# POTENTIAL OF USING SIMULATION FOR THE DESIGN OF DISTRIBUTION WAREHOUSE

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**Abstract**

A number of domestic and foreign companies have long been struggling with the problem of storage and supply. Warehouses are an important part of the logistics chain as a link among the supplier, the manufacturer and the final consumer. As such, their concepts and use should be considered in the light of defined strategic objectives of the company. Inventories in all their forms (input materials, semi-finished products, inter-operational supplies, stocks of finished products, etc.) significantly affect the entire logistics system, which they conclusively belong to. Their optimal management is reflected in the economic performance of the company.

The paper presents a case study of the distribution warehouse design in conditions of engineering company. This store should serve to balance unequal customer demand. A specification of key factors had been carried out, in particular, the types of stored materials and their distribution by type of packaging, inventory analysis, sales analysis. Subsequently, the size of the expedition store was determined. The proposals were verified with a dynamic simulation. That helped determine the suitability of the proposed solution.

**Keywords:** Storage, expedition, material analysis, dynamic simulation

## 1. INTRODUCTION

In the past, warehouse management was regarded as a passive, subordinate part of the supply chain in a number of companies. Currently, this attitude is being changed and the efforts to streamline these processes are leading the companies to optimization of the warehouse management and thereby the increase of the company´s competitiveness [1,2]. Thus, effective warehousing and right choice of warehousing technology (warehousing automation) are aimed at achievement of logistic goals of the company and also create the potential to save storage costs [3]. The warehouse is an important component of the supply chain. Bartholdi and Hackman define warehouses as "*points in the supply chain where product pauses, however briefly, and is touched*" [4]. Warehouses have their place in the company although they are related to the necessary technology and costs which are associated with their operation. They are important because they balance demand and supply and, in case of assembly warehouses, create added value this way [5].

The scientific contribution to the problems can be seen especially in the possibility of verifying the design of the distribution warehouse in a dynamic simulation. This paper provides an example of using a simulation model for inventory size determination and appropriate layout of storage space and handling equipment in the warehouse. Dynamic simulation contributes to the right choice of the suitable option at the lowest costs.

## 2. METHODOLOGICAL BASE

When designing a warehouse, it is necessary to classify its type properly and to identify all of its connections with the surroundings [6,7]. It is needful to gain complete information about the stored material (size, weight, dimensions) and, based on the obtained information, then design the means and storage units including the choice of appropriate handling equipment, aisle width and overall warehouse dimensions. When designing, we also have to take into account the areas that are vital for the receipt, storage, subsequent release from storage, packaging and loading.

### 2.1. Warehouse design methodology

The basic process for designing the warehouse is shown in the scheme (**Figure 1**).

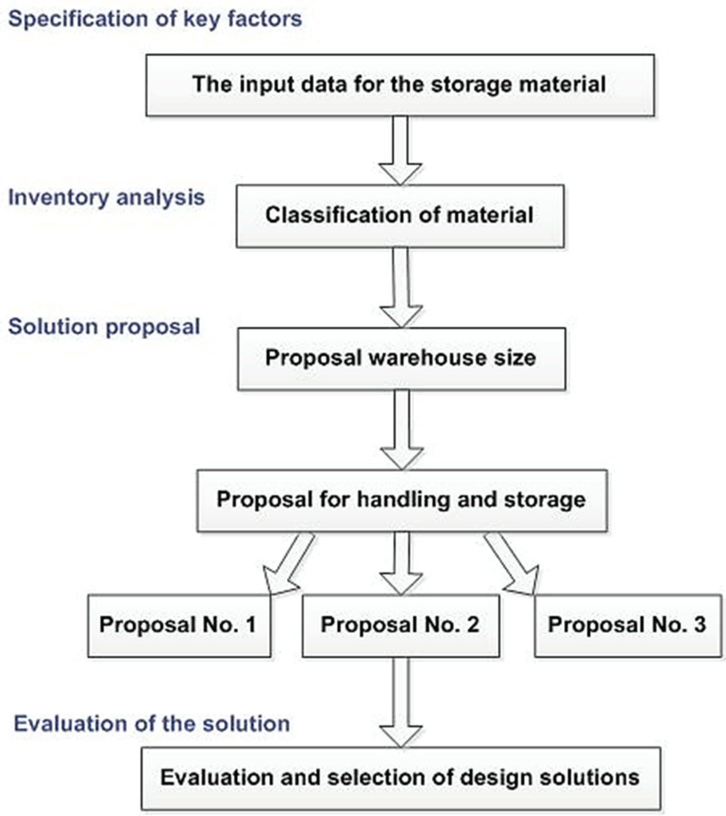



**Figure 1** Warehouse design scheme

Input information essential when designing the warehouse:

- volume of all materials or goods received into the warehouse in a certain period of time,
- number of receipts in a period of time,
- average size of one receipt,
- volume of all materials or goods released from the warehouse in a certain period of time,
- number of releases in a period of time,
- average size of one release.

### 2.2. Dynamic simulation

Dynamic simulation is a very effective tool to support the decision-making. Dynamic model is a part of real world that sufficiently accurately predicts real results and enables us to trigger What-If scenarios. In specialist literature, we can find a plenty of definitions of simulation. R. E. Shannon defines it as follows: „*Simulation is a process of creating a real system and doing experiments with this model in order to achieve a better understanding of the studied system or to evaluate different variants of the system´s activities*“ [8,9].

The simulation was carried out according to the following steps:

- characteristics and amount of handling equipment,
- setting the distance matrix,
- creating the simulation model,
- doing experiments and analysing the results.

## 3. THE CASE STUDY DESIGN OF THE EXPEDITION WAREHOUSE

The case study was prepared for a company which has several separate production facilities within the Czech Republic and which is engaged in the manufacturing of bearings for both the domestic and foreign markets. The aim of the project was the design of the central warehouse directly at one of the key production plants that could replace the four local warehouses of individual plants. In addition to the central function, this warehouse should also become a distribution warehouse and a place where supplies will be completed. The warehouse should be able to release any amount and type of products in the shortest time possible [10].

### 3.1. Key factors specification

At the inventory analysis phase, it was necessary to analyse the input data and to determine the total volume and number of receipts of all types of goods into the warehouse in the given period of time, the average size of one receipt, the total volume of releases in the period of time and the average size of one release. Based on the obtained data, the appropriate warehouse size will be proposed. The key feature that served to divide the stock items into particular groups was the type of packaging since it has the greatest impact on the optimal choice of handling and storage devices in this case. Four material groups were proposed:

- a "tatranka" is a special name for a package containing a certain number of smaller one-piece boxes. This kind of package is especially used due to easy handling and storage it serves primarily for the storage of small and medium sized bearings.
- a box is a package with only one piece of bearing.
- a bandage is a specific type of package that ensures perfect protection from external influences and that prevents the damage of bearings during handling.
- a tube allows easier handling and storage of a larger number of bearings with a small diameter.

In the proposed warehouse, standardized pallets will be used for the loading, transport, handling and storage of the above-mentioned types of packaging [10].

### 3.2. Inventory analysis

An important role in the design of the total storage capacity is played by the purchase and sales analysis that took place in 2012 a 2013. The term purchase in our case does not represent the conventional exchange of goods for money but only an administrative transfer of the finished product from the production to the corresponding warehouse. Based on the processed data, summary graphs (**Figure 2**) were compiled which summarize all items and their division into four groups according to individual types of their packaging described above.

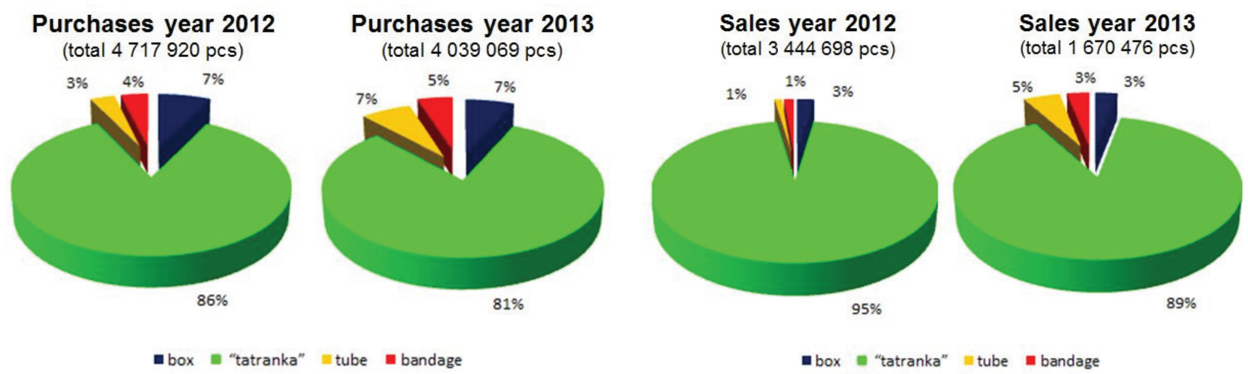



**Figure 2** Total purchases and total sales for the reference period by packaging type [10]

### 3.3. Proposed solution

For the design of the storage space, it was essential to determine the number of orders and the average ordered quantity of particular bearings. The maximum quantity to be stored in the warehouse was determined from the revenue and expenses record. This value represents the maximum quantity that must be accommodated in the proposed warehouse and its value is 4 410 000 pieces of bearings including the necessary reserves. It comprises 2724 different types of design versions. This given quantity is divided into four material groups according to their storage method.

Therefore, the total storage space was divided into two specific parts. The method of storage is important for the verification proposal of the handling and storage equipment. The first part of the warehouse will serve as the storage of poor sales bearing types. These bearing types and variants are mostly packaged individually (boxes and bandages). For these types of packaging, pallets are intended to be used for handling and storage. This first part of the warehouse will be labelled as a pallet warehouse. The other part of the warehouse will consist of a storage device enabling quick and easy release of any amount of high sales bearings stored primarily in tatranka-packages and tubes. This section will be labelled as a sales warehouse.

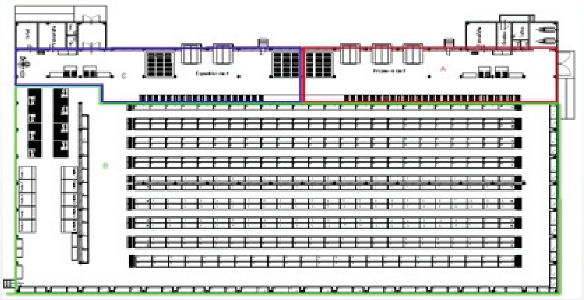
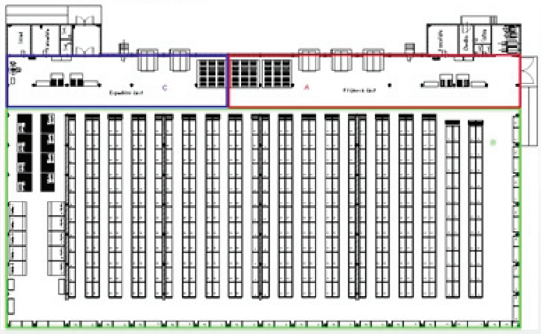
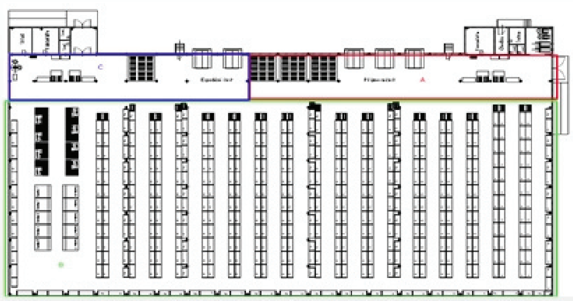
| Graphic labelling | Characteristics of the warehouse |
|---|---|
| Proposal 1 99,27 m x 59,21 m<br> | **area A - receiving part of the warehouse**<br>- unloading trucks,<br>- temporary storing of goods in temporary storage,<br>- operational, administrative and social areas,<br>- electric forklift.<br>**area B - storage part of the warehouse**<br>- a pair of longitudinally located rooms,<br>- pallet warehouse - 10,200 pallet spaces,<br>- the vertical lift part, Kardex - 10 pcs,<br>- racking shelves,<br>- rack stackers.<br>**area C - expedition part of the warehouse**<br>- assembly area with a wrapping machine, temporary storage, two loading stations,<br>- administrative and social areas,<br>- electric forklifts, manual forklift, manual pallet trucks. |
| Proposal 2 92,54 m x 59,21 m<br> | ***Total warehouse length is 7 meters shorter.***<br>**area A - receiving part of the warehouse**<br>- unloading trucks,<br>- temporary storing of goods in temporary storage,<br>- operational, administrative and social areas,<br>- electric forklift.<br>**area B - storage part of the warehouse**<br>- four transversely located rooms,<br>- pallet warehouse - 10,200 pallet spaces,<br>- the vertical lift part, Kardex - 10 pcs,<br>- racking shelves,<br>- rack stackers.<br>**area C - expedition part of the warehouse**<br>- assembly area with a wrapping machine, temporary storage, two loading stations,<br>- administrative and social areas,<br>- electric forklifts, manual forklift, manual pallet trucks. |
| Proposal 3 104,11 m x 59,21 m<br> | ***The total warehouse length is 5 meters longer than in the first design.***<br>**area A - receiving part of the warehouse**<br>- unloading trucks,<br>- temporary storing of goods in temporary storage,<br>- operational, administrative and social areas,<br>- electric forklift.<br>**area B - storage part of the warehouse**<br>- four transverse ships,<br>- pallet warehouse - 10,200 pallet spaces,<br>- the vertical lift part, Kardex - 10 pcs,<br>- racking shelves,<br>- rack stackers.<br>- manual pallet truck.<br>**area C - expedition part of the warehouse**<br>- assembly area with a wrapping machine, temporary storage, two loading stations,<br>- administrative and social areas,<br>- electric forklifts, manual forklift, manual pallet trucks. |

**Figure 3** Individual solution proposals [10]

Particular designs of the warehouse differ mainly in the overall dimensions and internal layout of the warehouse (**Figure 3**). A simple pallet is used for handling. A vertical lift system, a pallet rack system and storage racks using the Pick to Light system were used in the storage section.

Selected handling devices: diesel forklift, electric forklifts, forklifts with extensible lifting device, rack stackers, manual forklift, manual pallet truck STILL HPS 25.

Identical input data were used for the dynamic simulation. The models varied in warehouse layout, defining the distance matrix, using the handling devices. Output data for individual variants were compared with regard to the following parameters:

- usability of handling devices,
- travelled distance,
- cost evaluation,
- average time of request implementation.

The functionality of warehouse layout in individual designs was compared. The dynamic simulation enabled to evaluate the above-mentioned parameters. The most significant differences were found mainly in the pallet section of the warehouse. A different layout of rack system was proposed there and two variants of handling equipment were selected for their operation which affected especially the different length of the warehouse and also the various distances among the defined points on the warehouse area. The graphs make it obvious that the travelled distance is larger for design number 1 than for design number 3 (**Figure 4**).

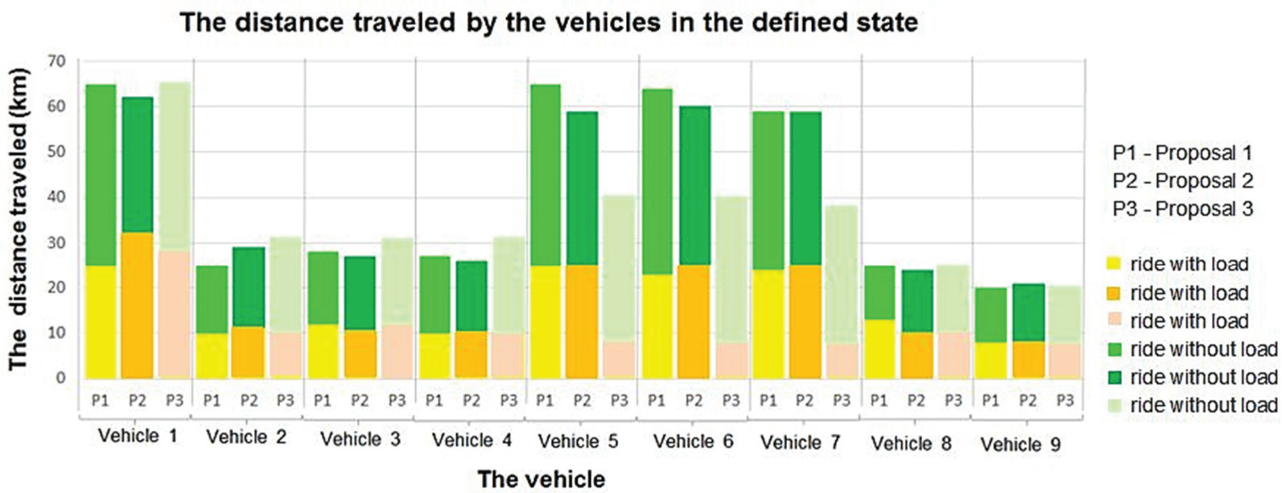



**Figure 4** Comparison of proposals 1 and 3 and evaluation of proposals [10]

The following graphs show that the usability of handling devices converted to the unit of the handling equipment is comparable in the first two designs. The lowest usability is in design number 3 (**Figure 5**).

In other parameters, simulation results were very similar.

Criteria were assigned to the individual items that resulted from the dynamic simulation and particular proposals were evaluated. After evaluating the results of the dynamic simulation, it is apparent that designs 1 and 2 have a comparable order. It is necessary to look at the overall design of the warehouse for both given variants. Design 1, which brings the following benefits, seems more suitable:

- sufficient space for temporary storage,
- brick partition,
- the possibility of extending the storage area.

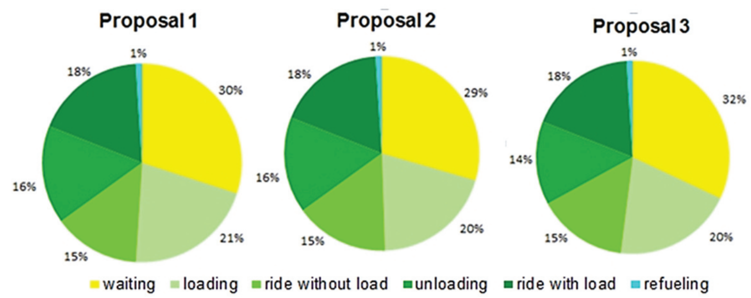



**Figure 5** Usability of handling devices converted to the unit of the handling equipment [10]

## 4. CONCLUSION

Modern storage systems should meet the requirements of the particular warehouse type. The right choice of storage equipment and proper layout of storage systems allow easy release and receipt of the required material in the shortest possible time intervals. The use of simulation represents a significant advantage in contrast to real systems, it enables experiments and has a certain degree of variability and repeatability. The case study was aimed at a proposal of a dispatch warehouse of a mechanical engineering company. It has proved that the practical use of the simulation model based on real layout of the storage systems and equipment enables a very reliable planning of their optimal usage. Verifying several variants by means of the dynamic simulation allows to choose the one which will effectively use the particular system and thereby reduce the level of inventory that will only take up the necessary amount of financial resources but will be large enough to ensure production continuity and release of required material. An effective way of managing the material stocks allows the enterprise to invest free financial resources in its development or innovations, for instance.

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