Computer Modeling Helps Automotive Manufacturer Upgrade Its Facility

Scope of Work

The work described in this paper included developing a computer simulation model of the material handling system (ASRS and conveyor), verifying the model, conducting experiments, and documenting the completed simulation analysis. This document focuses on activity on the conveyor and in the ASRS.

Model Development Process

HK Systems (HKS) follows a structured approach to simulation model development and verification that ensures the model is a valid representation of the system and includes an appropriate level of detail both in statistical accuracy and in animation for debugging, validating and presenting model results. The model was written in the AutoMod 12.2 simulation language and includes detailed representations of the system equipment and controls as described in this document.

Simulation Objectives

The purpose of the simulation analysis was to:

- Design a simulation model to reflect the existing layout
- Determine if the existing system can achieve 63 Jobs Per Hour (JPH) in degraded mode
- Identify potential enhancements to achieve 63 JPH in degraded mode

System Overview

Car body skids arrive from the Paint Line at the turntable in the trestle and are transported to the ASRS via conveyors, turntables, and lift tables. The inbound skids enter the ASRS at the lower level. Outbound skids exit the ASRS at the upper level and are transported to the Trim Line via conveyors, turntables, and lift tables. In degraded mode, 1 aisle is unavailable for use and the other two aisles use the rack locations facing the down aisle.

The ASRS consists of 3 aisles of double-deep storage racks with one storage and retrieval machine (SRM) per aisle. The SRMs store and retrieve one load at a time. Each aisle has one pick-up stand and one deposit stand located at the front end of the system at the lower (pick-up) and upper (deposit) level conveyor systems. In degraded mode, the SRMs can shuffle a load to another location to retrieve a blocked load in a double-deep position.

Skids arrive out of order and are required to be retrieved in sequence 98% of the time. A minimum inventory level must be maintained to achieve this rate. This sequencing is based on an arrival data stream provided by the customer. In this case, the stream was used from another facility since the new production hadn't started at this facility yet.

Summary of Results

A computer simulation model was developed for an existing ASRS and conveyor system in the Finishing area of a major automotive manufacturer. The company was in the early stages of re-tooling the assembly plant to produce smaller, more fuel-efficient vehicles when it commissioned HKS to analyze the existing system and provide recommendations to achieve 63 JPH in degraded mode. The primary area of concern was the system capabilities when in "degraded" mode.

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Numerous experiments were conducted with the model to analyze the performance of the material handling system. The results of the experiments indicate that the system can achieve 63 JPH outbound in degraded mode with some software and hardware modifications. A major constraint to the system is currently a positioning delay whenever the SRM starts/ends a move. The SRMs wait an average of 4.0 seconds prior to every move and at the end of every travel. In order to achieve the required rates, this time needs to be eliminated (leaving only a 1-sec communication delay prior to every move).

In addition, to achieve the higher throughput, the SRM cycle should be based on retrievals from the rack having priority over stores (as is currently done). This does result in occasional delays (about 6% of the time) at the outbound P&D for the SRM to wait for the P&D to be raised and clear (due to retrievals from the front of the rack). However, even with this delay, the outbound throughput is higher since a store takes much longer than the average time the SRM waits at the outbound P&D (roughly 5 sec).

Using the existing SRM parameters and the current storing/shuffling algorithm, the system achieves only 47.8 JPH outbound in degraded mode with a minimum inventory of 280 jobs.

If the SRM parameters are reset to the original design parameters (and without the 4.0 sec positioning time), an outbound average of 55.8 JPH are generated in degraded mode. If dual cycles are forced whenever possible rather than retrieves being a priority, the output decreases by about 4 JPH to 51.6 JPH.

To achieve the required throughput with the original design SRM parameters and the current storing/shuffling algorithm, a minimum inventory level of 150 jobs is required. This results in an average of 64.1 JPH outbound but with 12.1% out of sequence.

The original model included a 6-second delay time when the skid arrives at the inbound P&D and prior to raising. Including this time with the original design SRM parameters and the current storing/shuffling algorithm results in a about a 1 JPH decrease in throughput to 54.8 JPH outbound.

If all of the conveyor equipment parameters are modified to the optimum scenario (i.e. the faster value from either the original model or the site survey is used), the difference in throughput is negligible (55.8 JPH outbound).

If the conveyor zones are modified to accommodate 16' skids (possibly just through photoeye placement modifications), the degraded mode throughput increases to an average of 56.0 JPH outbound (a slight increase from 55.8 JPH).

Adding an 11th bay to the system results in a 2.8 JPH increase in throughput to 58.6 JPH outbound in degraded mode with 2.4% out of sequence. This is due to more normal storage locations available and a given aisle may not be at capacity as often. To achieve less than 2% out of sequence, a 300 minimum inventory level is required, resulting in an average of 56.7 JPH outbound.

The primary limitation to achieving higher throughput in degraded mode while maintaining a reasonable in sequence quantity is the amount of shuffling. With the current algorithm, the amount of shuffling averages just under 40% of retrievals. To reduce this amount, the model was changed to allow any available location to be used for shuffling rather than dedicating tier 1 or the last bays. Also, when a load is stored or shuffled it attempts to find the nearest location and if it's a single deep position, the rear skid's stream number is checked and if the current load's number is higher, a different location is checked. If no locations can be found using this algorithm, the closest location is chosen irrespective of the stream number. This results in dramatically fewer shuffles and more loads stored towards the front half of the rack.

With less SRM travel distance for stores/retrieves and shuffles, and fewer shuffles, the system can achieve an average of 64.0 JPH outbound in degraded mode and 2.7% out of sequence with a minimum inventory of 280 jobs. With a 310 minimum inventory, the system achieves an average of 61.2 JPH outbound with a 1.9% out of sequence.

To account for the SRM performing full bin checks, a 1-second horizontal/vertical pause time (instead of 0.75 sec) was tested. With a 280 minimum inventory, 63.5 JPH outbound with a 2.6% out of sequence is achieved. With a 310 minimum inventory level, an average of 60.6 JPH outbound with 2.0% out of sequence is achieved.

With less SRM travel distance for stores/retrieves and shuffles, and fewer shuffles but with the use of shorter conveyor zones and 310 minimum inventory results in an average outbound rate of 61.3 JPH with 2.0% out of sequence. If the existing SRM parameters are used but without the 4.0 second positioning time, the throughput decreases to 59.6 JPH outbound with 1.9% out of sequence.

In summary, to achieve the desired throughput of 63 JPH in degraded mode:

- A minimum inventory of 280 skids is required
- The SRM parameters need to be restored to their design parameters
- The skid storing algorithm must be changed: An attempt should be made to shuffle or store in front of skids with a higher blend number whenever possible.
- Non-dedicated shuffle locations should be used.