Design of Material Handling Systems in an Assembly Production System

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Abstract

Over the past several decades, a gradual progression in automation technology has led to the replacement of many conventional non-automated material handling systems (MHSs) with automated ones. Automated guided vehicle systems (AGVSs) and automated storage/ retrieval systems (AS/RSs) have become popular material handling devices in the modernized factory. Use of automated MHSs can lead to substantially lower overall material handling costs. However, the installation cost of such a system can be significant, and MHSs that do not function properly result in significant losses in productivity and profits. Hence, the design and control problems of automated MHSs have been of much interest to many researchers and a fair amount of the related research papers appeared in the literature. Most of the researches treated the design and control problems of automated MHSs as independent problems though they are closely related each other.

The system we consider in this paper consists of an AGV, a miniload AS/RS and several assembly production lines. Each assembly production line is characterized by a sequence of workstations linked together for the production of a given type of product. The assembly cycle time and the production quantities are assumed to be equal among the assembly lines. In assembly tasks, the base items are launched at the beginning of the each assembly line and subcomponents are added to the base components at the succeeding workstations to manufacture the final products. Subassemblies are transported by conveyor line and assembly parts (components) are

supplied to workstations by the AGV from the miniload AS/RS. The miniload AS/RS system consists of two-sided storage racks, a storage/retrieval (S/R) machine operating in each of the aisles, storage containers for housing parts and load stands at the front end of the aisle to facilitate order pickings. While order pickers at the load stands are picking parts from some container, the S/R machine returns the previously retrieved container to its original location in the rack, and then brings another container for the next picking operations. Since the parts needed at each workstation may not be a single component, it is assumed that kits are produced at a kitting station located in front of the load stands. The number of kits contained in the unit load affects the S/R machine and picker cost; S/R machine operating cost, AGV operating cost and inventory holding cost. A large unit load incurs a higher work-in process in workstations and higher inventory level at the miniload AS/RS as well as lager storage space requirement. On the contrary, a small unit load needs more frequent travels of the AGV from the kitting station to workstations and higher throughput requirements of the miniload AS/RS system.

We intend to solve simultaneously the design problem of miniload AS/RS and the problem of determining an optimal unit load size of the AGV. First, an AGV operating policy is proposed and then, under the proposed policy, a nonlinear mathematical model is formulated. Secondly, based on the characteristics of the objective function and feasible region, we determine an appropriate sequence of lines the vehicle visits and then develop a solution procedure to find an optimal solution. To illustrate the model, problems are chosen and solved.