HIGH-PERFORMANCE ORDERPICKING CONCEPT AROUND THE LOGISTACKER AS/RS

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Abstract

This paper deals with a high-performance orderpicking concept around the Logistacker, a high-throughput Automated Storage and Retrieval System (AS/RS), which is capable of handling fast moving items. It is described how the Logistacker grew from improvements to the first design to a complete orderpicking system, that comprises fast orderpicker work stations. Furthermore it gives an overview and the results of a performance analysis (by means of simulation) of the overall system.

1 Introduction

In [1] the Logistacker, a new high-throughput Automated Storage/Retrieval System (AS/RS), especially designed for handling fast-moving A-items, has already been elaborated. It is a new fast alternative for the rather slow conventional miniload AS/RS that even in case of dual commands cannot handle (store and retrieve) more than 100 totes per aisle per hour. Therefore it is not capable to handle A-items, which may be considered as a clear drawback.

The Logistacker is a rather simple system that consists for the greater part of conventional components. It is a co-production of the University of Twente and the consultancy company Logistore, both situated in The Netherlands. It represents a good example of fruitful cooperation between a university and trade and industry.

In the past several other attempts have been made to construct an AS/RS that realizes a high performance. The following may be mentioned: the Japanese Itoki system and a combination of a horizontal and a vertical carousel (both described in more detail by Oser [2]), the CDS (see Stadtler [3]), the Siemag system developed by the Fraunhofer institute and. the Casi carousel system from the US. In the latter one a revolving extraction unit with multiple compartments, which can travel up and down by means of an elevator, constitutes the main component of the system.

Furthermore [1] gives the results of performance calculations and compares them with those for conventional systems, such as a miniload, a horizontal carousel and manual orderpicking. The performance of the Logistacker in dual command mode amounts to 1500 totes in and out per hour (dual commands). This can only be achieved in case of batch-picking with a large batch size. The larger the batch size the more the Logistacker outperforms these conventional systems.

The performance of a high-throughput system is high due to the fact that as many actions as possible are carried out in parallel. Finally, it should be mentioned that the Logistacker also appears to be suitable for grouping truck loads.

The outline of this paper is as follows. Section 2 describes how the first design of the Logistacker system grew from a fast AS/RS to a total order picking system, by extending it with an environment consisting of fast orderpicker work stations. Section 3 presents the results of a simulation case study of the overall system and finally in section 4 several conclusions are drawn.

2 The Logistacker, from birth to a mature total orderpicking

2.1 First design of the Logistacker

The Logistacker is meant for storing and retrieving totes. First we give a short description of the first design of the Logistacker (for a more detailed description see [1]). We describe the main parts of the system. The core of the first version is a liftable conveyor (with a length of 6 meters), mounted in a gantry crane (see figure 1, left picture). This conveyor can travel up and down to all levels in an aisle with racks for totes at both sides of the aisle. On the conveyor air-powered push/pull mechanisms (to extract and store totes from and into locations) are mounted for all location positions in a layer. In addition, all mechanisms may be controlled individually if desired. Also changes of aisle are possible; i.e. the crane, with the conveyor lifted in top position, can move to another aisle.

The logical order of actions is as follows. The liftable conveyor starts at the I/O level, i.e. the height at which the fixed external conveyor is situated. All totes of a layer to be stored at a certain level are imported from the external conveyor onto the liftable conveyor by a pusher (see figure 2). Next the liftable conveyor goes to the level of the layer where these totes must be stored, after which the grippers store the entire layer of totes at one time. In case of a single command now the empty liftable conveyor goes back

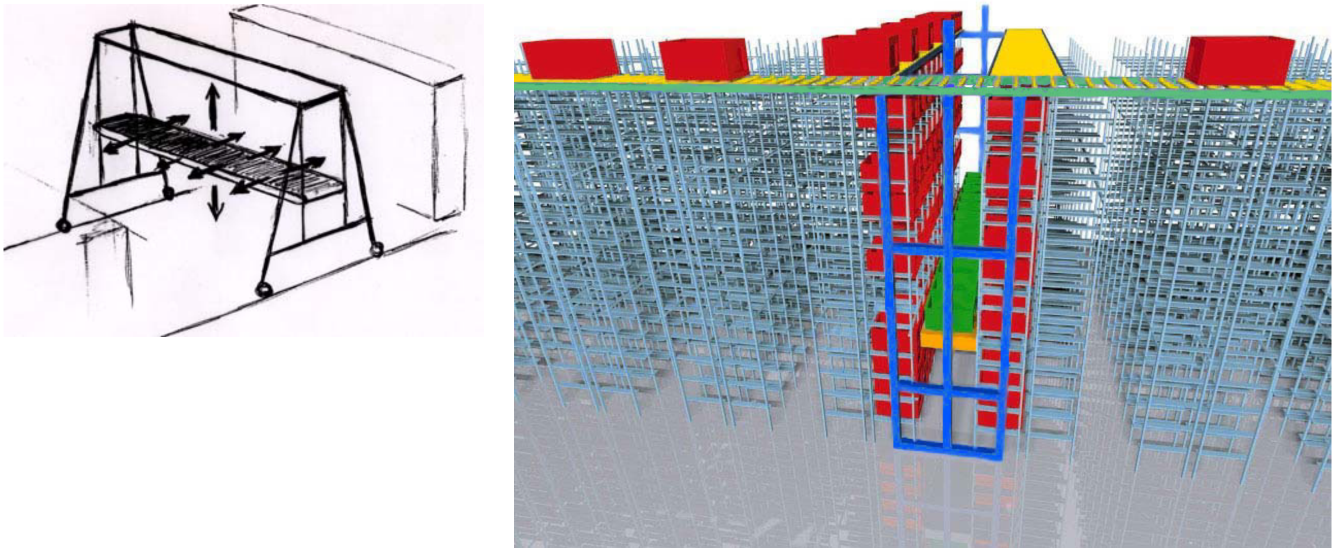

Figure 1: The Logistacker: from the first sketch (left) to its final version (right).
Important change: short input/output conveyors, mounted on top of the crane for incoming and outgoing totes (see section 2.2).

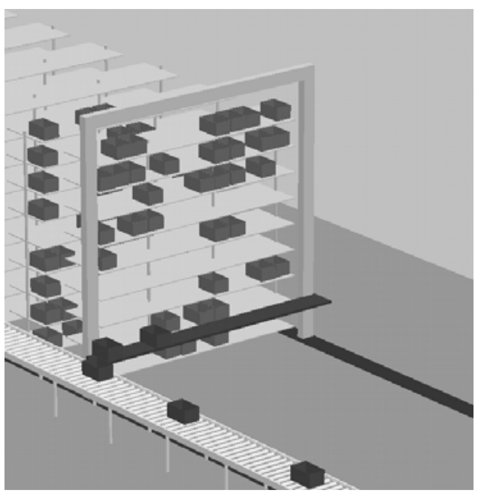

Figure 2: First version of the Logistacker with the liftable conveyor positioned at the I/O level, where the fixed external conveyor is situated.

to the I/O level to pick up a next row of totes. In case of a dual command the empty liftable conveyor travels to a layer of totes to be retrieved. As soon as the grippers have retrieved the entire layer of totes at one time, the conveyor goes back to the I/O level and subsequently it moves these totes onto the external conveyor via which they leave the system. Etcetera.

It is obvious that more than one crane may be installed.

The advantage of the Logistacker is that many handling actions are performed in parallel. For example with regard to retrieving; all extractions in a whole layer at a certain level are carried out simultaneously. Next all these totes together travel (i.e. move horizontally while the conveyor descends) fluently to the I/O level and leave the system.

In addition, it is possible to increase the performance further by creating in each rack a free layer at I/O level that is used as an input/output buffer in which all totes for (or from) a certain layer can be put available (or away). These free layers must be equipped with a fixed conveyor to enable horizontal movement of totes. This idea was a first step towards the final version of the Logistacker that has short (fixed) conveyors, mounted on top of the crane (see the next section).

As stated before the performance of the Logistacker in dual command mode is 1500 totes in and out per hour. From analysis it also became clear that it already makes sense to install a Logistacker in stead of a miniload system as soon as the number of “hits” per layer amounts to 4 totes or more. The Logistacker is a rather simple system that to a large extent consists of conventional components and so its costs are relatively low. The price of a crane amounts to 260,000 euro.

2.2 Improvements to the Logistacker

The original version of the Logistacker as described above has been improved (see figure 1, right picture). The most important improvement in the final version is that the liftable conveyor has been replaced by a liftable platform (a simple shelve) plus 2 short (6 meter long) fixed conveyors, mounted on top of the gantry crane, one for incoming and one for outgoing totes. The external fixed conveyor is now positioned at the same height as these small conveyors; so much higher than in the original version. The grippers for storage and retrieval of totes into and from the racks are mounted on the liftable platform. By this, as an advantage, the number of parallel actions further increased; it is possible to import and export, to lift or descend and to store or retrieve totes simultaneously (see figure 3).

Due to the improvement the logical order of processes becomes somewhat different: a complete row of totes arrives via the external conveyor and flows onto the short incoming conveyor on top of the crane. The grippers on the platform pick up these totes, after which the platform travels down to a free layer into which they have to be stored. As soon as this layer is reached, the grippers store the totes into the layer. Subsequently, in case of a dual command, the empty platform goes to a full layer of totes and retrieves that layer. Next it brings these totes to the outgoing conveyor (on top of the crane), after which they flow onto the external conveyor via which they leave the system.

Besides the standard configuration of the Logistacker as described above, other more simple configurations have been developed.

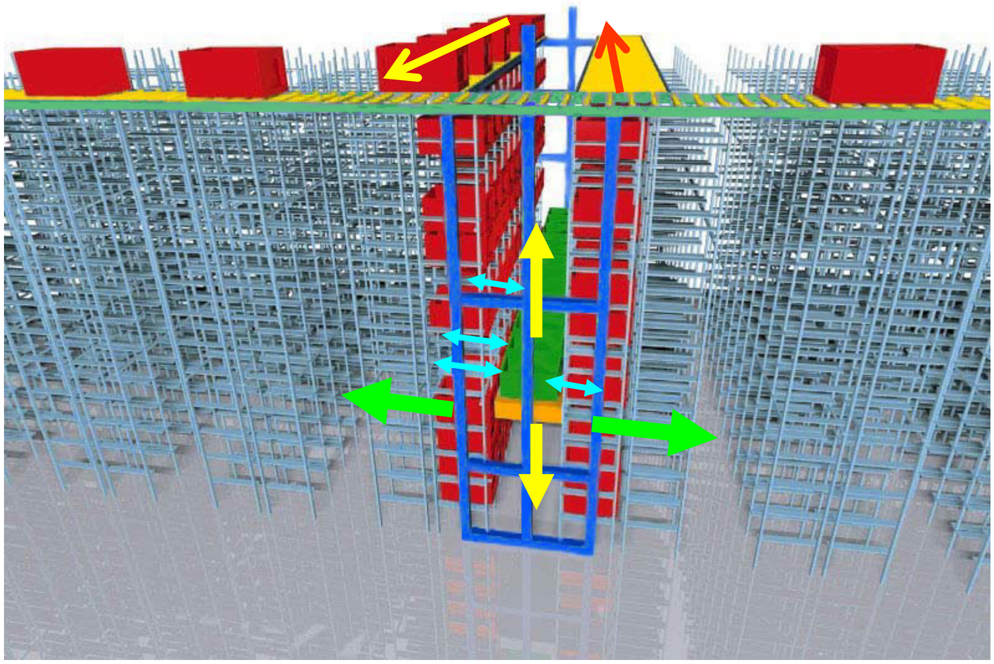

Figure 3: Many movements are performed simultaneously

With this final design of the Logistacker (i.e. a high-performance AS/RS) at hand the system was ready to be built. But then the question arose: how to adopt it? In other words; how to cope with the large streams of totes coming out of it? The answer was: we need a very fast high-performance orderpicking system around it. Next, this system has been invented and worked out. The main components are smart orderpicker workstations. One may state that the final result represents a complete orderpicking concept. It will be described next.

2.2 Orderpicking system around the Logistacker

The total system is a complete order picking concept (see figure 4). The orderpicking takes place at work stations, consisting of vertical carousels, which are used in a reverse way than is usual; putting actions instead of retrieving actions. The choice for carousels is based on their velocity and compactness. The carousels are positioned in a so called tandem configuration, i.e. two carousels face-to-face with the operator in the middle (see figure 5).

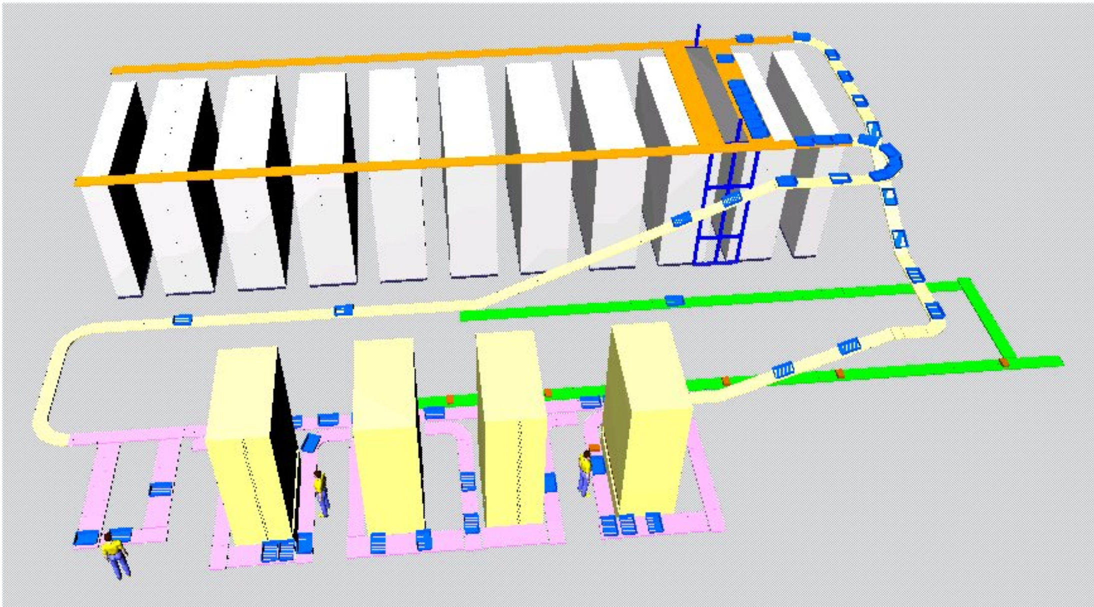

Figure 4: The integral Logistacker orderpicking system and its environment:
the Logistacker (at the top), the internal transportation system and the orderpick work stations (at the bottom).

Figure 5: Orderpick work station consisting of tandem carousels,
operated by one orderpicker

The carousels contain cartons that eventually will be shipped to the customers. At the beginning of a picking shift the empty (but dedicated to customers) cartons are put into the carousels. During the shift they are filled by the orderpickers with items ordered by the customers. It should be remarked that for orders consisting of only a single orderline a special (simple) work station has been designed.

The transportation of the totes from the Logistacker to the orderpicker work stations is taken care of by an internal transportation system consisting of a conveyor network. Its layout (e.g. loops) is critical because of risks of congestion.

The totes in the Logistacker contain SKUs. All (!) totes in this system are retrieved in one large batch. Totes not asked for are immediately sent back to be restored in the Logistacker. In this way only a simple WMS is required. The other totes go to one or more work stations. The orderpickers take out of the totes the items according to the customer orders and *put* them into the cartons involved in a carousel (this is the actual orderpicking!). Since we deal with batchpicking, the items picked out of one tote must be sorted to several cartons (i.e. customers) and so we may speak of Sort-while-Picking (SWP). Pick-to-light supports the orderpicker in this process. As soon as a carton is full or a customer order is complete, the carton is sent to the shipping area.

In addition, it may be noted that for specific items specific work stations are under development.

An important advantage of this Logistacker concept is its flexibility. For instance, during operation the number of active orderpicker work stations can be varied at any time. Furthermore, if the number of Logistacker cranes and/or the number of work stations often appear to be too small they can be increased in a modular way.

3 Results of a case study; a performance analysis of the total system by means of simulation

In order to get an impression of the performance of the proposed orderpicking concept around the Logistacker a simulation case study has been carried out based on data from practice. This case study features a Logistacker system with two cranes and about 10,000 storage locations for totes. Both the liftable platform and a layer in a rack may hold twelve totes. The totes with SKUs are randomly located in the racks. The Logistacker carries out dual commands.

The orderpicking area comprises 15 orderpicker workstations – each one consisting of tandem vertical carousels - for orders comprising multi-orderlines and 4 more simple stations for orders comprising only a single orderline. The buffers in front of each carousel can contain three totes at the maximum. All orders (with in total about 24,000 orderlines) that have to be delivered the next day are combined into 2 batches of 12,000 orderlines each. A WMS assigns the orders to be picked (i.e. the corresponding cartons) to the workstations in such a way that the total workload is balanced over the stations. It should be noted that for each batch all totes in the racks are exported and imported (see section 2). Totes with items that are not demanded by the customer orders are restored immediately after they have been retrieved via a detour conveyor.

The simulations reveal that each carousel orderpick station can handle 180 orderlines per hour. An important observation is that the carousels constitute the bottleneck. Since the average turning time of a carousel between two successive picks is 17 seconds one may conclude that in this case the maximum number of orderlines that can be picked per hour is (3600/17 =) 212 lines. It appears that it takes more or less 4 hours to complete a batch. This implies that the two batches fit into one shift of 8 hours.

For this configuration it turns out that the conveyors are no bottlenecks. Extra detours or a separate conveyor for transporting the totes back to the Logistacker do not improve the performance. Also the system appears to be rather insensitive to the velocity of the conveyors; varying this velocity within the range of usual values between 0.8 and 1 m/s has no effect on the performance. Raising the size of the buffers in front of each carousel does not affect the performance either.

Improvement of the performance can be achieved by:

- Adopting a more sophisticated assignment of orders to the picking stations (work load planning of the picking stations), for instance by taking account of the utilization of each carousel.
- Placing the cartons in the carousels according to a location strategy. By doing so the rotation time of a carousel can be reduced. Recent studies indicate that theoretically 260 orderlines per hour picked per workstation seems feasible.
- A pull-wise control of the flows of totes to the orderpicking stations. A current research has to indicate if this way of control indeed renders better results than a push-wise control does.
- Locating totes in the Logistacker according to a slotting strategy, based on the turnover rates of the SKUs. The totes in the racks may be reshuffled to other locations during non-picking hours. For instance by this it is possible to create rows with totes which are not frequently asked for and thus often can be bypassed by the cranes.

An alternative for this Logistacker system with carousels may be developed, namely a Logistacker system with the so called synchronous orderpicking concept, where a tote (filled with a SKU) “meets” a carton (to be filled with items ordered by a customer). Then the Logistacker will not only be adopted for storage and retrieval of totes, but also for temporary storage of the cartons during the orderpicking process. No carousels are involved in the latter concept, therefore resulting in lower costs. A drawback however is the more complex control it requires.

4 Conclusions

A consortium to build the Logistacker has been established, consisting of in-plant transportation equipment builders, carousel suppliers, etc. Also a system integrator has been found. The integral Logistacker concept has been presented at several fairs:

CEMAT in Hannover, Promat in Chicago and Logistica in Utrecht (The Netherlands). At the latter fair the concept won the second prize in the Logistica Award contest.

Many companies from all over the world have shown interest in the concept. At the moment a specific simulation study is carried out for a potential buyer. Hopefully shortly the first installation will follow. Patent has been granted for many countries.

Acknowledgement

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