

Warehouse design for production needs

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Abstract. The presented article was written based on experience from the proposal of design of a new storage system for the needs of creating student theses. Based on cooperation of our faculty with one local company, we were invited as consultants to help with preparations of a new warehouse that will be located in the recently purchased building. The aim was to design a warehouse layout and design storage systems for the materials used in the manufacturing process and the storage of finished products.

1 Introduction and theoretical background

Warehouse management is one of the most important parts of the logistics supply chain management. Warehouses helping to achieve transportation and production economies, supporting the firm's customer service policies or helping to overcome both time and space differences that exist between producers and customers [1]. Holding optimal stock levels and storing them properly can be a critical factor in firm's competitiveness.

The basic functions of warehouses include receiving, transfer, order selection, accumulation and often sortation, cross-docking and mostly shipping [2, 3].

Optimal warehouse layout, appropriate handling equipment and storage are critical factors in storage costs. One of the most significant type of these costs is human labour [2]. Poor deployment of warehouses or unsuitable handling means increase the storage and unloading time and thus directly affect storage costs. Warehouse design deals with four basic activities: overall structure, department layout, operation strategy selection, equipment selection, sizing and dimensioning. Size and dimensional decisions determine the size of the warehouse, as well as the distribution of space between the different storage departments. The department layout is a detailed configuration within the warehouse department, such as configuration of a search area aisle, a stacking pattern for block-pallet stacking, and configuration of an automated storage and retrieval system. [4]

In relation to warehouse equipment, it is necessary to determine the optimal level of warehouse automation. The equipment is also affected by conceptual design of a warehouse. This determines number of storage departments or selection of specific technologies. All decisions should be made with regard to cost minimization. [4]

For the needs of the submitted case study, the primary warehouse dimensioning and department layout represents most important activities during the warehouse design. The traditional approach looks at the warehouse as a whole - in fact, the warehouse is divided into sections that compete with each other for storage space and need to be viewed and managed as separate warehouses. The storage area can then be divided into five functional areas – receiving, shipping, cross docking, reserve and forward. [5]

Problem of department layout includes problems as pallet block-stacking pattern (storage lane depth, number of lanes for depths, stack height, pallet placement angle), storage department layout (doors, aisle orientation, length and width) and dimension of storage racks and number of cranes. [4]

The main goal of this paper is to try to design an optimal solution of warehouse management in the conditions of a particular company, while respecting all the restrictive conditions that were entered.

The basic limitations in the assignment are structural and technical. The building where the future warehouse is to be located was purchased under construction. This means that the load-bearing structure is fixed and the warehouse design needs to be subordinated to the already built building layout.

Due to the limitation of the perimeter walls and the main load bars, the task was mainly focused on the distribution of storage places, aisles and their orientation, and above all on the selection of storage equipment. The company is processing relatively non-standard materials whose storage has not been solved yet. The relatively non-standard dimensions are also the final products intended for dispatch, which require both a lot of space and also a specific storage (e.g. vertical, must not lie on top of each other, or only a limited number of pieces can be laid).

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2 Default situation

The purchased production hall was built in the 1990s for the development of a state-owned company that was engaged in the production of turboprop aircrafts. It was intended to expand production with a new aircraft model. This project was prematurely terminated in the preparatory phase and the hall the hall remained unfinished and dilapidate since then. The hall under construction is already advanced. The hall has foundations, perimeter walls, internal beams and a roof with skylights. The hall has been in this state for about 20 years.

The company that approached us is engaged in the development and production of composite and sandwich materials for a wide range of applications in the transport industry sector. The company specializes in demanding applications and specialty products where the need for light and solid materials is very important. The company is engaged in project and serial production. This means production in small series, on demand and customer needs, and assembly line production in large series.

The company management is located in an office building. Whole production is located in the largest building that means production lines and all production facilities. In this part of the building, there is also a materials storage. All materials for production are stored in this warehouse, which means resin honeycombs, adhesives and other raw materials.

This warehouse (W1) was originally equipped with pallet racks. This technology is simple and needs more than 50% free space for forklift movement. Of course, with increasing production, this warehouse was insufficient in terms of the quantity of input raw materials and consumption of other means of production. For this reason, storage technology was replaced. Pallet racks remained on the side of the wall, but the shelves were replaced. Because of the need to increase capacity, the technology of mobile pallet racks was designed and installed in the warehouse. This technology increases storage capacity by more than 90% of pallet locations. The advantage is the modular design and increased use of storage area up to about 80%. Of course, this technology allows direct access to all pallet locations.

A temporary tent warehouse (W2) was built for the needs of increasing production and the need to consolidate the consignment to the final customer. It is located opposite the production building. This tent serves for storing long produced profiles, which are placed on a mobile cantilever rack. In addition, profiles are stored in this warehouse before shipment to the customer.

Along the production hall are stored other materials that are needed for the production, or semi-finished product, which are sent as needed to the second production plant, about 8 km away. The next steps of the manufacturing process take place here.

Due to the scale of the production structure and the lack of space for product storage, the company was forced to temporarily rent a W3 warehouse. It is a roofed building with unpaved floors.

Over the last 5 years, production has increased several times. Production portfolio expanded from

composite production to sandwich (aluminium) profiles. Now the company supplies its products for the needs of buses, rail cars, trams, small airplanes and Airbus. Of course, this is also related to the increase in the number of employees and the necessary technology.

Based on these indicators, the company decided to buy a production hall under construction. This step is a long-term and strategic commitment to the company.

3 New warehouse management design

At present, the company is most worried about warehouse management, lack of space, i.e. free capacity. The preparation of the new production hall is divided into stages. So that the company can realize its intentions efficiently and with care.

3.1. Reconstruction and construction of a new warehouse

The construction of the new warehouse will be realized in the first part of the purchased hall (W4). The second and the third part is reserved for production and the new building will now include administration and facilities for employees, including changing rooms and canteen.

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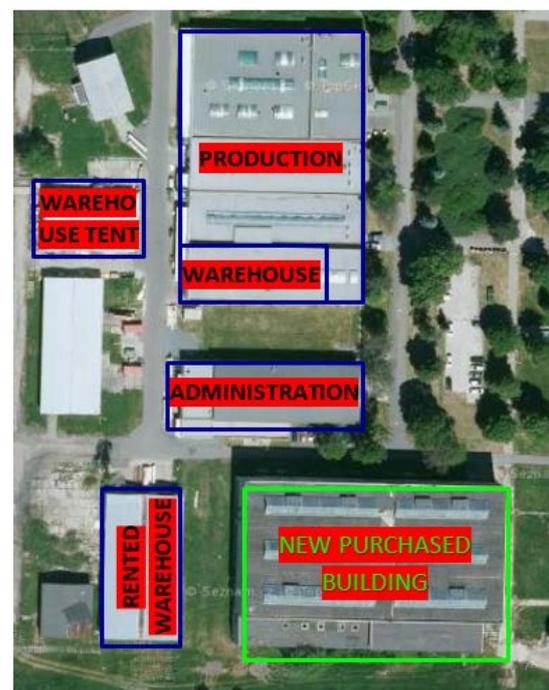


Fig. 1. Location of buildings [Author].

In the beginning, the building layout had to be created. Due to the age of the building, there was a problem with the original documentation. After creating

the layout in the CAD system, the warehouse technology was approached.

3.2. Fire protection

We have to realize that the processed material is classified as an area of increased fire hazard. For this reason, it will be necessary to separate the storage space from the future production area by a fire door. This measure in future operation will disturb the flow of supplies from the warehouse. This will not allow direct loading from the warehouse to freight elevators that will be supplying production. Because of the transport of the material, the fire door will have to open and close constantly. At this point, emphasis will be placed on the lifespan of the automatic fire door opening.



Fig. 2. Warehouses of company [Author].

3.3 Warehouse organization

The proposals for organizing the warehouse vary. From a business and supplier perspective, the solution is proposed.

From the west, the material quality will be controlled and material will be stored. On the north side (on the left side) there will be tree shelves and pallet racks. Along the south wall, the mobile pallet racks will be 12 meters high. The overall height of the hall ceiling is 13.8 meters. The two fire doors will separate the warehouse from production. The first half of the warehouse will be filled with mobile pallet racks. The second, back half, will stay empty for now, but after some time, this technology will be moved here (Figure 4).

Mobile pallet stackers have high efficiency in terms of storage space utilization, as described above. Due to the

survey of logistics companies, we encountered one problem with sliding pallet racking. These systems have a high level of safety, and are resiliently designed. The problem occurred with a long-term used system in one logistics warehouse. The system has been in use for over 15 years and is constantly in use. The height of the sliding shelf is 9 m. There are now problems with this system. Over 15 years there has been a slight wear of railheads and a slight drop in the load floor. One of the legs was derailed in one shelf. Fortunately, there was no drop in the shelf and any domino effect. The domino effect is known as a mass fall, beginning with the damage of one pallet rack, collapsing one rack to another and transferring the fall to all other racks under the weight of the stored material.

Furthermore, this solution does not guarantee the FIFO (First In / First Out) system. Material boxes will be loaded as needed. Of course, each box will have different content. The resin honeycombs have different thicknesses according to the order and each box contains honeycombs with different thickness. It is not solved how to sort honeycombs, so that the necessary thicknesses are carried out regardless of the unloading of human labour and order in the warehouse. And how they should be stored to comply with the FIFO system.

In the present warehouse, the received boxes with different types of honeycombs are stored on a pallet rack, after the material removal the collected material is recorded on the box. Then it is about the order in the bar code system and about putting information into the system.

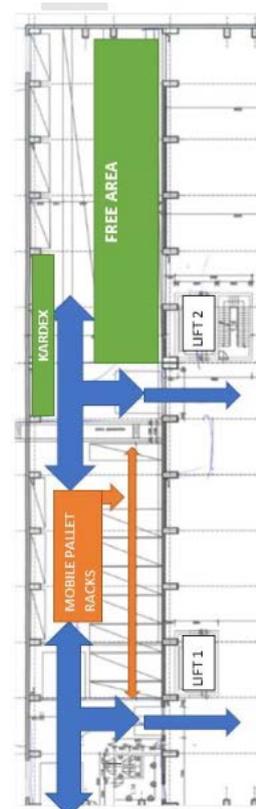


Fig. 4. Layout new warehouse W4 [Author].

4 Proposal from the view of faculty consultants

In the second half of the building, we agreed to store smaller items suitable for crates and use a vertical lift stacker. It would use the height of the space and the system to reach a height of 12 meters. This would allow storage of approximately 6,000 items within 3 vertical stackers. Due to the range and variety of materials, we get to 2,000 items per vertical elevator stacker. This would allow having the same material in each tower. Furthermore, a vertical carousel stacker could be used to store the product and the small material. It should be deployed in pairs to secure the system and prevent downtime. [7, 8]

These suggestions are focused on the northern wall. If this system were placed in the back of the warehouse closer to the middle fire door, the access time from the elevator to the material could still be shortened.

The most important question is how to store resin honeycombs with the FIFO method. Honeycombs are supplied in a pre-agreed size and thickness. We know for sure that the largest dimensions are 2,000 mm x 3,000 mm. At this point, the task is set up for the solution. The storage system supplier has nothing to offer.

4.1. Rotary tray

The rotary tray is an interesting idea to solve this problem. Placed honeycombs are accessible, just turn the tray to the desired position and remove the honeycomb from the tray (Figure 3). The bin has limited capacity per revolver. This can be improved by a system of two turrets in a row, or by the number of turrets that allow for a full length. We designed the container in the following dimensions with respect to the size of the honeycombs. Central Thousand Edge Drum should have 0.5 m in diameter. By this the revolver meets the honeycomb dimensions. The inner space of the fan, both on the thousands of drums and on the circumference, must be filled with a honeycomb shock absorbing material where a collision can occur during the revolver rotation. The revolver is designed with a height of 6.6 meters and a depth of 2.05 meters. Plates are stacked vertically. See the picture below. Of course, ergonomics is also meant. Resin honeycombs are lightweight and handling must be done using transport trolleys. Once they are inserted into the revolver, the manipulation is only about inserting and ejecting the honeycomb. The only problem with this solution is when the honeycomb must be lifted from its vertical position. There must be two employees in this handling to prevent the honeycomb from breaking or deforming.

The result of this design is the need to unpack the shipment and re-identify each honeycomb. The next step should be pairing the selected honeycomb information with the stored revolver space.

The shortcomings of this proposal are considerable. There is no full use of warehouse height and large occupancy within the floor plan.

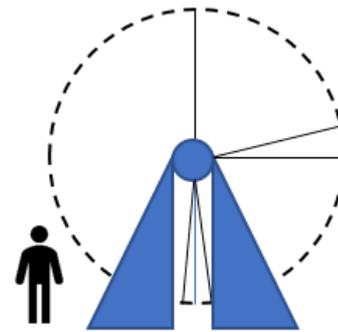


Fig. 3. Proposal rotary tray [author].

In the shortcomings, we tried to look for other areas of production. We had an idea of a system based on a vertical lift stacker. When one drawer would be for one particular type of material. FIFO would be guaranteed only by human manipulation, where new parts would be stored under existing or one position would be only for one honeycomb. As part of our search, we found a system of storing and dispensing large-sized metal sheets (Fig. 4.).

4.2. Tower metal sheet storage system

For storage of large-sized resin honeycombs, this system is fully compliant. Due to the different weight of the sheet and honeycomb, the system can be built to the full height of the future warehouse. In order to insert honeycombs, it is advisable to use a tower metal sheet storage system - a double tower with a transverse station.



Fig. 4. Tower sheet metal [6].

So one lift serves two towers. Two employees manually on the handling surface must place the material. Of course, this process must also include material identification and linking with the information system. The problem occurs during the material removal. Honeycombs are stored horizontally, so two employees must do the manipulation. The FIFO function can be provided by this system.

The disadvantage of this system is the purchase cost, as it is designed for storing plates with a load capacity of 3.000 kg per drawer.

5 Summary

When solving the problems presented by the manufacturing company, we worked on their order. Our

solutions are interesting. The turret stacker is considering the construction of a mezzanine, so the warehouse height would be used.

During the consultations, we concluded that we should have heard their demands and should work without the influence of the company. Before introducing our designs, we realized that the initial storage problem should have been addressed differently. First, we had a systematic approach to the problem and suggestions. We should have focused on logistics. Perform ABC analysis. Based on this, choose a Category A honeycomb system to enable the function within the FIFO. Categories B and C or D are based on LIFO. This material can be stored in boxes and disposed of as before.

In the deeper processing of the proposals, we also encountered problems with the corporate ERP system. We were not allowed to enter it in browsing mode. We did not reach the data for the ABC analysis.

6 Conclusion

Of course, this project of purchased building brings many realizations within industrial engineering, logistics and virtual simulations. The proposed solutions are feasible; only depend on the owners' approach to our proposals. ABC analysis will be carried out and changes will be made to the current stock management based on the data obtained.

A big task will be to design the material flow of production in the future production hall. Here, within the scope and size of production, modelling of production using software will proceed. The team has SW Witness and SW Plant simulator available. This solution has been adopted, as it is necessary to deal with the future three-storey production complex with a comprehensive approach.

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