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SELECTION METHOD FOR WAREHOUSE MATERIAL HANDLING STRATEGY SUPPORTED BY OPTIMIZED RUNNING OF DEMAND-DRIVEN STORAGE SYSTEM

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Abstract:
For production companies, the identification and elimination of logistics losses have a great importance, as it mostly determines their competitiveness. Reducing the turnaround time of logistics processes has so far been mainly in the production areas, however, in order to serve the production processes smoothly and efficiently, the proper selection of raw material warehousing strategies has become extremely important. The paper presents the currently used warehouse material handling strategies and the concept of their appropriate selection.

Keywords:
Supplier selection, decision-making methods, dietary supplement

INTRODUCTION

The definition of demand control in the case of a multinational undertaking engaged in production and warehousing activities is not clear. The primary "need" for a company's sustainability is to achieve continuous positive EBIT (earnings before interest and taxes) and, to that end, to reduce costs permanently and drastically [1]. The needs of automotive end-users are unknown and manufacturing companies are developing short-term unpredictable strategies to meet stringent environmental standards.

In practical life, one way to reduce costs is to identify and eliminate losses. This effort was mostly limited to production areas, with little consideration given to the operation of associated storage systems and their synergistic interconnection with production material flows. In the field of warehousing, the problems are mainly due to the fact that in the case of raw material and finished product warehousing, the input and output material flows fluctuate significantly, in many cases stochastically, so that inventory mechanisms can only be determined with significant inaccuracy.

This process poses serious challenges to the production management and inventory management of mass production companies. The increase in the number of product types required by customers, the decrease in product life cycles, the seasonally changing customer demands have led to an increase in raw material stock levels and/or an increase in production plan uncertainty [2]. Customers want to receive the ordered products in the shortest possible time, so reducing production lead times is a major market advantage for companies. The production lead time can be interpreted as the sum of the following components:

- time of purchase of raw materials,
- storage time of raw materials,
- time of removal, picking and transport of products to storage facilities,
- the time of technology operations, in-process storage of products,
- packing, unit load training and delivery time.

Reducing the part of the production lead time for raw material loading, storage and unloading is important with the need for increased - short life cycle, small order quantity - product range of raw materials, which can be ensured by proper selection of material handling strategies and optimized material handling tasks [3-9]. The paper describes the currently used inbound and outbound strategies and the concept of their optimal selection.

1. CURRENTLY USED WAREHOUSE HANDLING STRATEGIES

The section presents a kind of literature review of the material handling strategies currently used in practice (Figure 1) and their role in the warehousing process.

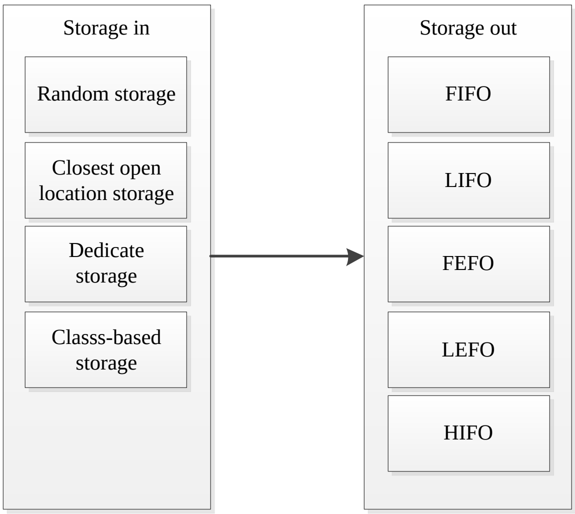

Fig. 1 *Loading and unloading strategies*
Source: Self made

STORAGE PROCESS STEPS:

Incoming

Incoming activities include unloading products, taking over products, updating stock records, possibly labeling, checking for quantitative or qualitative discrepancies [10].

Entry into storage

Basic entry into storage strategies include random storage, dedicated storage, class-based storage, and entry into storage to the nearest open storage location. Research has shown that material handling time can be significantly reduced in the transition from a dedicated storage site to a random storage strategy, and that class-based storage with relatively few clusters also results in a reduction in material handling time with a system of conditions [11-13].

Description of entry into storage strategies:

- Random entry into storage strategy: Materials to be stored are placed in empty storage areas in a random manner. For random storage, we assign a space in the warehouse to each incoming pallet (or similar quantity of product), which is randomly selected from all acceptable empty spaces with equal chance. The random assignment method means high space utilization and increased movement distance. The random storage policy only works in a computer-controlled environment. If customers could choose the storage location themselves, we would probably get a system called the nearest open storage location. The first empty space, which an employee experiences, is used to store products. This leads to the scaffolding being filled from the front and the utilization gradually decreasing going backwards [14-15].
- Entry into storage in the nearest open storage: Products are stored in the nearest empty storage [14].
- Fixed entry into storage: The storable raw materials are stored in a fixed storage location for each product type. In the case of an ever-changing environment, the model can only be used with high losses, as the disadvantage of dedicated storage is that space is reserved even for products that are not in stock. In addition, sufficient space must be reserved for each product in order to store the maximum inventory level, so space utilization is the lowest of all storage strategies. The advantage is that customers can easily identify the location of the products [7].
- Entry into storage by classification: The stored raw materials are grouped into ABC categories based on a selected criterion and the possible storage zones are defined for each group.

Groups can be trained:

- By popularity: It is based on the frequency analysis of the use of materials and visits to storage space.
- By turnover: The total quantity of received products is analyzed for a specific period.
- Volume analysis: The booked volume for the total quantity of received products is analyzed for a specific period.
- Pick Density: The relationship between the frequency and amount of use of the product is analyzed.
- Cube per Order Index (COI): The relationship between product volume and product use frequency is analyzed. If the index of a product is low, it is stored away from the removal point [4].

Storage

The materials are waiting at the storage point to perform the next operation.

Removal storage

Material removal storage may be required for multiple warehousing tasks. Delivery, communication, storage [16].

Description of removal storage strategies:
- FIFO (First in First Out): For each product type, the first product received is removed first.
- LIFO (Last in First Out): For each product type, the latest product received will be removed first.
- FEFO (First Expired First Out): For each product type, the product with the shortest expiration date is removed from stock first.
- LOFO (Low First Out): For each product type, the product that was purchased at the lowest price comes out of stock first.
- HIFO (High First Out): For each product type, the product with the highest purchase price comes out of stock first.

Stock transfer

Description of stock transfer strategies [8-10]:
- No stock transfer: Raw materials are not transferred to another storage location during their waiting time in the warehouse.
- There is stock transfer: In a dynamic warehouse environment, it is possible to move materials between storage locations during storage. The purpose of the transfer is to bring the materials closer to the point of removal, thus reducing the length of the material handling routes (providing an opportunity to partially take over the material handling tasks during peak periods).

Material removal (commissioning)

A prerequisite for fulfilling the order is the collection of the stored materials for the customers (next point of use). The activity includes scheduling the collection of orders, storing orders on the floor, picking up goods from storage locations. Customer orders consist of order lines [10].

Packing

The basic task of packaging is to prepare the goods for onward transport by any carrier in such a way that they do not adversely affect transport costs. If it is difficult to take out the orders, then the packaging is also complicated. Specifically, if all items from the order are not located in the packaging area at the same time, it is likely that delivery will be delayed and/or costs will increase [13;17].

Delivery out

The delivery process is the final process of warehousing processes. After packaging and preparing the units for transport (consolidation), the first step is loading into transport vehicles [13;17].

2. OPERATIONAL CONCEPT OF A SYSTEM FOR SELECTING A WAREHOUSE MATERIAL HANDLING STRATEGY

Defining the concept of "need" is an important step in explaining research options. The need can be interpreted in several ways. The need for the company is to maximize revenue and thereby reduce losses. The determination of warehouse "needs" and the "control" of warehouse processes come from several sources, which are based on the actors and corporate units involved in value creation. Such are the most important parts:

- The raw material designs
- Production
- Delivery

These areas all generate demands on material handling processes that determine the loading and unloading strategy.

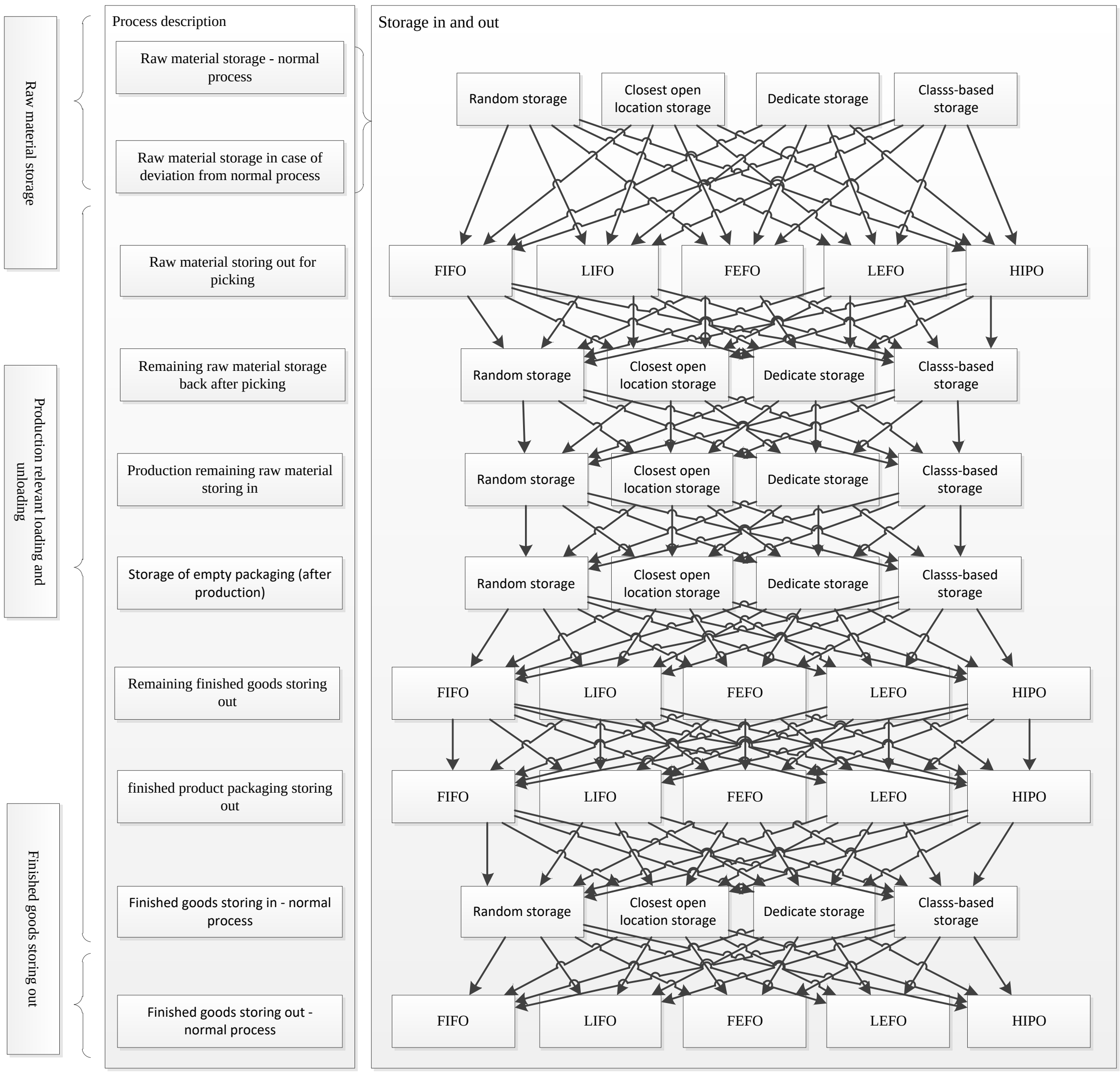

Fig. 2 *Relationship between loading and unloading processes and loading and unloading strategy*
Source: Self made

Loading and unloading strategies can be assigned to each loading and unloading step. From the receipt of the raw material through the production processes to the delivery, 640000 test alternatives can be identified (Figure 2).

The selection of the optimal warehouse material handling strategy variant is implemented with the help of a simulation model, which "simulates" the operation of the material flow system according to different strategy variants using the data of a designated past period and a pre-planned period. selects a version. The steps of the process are illustrated in Figure 3. The concept presented outlines the framework of the research topic.

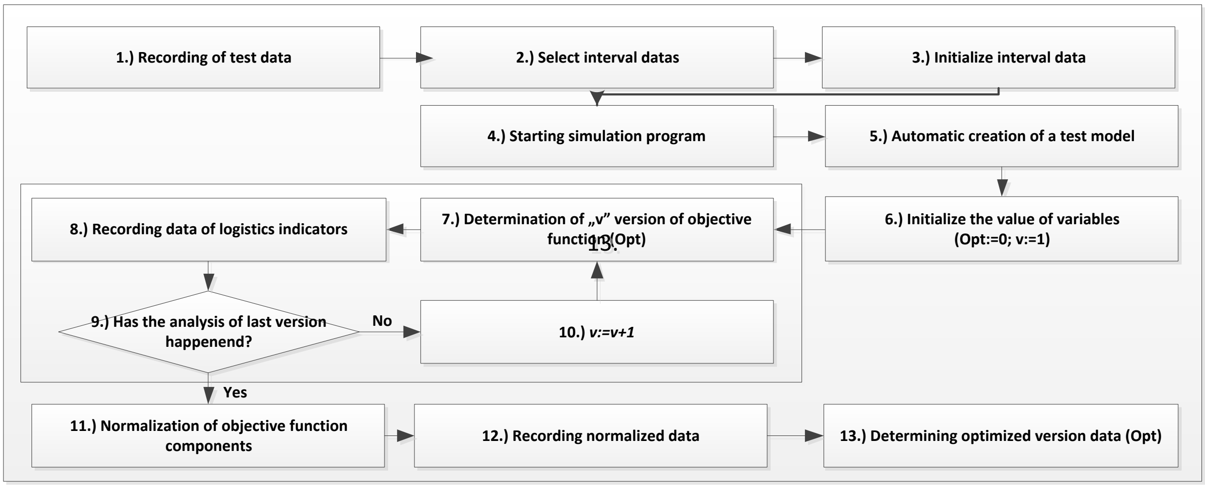

Fig. 3 *Concept of selecting a demand-driven optimal material handling strategy*
Source: Self made

The concept of selecting the right material handling strategy consists of the following steps [17]:

1. Recording of test data:

The databases required for the study and their contents are outlined below.

To record the elements of the information database:

- Part number and production schedule database data
- Customer database data
- Production database
- Delivery database data

Data of the elements of the warehouse database:

- Storage system database data
- Material handling system database data
- Product database data
- Human resources database

Evaluation database data:

- Weight of objective function components
- Specific cost functions based on historical data

2. Selection of information and warehouse database interval elements:

Only 1-1 elements with an interval value can be selected on both input sides at a time.

3. Recording interval data:

Setting the min. and max. values of the interval, together with the number of step units.

4. Start a simulation program:
After recording the data in the data tables, the simulation program is launched, which, based on the given historical and forecasted data, evaluates the warehouse material handling strategy variant through 10 material handling steps (4 storage and 5 removal strategies, which means 640000 variants in total) and the opportunity to select the best version. The basic requirement for the simulation program is the automatic creation of the examined system on the basis of past and future data, the running and evaluation of all material handling strategy versions, and the selection of the appropriate version.
5. Automatic creation of a test model:
Based on the test data, the tested logistics system is created automatically (material handling system, storage system, start-up stocks).
6. Initializing the value of variables:
In the simulation test model, two basic variables are initialized, namely *v*, which contains the material handling strategy variants under study, and *Opt*, which contains the identifier of the optimal variant. Of course, there are other technical variables used in programming that need to be initialized, but these are not covered now.
7. Definition of logistics indicators for the v-th version:
Warehouse handling cost: Warehouse handling cost is defined as the product of unit costs determined on the basis of future data, inefficiency indicators defined at the bottom of historical data, and total material handling path length determined by the simulation program. The dependent variables of the function are the average distance traveled per day and its standard deviation. The values of the dependent variables are also determined by the simulation program (essentially, by substituting the value of the dependent variables into a specific cost function, we obtain the specific cost).

- **a)** Logistic warehouse load index: Defines the warehouse load for strategy variants.
- **b)** Subjective factor: Overall impression of a material handling strategy variant (e.g. low chance of error, reliable, easy to apply,…, etc.). The value of the factor should be set between 1 and 10 (10 is the best value).
- **c)** Fixed inventory ratio: the ratio of the value of fixed inventory beyond 90 days to the base of the business plan.
- **d)** Cost indicator for non-stocked raw material: The cost of late stocking caused by a limited stock of raw materials in the business plan.
- **e)** Pre-shipped finished product cost indicator: The extra cost indicator for pre-shipped finished product limited in the business plan.

8. Recording of data on specific logistics indicators:
The values of the logistic indicators defined for each material handling strategy variant are recorded in a predefined data table, on the basis of which the target function components can be normalized later (step 11) and the target function can be generated.
9. Examining whether all possible variations have been examined ?:
If so, the process of selecting the optimal version follows, if not, the next version is examined.
10. Increment the material handling strategy variant identifier.
11. Normalization of objective function components:
The value of the objective function of the *v-th* strategy variant is determined on the basis of the values of the logistics indicators determined by the simulation model. In order for indicators of different dimensions to be applicable as objective function components, they must be normalized. After normalization, in our case the values of all indicators will be between 1-10, and we will try to select a material handling strategy variant where the goal will be to minimize these normalized indicators. Normalization steps:
Normalization of objective function components to be minimized (warehouse material handling cost):

- determine the mean value of the logistics characteristics to be minimized,
- the part between the minimum value and the mean value, moreover between the maximum value and the mean value is divided into 5-5 intervals,
- the values of the examined variants are scored using the obtained scale (1-10 points),
- the smaller the value of the examined component, the more favorable the value of the objective function.

Normalization of objective function components to be maximized (logistics warehouse load index, subjective factor):

- we take the mean of the logistics characteristics to be maximized,
- the part between the minimum value and the mean value, moreover between the maximum value and the mean value is divided into 5-5 intervals,
- the values of the examined variants are scored using the obtained scale (1-10 points),
- in order to be uniformly manageable, the transformation of the objective functions to be maximized must be performed (subtracted from 11, it transforms into a component of the objective function to be minimized),
- after the transformation, it can be achieved that the goal will be to achieve the smallest possible value for the objective function components to be maximized.

12. Recording normalized data:
The normalized version of the values of the logistics indicators defined for each material handling strategy variant is recorded in a predefined data table.

13. Determining the optimal version identifier*:* Determining the identifier of the optimal version through the objective function.

3. CONCLUSIONS

The selection and operation of the right raw material warehousing strategy significantly affects the competitiveness of companies through more efficient disposal of internal warehousing tasks and increased production service efficiency. In the publication, the currently applied loading and unloading material handling strategies are described, for the proper selection of which the literature does not provide a detailed examination system. The publication presents a concept for the proper selection of warehouse material handling strategies, which will also serve as a basis for our future research.

References

[1] Doron N., 2019, “EBITDA, EBITA, or EBIT?,” Columbia Business School Research, pp. 17-71.

[2] Fraunhofer, 2013, “Produktionsarbeit der Zukunft - Industrie 4.0,” Fraunhofer – Institut für Arbeitswirtschaft und Organisation IOA, Available at:

https://www.iao.fraunhofer.de/images/iao-news/produktionsarbeit-der-zukunft.pdf

[3] Deloitte, 2015, “Industry 4.0 – Challenges and solutions for the digital transfomation and use of technologies,” Available at:

https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf

[4] Manzini R., 2012, “Warehous in the Global Supply Chain,” Springer, pp. 31-51.

[5] Guerriero F., MusmannoR., Pisacane O., Rende F., 2013, “A mathemtical model for Multi-Levels Products Allocation Problem in a warehous with compatibility constraints,“ Applied Mathematical Modelling., 37, pp. 4395-4398.

[6] Sárvári J., “Logisztikai rendszerek I.”, Online jegyzet, Available at: www.bdf.hu

[7] Chen L., Langevin A., Riopel D., 2011, “A tabu search algorithm for the relocation problem in a warehous system,” Int. J. Production Economics, 129(1), pp. 147-156.

[8] Chen L., Langevin A., Riopel D., 2010, “The storage location assigment and interleaving problem in an automated storage/retrieval system with shared storage,” Internatinal Journal of Production Research, 45(4), pp. 991-1011.

[9] Chen L., Langevin A., Riopel D., 2009, “Minimizing the paek load in a shared storage system”, International Journal of Shipping and Transport Logistics, 1(1), pp. 20-36.

[10] Koster R., Le-Duc T., Roodbergen K.J., 2007, “Design and control of warehouse order picking: aliterature review”, EuropeanJournal of Operational Research, 187, pp. 481-501.

[11] Cselényi J., Illés B, 2004, “Logisztikai rendszerek I.,” University of Miskolc.

[12] Cselényi J., Illés B., 2006, “Anyagáramlási rendszerek tervezése és irányítása I. Tankönyv,” University of Miskolc

[13] Gu J., Goetschalckx M., McGinnis L.F., “Research on warehouse design and performance evaluation: A comprehensive review,” European Journal of Operational Research, 203(3), pp. 539-549.

[14] Manzini R., 2012, “Warehous in the Global Supply Chain,” Springer 2012, pp. 31-51.

[15] Koster R., Le-Duc T., Roodbergen K.J., 2007, “Design and control of warehouse order picking: aliterature review,” EuropeanJournal of Operational Research, 187, pp. 481-501.

[16] Govindaraj T., Blanco E., Bodner D., Goetschalckx L., McGinnis L., Sharp P., 2000, “Design of warehousing and distribution systems: An object model of facilities,” IEEE Intern. Conference on Systems, pp. 1099–1104.

[17] Dobos P., Illés B., Tamás P., 2015, "Optimális raktári anyagmozgatási stratégia kiválasztásának koncepciója," Gépgyártás, pp. 63-68.