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SIMULATION PROVIDES INSIGHT NEEDED TO BALANCE WAREHOUSE IN/OUTBOUND DEMAND

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EXTENDED ABSTRACT

A Beverage Company wants to balance its Warehouse's incoming vs outgoing demand, only possible if the underlying processes and bottlenecks are fully understood.

The key success parameter is Very Narrow Aisle (VNA) forklift tasks/hour.

A Simio model with free space movement of pallets and some forklifts, multi dimension arrays and the storage of pallets in 3D space was used to gain insight into the processes.

Palletised products enter the warehouse from two plants where dedicated double pallet forklifts are used to take pallets to put away staging areas in front of the aisles. Very Narrow Aisle (VNA) forklifts are used to put away (store) pallets in the bulk racks, which consist of 32 rows (16 aisles) with eight levels per row for a total of over 14,000 pallet bin spaces.

The same VNAs are used to pick pallets from the racks and take it to staging areas on the other side of the aisle. Dedicated single pallet forklifts are used to take pallets from the picked staging areas to the bulk prepack areas. Dedicated single pallet forklifts are used to load trucks.

The constraints that have an impact on operations in the warehouse are as follows:

As soon as the staged pallets in the put away staging areas are more than 5 deep, the double pallet forklifts cannot pass each other. A similar situation occurs between the bulk rack system and the block stack area, where pallets are temporarily stored when there is no space in the staging areas.

Although pallets may be stacked two high in the staging areas, pallets with glass product may only be stacked on another glass product pallet. Pallets with carton product may not be stacked at all, so if a carton product pallet is on the ground, no other pallet can be stacked on top. Glass products may only be stored in the bulk racks up to level three, while two liter products should preferably be stored up to level six, but if needed they can be stored up to level eight.

Double forklifts can only store pallets in front of an aisle when the adjacent aisles' staging areas are empty. This is due to movement constraints.

Picking of an order can only start when a prepack area is available.

This project posed substantial modeling challenges. Due to the over 14,000 bins in the bulk rack system there are 880 VNA load positions. If nodes had to be provided for each bin position and each VNA load position, almost 15,000 nodes would have been required to be included in the model. Instead, only 32 nodes were used as entrance points on both sides of the aisles. The VNAs travel on the normal network of links and nodes outside the bulk rack area, e.g. when moving from one aisle to another. Inside the aisles they travel in free space to store and pick pallets. Pallets are stored in 3 dimensional free space at specific coordinates which represent each bin position. The appropriate product information for each stored pallet is stored in a three dimensional state array.

The pallet staging areas are modeled by using 3D coordinates which depicts the physical staging position of a pallet, storage queues and state variables. The sequence in which pallets are staged (closest to furthest from aisle and bottom to top w.r.t. stacking) as well as the sequence in which pallets are removed from the staging areas (furthest to closest from aisles and top to bottom w.r.t. stacking) are regulated by queue priorities read from tables.

Before pallets can be stacked, the product type of the bottom pallets has to be determined to make sure pallets may be stacked, otherwise another staging area has to be found. It must also be ensured that there is adequate space to store two pallets adjacent to each other, because it is delivered by a double pallet forklift.

There were no fixed rules available to determine when a VNA in an aisle must switch between putting away (storage) and picking. Rules had to be designed by the modeler that would ensure continuous flow of pallets through the system as well as maintaining the right balance between the number of put away and picking aisles.

Although the use of objects makes one's modeling life much easier, there is the probability that internal object logic will act upon certain conditions in a way that the modeler hasn't pre-empted. This could cause problems when the model is running. Fortunately Simio's objects are open and one has insight into all of its internal logic. This means that these instances can be traced and either rectified or prevented.

Verification of the model was done by taking the total flow of pallets through the warehouse into account, always looking for potential flow stopping situations, e.g. forklift deadlock situations, forklifts missing a starting signal, etc. Validation was done comparing the model outputs to historical data, e.g. VNA tasks per hour, number of orders created, picked, loaded on trucks, etc.

The results proved to be quite interesting and indicated that improvement is possible. From the simulation results it was clear that an ***improvement of 24%*** could be achieved w.r.t. the key performance parameter (VNA Tasks/H) by just omitting bin reservation. Reservation is done by the automated system when inbound pallets are collected and scanned. This result alone proved the value of simulation once again!

Results are not always straight forward and much analysis and interpretation of the results were needed to explain certain results. Although the bulk of the results makes perfect sense, there is always the chance of certain outputs challenging the analyst's interpretation skills to the utmost, which happened in this project. An increase in utilization was expected for certain forklifts moving from one scenario to the next, but the results were exactly the opposite! In such a case results from various areas of the process had to be analyzed together to provide clarity. Plots will be shown during the presentation to elaborate on this issue.

A few operational constraints were identified during the study which, if they are removed, could have a further positive impact on total throughput in the warehouse:

1. Double forklifts can only put down pallets at an aisle where the adjacent staging areas are empty.
    a. Suggestion: Change forklift type so that pallets could be stored at any staging area. This will surely have a positive impact on VNA put away performance.
2. Bulk trucks keep on arriving at the same intervals (delays) after orders have been released across scenarios. This means that picking cannot really improve, because the bottleneck is the prepack areas.
    a. Suggestion: Change the order picking/truck arrival mechanism so that trucks arrive a shorter time after orders have been picked and prepacked. This will improve VNA pick performance and will also reduce the block stack levels due to the fact that bins will become available for put away quicker.

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