WAREHOUSE MANAGEMENT FOR IMPROVED ORDER PICKING PERFORMANCE: AN APPLICATION CASE STUDY FROM THE WOOD INDUSTRY

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Abstract: The study presented here considers arrangement and management policies to improve the order picking procedure in the existing company warehouse. The study was conducted in a timber goods production and trading company. The main objective was to reduce the overall picking time that is quite high due to the lack of proper management and the nature of the stored items. The first stage was to register the situation in the warehouse. The second stage involved the analysis of the obtained data, to identify promising modifications and quantify the benefits of adopting them. The proposed modifications were based on policies and methodologies suggested in the literature. After the company approved and implemented (some of) the proposed modifications, the final stage was to measure and analyse the achieved improvements.

Keywords: warehousing, case study, facility layout, order picking time

1. INTRODUCTION

Order picking (OP) appears as one of the most significant activities in a warehouse. The picking tasks may contribute by over 65% in the warehouse operating costs. In fact, the retrieval cost exceeds by far the storage cost of any given item (Coyle et al., 1996). The factors affecting the efficiency of OP typically include the product demand, the warehouse layout, the location of the items, the picking method in combination with the routing methods, the experience of the employees, and the extent of automation (Gattorna, 1997). Note that the high cost associated with the automation of the procedure forces the majority of companies to use manual operation, usually at the expense of efficiency and time.

The case study is carried out in a timber goods production and trading company. We consider one of the existing warehouse facilities and we attempt to improve its performance. The performance measure is the total picking time, so our objective is to find ways to reduce it as much as it is practically possible and desirable. At the first stage involves the collection of time data, to target the improvement that may be accomplished from the transition from a totally disorderly situation to an organized and controlled warehouse environment. The second stage suggests, implements and studies alternative storage, picking and routing schemes, according to observations made during the first stage. During the third stage, a second series of time measurements is carried out to investigate the achieved benefits.

2. REVIEW OF WAREHOUSE POLICIES RELATED TO ORDER PICKING

There is a variety of studies on methods, policies, principles and/or techniques developed to improve the overall OP procedure. The decisions usually concern policies for the picking of the product items, the routing of the pickers in the warehouse, and the storage schemes for the products in the warehouse. The research scope has been to investigate the effect of changes in these policies on the reduction of the overall OP costs and the increase of percent savings. Petersen and Gerald (2003) was the first to attempt a simultaneous evaluation of all the three policies, whereas the usual practice is to consider them separately.

2.1. Picking policies

In terms of the picking policies, Ackerman (1990) divided OP into strict, batch and zone picking and proposed policies tailored to each case. In *strict picking*, a single order is assigned during a picking tour, leading to lower service times and higher customer satisfaction. The policy is ideal when the group of the picking products is quite small and easy to be found. Drawbacks of the policy include an increase in the overall transportation time and a cost penalty. Alternatively, the *batch picking* policy assigns to a picker more than one orders during a picking tour (Gibson and Sharp, 1992; De Coster et al., 1999; Petersen, 2000). The batch scheme may bring significant reduction on the total picking time, but introduces an additional cost for monitoring and separating the orders at a later stage. *Zone picking* assigns a picker to a designated picking zone, where the picker is responsible for those products that are in his/her zone of the warehouse. This scheme decreases the chances for destructions and mistakes, but a possible delay in a zone is a threshold for the entire picking procedure for a big order. Frazelle and Apple (1994) further divided zone picking into: sequential zone, batch zone and wave OP. Petersen (2000) suggested that in the *sequential zone* scheme the order integrity is maintained, in *batch zone* the orders are batched together and each picker collects the products within a zone, and in *wave picking* a group of orders is programmed in precise time period.

2.2. Routing policies

Routing policies suggest the route for a picking tour and the picking sequence of the items on the pick list. The suggestions are based on decision-making technologies that range from simple heuristics to mathematical optimization procedures. Using *mathematical programming* tools Ratliff and Rosenthal (1983) found that optimal routing reduced the travel time, but the optimal routes were quite confusing routes and difficult to implement in practice. Hall (1993) and Petersen and Schmenner (1999) examined the efficiency of *heuristic routing* in minimizing the distance traveled by the picker. In practice, many warehouses use the traversal policy, where the picker must pass through the entire aisle and in order to collect the items. Petersen (1997) and Roodbergen and Koster (2001) examined the possibility of combined traversal and return routes to reduce further the travel distance.

2.3 Storage policies

Storage policies remain the least investigated among the three policy categories. *Random storage* is the most widely used option, and Schwarz et al. (1978) examined its performance. Petersen and Aase (2003) claimed that random storage is by far the simplest option and requires less space compared to the more sophisticated storage policies. The simplest structured-storage schemes apply class-based and/or demand-based policies in the arrangement of the products. In *class-based storage* the products are classified, and items of each class are placed within the same area of the warehouse. In *demand (or volume) –based storage* the products are stored according to their demand (or their size) near the Pick-up / Drop-off point (P/D). Jarvis and Mc Dowell (1991) suggested that the optimal storage strategy is to place the items with great demand in the aisle, thus reduce the travel time. Gibson and Sharp (1992) and Gray et al. (1992) stated that locating high volume items near to the P/D point increased the picking efficiency. Petersen and Schmenner (1999) examined the volume-based storage policies and concluded that the method resulted to less time compared to other storage policies. Eynan and Rosenblatt (1994) claimed that the class-based storage required less data processing and yielded similar saving with volume-based storage.

Tompkins and Smith (1998) suggested that the overall picking time could be reduced applying the Pareto principle on the storage arrangement. In a warehouse, a relatively small number of products constitutes the largest part of the stock and accounts for the largest part of the dispatches of the warehouse. Consequently, if high demand items are placed in near distance and grouped into classes, then picking time can be significantly reduced. The former is easy to apply by allocating a number of the front area piles to items of high demand or leftovers. In terms of more sophisticated storage options, Ven den Berg (1999) suggested a separation of the warehouse into a forward and a reserve area. The forward area was for order picking, while the reserve area was used for replenishing the forward area.

The variety of different methods and techniques makes it difficult to identify the most appropriate policy to increase the overall performance of the picking activity. The decision on the appropriate principles and policies to be applied depends on the characteristics of the particular system, i.e. product and warehouse. By reducing the non-productive elements during OP, Gattorna (1997) presented a set of basic and general productivity improvement principles.

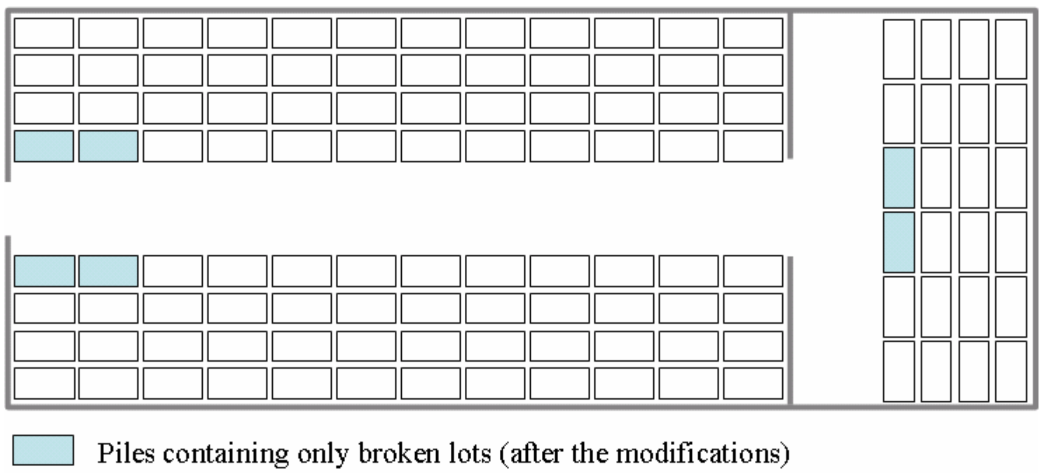

Figure 1: Layout of the panel warehouse section

3. DESCRIPTION OF THE STUDIED WAREHOUSE – INITIAL SITUATION

The company considered here deals with wood production and trading, and uses 6 warehouses for the finished products. Each warehouse is further divided into individual sections where different categories of products are stored. Panels, i.e. sheets of compressed wood (chipboard) account for 80% of the total product sales of the company. The panels are covered with coloured melamine to imitate the appearance of various types of wood. The panel warehouse has over 6000 codes of stored products, distributed into 4 individual sections. The study considers one of these sections, where the number of codes is around 1000.

The most frequent values for the size of the panels is 3.66×1.83m, and the thickness is between 6cm and 25cm. Instead of using shelves, the products are piled one on top of the other using small chocks between the packages. Great attention is paid to the alignment of the items in each pile, to avoid sheet warping. Warping can easily occur due to the small thickness of the packages and the large load they take.

The studied warehouse section consists of three parts: two of them have 12 front piles each and the third part has 6 front piles (Figure 1). The piles are 7m high and the products are stored in up to 4 depths of pile levels. The main aisle is used by the clarks to gain access to the front piles. The aisle is wide enough to allow the clarks to remove the items of the front piles and to retrieve items stored in the deeper levels. Each part of the section contains different groups of products.

Customer orders are collected by the Sales Department and sent to the Traffic Office on daily basis. The loading plans contain information on the ordered items and their quantities, the customer placing the order, and the requested mode of loading on the lorry. In the course of a day, the Traffic Office prepares over 25 order plans. The plans are usually collected and loaded at the same time.

Initially, the warehouse suffered from many problems that mainly affected the search and retrieval times. The picking followed the strict OP policy. Each pair of pickers (an operator and an assistant) undertook a single order-plan at the time. Orders from other plans were collected once the pickers completed their current plan, even if this required revisiting the same areas of the warehouse. There was no automated or optimal routing system used here, and the choice of an efficient route remained on the experience of the picker. The grouping of the products in the section parts was based on the type of their surface (e.g. porous or smooth), regardless of the kind of wood. This was the only storage rule, and then the items were stored randomly in the section parts. Tracing a product was relying on the experience of the warehouse managers and the memory of the pickers. From the point of management the process depended on the experience of the personnel, while even a simple WMS version was certain to improve the situation. Once the location of an item was specified, the retrieval time was affected by the size/weight of the products, and the mode of storage. For instance, if the ordered product was located on the second, third or fourth depth of pile levels, many items had to be removed until the product was finally retrieved. Then, the removed items had to be placed back to their original locations.

4. MEASUREMENTS AND PROPOSED MODIFICATIONS

The time measurements were carried out twice. The first measurement (stage 1) presented the initial anarchous situation of the system (see Section 3). The second measurement (stage 3) showed the effect of the improvements suggested by the authors and adopted by the company.

The picking procedure is divided into four phases, and the time measurements concern the:

1. the *travel time* required for the picker to reach the pick point,
2. the *search time* required for the products to be found,
3. the *retrieval time* required for the products to be retrieved, and
4. the *return time* required for the picker to transport the products to the order point.

Each time measurement considered 15 order plans selected by the Traffic Office of the company in collaboration with the authors. The selected plans were representative and included a large number of products, so that the analysis of the obtained time schedules yields reasonable and reliable conclusions. The number of orders in the studied plans ranged from 5 to 17 per plan. To allow comparison between the picking times measured for items of different size, the results are presented as the measured time over the volume of the respective item, namely in minutes per cubic meter.

4.1. Stage 1: Results of the 1^ST^ measurement series

The results of the 1st measurement series are reported on Table 1. The time required to complete the picking cycle is 5.69 min/m^3. In terms of the itemized times for travel, search, retrieval and return, we observe that finding and retrieving the products are the most time-consuming procedures. The *search time is around 36%* (2.05 min/m^3) of the total OP time. The percentage is quite high and reveals the need for an automated system to control and monitor the placement of the stock. Tracing the products becomes an extremely difficult and demanding procedure relaying mainly on the experience of the operator and the assistant. Many years of work in this particular position and the ability to locate the items using visual contact are decisive factors. In many cases, finding an item quickly is merely a matter of coincidence or luck. Our results include cases where locating a stocked product took over 45 minutes of searching and the product eventually failed to reach the customer on time.

Table 1: Final results obtained during the 1st and the 2nd measurements

	1^{ST} measurement before modifications		2^{ST} measurement after modifications		Relative time reduction
Phases	**t_1 (minutes)**	**% total**	**t_2 (minutes)**	**% total**	**$(t_1-t_2) / t_1$ %**
Travel time	0.51	9.0	0.33	11.5	35.3
Search time	2.05	36.0	0.37	12.9	82.0
Retrieval time	2.50	43.9	1.73	60.5	30.8
Return time	0.63	11.1	0.43	15.0	31.7
Travel & return times	1.14	20.0	0.76	26.6	33.3
Total	**5.69**	**100.**	**2.86**	**100.**	**49.7**

The *retrieval time is around 44%* (2.50 min/m^3) of the total OP time. Most of this time is spent on removing products in the front levels until the desired item comes to surface. The multiple storage depths combined with the surface type-based storage makes retrieval the most time-consuming procedure. Note that the initial choice of storage policies was based upon empirical criteria since, without a systematic measurement and consideration of the real system.

Typically, the travel and return times account for over half of the total OP time (Tompkins, 1998), and most of the research work in increasing the efficiency of OP has focussed on the assumption. This does not apply to the problem considered here, where the retrieval times are considerably higher due to the nature of the products. Supported by the results of Stage 1, the retrieval times can be reduced by rearranging the warehouse and applying storage principles as discussed in Section 2.

4.2. Stage 2: Proposed and implemented modifications

The scope here is to reduce the time spent to reach the picking area and the packaging point. Based on the analysis of the first measurements the following were suggested to the company.

- *Introduction of a Warehouse Management System (WMS):* The use of a WMS can facilitate and speed up the tracing of the products. This is expected to reduce significantly the search time that is over a third of the total OP time.

- *Improvement of the picking policies:* After introducing a WMS, it is advisable to change the method of OP from strict to zone picking.

- *Application of optimal routing policies:* In total, the travel and return time is only around 20% of the total OP time. A techno-economical feasibility study (in the form of an ABC analysis) can quantify how much of this can really be reduced by the choice of routing policies, and provide incentives to carry out the necessary modifications.

- *Changing the location of fast moving products in the warehouse*, to reduce the retrieval time for small orders. The number of the wood panels ordered is usually other than those contained in the panel lots. The initial policy was to leave the remaining items in their original locations until they were again in demand. The result was to have many broken lots of the same product stored randomly in various places and levels within the warehouse. The remainders of the product lots can be placed in easily accessible front piles assigned for this purpose.

- *Extending the storage space to reduce the storage depths from four to two*, to reduce the retrieval time. This however increases the fraction of the void over the total space in the warehouse, and creates a trade off between the time needed to access the products and the cost of extending the warehouse area.

The company adopted some of the above suggestions, namely the installation of a simple WMS and a change in the location of its products, following an ABC analysis. The storage mode changed to demand-based, hence the fast moving products were placed closer to the section entrance to reduce the travel and return times. Also, two piles were allocated on each side section, where the remainders under 20 sheets would be placed (see the broken lot piles in Figure 1). The company did not switch to zone picking, because separating the items of the different order packs needs extra space. Also, the company could not consider our suggestion to reduce the storage depth levels, since this required building an additional warehouse.

4.3. Stage 3: Results of the 2ND measurement series

Once our suggestions were implemented, the second measurement series was conducted to evaluate the subsequent reductions on the total OP time. The results and the differences between the first and the second measurements are presented on the Table 1. The total time to complete the picking cycle is now 2.86 min/m^3, thus a reduction of nearly 50% was achieved.

More specifically, the search time is down by over 80% and is now nearly 13% (0.37 min/m^3) of the total. This is because the item locations are registered and given to pickers along with the order plan. Further reductions could be achieved if the employed WMS specified the height along with the depth of the product location.

The demand-based storage and the use of the two piles for the broken lots reduced the retrieval time by 30.8%, to 1.73 min/m^3. There is also significant reduction (33.3% on average) in the travel time to and from the picking points, due to the new storage policies adopted. Despite the significant overall reduction on the OP time, the problem of item retrieval remains unresolved. In effect, the current retrieval time is 60% of the total OP time. Reducing the storage depths is not considered presently, as it requires expansion of the warehousing establishments.

5. CONCLUSIONS

This work presents a real case study to improve the performance of order picking in an existing company warehouse. The main objective is the reduction of the overall picking time. The work is divided into three stages. The first stage is to register the situation in the warehouse with regard to the required order picking times. The total time is divided into travel, search, retrieval and return time to allow a more detailed analysis of the situation. The analysis of the obtained data identifies promising modifications and quantifies the benefits of adopting them. In effect, the measurements indicated the need for more systematic management, storage and arrangement of the products in the warehouse, and more efficient routing. After the company approved and implemented (some of) the proposed modifications, the time measurements were repeated to see the benefits. Finally, a mean 50% reduction in the total picking times was achieved. There is still space for improvement, even given the reluctance of the company to carry out expensive modifications. Our future research considers the development of a simple warehouse simulation tool to apply different arrangement options and evaluate their performance, using the time data collected in this work.

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