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Developing design guidelines for a case-picking warehouse

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ABSTRACT

Warehouses can be characterized in many ways, including the number of items stored, the average number of cases per pallet, throughput and inventory requirements, and demand profile, to name a few. Thus, there is no one-size-fits-all design for case-picking warehouses, and hundreds of designs are possible. Moreover, the decision variables in warehouse design are interrelated and this further complicates the design process. The purpose of this paper is to provide a set of guidelines for arriving at a "good" design configuration for a manual, case-picking warehouse. Our goal in developing a set of guidelines is that it would provide a design that is close to the optimal solution, which could then be further analyzed and improved. We limit the decision variables considered in our analysis to include the size and layout of the forward area, dock door configuration, pallet area shape, and pallet rack height. To develop our design guidelines we employ a statistical-based methodology, whereby we use one set of data to develop the guidelines and an independent set of data to evaluate the performance of the guidelines. Our response variable is the number of labor hours. We use analytical models to evaluate labor hours for each design in the solution space. The most impactful parameter that influences our guidelines is using a forward area. Other parameters include: the ratio of SKUs to bottom-level pallet locations, ABC curve skewness, and number of lines per batch. Our results indicate that our guidelines provide a good design that minimizes labor hours.

1. Introduction

According to the 2012 "DC Measures" study conducted by the Warehousing Education and Research Council and *DC Velocity*, the number of distribution centers (DCs) with primarily full case-picking operations has increased over the last four years (Warehousing Education and Research Council, 2012). Approximately one third of the 2012 survey respondents characterized their facilities as having primarily case-picking operations, and based on previous years' surveys, the number of DCs with full case-picking operations has increased over the last four years (Warehousing Education and Research Council, 2012).

The study lists key benchmark metrics for warehouse operations such as inventory turns, put aways per hour, lines picked and shipped per hour, and cases picked and shipped per hour. These metrics are highly dependent on the layout and design of the warehouse. In order to improve such metrics, the overall design of the warehouse should be considered.

Analytical models can predict performance metrics such as put aways per hour and lines picked per hour for a given warehouse design, yet the best design is not always apparent, as hundreds of solutions are possible. The warehouse operating environment can be characterized in many ways, including the number of pallet locations, the number of SKUs, the number of cases per pallet, throughput requirements, and product activity, to name a few. Moreover, the decision variables in warehouse design are interrelated, and this further complicates the design process. Because warehouse design entails a vast solution space, practitioners would benefit in having a search algorithm that points to designs that are close to the optimal solution for its set of characteristics.

For a manual, case-picking warehouse that employs picking from pallet rack, two decision variables are the shape of the pallet rack area and the number of levels of pallet rack. The shape of the pallet area can be characterized using a ratio of the width-to-depth of the pallet area, where the depth refers to the distance along an aisle. In this paper, the designs that we suggest are limited to a shape of 4.0 because warehouses typically do not exceed this shape due to the low storage utilization involved with such wide staging areas. Both the shape and number of levels impact the footprint of the pallet area, as higher levels of pallet rack require a smaller footprint for a given number of storage locations. Another decision variable is the dock door configuration. A one-sided configuration involves a single staging area with shipping and receiving along only one side of the facility, whereas a two-sided configuration entails two staging areas and dock doors along opposite sides of the facility.

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Another important decision variable involves the question of whether or not to include a forward area for picking. A forward area can increase picking efficiency by placing fast-moving items in a smaller area, so as to decrease the travel required for picking these items. However, an additional cost is involved in replenishing the items in the forward area. And, as the forward area grows in size, the picking efficiency decreases due to increased travel. Thus, the size of the forward area is another decision variable requiring consideration. In addition, the layout of the forward area can include random or volume-based storage such as class-based storage. If class-based storage is utilized, the dock door configuration implies either a 1-sided or 2-sided layout.

Given the number of decision variables, the number of possible designs to consider can be overwhelming. For example, if one considers 7 possible pallet area shapes, 2 choices for pallet rack height, a one- or two-sided dock door configuration, 7 possible sizes for a random storage forward area, and 9 possible sizes for the 1-sided and 2-sided class-based forward area layouts, the number of possible designs is 476, as illustrated in Fig. 1.

With a large number of possible designs, some designs will perform better than others. For example, consider the distribution of labor requirements for each of the 476 designs (from the range of choices in Fig. 1) in Fig. 2 for a particular set of warehouse operating characteristics. For this warehouse environment, the designs with the 1-sided, class-based layout perform the best, and the worst designs are those with no forward area. Consequently, a set of guidelines that narrowed the solution space with these data to design choices with 1-sided, class-based layouts would benefit a practitioner, even if the guidelines did not provide the best size of the forward area. We later use this observation that the set of good solutions share characteristics that can be used to derive a "standard" solution (within the right area of the solution space). The standard solution provides a means for comparing the performance of other designs.

The purpose of this paper is to develop a set of guidelines that provides a good design configuration for a manual, case-picking warehouse. The guidelines consider the warehouse environment characteristics and provide an initial design that minimizes the total labor required. The resulting design configuration can be further analyzed and improved. We define a design configuration to include the following decision variables: the size and layout of the forward area, the dock door configuration, pallet area shape, and pallet rack height. We examine the warehouse operating environment data for a number of data sets, as well as the best warehouse that results for each data set from a complete enumeration of the solution space, to derive a set of guidelines that considers the warehouse operating environment.

In the next section we include a review of literature related to the aforementioned design variables. In Section 3, we provide a problem statement, and Section 4 includes the methodology for developing the guidelines described in Section 5. Then, in Section 6 we summarize our findings related to designing a case-picking warehouse that are intrinsic to our guidelines, and we also provide a comparison of the results from the guidelines to the best design that is obtained through complete enumeration.

2. Literature review

Research in the area of overall warehouse design is limited to models that are generally qualitative in nature, with a limited view into the solution space (Gu et al., 2010). Gu et al. (2010) note that simple models that provide actual results would be useful in guiding overall warehouse design. Nonetheless, individual components of warehouse design have received considerable attention, including the forward-reserve problem (Gu et al., 2007).

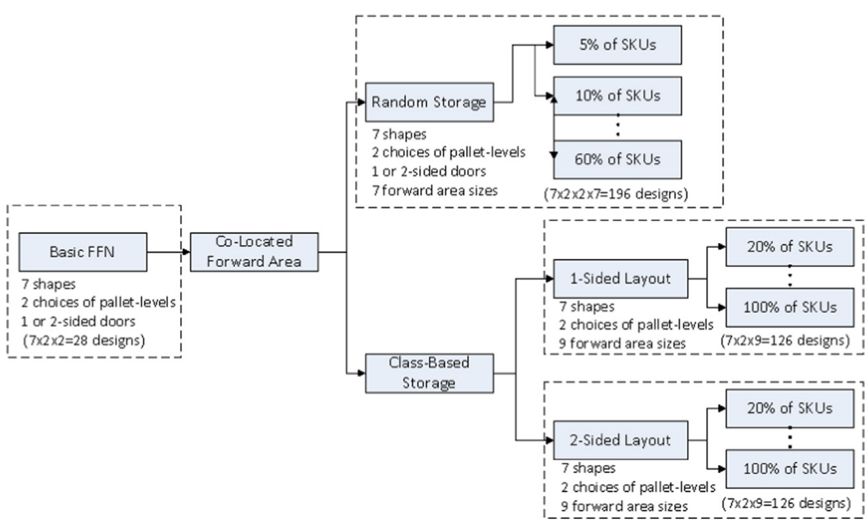

Fig. 1. Example of possible designs to consider.

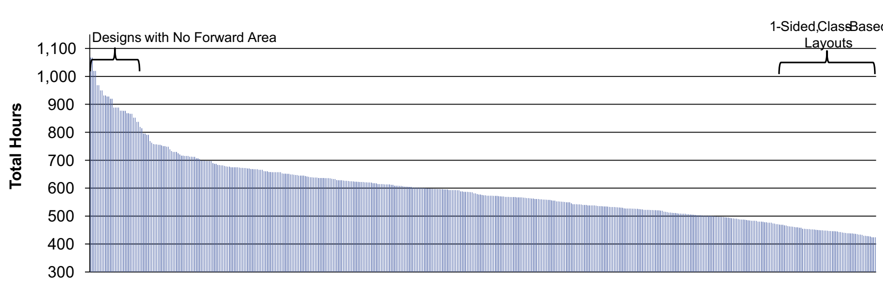

Fig. 2. Total labor hours (designs ordered from most to least hours required).