IMPROVING MATERIAL WAREHOUSE PREMISES AT THANG LONG METAL COMPANY BY RANKED POSITION WEIGHTED METHOD (RPW)

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ABSTRACT

The warehouse is a fundamental component of the logistics industry, serving as a storage facility for raw materials, supplies, goods, and finished products during the supply chain process. It provides the capability to store, preserve, and prepare goods for businesses, ensuring a seamless supply of goods in terms of both quantity and quality. Raw materials are one of the key elements constituting the entity of a product, alongside other factors such as labor and the workforce. For smooth and efficient production and business operations, enterprises must ensure an adequate and high-quality supply of raw materials, timely delivery, compliance with specifications, and a balance between outgoing production and incoming inventory. The paper improving material warehouse premises at Thang Long Metal Company using the Ranked Position Weighted (RPW) method to improve the usability of the warehouse. And there are solutions to improve the premises regulations on export and import of raw materials.

Keywords: *Preservation; ranked position weighted method; raw materials; warehouse.*

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NOMENCLATURE

N: Station number
H: Efficiency (%)
λ: Speed
L: Average number of molecules in the system
W: Average wait time in system
W_Q: Average waiting time in queue
L_Q: Average number of elements in the queue
N_S: Average number of occupied elements

1. INTRODUCTION

Current developments in the global market and various modifications have significantly impacted warehouse design. Enhancing and organizing material warehouses play a crucial role in optimizing warehouse operations, including material handling and arrangement. Abroad, notable studies have been conducted to address these challenges. For instance, Johannes Fisel, et al. explored optimal assembly line balancing configurations as a multi-objective optimization problem, focusing on a use case in automotive assembly line balancing [3]. Haile Sime, et al. assessed the feasibility of using simulation techniques for line balancing in the apparel industry [2]. Moreover, Jordi Pereira and Eduardo Álvarez-Miranda tackled the complexity of assembly line balancing problems, reducing the number of additional charges (stations) in shorter runtimes [4]. Additionally, Alexandre Dolgu and Evgeny Gafarov contributed new ideas for assembly line balancing research, aiming for fixed cycle times and minimal arrivals [1].

In Vietnam, companies are increasingly interested in improving raw material warehouse spaces, prompting several studies on reconstructing and upgrading factories and warehouses. These domestic studies focus on line balancing methods, including the application of balancing production line improvement for ABC Vietnam Joint Stock Company [9] and balancing the garment production line through simulation [10].

The research objectives in Vietnam aim to optimize the use of space and human resources, remove bottlenecks, and achieve a balanced material warehouse area using the RPW method. The study will investigate various factors affecting the raw material warehouse arrangement to create a rational production process sequence, particularly for the Thang Long Metal Company. This optimization will facilitate material movement, provide flexibility in material input, and adapt quickly to changes and new requirements.

2. METHODS

The Ranked Position Weighted (RPW) method is a production line balancing method. In the production layout by product, the production process is designed according to the “flow model” and is divided into many different work steps [5]. The goal of line balancing is to create groups of work steps of roughly equal duration. Applying the RPW method will minimize the movement between areas in the raw material warehouse, smooth workflow and make the most of the storage capacity of the warehouse.

3. RESULTS AND DISCUSSION

3.1. Line balance

A well-managed warehouse will help the production and business process be continuous, reduce related costs and make the exploitation and use of the warehouse more efficient. Warehouse management process at Factory No. 3, Thang Long Metal Company is as shown in Table 1.

Table 1. Material warehouse management process of Factory No. 3, Thang Long Metal Company

No	Process management	Device management	Time (T_i) Minute
1	Import goods	1	21
2	Check quality, quantity goods	2	28
3	Stamp the QC pass, issue the storage order	2	22
4	Fire protection equipment storage area	2	15
5	Scan the receipt code and make the receipt	3	5
6	Inspection, storage, maintenance of goods storage area 1	1	15
7	Inspection, storage, maintenance of goods storage area 2	2	8
8	Inspection, storage, maintenance of goods storage area 3	1	15
9	Inspection, storage, maintenance of goods storage area 4	3	11
10	Inspection, storage, maintenance of goods storage area 5	3	5
11	Inspection, storage, maintenance of goods storage area 6	3	15
12	Inspection, storage, maintenance of goods storage area 7	1	10
13	Check the exported goods in terms of quantity and quality	2	6
14	Warehouse staff scan the check code, make the delivery note	1	7

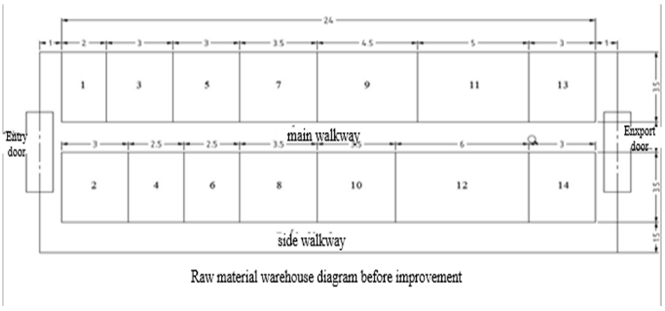

Fig. 1. Raw materials diagram before improvement

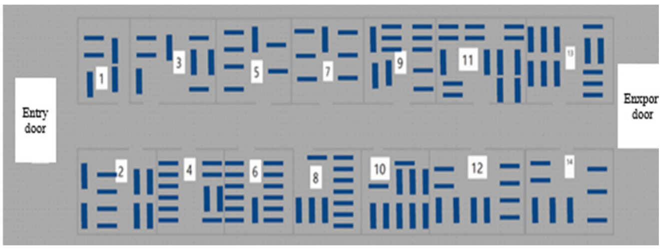

Fig. 2. 2D simulation of raw material warehouse diagram when not improved

Raw material warehouse at Thang Long Metal Company works:

8 hours/day, 30 days in a month, 3,280 parts/ 2 lines shipped every day.

- Total output time in a day is: T = 8 x 60 x 60 = 28,800 seconds
- Total work time: 183 minutes
- The factory has 2 lines
- Output: 1640 pieces/line/day
- Cycle time:

$$\text{Cycle time} = \frac{\text{Produce time}}{\text{Quality}} = 17.56 \text{ minutes} \quad (1)$$

- Minimum number of theoretical stations:

$$N = \frac{\text{Total worktime}}{\text{Cycle time}} = \frac{183}{17.56} = 10.42 \sim 11 \text{ stations} \quad (2)$$

- Theoretical efficiency:

$$H = \frac{\text{Total work time}}{\text{Actual station number x Cycle time}} x100\% = 94.7\% \quad (3)$$

- Unbalance rate = 100 - 94.7 = 5.3% (4)

Line balancing by Ranked Position Weighted (RPW) method: For works, areas with execution time less than cycle time (17.56 minutes), the research team grouped stations (from area 9 to area 14) so that the time in each station is less than or equal to the cycle time as shown in Table 2.

Table 2. RPW calculation table and substation

No	Implementation time	RPW	Previous work	Station
1	21	183	-	1
2	28	162	1	2
3	22	134	2	3
4	15	112	3	4
5	5	97	4	5
6	15	92	5	6
7	8	77	6	7
8	15	69	7	8
9	11	54	8	9
10	5	43	9	
11	15	38	10	10
12	10	23	11	11
13	6	13	12	12
14	7	7	13	

• Actual number of stations after balancing: N = 12 stations

• Actual performance:

$$H = \frac{\text{Total work time}}{\text{Actual station number x Cycle time}} x100\%$$

$$= \frac{183}{17.56 \times 12} = 86.8\% \quad (5)$$

• Actual rate of imbalance: 100 - 87 = 13%

Fig. 3. Material warehouse diagram of the factory after improvement

To explain the material warehouse diagram above, there is a glossary of sizes as shown in Table 3.

Table 3. Area size legend

No	Station	Size (m)
1	Import goods	5x3
2	Check quality, quantity goods	4x3
3	Stamp the QC pass, issue the storage order	4x3
4	Fire protection equipment storage area	2x3
5	Scan the receipt code and make the receipt	3x3
6	Inspection, storage, maintenance of goods storage area 1	6x3
7	Inspection, storage, maintenance of goods storage area 2	5.5x3
8	Inspection, storage, maintenance of goods storage area 3	2.5x3
9	Inspection, storage, maintenance of goods storage area 4,5	2x3
10	Inspection, storage, maintenance of goods storage area 6	4x3
11	Inspection, storage, maintenance of goods storage area 7	5x3
12	Check the exported goods in terms of quantity and quality, Warehouse staff scan the check code, make the delivery note	5x3

Area of new warehouse:

+ Warehouse length: 1 + 24 + 1 = 26m

+ Warehouse width: 2 + 3 + 2 + 3 = 10m

+ Warehouse area: 26 x 10 = 260m^2

Calculate the coordinates of the stations as shown in Table 4.

Table 4. Coordinates of the stations

Station	Coordinates a	Coordinates b	a+b	(-a+b)
1	6	10	16	4
2	10	10	20	0
3	14	10	24	-4
4	16	10	26	-6
5	19	10	29	-9
6	25	10	35	-15
7	6.5	5	11	-1
8	9	5	14	-4
9	11	5	16	-6
10	15	5	20	-10
11	20	5	25	-15
12	25	5	30	-20

• C_1 = minimum $(a_i + b_i)$ = 11 (6)

• C_2 = maximum $(a_i + b_i)$ = 35 (7)

• C_3 = minimum $(-a_i + b_i)$ = -20 (8)

• C_4 = maximum $(-a_i + b_i)$ = 4 (9)

• C_5 = max $(C_2 - C_1, C_4 - C_3)$

= max (35 - 11, 4 - (-20)) = 24 (10)

The optimal position lies on the link between two points:

(x_1^*, y_1^*) = 0.5 x $(C_1 – C_3, C_1 + C_3 + C_5)$

= 0.5 x (11.5 - (-20), 11.5 + (-20) + 24)

= 0.5 x (31.5, 15.5) = (15.75, 7.75) (11)

(x_2^*, y_2^*) = 0.5 x $(C_2 – C_4, C_2 + C_4 - C_5)$

= 0.5 x (35- 4, 35 + 4 - 24) = (15.5, 7.5) (12)

For the value of the objective function or the maximum distance to any of the parts is:

$$\frac{C_5}{2} = \frac{24}{2} = 12 \quad (13)$$

All points on the line connecting 2 points (15.75, 7.75) and (15.5, 7.5) have the maximum distance to go to other parts is 12 units.

To calculate the distance between machines, we use the formula:

$$D = |x_1 - x_2| + |y_1 + y_2| \quad (14)$$

Table 5. Distance between areas

From/to	1	2	3	4	5	6	7	8	9	10	11	12
1	0	4	8	10	13	19	0.5	3	5	9	14	19
2	4	0	4	6	9	15	3.5	1	1	5	10	15
3	8	4	0	2	5	11	7.5	5	3	1	6	11
4	10	6	2	0	3	9	9.5	7	5	1	4	9
5	13	9	5	3	0	6	12.5	10	8	4	1	6
6	19	15	11	9	6	0	18.5	16	14	10	5	0
7	0.5	3.5	7.5	9.5	12.5	18.5	0	2.5	4.5	8.5	13.5	18.5
8	3	1	5	7	10	16	2.5	0	2	6	11	16
9	5	1	3	5	8	14	4.5	2	0	4	9	14
10	9	5	1	1	4	10	8.5	6	4	0	5	10
11	14	10	6	4	1	5	13.5	11	9	5	0	5
12	19	15	11	9	6	0	18.5	16	14	10	5	0

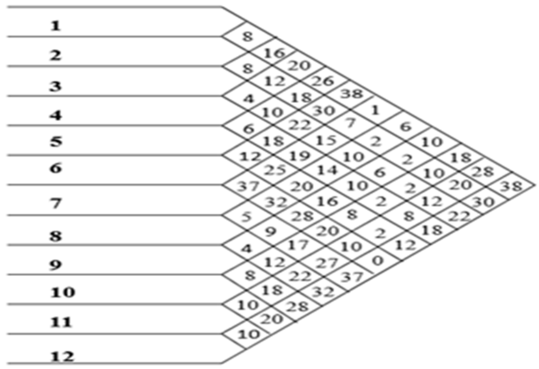

Fig. 4. From - to matrix showing the distance between areas

At the point of entry, materials arrive according to the Poisson distribution at a rate of 300 products/hour. The service time has an exponential distribution with an expectation of 10 seconds.

This is the (M/M/1) system with μ = 360 products/hour; λ = 300 products/hour

$$\lambda_I = \lambda = 300 \quad (15)$$

$$\rho = \frac{\lambda}{\mu} = 0.83 \quad (16)$$

The indicators of the import system are:

$$L = \frac{\lambda}{\mu - \lambda} = 5 \quad (17)$$

$$W = \frac{L}{\lambda_e} = 0.016 \quad (18)$$

$$W_Q = W - \frac{1}{\mu} = 0.14 \quad (19)$$

$$L_Q = \lambda_e \times W_Q = 4.16 \quad (20)$$

$$N_S = \rho = 0.83 \quad (21)$$

$$U_S = 100 \times \rho = 83\% \quad (22)$$

So on average there will be 5 products in the entry point; 4.16 products waiting, waiting time is 0.14 hours, time in point of entry is 0.016 hours, working efficiency of car wash is 83%. In order to increase the working efficiency in the raw material warehouse, the Research Team proposes to buy 1 more computer.

3.2. Analysis of shelves change

Analysis of racking in the raw material warehouse: choose from two common and suitable pallet racking systems: Double-deep Selective rack and Drive-in rack.

• Double-deep Selective racking: This racking system has the following parameters and advantages:

- Product Flow: FIFO (First In First Out)
- Convenient for taking pallets from both sides
- Usually used to store many pallets of the same type of goods.
- Over 90% usage

• Drive-in, Drive-through racking: This racking system has the following parameters and advantages:

- Product Flow: FIFO (First In First Out), LIFO (Last In First Out).
- Lane depth is large.
- Usage level is less than 60%.
- The shelves can be placed next to each other in a row, often used to store a large number of products of the same type.

To determine the best of the two options, we have the results of calculating the weighted scores for each option:

Table 6. Weight Score for Double-deep Selective Shelves

	Weight	Point	Total
Suitability	0.4	8	3.2
Price	0.3	9	2.7
Storage quantity	0.2	4	0.8
Convenience	0.1	6	0.6
Total			**7.3**

Table 7. Weight score for Drive-in, Drive-through shelves

	Weight	Point	Total
Suitability	0.4	8	3.2
Price	0.3	5	1.5
Storage quantity	0.2	8	1.6
Convenience	0.1	3	0.3
Total			**6.6**

When evaluating the weighted scores, we can see that the Double-deep Selective shelves and the Drive-in and Drive-through shelves both have good and good scores of 7.3 and 6.6. Conduct a selection of Double-deep Selective shelves with higher weights for use in material storage.

Table 8. Summary of equipment to buy for the warehouse

Current equipment	Equipment after redesign	Number of devices need to buy more	Reuse
Hand pallet truck: 2 pieces	Hand pallet truck: 4 pieces	2 pieces	
Forklift: 4 pieces	Forklift: 4 pieces	0	
Barcode scanner: 6 pieces	Barcode scanner: 6 pieces	0	
Computer: 1 pieces	Computer: 2 pieces	1 pieces	
Iron shelf: 52 pieces	Iron shelf: 52 pieces	0	52(reuse)
Double-deep Selective Shelves: 0 pieces	Double-deep Selective Shelves: 50 pieces	50 pices	

Finally, conduct the simulation of the material stock with Tecnomatix Plant Simulation software as shown in Fig. 5.

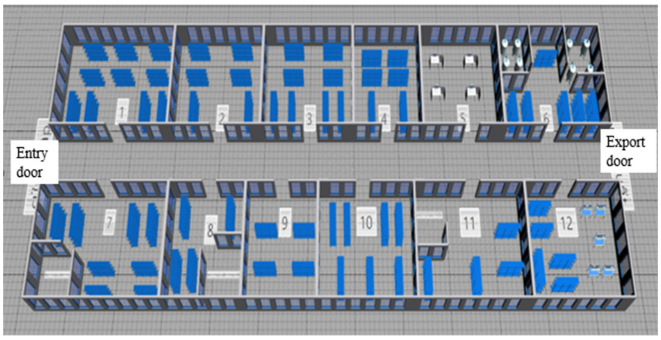

Fig. 5. Material warehouse diagram after improvement is simulated in 3D using Tecnomatix Plant Simulation software

4. CONCLUSIONS

The report has successfully demonstrated the positive outcomes of the warehouse space improvement, both in terms of efficiency and practicality. The number of stations in the warehouse has been reduced from 14 to 12, resulting in a decrease of approximately 1.667%. This reduction indicates a more streamlined and optimized warehouse layout.

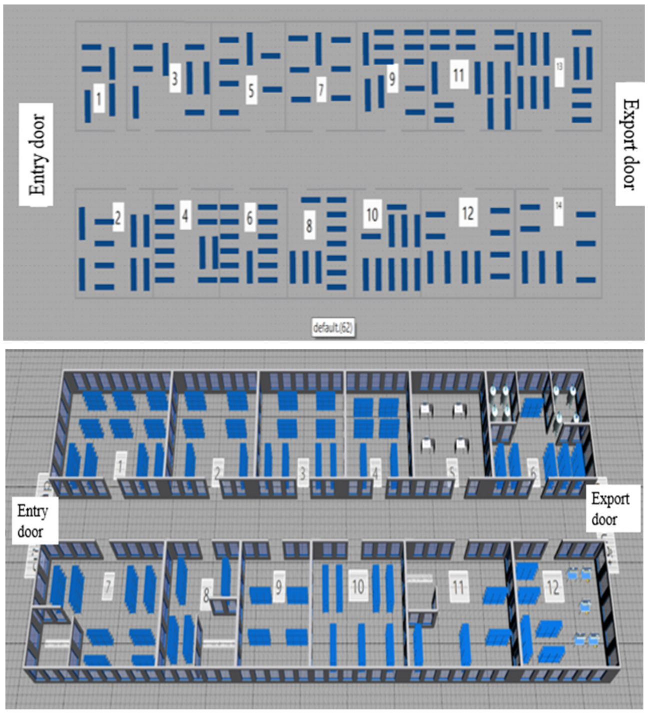

Fig. 6. The warehouse before and after applying RPW in 3D

The actual performance has increased significantly, nearly reaching the theoretical calculation efficiency of 94.7%. This improvement is a promising achievement as it shows that the changes made have positively impacted the overall efficiency of warehouse operations.

Furthermore, the rate of imbalance in the warehouse has been reduced by around 13% when compared to the previous state of the material warehouse. This reduction in imbalance signifies better organization and smoother material flow within the warehouse.

Another essential improvement is the modification of the warehouse floor layout, where the distance between stations and main aisles has been calculated and adjusted to cater to the import and export processes. Specifically, the entrance width for picking up goods has been widened from 1.5 meters to 2 meters. This adjustment facilitates the movement of hand trucks and hand pallet trucks, making material handling more efficient and convenient.

To support these physical changes, the report highlights the need to optimize the information system for controlling and managing the movement of goods within the warehouse. This includes tracking the time of goods' entry and exit and monitoring the precise location of materials. By implementing an efficient information system, the report aims to ensure that materials are properly managed, preventing issues like rusting and enabling better inventory control.

Additionally, the report emphasizes the importance of reorganizing the fleet's operation and providing guidance to drivers when transitioning to new storage spaces in the warehouse. This step is crucial to maintaining a consistent speed of goods transportation within the warehouse and ensuring that the optimization efforts continue to yield positive results.

Overall, the report's next development direction focuses on integrating technological solutions and further optimizing warehouse operations to achieve even greater efficiency and effectiveness in material handling and management.

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