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COST JUSTIFICATION OF MOVABLE RACK STORAGE SYSTEM – A CASE STUDY

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Abstract: Nowadays many storage systems exist, requiring proper analysis for a decision which one to implement in a real case. This professional paper presents cost-based analysis of one case study, aimed to evaluate implementation of storage system with moveable pallet racks. Main advantage of moveable racks, storage space saving, justified higher investment costs. Second part of paper illustrates implementation process of selected variant in practice.

Keywords: movable rack, pallet rack, green and brown field

1. INTRODUCTION

According to Gudehus and Kotzab [1], storage systems and their operation are highly underestimated areas of logistics. Due to lack of knowledge, many warehouses are wrongly planned or not optimally operated, which causes under occupation or shortages of storage locations and underutilization or bottlenecks of storage devices. The combinatorial possibilities for the layout and arrangement of warehouses lead to the different storage types, which in combination with storage units, storage devices and in- and outward transport system determine storage technique.

There are several basic types of storage systems in use in practice, related to the different possible arrangements of the storage locations and operational properties. One of them is movable rack storage system as an alternative to the most often used storage system of selective pallet racks. Taking into consideration that shortage of space is a universal problem, and that proper utilization of the available space is the best way to combat storage problems and space shortages, it is important to properly evaluate movable rack system (and capability of space saving) in comparison with other storage type systems.

This paper is a professional paper that shows a case study of construction a green field facility of a warehouse (together with several facilities of a production plant). Case study is based on cost-based analysis of four alternatives. Two types of racks (selective pallet rack and movable pallet rack) and two types of forklifts (reach truck and VNA turret truck) were used in combinations for analysed alternatives.

For the purpose of better understanding of paper, brief description of storage systems (racks) and forklifts, as well as some notes on planning industrial facilities, relevant to this case study, are given in next section. Cost-based analysis of a case study and some insights into implementation of selected solution (installation) are presented in Section 3. Final remarks are given in conclusion.

2. RACKS, FORKLIFTS AND FACILITY PLANNING OF A CASE STUDY

2.1. Selective and movable pallet racks

Selective (or standard, single-deep) pallet racks are most often used storage system for palletized goods in warehouses. Simple, inexpensive and adjustable solution, it offers direct accessibility to all pallet units (locations), decent utilization of storage space using vertical dimensions (several levels with up to more than 10 meters high). However, selective pallet racks requires aisles between each 2 parallel rows of racks, leading to the not so good space (surface) utilization. Some reduction of aisle space requirements is possible using very narrow aisle (VNA) forklifts.

Moveable (or mobile, sliding) racks, on the other hand, can obtain approximately two times more storing efficiency than fixed racks, because each rack moves independently and creates a workable aisle. It is most suited for storage of pallet and case units. Due to the fact that the rack is on a cart, it is especially earthquake-proof and utilizes drop prevention features effectively keep stock from falling. Additionally, the aisles can be uniformly opened to allow for smooth inventory work and the like while also improving cold storage efficiency. Moving of the rack can be achieved by pressing a button on the rack support, by wireless remote control via the forklift truck terminal or by a superior control system [2]. The rail-less type (flexible-path) shortens installation

time and can be installed in existing warehouses and in rented warehouses. Therefore, compared to a pallet type rack, moveablerack uses half as much space (offering very good utilization of storage volume), or for the same storage space offers up to 75% increase of storage capacity [3]. However, movable racks have also some disadvantages compared to selective pallet racks. Each pallet is not available in every moment - racks need to move to create an aisle. Existence of only one aisle per block implies only one forklift operating in warehouse block in the same time, making movable racks useful when inventory turnover is low [4]. To increase throughput using additional forklift(s), one can make system with two or more blocks of moveable racks, however with decrease in storage space utilization due to additional aisles. And finally, storage system with movable racks is a costly solution, with significantly higher investment cost per pallet position compared to selective pallet racks. Figure 10 illustrates one example of storage system with moveable racks.

2.2. Forklifts

In alternatives of case study analysis, two types of warehouse forklifts were used - reach truck (Figure 1) and VNA forklift - racking truck with turret head (Figure 2).

Reach truck is a classic pallet forklift for warehouses. The reach truck is a narrow aisle truck designed specifically for racked pallet storage, with requirement of aisles and cross-aisles (main transportation paths) width from 2.44 to over 3 meters [5]. Very narrow aisle trucks (VNA), as presented racking truck with turret head, have requirements for only 1.8 meters (or even less) wide aisles [5], however cross-aisles has to be 4+ meters wide. Also, this type of forklift requires guidelines for the driving within the aisles to increase safety and reduce property damage. Guidelines can be mechanical (rails) or inductive (wires in the floor). In the case of mechanical guidelines the pallets cannot be stored on the floor (ground level), resulting in some loss of the storage space and slightly increased cost of rack (additional beam). Of course, VNA turret trucks are also costly, being approximately 60% more expensive than the reach truck.

2.3. Type of facility planning

If a new storage system is planned, investment and operating costs can be minimized by optimal storage strategies which can improve the performance, utilization and operating costs. Planning any industrial production facility (including warehouse system) is a complex job and generally falls into one of the three basic categories (Figure 3) [6]:

- ✓ New planning of a factory (greenfield planning),
- ✓ Re-planning and/or extension of existing facilities (brownfield planning),
- ✓ Dismantling of factories, also categorized under brown field planning.

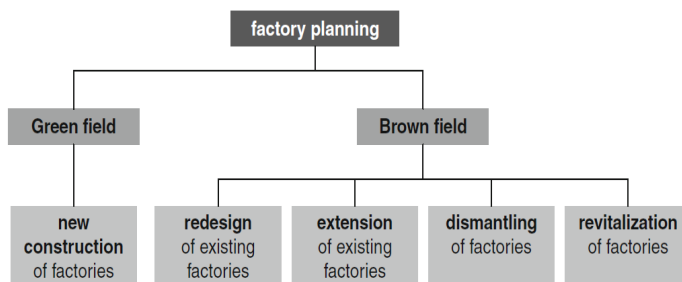


Figure 3 – Basic planning categories in factory planning [6]

With new planning, the factory is built on a “greenfield site” with the maximum level of freedom. Such a high level of freedom allows the optimum factory design to be achieved. However, with this increased level of freedom comes increased complexity and planning effort because with new planning, additional tasks arise such as choosing a site. When redesigning a factory, the existing facilities and processes are modernized and adapted to market-driven changes in the production range. Re-planning is a particular challenge because of the need to allow for existing constraints such as the current infrastructure, e.g., foundations and supply and waste lines, as well as crane equipment. Extending the existing factory is always an option when the available capacity is no longer sufficient.

Case study of storage system presented in this paper was a part of a larger project (part of a medium power transformers factory, including high-voltage laboratory, assembly plant, warehouse and offices) as green field project. However, due to the fact that the primary objective of this project was construction of a high voltage laboratory and assembly plant, the dimensions of the warehouse were limited to 45 meters in length and 13 meters in width. The warehouse solution had therefore some elements of brown-field project, to fit into available space an optimal storage system.

3. CASE STUDY

The case study is presented with cost-based analysis of four different alternatives of storage system as a part of a main green field project, followed by illustration of installation process of selected solution.



Figure 1 – Reach truck [2]



Figure 2 – Racking truck with turret head [2]

3.1. Cost-based analysis

Cost-based analysis presented was done for developed four alternative solutions (variants) of storage system, derived from the various configurations of movable and pallet racks in combinations with mentioned type of forklifts. They were named as listed below:

- ✓ Pallet racks – racking truck with turret head (mechanic guidelines),
- ✓ Pallet racks – reach truck,
- ✓ Movable racks – reach truck – 1 block,
- ✓ Movable racks – reach truck – 2 blocks.

Table 1 presents costs, required space and resulted storage capacity of analyzed alternatives. First three rows represent costs of racks, forklifts and their sum. Fourth row represent required rack space of alternatives. Since the main question from investors was how much space could be saved by using moveable racks (as well as related costs), the table also shows additional spaces needed for other alternatives as well as costs of those additional spaces. In case entire available space is used, and company needs additional space in the future, it should be built or rented. So cost comparison of alternatives is done relative to an optimal space saving alternative “movable racks – reach truck – 1 block” used as a baseline.

First alternative with pallet racks and racking truck with turret head requires also additional storage space because of forklift type, needing wider main transport path, i.e. 4 meters instead of 3 meters.

Both alternatives with selective pallet racks, as well as alternative with 2 blocks of moveable racks requires additional space for racks and aisles, compared to 1 block movable rack system.

Table 1 – Cost-based analysis of pallet and movable racks

Cost based analysis of pallet and movable rack alternatives				
	Pallet racks – racking truck with turret head (mechanical guidelines)	Pallet racks-reach truck	Movable racks – reach truck–1 block	Movable racks – reach truck –2 blocks
Price of racks [€]	22 702.70	16 689.19	90 405.41	75 335.38
Price of forklifts [€]	47 150	29 160	29 160	29 160
Σ Price of racks and forklifts [€]	69 852.70	45 849.19	119 565.41	104 495.38
Space needed for racks [m ²]	371.20	377.10	259.70	289.70
Additional space needed because of forklift [m ²]	37.30	-	-	-
Total additional space compared to the movable rack – 1 block [m ²]	148.80	117.40	-	30.00
The rental price of additional storage space (the 10-year amortization 10%/year) [€]	107 136	84 528	-	21 600
The price of building additional storage space (800 €/m ²) [€]	119 040	93 920	-	24000
Σ Price of racks and forklifts with the cost of renting additional storage space [€]	176 988.70	130 377.19	119 565.41	126 095.38
Σ Price of racks and forklifts with the cost of building additional storage space [€]	188 892.70	139 769.19	119 565.41	128495.38
Storage capacity [number of pallets]	680	650	690	680
Difference in cost regard to the movable rack – 1 block[%]	36.70	14.45	0	6.95

Rental price was 6 €/m², approximately an average price for renting a warehouse around the location where production plant and warehouse are located. Renting period is 10 years, because that is rapid depreciation rate in Croatia for the warehouse. The price of building additional space (new warehouse) was 800 €/m², which was an estimated price for building one square meter of a whole project.

It could be seen from both total prices (which includes price of the racks, forklifts and price of renting or building additional storage space), pallet racks with turret head truck is the most expensive variant. In this case saving spaces with narrower aisles can't even justify price of trucks and additional space for cross-aisle in comparison with pallet racks with reach trucks. The variant with the lowest investment cost is the one with one block mobile racks and reach truck. However, 2 block movable rack variant is very close. It is important to add that the construction site (land) was already owned, so that component of the costs has not been taken into the consideration. If that cost was included, the differences between variants would be even higher. Also the operational costs of heating, cooling and lightening of storage area were excluded from the analysis.

After presenting cost-based analysis, the management of the company decided to implement a variant with 2 block movable racks and reach. The main reason for that decision was the fact that the warehouse is divided into two parts, and in the future the

throughput of the warehouse can be increased by adding the second forklift. In that situation, each of the forklifts can work in his block with no interference. Also, if the one of the engine of a movable rack is malfunctioning, the other block of warehouse can work normally. Figure 4 shows this selected alternative.



Figure 4 – The variant with 2 block movable racks and reach truck

3.2. Installation of movable rack

The main problem of installation of movable racks is a foundation that requires more attention and has higher cost regarding the pallet rack installation. The type and the size of a foundation depend on the size (length and height) and the load capacity of the rack. In this case study, load capacity of the rack was 1500 kg per pallet space. Because of that, movable racks are more suitable for green field facilities than for the brown field facilities. The main reason for this is the fact that movable racks have higher investment costs due to the need for breaking down the old floors of the warehouse. Figures 5, 6 and 7 are showing armoring of the rails, Figures 8 and 9 are showing mounted undercarriage of the movable racks, while Figure 10 shows mounted movable racks, all together illustrating the process of installation.



Figure 5 – Connection of rails with armature



Figure 6 – Armoring plate with rails



Figure 7 – Concrete plate with rails



Figure 8 – Mounted undercarriage of the movable racks

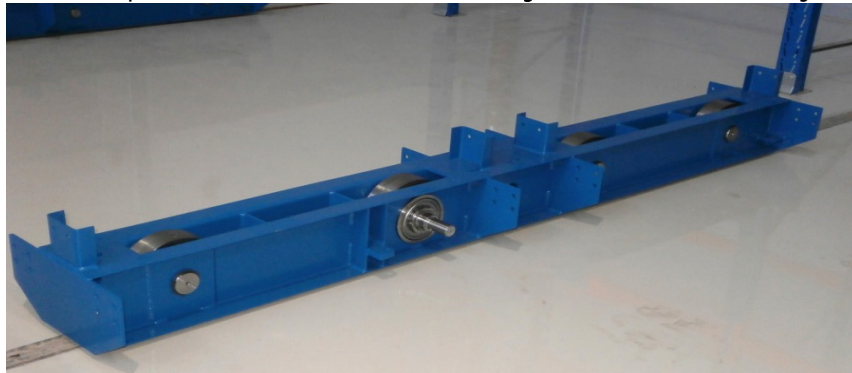


Figure 9 – Undercarriage of the movable rack



Figure 10 – Mounted movable racks

4. CONCLUSIONS

In this paper a case study of a warehouse with cost-based analysis of alternatives is presented. Various alternatives for storage systems in industrial applications exist. Despite well-known theoretical characteristics (advantages and disadvantages), to properly evaluate solutions various cost related and non-cost related factors should be taken into account. However, not many papers with case studies appear in literature. In our opinion such papers provide great value to practitioners, potential investors and designers, as well as valuable educational information to students.

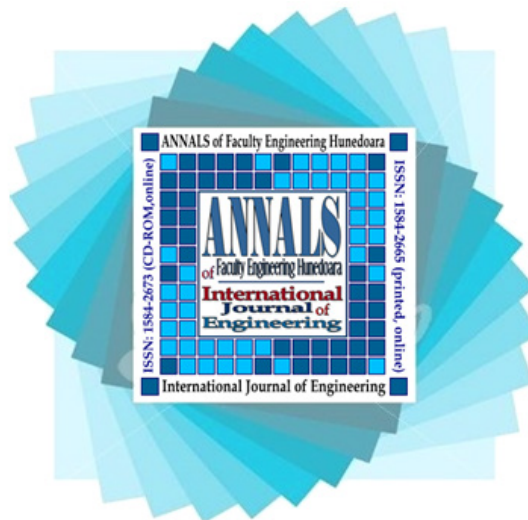
Paper presents a real case project with conducted cost-based analysis of four alternatives for pallet storage. The main idea behind analysis was to evaluate and justify system with moveable racks, according to the main characteristics of space saving. The presented analysis shows how reduced building costs (or costs of renting additional space) can justify higher investment costs of movable rack system. Additionally, decision by the investors also shows how some other factors may influence decision. Although the variant with one block movable racks was cheapest, the management of the company decided to accept the variant with two block movable racks. The main reasons for that was the possible risk of malfunctioning (and entire warehouse blocked) and possibility to increase throughput of the warehouse by easily adding the second forklift.

For further research, work with this case derived idea of possible development of a decision-support model for determination of storage system, given the parameters such as the size of the warehouse, number of blocks, price of the racks, forklifts, buildings, land, etc.

Also, a rail-less movable rack has not been taken into consideration in this case study. This is another topic that would be interesting to analyze. While movable racks with the rails are more suitable for green field constructions regarding the problem of the foundation, rail-less construction for this type of the rack is also suitable for brown field warehouse construction (installing moveable racks in existing warehouse).

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