Bulletin of TUIT: Management and Communication Technologies

Volume 4 *2021-fourth number* Article 1

April 2021

DEVELOPMENT OF A MODEL FOR ACCOUNTING THE MATERIAL VALUES OF THE WAREHOUSE DEPOT

T.R. Nurmukhamedov
"Bulletin of TUIT: Management and Communication Technologies", ab.shaxnoza84@gmail.com

Zh.N. Gulyamov
Bulletin of TUIT: Management and Communication Technologies

Sh.T. Shaxidaeva
"Bulletin of TUIT: Management and Communication Technologies

DEVELOPMENT OF A MODEL FOR ACCOUNTING THE MATERIAL VALUES OF THE WAREHOUSE DEPOT

Nurmukhamedov T.R., Gulyamov Zh.N. Shaxidaeva Sh.T.

Abstract. The methodology for calculating the total area of the warehouse of the carriage depot and the optimal size of the stock of inventory items in the carriage depot of the Joint Stock Company "Uzpasstrans". Defined formulas for determining the costs of placing and receiving all orders, costs of storing stock for a certain period, total costs. A logical data scheme is proposed that reflects the main entities necessary to automate the process of determining the inventory of goods and materials in the warehouse of the carriage depot.

Key words: *methodology, warehouse, optimal size of the stock of inventory items, railway transport, ER diagramm, relation database*

Introduction

With the independence of Uzbekistan and the well-chosen policy of the republic's leadership, large-scale changes began in the existing structure and topology of railway transport. It was necessary to lay new railway lines within the country, this would ensure complete independence from the movement of mobile units across the territory of neighboring states. Ultimately, the work performed in this direction provided additional foreign exchange earnings from the passage of transit trains from other states to the country's railway industry.

What has been achieved? Railway lines were built and put into operation connecting the capital of the Republic of Tashkent with Nukus (northern direction); Tashkent with Termez (Karshi and Surkhandarya regions, southern direction); Tashkent with the Fergana Valley (eastern direction). The commissioning of the latter direction opened up the possibility of reviving the silk road in the “steel version”: China-Kyrgyzstan-Uzbekistan.

If this was the first global program of industry restructuring, then the following directions of the industry development were:

- commissioning of high-speed and high-speed (passenger) transportation;
- transition to fiber-optic communication lines, providing uninterrupted and high-quality communication "Road Administration-Regional Railway Junction-Line Enterprises";
- electrification of railway lines, which made it possible to increase the local speed, a positive impact on the environment;
- modernization of the traction stock of railway transport;
- purchase of modern electric locomotives;
- construction of new and modernization of old railway stations, etc.

Ultimately, all this affected transportation and, naturally, freight and passenger transportation increased, which in turn requires an increase in the turnover of both freight and passenger cars.

Here are some statistical data: Railway transport carries out transportation of goods and passengers, both in the local direction and interstate traffic. According to official data, as of 01.01.2020, the railways of the Republic of Uzbekistan transported over 94.5 million tons of cargo and 23.4 million passengers. The freight turnover amounted to 23.4 billion ton-km, and the passenger turnover was 4385 million pass-km, the total length of railway lines was more than 6950.0 km.

Timely service of passengers, improving the quality of services provided to them is achieved by automating the management of all structural divisions involved in the transportation process. The analysis showed that the weak point in the passenger service of “Uzpasstrans” JSC is timely equipment and, if necessary, repair of passenger cars. This is due to poor logistics, as sometimes there are interruptions of component parts necessary for the prevention and repair of passenger cars. Full satisfaction of employees of equipment points involved in the service process wagons with quickly worn out components, spare parts requires their accounting, research of the availability in the warehouse of the wagon depot. For this purpose, we investigated the warehouse of the carriage depot VChD-2 of JSC “Uzpasstrans” as the main link in the supply chain and proposed an automated information system for accounting for inventory items (TMC) and spare parts. Based on this, the creation of an information system on the movement of goods and materials in the carriage depot (VChD-2) of the passenger service, the provision of timely information to management and responsible personnel via the global Internet is relevant.

FORMULATION OF THE PROBLEM

The purpose of the work is the rational placement of goods and materials in the warehouse, automation of the process of its distribution on the warehouse area, accounting and development of requests in order to quickly find them using the QR code. This goal requires the solution of the following tasks:

1. Analysis of existing methods of placing goods and materials in the warehouse and increasing the efficiency of using the warehouse.

2. Development of a model for placing goods in a warehouse and searching for them based on the use of a QR code.

3. Evaluation of economic efficiency through the use of an information system for the placement and search of goods and materials in the warehouse.

Main part

WAREHOUSE ZONES, THEIR CHARACTE-RISTICS

One of the most well-known and used methods in managing the supply of goods and materials is the method of calculating the optimal batch size for ordered goods [1-3]. The method is quite simple and does not require the amount of data to calculate the optimal batch size for ordered goods and materials. It should be noted that the warehouse of the wagon depot has been in operation for a long time, is characterized by established areas, and is not subject to reconstruction in the near future. Taking these factors into account, Fig. 1 shows the classic layout of a warehouse, which reflects the main sections of the warehouse, implementing the following basic operations:.

- section of the acceptance expedition - acceptance of goods in terms of quantity and quality. receipt of cargo - from the unloading area and from the acceptance expedition.
- storage area for goods and materials - sorting of goods placed at storage sites; placement of cargo for storage.

The storage area for goods and materials is one of the most important, since the staff responsible for replenishing stocks works here, selects goods whose movement routes do not intersect under the following conditions: replenishment of additional stocks and stock of picking areas is performed from both sides of the rack and the work of technical staff updating the stock and specializing in product selection, separated by time [4].

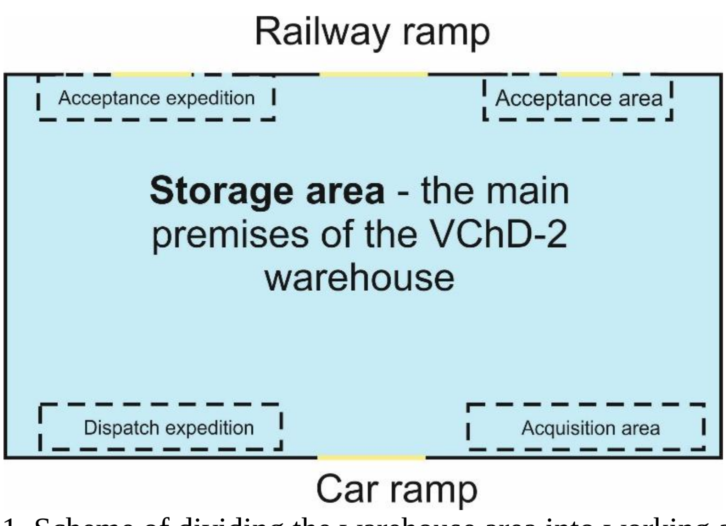

Fig. 1. Scheme of dividing the warehouse area into working areas

The areas in the warehouses of the carriage depot are usually divided into premises for main production purposes and auxiliary ones. The former are used to perform basic technological operations, including storage of goods and materials, expedition and processing. Auxiliary rooms are designed for storing containers, placing engineering devices and communications, as well as various services and other purposes. When drawing up a warehouse project, it is useful to know the functions of various zones, to be able to optimize their parameters and location, and to determine the efficiency of work.

Methodology for calculating the total area of the car depot warehouse.

The method for calculating the size of the premises of all warehouse zones with approximate calculations of the total area of the warehouse $S_{общ}$, m^2, can be determined depending on the usable area.

The entire storage space consists of two parts: areas used and unused for storage. When planning a wagon depot warehouse, it should be taken into account that the most rational is the ratio of these areas, equal to 2: 1.

The calculation of the warehouse of the carriage depot is carried out taking into account the entire area of the warehouse and its useful area [5, 6].

The total area of the wagon depot warehouse can be calculated using the formula:

$$S_{общ} = S_{пол} + S_{всп} + S_{пр} + S_{км} + S_{рм} + S_{пэ} + S_{оэ} \quad (1)$$

where $S_{пол}$ is the usable area, i.e. the area occupied directly under the stored products (racks, stacks and other devices for storing products), m^2;

$S_{всп}$ - auxiliary (operational) area, i.e. the area occupied by driveways and walkways, m^2;

$S_{пр}$ - area of the acceptance area, m^2;

$S_{км}$ - area of the picking area, m^2;

$S_{сл}$ is the area in the premises of the warehouse allocated for the workplaces of warehouse workers, m^2;

$S_{пэ}$ is the area of the acceptance expedition, m^2;

$S_{оэ}$ is the area of the dispatching expedition, m^2.

The total warehouse area is related to the usable area through the utilization factor by the following formula:

$$S_{общ} = S_{пол} / a \quad (2)$$

where *a* - is the utilization factor of the warehouse area (specific gravity of the usable warehouse area) and, depending on the type of stored goods, is in the range of 0.3 ... 0.6.

Usable warehouse area

$$S_{пол} = Q_{max} / q_{доп} \quad (3)$$

where Qmax is the maximum value of the established stock of products in the warehouse, t;

$q_{доп}$ - permissible load per 1 m^2 of warehouse floor area, t / m^2.

Consider the procedure for calculating the values included in the formula.

The useful area of the warehouse $S_{пол}$ in case of uneven receipt of goods and materials at the warehouse is calculated according to the formula for the minimum total costs:

$$S_{рез} * S_1 + 365 * P_k * S_2 \rightarrow \min$$

where $S_{рез}$ is the reserve area, m^2;

S1 is the cost of maintaining 1 m^2 of reserve area, sum / m^2;

Pk - probability of refusal to accept goods and materials;

S_2 - losses for each day of refusal to accept goods and materials, sum;

365- the number of days in a year.

1. The general formula for calculating the useful area of the warehouse is

$$S_{гр} = Q*З*К_н /(254*C_v*К_{иго}*H), \quad (4)$$

where Q is the forecast of the annual turnover, sum / year;

З - forecast of the size of stocks of products, the number of days of turnover;

Кн - coefficient of uneven loading of the warehouse, which is defined as the ratio of the turnover of the most busy month to the average monthly turnover of the warehouse.

$$К_н = Г_{мах} / Г_{ср},$$

where Γ_{max} is the maximum cargo turnover;

Γ_{cp} - average freight turnover.

In design calculations, $K_н$ is taken equal to 1,1 ... 1,3;

254 - the number of working days per year;

C_v is the approximate cost of 1 m^3 of packed products stored in the warehouse, sum / m^3, which can be determined based on the cost of a cargo unit and its gross weight.

The mass of 1 m^3 of products stored at the warehouse can be determined by means of sample measurements carried out by the warehouse staff;

$K_{иго}$ - the utilization rate of the warehouse cargo volume, characterizes the density and height of the stacking of goods. The technological meaning of this coefficient is that equipment, especially rack equipment, cannot be completely filled with stored products. In practical calculations, when storing products on pallets, $K_{иго}$ = 0.64, and when storing products without pallets, $K_{иго}$ = 0.67.

The utilization factor of the cargo volume of the warehouse is determined by the formula:

$$K_{иго} = V_{пол} / (S_{об} * H); \qquad (5)$$

where $V_{пол}$ is the volume of products in a package that can be stacked on this equipment along its entire height, m^3;

$S_{об}$ - the area occupied by the projection of the external contours of the carrying equipment on the horizontal plane, m^2;

H - product stacking height, m.

The values of Q and 3 of formula (4) are determined on the basis of predictive calculations.

2. Calculation of the auxiliary area: the area of walkways and driveways ($S_{всп}$)

The size of the area of walkways and driveways is determined after the adoption of the mechanization option and depends on the type of lifting and transport vehicles used in the technological process. If the width of the working corridor of the machines working between the racks is equal to the width of the rack equipment, then the area of the aisles and driveways will be equal to the cargo area or 90% of it.

The need for shelving equipment

$$N_{ct} = N_t / V_{ct},$$

where N_t is the amount of products to be stored in racks, m^3;

V_{ct} - capacity of one rack, m^3.

Warehouse capacity

$$E = F_c * q_m$$

where Fc is the area used for direct storage of cargo, m^2;

q_m - specific load, t / m^2.

The capacity of equipment for storing products (cells, racks, stacks, etc.), t, is calculated as

$$q_{об} = V_{об} * g * b,$$

where $V_{об}$ is the geometric volume of the corresponding equipment, m^3;

g - specific weight of material or product, t / m^3;

b - volume filling factor (packing density).

If the warehouse of the carriage depot does not use mechanization for loading and unloading operations, then in this case $S_{всп}$ = 0.

3. Areas of acceptance and picking sites ($S_{пр}$ and $S_{км}$)

The areas of acceptance and acquisition sites are calculated on the basis of enlarged indicators of the design loads per 1 m^2 of the corresponding areas. In the general case, design calculations are based on the need to place acceptance and picking areas for 1 m^3 of products on each square meter.

The required front length of loading and unloading operations (length of road and rail ramps) is calculated as follows:

$$L_{фр} = nl + (n-1) * l_i$$

where n is the number of transport units simultaneously supplied to the warehouse;

l is the length of the transport unit, m;

l_i - distance between vehicles, m.

The area of the goods acceptance and picking areas, m^2, is determined by the formulas:

$$S_{пр} = Q_г * K_н * A_2 * t_{пр} / (365 * q_{доп} * 100) + S_в, \quad (6)$$

$$S_{км} = Q_г * K_н * A3 * t_{км} / (254 * q_{доп} * 100), \quad (7)$$

where $Q_г$ is the annual receipt of products, t;

$K_н$ - coefficient of unevenness of the receipt of products at the warehouse, $K_н$ = 1,2 ... 1,5;

A_2 is the share of products passing through the acceptance area of the warehouse,%;

$t_{пр}$ - the number of days of finding products at the acceptance site;

365 - the number of days in a year;

$q_{доп}$ - design load per 1 m2 of area, taken equal to 0,25 of the average load per 1 m^2 of warehouse area, t / m^2;

$S_в$ is the area required for weighing, sorting, etc., m^2; $S_в$ = 5 ... 10 m^2;

A_3 is the share of products to be picked at the warehouse,%;

tkm is the number of days the products are at the picking site;

254 is the number of working days per year.

4. Area of workplaces $S_{рм}$

The area of the warehouse office space is calculated depending on the number of employees. With a warehouse staff of up to three employees, the office area is determined based on the fact that each person has 5 m^2; from 3 to 5 people - 4 m^2 each; with a staff of more than five employees - 3.25 m^2 each [6]. The workplace of the warehouse manager (area 12 m^2) is recommended to be located near the picking area so that there is a maximum view of the warehouse. If it is planned to check the quality of the stored products at the warehouse, it is recommended to equip the workplaces of the personnel responsible for this near the acceptance area, but away from the main cargo flows.

5. Area of the acceptance expedition ($S_{пэ}$)

An acceptance expedition is organized to accommodate goods received outside of working hours. Therefore, its area should be able to accommodate the amount of goods that can arrive over the weekend.

The minimum size of the area of the acceptance expedition

$$S_{пэ} = Q_г * t_{пэ} * K_н /(365 * q_э), \qquad (8)$$

where $Q_г$ is the annual receipt of products, t;

$t_{пэ}$ - the number of days during which the products will be on the acceptance expedition;

$K_н$ - coefficient of unevenness of the receipt of products at the warehouse, $K_н$ = 1,2 ... 1,5;

$q_э$ - the enlarged indicator of the design loads per 1 m2 in the forwarding premises, t / m^2.

6. Area of the dispatching expedition ($S_{оэ}$)

The area of the shipping expedition is used for picking shipping lots. The minimum area of the dispatching expedition should allow performing work on the acquisition and storage of the average number of shipping lots. The size of the area is determined by the formula:

$$S_{оэ} = Q_г * t_{оэ} * K_н /(254 * q_э) \qquad (9)$$

Where $t_{оэ}$ is the number of days during which the products will be on the shipping expedition.

The dimensions of the aisles and driveways in the warehouse are determined depending on the dimensions of the stored products and lifting vehicles, as well as the size of the cargo turnover. If the width of the working corridor of machines working between the racks is equal to the width of the rack equipment, then the area of the aisles and driveways will be equal to the cargo area. Passage width, cm,

$$A = 2 * B + 3 * C, \qquad (10)$$

where B is the width of the vehicle, cm;

C - the width of the gaps between the vehicles themselves and between them and the racks on both sides of the passage (taken equal to 15 ... 20 cm).

In absolute terms, the width of the main aisles (aisles) is taken from 1.5 to 4.5 m, the width of the side aisles (aisles) - from 0.7 to 1.5 m. from 3.5 to 5.5 m in multi-storey buildings and up to 18 m in single-storey buildings.

The formula for the need for warehouse space

Determination of the required cargo area - $S_п$ can be calculated using the following formula:

$$S_n = Q * K_1 / K_2 * h \quad (11)$$

where Q is the stock of goods to be stored in the warehouse;

K_1 is the coefficient of unevenness of the receipt of goods;

K_2 is the utilization factor of the volume of storage facilities;

h is the height of the warehouse.

Warehouses of the carriage depot for the purpose of rational use of the area should be divided into two functional zones. The first is intended for storage of goods and materials, its issuance. The second functional area contains technical and engineering rooms. In order to effectively organize the work of the warehouse, it is necessary to calculate the optimal parameters of both sections and determine their location.

Before planning storage areas, the designer studies the specifics of the enterprise and the specifics of the turnover.

DEVELOPMENT OF AN AUTOMATED SYSTEM

As a result of the analysis of the subject area, we made attempts to develop a logical data scheme that reflects the main entities necessary to automate the process of determining the goods and materials necessary for placing goods and materials in the warehouse of the wagon depot. The developed logical data model, in the IDEF1X notation, is supposed to consist of the following entities:

- Goods and materials - reflects the main properties of the object placed in the warehouse;
- Warehouse - a place of storage of goods and materials;
- Dimensions - the width, height and depth of the warehouse are indicated to determine the storage capacity of goods and materials;
- Shelving - a multi-tiered device for storing piece goods;
- Location - the location of this rack, which is indicated in order to quickly find it;
- Rack dimensions - indicated for a quick search of the required rack and the selection of a convenient storage location for goods and materials, depending on its parameters, as well as on the demand for this inventory;
- A batch is goods and materials entering the warehouse, which must take into account the expiration date, storage conditions;
- Supplier - a natural or legal person supplying goods and materials to the warehouse;
- Receipt invoice - a document created with each movement of goods in the warehouse, which is the internal documentation required to post the fact of movement of goods and materials;
- List of goods and materials - they are listed in the invoice, that is, they are the subject of movement;
- Invoice - a document created when goods and materials move from the warehouse, that is, when they are released to specialists who repair mobile units;
- Warehouse balances - shows the inventory balance for a certain period, which shows the number of goods in the warehouse, as well as see statistics on the popularity of goods.

The improvement of the monitoring processes of components and spare parts in production structures is carried out by the creation of a database (DB) on the availability of the necessary goods and materials in the warehouse. The developed functions and procedures for working with data from the database of components and spare parts of the VChD-2 are reflected in the ER-diagram of the carriage depot (Fig. 2). When developing the ER-diagram of the VChD-2 depot, a study of the inventory (spare parts and other components of the rolling stock) was carried out [7, 8].

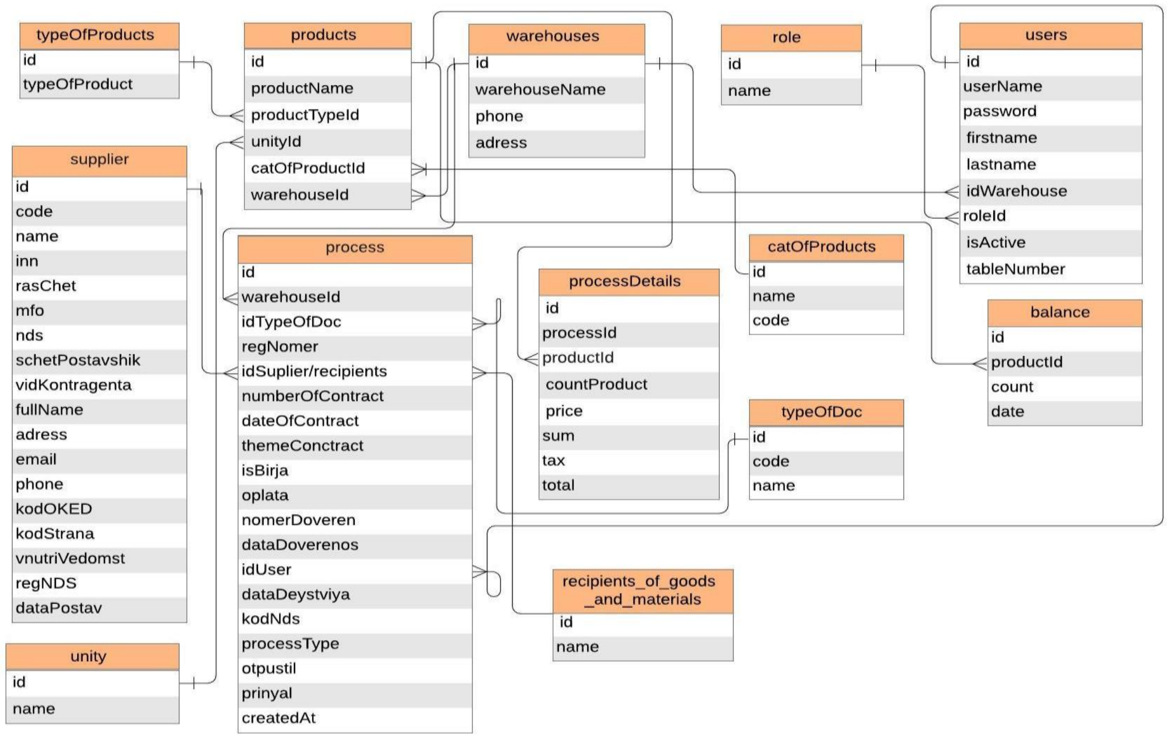

Figure: 2. Scheme of the ER diagram of the database of the warehouse of the carriage depot VChD-2 of JSC "Uzpasstrans".

When developing an information system for accounting of goods and materials at the warehouses of the VChD-2 depot of Uzpasstrans JSC, the object-oriented modeling language UML was used [9].

Conclusion

As a result of the analysis of the functioning of the warehouse of the railway depot, the existing methods for calculating the rational placement of goods and materials, it was determined that it was possible to increase the efficiency of using the space by developing an automated information system.

1. As a result of the study, it was revealed that at the moment there is no automated system in the VChD-2 carriage depot. This imposes restrictions on the efficiency of the placement of goods and materials in the warehouse, quickly determine their location and predict the necessary components for the repair of rolling units of the carriage depot.

2. The developed automated information system is designed for the effective placement of goods and materials in the warehouse, taking into account the parameters of the placement of goods, which will ensure the best storage of goods in accordance with the quality of the goods, reduce the processing time of the order, and thus increase the efficiency of warehouse workers.

3. When placing the goods in the warehouse, the following parameters will be taken into account: size, demand, requirements for storage conditions. The developed system of automated accounting of goods and materials will improve the efficiency of the warehouse of the carriage depot by optimizing the placement of goods in the warehouse.

References:

[1] V.S. Lukinsky. “Inventory management in supply chains”: Textbook. *SPb .: SPbGIEU*, p. 372, 2010.
[2] B.A.Anikina. “Logistics”. *INFRA-M*, p. 368, 2008.
[3] A.M.Gadzhinsky. “Inventory management in logistics”. *Handbook of the Economist. No. 2.* – pp. 66-77, 2008.

[4] V.I.Sergeev, M.N.Grigoriev, S.A.Uvarov. “Logistics: information systems and technologies: study guide”. *Alfa-Press,* p. 608, 2008.
[5] S.F.Pilipchuk, A.E.Radaev “On the question of determining the optimal volume of a delivery consignment” *Logistics and supply chain management*, No. 2 (55). –pp.71-77, 2013.
[6] O.V.Badokin, V.V.Lukinsky, Yu.V.Malevich, Stepanova A.S., T.G.Shulzhenko “Inventory management in supply chains”: Textbook. *SPbGIEU,* p. 372, 2010.
[7] T.R.Nurmukhamedov, Zh.N.Gulyamov “Develop-ment of a database for accounting of warehouse inventory of a carriage depot”. *Collection of scientific articles based on the results of the eleventh international scientific conference: “Advanced innovative developments. Prospects and experience of use, problems of implementation in production ”*, part 2. –Kazan, pp. 212-215, 2019.
[8] T.R.Nurmukhamedov, Zh.N.Gulyamov. “Creation of an information system for inventory control of material assets in railway transport (on the example of a carriage depot)”. *Collection of abstracts of the participants of the scientific and practical conference "Innovative directions of integration of science, education and production." -Kerch*, pp. 425-428, 2020.
[9] A.V.Leonenkov “UML self-study guide”. *BHV-Petersburg*, p.432, 2004.