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Intelligent solutions for warehouses – a case study

KEYWORDS
Warehouse, intelligent warehouses, automatic warehouses, construction, company

ABSTRACT
In an era of widespread automation, the aim is to create intelligent buildings, including intelligent warehouses. The smart warehouse aims to cope with the increasing dynamics of processes and maximise the efficiency of resource management. A company that wants to gain a competitive advantage and meet the growing needs of its customers must be open to modern solutions. Companies working in the field of designing solutions that improve warehouse efficiency provide customers with a full range of solutions to boost growth and improve the production process by increasing warehouse capacity. These include warehouse management software, automatic storage systems, warehouse racks and internal transport systems. Basic warehouse processes carried out by humans are being replaced by machines and automated tools. In Poland, many companies are considering the implementation of automation in warehouses, while in other countries around the world there is much greater awareness of warehouse automation. The aim of the article is to present modern solutions applied in various warehouses on the example of a company dealing with the supply and implementation of complex solutions of storage systems. In order to realise the above topic, research was conducted, which consisted of a review of scientific literature and Internet sources in the field of storage logistics. The available literature sources, after careful selection, were analysed and presented in this article. The results are presented in descriptive form.

1. Introduction

Nowadays, when the demands of society have to be met and consumerism is a widespread phenomenon, companies try their best to satisfy human needs. The mass production of goods and the desire to have new products has meant that the production company, and consequently the entire logistics of production, is closely linked to warehouse logistics. The decisionmaking process regarding the selection of a suitable warehouse represents a challenge for companies, as the decision-makers must take into account many factors that will affect the implementation of warehouse logistics right from the start [1, 2].

The ever-increasing demand for warehouse space is forcing companies to innovate in order to use it as efficiently as possible. Nowadays, the scale, complexity and importance of logistic processes, including the management of the flow of raw materials, semi-finished and finished products, are increasing rapidly. For their efficient and effective functioning systemic, integrated and tailored solutions based on information technology and automation are needed [3].

The aim of the study was to present modern solutions applied in various warehouses on the example of a company dealing with the supply and implementation of complex storage system solutions. In order to realise the above topic, research was conducted, which consisted of a review of scientific literature and Internet sources in the field of storage logistics. The available literature sources, after a careful selection, have been analysed and presented in this paper. The results are presented in a descriptive form.

2. Literature review

A warehouse can be defined as a functional-organizational unit intended for storage of material goods (stocks) in a separate warehouse building according to established technology, equipped with appropriate devices and technical means of management and operation by a human team [4]. A warehouse may be a separate area (space) which is used for storing and handling stock [5].

A storage and handling system (warehousing) is defined as a coordinated activity in time and space consisting of the accumulation of stocks, their storage together with handling, care and control activities. This activity is carried out using the entire storage infrastructure [6].

In the logistics system, the warehouse has many functions. The most important functions include the storage of goods and handling activities. Storage is understood as storing goods in a place intended for this purpose, at a suitable temperature, cleanliness, air humidity and proper protection against access of third

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parties. The manipulation activities are related to the receipt of goods, their release and movement within the warehouse [7, 8].

In every warehouse, three basic zones must be distinguished. The first one is the receiving zone, where goods are received from the supplier and prepared to go to the next zone, which is the storage zone, where goods are stored until the company needs them. The last one is the issuing zone, here the goods are issued for consumption by the company. [9], An example of a warehouse diagram with zoning is shown in Figure 1.

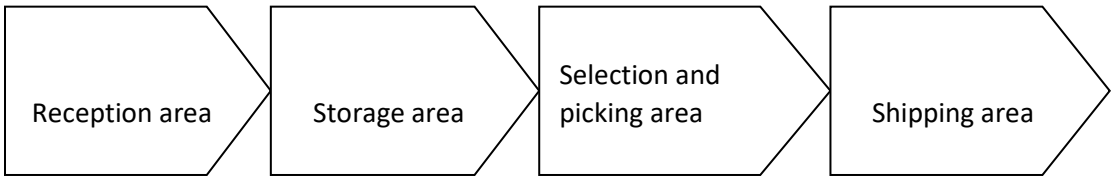

Figure 1. Basic warehouse diagram with zoning Source: [10]

In order to effectively carry out tasks related to temporary storage of products in appropriate conditions and to their transport over short distances, the following factors must be taken into account [11]:

- the technical conditions of warehouses as buildings and their suitability for their function, and the technical equipment of these warehouses (e.g. suitable equipment for unloading etc.)
- goods streams (including: volumes of deliveries, their structure, distribution over time, loading and unloading method, quality control of deliveries, etc.)
- the temporal and quantitative distribution of demand the organisation (workflow, information system, preparation of deliveries, task areas, etc.)

The intelligent warehouse forms an organisational and functional logistical link capable of quantitatively and temporally aligning the material flow in the supply chain. Modern transport and storage systems differ primarily in (Korzeń 2000):
– the scope of the activity in question,
– the tactical and operational functions performed,
– organisational and functional affiliation,
– the type of cargo stored and moved.

In 2014, the Panel of Polish Logistics Managers conducted a study which showed that nearly 60% of Polish companies had not thought about implementing automation in warehouses. In other countries, there is much greater awareness of the need to automate particular segments of production facilities, including warehouses.
Automated storage systems improve the incoming operations and, in turn, the storage and dispatch of loads on pallets. They increase both the speed of all operations and the safety of the storage process. This type of warehouse is available as a built-in silo or as a free-standing warehouse. Its purpose is to automatically store pallets, grid boxes and individual carrier systems [3].

3. Case study

Company X is one of the leading companies in the global logistics solutions market. The researched company is at the forefront of advanced warehouse systems manufacturing. It has been designing and delivering effective and efficient warehouse solutions to its customers for over half a century. The company operates worldwide as a one-stop supplier, implements and integrates its products: warehouse management software, automated storage systems, warehouse racks and material handling systems. Company X has several production plants in Europe and America with a total area of more than 350,000 m^2, and a centre for the development of warehouse software. The company is present in more than 65 countries and has an international workforce of more than 3,000 professionals. It has four technology centres, where it works on improving the technologies used, designs new products, researches raw materials and construction solutions and carries out strength calculations and tests. All products must comply with the applicable safety quality standards. Advanced calculation and 3D modelling software is used to simulate static and dynamic behaviour. The surveyed company pursues an integrated environmental policy in line with the principles of sustainable energy development. Coope-ration with many entities from various fields and industries allows it to act as a general contractor even for the most complex projects. A full range of services is offered to customers, accompanying them through every stage of implementation, from design to after-sales service. At the company headquarters there are two showrooms with an area of over 8000 m^2, where you can see how modern storage solutions work. Company X has implemented thousands of storage installations. The article presents modern solutions designed and implemented by Company X on the example of companies located in different parts of the world (Figure 2).

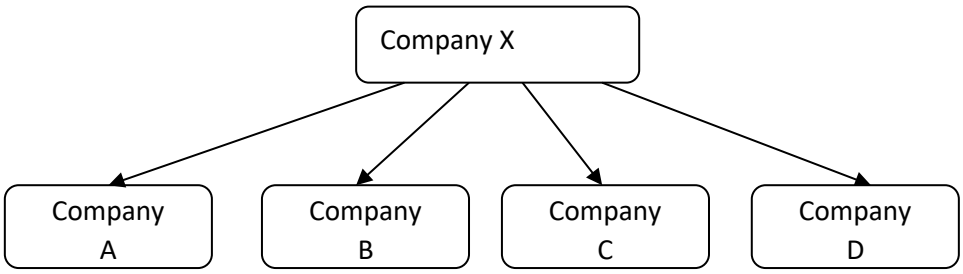

Figure 2. Example companies where modern storage solutions have been implemented by Company X
Source: Own development

Company A

The first logistics centre is located in Mexico, which distributes fast moving consumer goods. The facility was completely designed and equipped by company X. The processes taking place in the modern logistics complex are a combination of speed, efficiency and control. For a company that manages more than 6,500 assortment items, high complementation efficiency is particularly important.

Company A was looking for an efficient system that would give them adequate control over their supply chain processes and allow them to expand to another part of the country by opening a new branch. From a number of suppliers specialising in this type of solution, Company A chose Company X because it offered a comprehensive solution that would provide control over a large number of product items and handle a large inventory.

The facility combines a number of solutions. In the first zone there is an automated warehouse and accumulation storage racks with Pallet Shutte system. It is adjacent to an area with picking mezzanines and a sorting area. The goods enter the warehouse from the unloading racks. In this area, they are stacked and await transport to the shelves. The automated warehouse is a self-supporting structure with a height of more than 30 m and a length of more than 65 m, which accommodates more than 27,000 pallets. Two stacker cranes are used to manage the 8 aisles, since a low number of stacker cranes means lower costs. This saving is made possible by the use of a transfer bridge. This is the device responsible for transferring the stacker crane from one aisle to another. The stacker crane is anchored to the transfer bridge so that it can be moved safely to another aisle. This solution is used in warehouses in which the turnover of goods is not very high but there is a large stock of goods. This solution makes it possible to store a large number of goods at an optimum cost for the entire self-supporting warehouse, which is why this solution is more economical for company A. In the front part of the automated warehouse, both the entry and exit of goods take place. With the help of a double shuttle, the pallets are transported to their designated aisles. Opposite the automated warehouse, there are several double-decker racks with the Pallet Shutte system. In this area Company A stores goods with a higher turnover.

The second large area of this logistics centre is the order preparation area, where the picking mezzanines and the sorting area are located. Forklift operators deliver goods to the mezzanines from both the automated warehouse and the Pallet Shutte system racks. This operation takes place during the day so that at nine o'clock in the evening, the operators can start picking. The picking mezzanines are three five-storey racking blocks. On the three lower floors picking takes place. They are equipped with flow racks where goods are stored according to the FIFO method, which means that the first pallet in is the first pallet out. The other two floors are equipped with push-back racks, where the stock of products is stored for fast delivery to the first three floors. Operators take the catons indicated by the system and place them on conveyors running through the middle of each storey. At the end of the first and second floors is a spiral conveyor that transports the cartons to the third floor, where cartons from all three floors are collected. The cartons transported by conveyors from the three towers meet on one conveyor, and this is the sorter. A scanner at the beginning identifies the cartons with barcodes in order to assign them to the correct orders. The sorter is equipped with a system which directs each carton to the correct exit. Eleven exits take the goods to 11 loading ramps, from where they are dispatched. This system enables several orders to be picked at the same time. Operators place the cartons on conveyors and an automatic sorter separates them into individual orders. Company A has been provided with a highly efficient end-to-end solution, which allows for fast and effective order preparation and thus an efficient response to customer needs.

Company B

Company B is a chemical industry leader in the Turkish and Eurasian markets and is based in Turkey. The company's four production facilities for cleaning and hygiene products are located there. Due to a significant increase in production in recent years, Company B commissioned Company X with the construction of a warehouse that would enable the integrated and automated management of logistics and warehousing processes. Company B's self-supporting warehouse was constructed using 10,000 tonnes of steel and its impressive dimensions far exceed those of conventional warehouses. The warehouse is 46 metres high, 120

metres long and 105 metres wide and can store more than 160,000 pallets.

Company B has invested heavily in the construction of a new warehouse and is very pleased with the results, as the investment has resulted in an immediate profit. The dismantling of external warehouses and the construction of a new central warehouse resulted in significant savings due to the elimination of transport between different locations. The movement of goods between processes is now carried out without the involvement of employees.

Communication between the production plants and the warehouse is via four above-ground tunnels that connect the tissue, hygiene and laundry detergent factories with the logistics centre, reducing the time needed to move goods. These tunnels allow the transport of a large number of pallets thanks to accumulation conveyors installed in them and thanks to vertical lifts handling two loads each, which move the pallets to the warehouse entrance level.

The warehouse of company B consists of a silo and a four-storey technical building. The offices are located on level one, level two houses the picking area and level zero and three are the entry points for the goods into the silo. Most of the goods are transported from the factory through tunnels and delivered to the silo by means of two Monorail installations, each 450 metres long, located on levels zero and three. This transport is completely automated. Thanks to its high transport speed of up to one hundred metres per minute, the Monorali system enables more goods to be received and dispatched. On level zero, company X has installed an automatic unloading system for trucks delivering goods from a laundry detergent factory two kilometres away. Both levels are equipped with a pallet size checker and a weighbridge which checks that the pallets are within the allowed weight. After passing through the checkpoint, the pallets are loaded onto Monorali system trucks and transported to the silo. Company B's silo is served by 15 stacker cranes that distribute the goods on twenty-four storage levels using state-of-the-art technology. By means of the stacker cranes, the goods are moved both vertically and horizontally, which shortens storage and retrieval times with a maximum speed of 180 metres per minute. The stacker cranes are equipped with a telescopic gripper, i.e. a horizontal handling mechanism for extracting or placing load units in single or double-depth racking. Company B's warehouse is also equipped with a safety system to limit any risks, as well as a fire protection system. Company B's premises are located in a high seismic risk zone, which required anchoring and additional structural elements weighing more than 2,000 tonnes.

The picking area in warehouse B is located on level 2 and consists of two zones. In one of them, the goods are taken from the pallet racks and in the other, there are dynamic channels served by four shuttles. The goods are transported from the silo by means of four vertical lifts which connect the Monorail system on level 3 with the picking area. The warehouse's WMS software places the loads in the most favourable way and shows the operator the optimal route for picking the order in question. Once the pallets are completed, they are wrapped, labelled and sent by two vertical lifts to the Monorali system on level zero, which in turn transports the pallets to the dispatch area.

The dispatch area is located on level zero. It is equipped with 17 dynamic channels. gravity channels with a capacity of 33 pallets each are flow storage systems that allow the movement of pallets and group goods by order or route. At Company B, the van loading and unloading system operates 24 hours a day, seven days a week and handles more than 150 vehicles per day. Achieving this number was made possible by automating the entire complex.

Company X built one of the largest self-supporting warehouses in Europe for Company B. The implementation of a customised design for storage, production and dispatch of goods made it possible to optimise warehouse space, introduce precise control of goods and ensure the highest level of efficiency by fully automating the processes.

Company C

The German company C, an international leader in the sale of assembly and fastening materials, has expanded its facility in Spain. The 70,000 m^2 logistics centre has enabled it to meet customer demand throughout Spain. Company X supplied a turnkey installation for it, implementing many solutions to meet the company's growing needs. One of the main advantages of the installation supplied by Company X is that it can accommodate 15,000 pallets on just 3,500 m^2. This was not possible with the traditional pallet warehouse the company previously had.

The new distribution centre, built in the immediate vicinity of the existing halls, includes an incoming and outgoing area and an automatic self-supporting warehouse, 26 metres high and 115 metres long, served by five stacker cranes. The adaptation that the company had to undergo, as well as the work that had to be carried out, could not have a negative impact on C.

Company X took care of every detail, including colouring the installation to match the colours of Company C. The result is a self-supporting warehouse with a capacity of 15,000 pallets and a two-storey incoming and outgoing area. On the lower level, goods are received and released via 12 loading ramps. On this level there is a conveyor loop and three infeed and two outfeed lines. One of the infeed lines is equipped with an automatic system for placing damaged pallets on base pallets. The pallets then pass through an inspection station, where their dimensions and weight are checked as well as the condition of the load checked. At this point, a scanner reads the pallet's information into the computer management system, which decides whether to put the goods into the automated warehouse. Once the pallet has passed verification, it is transferred to the upper floor for entry into the warehouse. The entries are made by means of a monorail overhead transport system, which makes it possible to achieve a flow of 300 pallets per hour, 150 incoming and 150 outgoing. The pallets leave the warehouse using conveyors and

a monorail overhead transport system. The pallets are delivered to the lower floor, from where shipments are made, by means of a lift. Directly next to the overhead trolley line are two manual picking stations for low and medium-rotation products. The picking stations are equipped with pneumatic arms to facilitate the operators' work when handling large and heavy products. This system allows several orders to be prepared simultaneously. Once the required product has been picked, the pallet is returned to the automatic warehouse. On the upper floor, there is also a pallet conveyor system with a bidirectional entry and exit line. This conveyor is connected to the pre-existing warehouse by a pallet lift which lowers the pallets to the lower level. High-rotation picking operations are carried out in this warehouse. The whole system is managed by the WMS software of company X, which cooperates with the superior IT system of company C, making it possible to track and manage all the loads: from their reception, through storage, to their release. The installation is supervised by a control system that monitors the different zones by means of cameras.

Company X provided Company C with a full range of solutions to boost its growth and streamline its production process by achieving greater storage capacity, improving quality and speed of service.

Company D

Drinking a glass of juice or heating up a soup are simple everyday tasks. But behind every packet there are hundreds of kilometres from the orchard to the shop shelf. Company D supplies juices, nectars, smoothies and cream soups to supermarket chains. The company's 66,000 m2 production facility in Spain is one of the most efficient, modern and comprehensive in Europe. As a leader in its field, Company D needed a partner like Company X to finalise the design of an innovative automated warehouse capable of serving Spain's largest food companies. The most distinctive part of the entire project is the tall, automatic self-supporting warehouse. The carefully selected finishing elements harmonise with the surrounding landscape.

Company D's warehouse is divided into two levels. The lower level is used for incoming and outgoing goods, while the upper level delivers goods to the silos. Pallets with finished products are delivered to the warehouse by automatic carts from the packaging area on conveyors located in the lower area. A control gate validates the status of each pallet. The pallets are entered by a double pallet lift, which transports them to a higher level. Four stacker cranes then pick up the pallets and place them in the correct position in the racking. Company D handles two types of load units: europallets (1200 x 800 mm) and half-pallets (600 x 800 mm). In order to be able to handle the half-pallets, Company X installed roller conveyors with less space between the rollers, chain conveyors with four chain strings and three crossheads each on the racks to maintain greater safety during load placement.

He operation of the silo is organised as follows: three stacker cranes handle the products at ambient temperature, while one is dedicated to the products in the cold store, separated by a refrigerated door with automatic access. The warehouse was designed and built to be able to expand in the future, taking into account the space required for the installation of three new stacker cranes.

Stacker cranes place the issued pallets on the lower level and two shuttle trucks transport and place them in the corresponding flow channels in the loading docks. There are seven groups of channels: five for products stored at ambient temperature and two for refrigerated products, guaranteeing the continuity of the cold chain. Each group of channels accommodates the number of pallets required for a full truck load. The channels are equipped with a modern system of hinged modules that make it easy to keep the warehouse clean. The WMS software of company X manages all the processes from reception to goods issue. Company D has strict conditions regarding the quality and safety of food products and needed a warehouse that met their expectations. The company has a high level of requirements which it also applies to its suppliers, and company X was able to meet these requirements.

Conclusion

In today's age of widespread automation, the aim is to create intelligent buildings, including intelligent warehouses. The intelligent warehouse aims to cope with the increasing dynamics of processes and to maximise the efficiency of resource management [14, 15].

Before building an automated warehouse, it is most important to identify and correctly define your needs and expectations. This enables all the processes involved to be designed optimally. The better the initial design, the better the level of efficiency and profitability of the automated warehouse will be.

One of the reasons why the companies chose company X as their warehouse solution provider is that it provides both storage systems and warehouse management software that guarantees total control of the stored loads.

All companies have received highly efficient, comprehensive solutions from Company X, which allow them to prepare orders quickly and efficiently, thus responding to their customers' needs. Company X has implemented a number of customer-specific projects in the field of warehousing and dispatch of creations, which has enabled it to optimise its warehouse space, introduce accurate control of goods and ensure the highest level of efficiency by fully automating the processes: from receipt, through storage, to loading the goods onto the truck. Company X provides the company with a full range of solutions to boost the company's growth and streamline the production process by achieving greater storage capacity, improving quality and speed of service. Company X has developed and implemented many customised solutions, contributing innovation, technology and excellence.

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