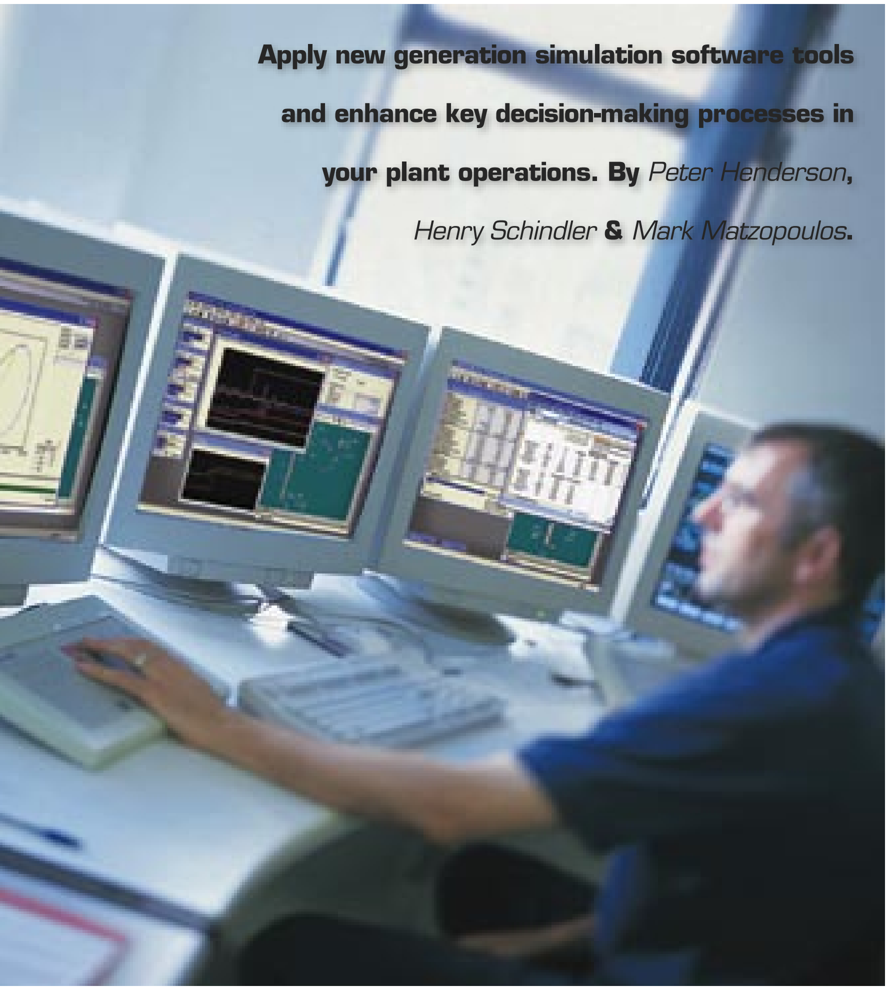
Simulation For Operational Effectiveness

Apply new generation simulation software tools and enhance key decision-making processes in your plant operations. By *Peter Henderson*, *Henry Schindler* **&** *Mark Matzopoulos*.



The challenge in improving the plant production environment is finding a balance between contrasting objectives: improving production capacity and maintaining plant reliability. Where is the benefit in boosting production capacity by two to five percent if pushing equipment harder results in plant shutdowns, equipment damage or personal injury?

Over the past 30 years, simulation has been used to assist an engineer's decision-making process in plant design, and as an effective tool for preparing operators and process automation systems for initial operations. Improvements in simulation capabilities have created multiple uses and maximised the return on investment.

Honeywell's UniSim (Unified Simulation Solution) is an example of simulation software that can be used throughout the lifecycle of a plant, each cycle depicting a simulated phase of validation for each defined plant asset: process equipment, control configuration, operating procedures and operation teams.

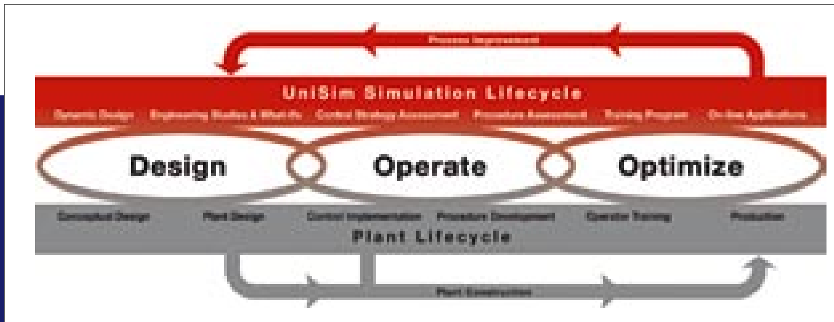
The final cycle, Operations, is where many opportunities exist to apply simulation in the operator decision-making process during plant operation

Solutions that can assist an operator's understanding and control of current plant operating conditions can deliver apparent advantages.

In Real-Time

Real-time automation systems efficiently capture, organise and present large amounts of data to the operator, but do very little to help interpret the information required to make decisions.

Process simulation technology has made it



For Operations as well as Engineering – simulation can be applied across the plant lifecycle.

easy to prepare and maintain models that closely match industrial processes. They can be easily integrated in advanced software applications because of modern software design.

The integration of simulation components within automation systems is a strategy to address today's production challenges. In this form, simulation components represent users' understanding of the relationships between plant materials, process equipment, controls and operating philosophy. Embedding this understanding within advanced solutions in automation systems transforms them into process knowledge systems.

In this case, simulation models (not operators) are stimulated by vast amounts of real-time data. Computers can then be employed to plough through performance calculations, instrument errors can be mitigated by reconciled plant data, and estimates can be made for some qualities that cannot be easily measured. This approach helps detect a number of common adverse operating or equipment conditions.

The ability of the computer to serve operators in this way allows them to focus on making better-informed decisions while operating their plant, enabling them to:

- Look at real-time data to assess the current operating state
- Direct changes in closed loop control

To be useful and trusted in a new multi-billion dollar production environment, models must be easily prepared/maintained, robust, and properly reflect the system they are simulating. This relies heavily on two critical components – the knowledge of the engineer preparing the model and the simulation application that hosts the model under development.

If the goal is to embed knowledge in the online solution, the engineer must collect and package that domain knowledge in such a way that it is available as a tool for operators to reference in online applications. That knowledge will include details of process feeds/products, equipment design, and the controls and operating procedures applied during plant operation.

The applications must be simple to create and maintain. Otherwise, operators will have little confidence in them as the predictions of the simulator diverge from actual plant conditions. A good simulation development environment will consist of tools to create a library of common process equipment and a graphical flowsheet for the model development of industrial applications.

Dynamic parameter estimation is another powerful technique that allows differences between simulation and plant to be minimised by systematically and periodically adjusting related model parameters while plant conditions change.

The initial process simulation is built off-line according to the plant design basis created in the construction project. At this stage, the simulations can also be used for operator training, control system implementation and validation, and operating scenarios assessment (HAZOPS).

Once the plant is operational, the model can be implemented online and used in conjunction with real-time plant data to provide high-quality information for rapid decision support at all levels.

True Lifecycle Modelling

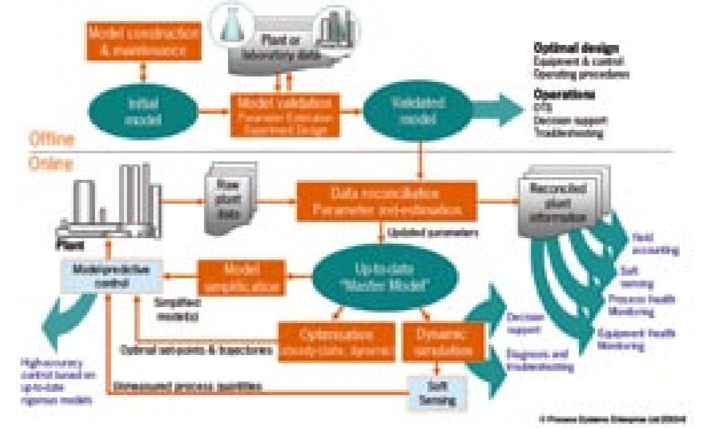
Much has been made of such "lifecycle modelling" in the past. However, in reality, applications failed to deliver satisfactorily on numerous counts; some because the starting point was a sequential-modular flowsheeting tool used primarily for design and incapable of meeting the speed and robustness demands of online execution, others because the lifecycle solution was a collection of poorly-integrated tools that required models to be rewritten for different applications.

In addition, slow solution speeds meant that models had to be kept simple and thus could not capture the full complexity of operation. Most simulation environments had limited or no model validation capabilities, meaning that it was very difficult to keep the model close to the current plant state. Even more limiting, most online applications were restricted to steady state solution, requiring plants to reach "near steady state" before data reconciliation was initiated.

These translate into inaccuracies that seriously limited the quality of the optimisation achieved, making it difficult to realise real percentage benefits in plants that are operating close to constraints (as most plants are) and are already highly optimised.

Enter new generation advanced process modelling (APM) tools such as Process Systems Enterprise's gPROMS, which are specifically designed to address such shortcomings.

Based on process modelling (as opposed to simulation) technology, these "true lifecycle" environments use a single modelling framework to perform many different online activities using high-accuracy models from



The application of offline and online simulation in the product workflow of the modern process plant.

engineering design: automatically tuning the model to reflect the current operating state (whether steady-state or transient), simulating potential scenarios, and optimising controller set-point trajectories.

These activities use a single underlying "master model" that embeds corporate knowledge from laboratory to operating plant. The master model is capable of generating models of appropriate complexity for many different activities – for example, linearised models for MPC, or simplified, fast-response dynamic simulation models for operator training.

A key advantage is that APM environments are built on modern software principles. Open architecture means that applications can easily be embedded within process automation and knowledge systems such as Honeywell's Experion Process Knowledge System (PKS).

Open models allow easy maintenance and extension, and enable companies to take control of their corporate knowledge and easily transfer it between different groups across the organisation. Equation-based solution techniques provide solution speed, robustness and power, plus the ability to perform many different types of calculations on the same model.

Such new environments now make the lifecycle application possible, vastly expanding the amount of high-quality information available to operators and the plant control and decision support systems.

Operating Scenarios

The assessment of operating scenarios with the use of simulation tools can be considered in three time domains:

- Assessment of past incidents captured by the plant historian
- Monitoring and understanding of current equipment and production parameters in real-time
- Look-ahead assessments to predict future outcomes of current operation actions

Examples of each of these scenarios are provided below.

> Incident Assessment

A process is running at steady conditions and then without warning, something happens to upset the process. After several hours, the operations staff are able to bring the process back under control, but product quality suffered during the upset. A process engineer is assigned the task of identifying the cause of the upset and recommending ways to monitor and avoid it in the future. A simulator process model already exists for the process.

The cause of a problem is not always discernable from the process measurements. Therefore, a dynamic simulation synchronised to the process can be a valuable tool in such post-event analysis. If a model of the process is already available, the incremental cost of using the model for post-event analysis is low.

> Equipment Performance Monitoring

An offshore production platform operates a process requiring gas compression, where the driver is a gas turbine. Offshore production engineers, by nature of their environment, have few resources to monitor the performance of their process equipment. Consequently, online gas turbine performance monitoring is a prime example of how simulation can be an effective solution.

The simulation is used to monitor key real time operating variables. With a good fit between plant and simulated data, engineers gain confidence in supporting the extrapolation to other variables and conditions that cannot be measured directly. This interpreted data becomes the basis of the health of the gas turbine, and can influence recommendations for modified operation steps or service.

As operating conditions change, the model of the gas turbine predicts the impact on machine performance, and relates this to available equipment capacity and detects common faults. The model alerts operators when conditions change and require attention. On receipt of the alert, the maintenance and operations teams take action and schedule servicing as required. Plant historian software also tracks equipment performance for record keeping.

Simulation can be an effective solution for equipment performance monitoring.

> *Look-Ahead Assessments*

When known production changes are planned, look-ahead simulation or optimisation can help determine the most economic course of action for effecting those changes.

An example is grade change in polymer production, where changing from one product quality to another typically involves many hours of off-spec production. This results in material that must be discarded, recycled or sold at a much lower price than on-spec product. A good dynamic model of the polymer process and its operating procedures allows operations to optimise the trajectories of key operating variables in advance, providing a series of optimal set-point changes to operators.

Furthermore, the model can generate localised linear models at various points during the transition, for use in model-based predictive controllers and online optimisers. This minimises the time taken for off-spec material to be produced, and typically also the throughput during this time. Companies can apply the same approach to many different operations, including providing decision support for unplanned changes or upsets.

Huge Step Forward

The simulation approach helps detect a number of adverse operating or equipment conditions. The ability of the computer to serve operators in this way allows them to focus on making informed decisions while operating their plant.

Automation systems have business objectives and interactive behaviour built into advanced control strategies that offload operator responsibility to interpret optimal operating states of their plant's integrated process areas.

Through these simulation strategies, the industrial control domain takes a huge step forward in directing the operation of these plants with guidance systems. This has many strong comparisons with aeroplane autopilots.

Operating performance is the balance between production efficiency and reliability. And improving plant reliability through informed decision-making is critical to this success. When this is achieved, plant managers can:

- Accelerate operating profits with faster start-ups
- Sustain operating profits through incident avoidance
- Protect plant assets and the environment

In summary then, a simulation synchronised with process operating conditions that shadow a plant's operation can greatly assist with operators' decision-making processes. That is a substantial achievement.

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