Technical Articles/ White Papers

"SIMULATION AND THE ADVANCED PERFORMANCE WAREHOUSE"

Before purchasing an automobile, it makes sense to take it for a test drive. Likewise, before spending millions of dollars on a new distribution center, it would make sense to take it for a test run. Fortunately today, computer simulation makes this possible. Simulation can recreate a warehouse design in the computer and allow warehouse managers and supervisors to determine if changes should be made to the layout or equipment before investing any capital.

In the past, computer simulations were too expensive and time-consuming to justify for material handling operations. Now, faster, less expensive personal computers and more powerful simulation programs have dramatically reduced the time and cost. Combined with the increasing costs, service demands, and complexity of warehousing operations, simulating material handling systems is now an advisable and indispensable step in the design of warehouses and distribution centers.

What is Simulation?

Formally defined, simulation is the process of developing a mathematical model that will duplicate the performance of a design or operation. The running model produces statistical outputs that provide timely measures of system performance. Most simulation programs include graphic capabilities that allow the user to view the model as an animation on a video display terminal. Until recently, simulating a system involved programming lines of code in special simulation languages. Current simulation programs are easier to use and more concise with ready-made subroutines for conventional material handling equipment. The actual programming involves dragging and dropping graphical programming logic in the layout and entering the correct information.

Simulation in the Changing Warehouse

The prevalent use of automation and real-time information technology in warehousing operations has increased the need for this analytical tool. High initial capital costs of some of these material handling systems can produce skeptics in upper management who want to 'see' the operation demonstrated before investing any capital. Simulation can provide them with the data to validate the effectiveness or ineffectiveness of the system, including an animation of the actual operation.

What would happen if sales suddenly shot through the roof, or if an automated picking device broke down, or a new product dominated the picking area? By programming these scenarios into the simulation model, the analyst can see first-hand the different possible effects. The animation may reveal orders stuck in a conveyor bottleneck, increased congestion in manual picking areas, or idle pickers in unbalanced zones. Contingencies and allowances can then be readily integrated into the design.

Use and Benefits

Simulation of warehousing operations has been concentrated mainly but not solely on testing proposed material handling system designs. Simulation can actually clarify concerns such as:

-Will this design satisfy projected throughput requirements?

-Can it handle unexpected surges in the business?

-Which areas have the potential to cause system failure?

-What aspects of the equipment, operation, or software need to be corrected during the design phase before encountering them in the actual operation?

-What portions of the operation should be modified to improve throughput and/or productivity?

If multiple design alternatives are under investigation, each alternative can be modeled, simulated, and the statistical outputs compared to determine the most feasible design. In some cases, simulation may be worthwhile for studying an existing operation. There is a two-fold objective to this approach. First, it allows the simulation analyst to validate data to be used in future simulation runs. Actual operating statistics can be compared to the results of a simulation run of the operation. Deviations can be corrected by the analyst until the model closely replicates reality.

Secondly, it provides a basis for testing different scenarios to determine if the existing system is capable of overcoming projected business surges, unexpected anomalies in the operation, or proposed changes to the operation. All this testing can be done without disrupting existing operations. Simulation also allows us to investigate proposed operational strategies that do not necessarily require any equipment or layout modification. For example, work dispatching and scheduling alternatives can be tested and monitored to determine the best scheduling plan and improve worker utilization. Different order batching and wave picking strategies can also be modeled to identify the scheme with the highest throughput results.

Warehouse management system (WMS) logic alternatives can also be evaluated and compared to detect each alternative's effect on the operation. Simulation is useful in developing benchmarks to measure against actual performance. If a simulation run has determined that a distribution center is capable of processing 2,500 orders per day under certain operating conditions, management has provided itself with a statistical goal to achieve under similar conditions. Deviations from this statistical goal can prompt management to investigate their current system. Perhaps certain programming logic that was incorporated into the simulation model may not have been incorporated properly into the WMS.

With simulation, the concept of value engineering also becomes easier to implement. Value engineering involves the replacement of high cost components with more economical options that do not compromise a system's efficiency but can significantly lower costs. Simulated throughput values of the hybrid system can be compared to the simulated throughput values of the more expensive alternative. In addition, other replacement options can be modeled and investigated.

It is not necessary to have a highly mechanized or automated material handling system to justify using simulation in design analysis. Simulation is often used to investigate the manual processing of orders and the operation of conventional storage systems. In a typical distribution center, simulation can help answer the following basic questions:

-Does the conveyor system have enough accumulation?

-Are there enough dock doors in the facility?

-What is the optimum number of lift trucks based on projected through-put requirements?

-How many order pickers does the system need?

-How should products be zoned and slotted?

-How should workloads be balanced?

When is Simulation Unnecessary?

With all the advantages of simulation, there are also conditions when it is NOT the answer to all design problems. Generally, simulation allows warehouse management to study various interacting systems with a wide range of conditions, over a period of time. If the design merely consists of one system, a simulation study may be excessive. The analysis may require simple spreadsheet calculations or a layout drawing, especially if there is a high predictability to the operation.

You cannot use simulation if you are looking for results in a day. To do it right, the entire process requires a generous amount of time for the development of the model and its programming logic. Depending on the software, a simple conveyor system from picking to shipping may require three days to a week to program. This does not include the time to gather and analyze data for input into the model.

The collection of good information is essential to a successful simulation study. It defines the parameters of the model. Unless good information is available, simulation should not be attempted because it is likely to produce incorrect results.

The Process

A typical simulation project consists of four major steps:

1. **Data Collection and Analysis** This first step is the most important and sometimes most time-consuming of all the steps. Here the analyst gathers relevant information regarding the system to be studied. The data request may include layout drawings, procedures, time standards, throughput data, product characteristics, etc. Mathematical distributions of the raw data, (i.e., order profiles, production outputs, and product movement) should be obtained over a significant time period to provide an accurate picture of the operation. Most simulation software is equipped with statistical tools that will automatically analyze raw data and provide an appropriate distribution. Avoid the use of averages. Warehouse managers know how much day-to-day operations can deviate from the so-called ‘average.’

2. **Model Development**. This step involves creating the programming logic and animation of the model, preferably using an object-oriented graphical simulation program. However, any simulation software can be used. The model is written to follow the structure and decision points required by the operation. Once complete, a preliminary model is run on the computer and general statistics are collected.

3. **Model Verification**. The collected statistics are analyzed and compared to actual operating data or projections. The analyst investigates deviations and checks the model for logic errors, unrealistic assumptions, and faulty data. The model is repeatedly refined and modified until the simulation analyst and other involved parties are satisfied with the base results.

4. **Sensitivity Analysis** This part of the study involves running the model with different variables and operating parameters to test responses to fluctuations and utilization. After each run, statistical results are collected and analyzed. A comparison of results for different simulation runs will determine the optimum system design. The analyst will then recommend changes to the design.

Case Study

A new Very Narrow Aisle (VNA), paperless distribution center was designed for a manufacturer. Before management would invest millions of dollars to construct the facility, they wanted to test the interaction of all the system components under projected average and peak conditions. They also wanted to verify the equipment and labor requirements for the facility to ensure its efficient operation. A simulation model was developed and alternative runs were tested.

From the simulation, it was determined that only three turret trucks would be required for putaway and replenishment operations from the time the facility would open in 1994 until 1996. The facility would require a fourth truck for peak conditions in 1996. A fifth truck would be required for peak conditions in the year 2000.

In the proposed system design, multiple orders for one wave are batch picked in full cases from a four level pallet flow rack system to conveyor belts. These conveyors fed an automated sortation system where each box was scanned and diverted to a designated order lane. When the entire order was completed and palletized, the lane was used for a new order.

Preliminary runs showed that it was critical to maintain proper timing between the batch picking and palletizing operations. The simulation revealed the following problems:

1. Cases belonging to later waves started accumulating on the recirculation loop until the system came to a halt.

2. Because pickers pick ahead of the palletizers, cases belonging to large orders from older waves would end up behind cases belonging to newer waves. Thus, orders from older waves could not be completed. Consequently, a lane could not be freed for a new order and a new wave.

3. Although pickers were effectively utilized, palletizers were idle as they waited for the system to sort through cases belonging to multiple waves.

To alleviate this problem, all pickers picked one wave at a time. No picker could start on the next wave until the previous wave was completed. Picking one wave at a time, however, resulted in the inability of the system to ship the projected number of cases per day. Actually, only half of the required number of cases could be processed.

Bearing these in mind, the model was repeatedly refined and different wave strategies were tested and evaluated. Picking two waves at a time produced the best throughput results.

The simulation also pointed out the need for more accumulation on each divert lane and suggested conveyor speeds, labor requirements, and the number of divert lanes required for a smooth and efficient operation.

Without simulation, the company would have installed millions of dollars of sophisticated equipment only to realize that the system would not be able to perform at the desired level. With simulation, necessary equipment and WMS software logic modifications were identified before any physical implementation. In addition, management was assured that the facility would be able to deliver the projected order throughput. The capital for the project and the WMS software specifications were approved and the facility is now operating and operating efficiently.

Perhaps the most significant result common to most simulations is the reassurance that management gains from visualizing the design. Simulation is no longer a mystical tool for use solely by the likes of rocket scientists and nuclear engineers. Easier programming techniques and more powerful personal computers have made it accessible to everyone. In this age of computerdriven, increasingly automated, complex warehouses and distribution centers, simulation cannot be overlooked as a valuable design tool.

Compliments of:
Gross & Associates
Corporate Headquarters
167 Main St.
Woodbridge, NJ 07095
Phone: (732) 636-2666
FAX: (732) 636-2799
info@grossassociates.com