

Simulation models are playing an increasing role in plant operations. **Suresh Sundaram** explains how the advent of new modelling environments based on open standards will make it easier to build and use these complex models across the plant and the business

Simulation in operation



Process simulation models can be used to support real-time operational decision-making

PROCESS simulation practice has evolved rapidly over the last 20 years. In the engineering domain, the role of simulation has changed from simply 'automating design calculations' to being the centre of 'integrated engineering workflows' that support a variety of decision making tasks, from conceptual design to process design to plant troubleshooting. Process companies are using a variety of synergistic engineering technologies (in-house and commercial) in conjunction with steady-state process simulation, such as process synthesis, economic evaluation, dynamic modelling, and detailed equipment modelling.

In parallel, modelling technologies are playing an increasingly critical role in the plant operations, planning and supply chain domains. Empirical modelling technologies in advanced process control (APC) are now standard in the continuous process industry; first-principles simulation models have a proven track record in real-time optimisation (RTO) in many process industry segments; and linear programming (LP) modelling in planning and supply chain management activities is the norm. In addition, companies are using a variety of in-house and third-party models to support decision making across enterprise operations.

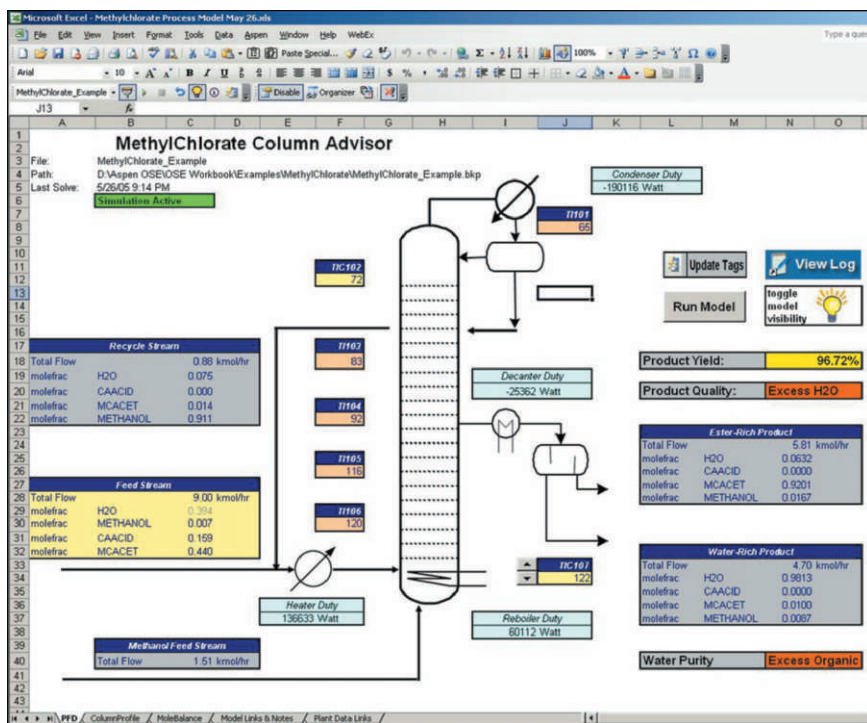
IT infrastructure has also rapidly evolved, so that today's process companies are able to easily access plant data on every desktop across all the disciplines in the organisation. This ability has improved common understanding of plant operations, facilitating multiple disciplines to work together and make collaborative decisions.

The spectrum of use of simulation models within plant operations today is summarised in Table 1 overleaf. The use of process engineering models to do process analysis, troubleshooting and debottlenecking is well-established in most petroleum and chemical companies, and process models are standard for design and analysis of process plants.

At the other end of the spectrum, closed-loop real time optimisation coupled with advanced process control is also well-established, but only for specific petrochemical and refining processes. The benefits are derived from enabling the process to run reliably closer to its true constraints, resulting in increased throughput, less downtime and a significant reduction in off-spec product. Typical payback on projects is approximately three months.

The cost-benefit analysis of the use of models in plant operations is summarised in Table 2 overleaf. Where we expect to see rapid growth of models in operations is in the use of offline operations models and real time models. Their use is well established in leading companies such as BP, DuPont, Degussa, DSM and Lyondell.

Degussa, for example, routinely uses offline operations models to increase understanding of the process, optimise operation, calculate new operation points based on changes in market conditions, and validate measurement data. The approach is to use a complex simulation model in the background and make it available to the plant engineer or operator via a simplified user interface, usually Excel. Typical benefits of this approach are a reduction in



A simplified Excel user interface to a complex simulation model. Using the familiar interface shields the end-user from the inner workings of the model and removes the need to learn the simulation tool

asset-wide analysis.

As shown by the examples of Degussa and Lyondell above, offline process models can be used for such tasks as operations decision support for day-to-day decision making — providing simulation-based analysis of the current operation and what-if analysis for performance improvement — and plant or equipment performance monitoring.

Although the benefits speak for themselves, the effort required to implement such systems is often prohibitive. The opportunity is in making these benefits more widely available in a cost-effective manner.

An emerging area is the significant value that can be created by linking engineering with business decision making for capital investment and operations decisions. This can be achieved by bringing together process, utility system and infrastructure simulation models into an integrated, site-wide environment, allowing producers to model and understand the economic and technical trade-offs required for site-wide optimisation of a production facility.

BP's Trinidad Field Optimiser, for example, is a decision-support tool that is used by the gas-pipeline infrastructure team to manage the offshore gas production portfolio in order to meet the demand of the various shore-based gas customers. The

operating cost of 2-5%, increased capacity in many cases, and higher process reliability due to fewer operating problems.

Lyondell has successfully used real time models for operations improvement. The steps involved were to:

- Re-use existing process model developed when the plant was designed;
- Tune the process model to match current operating conditions using real-time process data and parameter estimation techniques;
- Deploy the process model on-line to calculate optimal operating conditions, and provide these results as guidance to operators in the form of an electronic shift report;
- Store selected on-line process model predictions in the plant data historian.

The solution leveraged existing plant infrastructure such as the DCS, process data historian, laboratory information management system and IT network. Other information such as the company's model library, including process design models and physical properties work, served as building blocks for the application.

Lyondell used this approach at three of its propylene oxide/styrene monomer plants, achieving a decrease in steam consumption which translated to well over \$1million in energy savings per year across the three plants. Moreover, these

achievements were realised with no significant capital expenditures. In addition to real time process optimisation, Lyondell executed a number of off-line modelling studies, which provided significant additional economic benefits.

The two key areas of opportunity to create value through the application of modelling and simulation technologies in plant operations are:

- Accelerating the use of offline process models into plant operations; and
- Expanding the scope of simulation models from single-process to site-wide and

TABLE 1: SIMULATION MODELS USED WITHIN PLANT OPERATIONS

Type of model	Model used for	Characteristics of usage
Process engineering models	Analysis, troubleshooting, debottlenecking	Used on an 'on-demand' basis when plant engineers believe that a simulation model can be used to solve a problem
Offline operations models	Calculate and optimise plant operations	Used on a daily, weekly or monthly basis to optimise the plant to changing market conditions such as demand and cost
Real-time models	Calculate and optimise process and financial performance in real time	Used on a real-time basis to determine optimum process conditions, also referred to as 'open-loop' optimisation
Closed-loop real time optimisation (RTO)	Automatically run plant at optimum process conditions	Model runs the plant in real-time. Model is interfaced directly to the plant control system and adjusts the process automatically.



More and more process companies are recognising the value of using simulation models to help optimise their operations, both at the plant level and across the enterprise

asset-wide optimiser predicts the best well selections and operation to meet prevailing gas demand, while maximising condensate recovery. The heart of the system is a full asset-wide model based on a combination of hydraulic models of rigorous process models (built using Aspen HYSYS) and third-party models, coupled with the RTO optimisation capability within Aspen HYSYS that reconciles and optimises the incoming plant data. The system uses an Excel-based user interface layer to allow rapid use of the integrated application without requirement to interact with any of the underlying tools.

Site-wide analysis yields the following benefits:

- Business wide what-if analysis that uses integrated models of the entire business unit to quantify the net impact on the

business of alternative design and operations changes (for example, capacity increase versus capital investment on one site versus another site);

- Site-wide performance modelling by creation of a holistic model of the site and performing consistent evaluation of any changes inside the process or utility system. The integrated site-wide model will fully account for the net impact on the overall site business performance relating to feeds, products, power and fuel and other utilities. This tool can be used for day-to-day decision making, as well as for setting a long-term investment roadmap.

The above value-creation opportunities can be made available to all companies by creating a more productised, configurable and scalable simulation and modelling environment that is based on open

standards. The single open environment will deliver the value by:

- Bringing all the disparate tools together and creating a common end-user experience;
- Enabling the seamless interoperability of multiple modelling applications, allowing disparate teams of engineers to work simultaneously on different parts of the same problem;
- Enabling the use of consistent models across the operations lifecycle, from engineering and innovation, to plant operations, to supply chain management.

AspenTech is spearheading the effort to provide this open environment to the process industries via the Aspen Open Simulation Environment (OSE). Using Aspen OSE, companies will be able to realise value in the emerging areas of simulation models in plant operations.

A growing number of leading companies are recognising that applying simulation models in plant operations, and for site-wide and business-wide decision making, can unlock tremendous value. The advent of technologies like OSE will help to accelerate this trend by making it easier for companies to build and use complex models. **PE**

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TABLE 2: COST-BENEFIT ANALYSIS OF THE USE OF MODELS IN PLANT OPERATIONS

Type of model	Effort	Typical Benefit
Process engineering models	<ul style="list-style-type: none"> • Model unit operations • Match heat and material balance • Equipment as unit operations 	<ul style="list-style-type: none"> • Process engineering design • Capital alternatives • Plant troubleshooting
Offline operations models	<ul style="list-style-type: none"> • 1-3 weeks model tuning • 1 week of Excel linking 	<ul style="list-style-type: none"> • 2-5% operating cost saving • What-if analysis capability
Real-time models	<ul style="list-style-type: none"> • 3-6 weeks model tuning • 1-2 real time interface 	<ul style="list-style-type: none"> • 3-10% operating cost saving • Real time monitoring • Calibrated what-if analysis
Closed-loop real time optimisation (RTO)	<ul style="list-style-type: none"> • 3-6 months model dev. • 1-2 months tuning 	<ul style="list-style-type: none"> • 2-5% capacity increase • 3-10% operating cost saving • Automated execution

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