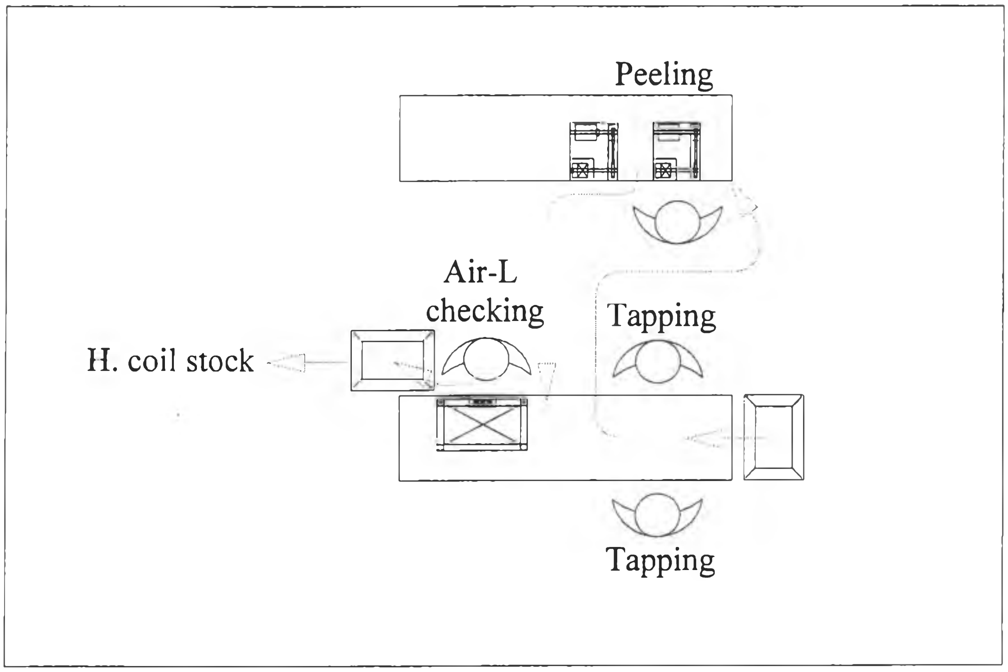


Figure 4.2: Sub assembly process before re-layout

After re-layout

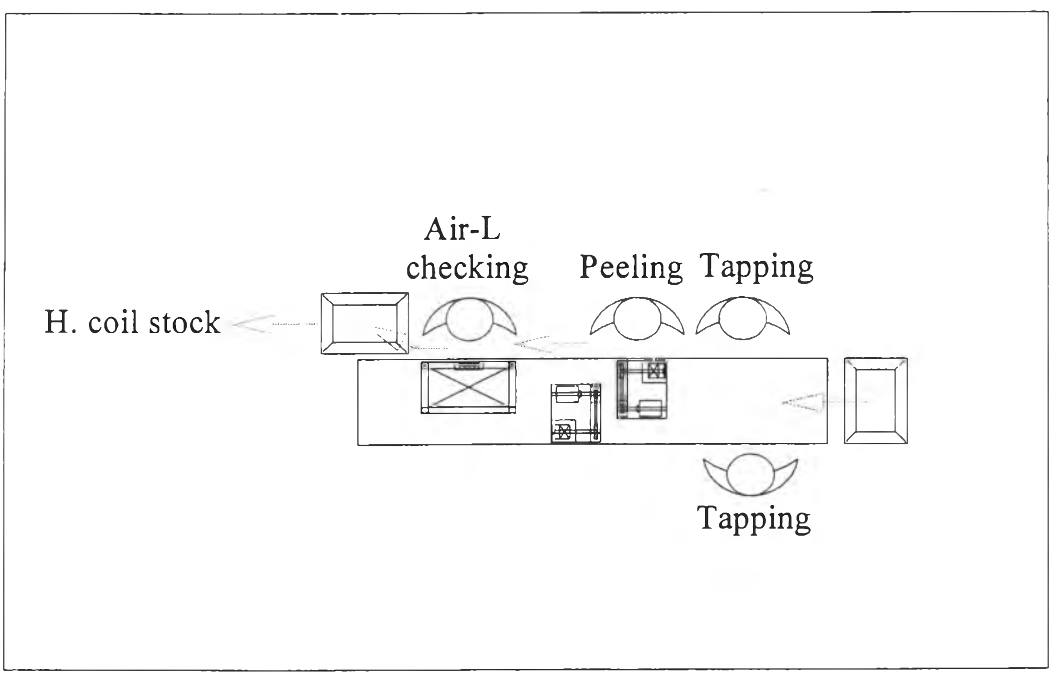


Figure 4.3: Sub assembly process after re-layout

4.1.4.2 Balancing assembly line

After operation improvements are accomplished, all work elements are assigned into new workstations based on the assembly line balancing technique as follows:

Step1: Specify the sequential relationships among tasks of all DY product types by using precedence diagrams (as see details in Appendix G)

Step2: Determine the theoretical minimum numbers of workstations (Nt) based on required cycle time.

Using the formula,

$$Nt = \frac{\text{Sum of task times (T)}}{\text{Cycle time required(C)}}$$

Because cycle time required in assembly lines is 15.12 sec, the minimum number of workstations of each DY product type can be determined as follows:

- ***DY size 14"***

Product type	Total task time (sec)	Minimum no. of WS
Type 1	266.81	18
Type 2	258.29	17
Type 3	221.71	15
Type 4	213.19	14

- ***DY size 20"***

Product type	Total task time (sec)	Minimum no. of WS
Type 5	253.97	17
Type 6	245.46	16
Type 7	208.87	14
Type 8	200.36	13

- ***DY size 21"***

Product type	Total task time (sec)	Minimum no. of WS
Type 9	267.56	18
Type 10	259.04	17
Type 11	221.36	15
Type 12	212.84	14

Step3: Assign tasks to achieve required cycle time.

In this step, all tasks of each DY product type are assigned to a workstation until the sum of the task times is equal to cycle time (15.12 sec), or no other tasks are feasible because of time or sequence restrictions.

For all product types, the concept to assign assembly tasks to workstations can be summarized as follows:

- **For all DY product types**

1. Assign the assembly tasks from separator assembling to soldering operation one by one to the workstations.

   Because the standard time of the assembly tasks from separator assembling to soldering operation is approximately required cycle time which is between 12-15 sec, and no other tasks are feasible because of time or sequence restrictions. So, they are assigned one by one to the workstations.

2. Assign heat shrinking tube operation to withstand voltage checking workstation when produce DY assembled with terminal board & leads.

   Although standard time of withstand voltage checking task is 14.73 seconds, it consists of testing time by device 10 seconds, and operating time to take DY in and out of the device 4.73 seconds. Then, while the device is testing, the operator has time available to operate some tasks. So, heat shrinking tube operation, which its standard time is 5.61 seconds, is assigned to withstand voltage checking workstation so that an operator in the workstation can heat shrinking tube while the device is testing.

3. Split the inspection task into 7 workstations when inspect DY for customer and 4 workstations when inspect DY for ITC

   According to improved method, the inspection time of DY inspected for customer and ITC are 99 and 55 sec which exceeds the required cycle time (15.12 sec), so it is needed to split into 7, and 4 workstations respectively.

- **For specific DY product types**

1. Share bonding operation in packing operation when produce DY size 14"

Because standard time of bonding operation is 15.62 seconds in case of producing DY for external customer and 14.52 seconds in case of producing DY for ITC, and y2002 demand proportions are 43% producing for external customer, and 57% producing for ITC. Then, it means that almost half of the bonding tasks are performed more than cycle time 15.12 seconds. However, the standard time of the adjacent workstation; packing operation, is 13.22 seconds, bonding operation is considered to share in packing operation so that packing operator can assist to do some parts of the bonding task.

2. Assign magnet attaching task to withstand voltage checking workstation and inspection workstations when produce DY size 20"

For assembling DY size 20", two magnets are required to attach to the specified positions which it standard time is 5.89 seconds. This task is considered to assign to two workstations; withstand voltage checking workstation and inspection workstations, as follows:

2.1) Assign two magnet attaching task to withstand voltage checking workstation in case of producing DY 20" which is assembled with terminal board.

As explained earlier that the operator in withstand voltage checking workstation has time 10 seconds available to operate some tasks, while the device is testing. Additionally, there is no heat shrinking tube required when producing DY that is assembled with terminal board. Then, all two magnets are assigned to assemble in withstand voltage checking workstation.

2.2) Assign one magnet attaching task to withstand voltage checking workstation and the other one magnet attaching task to inspection workstation in case of producing DY 20" which is assembled with terminal board & leads

When producing DY size 20" which is assembled with terminal board & leads, both heat shrinking tube task, which it standard time is 5.61 seconds, and two magnet attaching task, which it standard time is 5.89 seconds, are required. However, both tasks cannot be assigned to only withstand voltage-checking workstation because their accumulated standard time exceeds device testing time. Then, the two magnet-attaching task is considered to split into two equal tasks. One magnet-attaching task, which its standard time is approximately 3 seconds, is assigned to withstand voltage-checking workstation because the operator has available time, 4 seconds, left after performing heat shrinking tube task. And the other one magnet is assigned to assemble in inspection workstation because the inspection operator also has available time left approximately 5 seconds per DY.

For each DY product type, the concept to assign assembly tasks to workstations can be explained in detail in Appendix G.

Step4: evaluate efficiency of the assembly lines

After new workstations of all product types are designed, the efficiency of new balance is evaluated that results in 12% efficiency improvement. The evaluation in detail will be described later in Chapter 5.

4.1.4.3 Manpower allocation

After the new system is designed, manpower of the new system is allocated and compared with the current system based on product type in Table 4.6 as follows:

Table 4.6: Manpower allocation of the new system

Product type	Current system manpower/ line/ shift				New system manpower/ line/ shift			
	Capacity 8,000 piece DY /day				Capacity 10,000 piece DY /day			
	Before inspection	Inspection	After inspection	Total	Before inspection	Inspection	After inspection	Total
Type1	8	6	3	17	9	7	2	18
Type2	8	6	3	17	9	7	2	18
Type3	8	5	3	16	9	4	2	15
Type4	8	5	3	16	9	4	2	15
Type5	8	6	3	17	8	7	3	18
Type6	8	6	3	17	8	7	3	18
Type7	8	5	3	16	8	4	3	15
Type8	8	5	3	16	8	4	3	15
Type9	8	6	3	17	9	7	3	19
Type10	8	6	3	17	9	7	3	19
Type11	8	5	3	16	9	4	3	16
Type12	8	5	3	16	9	4	3	16

According to demand proportion in Table 4.1, the proportion demand of DY14", 20", and 21" are 42%, 44% and 14% respectively. Based on demand, one assembly line is allocated to mainly produce DY size 14", the other one is allocated to mainly produce

DY size 20, and all the rest are used to produce DY size 21". Because required manpower extruding inspection operators to produce DY 14", 20", and 21" are 11, 11, and 12 persons/ line respectively. Then, the required manpower of two assembly lines extruding inspection operators is 23 persons per shift.

According to demand proportion in Table 4.3, proportion demand of DY inspected for customer and ITC are 43% and 57% respectively. Based on demand, one assembly line is allocated to mainly produce DY inspected for customer; the other one is allocated to mainly produce DY inspected for ITC. Because required inspection manpower to inspect for external customer and ITC are 7 and 4 persons/ line respectively. Then, the required inspection manpower of two assembly lines is 11 persons per shift.

In summary, the total assembly manpower required for the new system is 34 persons per shift. Finally, the assembly manpower and their throughput generated by the current and new system is compared to determine how the productivity of the new system is improved in Table 4.7 as follows:

Table 4.7: Comparison of the assembly manpower and their throughput generated by the current and new system

System	Manpower/ day	Pieces DY / day	Pieces DY/ person
Current system	33 x 3	8,400	85
New system	34 x 3	10,000	98

4.2 Design new process layouts

In this section, the defection yoke layout is redesigned in order to be the alternatives for the company to make decision for implementation in the future. To avoid the negative effect to the product quality, the new proposed layouts in this thesis are designed based on current process flow in order to reduce materials handling, increase effective space utilization, and improve quality of the product. There are three alternative layouts designed to best fit for specific situations as follows:

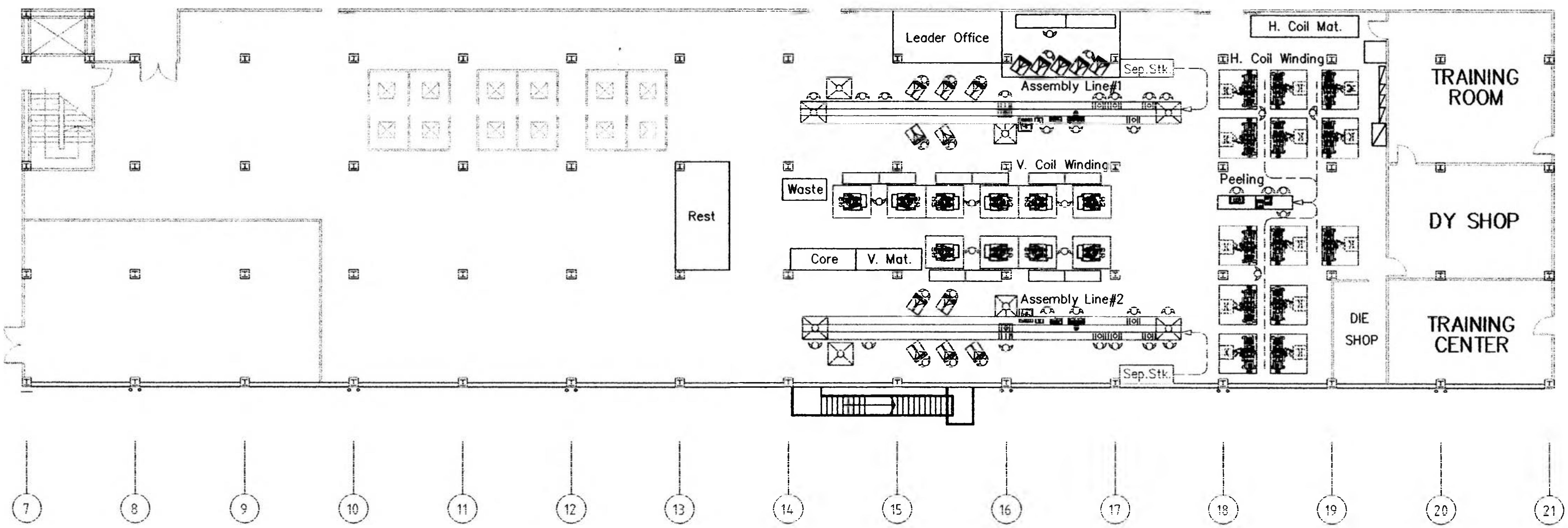
Alternative layout I:

This layout is the process layout design. H-coil winding machines are grouped at the left-hand side of the processes; however, they are located closely to subassembly and assembly lines. V-coil winding machines are grouped and redesigned to be located between two assembly lines. All processes are designed to eliminate all wasted aisle spaces and use only the essential space required by manufacturing areas. The advantages gained from this alternative layout can be explained in detail as follows:

1. Maximize space utilization

   The layout is designed based on the concept that maximize area utilization by allocating current asset and equipment to only the essential space required by manufacturing areas. As obviously seen in the drawing layout #1, all processes are very closely located together at the left area, it results in the right area, which is used to locate two assembly lines, saving while the same throughputs are generated. The area saving benefit not only the potential to use the more available area to generate more profit, but also reduce the utility cost (such as lighting, air conditioning, and so on.) if such area is not utilized.

Layout 1



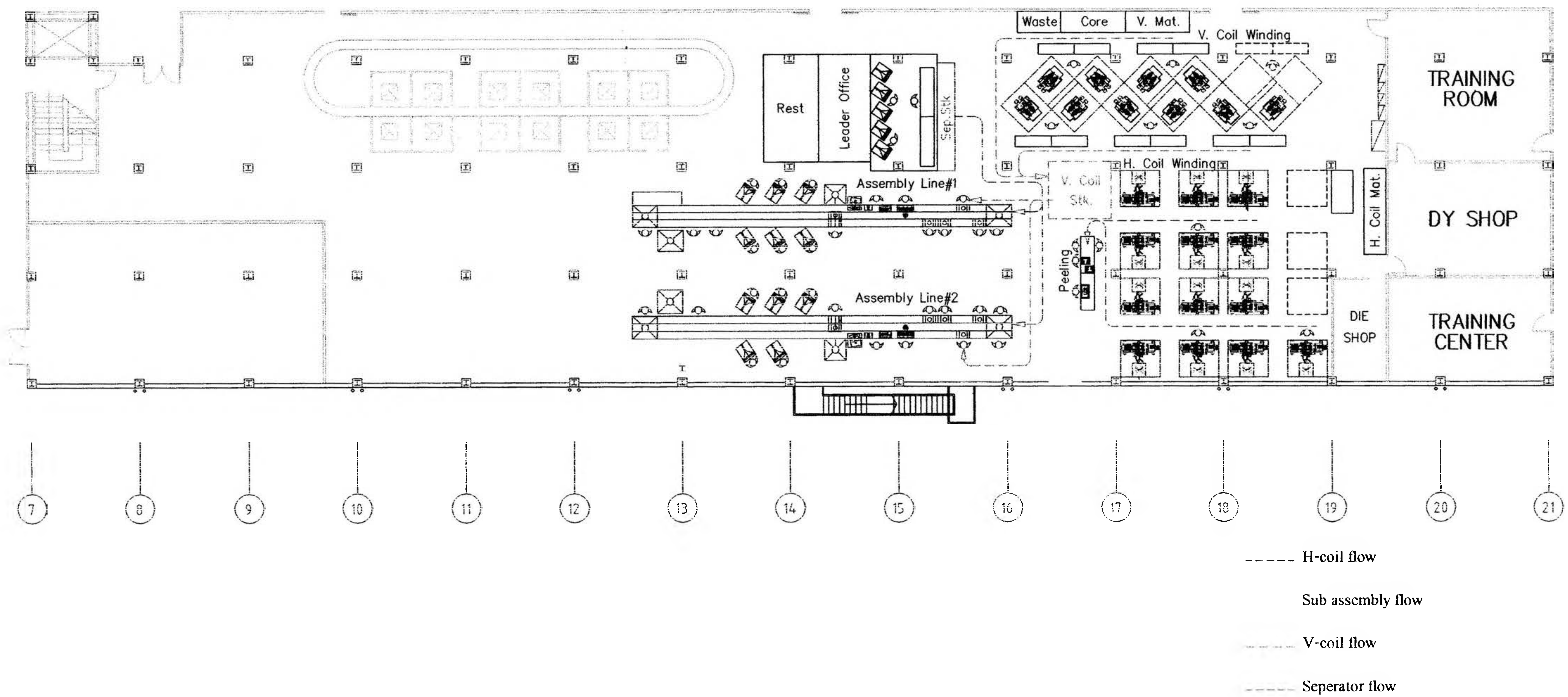
H-coil flow

Sub assembly flow

V-coil flow

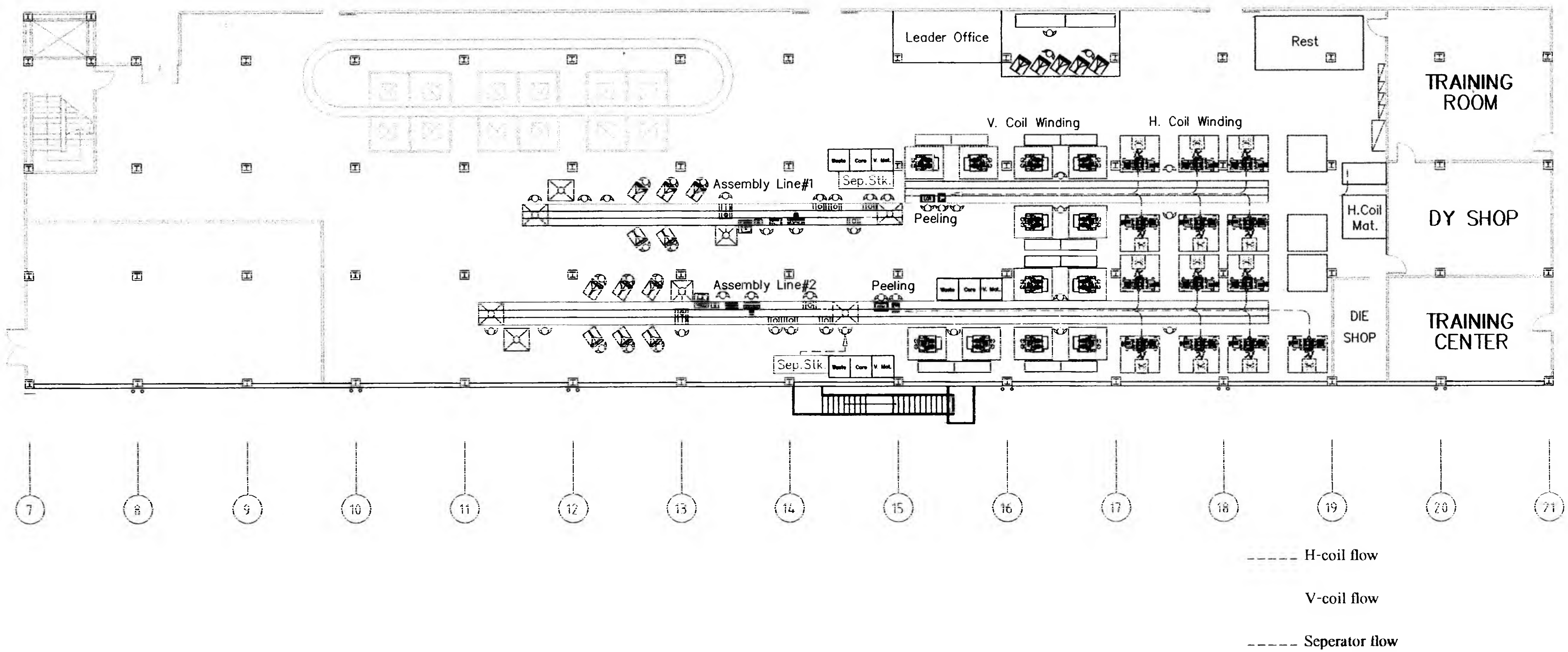
Seperator flow

Layout 2



Waste
Core
V. Mat.
V. Coil Winding
Rest
Leader Office
Sep.Stk
TRAINING ROOM
H. Coil Winding
V. Coil Stk.
Assembly Line#1
H. Coil Mat.
DY SHOP
Peeling
Assembly Line#2
DIE SHOP
TRAINING CENTER
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
H-coil flow
Sub assembly flow
V-coil flow
Seperator flow

Layout 3



Leader Office
Rest
TRAINING ROOM
V. Coil Winding
H. Coil Winding
Assembly Line#1
Sep.Stk.
Peeling
H.Coil Mat.
DY SHOP
Assembly Line#2
Peeling
DIE SHOP
TRAINING CENTER
Sep.Stk.
7
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H-coil flow
V-coil flow
Seperator flow

2. Low material handling

The layout is designed to reduce material handling by providing easier access of the materials and sub products to the next processes. Many processes are designed to relocate to achieve above objectives as follows:

- Subassembly is designed to locate between the h-coil winding machines. It results in reducing machine operator effort and minimizing their manual wound h-coil handling to subassembly area. The man-hours saving from less handling distance make the machine operators have more time available to quality check and do daily TPM, which will result in further cost saving and productivity improvement.

- V-coil winding machines are designed to locate between two assembly lines.

Because current v-coil winding machines are located between h-coil winding machines and assembly line, the h-coil machine operators need to travel around the v-coil winding area before supply the wound h-coil to the subassembly. And the subassembly operators also face the same problem, travelling around the v-coil winding area before supply the coils to the assembly lines. This result in man-hours loss due to unnecessary movement occurred in the current process. The new v-coil location is then much more effective than the current one because it eliminates unnecessary h-coil handling problem and also provides easier access of wound v-coil to assembly lines.

3. High flexibility

According to demands, DY has many types of products. Although only few products have high volume and all the rest has relatively low volume of production on individual items, the production are still needed to respond all demands. Then, this process layout design seems to gain advantage because of its greater flexibility of production and easier to handle breakdowns of equipment by transferring work to another machine or station.

However, there are some disadvantages of this alternative layout. Because the layout is designed to maximize area utilization by allocating current asset and equipment to only the essential space required by manufacturing areas and to reduce material handling by providing easier access of the materials and sub products to the next processes. As a result, all processes are fit in the specific area size and location. This may lead to difficult to capacity expansion, congestion between the processes and make supervision control the process harder. Additionally, h-coils kept in stock (WIP) for long time will have the possibility to deform its shape, which result in low quality of the coils.

Alternative layout II:

The layout is also designed as the process layout, but reduce level of congestion and increase the potential for capacity expansion. H-coil and v-coil winding machine groups are parallel located at the left area and the assembly lines are shifted to the right area. The advantages gained from this alternative layout can be explained in detail as follows:

1. Provide high flexibility and future expansion

   Because DY has many types of products and the trend of DY demand is increasing, the layout that can provide high flexibility to respond product variety and also provide the potential to support more demand in the future seems to be useful alternative layout. According to proposed layout II, it is obviously designed as process layout so has high flexibility for production. Moreover, although this layout save the less right area when compare with the proposed layout I, they have the potential to expand the capacity because it is designed extra area to allocate three more h-coil winding machines and two more v-coil winding machines which means capacity expanding approximately 60,000 pieces DY per month.

2. Provide better working condition

   For v-coil machine winding, the machines are located in the position that allow the operator to work with the machines with only 90° body rotation whereas he currently work with 180° body rotation. The new design results in reducing the fatigue due to stretch and satisfying relax body muscles.

   For assembly process, this layout provides better working condition by eliminating congestion than the alternative one. Additionally, although the material handling distance is longer than the alternative one, but much shorter than the current system, so it seems to satisfy the worker at acceptable level.

3. Reduce number of accident and indirect manufacturing costs due to scrap and spoilage due to difficult handling situations

However, as same as layout I, this layout still have the possibility to face the problem of deforming h-coil shape if keep them in stock (WIP) for long time, which result in low quality of the coils.

Alternative layout III:

According to demand in y2002, there are few main product types that have large volume of production over a considerable period of time. So, the alternative layout III, that is the product layout design, is proposed to the company to make decision for implementation in the future.

There are two production lines, 14" and 20", are designed and located along the manufacturing area from left to right. The h-coil winding machines, v-coil winding machines and equipment such as peeling machines are equally dedicated and located to two production lines. The raw material arrives at left end of the line and progressively produces from one operation to the next operation quite rapidly, with a minimum of work-in-process storage and material handling. The material-handling device used to link all process together is conveyor. The advantages gained from this alternative layout can be explained in detail as follows:

1. Minimize operator manual material handling, indirect manufacturing costs by decreasing scrap and spoilage due to difficult handling situations and reduce number of accident

Because a product are linked from one to the next operation by using conveyors, then all manual material handling scrap, spoilage, and number of accident causes from difficult handling situations will be eliminated.

2. Lower total production lead time, less work-in-process and increase h-coil quality.

   Because the current system keeps work-in-process inventory, it makes the company loss the interest or the opportunity to use such money to generate profits. Additionally, h-coils kept in stock (WIP) for long time will have the possibility to deform its shape, which result in low quality of the coils. Then, this alternative layout benefits not only more money saving (interest), but also providing higher quality h-coils. Moreover, it provides greater simplicity of production control and better working condition by eliminating congestion

However, there are some disadvantages of this alternative layout that are low flexibility and high capital investment and may need some duplication of equipment.

In summary, there is no good plant layout can achieve all advantages. The alternative layouts will be best fit to different situations at specific period of time. To select the proper layout to suit to specific situation, four systematic evaluating approaches, cost comparison, productivity evaluation, space utilization, and factor analysis, are used to evaluate the effectiveness of each alternative layout as will be explained in detail in Chapter 5.