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A new approach to model and optimize the order sequence of a two-stage storage and order picking system with particular attention to restrictions of the material flow

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Abstract

This article shows the fundamental research concerning the modeling and optimizing a two-stage storage and order picking system. Therefore are elected for the type of modeling flexible flowshop problems and for the optimizing method tools as constraint logic programming. For example, it is detected that the sequencing of picking is a major influencing factor in order to increase the picking performance while minimizing the processing times of jobs. Based on a computed program the results are shown for different cases. As a main conclusion, you can estimate the benefit in real cases.

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1. Introduction

The constantly increasing competition forces companies to install more and more efficient production processes. In the area of distribution logistics, this development caused to increase by optimizing the picking action and thus to reach the increasing performance requirements in terms of the material flow rate (Arnold, D., *1995*). Consequently, an interesting research focus is the optimization of such storage and order picking as following. In the second

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chapter there is shown the physical material flow system, which has to be described in the next chapter by modeling as a machine scheduling problem. In the fourth chapter, it is shown which target functions will be considered and in the fifth chapter is explained the methodology how to solve the optimization problem herewith. It is discussed in the sixth chapter, how to apply this methodology on a real system. In the seventh chapter this approach is validated for different types of problem complexities mainly in getting computing results and at the end are explained the following research steps. The main objective of this article is to show how to model such real logistic systems with the purpose of a formulation of an optimization problem with practical target functions and to show than by a computed real system what are the results and benefits for different structures of applications.

2. Problem formulation

The central components of modern storage and order picking systems (see Fig. 1) are high-bay warehouses (HBW) with a certain number of storage aisles (L) and a sort heap e.g. in the form of an automatic container storage (ABL) also with a certain number of lanes (B). In front of the zone of high-bay warehouse are picking stations (K), which are connected by conveyors with the high-bay warehouse and the automatic container storage. The necessary pallet units needed to consolidate the orders have to remove from high-bay warehouse by the stacker cranes and transport on the conveyors to the order picking places as shown.

There is placed the order picker who takes out certain pieces of goods of the pallets, and put them into a provided container, which is then transported to the automatic container storage. Since the picking of orders occurs in two steps, multiple picking positions are taken from a pallet accordingly. This means that each item is related to the necessary number of articles, which is required by the customer. Thus, at least a separate container is required for each position of a picking order. After all picking orders is removed from the pallet unit, it has to transport back into the high-bay warehouse and put back into storage position. Once all the containers required for a certain customer order are stored in the automatic container storage, these have to transport and pack at working places of final packing and control (P). There it is the task to pack the different articles into a complete customer order unit and to carry out a final check with respect to identity, quantity and quality. Then the shipping units are provided in the dispatch area and sent to the customer.

3. Modeling as machine scheduling problem

3.1. Basics

In practice, the above sequence planning is often done by simple priority rules or even by hand, for example, on the basis of experience. More and more, however, the planning of machine scheduling is used in the context of modern methods of Operations Research and Artificial Intelligence, especially in other similar problem areas (Neumann, K.; 1996). In many applications this planning is further supported by an electronic control interface console for visualization (Baptiste, P., Le Pape, C., Nuijten, W., 1995).

In the studies on the modeling of such systems, the decision is taken on flexible flow shop problems (also called FFS problems or hybrid flow shop problems) like (Lock, H.C.R., Breitlinger, S.; 1994). They represent a generalization of the flow shop problems. Here are considered m machines instead of m machine levels, on each of which we have a certain number of identical parallel machines (Blazewicz, J., Domschke, W., Pesch, E.; 1996). There are given

- n Jobs J_j (j = 1, ..., n) on the
- m ≥ 2 machines stages each $s_i \geq 1$ identical parallel machines $M_{i1, i2}$ M, ..., M_{isi} to be processed.

Job j can be scheduled on each of the si machines. So there are n jobs on m stages to be processed, first at level 1, then at level 2 and so on up to the m-th stage (Domschke, W., Scholl, A., Voß, S.; 1993).

The basic method for solving FFS problems is taking a division into three sub problems. The first part of the problem involves the assignment of jobs to machines at each stage (resource allocation), the second part of the problem determines the sequences of jobs on each machine (sequencing) and the third consists of the setting of start