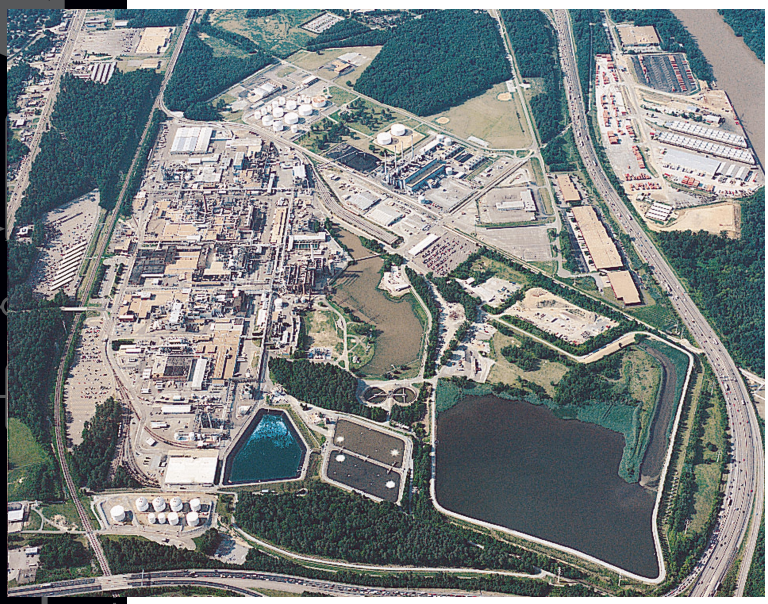
Case Study

Authors: *Extracted from a paper by Hank Graeser (DuPont) and Andy Waite (EnTech)*

VisSim

DuPont & EnTech Use VisSim/Real Time for Dynamic Process Control Simulation



Aerial view of the DuPont non-woven sheet manufacturing facility in Richmond, Virginia.

In a joint effort, engineers from E. I. DuPont de Nemours and EnTech Control Engineering used Visual Solutions VisSim control system design software, and its real-time option VisSim/Real-Time, to develop a high-fidelity dynamic simulation model of DuPont's non-woven sheet manufacturing facility in Richmond, Virginia. The model consists of approximately 31,500 blocks and 250 differential equations and simulates roughly a half dozen interrelated processes. It is used by DuPont's control and design engineers to verify process dynamics during product transitions; develop and tune control strategies; and explore possible design changes to enhance control performance. In addition, system operators train on the model to maintain proficiency and learn new procedures without impacting plant operations.

According to Hank Graeser, senior engineer at DuPont, *"VisSim is a highly intuitive environment for developing large scale high-fidelity process models. The DuPont Spruance model, developed in VisSim, has saved the company an estimated one million dollars to date.*

We developed the model in a third of the time it would normally take using conventional methods. VisSim's block diagram interface made it easy to document and maintain the model.

Every time we use the model for control design and off-line tuning, DuPont saves significant dollars as plant down time is reduced. We also train our operators using the VisSim model."

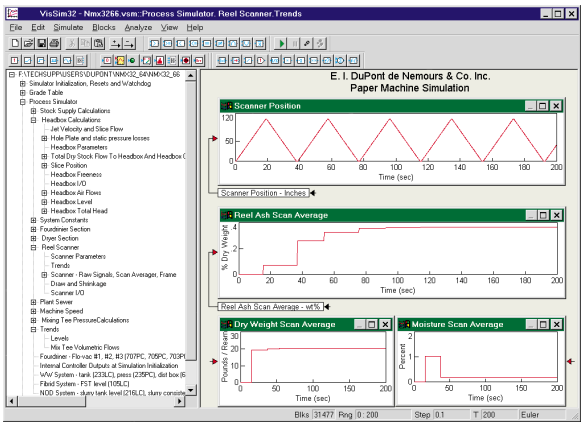
"High Fidelity modeling of a large scale project can be done with VisSim. From a financial standpoint, it is extremely worthwhile to the process control community. There are tremendous cost savings in reduced downtime due to offline tuning and control design as well as operator training. "

Andy Waite: Chief Designer DuPont Model EnTech Control Engineering

The Ideal Simulation Software

As DuPont engineers drew up the specifications for the model, EnTech engineers were tasked with finding the best simulation software with which to build it.

The sheer scope of the model, which included the entire DuPont facility — 15 tanks; 20 sets of pumps, lines, and valves; refiners; headbox and drainage table; vacuum devices, dryer cylinders, and scanning sensors; and other minutiae—warranted a simulation software package capable of modeling and simulating large, multivariable dynamic processes with a high degree of fidelity.



DuPont paper machine simulation in VisSim, showing Reel Scanner Trends. Reel scanner position, reel ash, dry weight, and moisture scan averages are displayed.

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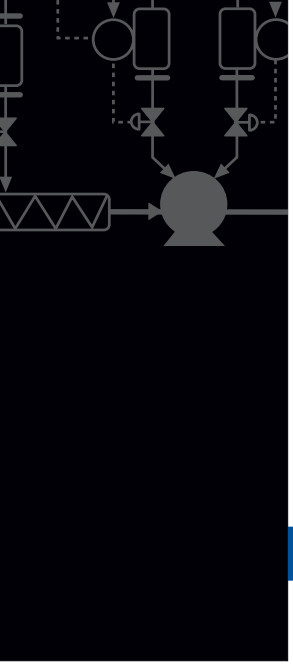
Modeling The Future

Application: *Process Control/Large Project Modeling and Simulation*



The software had to be interactive and graphically oriented so that dynamic information could be presented in an intuitive manner. In addition, the block set had to include a complete selection of continuous, discrete, transfer function, Boolean, arithmetic, and I/O blocks.

Other key requirements included the capability to run in simulated time, real time, and continuous time; drive real-time analog and digital I/O; stop and continue simulations; initialize all state variables; and extend the block set with custom blocks written in C, for enhanced speed and additional functionality.

Because system operators would also use the simulation model for training purposes, the ability to create realistic control panels with controller faceplates, dynamic tank levels, and built-in alarms was also important.

Based on these requirements, the simulation software that best met EnTech's needs was VisSim and the VisSim/Real-Time companion software.

Model Design

According to DuPont and EnTech engineers, the DuPont model simulates the outputs of 80 sensors and transmitters and accepts input from 50 controller outputs. In addition, the model provides high integrity dynamics as "seen" through the eyes of the actual sensors and transmitters, with a time constant in the range of about 3 seconds. This means that the truly fast dynamics, such as that of incompressible fluid flow, which typically have time constants of 20 milliseconds, do not have to be solved rigorously. Instead, the equations associated with the pump curves, fluid flow, and control valve characteristic curves can be approximated by solving only the nonlinear algebraic equations.

These "algebraic loops" involve the on-line iteration from the last known flow and are solved using algebraic loop time constants of typically 1 second, which provides an adequate safety margin compared to the high-fidelity specification of 3 seconds.

In the resulting simulation, the time constant spread ranges from a fast value of 1 second to that of the mixing time constant for some tanks of 20 minutes. This time constant spread, even though quite large, means that the simulation avoids some of the pitfalls of "stiff systems of differential equations" which are very difficult to solve numerically.

The final simulation model is organized in a multi-layer format in which detailed simulation subelements collapse into "compound blocks." There are 900 compound blocks, in about six layers, organized in an easy-to-follow, process-oriented layout.

Model Verification

In the testing phase, close to 200 real-time I/O channels were used to validate the model and control hardware. The simulated process runs ten times faster than the real process on a Pentium 100 MHz personal computer, at a simulation step size of 0.5 seconds.

Predicting the Future

The DuPont model is an excellent example of how a dynamic multivariable process control model can be developed and utilized using VisSim and VisSim/Real-Time. Graeser and other DuPont engineers have observed a "close match" between model and actual plant data. Based on these results, they are confident that the DuPont model can be used as a "life-cycle" tool to faithfully predict the effects of future design decisions before modifications are actually made to the plant.

For More Information

DuPont and EnTech engineers presented a paper on the creation and validation of a VisSim dynamic model for a non-woven sheet manufacturing facility at the Control '96 conference. For a copy of this paper, contact Visual Solutions Sales Department.

Download a Process Control tutorial/VisSim models from our web site: www.vissim.com