CHAPTER IV

METHODOLOGY IN THE WAREHOUSE

4.1 Introduction

In this chapter, the new locations of each item in the warehouse have been proposed. The processes in arranging them are shown in Fig. 4.1. When the new locations have been adapted, the performance has been evaluated as shown later in Chapter 6.

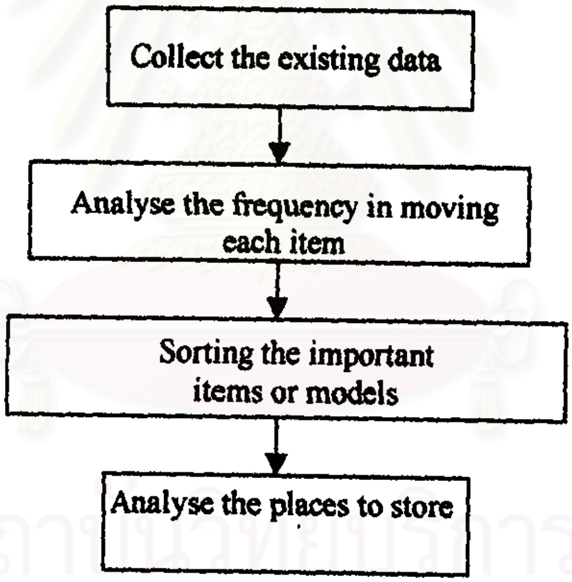


Fig. 4.1: The processes in arranging new location for a stored item.

4.2 Collect the Data

In this company, any unfinished or imported items are located in their specific places. Items used for a certain product are stored together or near to one another. When the assembly department wants to produce some products, the raw materials are ordered. That is why the ordered items should be located near one another for convenience. However, the existing system does not take into account the frequency of an order for each model.

The information about the warehouse system in this thesis is from personal communication and some warehouse documents. The order picking document is to be determined first. There are two sources of the order picking document catagorised according to sources; the machining order picking and the assembling order picking. Then the lay out of the raw materials storage is determined prior to proposing a new location for each item.

4.3 Analyse the Data

When the data have been collected, the demand frequency for each item is determined. Firstly, the data is separated into two groups since each group has unique order nature. The first group is the machining data and the second group is the assembly data. In the machine order, there are many small items in each order but each item does not relate to any other items. On the other hand, the assembly department orders items which are for producing the finished products. Hence, they are of the same model. Therefore, small items are grouped into models to ease the arrangement of the location layout for the assembly order documents.

The frequency in ordering each item of the machining department is shown in Table 4.1 below.

Table 4.1 : The frequency in ordering items for the machining department for a period of four months in 1999.

No.	Model	Type	Part name	Frequency of order				
				Jul	Aug	Sep	Oct	Total
1	2L-II	W/P	BODY	9	7	8	12	36
2	4D56	W/P	BODY	9	3	9	8	29
3	4G1	W/P	BODY	13	0	0	2	15
4	4G1	O/P	PLUG	0	0	0	0	0
5	4G1E	O/P	CASE	0	1	1	0	2
6	4G9E	O/P	CASE	0	3	5	10	18
7	4JA1	W/P	CENTER	11	2	0	0	13

8	4JA1	T/P	COVER	0	0	0	0	0
9	4JA1	T/P	ROTOR	0	0	0	0	0
10	4JA1	T/P	CASE	0	0	0	0	0
11	4JA1	O/P	SHAFT(SHORT)	8	9	4	7	28
12	4JA1	O/P	SHAFT(LONG)	10	13	7	10	40
13	4JA1	O/P	COVER	10	16	8	9	43
14	4JA1	O/P	GEAR	13	13	8	14	48
15	4JA1	O/P	GEAR(RAW)	0	2	2	3	7
16	4JA1-E	O/P	BODY	0	0	0	0	0
17	4M4	O/P	PLUG TAPER	1	0	0	1	2
18	4M4	O/P	GEAR	5	3	5	5	18
19	4M4	O/P	SHAFT(SHORT)	3	3	4	2	12
20	4M4	O/P	SHAFT(LONG)	4	3	3	3	13
21	4M4	O/P	GEAR HEAD	0	0	0	0	0
22	AIR	COMP	GEAR HEAD	17	23	21	20	81
23	AIR	COMP	CYLINDER	21	20	16	10	67
24	AIR	COMP	CRANK SHAFT	25	19	16	14	74
25	BD25	W/P	BODY	6	6	18	18	48
26	BD25	O/P	BODY	4	3	6	2	15
27	BD25	W/P	BODY	0	0	0	0	0
28	BD25	W/P	WHEEL	0	1	0	1	2
29	BD25	O/P	GEAR DRIVE	1	2	3	4	10
30	BD25	O/P	SHAFT DRIVE	1	2	3	3	9
31	BD25	W/P	COVER	0	0	0	0	0
32	HF	F/C	FRONT COVER	14	13	12	12	51
33	HF	F/C	FRONT COVER-SHOT BLAST	5	3	3	6	17
34	HF	O/P	COVER	7	4	4	6	21
35	P-CAR	W/P	BODY	16	15	15	16	62
36	P-CAR	O/P	COVER B/S GEAR	16	15	3	0	34
37	P-CAR	O/P	BALL STEEL	0	0	1	0	1
38	P-CAR	O/P	CASE FRONT	26	21	22	23	92
39	P-CAR	O/P	PIN DOWEL	17	15	17	16	65
40	P-CAR	O/P	PLUG TAPER	5	4	5	5	19
41	P-CAR	O/P	BOLT	0	0	0	0	0
42	P-CAR	W/P	HUB	7	0	0	0	7
43	TD27	W/P	WHEEL	4	4	3	4	15
44	TD27	W/P	BODY	4	4	2	3	13
45	TD27	W/P	COVER	5	4	2	7	18
46	4G9E	O/P	CASE	12	7	3	2	24
47	Y71	O/P	PLUG	0	0	0	0	0
48	4G9E	O/P	CASE	0	0	4	9	13
49	M1	COMP	REAR HEAD	0	0	0	0	0
50	M1	COMP	CRANK SHAFT	7	11	5	7	30
51	M1	COMP	CYLINDER	17	9	11	15	52

For the assembly department, workers order items for assembling finished products. Therefore, the ordered items are grouped. The company stores these items near to one another. According to Rosenwein (1994 : 101), " Items within the same cluster may be stored near one another in a warehouse. Thus, the picking effort (i.e., the selection of items from storage areas) required to select all items required by a particular order is minimized." The company clusters items for the same model together. The frequency in picking each model is shown in Table 4.2.

Table 4.2 : The frequency in ordering items for the assembly department in the period of four months in 1999.

		Frequency of order				
No.	Model	Jul	Aug	Sep	Oct	Total
1	4G1E O/P	1	0	0	0	1
2	4G1E W/P	1	2	2	1	6
3	4G1 W/P	21	19	23	20	83
4	4G9 W/P	0	0	1	3	4
5	4M4 O/P	8	8	10	9	35
6	P-CAR O/P	21	19	19	19	78
7	P-CAR W/P	21	12	17	14	64
8	4JA1 C/F	25	23	18	23	89
9	4JA1 D/C	3	2	2	1	8
10	4JA1 R/V	13	15	12	16	56
11	4JA1 O/P	19	14	13	17	63
12	4JA1 W/P	20	13	18	18	69
13	Y71 O/P	2	1	0	1	4
14	Y71 W/P	1	1	0	2	4
15	2L-II W/P	9	14	17	14	54
16	5L W/P	0	0	0	13	13
17	VQ O/P	2	3	2	1	8
18	VQ W/P	2	3	2	2	9
19	BD25 RS	7	12	13	13	45
20	TD27 RS	6	12	10	13	41
21	BD25 O/P	5	6	9	9	29
22	BD25 W/P	13	11	19	21	64
23	TD27 W/P	9	7	14	12	42
24	HF O/P	15	11	15	5	46
25	HF W/P	3	6	6	11	26
26	4G9E O/P	7	10	11	11	39

When the ordering frequency of each model is compiled, the high frequency items in the machining order and models in the assembly order are cascaded from high frequency to low frequency. They are shown in Table 4.3 and Table 4.4.

Table 4.3 : Order picking for the machining department from Table 4.1 sorted by ordering frequency.

No.	Model	Type	Part name	Frequency of order				
				Jul	Aug	Sep	Oct	Total
1	P-CAR	O/P	CASE FRONT	26	21	22	23	92
2	AIR	COMP	GEAR HEAD	17	23	21	20	81
3	AIR	COMP	CRANK SHAFT	25	19	16	14	74
4	AIR	COMP	CYLINDER	21	20	16	10	67
5	P-CAR	O/P	PIN DOWEL	17	15	17	16	65
6	P-CAR	W/P	BODY	16	15	15	16	62
7	M1	COMP	CYLINDER	17	9	11	15	52
8	HF	F/C	FRONT COVER	14	13	12	12	51
9	4JA1	O/P	GEAR	13	13	8	14	48
10	BD25	W/P	BODY	6	6	18	18	48
11	4JA1	O/P	COVER	10	16	8	9	43
12	4JA1	O/P	SHAFT(LONG)	10	13	7	10	40
13	2L-II	W/P	BODY	9	7	8	12	36
14	P-CAR	O/P	COVER B/S GEAR	16	15	3	0	34
15	M1	COMP	CRANK SHAFT	7	11	5	7	30
16	4D56	W/P	BODY	9	3	9	8	29
17	4JA1	O/P	SHAFT(SHORT)	8	9	4	7	28
18	4G9E	O/P	CASE	12	7	3	2	24
19	HF	O/P	COVER	7	4	4	6	21
20	P-CAR	O/P	PLUG TAPER	5	4	5	5	19
21	4G9E	O/P	CASE	0	3	5	10	18
22	4M4	O/P	GEAR	5	3	5	5	18
23	TD27	W/P	COVER	5	4	2	7	18
24	HF	F/C	FRONT COVER-SHOT BLAST	5	3	3	6	17
25	4G1	W/P	BODY	13	0	0	2	15
26	BD25	O/P	BODY	4	3	6	2	15
27	TD27	W/P	WHEEL	4	4	3	4	15
28	4JA1	W/P	CENTER	11	2	0	0	13
29	4M4	O/P	SHAFT(LONG)	4	3	3	3	13
30	TD27	W/P	BODY	4	4	2	3	13
31	4G9E	O/P	CASE	0	0	4	9	13
32	4M4	O/P	SHAFT(SHORT)	3	3	4	2	12
33	BD25	O/P	GEAR DRIVE	1	2	3	4	10
34	BD25	O/P	SHAFT DRIVE	1	2	3	3	9
35	4JA1	O/P	GEAR(RAW)	0	2	2	3	7
36	P-CAR	W/P	HUB	7	0	0	0	7
37	4G1E	O/P	CASE	0	1	1	0	2
38	4M4	O/P	PLUG TAPER	1	0	0	1	2
39	BD25	W/P	WHEEL	0	1	0	1	2
40	P-CAR	O/P	BALL STEEL	0	0	1	0	1
41	4G1	O/P	PLUG	0	0	0	0	0
42	4JA1	T/P	COVER	0	0	0	0	0
43	4JA1	T/P	ROTOR	0	0	0	0	0
44	4JA1	T/P	CASE	0	0	0	0	0
45	4JA1-E	O/P	BODY	0	0	0	0	0

46	4M4	O/P	GEAR HEAD	0	0	0	0	0
47	BD25	W/P	BODY	0	0	0	0	0
48	BD25	W/P	COVER	0	0	0	0	0
49	P-CAR	O/P	BOLT	0	0	0	0	0
50	Y71	O/P	PLUG	0	0	0	0	0
51	M1	COMP	REAR HEAD	0	0	0	0	0

Table 4.4 : Order picking for the assembly department from Table 4.2 sorted by ordering frequency.

		Frequency of order				
No.	Model	Jul	Aug	Sep	Oct	Total
1	4JA1 C/F	25	23	18	23	89
2	4G1 W/P	21	19	23	20	83
3	P-CAR O/P	21	19	19	19	78
4	4JA1 W/P	20	13	18	18	69
5	P-CAR W/P	21	12	17	14	64
6	BD25 W/P	13	11	19	21	64
7	4JA1 O/P	19	14	13	17	63
8	4JA1 R/V	13	15	12	16	56
9	2L-II W/P	9	14	17	14	54
10	HF O/P	15	11	15	5	46
11	BD25 RS	7	12	13	13	45
12	TD27 W/P	9	7	14	12	42
13	TD27 RS	6	12	10	13	41
14	4G9E O/P	7	10	11	11	39
15	4M4 O/P	8	8	10	9	35
16	BD25 O/P	5	6	9	9	29
17	HF W/P	3	6	6	11	26
18	5L W/P	0	0	0	13	13
19	VQ W/P	2	3	2	2	9
20	4JA1 D/C	3	2	2	1	8
21	VQ O/P	2	3	2	1	8
22	4G1E W/P	1	2	2	1	6
23	4G9 W/P	0	0	1	3	4
24	Y71 O/P	2	1	0	1	4
25	Y71 W/P	1	1	0	2	4
26	4G1E O/P	1	0	0	0	1

4.4 Analyse the storage locations

Prior to the determination of the storage locations, the mathematics formulation is presented as follows.

The following variables will be used to determine the new warehouse layout.

Given, X_{ij} = item in warehouse,

d_{ij} = distance between item X_{ij} and the dock,

f_{ij} = frequency of each item,

M = amount of model,

N = amount of items in each model,

i = model 1,2,3,..., M, and

j = item 1,2,3,..., N.

Therefore,

$$\text{Total distance} = \sum_{i=1}^{M}\sum_{j=1}^{N} d_{ij} f_{ij} \qquad \text{----- equation 4.1}$$

From the above equation, the objective of this study is to minimise the total distance. Therefore, d_{ij} must be reduced for the items with high frequency of order.

In side the warehouse, the rack can be aligned vertically instead of horizontally as existed. However, the change in rack position require expenses in removal the existing racks, constructing the new racks, and interrupt the production line. Furthermore, the change in rack position would make the access of items more difficult. As a result, the rack position remains in the same position as the existing one which provides benefits as follows :

- save cost in racks removal and construction,
- easy access to items location because of many aisles available, and
- workers are familiar with this rack setting.

The details of storage locations in our warehouse are shown in Fig. 4.2.

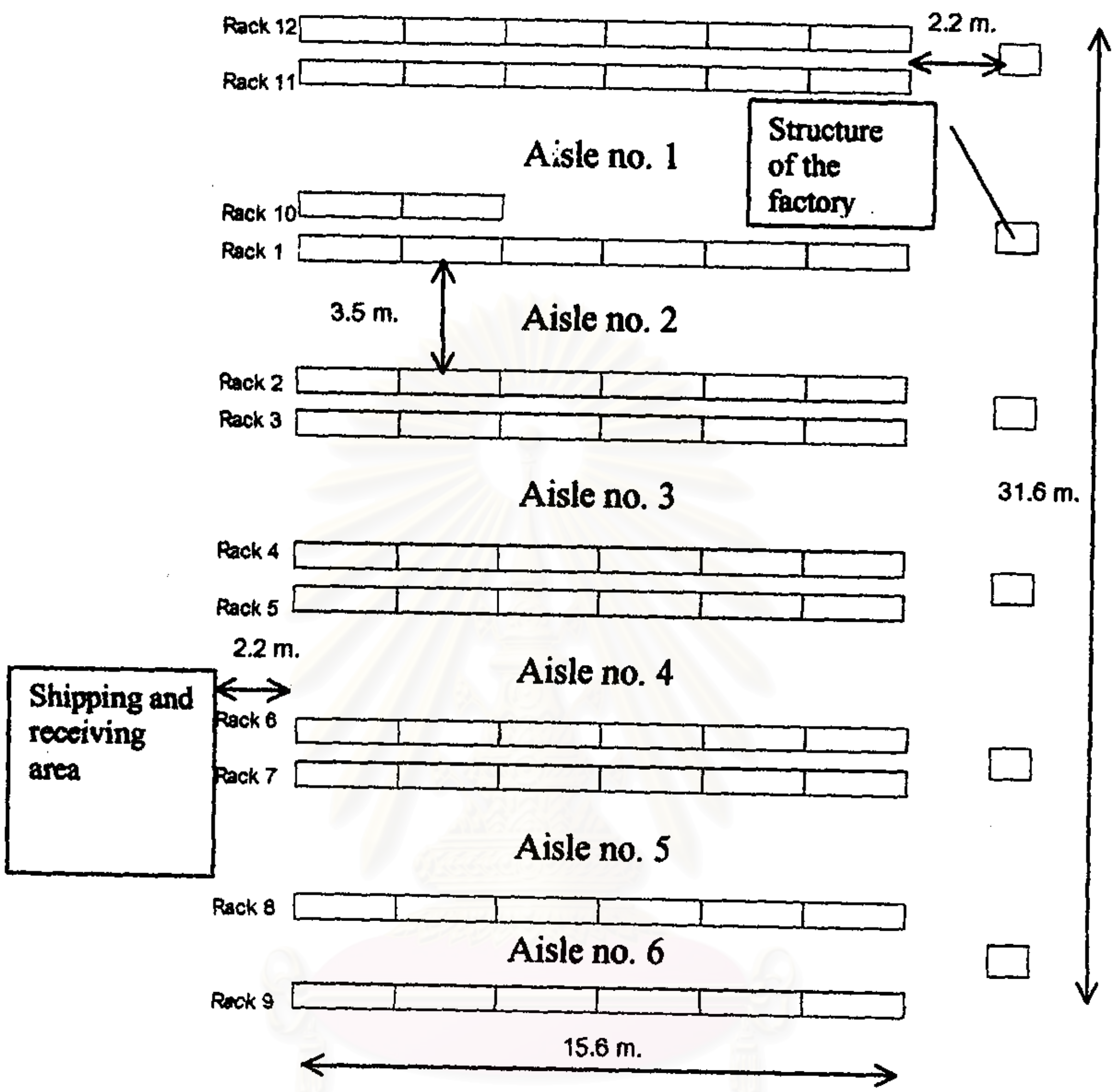


Fig 4.2 : Details of the warehouse layout

There are twelve racks in this warehouse. Each rack contains different numbers of rows and columns. Each row is divided into blocks. In each block, there are two locations left and right hand sides. Fig 4.3 exhibits a block with its location number.

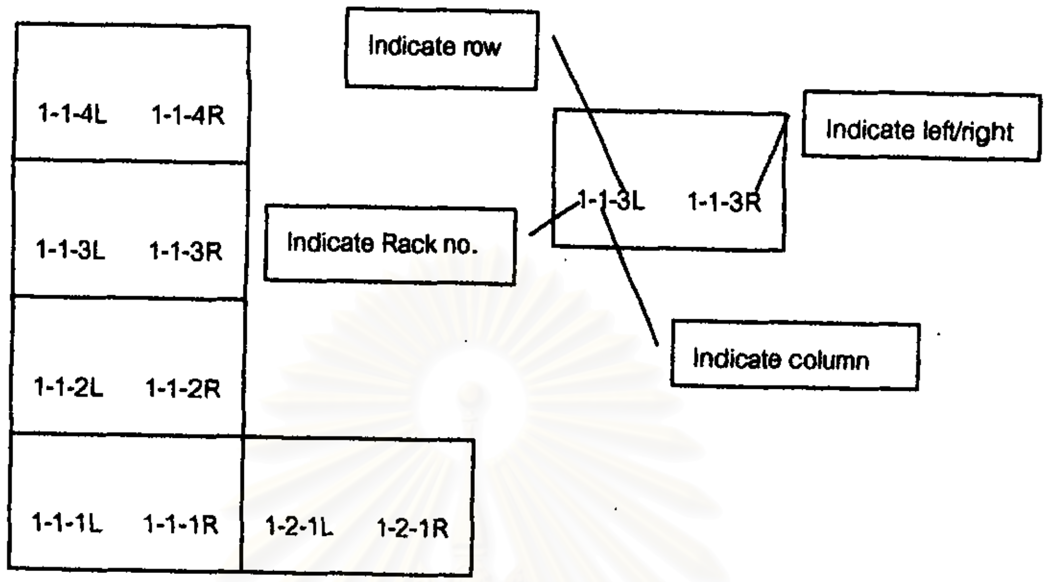


Fig. 4.3 : Details of location numbers in a block.

When all items are allocated to the new location, there are many constraints to be considered. Firstly, some items have to be stored in the top part of the rack because they are lightweight materials and require large space. For the heavyweight materials, they must be stored at the lowest level in the rack. For some certain parts, they need FIFO (First in First out) treatment. Only some locations in the Rack nos. 6 and 7 are used to store FIFO materials and imported materials. Moreover, the Rack no. 10 is used to store imported materials which are large therefore, they are stored as a pack on pallets and piled on the floor.

The space requirement for each item and each model is then determined. Fig. 4.4 shows the process in determining the new storage location. The new location layout is presented in Appendix 3.

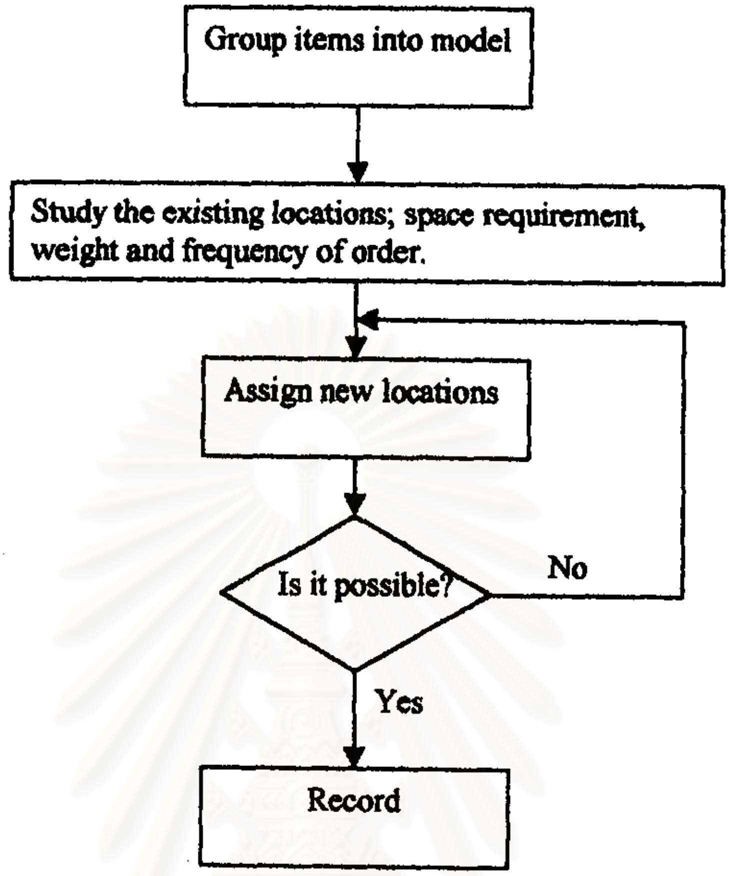


Fig. 4.4 : Process in assigning the new storage location.

4.5 Picking Process

In this warehouse, there are eleven picking order documents. When the Machining Department or Assembly Department requires raw materials in the warehouse, their workers fill in a picking order. Then warehouse workers will pick these items and send to each department.

Picking processes are made everyday and take a long time to pick the ordered items. The route used to pick them is more complicated when the number of items increases. Therefore, the systematic picking method is proposed to improve material handling routing in this warehouse. The route configuration is shown in Fig. 4.5.

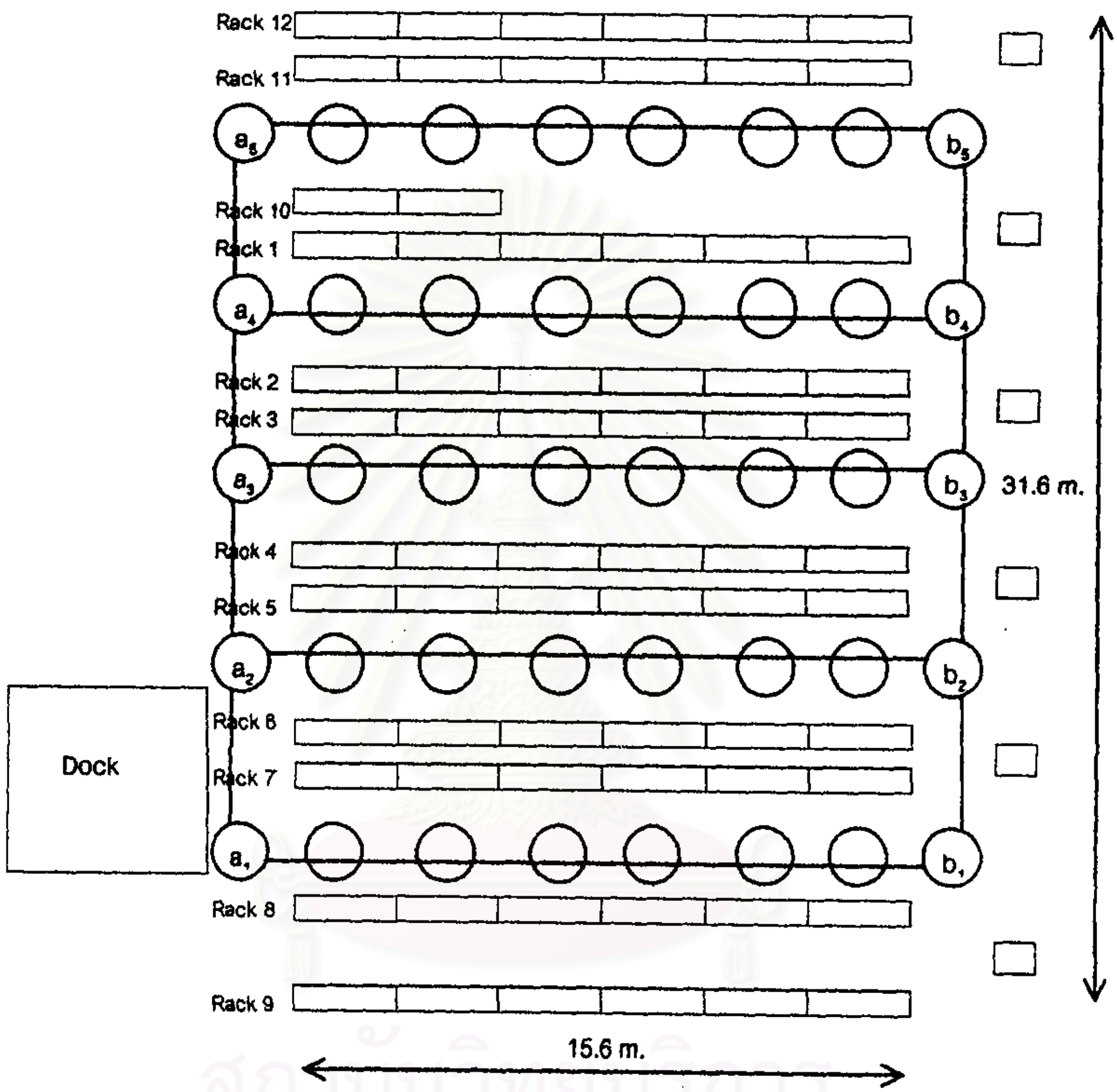


Fig. 4.5 : Possibilities of picking route.

Vertices a_j and b_j are the ends of each aisle where $j = 1,2,\ldots,5$. For simplicity, the vertex a_1 is the shipping area location (dock). Assuming that, items can be picked from both sides of an aisle with equal distance from a point without any difficulties from the height of shelves.

Nearest Neighbor Heuristic technique is used to generate a picking tour. The principle of this technique is to pick the nearest item first. The process of the tour generation is shown in Fig. 4.6.

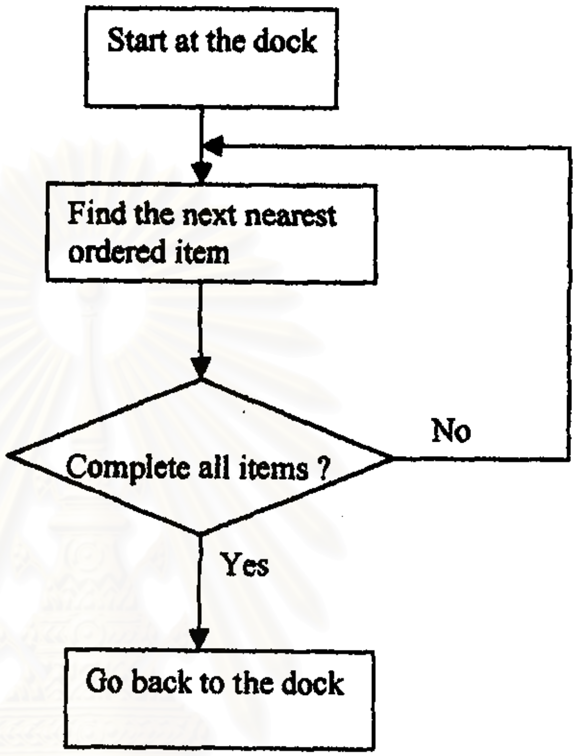


Fig. 4.6 : The methodology of Nearest Neighbour Heuristic.

This Nearest Neighbour Heuristic technique is applied in this warehouse. Assuming that the amount of raw materials ordered by the machining department is not much, therefore all the raw materials in each order could be picked up in a single tour by using a forklift. The sample of ordered items for machining department are shown in Table 4.5 below.

Table 4.5 : Samples of ordered items from the machining department.

Item	Part no.	Partname and Model	Existing Location	Proposed Location.
1	215	Cover HF	12-2-3R	8-2-2L
2	558	Body 4G1	11-1-5L	8-1-4L
3	35	Shaft 4JA1	11-1-3R	7-4-5R

4	25	Cover 4JA1	12-2-2L	7-5-2L
5	386	Gear 4M4	11-4-3L	7-1-3R
6	368	Gear head AIR	11-3-1R	8-1-1R

After the ordered items are informed, the location for each item is known from the layout. The picking tour is generated manually and the graphs are shown in Fig. 4.7.

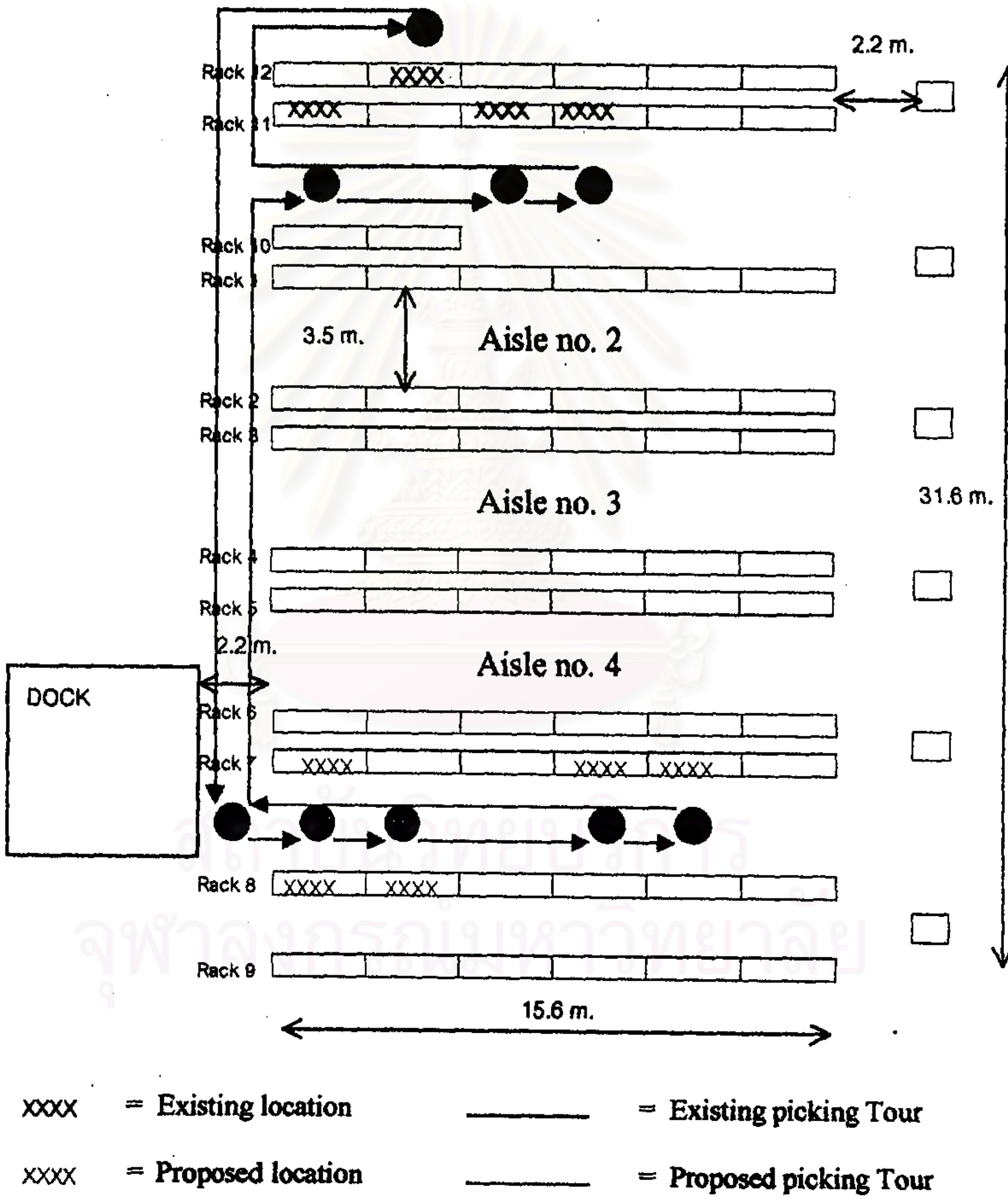


Fig. 4.7 : Picking tour by Nearest Neighbor Heuristic.

For the machining department, most of ordered items are located at the same rack. Workers use forklift to pick these items. In each tour, only one item can be picked because these items are heavy in weight. Therefore, the distance between each item and the dock is calculated so that the proposed locations can be compared with the existing locations. The distance can be measured from Fig. 4.2 and Fig. 4.5. After all the machining department's ordered items are determined, a comparison of the existing distance and the proposed distance are shown in Table 4.6 below. The evaluation is performed in Chapter 6.

Table 4.6 : Comparison of the existing distance and the proposed distance for the machining department's items.

No.	Model	Type	Part No.	Part name	Existing Distance (m.)	Proposed Distance (m.)
1	2L-II	W/P	237	BODY	62.08	5.08
2	4D56	W/P	382	BODY	62.08	15.24
3	4G1	W/P	558	BODY	50.68	2.54
4	4G1E	O/P	431	CASE	82.40	15.24
5	4G9E	O/P	451	CASE	62.08	20.94
6	4JA1	W/P	55	CENTER	65.92	12.70
7	4JA1	O/P	33	SHAFT(SHORT)	50.68	10.16
8	4JA1	O/P	35	SHAFT(LONG)	50.68	10.16
9	4JA1	O/P	25	COVER	67.16	12.70
10	4JA1	O/P	32	GEAR(RAW)	50.68	12.70
11	4M4	O/P	386	GEAR	65.92	2.54
12	AIR	COMP	368	GEAR HEAD	60.84	2.54
13	AIR	COMP	369	CYLINDER	55.76	5.08
14	AIR	COMP	367	CRANK SHAFT	50.68	2.54
15	BD25	W/P	125	BODY	55.76	5.08
16	BD25	O/P	100	BODY	67.16	7.62
17	BD25	W/P	127	BODY	60.84	7.62
18	BD25	O/P	105	GEAR DRIVE	55.76	15.24
19	BD25	W/P	128	COVER	60.84	2.54
20	HF	F/C	213	FRONT COVER	82.40	5.08
21	HF	O/P	215	COVER	67.16	5.08
22	P-CAR	W/P	283	BODY	77.32	7.62
23	P-CAR	O/P	256	COVER GEAR	67.16	7.62
24	P-CAR	O/P	255	CASE FRONT	72.24	10.16
25	P-CAR	O/P	271	BOLT	59.60	7.62
26	P-CAR	W/P	284	HUB	76.08	10.16
27	TD27	W/P	132	WHEEL	65.92	8.24
28	TD27	W/P	130	BODY	71.00	13.32
29	TD27	W/P	131	COVER	76.08	8.24
30	4G9E	O/P	453	CASE	44.36	12.70

For the assembly department, the items are grouped according to model. Workers use pushcarts to pick those models. Only one model is always picked and sent to the assembly department in each tour. Therefore, the distance between each model and the dock is calculated and shown in Table 4.7 below.

Table 4.7 : Comparison of the existing distance and the proposed distance for the assembly department's models.

No.	Model	Existing Distance (m.)	Proposed Distance (m.)
1	4G1E O/P	59.60	30.42
2	4G1E W/P	36.80	27.88
3	4G1 W/P	39.28	18.40
4	4G9 W/P	49.44	27.88
5	4M4 O/P	53.28	65.92
6	P-CAR O/P	64.68	38.04
7	P-CAR W/P	59.60	21.56
8	4JA1 C/F	32.96	21.56
9	4JA1 D/C	38.04	53.28
10	4JA1 R/V	38.04	41.88
11	4JA1 O/P	48.20	48.20
12	4JA1 W/P	53.28	41.88
13	Y71 O/P	31.72	48.20
14	Y71 W/P	26.64	48.20
15	2L-II W/P	21.56	39.28
16	5L W/P	21.56	53.28
17	VQ O/P	53.28	59.60
18	VQ W/P	64.68	54.52
19	BD25 RS	59.60	38.04
20	TD27 RS	21.56	49.44
21	BD25 O/P	32.96	43.12
22	BD25 W/P	32.96	32.96
23	TD27 W/P	58.36	49.44
24	HF O/P	48.20	39.28
25	HF W/P	48.20	39.28
26	4G9E O/P	49.44	91.32

4.6 Shelf-Filling Process

There are about thirty suppliers for this company. They mainly supply raw materials. Some raw materials are supplied from more than one supplier. The details of raw materials and suppliers are shown in Appendix 4.

When a supplier delivers raw materials, the quality control department checks the raw materials. Then the raw materials are delivered to the warehouse at the specific location. In this process, the warehouse workers bring all the items to the specific locations in one tour. All the materials handling in this process is aided by a forklift.

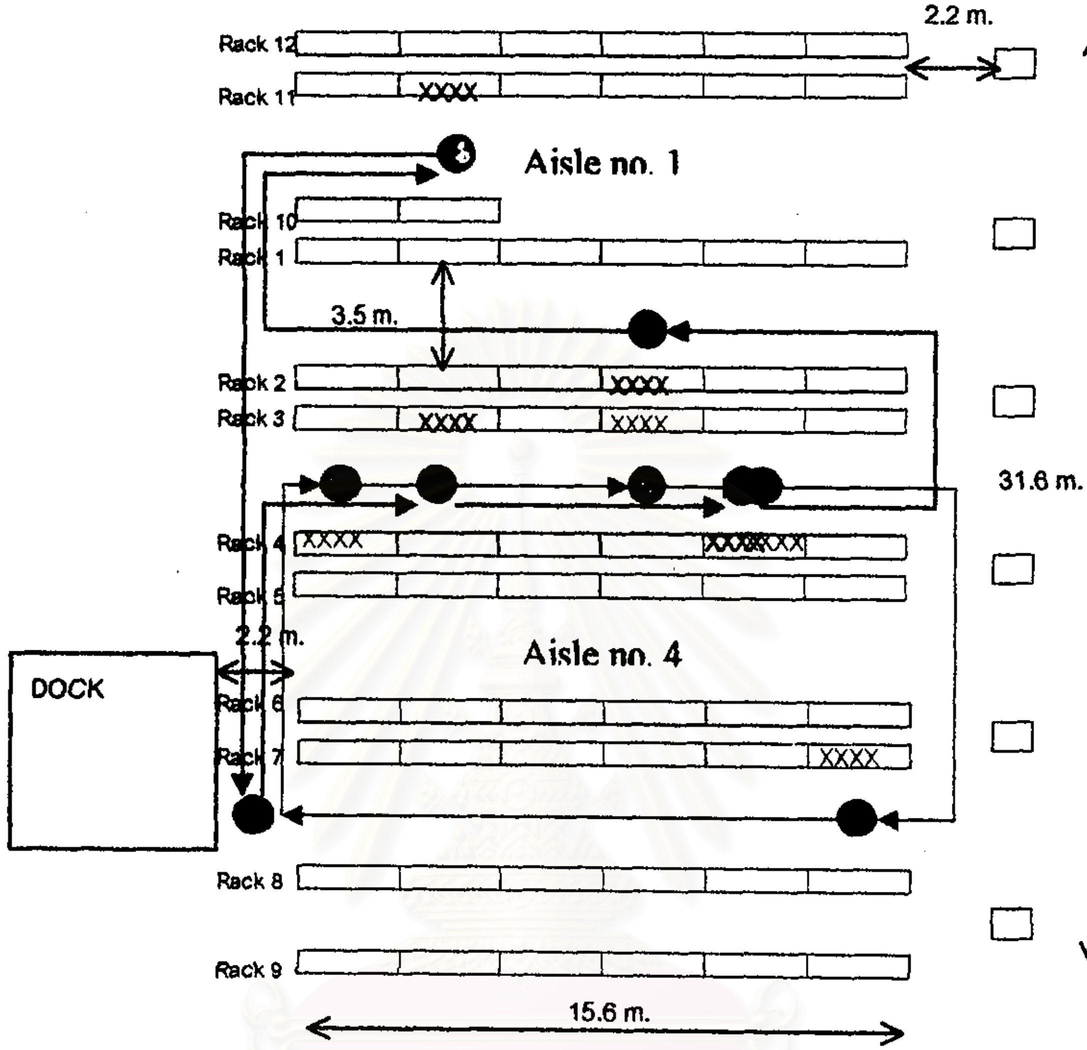
In this thesis, the location of each raw material from each supplier is determined so that the distance between the receiving area and the storing area is defined. Then the Nearest Neighbor Heuristic method is used to generate the shelf-filling tour. Finally, the distances from the existing location and the proposed location are compared.

An example in calculating the distance in the shelf-filling process for one supplier is done as shown in Table 4.8 below.

Table 4.8 : Items supplied by SMEC and their locations.

Part no.	Part Name	Model	Existing Location	Proposed Location
37	PINION	4JA1 O/P	4-5-2L	4-5-2R
103	GEAR	BD25 W/P	3-2-2R	3-4-3L
105	GEAR	BD25 O/P	11-2-2L	7-6-3R
273	GEAR B/S	P-CAR	2-4-1L	4-1-1L

The items are plotted in the warehouse layout to find the shelf-filling tour distance by using Nearest Neighbor Heuristic method. The existing locations and the proposed locations for each item are shown in Fig. 4.8.



XXXX = Existing location ——— = Existing filling Tour

XXXX = Proposed location ——— = Proposed filling Tour

Fig. 4.8 : Comparison of shelf-filling tours from SMEC.

After the shelf-filling tours are plotted on the layout, the distance of both tours is measured. The distance of the existing shelf-filling tour and the proposed shelf-filling tour are 91.32 metres and 58.36 metres, respectively. When the distance of all the suppliers' items are determined, the shelf-filling distance for each supplier is shown in Table 4.9.

Table 4.9 : The shelf-filling distance for each supplier.

No.	Supplier Name	Existing Distance (m.)	New Distance (m.)
1	ADS	82.40	10.16
2	AP	74.84	91.32
3	ASA	82.40	41.26
4	BEW	43.12	38.04
5	BTA	69.76	43.12
6	CMM	27.88	16.48
7	DM	64.68	71.00
8	ICC	60.84	10.16
9	IFC	76.08	20.32
10	ITO	71.00	63.44
11	JBT	43.12	59.60
12	KOYO	64.68	91.32
13	KTH	85.00	96.40
14	MSC	54.52	27.88
15	NHK	69.76	79.92
16	NSO	58.36	81.16
17	P&SON	60.84	10.16
18	PCR	27.88	16.48
19	PR2	43.12	36.80
20	SGT	59.60	74.84
21	SMEC	91.32	58.36
22	SMTE	71.00	25.40
23	SNF	65.92	25.40
24	SSI	54.52	38.04
25	SW	48.20	43.12
26	TAC	59.60	43.12
27	TAP	101.48	95.16
28	TEP	102.72	58.36
29	TSS	69.76	96.40

The proposed location can help reducing the picking and shelf-filling tour distance for some items. Therefore, the requirement frequency for each item is collected to evaluate the effectiveness of each proposed location. The evaluation process is performed in Chapter 6.

4.7 Proposed Technique in Items Relocation in the Warehouse

There is a great variety of items stored in this warehouse, however the space in storing them is limited by the number of racks. As a result, several steps are required in moving all the items from their existing locations to the proposed locations.

Every item should be moved around the middle of a month because suppliers usually deliver raw materials in the beginning of the month. The processes in reallocating them are as follows.

1. The machining department and the assembly department must order the required items one week in advance instead of one day in advance as for the present practice. Therefore, both departments have increased the number of buffer stock. Hence, the warehouse department will have one week to move all the items to the new locations.

2. The items ordered by the machining department must be moved first because the number of items is less than that from the assembly department. Therefore, the items in rack nos. 6, 7, and 8 must be moved out. Then the items ordered by the machining department are moved from rack nos. 11 and 12 to the rack nos. 6, 7, and 8.

3. The moved items from rack nos. 6, 7, and 8 are grouped according to their models. The model which require the largest space must be moved into the new locations prior to those which require smaller space. Some of the remaining items to be included in these models are picked up from any racks in the existing locations to combine in these groups.

4. The existing items in the new locations for the largest space requirement model must be moved out and categorised.

5. The moved out and categorised items are then determined for the space requirement. The largest space requirement model is then selected and step 3 is repeated until all the items are relocated.

For this activity, the warehouse workers require two forklifts and one pushcart to move items into the shelves and out of the shelves

4.8 Summary

In this chapter, the new locations of all items in the warehouse are determined by considering frequency of order, model category, weight, and space requirement.

The proposed layout is shown in Appendix 3. When the items are relocated, the picking tour distance and shelf filling distance are measured. The Nearest Neighbor Heuristic is used to generate the picking tour and shelf-filling tour. These techniques provide the near optimal solutions. The evaluation process is performed in Chapter 6.

The proposed technique to relocate items is carried out to assist the company to move most of the items in the warehouse.