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INNOVATIVE DEVELOPMENT OF WAREHOUSE TECHNOLOGY

Case Study

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Order picking system

JEL Classification
M19, M21

Abstract

The smooth operation of stocking and the warehouse play a very important role in all manufacturing companies; therefore ongoing monitoring and application of new techniques is essential to increase efficiency. The aim of our research is twofold: the utilization of the pallet shuttle racking system, and the introduction of a development opportunity by the merging of storage and order picking operations in the pallet shuttle system. It can be concluded that it is beneficial for the company to purchase two mobile cars in order to increase the utilization of the pallet shuttle racking system from 60% to 72% and that of the storage from 74% to 76%. We established that after the merging of the storage and order picking activities within the pallet shuttle system, the forklift driver can also complete the selection activities immediately after storage. By merging the two operations and saving time the number of forklift drivers can be reduced from 4 to 3 per shift.

INTRODUCTION

The market is continually changing, and the ability to adapt is essential for both industrial and service firms. The position of a firm in the market is largely determined by its competitiveness, its client-centredness, the quality it offers, its flexibility and its innovation (Takács-György & Toyserkani, 2014). These objectives can only be achieved by extremely cost-efficient management, and the level of warehousing processes can have a significant influence on this.

Our research examines the ready goods warehouse of SCA Hygiene Products Slovakia s.r.o (SCA) in Slovakia. Our objectives are to discover what possibilities there are in ready goods warehousing, and to study in depth the use of the pallet shuttle racking system. We also describe a further possibility, which combines the pallet shuttle racking system with the warehousing and order picking process.

The significance of warehousing in the supply chain

Traditionally, the concept of a warehouse can be defined as that part of the corporate logistics system (and/or the supply chain) that stores the products (raw materials, sub-assemblies, semi-finished or finished products) and the points of use and/or the information serving the link between them (e.g. product status, characteristics) (Stock & Lambert, 2001). The most important reason for stockholding is to meet the differences between supply and demand. This is because it is almost impossible to accurately synchronize demand with supply (Rushton et al., 2010). Storage is a subsystem that promotes the consistency of inventory, alignment of flows and, where appropriate, balances it with its own equipment and facilities. The solutions to these tasks are found in the warehouse. Warehouses do not only include internal processes, but also have external relationships (Prezenszki, 2004).

Thanks to the continuous development of the logistics system and the practical appearance of the supply chain, the role of warehouses has been expanded. Apart from the storage of the products and the transfer of information, emphasis is also placed on carrying out the handling of goods, something which has so far been insignificant, but has now become particularly important (Gelei, 2007). Considering the sophistication of today's modern technology, improvements in the operation of warehouses have brought about large-scale change, which also allows companies to save costs because of the constant changes in economic life. In addition, it promotes market competitiveness and expands the range of new service activities.

The development of business entails new leadership, management and technology processes, and if they prove effective, more and more businesses will use these methods. We have to look for reserves that have not yet been exploited. A supply chain which is able to coordinate activities will enjoy a competitive edge against one that is disorganized (Red, 2010). The warehouse is an essential component of the supply chain and the wider business context should be considered when reviewing potential choices for key decisions (Rushton et al., 2006).

Inventory and warehousing costs are dependent on the value of the product and the time the product is in the warehouse. This entails additional costs, and increases proportionately (Süle, 2014). The warehouse is a major player in the logistics system, its so-called soul, and has a direct impact on the entire corporate structure. Over the past decade or decades, warehouse management has undergone significant development, thanks to the complex and continuously updated logistics processes. In addition to this, the rapid change in technology also contributes to development, which simultaneously improves the quality of operation. Warehousing is involved several times in the whole logistics process. A warehouse carries out the collection and distribution functions, combining 3 processes (subtraction, production, distribution) into subsystems. This enables the implementation of integrated material and information flows and the creation of an optimal supply chain (Prezenszki, 2004). Storage has two important functions: one is storage, the other is supply. Storage is responsible for the conservation of finished products, while supply means deliveries to meet the demands of consumption and sales (Némon, 2013). From a warehousing point of view, based on the general logistic process model of moving raw material from producer to user, it can be stated that warehousing fulfils the collecting and distributing function multiple times in the whole process, combining the sub-processes of raw material production, product manufacture and distribution as a specific subsystem, and making possible the integration of material and information flows (Prezenszki, 2010).

Racking and static storage systems

Various storage systems can be used in warehouses; here we will only focus on the rack storage system in detail because it is used in the warehouses we are investigating. A decision can be made to use this system in two cases; on the one hand, if we store goods that do not have sufficient strength (neither in their packaging), and thus no stable unit can be achieved. The other case is where all kinds of goods require any type of preferred access. One of these types is push back- and drive-in pallet racking.

Push back- and drive-in pallet racking can be used in warehouses where the number of stored unit loads is greater than the number of commodities and there is no need to break the unit loads, and so there is no need for direct access (Szegedi & Prezenszki, 2003). Here we can mention a pallet shuttle racking system that is a system similar to a pallet stand that uses a radio controlled, semi-automatic moving car for storing and extracting pallets. In the pallet shuttle system, the forklift truck does not have to enter the storage paths, eliminating damage to the columns in the channel, and providing a cost-effective storage solution. The pallet shuttle system is an ideal solution for large warehouses and is suitable for different temperature ranges. A high density solution can significantly reduce the amount of storage space needed, and this can reduce operating costs. Different pallet types can be used together and placed at varying distances between individual pallets. The length of the storage slots can be over 50 meters, which means that the pallet shuttle system is one of the most effective mass storage solutions compared to conventional pallet scaffolding solutions (Gwynne, 2014).

MATERIALS AND METHODS

Our research was carried out at the Swedish-owned company SCA Hygiene Products Slovakia s.r.o., at the company's finished product warehouse. The warehouse is also an international distribution center and can store 13,569 pallets. Both primary and secondary studies were used in our research. The research lasted 8 weeks, from the beginning of July 2016 to the end of August.

During the primary research we mainly conducted interviews with the warehouse owners. The interview is a guided conversation that is based on a succession of questions and answers (Szokolszky, 2004). The other major form of analysis was the case study. This means that a particular group or event is observed at a given time, usually after a phenomenon that has caused some change (Ghauri & Gronhaug, 2011).

EVALUATING THE RESULTS

In our research, we examined the SCA Hygiene Products Slovakia s.r.o. finished goods warehouse. The stock warehouse area is 8,565 m^2 and is divided into different zones. Based on this, the Warehouse Management System (WMS) provides the truck driver with the opportunity to store the goods in the right place. There are two types of scaffolding in the ready-made warehouse, with 23 partial layouts. The first is a drive-in pallet rack system, consisting of 19 blocks (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 18, 19, 20, 22, and 23). This drive-in system is advantageous because large quantities of similar type goods can be stored in bulk. This is advantageous for the company under investigated, because the available space can be utilized more 90% effectively than in conventional, serial pallet racks. The other is the shuttle pallet system, which has 4 elements in the warehouse under analysis (14, 15, 16, and 17). The special feature of the rack system is to provide more advanced technology, higher space utilization and flexibility compared to conventional pallet storage systems. Together with a larger scale, and simultaneous movement of goods, it provides a faster turnover fluctuation. The basic concept of the system is based on compressed block storage. In shuttle systems pallet goods with similar loads are stored in each channel or corridor. Continuous development is needed to maintain competitiveness and meet customer needs. A problem that emerged with the entire stock utilization was that the utilization of the pallet shuttle system was inappropriate compared to the drive-in rack systems. For the company under review, this utilization is 60%, which can be considered unfavorable when compared to the expected 90% utilization.

Analysis of the utilization of the pallet shuttle

The main objective of our research is to examine the utilization of the pallet shuttle system. The operation of the system is supported by the WMS warehouse management system, which makes it easier for warehouse staff to work. The system uses a semi-automatic moving car for storage and recovery of pallets. On the trucks, there is a tablet with which the moving car is driven by the truck driver using a built-in WI-FI system. The 4 shuttle element is operated in the SCA ready warehouse by 2 moving cars. The pallet shuttle system is compared to the flow rack and the palletized mobile rack system. The warehouse area is 8,565 m^2 and the total capacity is 13,569 pallets. In our research, only the utilization of scaffolding systems was investigated, so only the quantity of pallets stored in them was considered, i.e. 13,448 pallets. Table 1 shows the utilization of scaffold systems. It can be seen that the value for shuttle racks 14, 15, 16 and 17 is:

$$\frac{346}{576} \text{ x } 100=60\%,$$

and thus these are not properly exploited compared to the drive-in systems (scaffold systems 1, 2, 3 ... ..18) where this value is 77%.

$$\text{For example: } \frac{388}{504} \text{ x } 100=77\%$$

Our goal is to measure the time during which the truck driver places the rolled racks into the pallet shuttle rack system. During the measurements we divided the time taken into three sub-periods. The first is when the truck driver takes the 2 pallets to the shuttle rack system line. The second when he/she is looking for a moving car. The third is the loading period. The sub-periods are shown in Table 2.

The average loading time was 2 min 50 sec. It can be seen that the search for a moving car took a lot of time. There were situations when it was not far from the car and soon found, but the average was 1 min. An average of 40 seconds passed between the first and the second processes. The storage of pallets took so long because the moving car was loaded with two pallets. In order to reduce the duration of the search, several mobile shuttle cars would be needed. If each shuttle rack system (14, 15, 16, and 17) had a moving car, then there would be no need for the truck drivers to search among the sections. Using the WMS system, we ran a simulation to see what time savings could be achieved by purchasing two moving cars. Using the extra two moving cars, and taking into account the original measurements shown in Table 3, would produce time savings of 35%.

In this case, only the average time is used to describe the course of our calculation. Average search time after reduction:

01:01 - (01:01 x 0.35) = 00:40 sec.

Meanwhile, the average storage time for pallets also decreases:

02:50 - (01:01 x 0.35) = 02:29 min.

After comparing the two average times, it can be concluded that the process lasts an average of 21 seconds less. There is no reduction in the time taken to transport the pallets; however, the search time and the storage time interval is reduced. With time savings, the utilization of shuttle rack systems would increase from 60% to 72%:

$$100\% - \left(\frac{02:29}{02:50} \text{ x } 100\right) = 12\%$$

The change would increase the utilization of the complete warehouse, as shown in Table 4.

We have found that it would be worthwhile to buy two moving cars for the company under investigation. The price of a moving car would be € 25,000, i.e. around € 50,000 for two, which would be a much better solution than the other racking systems under comparison. Achieving this is a realistic option for the company, as storage utilization would increase from 74% to 76%. Instead of the current 9,963 pallets, 10,240 pallets could be stored, i.e. an extra 277 pallets.

3.2. Merging the loading and order picking activities within the pallet shuttle system

In the section devoted to an examination of the use of the pallet shuttle system we presented in detail the data measured during storage. In order to examine the two processes together, we have also prepared a timeline for the storage process. We also measured three sub-periods during the measurement. The first is when the forklift finds the prepared 2 stacks. The second is the search for a moving car. The third is order picking. Table 5 shows the sub-periods combined with the time savings.

We have found that the order picking process took about the same time as storage. Based on the time values obtained, the two processes can be combined. The truck driver would receive instructions from the WMS to determine where to place the stacks. After the stacking, the truck driver would not return to the roller conveyor for new stacks, but would have another instruction from the system to determine which pallets to prepare. After receiving this information, he would prepare the stacks and only return to the roller conveyor for new stacks. This would be simpler in that the mobile moving car would be available to the forklift truck after stacking, so he/she would not have to look for it, just put it in the rack and unload it, then transport it to the ramp. By aggregating the processes, the average time would be 6 minutes. We have already calculated that if they were to work with two more moving cars, the time would be reduced. The WMS system is able to give the truck driver instructions for both storing and unloading at the same time. With the WMS there should be no need for new information for order picking, since when the moving car has moved to another row, or stand, and the stacks have been put down, it can be taken to the ramp. In total, therefore, it would only take 5 time units because the second search sub-period would be excluded. With the time gained by the two moving cars, the whole process could be even faster. The consolidation of processes with the reduction in the search time is illustrated in Table 6 below.

The first three time values include the calculated values for loading, as nothing changes here.

01:01 - (01:01 x 0.35) = 00:40 sec.
02:50 - (01:01 x 0.35) = 02:29 min, sec.

Since the WMS system provides both pieces of information, it is no longer necessary to request a second time, so the truck driver can start stacking the loads. Based on the data shown in Table 5, the time needed to move the mobile shuttle car is also reduced because the device is already with the truck driver and does not need to be searched for. The final time, taking into account the average of all the sub-periods and calculating the data in Table 5, would be:

02:29 – 00:20+(00:40-(00:40x0.35)) + 02:29 – (00:40-(00:40x0.35)) = 04:37 min, sec

The 6 minute average time would be reduced by nearly one and a half minutes by merging the loading and order picking processes and by purchasing 2 moving wagons. This would also enable SCA to cut costs. In the ready goods warehouse, one shift requires 4 truck drivers. Since there are 4 shifts, 16 people are employed altogether. By reducing time, it is possible to employ fewer people.

$$\text{Daily movement of pallets} = \frac{\text{Monthly quantity of pallets (23 000 pieces/month)}}{\text{Number of days (30 days)}} = 767 \text{ pieces}$$

$$\text{Average pallet movement of a shift} = \frac{\text{Daily pallet movement (767 pieces)}}{\text{Number of shifts (days)}} = 256 \text{ pieces/day}$$

One shift is 8 hours, but considering lunch breaks, and the personal needs of the staff, there is an average of 6.5 hours of full-time work. Calculated per minute, this is 6.5 x 60 = 390 min. Within a shift, the 4 fork lift truck drivers, working at an average of one every 6 minutes, without any time reduction, would move 256 pallets in the 1531 minutes (256 x 6 = 1531 mins), after time reduction, with an average of 4:37 min, 256 pallets could be moved in 1181 min (256 x 04:37 = 1181 min). Based on the values obtained, we found the following.

Number of people on one shift based on original measurement:

$$\frac{1531 \text{ min}}{390 \text{ min}} = 4 \text{ fork lift truck drivers}$$

Number of people on one shift after development:

$$\frac{1181 \text{ min}}{390 \text{ min}} = 3 \text{ fork lift truck drivers}$$

It can be stated that with the changes one shift could be completed with one truck driver less, so instead of 16 truck drivers in the 4 shifts, only 12 would be needed.

With this reduction, the company may have the opportunity to carry out more efficient storage. In our opinion, if the company had more mobile cars, the utilization of the shuttle rack system could approach the 90% achieved by other European companies.

CONCLUSIONS

During our research, it was found that, for the company under consideration, it is worth buying two moving wagons, thus increasing the utilization of the pallet shuttle rack systems from 60 to 72%, and the total utilization of the warehouse from 74% to 76%, i.e. 277 extra pallets could be stored.

Within the pallet shuttle system, following the merger of loading and order picking operations, it was established that the truck driver could carry out order picking immediately after loading. Merging activities and saving time would allow the company to work with 3 truck drivers instead of 4.

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REFERENCES

[1] Gelei A. (2007). *A vállalati logisztikai rendszer kitüntetett eleme a raktár - folyamat alapú megközelítés*. 81. sz. Műhelytanulmány. Budapest: Budapesti Corvinus Egyetem.

[2] Ghauri P., & Gronhaug K. (2011). *Kutatásmódszertan az üzleti tudományokban*. Budapest: Akadémiai Kiadó.

[3] Gwynne, R. (2014). *Warehouse Management.* (2nd ed.). India: Replika Press Pvt. Ltd.

[4] Némon Z. (2013). *Raktározási ismeretek.* Budapest: KIT Kft.

[5] Prezenszki J. (2004). *Logisztika I. (bevezető fejezetek).* Budapest: BME Mérnöktovábbképző Intézet.

[6] Prezenszki J. (2010). *Raktározás-logisztika*. Budapest: AMEROPA Kiadó.

[7] Rushton, A., Croucher, P., & Baker, P. (2006). *The handbook of logistics and distribution management.* (3tnd ed.). Glasgow: Bell & Bain.

[8] Rushton, A., Croucher, P., Baker, P. (2010). *The handbook of logistics and distribution management.* London: Kogan Page.

[9] Stock, J.R., & Lambert D.M. (2001). *Strategic Logistics Management.* Singapore: McGraw Hill Irwin.

[10] Süle E. (2014). *Logisztika az idő fogságában*. Pécs-Győr: ID Research Kft./Publikon Kiadó.

[11] Szegedi, Z., & Prezenszki, J. (2003). *Logisztika-menedzsment*. Budapest: Kossuth Kiadó.

[12] Szokolszky Á. (2004). *Kutatómunka a pszichológiában*. Metodológia, módszerek, gyakorlat. Budapest: Osiris Kiadó.

[13] Takács-György K., & Toyserkani, A. M. P. (2014). Imitation vs. innovation in the SME sector. *Annals of the Polish Association of Agricultural and Agribusiness Economists 16*(2), 281-286.

[14] Vörös J. (2010). *Termelés- és szolgáltatásmenedzsment*. Budapest: Akadémiai Kiadó Zrt.

ANNEXES

Table 1
SCA warehouse utilization rates (%)

Type of rack	Serial number	Maximum utilization (items)	Actual utilization (items)	Utilization (%)
2SA-shuttle	**14**	**576**	**346**	**60**
2SA-shuttle	**15**	**576**	**346**	**60**
2SA-shuttle	**16**	**576**	**346**	**60**
2SA-shuttle	**17**	**576**	**346**	**60**
1DR-drive in	18	504	388	77
1DR-drive in	19	504	388	77
1DR-drive in	20	504	388	77
1DR-drive in	21	504	388	77
1DR-drive in	22	240	185	77
1DR-drive in	23	160	123	77
1DR-drive in	12	352	271	77
1DR-drive in	13	288	222	77
1DR-drive in	11	684	527	77
1DR-drive in	10	616	474	77
1DR-drive in	9	720	554	77
1DR-drive in	8	860	662	77
1DR-drive in	7	896	690	77
1DR-drive in	6	640	493	77
1DR-drive in	5	640	493	77
1DR-drive in	4	468	360	77
1DR-drive in	3	468	360	77
1DR-drive in	2	456	351	77
1DR-drive in	1	608	468	77
1RC- rack side-stand		488	376	77
Smaller sized 1PC-pallet stand		544	419	77
Total		**13 448**	**9 963**	**74**

Source: Authors' own research (2016)

Table 2
Loading time in the shuttle pallet systems

1. Transporting the pallets (min, sec)	**2. Searching for a moving car (min, sec)**	**3. Loading the pallets (min, sec)**
00:12	00:55	03:14
00:20	00:50	02:01
00:13	01:19	03:22
00:16	00:43	03:18
00:20	01:31	02:57
00:14	01:13	03:04
00:20	00:41	02:51
00:23	01:00	02:58
00:19	00:53	02:18
00:22	00:54	02:38
00:28	01:30	02:20
00:18	00:58	02:43
00:26	00:48	03:05
Average		
00:19	**01:01**	**02:50**

Source: Authors' own research (2016)

Table 3
Stacking times after development (purchasing two mobile cars)

1. Transporting the pallets (min, sec)	**2. Searching for a moving car (min, sec)**	**3. Stacking the pallets (min, sec)**
00:12	00:36	02:55
00:20	00:33	01:43
00:13	00:51	02:54
00:16	00:28	03:03
00:20	00:59	02:25
00:14	00:47	02:38
00:20	00:27	02:37
00:23	00:39	02:37
00:19	00:34	01:59
00:22	00:35	02:19
00:28	00:59	01:49
00:18	00:38	02:23
00:26	00:31	02:48
Average		
00:19	**00:40**	**02:29**

Source: Authors' own research (2016)

Table 4
Utilization of the SCA warehouse after purchasing two extra mobile cars

Type of rack	**Serial number**	**Maximum utilization (items)**	**Actual utilization (items)**	**Utilization (%)**
2SA-shuttle	14	576	415	72
2SA-shuttle	15	576	415	72
2SA-shuttle	16	576	415	72
2SA-shuttle	17	576	415	72
1DR-drive in	18	504	388	77
1DR-drive in	19	504	388	77
1DR-drive in	20	504	388	77
1DR-drive in	21	504	388	77
1DR-drive in	22	240	185	77
1DR-drive in	23	160	123	77
1DR-drive in	12	352	271	77
1DR-drive in	13	288	222	77
1DR-drive in	11	684	527	77
1DR-drive in	10	616	474	77
1DR-drive in	9	720	554	77
1DR-drive in	8	860	662	77
1DR-drive in	7	896	690	77
1DR-drive in	6	640	493	77
1DR-drive in	5	640	493	77
1DR-drive in	4	468	360	77
1DR-drive in	3	468	360	77
1DR-drive in	2	456	351	77
1DR-drive in	1	608	468	77
1RC-rack side-stand		488	376	77
Smaller sized 1PC-pallet stand		544	419	77
Total		**13 448**	**10 240**	**76**

Source: Authors' own research (2016)

Table 5
Time sub-periods for the order picking, together with time savings

1. Searching for stacks (min, sec)	2. Searching for mobile car (min, sec)	3. Preparing stacks (min, sec)
00:18	00:40	02:18
00:22	00:33	01:58
00:16	00:47	02:41
00:19	00:30	02:50
00:20	00:58	02:02
00:14	00:47	02:11
00:20	00:27	03:04
00:23	00:39	02:52
00:19	00:41	02:04
00:22	00:35	03:03
00:28	00:59	02:41
00:21	00:38	02:05
00:24	00:31	02:31
Average		
00:20	**00:40**	**02:29**

Source: Authors' own research (2016)

Table 6
Merging the stacking and order picking times from a time-saving perspective

1. Transporting the pallets (min, sec)	2. Searching for a moving car (min, sec)	3. Stacking the pallets (min, sec)	4. Re-positioning the mobile car (min, sec)	5. Preparing the stack (min, sec)
00:12	00:36	02:55	04:07	04:54
00:20	00:33	01:43	02:27	03:20
00:13	00:51	02:54	04:15	05:19
00:16	00:28	03:03	04:50	05:34
00:20	00:59	02:25	02:48	04:07
00:14	00:47	02:38	03:34	04:35
00:20	00:27	02:37	04:34	05:21
00:23	00:39	02:37	04:04	05:06
00:19	00:34	01:59	02:51	03:45
00:22	00:35	02:19	04:03	05:00
00:28	00:59	01:49	02:35	04:02
00:18	00:38	02:23	03:11	04:07
00:26	00:31	02:48	03:58	04:56
00:19	**00:40**	**02:29**	**03:38**	**04:37**

Source: Authors' own research (2016)