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SIMULATION FOR HIGH-SPEED PROCESSING

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ABSTRACT

High-speed processing lines are fundamental to the manufacturing processes of several industries, including food and beverage, consumer products, and pharmaceuticals. A *high-speed process* is defined here as a process where the volume and rate of jobs is such that discrete modeling and analysis cannot be done effectively. Traditionally, simulation analysis of high-speed processing lines has required a series of aggregations and simplifying assumptions to address the large volumes encountered. These approximations often cause the models to be poor predictors of real-world systems.

HiSpeed$im is a powerful, new approach for analyzing high-speed systems. It incorporates an interface and algorithmic engine specifically designed for simulating the complex control logic and equipment of high-speed processing. HiSpeed$im also leverages the powerful simulation platform of SIMAN/Arena. This combines the ease of use of a simulator and the speed of a custom-written product with the complete power and flexibility of the Arena general-purpose tool.

1 INTRODUCTION

High-speed processes typically take place at hundreds, sometimes thousands, of entities per minute. Typical examples include cans or bottles in food processing, pills in pharmaceuticals, or cigarettes in the tobacco industry. Simulation studies of these systems usually have many of the same modeling objectives as studies of other industries (e.g., system design, configuration, capacity analysis and planning). However, modeling high-speed processes also involves additional modeling obstacles due to the high speeds and large volumes of entities. Discrete entity approaches often overwhelm traditional simulation languages, resulting in significantly slower execution times.

There are two popular approaches to overcome the above problem: continuous equations and aggregation. Modeling a system with *continuous equations* typically has the advantage of very fast execution speeds. However, the complexity of mathematical equations increases rapidly for all but the simplest of models. Thus, the detail necessary to solve real problems can often not be represented by a set of equations. In addition, the lack of an interface between the system of equations and a discrete component often makes it impossible to model all aspects of the system (e.g., incoming supply or outgoing product flow).

The second approach, *aggregation*, works by allowing each logical entity to represent a quantity or lot of real entities. For example, each entity might represent 24 cans or 500 candies. Aggregation improves model execution speed and generally retains good modeling flexibility. However, sacrifices must be made in model accuracy and detail. For example, if each entity represents 500 candies, then all processing must be rounded to the nearest 500 candies. Furthermore, it may be very difficult to implement complex control logic. For example, continuing the problem above, it would be difficult to model the placement of sensors on a conveyor line to determine when there is a backup of 400 candies or when the conveyor is backed up to a point 10 feet from its end.

Clearly, another approach is needed. The simulation of high-speed processes requires a tool designed to handle the high volumes of entities, yet still able to retain modeling detail and flexibility.

2 MODELING APPROACH

HiSpeed$im is a collection of modules specifically designed for modeling high-speed operations. Each module incorporates all aspects of a particular system element (e.g., a machine). The modeling approach is illustrated in Figure 1.

Basically, you place and connect modules to represent the elements of the system. Then you fill in the descriptive information in the module dialogs. A good approach is to start simple and then, as your study develops, select options to specify more advanced features (e.g., sensors, failures, etc.). Model animation is automatically generated with each module, but these may be customized to your exact system.

The dialogs are self-contained and designed with terminology for high-speed applications. Thus, through a point-and-click graphical interface, you can develop models of sophisticated systems without writing any code. Finally, if the "built-in" operation of HiSpeed$im does not entirely address your operation, you can interface to modules of other products, such as the Arena template, to model the discrete portions of your logic exactly.

3 SYSTEM ELEMENTS

The main system elements in HiSpeed$im include Machines, Conveyors, Operators, and other devices such as Split and Merge.

3.1 Machines

Machines are the starting point for most models. This is where most of the actual processing or entity conversion takes place. After placing a machine, its description, run parameters and options can be accessed via the dialog illustrated in Figure 2.

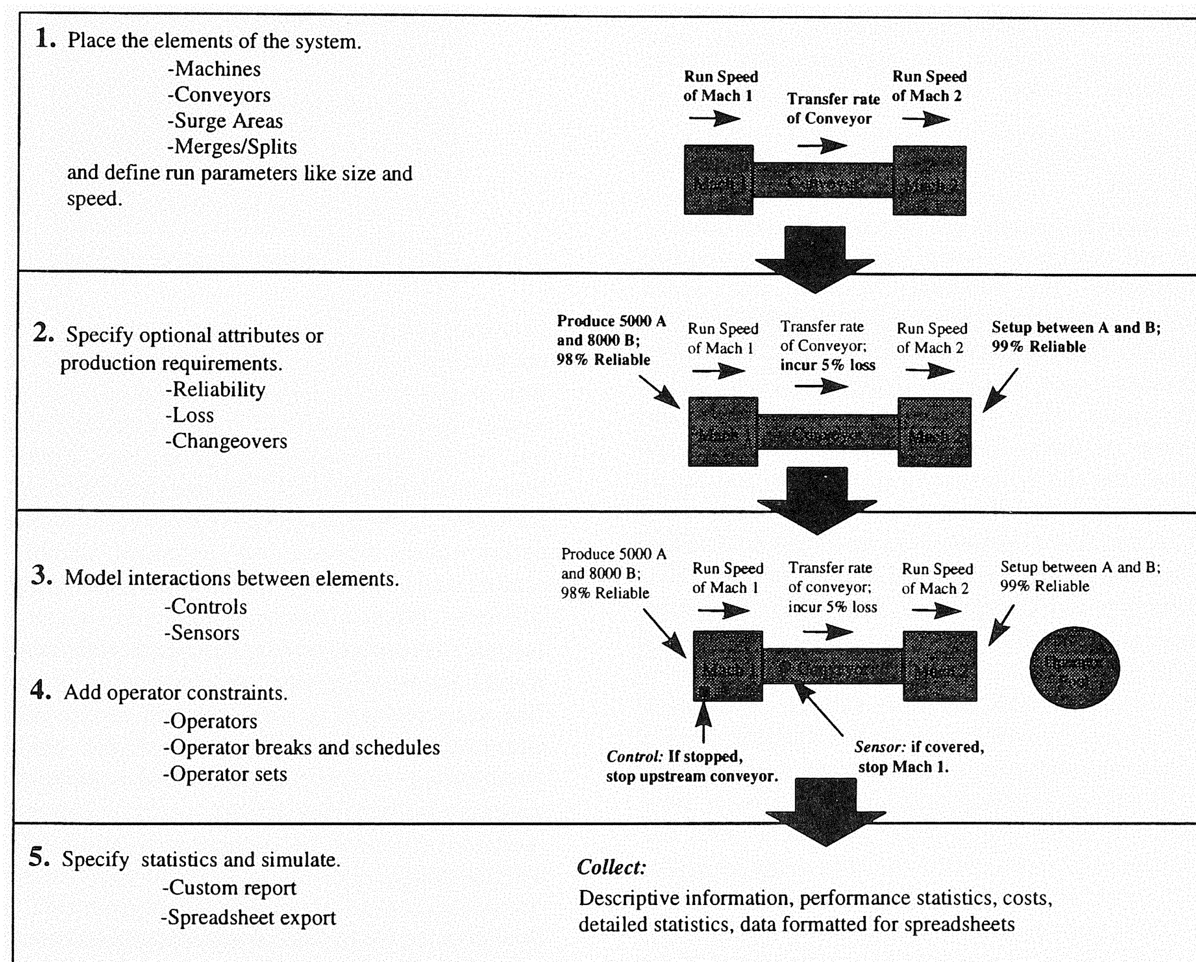


Figure 1: HiSpeed$im Modeling Approach

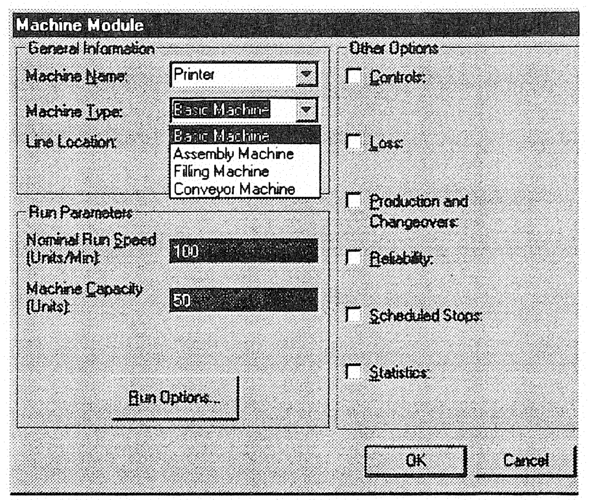


Figure 2: Machine Module Dialog

HiSpeed$im supports four types of machines:

•Basic Machines for standard processing;

•Assembly Machines for merging input from two or more lines (e.g., packaging processes);

•Conveying Machines for processes that involve significant product movement (e.g., washing or drying);

•Filling Machines for combining fluids with containers.

Depending on the machine type, the run parameters will change to prompt only for the appropriate information. For example, *Nominal Run Speed* applies to all machines, but the meaning of *Machine Capacity* changes with the machine type. Conveying machines require a capacity in terms of length, width, and density, while basic machines only require the number of units. The *Run Options* for machines include the ability to specify acceleration and deceleration parameters.

A machine's operation can be further customized by selecting from six optional areas: Controls, Loss, Production and Changeovers, Reliability, Scheduled Stops, and Statistics. *Controls* allows you to detect sets of conditions, such as a production levels or flow rates, and to take selected actions when such conditions occur (see Figure 3). For example, when a machine's production rate is decreased, it may in turn dictate that an upstream machine or conveyor slow down. Or, every time a target production level has been met (e.g., 1000 units), an entity might be generated to execute discrete logic such as operator intervention or custom statistics collection.

Loss allows you to specify product that will be lost (spoilage) due to routine production or special events such as changeovers and stoppages. *Production and Changeovers* allows you to specify the products produced at a machine, the effect of changeovers, and whether operator intervention is required. *Reliability* allows you to specify expected downtimes, repair times, and repair operators. *Scheduled Stops* specifies the times when a machine is scheduled to be out of service such as for breaks or preventive maintenance. *Statistics* allows you to define the statistical reports for machines.

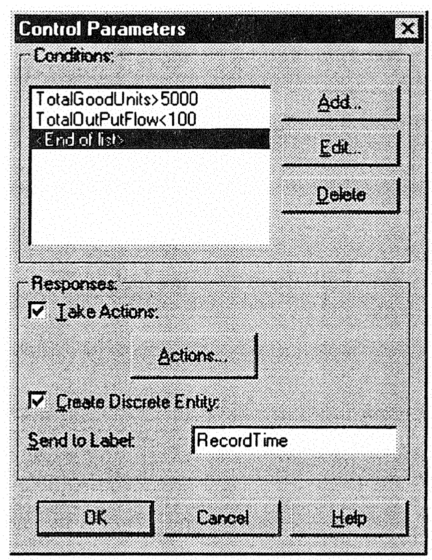


Figure 3: Control Parameters Dialog

3.2 Conveyors

Conveyors are the devices that move product between machines. Conveyor modules are placed the same way as machine modules. Their dialogs also have similar layouts and options (e.g., Controls, Reliability, etc.). HiSpeed$im supports two types of conveyors: accumulating and non-accumulating. In particular, accumulating conveyors have an additional option called *Sensors*. An unlimited number of sensors may be placed at specified positions along the conveyor. When a sensor is triggered, it can take actions identical to those described with controls above. Sensor triggering can be finely controlled. You can specify if a sensor should be covered or uncovered, the minimum time of the covering (uncovering), and whether additional conditions are necessary before taking actions.

3.3 Operators

Operators are the personnel who operate and maintain the equipment. Within equipment modules, operator involvement can be specified optionally for activities such as repairs, stoppages, and changeovers. They may also be controlled by discrete logic. Operators are defined in the Operators module (see Figure 4).

Operators may have a fixed capacity or follow a schedule. For example, you might require four operators for the day shift and only one for the other shifts. Operators may also have random breaks defined that affect their availability.

Operators can be grouped into sets (e.g., a set of electricians). When operators are required, you can select members from sets using operator selection rules. Each operator also has a skill factor defined. This value establishes an operator's proficiency in relation to the "average" proficiency. Skill factors may be used to adjust the delay times of operator activities.

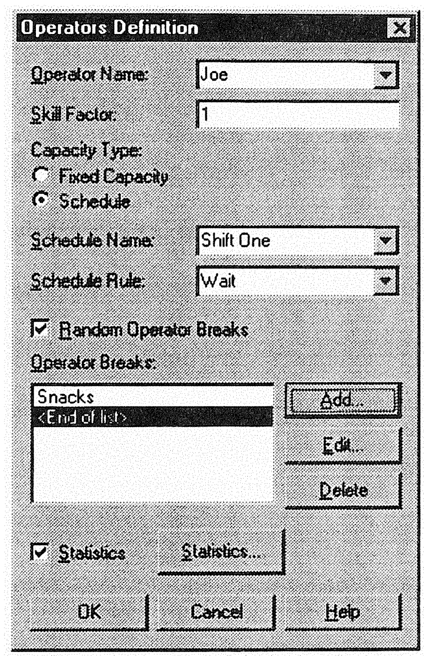


Figure 4: Operators Dialog

3.4 Other Devices

HiSpeed$im contains other system elements focused toward fulfilling specific needs. *Split* and *Merge* modules allow product flow to be separated and combined. The *Switch* module is similar to Split, but allows more sophisticated product or count-based flow control.

The *Surge Area* module facilitates the modeling of various types of surge or temporary accumulation areas. This module includes similar control options to those of machines and conveyors.

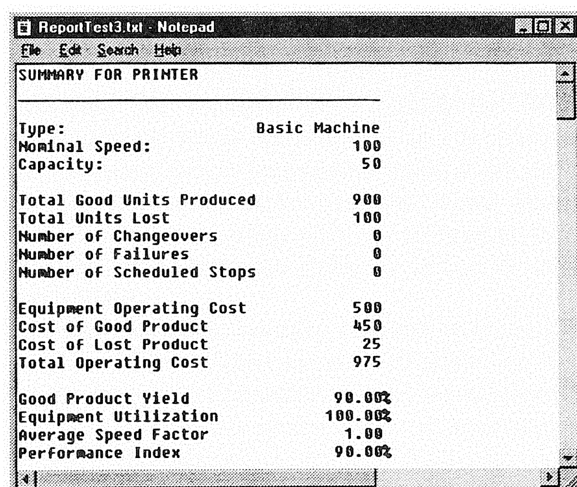
The *Palletizer* module represents palletizers, depalletizers, and combined units as well as the associated storage areas. In addition to the standard machine control options, it has options for controlling the storage area using a discrete interface. This allows discrete system logic such as pallet removal or creation.

4 MODEL OUTPUT

Model output takes several forms. The most obvious is animation. Animation of the machines and conveyors is automatically created as the logic is defined. This animation can also be customized by drawing your own pictures or selecting from supplied libraries. You may also import existing drawings from CAD packages. Business graphics like plots and histograms may be added to supplement the animation.

A second form of model output is summary report information. This report contains information about the system and its performance. The actual contents are customized by options in the appropriate modules. For each system element, you can choose to report descriptive information, production data summary, equipment performance summary, cost data, and detailed state statistics. Figure 5 illustrates part of a typical report for a machine.

Another output option is to export the summary report information to another program. This facilitates the use of a spreadsheet program to further sort or study the data and/or generate more extensive graphical analysis.


ReportTest3.txt - Notepad
File Edit Search Help

SUMMARY FOR PRINTER

Type:	Basic Machine
Nominal Speed:	100
Capacity:	50
Total Good Units Produced	900
Total Units Lost	100
Number of Changeovers	0
Number of Failures	0
Number of Scheduled Stops	0
Equipment Operating Cost	500
Cost of Good Product	450
Cost of Lost Product	25
Total Operating Cost	975
Good Product Yield	90.00%
Equipment Utilization	100.00%
Average Speed Factor	1.00
Performance Index	90.00%

Figure 5: Summary Report

5 SUMMARY

The benefits of simulation are well known in the high-speed processing industry, including reduced startup time and the security of making better, well informed decisions. Even a small improvement to system performance can realize tremendous gains. Unfortunately, the barriers to effective use of simulation are also well known—particularly the difficulty of modeling and the slow execution speeds.

HiSpeed$im is a new approach to modeling high-speed systems that overcomes the common difficulties. Because it is specifically designed for this industry and its challenges, difficult and complex systems can be modeled easily without writing code. Its intuitive interface allows non-simulationists to use simulation tools effectively.

HiSpeed$im is only one part of Systems Modeling's solution for high-speed process simulation. A related product is currently being developed for modeling liquid processing, storage, and flow. For example, modules will be available for modeling elements such as tanks, pipes, and valves with appropriate sensors, controls and actions. This product will seamlessly integrate with HiSpeed$im.

HiSpeed$im is the latest in a series of products from Systems Modeling to advance the state-of-the-art in simulation.

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