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Performance analysis of assembly systems with highlift stations: a practical approach

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Abstract

One common problem associated with automatic assembly systems is that some assembly operations may have relatively long cycle times. As a consequence, the productivity, as determined by the operations with the longest cycle time, can be significantly reduced. Therefore, a special form of parallel workstation known as a highlift station was developed to improve the performance of an automatic assembly system. In this paper, we present a simple analytical model that can help engineers to estimate the performance of highlift stations. This model is particularly useful at the design stage, as only approximate results are necessary for selecting the configuration.

Keywords: Assembly systems; Highlift stations; Analytical models

1. Introduction

One of the problems associated with automatic assembly systems is that they are usually structured as serial production systems. As a consequence, it is not generally impossible to improve the productivity of an individual station in the line by using multiple parallel stations installed next to one other. However, highlift stations arranged in a serial form can serve the parallel processing purpose. With this design, several identical in-line parallel stations performing the same function are installed at one stage in the series, and the pallet is then transferred to the first idle highlift station encountered. While one of the highlift stations is working, additional pallets can be processed by another station. If an assembly has been processed by a highlift station, it will be allowed to pass through the others without further processing. In this way, a form of parallel processing can be achieved.

Most of the researchers are interested in studying serial production systems (Buzacott & Shanthikumar, 1993; Pike & Martin, 1994). However, the results of the performance characteristics

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of highlift stations using simulation have been examined by the authors (Lai, Lam, & Leung, 1994; Leung & Lai, 1994a,b, 1996). The underlying idea of the estimation is mainly based on the observation of the arrival sequence and the working cycles of the model. Three different working cycles were identified, namely the synchronization cycle, jam cycle and non-synchronization cycle.

2. Model description

In a highlift system, an assembly enters the system at station 1 and undergoes the required operations of stage 1. It is then transferred to the first available highlift station to perform operations in stage 2. If no highlift station is available, the assembly will be transferred to the next downstream station that performs the same kind of operations as the highlift stations. If the next downstream station is busy, assemblies will be queued up at the downstream station. After the required operations in stage 2 are finished, the assembly leaves the AAS at the last station with no further processing (Figs. 1 and 2).

3. Working cycles of the model

As highlift stations will be balanced before they are used, we will only analyze the situation when the line is balanced. With this arrangement, two different types of working cycles, namely, the (i) synchronization cycle and (ii) the non-synchronization cycle will occur.

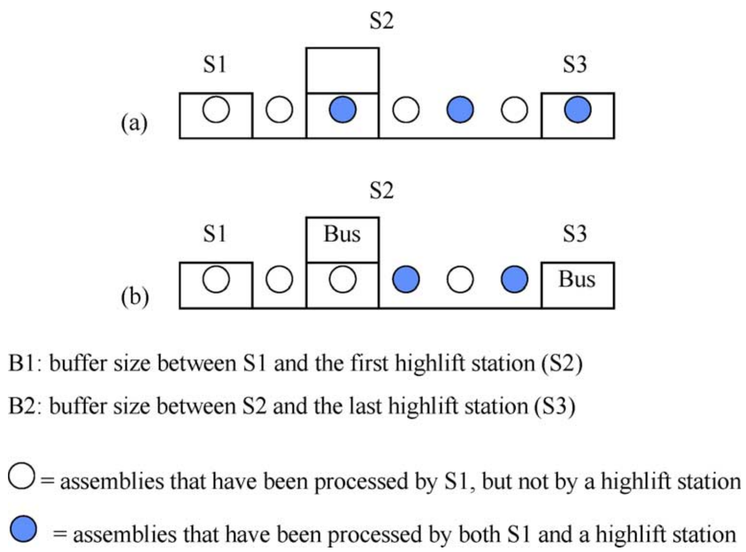

Fig. 1. The synchronization cycle. (a) The assembly under S2 moves forward one buffer unit once S3 has received a new assembly, which has been processed by S2. (b) The assembly under S2 moves forward one buffer unit after S3 has received a new assembly, which has been processed by S2. S3 passes it forward without processing it. Consequently, both S3 and S2 pick up a new assembly to process simultaneously.