Computers & Industrial Engineering 126 (2018) 88–98

Contents lists available at ScienceDirect

Computers & Industrial Engineering

journal homepage: www.elsevier.com/locate/caie

A method to choose between carton from rack picking or carton from pallet picking

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ARTICLE INFO

Keywords:
Warehouse picking
Picker-to-parts
Items storage
Design methodology

ABSTRACT

In a manual picker-to-parts picking warehouse, a usual approach is to divide the whole stocking area in two different zones, the reserve and the forward areas. The dimensioning of the forward area, which is dedicated to picking activities, has an important impact on the overall performance of the picking system. Indeed, its size as well as the item allocation deeply influence the travel time of the operators on one side and the frequency of the refilling activities on the other. The present paper aims to provide a new method that can be easily used to assess the most suitable way of storing a product in the forward area, considering the possibility of keeping a product directly in a pallet or storing it in racks. Starting from simple data, such as the picking orders of the items to pick and their physical dimensions, as well as the characteristics of the warehouse, the method focuses on the comparison of the total times to define the *Carton Pick from rack Convenience Condition* (*CPCC*). The *CPCC* formulation and its application methodology allow to quickly establish which items should be stored on pallets and which on racks, with interesting impacts on space and time savings. This is shown also in the reported case study, the results of which prove the effectiveness as well as the easy and full applicability of the methodology, also in different warehouse contexts.

1. Introduction and background

Warehouse manual picking is the activity performed within a warehouse by a human operator to retrieve products required by one or more customers. Due to its characteristics, the picking activity is often the target of several studies and debates, which propose various methods that can be used to solve its main issues (Thomas & Meller, 2015). In particular, one of the main topics dealt with in the literature concerns warehouse performance improvement, through the reduction of the time needed to process the picking orders, and, as a consequence, of the time spent travelling from one stock location to another one (De Koster, Le-Duc, & Roodbergen, 2007; Tompkins, White, Bozer, & Tanchoco, 2010).

Strictly linked to the question of performance increase and distance reduction is the problem of the dimensioning and allocation of the forward and reserve areas. The forward picking area is generally a sub-region of the warehouse dedicated to the pick and the order activities; such activities are often concentrated in a small physical space, in order to warrant more processing efficiency. On the other hand, the reserve area is the part of the warehouse designed for storage of bulk pallets, which are also used for the replenishment of the forward area (Rouwenhorst et al., 2000; De Koster et al., 2007; Bartholdi & Hackman, 2017). The forward area and the reserve area can also be located in the same zone of the warehouse: in this case, the stock-keeping units (SKUs) of the forward area are on the lower floor of the shelving (ground floor), while on the other upper racks there are the SKUs for bulk storage and replenishment. In such a configuration, also called low-level picker-to-parts system, the SKUs of the forward area are usually pallets, with one pallet for each one of the different product codes that are needed for order picking (Caron, Marchet, & Perego, 2000).

The allocation and dimensioning issues for these two warehouse zones have been studied by many researchers, with several proposed models and methods. In general, most of the authors underline that during the design of such zones a fundamental trade-off has to be considered. This deals with the fact that by enlarging the forward area through the introduction of more stock keeping units, there is a saving due to a faster picking and to a reduction in the number of restocks; however, such benefits are inevitably accompanied by an increase of the distances travelled to process the picking orders, leading to a reduction (and in some cases also a nullification) of the first possible saving (Gu, Goetschalckx, & McGinnis, 2007). Hence, it follows that the

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https://doi.org/10.1016/j.cie.2018.09.017
Received 27 January 2017; Received in revised form 9 June 2018; Accepted 7 September 2018
Available online 08 September 2018
0360-8352/

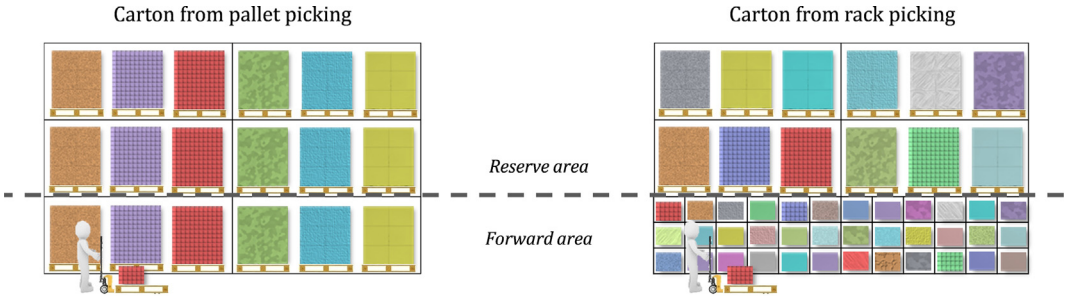

Fig. 1. Carton from pallet picking and carton from rack picking.

design of the forward area has to consider both these conflicting aspects: some authors propose models that can be used to assess the most suitable dimensions, while others are focused on the choice of which SKUs should be stored within.

The first contribution on the so-called *forward-reserve problem* is by Bozer (1985), in which it is acknowledged the usefulness of splitting the warehouse shelving into an upper reserve area and a lower forward picking area. Hackman and Rosenblatt (1990) start from this idea proposing a heuristic based on the knapsack problem. The objective is to decide which SKUs have to be assigned to a forward area of a fixed dimension, minimizing the total material handling costs of order picking and refilling. Frazelle, Hackman, Passy, and Platzman (1994) extend this method, modelling the investment costs and the material handling costs and considering the dimension of the forward area as a variable. Van den Berg, Sharp, Gademann, and Pochet (1998) focus on the storage replenishment from the reserve area to the forward one, minimizing the impact of this activity from a time perspective. Bartholdi and Hackman (2008, 2017) deeply study the dimensioning of the forward area, from various points of view, taking into account the trade-off between the number of items to store, the number of restocks and the occupied space. Walter, Boysen and Scholl (2013) propose to investigate discrete forward-reserve problems, comparing them with the fluid ones. The focus is the sizing of the forward area, taking into account space allocation and products selection.

2. Description and aim of the study

An interesting question concerning the *forward-reserve problem*, that until now has received very little attention, concerns the decision on how to store a certain item in the forward area. This problem is typically not often addressed, either in the literature or in industrial contexts, since in many cases the products stocking mode is defined *a priori*, referring only to people's experience or common sense and considering only a limited number of the aspects that can, in fact, come into play. For example, warehouse managers could decide to store all the products in a pallet in order to warrant easier warehouse management and maintenance. Alternatively, they could establish that small dimension items have to be stored in cartons and picked directly from racks, without considering how frequently they are ordered. However, an in-depth study in this field, leading to an understanding of the possible convenience of storing a certain item in a certain way with respect to another one can bring relevant benefits. Among others, establishing that some product codes are more conveniently picked from racks than from a pallet implies a potential reduction of the space needed for storing such items in the forward area, with a subsequent decrease of the distances travelled by the pickers to process the picking orders and of the overall picking time (Tompkins et al., 2010). A very similar problem has already been addressed successfully in assembly systems design. Various methods and models have been proposed to evaluate and compare the feeding and the picking activity, when these are done with pallets or from boxes (Battini, Calzavara, Otto, & Sgarbossa, 2017; Calzavara, Hanson, Sgarbossa, Medbo, & Johansson, 2017). Besides to a space reduction, it is demonstrated that there could be also time savings and ergonomics benefits.

The present paper proposes a design methodology that can be used to understand the best way of storing goods in a warehouse forward picking area. Starting from simple information referring to the stored item, including also the characteristics of the carton and pallet employed, together with some typical warehouse times, it allows to establish, for every single product, whether this is more suitable for carton picking from a rack or from a pallet. The proposed method considers a typical picking low-level picker-to-parts warehouse configuration, where the forward area is on the ground level of the shelving, and the various items are stored on pallets, with only one stock location dedicated to each item. Then, the procedure allows to evaluate if this configuration is the most suitable one for a certain item, or if it is better to stock it in a specific warehouse aisle, in which the cartons are stored on racks. Fig. 1 shows the comparison of the two alternatives under study: on the left, the carton from pallet picking configuration; on the right, the carton from rack picking one. Also in this latter case, each stock location is dedicated to one product code. Moreover, according to the depth of the shelving, there could be the possibility of storing more than one carton of the same item in the same stock location, one behind the other.

In order to give a clear exposition of the proposed methodology, the remainder of the paper is structured as follows. The following section reports the mathematical modelling of the problem, leading to the introduction of the so-called *Carton Pick from rack Convenience Condition* (*CPCC*). Subsequently, two individual cases are presented, referring to as many circumstances that are observable in practice and that can lead to a simplification of the *CPCC* formula. The same formula is then studied through a parametric analysis, to help understanding which parameters mainly influence the storage decision of a certain product code. Once the mathematical formulation has been described and proved, Section 4 introduces the full decision-making procedure, reporting also an example of application of the method in a real industrial case study. Furthermore, Section 5 comments upon the results obtained, while in the concluding paragraph some final considerations and ideas for further research are suggested.

3. The carton pick from rack convenience condition (CPCC)

As far as manual warehouse picking is concerned, there are several factors that can usually influence the outcomes of a picking tour. One of the most widespread and proven ways of describing and evaluating a manual warehouse picking system is to consider the time spent in processing a picking order. In fact, such time is indicative of the overall performance of the picking system, and it can be used as a reference to understand the effectiveness of any change that can be introduced. If a certain change leads to a decrease of the picking time, it means that probably this change deserves to be implemented (Gu, Goetschalckx, & McGinnis, 2010; Tompkins et al., 2010).

For the study presented in this paper, the various time components involved in the picking process, in the case of cartons from both pallet