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Application of the methods of ergonomic, operations research and theory of systems in modeling of the main parameters of a warehouse for tared and piece cargoes

The paper considers the application of methods of operations research and systems theory to the tasks of logistics management and modeling of the main parameters of the warehouse of tared and piece cargoes.

The method has been developed for selection and comparison of the efficiency and economy of devices and equipment for storage and processing of tared and piece cargoes, modern means, machines and equipment for cargo work. The parameters are defined that describe the warehouse of tared and piece cargoes as a system, and the connections between them.

warehouse, tared and piece cargoes, structural-parametric model, algorithm, theory of systems, operations research, ergonomic

Formulation of the problem. Warehouses of the tared and piece cargoes are of particular importance in the country's economy, as mainly finished products of our and foreign industries pass through them, that are the most valuable cargoes.

The warehouse system serves as a place of transshipment for various types of transport, primarily road and rail. The development and further improvement of the logistics process, increasing the level of its economic and technological efficiency puts forth requirements for the improvement of all links of the logistics process, including warehousing.

Analysis of recent research and publications. A modern warehouse is a very complex object, both from a technical and managerial point of view [1-4].

Modern mechanized and automated warehouses are distinguished by a wide variety of technological, layout and volume-planning solutions. Therefore, with the development of warehouse technology, their design methods, based on scientific research, must also be improved [5, 6].

The project of the warehouse as a complex technical object consists of several parts: technological, design, construction, electrical, automated control system, and economic [6].

The issues of rational design of transport-warehouse complexes and their components for storage and processing of tared and piece goods are especially relevant in order to organize effective management and control of material flows in the warehouse system of cargo management in order to improve the efficiency of providing relevant services [7, 8]. The development of the technological part of the mechanized or automated warehouse project causes the greatest methodological difficulties [8].

The analysis of modern literary sources on the topic of the study showed that in the total volume of transportation carried out by all types of transport, the specific weight of tared and piece goods is about 20% [4, 7]. At the same time, the costs associated with their loading, unloading, sorting and warehouse operations reach about 50% of the total costs for loading and unloading operations [9].

Setting objectives. The purpose of the paper is to increase the efficiency of the transport and logistics system of goods delivery by modeling the optimal solutions of the transport and storage complex for tared and piece goods.

Research objectives: analyze the features of the modern warehouse for tared and piece goods as a technical system; to analyze the design methodology of the warehouse for tared and piece goods at the current stage; to develop a structural-parametric model for determining optimal technical and technological solutions when designing a warehouse for tared and piece goods.

Presenting main material. In the paper such research methods used: methods and models of theory of systems, operations research, ergonomic, optimization methods.

All requirements for modern warehouses can be divided into the following groups [5]:

– technical requirements (increasing warehouse capacity, vehicle productivity, equipment reliability);

– organizational requirements (managing the progress of warehousing, recording intra-warehouse movements, readiness to issue information about goods and to deliver goods);

– economic requirements (minimum capital costs per unit of stored cargo, reduction in processing costs).

A certain drawback of this algorithm is the approximate nature of the calculation of individual values (the height of stacking the cargo on the pallet, the total dimensions of the warehouse, capital investments) based on aggregated indicators and methods [10].

This algorithm for approximate design of the warehouse can be used at the first stages of design or in other cases when detailed calculations and detailing of design solutions by composition are not required.

When calculating according to this algorithm, the following arrays of normative and reference information are used:

– part of the TARA massive (characteristics of transport and storage tare), which has the structure [4]:

$$\{I, A, B, C, V, G, KP, AP\}_I, I = 1,..., N \quad (1)$$

where I – pallet type number;

A is the length of the pallet (the size by which it is installed in the storage area along the longitudinal aisles);

B – the width of the pallet (the size by which it is installed in the depth of the stack or rack);

C, V – the maximum height of stacking cargo on a pallet and the volume of the pallet;

G – load capacity of the pallet; N is the total number of types of pallets;

KP and AP – the cost of the pallet and the share of deductions for depreciation, maintenance and repair of pallets;

– an array ZDA – is specific cost of 1 m^3 of useful volume of a warehouse building

$$\{J; [HH, HB[; KZ\}_J, J = 1,...,5, \quad (2)$$

where […[– closed from the bottom and open from the top intervals of the useful height of the warehouse building H (lower limit of the interval – HH, upper – HB), KZ – cost of 1 m^3 of the volume of the building of the corresponding useful height;

J is the interval number;

– an array OPT – characteristic of the optimal sections of the storage area, which has a structure:

$$\{[(HS, Z, X, R)_J]_M\}_N, \quad (3)$$

where HS, Z – height and number of tiers;

X, R – the number of cargo storage units across the width of the storage section and the total in the section;

J = 1,2, …, 4 – numbers of options with different tier heights; M = 1,2,...,7 – numbers of cargo storage term ranges from [0;5] to [55;65] days;

N = 1,2,...,26 - numbers of cargo storage methods. Thus, the ORT array contains everything 26×4×7 = 728 optimal options for the cargo storage area;

– an array SPS – characteristics of cargo storage methods, which includes 26 options and has a structure:

$$\begin{Bmatrix} N, XXXXX, A, B, G, EZ, EB, EH, XS, \\ LE, LT, QV, OK \end{Bmatrix}_N, \tag{4}$$

where XXXXX – code for the method of cargo storage;

EZ - the gap between loads in the height of a stack or rack;

EB – size in height from the supporting surface for the load of the upper tier to the bottom of the construction structures of the covering of the warehouse building;

EH – size in height from the floor of the warehouse to the supporting surface for cargo on the lower (first) tier;

XS - the width of the longitudinal passage for the stacking machine between racks or stacks;

LE, LT – the lengths of the sections for the exit of the stacking machine from the warehouse from the side of the expeditions and from the dead-end part of the warehouse;

QV – the number of cargo storage units per warehouse worker;

OK is a coefficient that shows what part of the cost of the building is the cost of the equipment.

The following values are set as initial data: Q – annual freight flow; ZA – stock of one-time storage of goods; LL - the number of different types of goods stored in the warehouse; U – volumetric mass of goods in stacking; KR – factor of volume of assembly works; NH, NK – numbers of the first (initial) and last (final) storage methods (according to the ORT array), which must be considered during the calculation.

The results of the calculations are displayed in the form of two tables of this structure:

$$\begin{aligned} &\begin{Bmatrix} N, XXXXX, A, B, CNN, G, REE, L, \\ SSKL, PL, HX, HE \end{Bmatrix}_N; \\ &\begin{Bmatrix} N, XXXXX, CH, X, Y, R, Z, L, \\ AR, LU, K, MEX, ER, PZ \end{Bmatrix}_N; \quad , \\ &N \in [NH, NK] \end{aligned} \tag{5}$$

where CNN is the height of stacking the cargo on the pallet;

G – pallet loading; REE – number of pallets with one cargo name;

L, SSKL, PL – length, width and area of the warehouse;

HX, HE – useful height of the warehouse in the storage area and in the area of receiving and dispatching expeditions;

CH – number of stacking machines;

X, Y, R – the number of pallets in the storage area in width, length and total;

Z, AR – number and height of tiers;

LU – number of warehouse workers;

K, MEX – capital costs for the construction of the warehouse and the cost of equipment, including;

ER, PZ – annual operating costs and reduced costs.

This algorithm includes the following procedures for optimizing technical decisions by composition [10]:

– consolidation of cargo storage units;

– maximum filling of cargo storage units and warehouse building with cargo;

– maximum use of stacking machines in terms of time and load capacity;

– optimization of the movement cycles of stacking machines when servicing the cargo storage area;

– optimization of the storage method and parameters of the cargo storage area (number of cells, height, length, width).

Compared to existing warehouse design methods (design institutes, industrial enterprises), this algorithm provides a more reasonable choice of warehouse parameters, as it considers and compares many options for warehouse technical equipment and optimizes technical solutions.

The developed algorithm for choosing the method of storage of container loads is given in [8]. The algorithm for determining the parameters of the typical representative of the nomenclature group allows to determine the parameters of the cargo - a typical representative of the nomenclature group: dimensions TA, TV, TS, weight TQ, storage stock TS.

A matrix of similar characteristics of real cargo processed in the warehouse is set as the initial data:

$$\{I, AO, BO, CO, GO, ZA\}_I, I = 1,...,N, \tag{6}$$

where I is the cargo number in the nomenclature group;

AO – cargo length (larger size in the plan), BO, CO, GO – width, height and mass of one place of cargo;

ZA – storage stock; N is the total number of cargo items in the nomenclature group.

The algorithm for determining the parameters of the cargo - a typical representative is based on the principle that the stock of the cargo - a typical representative - occupies the same volume in the composition as all the stocks of cargo of the nomenclature group that it replaces [6].

Also, according to the model given in the previous paragraph, the algorithm for determining the capacity of transport and warehouse containers by the method of theoretical cargo stacking was developed.

The algorithm for determining the types, parameters and quantity of transport and storage containers was developed.

This algorithm allows (after compiling the appropriate program) to determine the type, parameters and quantity of transport and storage containers for the storage of artificial cargo.

The following arrays of normative and reference information are used in the calculations:

– the matrix of characteristics of the cargo nomenclature is used as the initial data:

$$\{J, ZA, AO, BO, CO, GO, L\}_J, J = 1,...,N, \tag{7}$$

where J is the cargo group number;

ZA – cargo storage stock;

AO – cargo length (larger size in plan);

BO, CO, GO – width, height and weight of one place of cargo;

L – the number of items of cargo in the group; N is the number of cargo groups.

In addition, the value of the attribute D is fixed, which shows that the pallet type is not specified (D = 0) or specified (D = 1), such cases are possible during design.

The developed algorithm for approximate design of the warehouse is given in Figure 1.

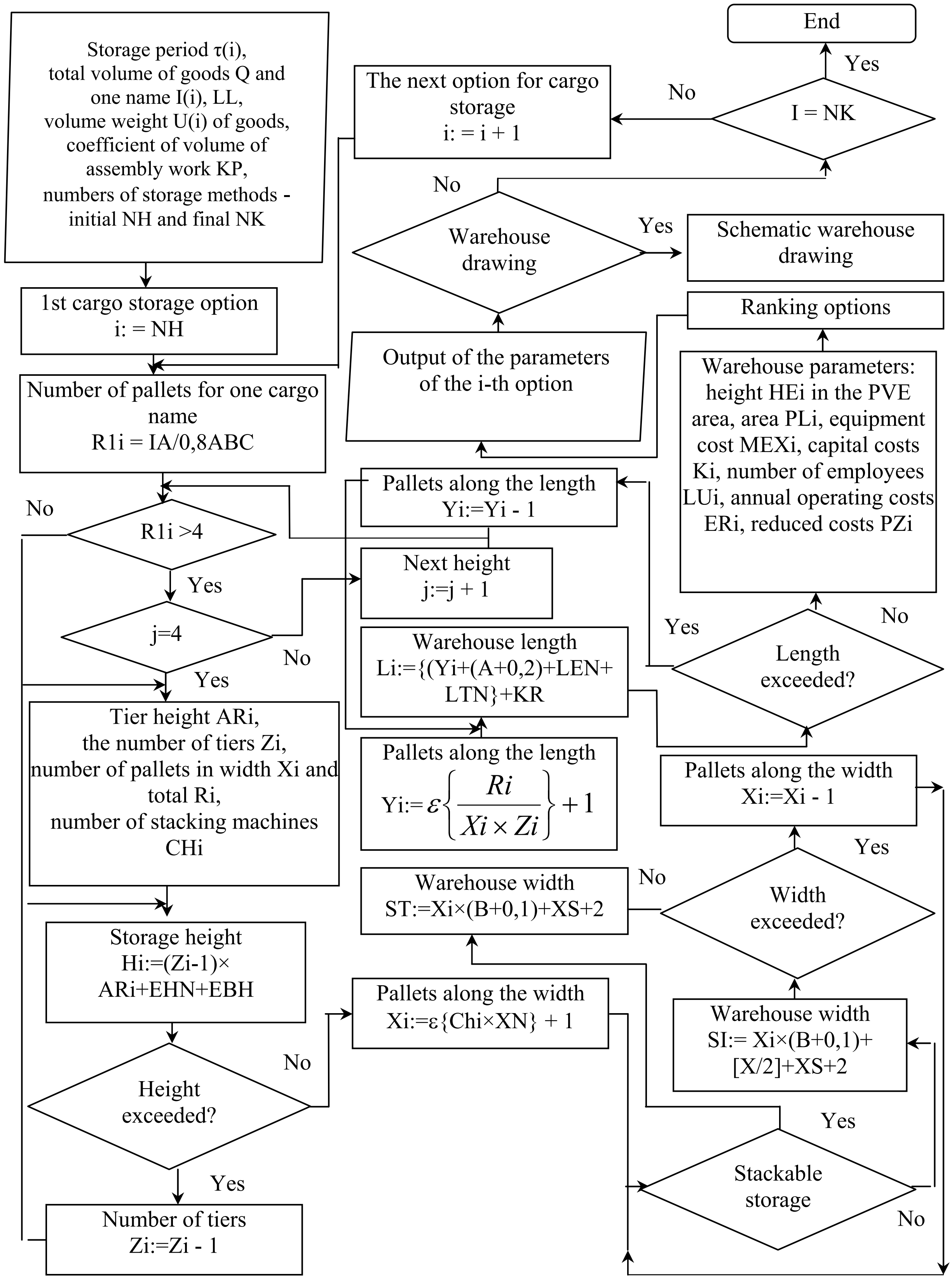

Figure 1 – Algorithm for approximate design of the composition of tared and piece goods warehouse
Source: developed by author

Conclusions. 1. The method of selection and comparison of the efficiency and economy of devices and equipment for storage and processing of tared and piece goods, means, machines and equipment for loading and unloading and transport and storage works at warehouse has been developed. Arrays of parameters selected when creating a warehouse include parameters or various rack structures, specialized lifting, transport and storage equipment, stackers and package forming machines, weighing equipment, robotics tools, computer information and control systems etc.

2. The structural-parametric model for determining optimal technical and technological solutions when designing a warehouse for tared and piece goods consists of a set of parameters describing warehouse of tared and piece goods as a system, i.e. a separate the set of initial parameters of the warehouse, and the set of parameters that are calculated and selected during the creation or reconstruction of warehouse complex.

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Застосування методів ергономіки, дослідження операцій і теорії систем в моделюванні основних параметрів складу тарно-штучних вантажів

У роботі розглянуто застосування методів дослідження операцій та теорії систем до завдань логістичного управління та моделювання основних параметрів складу тарно-штучних вантажів. Метою роботи є підвищення ефективності транспортно-логістичної системи доставки вантажів шляхом моделювання оптимальних рішень складу тарно-штучних вантажів. У роботі використані методи та моделі ергономіки, теорії систем, дослідження операцій, структно-параметричне моделювання. Основою запропонованих у роботі рішень став практичний досвід проектування складських приміщень підприємств різних галузей промисловості та торгівельної мережі України для трано-штучних вантажів, а також нові уточнені методи проектування таких механізованих та автоматизованих складів.

Розроблено методику вибору та порівняння ефективності та економічності пристроїв і обладнання для зберігання та обробки тарно-штучних вантажів, сучасних засобів, машин і обладнання для вантажних робіт.

Наукова новизна отриманих результатів полягає в тому, що визначено параметри, що описують склад тарно-штучних вантажів як систему, та зв'язки між ними, розроблені структурно-параметричні моделі підсистеми розрахунку запасів вантажів і пропускної спроможності складу ь підсистеми обґрунтування вибору оптимальних техніко-технологічних рішень зберігання вантажів складу та пов'язаних з ним робіт, структурно-параметричну модель підсистеми розрахунку та вибору основних параметрів компонування дільниць і всього складу. Практична значущість полягає в тому, що розроблено методики вибору та порівняння ефективності та економічності пристроїв і обладнання для зберігання вантажів складу для тарно-штучних вантажів, вибору та порівняння ефективності та економічності сучасних засобів, машин та обладнання для робіт на складі, розрахунку економічної ефективності проектних рішень будівництва нового складу або реконструкції існуючого.

тарно-штучний вантаж, склад, теорія систем, дослідження операцій, ергогоміка, структурно-параметрична модель, алгоритм

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Удосконалення організації дорожнього руху та експлуатації транспортних засобів методом математичного і комп'ютерного моделювання

Успішне управління пасажирським транспортом у швидкозмінному середовищі вимагає постійного вдосконалення. Це стосується структур управління та використання сучасних інструментів, таких як математичні моделі та автоматизовані системи. Інформація відіграє дуже важливу роль. Вона потрібна на всіх етапах роботи: від планування маршруту до аналізу ефективності. Розклад руху - це основа, на якій будується вся система пасажирських перевезень

організація безпеки дорожнього руху, експлуатація транспортних засобів, транспортні засоби, транспортні технології, транспорт, математична модель