5th International Conference on Industrial Engineering and Industrial Management
XV Congreso de Ingeniería de Organización
Cartagena, 7 a 9 de Septiembre de 2011

Improving Picking Productivity by Redesigning Storage Policy Aided by Simulations Tools

C. Chackelson [1], A. Errasti, D. Cipres, M. J. Álvarez

[1] Tecnun, University of Navarra, Manuel Lardizabal 13, 20018, San Sebastian, Spain
e-mail: cchackelson@tecnun.es

Palabras clave: Storage policy, productivity, simulation tool

1. Introduction

Order picking is defined as the process of clustering and scheduling orders, assigning stock on location to order lines, releasing orders to the floor, picking the articles from storage locations and the disposal of the picked articles (De Koster et al. 2007). Picking is the most labour-intensive operation in warehouses with manual systems and a very capital-intensive operation in warehouses with automated systems (Tompkins et al. 2010) so it is therefore a key process in warehouse design as it has a significant impact on capital and operating costs. Coyle et al. (2003) state that this activity's contribution could arise a 65% of total operating costs of a common warehouse.

According to Malmbor and Al-Tassan (2000), there are three operation rules that influence the order picking system operating performance: storage locations assignment, batching and routing. To implement cost-effective solutions, some ideas have being proposed. One of these ideas is to use ABC analysis in order to cluster items into storage classes (Kee 2003), resulting a successful way of both reducing the picking cycle time and maximizing the throughput of the system Manzini et al. (2006). In addition, according to De Koster et al. 2007, there is a potential for improving picking productivity by picking a group or batch of orders in a unique picking tour.

Petersen and Aase (2004a) have studied the impact of different combinations of the three previously mentioned operational policies developing a simulation model that considers fixed order sizes. Other authors (Petersen and Aase 2004b, Manzini et al. 2006, and Manzini et al. 2007) have also studied these strategies, but none of them has take real demand information into account. Gu et al. (2010), state that there is a significant gap between academic research and practical application. A possible way of bridging it is conducting case studies and developing simulation models that include real archival data, with the aim of designing and operating actual order picking systems.

This paper presents a case study where order picking process is improved by implementing class-based storage policy. Within-aisle storage and across-aisle storage are also compared employing archival demand information. Once the best storage policy is determined, batching is analyzed. The results are obtained building a Discrete Event simulation model that emulates three different demand scenarios: low, medium and high demand.

The following sections describe the most common order picking strategies and simulation tools; state the research objective and the methodology selected to reach it, present the case study, and detailed the simulation model. Finally, the obtained results and conclusions are illustrated.

2. Order Picking Alternatives and Simulation Techniques

Storage policies assign products to storage locations, and there are several types of storage assignment: random storage, closest open location storage, dedicated storage, class based storage and family grouping (Rouwenhorst et al. 2000, De Koster et al. 2007).

- Random storage: All incoming products are assigned a location that is selected arbitrarily from empty locations. Space utilization while using this method results really high, but travel distance and products identification results more time consuming.
- Closest open location storage: In this case is the worker who chooses the first free location for storing the products. Following this logic, locations situated more closed to depot have mayor utilization than the others.
- Dedicated storage: Each item has a fixed location called dedicated storage. The principal advantage of this method is that worker becomes familiar with products position; although this does not work when hundreds or thousands of items are storages. In addition, space utilization while using this method results low, because locations are reserved only for a specific product and warehouse should be large enough to store maximum inventory level.
- Class-based storage: According to De Koster et al. (2007) the concept of class-based storage combines some of the methods mentioned so far. Items are cluster into classes in such a way that the fastest moving class contains about 15% of the products stored but contributes to about 80% of the turnover. Each of the mentioned classes is assigned to a dedicated zone, and products are located arbitrarily within their area. Fast moving items are called A-items; next fastest moving category is known as B-items, and so on. Consequently, class-based storage requires more space than random storage policy. The principal advantage of this strategy is the reduction of travel time.
- Family grouping: All storage assignment policies discussed so far have not incorporated possible relations between products (De Koster et al. 2007). Although, it might be interesting to locate similar items close to each other. It is important to highlight that this policy could be easily combined with some of the strategies previously described.

Some examples of the storage policies detailed above are shown in Fig. 1.1.

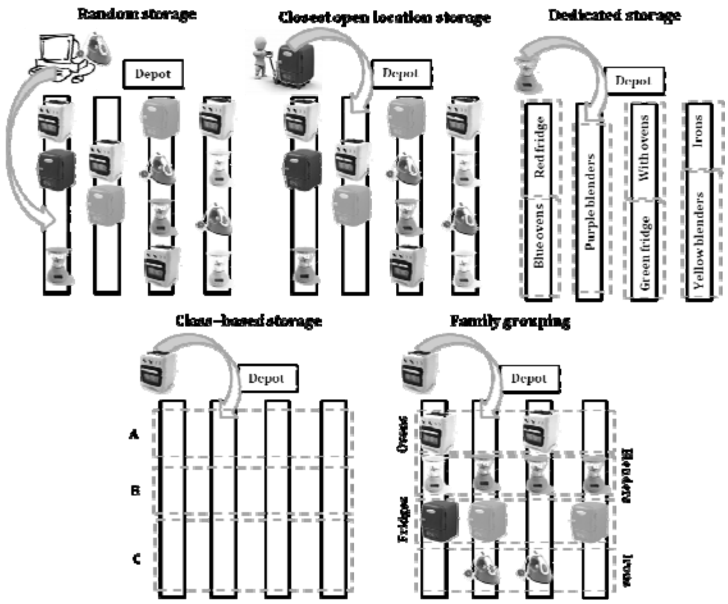

Fig. 1. Examples of most common storage policies

There also exist different ways of implementing storage policies. Product classes could be located using within-aisle, across-aisle, diagonal or rectangular storage implementation strategy (Petersen and Aase 2004b, De Koster et al. 2007). This research compares family grouping and class-based storage following a within-aisle or an across-aisle storage implementation strategy.

Regarding to **batching strategies**, two alternatives are commonly implemented. Each order could be picked individually (picking by-order); this policy is frequently selected because it is easily implemented and always keep order integrity (Petersen and Aase 2004a). On the other hand, according to De Koster et al. 2007) there is a potential for improving picking productivity by picking a group of orders in a unique picking tour (pick by-article).

In the **routing method** the travelling salesman problem is considered and six routing methods are considered by Roodbergen (2001): S-Shape, Return, Mid-point, Largest-gap, Combined and Optimal. Although routing policy should be determined at the same time that the storage strategy is, this research considers only a Return strategy.

Simulation is a technique that uses the computer to model a real-world system, especially when those systems are too complex to model with direct mathematical equations without disturbing or interfering with the real system (Banks et al. 1996). The main advantages of simulation arise from the better understanding of interactions and identification of potential difficulties that simulation offers, allowing the evaluation of different alternatives and therefore, reducing the number of changes in the final system. There are several simulation techniques; however, Discrete Event Simulation is the most commonly used (Jahangirian et al. 2010).

3. Objective and Methodology

Our examination of the literature revealed that simulation techniques could aid configuring the picking process while integrating storage location assignment, batching and routing. This proposition gives rise to the following research question: Which is the most efficient storage and order clustering strategy for concrete warehouse picking needs? How could Discrete Event simulation aid the selection of the most adequate alternative?

A Case Study approach is selected because it has been pointed as a useful tool for theory building as well as for exploratory, descriptive or explanatory research (Rowley 2002). In addition, a Single Case design based on archival data of a “common distribution centre environment” is chosen, following Miles and Huberman (1994) suggestion: a typical or representative single case is an instance that have grate payoff in case research. According to Yin (2009), the essence of a Case Study is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result.

4. Case Study

A home appliances manufacturer that manages a large number of Make to Stock product families was selected. According to Errasti et al. (2010) and Errasti (2011) the manufacturer represents a common “distribution centre environment” (thousands of stocked references, 24h-48h delivery time; 85-93% error free and full orders), making it an appropriate location to carry out the Single Case Study. This research focuses on the small appliances warehousing order picking process where all products are storaged in pallets in a conventional rack system, following a family grouping storage strategy in order to simplify multi-product pallet consolidation. The picking is conducted by order, employing electric pallet trucks. Several Analysis Workshops with warehouse manager have been coordinated with the aim of selecting the most suitable operation strategies, restricting the amount of policies to be studied. This process ended with the selection of the following alternatives to be compared:

- Class-based storage strategy vs. family grouping
- Within-aisle vs. across-aisle storage implementation strategy
- Pick by-article vs. pick by-order

5. Simulation Model

This section describes the warehouse simulation model developed in this research. It is based on historical data of client orders taking into account three different scenarios: low, medium and high demand; and compares the alternatives previously mentioned. The objective is to indentify which policy provides the most significant reduction of total picking travel time, and measure the potential productivity improvement.

Three different operating activities are emulated: ABC class-base storage with a within-aisle strategy implementation and a pick by-order policy, ABC class-based storage with an across-aisle strategy implementation and pick by-order, and ABC class-based storage with an across-aisle strategy implementation with a mix picking policy (A-items by article and B and C items by order). Figure 1.2 shows both storage implementation strategies compared in this research.

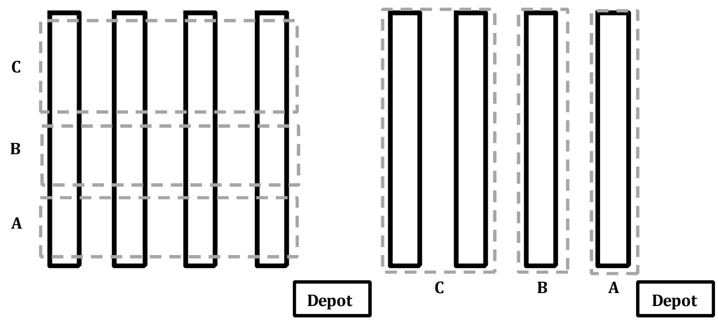

Fig. 1. 1 ***Across-aisle storage (left) and Within-aisle storage (right)***

The specifications for the warehouse simulation model are:

- Number of aisles: 6
- Locations per aisle: 144
- Routing strategy: Return
- Amount of classes: 3 (ABC)
- Demand patterns: number of orders, pick lines per order and quantity per line
- Picker travel rate: 80 meters per minute
- Pallet capacity: 1400 dm^3
- All storage locations have the same size

AnyLogic 6.5.0 University Researcher was the selected software to build the event simulation model. The following figure illustrates a 3D view of the previously described model.

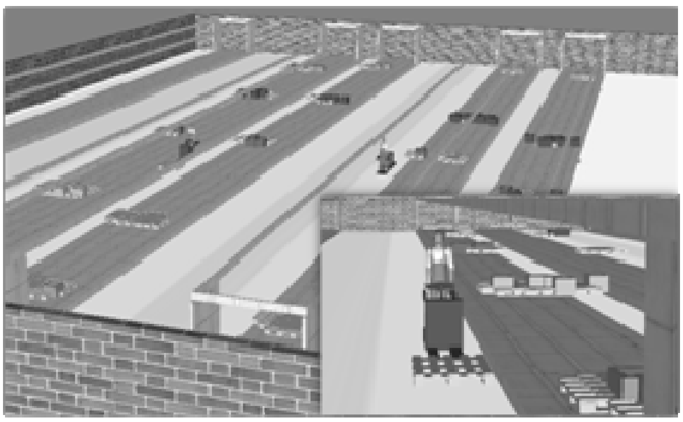

Fig. 1. 2 ***Simulation model***

6. Results

After a two step analysis, ABC class-based storage policy across- aisle is selected, combined with a mix picking policy (A-items by article and B and C items by order). A 16% of reduction of travel distance is achieved, resulting on important cost savings and productivity improvement. Table 1.1 shows a comparison between the analyzed order picking operational rules.

Table 1 Picking operational rules comparison

Storage strategy	Implementation policy	Batching	Travel distance	Improvement
Family grouping	-	By-order	46.191 m/day [2]	-
ABC class-based	Within-aisle storage	By-order	45.570 m/day [2]	1,4%
ABC class-based	Across-aisle storage	By-order	40.561 m/day [2]	14%
ABC class-based	Across-aisle storage	Combined [1]	39.724 m/day [2]	16%

[1] Combined: A-items by article and B and C items by order

[2] The above travel distance data have been modified due to confidentiality reasons

It is important to highlight that these results can be used to support decision making process because the simulation model has been subjected to a verification and validation process. This V&V process has been based on Law and Kelton (1991) definitions: "Verification is determining that a simulation computer program performs as intended" and "Validation is concerned with determining whether the conceptual model is an accurate representation of the system under study".

Besides, Kleijnen (1995) and Sargent (1996) state that to verify a computer simulation program Animation may be used. Since, in this research, the warehouse manager is familiarized with the corresponding actual system, programming and conceptual errors were discarded analyzing the 3D view shown in Fig. 1.3.

To validate the model, the simulated and the real data were compared (Kleijnen 1995). With this purpose in mind, real data collection was needed. In this case, this is possible because actual system data is recorded electronically at each system state change (event). Once real-world data has been obtained, it has been used to feed the model in historical order, calculating simulated time and productivity according to the original order picking process design. The comparison of the simulated values and the actual system outputs turned up to be acceptable for the home appliance warehouse manager.

7. Conclusions

This study has improved order picking performance by examining different operational alternatives. Results of the simulation model support previous studies by showing that batching policy and class-based storage have great impact on reducing travel distance. Moreover, it shows the importance of selecting the most suitable storage policy and deciding the appropriate implementation strategy.

This research also ratifies that simulation techniques are useful when solving real problems, and on particular when redesigning order picking operational rules. Thus, a simulation model allows evaluating picking alternatives proposed by warehouse managers in the Analysis Workshops. The case study also reveals that the results obtained are not always the expected by warehouse managers, helping them to make the right picking design decisions.

The authors of this paper propose that more research is needed to structure a warehouse design approach including robust and adaptive design criteria in order to satisfy order fulfilment in more dynamic demand environments. However, this is an important step into bridging the existing gap.

References

Banks J, Carson JS and Nelson BL (2010) Discrete-Event System Simulation. 5th Edition. United States: Prentice Hall, 640p. ISBN-10: 0136062121

Coyle JJ, Bardi EJ, Langley CJ (2003). The Management of Business Logistics: A Supply Chain Perspective, 7th ed., South-Western, Mason, OH.

De Koster R, Le-Duc T, Roodbergen J (2007) Design and control of warehouse order picking: A literature review. European Journal of Operational Research 102: 481-501

Errasti A, Chackelson C, Arcelus M (2010) Estado del arte y retos para la mejora de sistemas de preparación de pedidos en almacenes: Estudio Delphi. Dirección y Organización.40: 78-85

Gu J, Goetschalckx M, McGinnis L (2010) Research on warehouse design and performance evaluation: A comprehensive review. European Journal of Operational Research 203(3): 539-549

Jahangirian M, Eldabi T, Naseer A, et al. (2010) Simulation in manufacturing and business: A review. European Journal of Operational Research 203: 1–13

Kee MR (2003) The well-ordered warehouse, APICS: The Performance Advantage, March: 20-24.

Kleijnen JPC (1995) Verification and validation of simulation models. European Journal of Operational Research 82, 145-162

Law AM, Kelton WD (1991) Simulation Modeling and Analysis. 2nd ed. McGraw-Hill, New York

Malmborg CJ, Al-Tassan K (2000) An integrated performance model for order picking systems with randomized storage. Applied Mathematical Modelling 24(2): 95–111

Manzini R, Gamberi M, Regattieri A (2006) Design and control of an AS/RS. International Journal of Advance Manufacturing Technology 28: 766-774

Manzini R, Gamberi M, Persona A, et al. (2007) Design of a class based storage picker to product order picking system. International Journal of Advanced Manufacturing technologies 32: 811-821

Miles H, Huberman M (1994) Qualitative data analysis: a sourcebook. Beverly Hills CA. Saga Publications

Petersen CG, Aase G. (2004a) A comparison of Picking, storage, and routing polices in manual order picking. International Journal of production economics 92:11-19

Petersen and Aase (2004b) Improving order-picking performance through the implementation of class-based storage. International Journal of Physical Distribution and Logistics Management 34: 534-544

Roodbergen KJ (2001) Layout and routing methods for warehouses. Ph.D. thesis, RSM Erasmus University, the Netherlands.

Rouwenhorst B, Reuter B, Stockrahm V et al. (2000) Warehouse design and control: framework and literature review. European Journal of Operational Research 122: 515–533

Rowley J (2002) Using case studies in research. Management Research News 25(1)

Tompkins JA, White JA, Bozer YA et al. (2010) Facilities Planning. 4th Edition. NJ: John Wiley & Sons. 854p. ISBN: 978-0-470-44404-7

Sargent RG (1996) Verifying and validating simulation model, Proc. of 1996 Winter Simulation Conf: 55-64

Yin RK (2009) Case Study Research: Design and methods. 4th Edition. SAGE Publications, Inc.