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COMPUTER ASSISTANCE PROGRAM USED FOR THE OPTIMAL UTILIZATION OF STORAGE RACKS & PALLETS IN THE BEARINGS MANUFACTURING PROCESS

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Abstract: Well designed storage facility is the heart and soul of every logistic system. The subject of detailed storage solution and layout is so far inadequately covered. My goal was to create a software program that would support companies in their selection of ideal types of storage racks and pallets to store various materials on inside their warehouse. For this purpose, I've decided to specifically focus on the concept of weight load and storage capacity utilization as an optimal criteria as part of a system application. This criteria belongs to the most important vantage points according to which storage equipment is selected in real practice. In today's market, there exist a great deal of companies that offer various types of racks and pallets. The structure of available data however (e.g. company e-catalogues) is highly diverse and as a result doesn't offer automatic processing and devising. This is why I have made it my goal to design a clear cut database which stores only those parameters of racks and pallets that are important for work with a computer system when searching for an optimal solution. The actual structure of the proposed database, lets the computer program choose optimal racks and pallets from stored data, conduct capacity calculation of a warehouse as well as draw a possible layout of the proposed number of racks and pallets stored inside a storage facility. The key solution for creating similar computer programs is in fact a well designed database of specific objects (e.g. pallets) used in technological planning.
Keywords: software, optimization, logistics, storage facility, console shelving, weight utilization

INTRODUCTION

The main aim of my work was to design a computer program that help support companies with designing of technological projects in the field of logistics that focus on selecting most suitable storage equipment inside their facility (console shelving and pallets). One condition was that the created software had to have reached a stage where it would enable an ordinary user with basic knowledge of Windows to work with it easily. Working with the computer system had to be uncomplicated so that not only project organizations, but more so companies who are considering to build new storage facility or those who are thinking of rennovating existing warehouses can utilize the program effectively. The expected ways of software application is extensive and ranges from selection of optimal types of pallets and the most ideal way of storing parts inside each pallet taking into consideration its capacity and weight utilization, to a complex design of optimal racks and pallets and their manner of arrangement inside a storage facility. I've particularly stressed upon the versatility when designing the computer program. The user for instance, can him/herself simply update the database in such a way so that the result generated by the system can always be implemented in a real life practice.

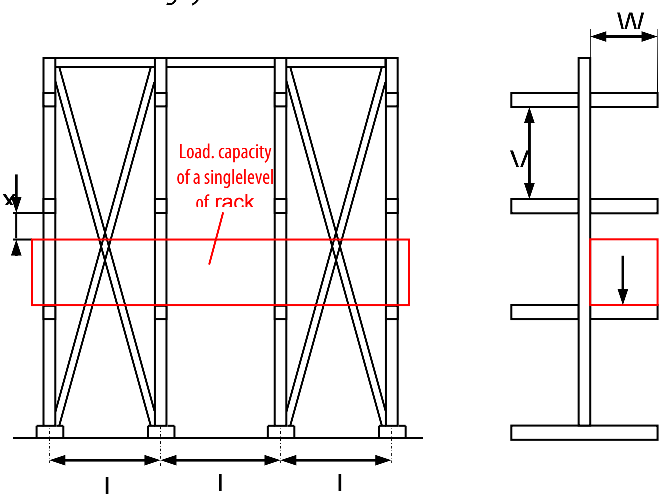
First of all, it is necessary to determine the required capacity of the warehouse. In the course of production of metal bar components, initially, semi-completed parts for these components are stored in a bundle of long rods. When we look at the cross-section profile of stored material with a circulatory shape stacked together, there exist a variety of ways one can store these rods on a single level of a rack. All possible laid down options is considered and implemented by the program. This way, the user for instance, can immediately view the changes to the utilization of specific type of racks during a changeover from a triangular profile to a bundle of stored material with a hexagon shaped cross section profile.After entering the manufacturing process, these rods, stored on racks, can be further divided into parts and later stored inside pallets (storage boxes) of an interim storage facility awaiting expedition [2,6].

SELECTING AN OPTIMAL SHELVING SYSTEM

Lets' clarify the methods used by the program when selecting an optimal rack. The system initially goes through the database of storage racks and then calculates each holding weight. It then tries to find out true length of metal rods to be stored on the rack, given that the user has a certain idea of the range of size of metal rods to be stacked up in a pile (e.g. 1,7 m – 2 m). The selection of an optimal length of metal rods is conducted for every type of console within the database with respect to the distance of supportive stands. The computer program helps determine the final length of the bar for use with optimal size of shelving. On the other hand, the user *him/herself, can also enter fixed length of the bar (if known) into the system which must be strictly observed. As a result, the system finds out the number of supportive stands needed in order to accommodate the storage of selected size of the bars.*

When calculating weight utilization and storage capacity, the program takes into account the max. number of bars that can be conveniently stored on a single floor of brackets. This quantity of bars is limited to the load bearing capacity and dimensions of the brackets. The load carrying capacity of one floor can be calculated as a product of a load of a console shelf and the number of supportive stands which the system has proposed [3]. The weight load capacity of a storage console is stored in a computers' database which can be later accessed by the system and used for evaluation of every type of shelving system. The computer system is also capable of selecting additional parameters such as length of the brackets, vertical distance between each bracket and the amount of brackets on a stand needed for individual storage rack.

The max. number of metal bars stored on a single floor of a storage rack is further limited to its optimal utilization. The system attempts to reduce the max. accessible loading capacity to create space for comfortable stacking up and pulling out piles of stored material. An optimal utilization of space and loading capacity is there for achieved. Metal bars can additionally be stored in bundles. A metal bar with a circulatory cross-section profile such as a pipe, can be stored in variety of ways. The user can choose to store rods in a bundle shaped into a hexagon, pyramid, triangle or a rhombus. All these types of stock piles are supported in the system. On the basis of selected diameter of metal rods, weight of the rods, the geometry of the shelf floor and its load bearing capacity, the computer program can, with the help of algorithm, calculate the amount of rods that can be put together in a stack and the number of stock piles conveniently stored on a single level of the shelving system.



L – length of a single rack (mm)
W – width of a bracket (mm)
V – vertical distance between top and bottom bracket (mm)
x – additional space to allow convenient loading and unloading of stock piles off the rack (mm)

Figure 1: *Diagram of an assembled console shelf [3]*

Fig. 1 represents a double sided bracket storage system assembled from four metal stands [3]. The symbol "L" marks the distance between each supportive stand, which is at the same time the smallest possible width of the rack. The total dimensions of an assembled storage console is in this case three times the length of "L". A single floor of the rack is formed by four storage brackets having a depth of "W". The symbol "V" marks a vertical distance between two storage brackets. The symbol "x" on the other hand represents a safety margin for an optimal stacking up and pulling out piles of material off the rack. The coloured rectangle highlights an area which can be used for storing metal bars.

Inside the computers' database you will find all the accessible variety of racks arranged in a descending order according to their weight utilization – see fig. 4. Every type of rack can be displayed with an overall expense of purchase, depending on the total numbers required. The cost burden is calculated from the price of a single free standing rack entered into the database. The first rack listed is the number one choice of rack selected by the program. The system simultaneously displays concise data as well as the anticipated number of racks required for the proposed storage capacity of a warehouse to store rod shaped material. The computer system also makes a list of the floor space necessary to store racks. (This however relates purely to the net space area that later must be expanded to make way for a road path, checking station and other much needed ground space [3,6]).

SELECTION OF AN OPTIMAL PALLET

As was mentioned earlier, only a certain percentage of material can be stored inside pallets. The pallet with the best space utilization, according to its size, is selected as the number one choice. Naturally, it cannot exceed its load carrying capacity. The storage capacity of a pallet is calculated by the system as a portion of a sum of a cubature of a part packed in a virtual smallest possible rectangular box packaging, the max. number of packaged material stashed inside a pallet and the internal dimensions of the pallet [3]. As a general rule, the virtual rectangular box can be stored in six different positions inside a carrier unit. If the virtual packaging has a square shaped (cross–section) profile, then the number of possible laid down positions is reduced down to 3. (Stored vertically, horizontally and width-wise).

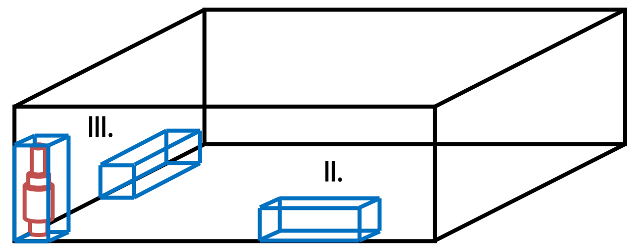
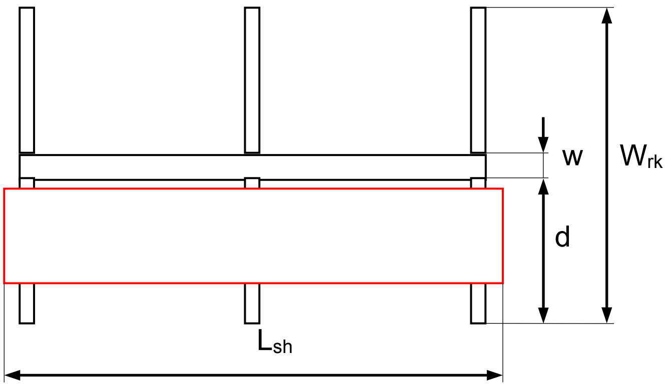


Figure 2*: Possible laid down positions of virtual rectangular box packaging (with a square cross section profile) used to store various component parts of a semi product inside a pallet*

The system progressively analyses each type of pallet stored in its database and then determines the best size of the pallet to be used *and the best laid down position of the packaged material stored within it, in order to prevent wastage of space and enhance its max. storage capacity. The internal storage utilization of a pallet is expressed as a percentage.*

THE LAYOUT PROPOSAL OF A WAREHOUSE

The term "layout" of a warehouse relates particularly to a ground plan of a hall and its ideal distribution of storage racks and pallets [3]. The database of racks also contain figures relating to the depth of two wall brackets (in case of reversible racks), that together with the width of its supporting columns give the overall breadth of a rack. See fig. 3. The system selects the type of rack (when the width of the rack is known) to be used to store rods of specific lengths (assuming the length of the stored bundle of rods is known). The product of the two figures determines the total surface area a rack will occupy inside a warehouse. If we were to multiply the total surface area (m^2) of one rack shelving withthe required number of racks, we will obtain net surface area of a ground floor designated for the rack shelving in a warehouse. The computer program automatically sketches a detailed ground plan of a hall together with the proposed layout of storage racks with respect to the established span length of a hall, its ground surface area that the rack will need to occupy, the nominated number of racks, the size of gaps between each free standing racks and the space between racks and the walls of the hall. See fig. 5. Similarly, it is possible to calculate the net ground floor area of a hall allocated for the storage of material inside pallets (based on the external size of pallets and the max. number pallets capable of being stacked up on top of each other).



W_{rk} – width of a rack (m); d – depth of a storage rack (m); w – width of a support stand (m); L_{sh} – length of a sheaf stored on a single level (m)

***Figure 3**: Ground plan of a rack shelving system holding sheaf of metal rods*

USER-DEFINED INTERFACE OF THE CREATED COMPUTER SYSTEM AND THE USE OF DEVELOPMENTAL TOOL

The computer system was developed with the aid of a developmental tool known as Delphi (from Borland company), which combines strong set of visual tools for the purpose of creating all parts of applications [5]. The nominated user defined interface enables simple and user friendly working with the system. The following pictorials contain main electronic forms for entering initial data and enabling visualization of results based on different stages of the design process of a storage facility.

DATABASE OF FREE STANDING RACKS AND PALLETS

The database of racks contain all the parameters of a rack shelf necessary for its optimal selection. The supportive stands placed behind each other in a row create a so called „composed module rack" long enough to accommodate storage of rod piles – see above. The database of rack shelving contain the following parameters: internal identification code of a rack, its manufacturing code, name of manufacturer, load bearing capacity of a storage bracket (kg), length of a storage bracket (mm), number of storage brackets on 1 support stand, length of 1 rack (mm), width of a rack (mm), vertical space between storage brackets (mm) and price of 1 rack stand (EUR).

The database of a pallet (carrier box) once again contain all the parameters of a pallet which are important for algorithmic selection of an optimal type of pallet. For its selection, it is of paramount to have access to inner dimensions of a pallet as well as its load carrying capacity. In order to calculate net floor plan of a warehouse reserved specifically for the storage of pallets (excluding work space, checking stations etc.), it is also important to know its outer dimensions and the weight of a pile. These figures can also be entered into the database. The cost of a pallet is also another component of the database. The system uses this figure to help calculate total price of a nominated pallet using analogous method as in the case of a rack.

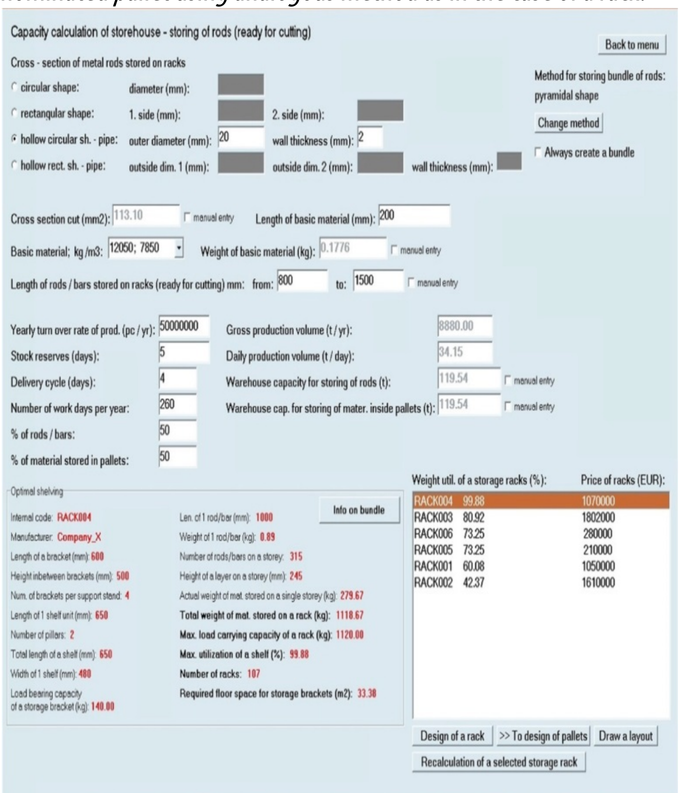


***Figure 4:** Electronic form for entering basic data and selecting an optimal rack*

The database of pallets contain the following parameters: internal identification code of a carrier box, manufacturing code of a carrier box, name of manufacturer, load carrying capacity of a pallet (kg), weight of a pile (kg), inner dimensions (mm), outer dimensions (mm), price of a pallet (EUR).

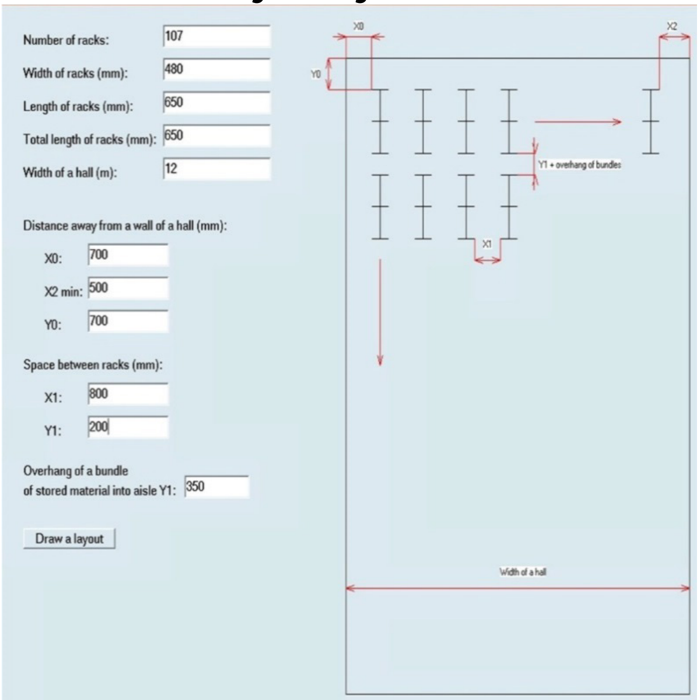


Figure 5: *Form used for entering complimentary data that is vital for generating a diagram of a rack field*

CONCLUSION

By creating a simple database of important object parameters used in technological planning and applying optimal rules over these objects, it becomes possible to greately support the actual process of technological design. The user of the program, this way obtains a tool, which enables him/her to carry out hypothetical analysis „what would happen if....“ (what if analysis). The key foundation for creating similar computer program for the purpose of searching for an optimal solution is clearly the use of a unified database of objects of technological design (in this case racks and pallets). Without such a database, it is not possible to carry out such optimization. Lately, there has been a developmental advancement in the field of information technology. Despite so, no easily accessible central database of technological design objects with a uniform structure exists that would enable the application of a computer program search for an optimal solution. If we were to take a look at the subject of console shelving, despite of seeing vast content of advertised material on the Internet on currently manufactured types of racks and a list of their retailers (mainly inside e-catalogue) the structure of such data is extremely diverse. It is not farfetched to think about whether or not it would be more convenient to come up with a project such as central internet relational database as mentioned above. The editing of this data would be done directly by retailers, knowing that it would assist users to both manually (search through an internet database) or by means of computer program assistance to specifically select their products that would suit them most.

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