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Social Science Journal

The Analysis of Space, Inventory and Transporter for Large-Sized Products Placement Based On ABC Class by Simulation Modeling

By

Panya Sumranhun
Assistant Professor, Faculty of Engineering and Industrial Technology, Bansomdejchaopraya Rajabhat University, Thailand panya.su@bsru.ac.th

Chotima Jotikasthira
Assistant Professor, Faculty of Business Administration Rajamangala University of Technology Thanyaburi, Thailand Chotima_j@rmutt.ac.th

Prachak Promngam
Faculty of Logistics and Aviation Technology, Southeast Bangkok College, Thailand prachak@sbc.southeast.ac.th

Abstract

This research aims to present a model for analyzing the storage space adequacy of a new warehouse. This research is quantitative research, which uses a systematic research method, starting from the study of the environment of the new warehouse to design the warehouse racking, collecting data in modeling, data type, and quantity period of sales volume. The delivery volume of suppliers and standard inventory policies will be collected for the analysis of the flow of goods to segment the goods by ABC Analysis concept. It is important to note that the data for the analysis is for three periods of ice machine distributors in Thailand. The FlexSim software application is used as a simulation tool to investigate the results of storage space utilization, time, and adequacy of loading and unloading equipment and present the results as storage space utilization at different times. The research results revealed that grouping products into three classes according to the product turnover cycle is appropriate and has enough space for storing goods. The highest utilization rate of A, B, and C class products have space utilization rates divided into 89.51, 75.75%, and 66.67%, respectively, and the positioning of the 3 product classes is appropriate as designed. In addition, the standard inventory levels and the vendor recovery plan are consistent with the customer's needs, while there is sufficient space to accommodate appropriate inventory storage .

Keywords: Simulation modeling, Warehouse racking area, ABC analysis

Introduction

Whether there is enough space in the warehouse for product racking may be a question that warehouse managers must constantly evaluate and plan. Space optimization is also a key performance indicator for warehouse management tasks. Increasing inventory is one of the key strategies to support sales expansion to meet customer demand. It can be seen in the tremendous growth in the volume of new warehouses being built. However, even if there were more room to store inventory, it is also a valuable investment.

Moreover, if resource utilization is poorly managed, the B/C ratio will also be reduced. In addition, there is the problem of having too much storage space, even if it can handle large volumes of products. However, this will result in a significant increase in inventory. It takes a long time to find the product. However, increasing the warehouse size will help expand storage space and related activities for shipping. The solution to the problem of insufficient warehouse space for future deliveries also helps solve chronic problems that arise from working in confined spaces. It also contributes to good delivery response (Ganbold et al., 2020), increasing efficiency following the warehouse control policy)Roodbergen et al., 2014). In addition, this allows for more efficient use of resources for the move and ultimately affects the total cost. In defining an appropriate structure, only the number of rows of stock and the quantity stored need to be determined(Berry, 2007). In addition, when there is a need to store large quantities of goods during certain seasons. Organizations can have alternative temporary outsourced warehouse services instead of costly individual investments (Sumranhun et al., 2019).

Based on the in-depth study of the company's resources for this research. Organizations should consider space for a new warehouse to support their growing capacity to meet customer demand. After applying the principles of systematic layout design and warehouse management principles, the result of this new warehouse space is in various shapes of the warehouse before being arranged according to the actual space. Product and zone details are considered from the zone size for the standard stock with the list of new products added minus the goods issued. In other words, the flow of goods directly affects the zone size. In addition, the ability to move, the unloading pattern, and the number of workers also affect the inventory flow.

However, the storage space's design and choosing an appropriate warehouse layout before putting it into practice should consider various factors in the area. Nevertheless, the result is untenable in addition to the simulation of the situation because of the product flow. In this article, the simulation is applied by analyzing the movement of goods from the information related to the supporting factors of standard inventory determination, supplier product call plan, and customer delivery plan. It evaluates the space utilization rate in the storage of goods over time because the study on space allocation plays a vital role in resource allocation in warehouse management. Furthermore, analyzing space utilization with pre-implementation simulations is more manageable than solving iterative problems (Guimarães et al., 2022). Therefore, this can be considered a challenge—furthermore, the possibility of studying to identify the location of the decision-making system

Literature Review

Simulation and Warehouse Management System

This research focuses on the study of space allocation for new warehouses, in which simulation was used to analyze and report results. It is one of the problems of warehouse management. It has received much attention from accepted research. Application of simulation techniques in education, the parameters' results affect the warehouse's space management. Study of the delivery rate of bulk orders, bulk transportation and complex working conditions are also possible (Seng Fat & Zhenning, 2019). Find the desired space and compare available areas to allocate space for use. It is a step in systematic layout planning (D. Liu & Zhang, 2022; Muther, 1987). Allocation of new storage space concerns the warehouse's design, which affects the main decision-making issues. Both define the structure of the departmental warehouse planning. It is choosing an operational strategy, selecting tools and equipment, and determining the size and quantity of storage space (Gu et al., 2010). In addition, the definition of the material flow model in the warehouse is a requirement for determining the overall structure. According to the department's requirements and the relationship of the workstation, including the allocation of space for each type of product, There may be additional details to consider, such as corridors, queue areas, directions of entry and exit of the system, Etc.

Stock Picking

Determining the layout of picking areas in different warehouses affects the time it takes to reach the item. Sancaklı et al. (2022) propose that picking and removing orders from the warehouse is time-consuming and expensive. The problem with picking is to reduce the overall distance traveled by the picker, which leads to an increase in workload (number of selections per time). In addition, Kees Jan Roodbergen & Vis (2006) attempted to reduce the average walking distance of pickers by considering the average walking distance in a non-linear manner. The optimal walking in the picking area depends on the required storage space and the size of the picking list. In addition, (Alnahhal et al., 2022) indicate that storage allocations near the point of entry, more yield will reduce service time by approximately 21-28% from determining the appropriate storage space based on product class. Moreover, the picking process has the highest proportion of cost and processing time in the warehouse. The layout improvement will also affect the product selection path (H. Liu et al., 2022). In addition, the definition of storage, movement routing and ordering policy also helps to evaluate the cycle times to be accurate enough for the practical demand (Yang et al., 2022). Therefore, in this paper, the focus on the storage location is given. Moreover, consider the time efficiency of the put away and picking for products that match the research mentioned earlier.

Warehouse Location Management

Assessment of system capacity and inventory performance requirements. This is due to the essential specification variables of the warehouse design, number of spaces, storage rows, and storage compartments in the system. Estimating storage capacity requirements are another critical element of the warehouse space management concept. To configure a two-sided storage compartment, the number of storage bins is double the product of the number of aisles, rows, and bins. Space requirements for storage policies can be determined from the probabilistic space requirement enumeration (Eldemir et al., 2004). Storage space decisions are important because they affect warehouse management's efficiency in many ways, such as handling costs, storage capacity, efficient use of tools, equipment, and labor (Rakesh & Adil, 2015).

Large-sized product placement must consider the size of the area. Moving equipment and the ability to support the weight of the rack is an essential factor in determining product placement, in addition to the frequency of movement and the value of the product, as presented by available research.

Research Methods

The research methodology included seven steps: 1) Determine modeling conditions, 2) Collect data, 3) Analyze data models, 4) Model concepts, 5) Test models, 6) Test Define the number of simulation repetitions, and 7) Process the model. The details are as follows.

Determine modeling conditions

This article is based on the actual layout of the ice machine warehouse. According to the preliminary results of the warehouse layout design, products will be placed on the racks according to the fixed positions. For restocking, products will be called by the supplier. According to the purchase order, the warehouse manager and the purchasing and marketing departments mutually agree based on the customer's order volume forecast. Formulating incoming goods is done through the arrival program to maintain the standard inventory balance according to the planned management policy. The inventory standards of 85 SKUs are defined in 3 classes according to the rotation cycle of the product: class A, 15 units; class B, 25 units and class C, 45 units. The standard stock of goods is determined by the safety stock multiplied by group SKU in proportion to each class, divided into a triple for class A, a double quantity for class B, and one for class C. The standard storage is 140 units, corresponding to the total inventory placed on the rack.

The company will import the machines from foreign suppliers as planned every month, but the delivery of the machines to the customers cannot be planned because they must be delivered immediately after the order confirmation. Therefore, the standard stock should be defined as proposed above.

Upon product arrival, the forklift can be put on the rack immediately without packaging and lifted to sell immediately without additional processing. It follows the steps of the flow operation, as shown in Figure 1 below.

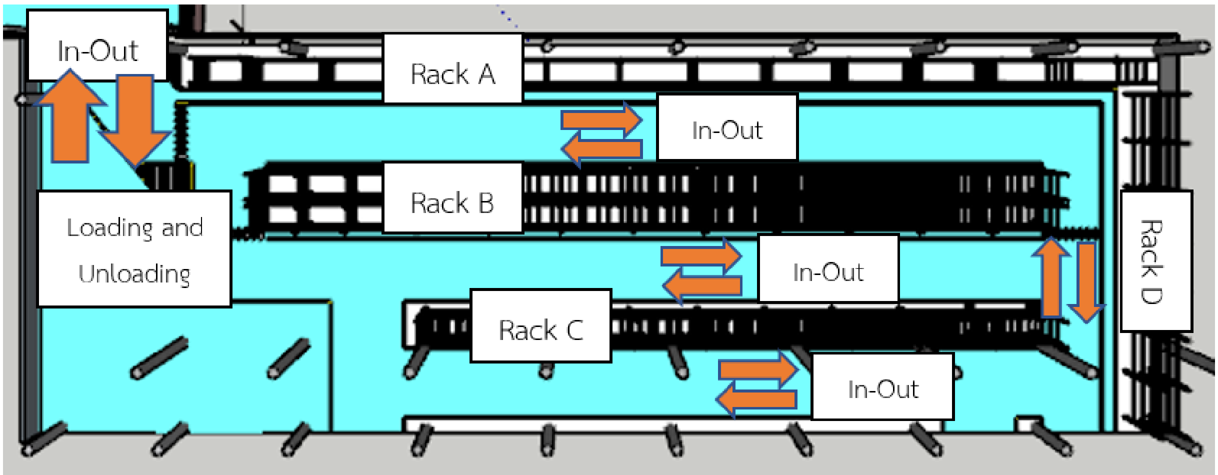

Figure 1. Placement area and process flow in the warehouse

Data Collection

The information used to define the conditions of the simulations is in this document. Use the planned route for pickup and delivery. According to the actual sales in 3 months with the best sales of the season of the ice machine distribution company in Thailand. The transfer of goods between workstations can also be moved by one forklift. The time information comes from the time study directly according to the principle of work to find the standard time. Layout and dimensions of the collected warehouse, write the report according to the standard and define the flow sequence that covers the type and quantity of the product.

Analysis of Data Patterns

It ensures that the generated model can accurately describe the existing system. At the heart of the simulation are parameter modeling and control. This research combines the merchandise suppliers' actual demand and delivery plans to match the actual inventory data for the generated model. Parameters of the product placement area sufficiency. The simulation, In this research is derived from the following initial assumptions:

- The volume of incoming products: is defined as a call plan of the supplier's products, the arrival of all types of products, and the quantities are scheduled at a specific time interval.
- For the volume of delivery, the data of the customers' demand were used for statistical analysis with the program Expert Fit. An exponential statistical distribution was obtained.
- Standard stock quantity: 140 units are assigned to a specific rack location.
- Transport time: moving the ice machine using a forklift with normal distribution. The data were analyzed for $N(\mu, \sigma)$, where: μ - mean value, σ - standard deviation.
- Time to simulate the situation over 30 days until the end of the product recall plan. and delivery of goods.

Modeling Concepts

This research considers the storage usage rate according to the inventory replenishment principle based on standard stock, delivery and replacement quantities are considered given the size of the area with a simulation usage rate(Ganbold et al., 2020). It leads to proof of whether the available space is sufficient or not. Moreover, when is the highest usage rate (risk of not enough storage space).

Warehouse space requirement = standard stock + goods replenishment – goods withdrawn

From the equation, the product is always in motion. Doing the math by manual would be inadequate for finding an answer. Therefore, an actual warehouse scenario model is created, as shown in Figure 2, where the ice machine is the object of interest in the system or resource model that moves through the model that is stored on the rack and taken off the rack for delivery according to the planned delivery schedule.

The components included in the model include storage space with four rack, divided into rack A for class A products with 143 units, rack B for class B products with 132 units, then rack C for class C products. 99 units from all classes of products are larger than the area as mentioned earlier. Another 77 units are stored on rack D. Source to be sent to a receiving area, used for processing, displayed in a queue, and waiting to be continuously moved to a specific location in the rack. The product's weight does not affect its positioning (the rack's strength is able to support the weight of the goods). All three delivery areas are used as goods acceptance areas outside the system and are considered to complete the operation. Movement of goods in all systems according to priority sort by task sequence, with one forklift working in the warehouse.

FlexSim version 2020 software is used to model and process the required results. The model represents the operational processes within the warehouse from validated data—elements to control the work of the model. Incoming goods are controlled according to the arrival sequence table, shown as Source 1, to create standard stock in the arrival sequence and replenished by the supplier in the arrival schedule, represented by the Source 2 icon. The outbound control or loading area is represented by three sinks, separated by ABC group which is assigned an exact position, as shown in Figure 2.

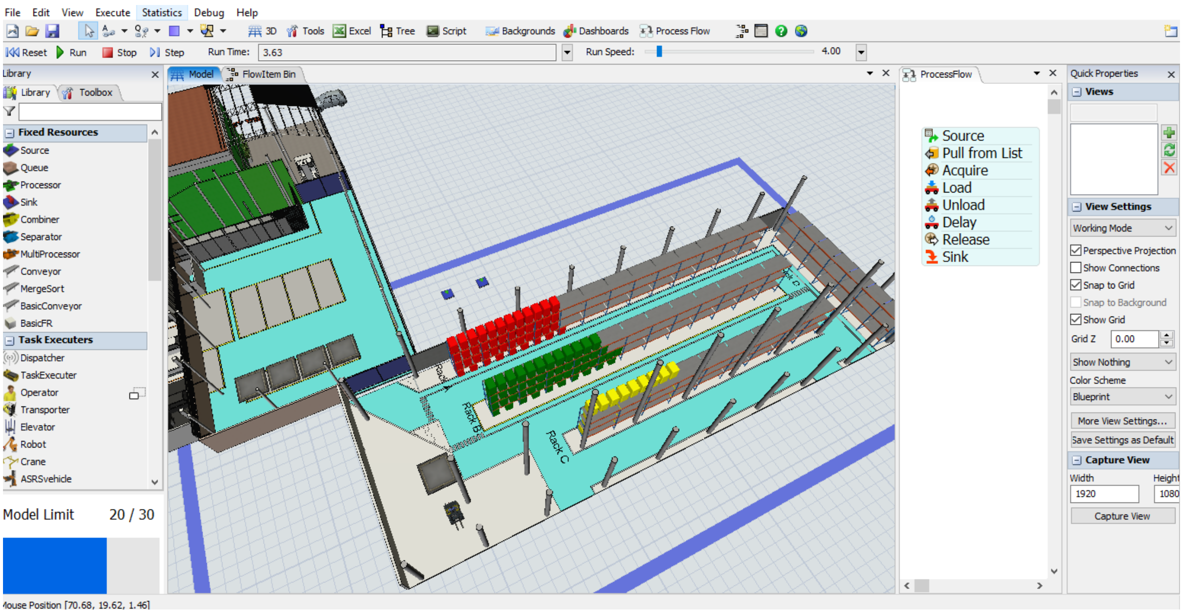

Figure 2. Simulated Model of the Warehouse

During the experiment, the model considers the bottleneck as the incoming goods represented by the queue quantity, Indicating an unloading problem. The adequacy of storage (rack) is caused by too much inventory. It is displayed on the simulation model with output as follows:

- Dashboard: Minimum-Maximum Stock.
- Queue: Waiting for storage.
- Dashboard: Total delivery time.

Verification of the Model

Model validation consists of two steps: 1) Model verification consists of verifying that the model is within the conceptual framework, and 2) Validation is a test of whether the model can genuinely represent the system's behavior, with repeated comparisons between the model and the actual system. In this document, the test is performed by comparing the results of running the model at the appropriate number of cycles, i.e., the mean of the 30-day operating time and the standard deviation, with the actual operating time. The statistical test (Chi-Square, p-value > 0.05). The data set from real and simulated situations are not significantly different.

Replication of the Simulated Model

In the above equation 2. Analysis of the number of Analysis of the number of replication of program execution or n. After obtaining the model of the actual system, the accuracy level of the system (h) is set to an accuracy level of 0.05, and the first processing frame (n_0) is set to 10 cycles, after which the appropriate number of replication cycles is calculated. It was found that the average run time of 829.58 hours with h_0 at an acceptable error value of 5% is equal to 1.73, which makes h equal to 41.48. Therefore, the number of replications does not exceed one cycle from the following equation:

$$n \cong n_0 \frac{h_0^2}{h^2}$$

Simulation and Results

Based on the model's performance, the simulation period of 49,775 minutes has a movement load of 311 units, divided into 56 purchase orders (152 units), goods received in quantity, and 16 shipments (159 units).

Storage space analysis

Class A product with high rotation storage space is defined on rack A as a result of running the model for a certain period. It was found that the maximum inventory volume was 128 units at 134 out of 223 events, and then the inventory gradually increased and decreased sharply as the product was released for sale. Furthermore, consistent with being a fast turnover product can be seen in Figure 3 below.

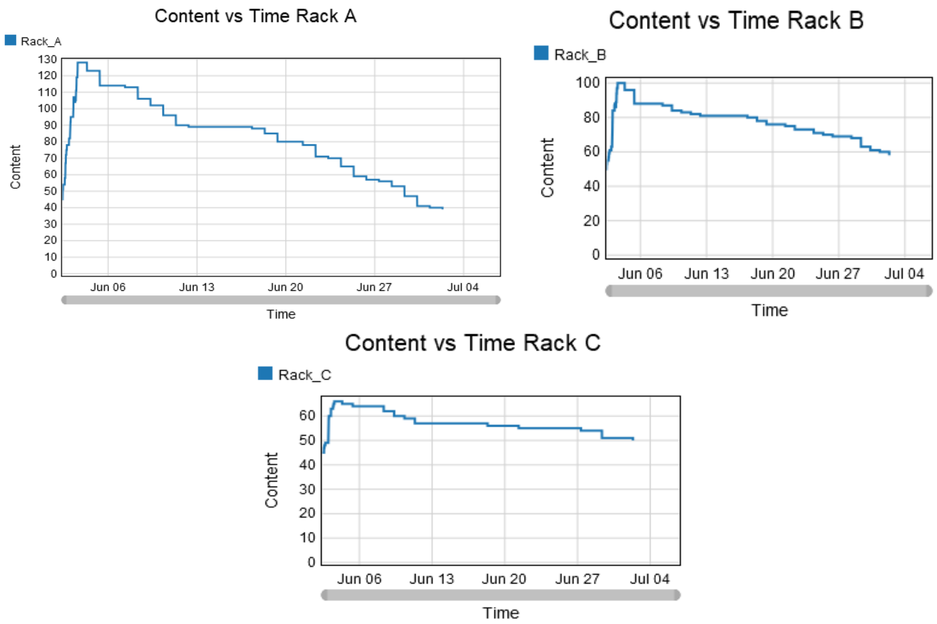

Figure 3. Event-time relationship of stock quantities of classes A, B, and C.

Figure 3 shows the simulation result, which represents the ratio of the quantities of the three stock classes at different times during the month. The displayed inventory quantity starts with the standard inventory quantity at the beginning of the month and incoming and outgoing products. Class A products are fast-turnover items stored on rack A for all three product classes. As a result of running the model, the maximum inventory quantity at the beginning of the month was 128 units. In addition, if one looks at the events with the number of goods received and issued.

Furthermore, it caused the remaining inventory to be displayed on the graph. It is found that inventory spikes occurred during 134 of the 223 events and after the peak inventory. The volume of the product sharply decreases because it is a fast-moving product. Furthermore, considering Class B items as medium rotation items stored in Rack B, the model run showed a maximum inventory storage volume of 100 units during 104 of 146 content events. After that, the number of products gradually moderate declined. It corresponds to a medium circulation product. Finally, if class C products are considered slow-turnover products, they are placed on rack C, the farthest from the entrance and exit. As a result of running the model, a maximum inventory volume of 66 units occurred in 66 out of 82 events, and then the inventory slowly decreased, which also corresponds to a low inventory turnover.

Finally, consider that rack D is used for storage if all three classes of products are larger than the designated storage space. It was found that no products were stored on rack D, which led to the conclusion that all three classes of products were allocated enough space for storage.

Analysis of Inventory

Figure 3 shows that class A products have inventory quantities at the end of the period. Besides, the minimum quantity is 39 units, less than the specified quantity of 6 units or 13%. Units accounted for 16%, and finally, Class C products had an inventory of 50 units at the end of the period, which is 10% higher than the number of standard products defined by five units.

Looking at the inventory quantity from goods received and goods issued, in Figure 4 that class A products had an average movement rate of 76.68 units. In addition, class B products have an average inventory rate of 74.98 units, and finally, class C products have an average inventory rate of 56.16 units, which is consistent with the EOQ principle that the average inventory rate is Q/2 and is close to the standard product level defined. In other words, the turnover rate is consistent with the product classification. Furthermore, a high turnover rate indicates that space utilization is also high, which is good.

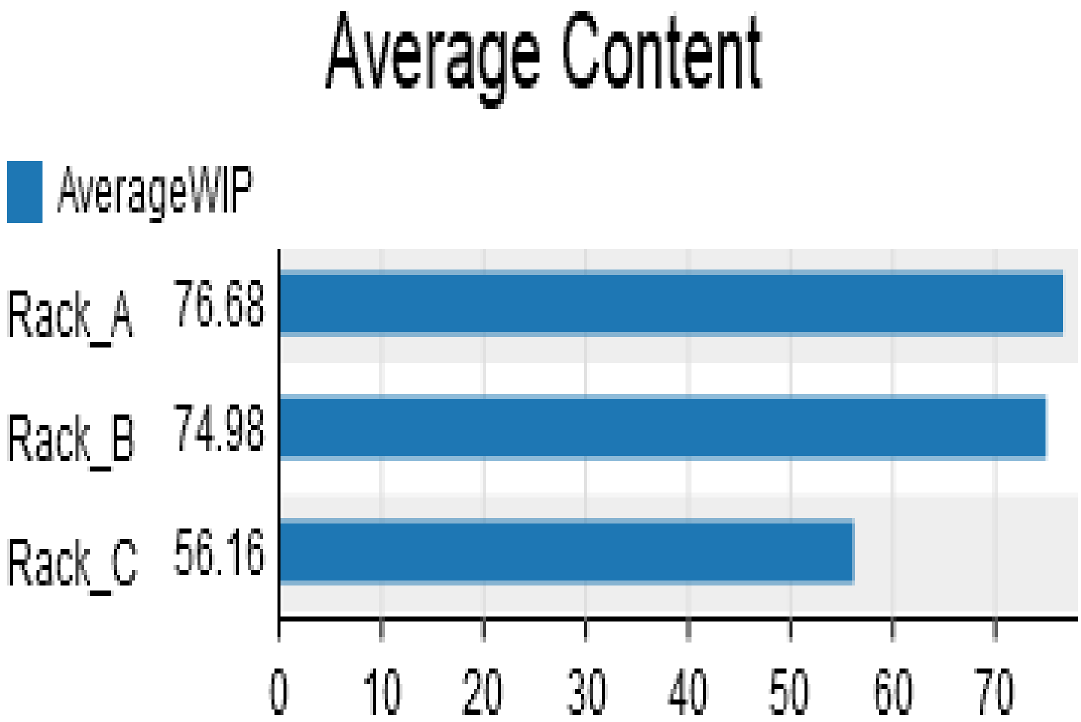

Figure 4. Average inventory rates for class A, B, and C products

Transporter analysis

Figure 5 shows the dashboard of forklift movement practices. With a total working time of 77.98 hours per month. Bar chart showing the ratio of the six operating states, categorized as Idle with the highest 91.98 percent, representing 77.86 hours, followed by Load and Unload with the same 3.78 percent, representing 3.2 hours, and Drive Load and Drive Idle lasted a small amount of only 13.81 minutes, or 0.27 percent of total work time.

The Stay Time section represents the maximum, minimum, and average time spent in the system. It has little impact on consideration, as it takes little time compared to the total operating time. In addition, throughput represents an equivalent take-and-deliver situation, referring to the total number of operations. No backlogs during the process.

Finally, stay time vs time indicates how long the forklift is active in the system at a given time. It makes it possible to know the working hours and unemployment of forklifts. Alternatively, it can be said whether that forklift is sufficient for use. It leads to an appropriate allocation of working time.

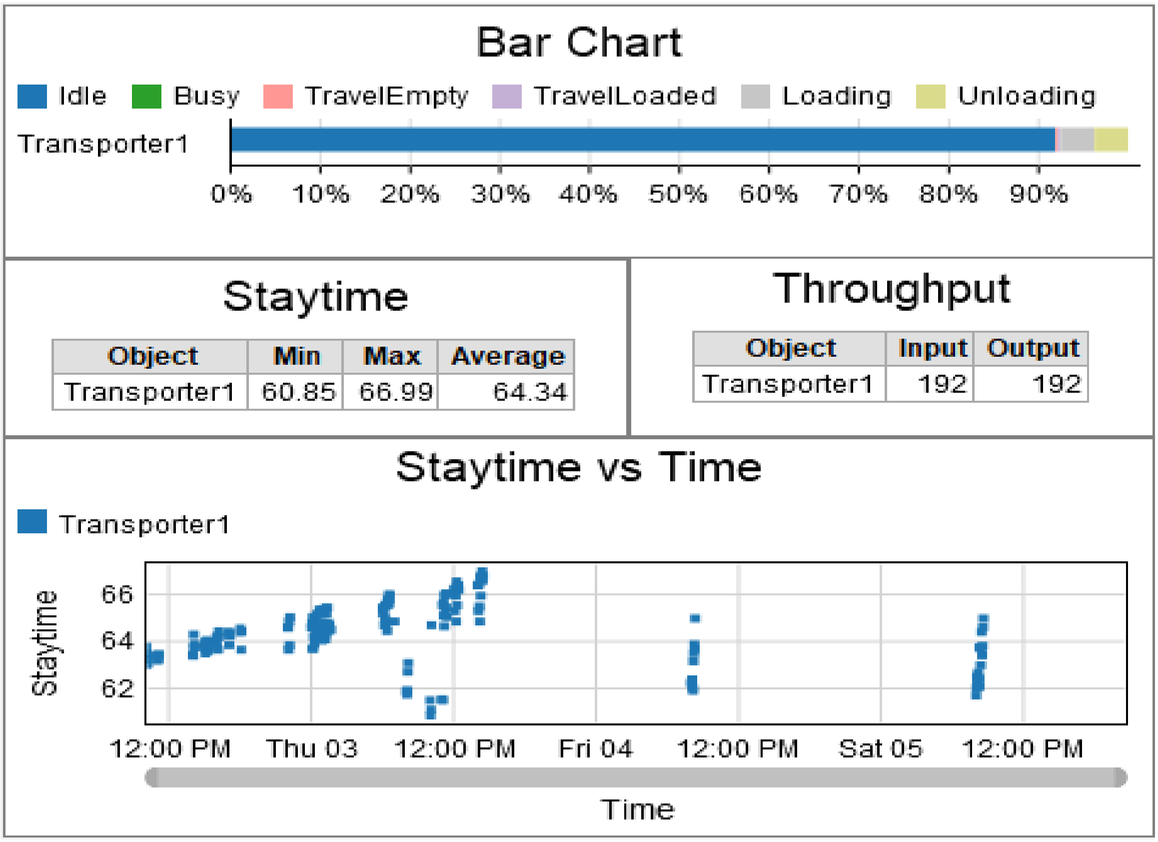

Figure 5. Dashboard of Forklift's work situation over one month

Discussion and Conclusion

The study of the existing area and required area for the new warehouse of this research uses simulation techniques to evaluate the amount of demand for each period, which is how the inventory moves. Inventory positioning is defined by three classes with three different product movement cycles. Fast-moving products it is placed near the loading and unloading area. There is a storage location in the middle of the warehouse for medium movement products. Finally, the product does not move. It is also stored in the innermost part of the warehouse. The result of running the model with the simulation model showed that the amount of storage space is sufficient for the movement of all three types of products due to their simple placement. It can quickly respond to the moving of each type of product, which makes the operation flexible. It is consistent with Marolt et al., (2022) that the storage depth affects efficiency and flexibility due to the time-consuming process and therefore requires the proper positioning of the product according to the rotation speed near the work area.

More than the adequacy of this area, When considering the benefits, the use of storage resources is also crucial for efficiency in warehouse management (Kluska, 2021). If there is too much-unused space, it is not a worthwhile investment. Therefore, the maximum use of space should be made. This research showed that the storage model has a unique location. It considers the rate of entry from the product, including standard stock quantities and the ability of the operator to move goods. The simulation allows the event to be assessed in advance on the efficiency of space in terms of used area per period, the management can decide on other uses when the space is not being used.

Finally, in terms of the operating time of the product movement of goods in this document, Select unloading with a forklift to be sufficient for use. This was in line with the recommendations for selecting the appropriate means of transport from the relative level of transport time and volume (Fedorko et al., 2020). The forklift has low-use life, and the number of forklifts is sufficient to meet the demand. Therefore, it can allocate additional use of the forklift. based on the same concept as the space utilization mentioned above.

Recommendation

To determine the placement of inventory. The relationship to each time interval of the area size must be considered the inventory quantity for each type of inventory is generated by the flow rate of the original goods plus the incoming goods. Moreover, subtract the product until the inventories are placed in the designated area to determine whether the area is sufficient to meet the demand. According to this research study, the flow of goods occurs constantly. Therefore, it is difficult for those involved to calculate the results of space utilization and operation time alone. Therefore, for those who want to analyze the inventory turnover. Scenario models are, therefore, an ideal tool to study and determine the results of inventory volumes that occur during each period. It makes it possible to plan resources for upcoming events in advance.

Furthermore, since the freight pattern of this research is a one by one movement of goods, academic or industrial sectors have a small picking pattern. Alternatively, the products for which multiple pieces can be picked up simultaneously should be further considered for placement under the association rule concept.

Acknowledgment

This research was funded by Bansomdejchaopraya Rajabhat University, Thailand. The researchers would like to thank the university's administrators, related people, and providers for helpful information for this research.

References

Alnahhal, M., Salah, B., & Ahmad, R. (2022). Increasing Throughput in Warehouses: The

Effect of Storage Reallocation and the Location of Input/Output Station. Sustainability (Switzerland), 14(8), 1–16. https://doi.org/10.3390/su14084611

Berry, J. R. (2007). Elements Of Warehouse Layout. International Journal of Production Research, 7(2), 105–121. https://doi.org/https://doi.org/10.1080/00207546808929801

Eldemir, F., Graves, R. J., & Malmborg, C. J. (2004). New cycle time and space estimation models for automated storage and retrieval system conceptualization. International Journal of Production Research, 42(22), 4767–4783. https://doi.org/10.1080/00207540412331281953

Fedorko, G., Molnár, V., & Mikušová, N. (2020). The use of a simulation model for high-runner strategy implementation in warehouse logistics. Sustainability (Switzerland), 12(23), 1–17. https://doi.org/10.3390/su12239818

Ganbold, O., Kundu, K., Li, H., & Zhang, W. (2020). A simulation-based optimization method for warehouse worker assignment. Algorithms, 13(12). https://doi.org/10.3390/a13120326

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2010). Research on warehouse design and performance evaluation: A comprehensive review. European Journal of Operational Research, 203(3), 539–549. https://doi.org/10.1016/j.ejor.2009.07.031

Guimarães, R., Almeida, L., Barros, M., Afecto, M. C., Figueira, M. L., Mota, D., Galvão, M., Barreira, M., & Lima, R. M. (2022). Restructuring picking and restocking processes on a hypermarket. Production Engineering Archives, 28(1), 64–72. https://doi.org/10.30657/pea.2022.28.08

Kees Jan Roodbergen, & Vis, I. F. A. (2006). A model for warehouse layout. IIE Transactions, 38(10), 799–811. https://doi.org/https://doi.org/10.1080/07408170500494566

Kluska, K. (2021). AUTOMATIC SIMULATION MODELLING OF WAREHOUSES. Scientific Journal of Logistics, 17(1), 59–69. https://doi.org/http://doi.org/10.17270/J.LOG.2021.547

Liu, D., & Zhang, Y. (2022). Research on the Layout Optimization of the Functional Areas of the Logistics Distribution Center - Taking Z Company as an Example. Proceedings of The 11th International Conference on Logistics and Systems Engineering, pp. 167–185.

Liu, H., Wang, F., Zhao, J., Yang, J., Tan, C., & Zhou, L. (2022). Performance Analysis of Picking Path Strategies in Chevron Layout Warehouse. Mathematics, 10(3). https://doi.org/10.3390/math10030395

Marolt, J., Kosanić, N., & Lerher, T. (2022). Relocation and storage assignment strategy evaluation in a multiple-deep tier captive automated vehicle storage and retrieval system with undetermined retrieval sequence. International Journal of Advanced Manufacturing Technology, 118(9–10), 3403–3420. https://doi.org/10.1007/s00170-021-08169-x

Muther, R. (1987). Systematic Layout Planning (2nd (ed.)). Van Nostrand Reinhold.

Rakesh, V., & Adil, G. K. (2015). Layout Optimization of a Three Dimensional Order Picking Warehouse. IFAC-PapersOnLine, 28(3), 1155–1160. https://doi.org/10.1016/j.ifacol.2015.06.240

Roodbergen, K. J., Vis, I. F. A., & Jr, G. D. T. (2014). Simultaneous determination of warehouse layout and control policies. International Journal of Production Research, 53(11), 3306–3326. https://doi.org/https://doi.org/10.1080/00207543.2014.978029

Sancaklı, E., Dumlupınar, İ., Akcın, A. O., Cınar, E., Geylani, İ., & Duzgit, Z. (2022). Design of a Routing Algorithm for Efficient Order Picking in a Non-traditional Rectangular Warehouse Layout. In G. M. G. Durakbasa N.M. (Ed.), International Symposium for Production Research (pp. 401–412). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-030-90421-0_33

Seng Fat, W., & Zhenning, Y. (2019). Flexsim-based modulation and simulation for logistics batch picking. ACM International Conference Proceeding Series, 141–145.

https://doi.org/10.1145/3374549.3374554

Sumranhun, P., Saisuwan, N., Punthanokoraphat, N., Saelek, P., & Chanchamnian, P. (2019). A Selection Of Warehouse Service Providers For Animal Feed Companies : Case Studies In Samutsakhon. Journal of Energy and Environment Technology, 6(2), 10–20.

Yang, M. F., Shih, P. H., Pan, J. C. H., & Li, M. C. (2022). The optimal layout design for minimizing operating costs in a picker-to-part warehousing system. International Journal of Advanced Manufacturing Technology, 118(7–8), 2523–2537. https://doi.org/10.1007/s00170-021-08026-x