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"LEAN PRODUCTION" IN WAREHOUSE REAL ESTATE MANAGEMENT: RUSSIAN AND FOREIGN EXPERIENCE OF IMPLEMENTING DIGITAL TECHNOLOGIES AT WAREHOUSE FACILITIES

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Abstract. In modern economic conditions, warehouses are one of the most stable segments of commercial real estate. warehouses are among the most important and in-demand elements of the functioning of large non-food manufacturers, logistics operators, retailers and distributors, transport and pharmaceutical companies. The purpose of the study is to evaluate the Russian and foreign experience of implementing digital technologies at warehouse facilities as part of the formation of the concept of lean manufacturing. in the course of the research, the concept of "lean production" within the management of warehouse real estate is considered, the share of non-forced operations performed during production and expressed in the form of losses is revealed, the classification of non-forced losses in production is given, the principles of lean warehousing and the stages of implementing the principles of lean production within the framework of warehouse activities are considered. as a result of the study, an assessment of the Russian and foreign experience of the introduction of digital technologies in the framework of the formation of lean culture is given.

Keywords: lean manufacturing, lean production, lean technologies, digital technologies, commercial real estate, distribution center, warehouse facility

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КОНЦЕПЦИЯ «БЕРЕЖЛИВОГО ПРОИЗВОДСТВА» В РАМКАХ УПРАВЛЕНИЯ СКЛАДСКОЙ НЕДВИЖИМОСТИ: РОССИЙСКИЙ И ЗАРУБЕЖНЫЙ ОПЫТ ВНЕДРЕНИЯ ЦИФРОВЫХ ТЕХНОЛОГИЙ НА СКЛАДСКИХ ОБЪЕКТАХ

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Аннотация. В современных экономических условиях складские помещения – один из самых стабильных сегментов коммерческой недвижимости. Склады относятся к важным и наиболее востребованным элементам функционирования крупных производителей non-food, логистических операторов, ритейлеров и дистрибуторов, транспортных и фармацевтических компаний. Целью исследования является оценка российского и зарубежного опыта внедрения цифровых технологий на складских объектах в рамках формирования концепции бережливого производства. В процессе исследования рассмотрена концепция «бережливого производства» в рамках управления складской недвижимости, выявлена доля невынужденных операций, совершаемых в ходе производства и выражаемых в виде потерь, дана классификация невынужденных потерь на производстве, рассмотрены принципы бережливого складирования и этапы внедрения принципов бережливого производства в рамках складской деятельности. В результате исследования дана оценка российского и зарубежного опыта внедрения цифровых технологий в рамках формирования lean-культуры.

Ключевые слова: бережливое производство, lean production, lean технологии, цифровые технологии, коммерческая недвижимость, распределительный центр, складской объект

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Introduction

The real estate market is extensive and includes many areas, divided into several segments, which in turn consist of sectors. In the real estate market, not only production activities are carried out, but also management and investment. Real estate market research involves the study of theoretical foundations about the features and structure of the real estate market, and it is also necessary to study classifications. It is also impossible to draw a conclusion about the structure of the real estate market without studying its dynamics. With the help of graphical interpretation of market indicators, it is possible to draw a conclusion about positive or negative trends.

During the covid-19 pandemic in 2020, warehouse real estate became one of the most stable markets, as there was an increase in demand for the services of logistics and distribution companies from retailers and representatives of online commerce, who are the main users of warehouse real estate. The warehouse real estate market is experiencing an increase in rental rates, an expansion of the range of warehouse services, and there are also more and more participants in this segment. Therefore, in the current

period, it is especially important to increase the competitiveness of warehouse real estate market objects.

In modern economic conditions, warehouses are one of the most stable segments of commercial real estate. Warehouses are among the most important and in-demand elements of the functioning of large non-food manufacturers, logistics operators, retailers and distributors, transport and pharmaceutical companies.

Despite the low economic growth rates of the Russian Federation in recent years, the commercial real estate market continues to demonstrate an increasing need for high-quality storage facilities. The need to meet the needs of the population in constantly changing market conditions pushes large corporations, retail and online stores to expand their logistics complexes, allowing them to receive, store and distribute a variety of products. This was one of the reasons for the rapid growth of warehouse real estate throughout Russia.

The growing retail turnover forces consumer market participants to expand their product storage capabilities, which, in turn, makes the warehouse real estate segment attractive to investors and developers (Keyes, Barner et. All, 2021).

Until recently, the construction of warehouse complexes was considered by market players as the least attractive opportunity compared to the retail and office segments. But with the development of the market, tenants' requirements for the quality of warehouse premises are increasing, and there is also a need for professional logistics services.

In this situation, the repurposed warehouse buildings of former production facilities and built-in storage facilities presented on the market in large numbers no longer meet the increased requirements of tenants. Therefore, modern warehouse complexes that meet international standards are becoming more and more in demand, and therefore more attractive from the point of view of investment.

According to the center for investment real estate Becar Asset Management, the level of profitability of warehouse real estate is 14-20% if the object is built to generate a permanent income. With a speculative transaction, the yield is 25-40%, depending on the stage of entry into the project – design, construction or ready-made business

For the owner of the company, one of the main tasks is to maintain the effective functioning of the system, which allows to fully meet the needs of customers, reduce costs and increase the profitability of the business.

Improving the efficiency of business processes is a special driver of the growth of the Russian economy. Such a segment of commercial real estate as industrial and warehouse facilities are no exception in matters of efficiency of the organization of functioning and management (Cai, 2011).

There is a need to modernize and optimize storage facilities, so you should turn to the concept of lean manufacturing, which has proven to be an effective tool for managing production, logistics chains and warehouse centers.

Materials and Methods

The following research methods were used to implement the tasks: analysis and synthesis, coefficient and comparative methods, SWOT analysis, economic calculations, etc.

The information basis for writing the work was: special literature, federal evaluation standards, reference books, collections, scientific works of such authors as Faber N, Kindeeva, E. But. Borovkova V.A., Pirogova O.E. and others, as well as Internet resources: reviews and research of analytical companies, statistical data, warehouse real estate portals and other sources. Analytical reports and industry reviews by Colliers, an international company providing real estate and investment services, as well as Knight Frank real estate agencies (Faber, 2002) were also used as an information base.

Results and Discussion

A unified system of lean production was formed in the 1990s thanks to the work of Japanese scien-

tists. This enterprise management system is based on improving the quality of the product while reducing production losses.

The task of lean manufacturing is the continuous elimination of unnecessary losses, while achieving an increase in the competitiveness of products by reducing cost and improving quality.

Among the business processes of the enterprise there are three categories:

– operations that add value to the final product,

– forced operations necessary for the implementation of the production activities of the enterprise,

– non-forced operations, which are expressed in various types of production losses (see Figure 1).

As we can see, the share of processes that add value to products is small and amounts to only 5%. Most operations are losses for production, while some operations cannot be abandoned, since they relate to forced processes. However, usually 60% of losses are unconstrained, which opens up the possibility of reducing the cost of production.

Thus, lean production is a concept of management of a manufacturing enterprise, which is aimed at eliminating all types of losses that arise when performing operations or actions that do not bring profit (Cherkasskaya, 2017).

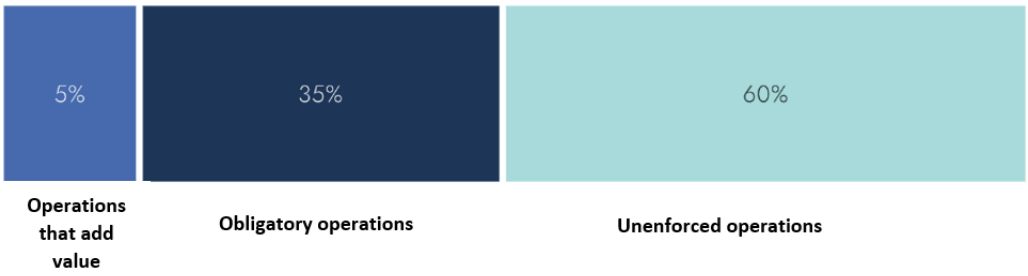

Fig. 1. The share of non-forced operations performed during production and expressed as losses

Within the framework of the concept of lean production, seven main types directly related to the company's activities are attributed to unforced losses (Frolov, 2021):

– excess stocks, which can be expressed by low-liquid inventory values,

– unnecessary human movement on production sites between technological zones,

– excessive processing of products or document flow,

– excessive transportation,

– low accuracy of operations and defects,

– excessive waiting and disruption of flow rhythmicity,

– overproduction,

– unrealized human potential (see Figure 2).

It should be noted that the last type of production losses appeared recently. This is due to the fact that much attention has been paid to labor productivity in recent years. If the human potential is not fully realized, then we can talk about unintentional losses (Mayer, DeWitte, 1998).

The principles of the concept apply not only to the management of manufacturing companies, but also to the management of warehouse real estate.

In the course of managing industrial and warehouse real estate, the manager faces many tasks, ignoring or irrational solution of which can lead to additional non-production losses.

Let's list the main losses of the warehouse:

– storage of excess stocks and the cost of maintaining additional storage space,

– zeroing of orders due to the lack of inventory items in the required volume,

– large time costs for registration and collection of accompanying documentation,

– excessive movement of vehicles due to irrational placement of technological zones,

– damage to goods and materials during transportation,

– processing of employees due to the irregular flow of goods and materials,
– storage of unclaimed goods and leftovers,
– imperfect methods of input control, defects and deviations from the assortment,
– time spent on inventory and inventory search.

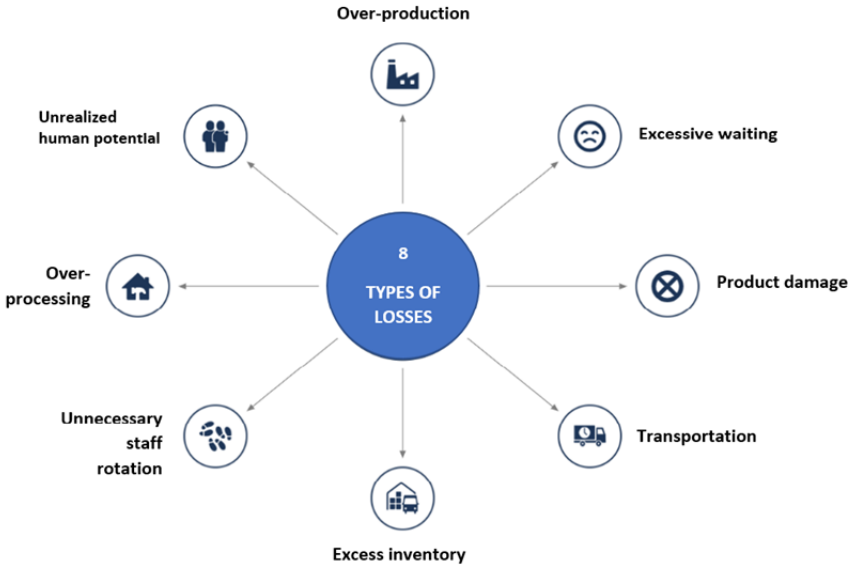

Fig. 2. Type of involuntary losses in production

The lean warehousing system, as it is one of the directions of lean manufacturing, should take into account three important aspects: optimization of the work of warehouse employees, increasing the speed and rhythm of product movement and the use of relevant lean technologies to eliminate losses in the warehouse.

Non-production losses of a warehouse may arise in principle due to an ill-conceived warehouse management concept, but there are also special cases, such as seasonal or unstable demand, an increase in the number of SKUs (commodity item), a shortage of warehouse space for the placement of goods and materials, an increase in the cost of labor, urgent orders, an increase in operating costs, an increase in the number of orders, the appearance of new delivery channels and the need for timely and rational management, and others (Kindeeva, 2018).

To optimally solve the problems faced by an ordinary warehouse manager and eliminate non-production losses when implementing a new management system, it is necessary to apply not only economic analysis of logistics processes, but also the principles of a lean warehouse (see Figure 3).

The main principle of lean warehousing is sorting, which provides for the removal of illiquid, outdated and damaged goods, reduction of unnecessary movements and travel time of loaders, as well as digitalization of data collection.

The second principle implies compliance with the order and effective organization of product placement and movement. To implement this principle, the following actions may be useful: prioritization of technological zones and placement of the most used goods in an easily accessible place, placement of navigation schemes, use of digital technologies for quick search of goods (Voronova, Khareva et all., 2022).

Keeping warehouses clean is the third principle of lean warehousing. Regular cleaning and inspection of warehouse areas will allow timely detection of defects, damages or any errors.

Standardization is one of the key principles of lean warehousing. Creating standards for all work areas will allow you to optimize and control all actions in the warehouse.

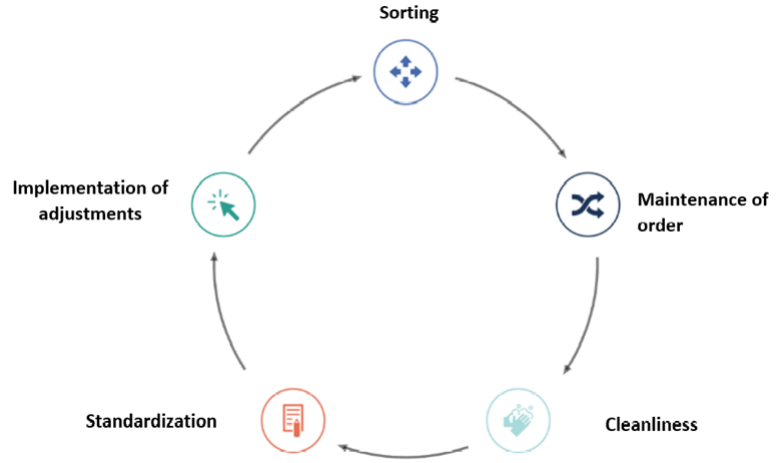

Fig. 3. Principles of lean warehousing

After the introduction of a new management system of an industrial warehouse facility, it is necessary to constantly analyze the results and make adjustments to the warehouse operation, this is the last principle of lean manufacturing – improvement.

There are 3 stages of implementing the lean warehouse concept: diagnostics of the current state of the warehouse, the implementation stage, the creation of a control system (see Figure 4).

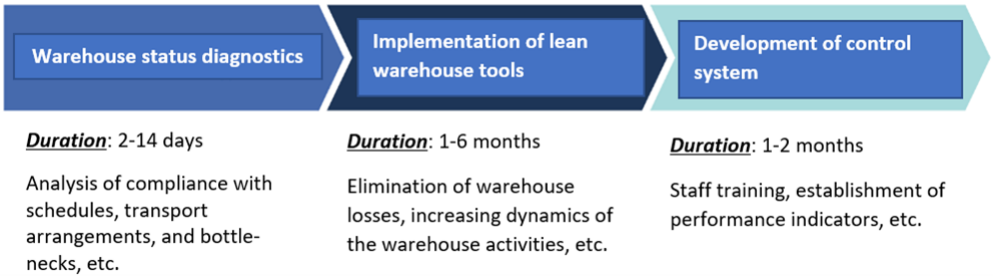

Fig. 4. Stages of implementation of lean manufacturing principles in the framework of warehouse activities

The first stage involves the diagnosis of the current state of warehouse and transport logistics, which consists of an analysis of the calendar activity of the warehouse and the demand for inventory items, providing ABC and XYZ methods. Also at this stage, the calculation of the main economic indicators is carried out, the rhythmicity of traffic flows is assessed, the "bottlenecks" of the warehouse are assessed, losses are determined, measures are developed to improve the efficiency of the warehouse and prioritization of tasks. Depending on the volume of available commodity items and the complexity of the material flow, the duration of the stage ranges from several days to several weeks (Grigoryants, Akopyan, 2020.).

The results of the first stage can be digitized stock flow maps, reports on non-production operations and unforced losses, as well as a list of identified weaknesses that disrupt the rhythm and continuity of warehouse activities. In addition, a checklist of planned improvements is formed, most often presented by the Kaizen method (Voronova, Il'in et all., 2021).

At the second stage, the implementation of lean warehouse tools is carried out, taking into account the identified "bottlenecks" of the warehouse and the resulting losses. According to the results of the stages, an increase in the speed and rhythm of the warehouse operation should be achieved, as well as the elimination of non-production losses. Depending on the specifics of the warehouse and its scale, the process of preparation and implementation can last from one month to one year (Renigier-Bi ozor,

Wisniewski et all., 2018).

The final stage of implementing the lean manufacturing concept consists of establishing the KPIs of the warehouse operation, developing control methods, including frequency, type of control, as well as a map of those responsible and their powers. At the last stage, a system of employee motivation is formed, the organization of favorable working conditions, as well as training of warehouse complex employees. The duration of the stage is on average from 1 to 4 months.

In order to develop an investment project to implement the principles and technologies of lean manufacturing, it is necessary to consider existing lean tools and specific digital solutions that can increase the efficiency of the warehouse and minimize costs that are not involved in the formation of the value of products.

Experience shows that many lean manufacturing tools can be effective in warehouse activities, for example, the "Just-in-Time", "5S", "Kanban" and "Kaizen" systems. The use of these tools can contribute to achieving noticeable results, such as reducing all types of losses, rational use of technological zones and increasing labor productivity. To begin with, let's focus on standard tools that are closely related to warehouse activities.

The "Just-in-Time" system is one of the most common concepts of the organization of production and warehouse activities, which is based on the release of only those products for which there is a request from the consumer in exact quantity and at a specific time. This tool allows you to effectively meet the needs of customers, reducing the cost of maintaining a large assortment and low liquid stocks. At the same time, there are risks of the formation of unintentional losses during the changeover of equipment, assembly and assembly of goods.

The Kanban system is often used, which helps to control the volume of stored products in the right quantity and in the right time. This tool is quite difficult to implement, however, it has a number of advantages:

– reduction of losses from overproduction and excess inventory,

– increasing the company's flexibility to changing demand,

– maintaining the rhythm of the material flow,

– standardization of product information, etc.

Also, the 5S system, considered earlier, can act as the main lean production tools within the framework of warehouse activities. The methodology includes 5 consecutive steps: sorting, maintaining order, maintaining cleanliness, standardization and continuous improvement of processes (Wader, 2020).

The Kaizen system is based on continuous improvement of the production or warehousing process by considering individual processes and developing measures to improve them. The key objective of this tool is to increase the share of operations that add value to the product, while minimizing losses generated during non-forced operations. The advantages of the system include the following characteristics:

– ensuring the rapid implementation of improvements in individual areas, maintaining the continuity of the entire warehouse complex,

– elimination of unnecessary human movements and reduction of the waiting period,

– involvement of employees at all levels helps to comprehensively approach the analysis of activities and identify hidden losses (Lawin, 2018).

Within the framework of the Kaizen system, the use of the Deming wheel tool or the PDCA/SDCA cycle is often found (see Figure 5).

The PDCA (plan-do-check-act) cycle is a popular tool within the framework of continuous process improvement and consists of four stages: planning, implementation, verification and analysis, as well as the reaction stage, which provides for an assessment of the entire procedure and making changes.

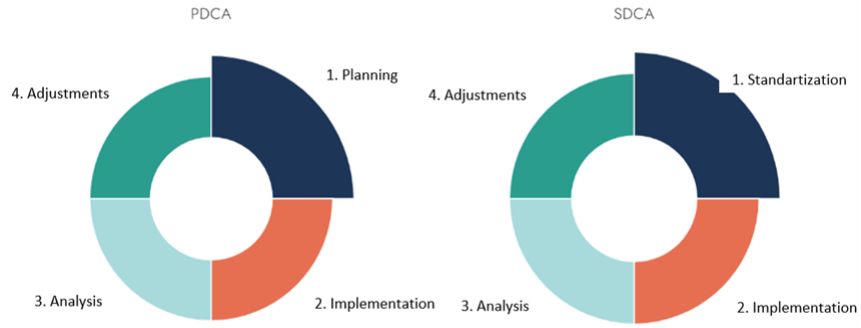

Fig. 5. Process improvement and standardization cycle

Next, the procedure goes through the SDCA standardization cycle, which provides for making proposals for standardization of processes, direct implementation, analysis of results and proposal of changes. This tool, demonstrating the continuity of the process of improving operations, can also be used in the course of improving the activities of the warehouse complex (Voronov, Lassal et all., 2021).

Lean culture is the organization of a multi-stage system of planning, analysis and implementation of changes that affect productivity improvement and reduction of unforced losses, the share of which in the entire set of operations of the enterprise can be about 60%.

It should be noted that lean manufacturing is a continuous process, and examples of lean tools only form a philosophy and help organize the process of managing warehouse facilities in the most efficient way.

At the same time, solving specific problems, eliminating bottlenecks at an industrial facility requires specific measures that are based on the introduction and application of digital technologies that help increase the efficiency of the entire logistics chain and a specific industrial and warehouse facility. Before turning to the Russian and foreign experience of using digital technologies in the framework of warehouse activities, let's consider the classification of technological solutions and their essence mainly for companies related to retail, FMCG segments (fast moving consumer goods - fast–turn consumer goods), and for logistics operators (Yakhyaeva, 2020).

It is necessary to start with complex solutions that require considerable effort in the preparation and implementation of changes, but having the most significant effect on the performance of the warehouse facility.

Smart slotting ("smart slotting") is the process of maximally efficient zoning of the warehouse and finding a suitable place for each SKU unit, taking into account the specifics of the products and their demand. The mechanism of this tool involves 3 stages of implementation:

- digitization of the 3D model of the warehouse taking into account technological zoning,
- simulation of the current work of the warehouse, taking into account human movements and the movement of vehicles,
- formation of an optimal product placement model.

Creating a 3D model of a warehouse allows you to create arbitrary configurations, put forward hypotheses and test them in a virtual environment, which corresponds to the philosophy of lean manufacturing and helps to continuously analyze the activities of the warehouse and, if necessary, make adjustments. The result of using this tool can be a reduction in the distance of movement, which leads to significant time savings for employees and a reduction in the mileage of equipment (see Figure 6).

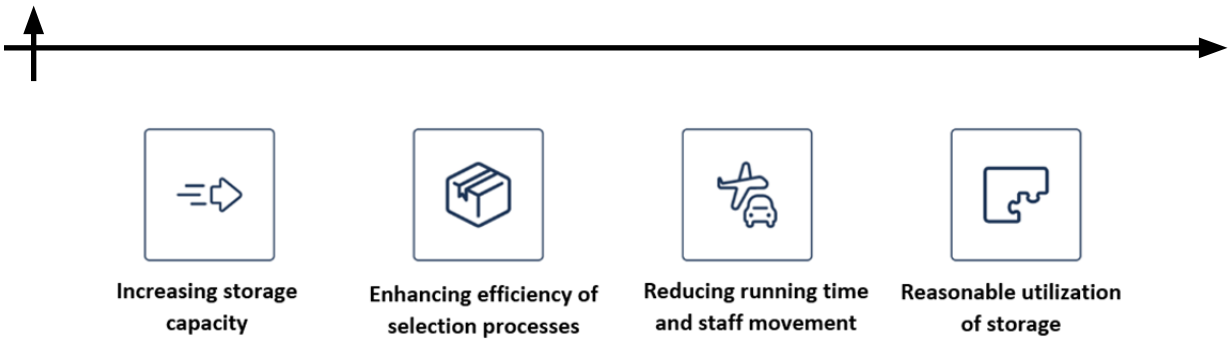

Fig. 6. The effect of creating a 3D model of the warehouse and the introduction of Smart Slotting technology

This technology is based on the creation of a digital double of a warehouse. With the help of simulation modeling, it is possible to avoid experiments in a real warehouse and protect the management of the complex from erroneous decisions (Seng, 2000).

There is a separate direction of technologies that contribute to the improvement of processes in which direct participation of warehouse employees is required. Man-to-product technologies allow you to increase the speed of order collection and picking and at the same time minimize employee involvement (see Figure 7).

Pick-by-Voice (voice selection of goods) is a technology that allows you to automate the identification of goods in a warehouse using voice control. When using Voice Picking tools, the employee puts on a special headset with which the computer sets the route when completing the goods. Thus, the technology frees the employee from having to carry a tablet or a mobile terminal. The build process is simplified and increases productivity, as well as reduces the number of errors to minimum values.

In addition, voice technologies can be used during the unloading and shipment of goods, inventory, movement inside the warehouse and packaging of products in prefabricated batches.

Pick-by-Vision is a technology based on the use of augmented reality smart glasses, which simplifies the movement of employees around the warehouse and reduces errors about picking and inventory. According to the mechanism of operation, the technology is similar to Voice Picking tools, but here the main sources of information are a virtual three-dimensional display located in glasses, which reflects the necessary route, information about products transmitted via a server via a Wi-Fi system.

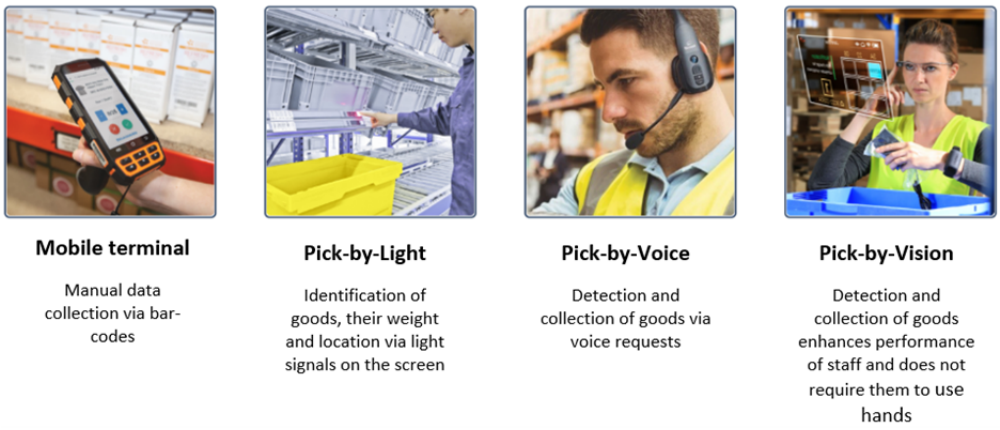

Fig. 7. Digital technologies "person to product", allowing to optimize the work of employees in the warehouse

Vision Picking technologies also make it possible to free an employee from the need to have a tablet or mobile terminal with him, which increases employee productivity and reduces the number of errors and unforced losses. In addition, Pick-by-Light technologies are distinguished, which allow identifying the product, its weight, quantity and location by a light signal that is displayed on a digital display.

The concept of Smart Glasses ("smart glasses") is also used to train new employees and reduce equipment downtime due to changeovers and repairs due to augmented reality and remote access. So, with

the help of remote communication, an employee located at another location can instruct an employee how to perform certain actions in order to eliminate a malfunction of the equipment. This technology is becoming especially relevant in the context of a general lockdown during the covid-19 pandemic, as the mobility of employees has decreased (Yakhyaeva, 2021).

Quick-Pick Remote is a remote lifting technology that significantly simplifies the process of picking orders. During the order collection, the operator makes many movements among the racks. When using loaders, the employee is forced to return to the cab of the transport every time and move it to the next reference point. Remote control technology allows you to eliminate most of these operations by using a wireless remote control. This technology accelerates the work of employees, reducing the volume of human movement, reducing physical stress on a person and injury risk. Also, with the help of remote access, you can adjust the required height of loading or unloading (Womack, 2003).

Biotelemetric technologies are tools that track critical indicators of the condition of employees. First of all, these are technologies for adaptive intelligent load distribution between existing employees by reading the bio-telemetry indicators on fitness bracelets, in particular the employee's pulse. The fitness bracelet, which is on the employees' hand, transmits information about the status of the warehouse employee to the automated control system. Based on the data obtained, the system adjusts the workflow and, if necessary, redistributes the load between employees. The technology makes it possible to optimize the physical load on employees, ensure control of important indicators of the condition of workers and ultimately avoid a decrease in overall labor productivity during the working day.

The next category of innovations in warehouse logistics includes "goods to people" technologies, the purpose of which is to simplify the accounting, placement and picking of orders.

It is difficult to imagine a large warehouse complex without modern technologies for tracking inventory.

RFID tags (Radio Frequency Identification) are widely used in folding activities and in the coming years this technology will become more and more perfect. The advantage of such labels in comparison with conventional barcodes is the content of more information about products, while scanning by means of radio waves allows you to receive information about the cargo without opening the package, which increases the speed of material flow.

The use of radio frequency identification includes more complete control and transparency of inventory, as well as greatly simplifies the inventory process and reduces the risks of theft at the warehouse facility.

Automatic Guided Vehicle (AGV) - automatic transport systems make a significant contribution to the automation of the warehouse facility and the reduction of unforced losses. Most often, an AGV is understood as an electrically driven conveyor designed to move goods, however, a separate employee is not required for its maintenance. "Robotkars" move without human intervention along a pre-programmed route, and also performs the necessary actions with the goods, for example, capturing, moving and installing cargo.

Separately, we note the possibility of using autopilot drones to conduct a quick and high-altitude inventory. Robotic drones, flying along the warehouse areas, read the markings on pallets with an accuracy of more than 99% in offline mode, which significantly speeds up the inventory process, reduces the risks of human injury and saves employees' working time.

In order to assess the applicability of the above technologies used to optimize warehouse activities, it is necessary to study the practical experience of Russian and foreign companies.

The American company Amazon is the largest player in the e-commerce market, having more than 100 warehouse complexes in the USA alone, with an average area of 50-60 thousand square meters. m., in Germany, for example, there are 13 such facilities. Despite the fact that the head of the Robotics Fulfillment company, Scott Anderson, said that there are no plans to launch fully automatic warehouses in the next 10 years, Amazon is a world-famous user of industrial warehouse real estate, setting trends in

the industry. At the moment, the company is actively using robotic loaders, the number of which tends to 15 thousand worldwide. This allows you to significantly reduce time costs, as well as human efforts in the movement, loading and unloading of goods and materials.

The largest retail chain in the world, Wal-Mart Stores, is represented by 12 thousand outlets in 28 countries, so the logistics function and warehouse activities are extremely important for the effective functioning of the company. With the development of online trading in 2020, the company began using Alphabot robots in the warehouse to assemble orders. The first tests showed that robots are now collecting orders 10 times faster than a human, which opens up good prospects for further robotization of the company's warehouse activities

The logistics infrastructure of the Russian supermarket chain "Lenta" includes 13 large distribution centers, each of which serves a dozen cities and up to 100 retail outlets. One of the key business processes in warehousing is the shipment and unloading of inventory. To speed up these processes, the company exchanges information with its partners and suppliers using the EDI (electronic data exchange) system. This allows you to reduce the time of acceptance of the goods by 1.5-2 times. Indirect effects from the use of EDI technology: acceleration of information exchange, minimization of errors and inaccuracies in document flow, automation of acceptance and loading of goods.

X5 Retail Group, one of the leading food companies in Russia, operates outlets of various formats: Karusel hypermarkets, Perekrestok supermarkets and Pyaterochka convenience stores. There are 20 warehouse complexes and more than 3 thousand retail outlets on the territory of Russia. For effective inventory management, the company uses digital technologies to reduce time and labor losses in the warehouse. For example, X5 Retail Group uses a Pick-by-voice system that helps manage warehouse operations using voice commands. The introduction of this technology allowed for a 10% increase in employee productivity and a 2-fold reduction in the number of errors when picking orders.

Conclusions

The concept of lean production is aimed at improving the activities of companies, including those involved in working with warehouse real estate. It is based on the continuous improvement of processes and the elimination of unforced operations that do not add value to products, but are net losses of production or warehousing. The concept of lean warehousing identifies 8 main types of losses: excessive overproduction, expectations, excessive transport and human movements, excessive processing, excess inventory, defects and inaccuracies in processing and unused human potential. Within the framework of warehouse activities, excessive storage of stocks, long waiting for assembly and completion of shipment, inefficient use of technological zones, etc. are most often singled out.

Despite the fact that the concept of lean manufacturing was formed at the end of the last century, Russian companies began to apply this practice only since 2008, when large corporations such as Sberbank, Russian Railways and Russian Post acted as flagships. At the same time, most of the industrial and warehouse real estate still does not use the principles of lean manufacturing and digital technologies that can reduce the level of unintentional losses in the course of warehouse activities. This is the reason for low throughput and many types of losses during warehousing activities.

As we can see from the analysis of the stages of implementing the principles of lean manufacturing, modernization and automation of the warehouse complex requires not only significant financial investments, but can often last from several months to 1 year, which limits the activities of the warehouse and requires time and labor costs. Thus, each project providing for an increase in the efficiency of warehouse activities and reduction of unforced losses should be thoroughly worked out, investment-attractive, timely and reasonable.

The use of lean tools in the management of industrial and warehouse real estate can help to form a lean culture at the enterprise, that is, the commitment of employees to the concept of lean production,

namely, to continuous improvement and improvement of business processes.

In the course of the research, the range of digital solutions that can be used by the company to reduce unforced losses in the framework of warehouse activities was considered. Within the framework of warehouse activities, 3 groups of digital technologies were identified: integrated solutions, technologies "person to product" and "product to person.

Fig. 8. Classification of digital technologies aimed at the formation of lean culture in the framework of warehouse activities

The introduction and application of digital solutions listed in this study makes it possible to improve the activities of the warehouse complex by eliminating unnecessary losses, such as excessive waiting during acceptance and shipment, unnecessary human movement and excessive mileage of vehicles, unprofitable zoning, temporary losses on equipment and others.

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