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An Integrated Modelling Framework for Asset-Wide Lifecycle Modelling

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Abstract

This century is bringing new challenges to the engineering community, compelling it to undergo rapid change. The lines between traditional engineering disciplines are beginning to blur, requiring cross-functional knowledge and expertise across process, design, project management, environmental, mechanical, operations, maintenance, planning, scheduling, cost estimation, supply chain, process control, and other disciplines. This paper presents the Open Simulation Environment™ (OSE) that will meet the challenges presented by the changing industry and technology landscape. The Open Simulation Environment is a critical component by which the engineer of the 21st century will provide greater value-added, utilizing any of the technical modelling tools required to perform his/her job.

Keywords: lifecycle modelling, asset-wide modelling, modelling framework

1. Introduction

The 21st century is bringing new challenges to the engineering community, compelling it to undergo rapid change. The driving forces for this change include:

- **The traditional deployment of operational budgets (OPEX) and capital budgets (CAPEX) is changing**. In Western Europe, the United States and Japan, CAPEX is employed primarily to increase the effectiveness of OPEX through de-bottlenecking projects and meeting environmental or other regulatory constraints. In developing economies, CAPEX is employed primarily on new construction of massive plants to meet the needs of bourgeoning regional wealth and a growing global economy.
- **Process simulation has changed** from simply "automating design calculations" to being the center of "integrated engineering workflows" that support a variety of decision making tasks, from conceptual design to process design to plant troubleshooting.
- **Modeling technologies have established themselves as critical components** of several specific tasks in plant operations, including model-based control technology in advanced process control (APC), first-principles simulation models in real-time optimization (RTO), and LP-based models in planning and supply-chain management.

- **Information technology (IT) infrastructure has evolved** so that most process companies are today able to access plant data on every desktop, across all disciplines in the organization.

In this new environment, the lines between traditional engineering disciplines are beginning to blur, requiring cross-functional knowledge and expertise across process, design, project management, environmental, mechanical, operations, maintenance, planning, scheduling, cost estimation, supply chain, process control, and other disciplines. Meeting these challenges demands that engineers become more proficient in a broader range of disciplines. He/she must be able to model more complex processes across a wider array of assets and variables in order to perform their jobs professionally.

2. Value Creation Opportunities in Simulation and Modelling

As we look forward and identify where the value creation opportunities are going to come from over the next decade, simulation and modelling will continue to be the critical elements that enable owner operators and engineering & construction companies to address the challenges they face ─ and ultimately profit from them.

We have identified three key areas of opportunity for customer value creation through the application of modelling and simulation technologies:

- Accelerating the use of process simulation beyond engineering into plant operations
- Performing simultaneous simulation and engineering design
- Expanding the scope of simulation models from single-process to site-wide and business-wide analysis.

The following sections describe each of these value creation opportunities in more detail.

2.1 Accelerating the Use of Process Simulation beyond Engineering into Plant Operations

Customer value can be created by the following activities:

- Using consistent models across the process lifecycle, from engineering to operations
- Taking advantage of the knowledge embedded in first-principles, empirical, statistical and planning models ─ deployed both off-line and on-line ─ to guide operational decision making and improve plant performance
- Being able to use third-party and in-house models seamlessly with off-the-shelf simulation tools
- Exploiting the knowledge within models by utilizing case management and case comparison capabilities for models
- Using custom modelling capability for rapid development of new models that work inside the individual modelling tools, as well as in an integrated modelling environment. Creation of new custom models is also key for the innovation process.

Lyondell (McGrath, 2004) has implemented a real-time operations decision support system for a propylene oxide/styrene monomer unit. The decision support system consists of an Aspen Plus plant model (adapted from an existing Aspen Plus design model), and online data connectivity using Aspen OnLine connected with the Aspen IP.21 plant information management database. The model runs with the Aspen Plus optimizer to reduce the combined cost of steam, solvent losses and propylene oxide product losses. Lyondell has reported that this real-time decision support system has resulted in savings in refining steam use of more than 8%.

2.2 Performing Simultaneous Simulation and Engineering Design

Customer value can also be created in the engineering workflow through the open and flexible integration of commercial, third-party, and in-house models and engineering tools. Engineering analyses can be performed more productively and consistently, resulting in superior designs that consider technical and economic constraints.

As the largest ethylene producer in Asia, YNCC (Lee, 2002) had a goal of increasing capacity at one of its major ethylene facilities. Original engineering proposals provided a 16% capacity increase at a 10 cents/lb capital investment. Working with AspenTech, YNCC adopted a new integrated engineering approach to identify the most cost-efficient revamp projects. The key aspect of the new approach was that simulation, process analysis and equipment modelling were executed in a simultaneous, integrated workflow, rather than in a sequential workflow. The new integrated engineering approach enabled capacity increase of 20% at 7 cents/lb, resulting in a 40% reduction in capital investment rate and at the same time 4% higher capacity than the original proposal. In addition, the new approach predicted $3.3.M/year in energy savings.

2.3 Expanding the Scope of Simulation Models from Single-Process to Site-Wide and Asset-Wide Analysis

Customer value can be created by linking engineering with business decision making for capital investment and operations decisions 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 optimization of a production facility.

BP’s Daily Optimizer (Stenhouse, 2000) predicts the offline operating conditions and available safety margins for the Harding Asset, from wellhead to tanker. The system displays the best selection of well production schedules and process facility parameters to the operations staff, thereby maximizing the profit for the given asset and economic constraints. The heart of the system is a full asset-wide model based on a combination of Aspen HYSYS process models and third-party models, coupled with in-house optimization technology that reconciles and optimizes the incoming plant data. The system uses a custom spreadsheet front-end to provide an overview of the asset. BP has reported incremental oil production of 43MBPD due to the use of the daily optimizer, totalling approximately $30 M/year in benefits.

3. The Open Simulation Environment (OSE)

The above value-creation opportunities can be made available to all companies by creating a more productized, configurable and scalable simulation and modelling environment that is based on open standards. The single open environment will also meet the challenges that engineers face in today's changing industry and technology landscape, by:

- Bringing all of their disparate tools together and creates 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.

As the leader in providing engineering applications for Front End Engineering and Design (FEED), plant operations and supply chain management for the process industries, AspenTech is spearheading the effort to provide this open environment to the process industries.

3.1 Open Simulation Environment (OSE)

OSE is AspenTech's initial step in delivering a common experience for traditional process simulation and modelling. OSE will enable expert applications to be easily applied in a plant operations environment, bringing the various engineering disciplines together over time so users can collaborate more effectively and leverage their expertise across engineering and operational disciplines into the plant.

3.1.1 OSE Capabilities

OSE extends the value of models across the enterprise through the following five key capabilities as described below, and as shown pictorially in Figure 1:

Figure 2. The Open Simulation Environment

- **Model interoperability**
  - Integration "plugs" for AspenTech, third-party, and in-house models
  - The Aspen Simulation Interface (ASI), an interface standard for integration
  - Support for CAPE-OPEN and other industry interface standards

- **Model execution**
  - Combination of first-principles with empirical and/or statistical models
  - Creation of integrated site-wide and asset-wide models representing entire business performance
  - Common asset-wide representation interface
  - Multiple modes of model execution, including sequential, simultaneous (equation-solving) and mixed-modes
  - Updating (synchronizing) of one model type with another, such as planning model updated by simulation model
  - Support for distributed computing
- **Model-based analysis**
  - Layered engineering analysis tools, such as equipment design, sizing, and economic analysis
  - Open interfaces to in-house and third-party engineering tools
- **Model management**
  - Model repository for accelerating model reuse and central deployment
  - Case comparison utilities
  - Support for model authoring tools
- **Model deployment**
  - Integration to plant information and automation systems for both off-line and online applications
  - Layered utilities for data validation, steady-state detection, and data reconciliation
  - Configurable end-user interfaces, via Excel or Role-Based Visualization from Aspen Operations Manager

OSE builds on the investments users have made in their existing models, and allows them to gain considerably greater value from these models by deploying them to address a wider range of business problems. As a long-term objective, OSE will incorporate planning and supply chain modelling to enable consistent decision making across the engineering, operations and business domains.

The table below reflects the paradigm changes anticipated as a result of OSE.

Table 1. Paradigm changes expected as a result of OSE

From	To
Models for process design and engineering	Models for operational decision support and asset-wide decision making, *and* process design and engineering
First-principles-only models	Integrated models incorporating first-principles, empirical, and statistical models
Models of a single plant	Integrated site-wide models

Single point optimization	Scenario optimization over extended time periods

4. Conclusions

At the dawn of the 21st Century, the engineering community is undergoing rapid change. The lines between traditional engineering disciplines are blurring, requiring engineers to be proficient in a dozen or more technical computing applications to perform his/her job professionally across several of fields of expertise. The net result of is that the engineer is getting pulled deeper and deeper into the business of operations.

The Open Simulation Environment is a critical component by which the engineer of the 21st century will provide greater value-added, utilizing any of the technical modelling tools required to perform his/her job, with potential impact on the business of:

- More efficient deployment of capital by 15-20%
- 10-15% reduction in energy and environment related expenses
- 1-5% increase in operating margin
- Double engineering productivity over the next decade: CAPEX and OPEX in the process industries are increasing at a much higher rate than the engineering workforce. Engineering productivity will thus need to double in the next decade when measured in CAPEX/OPEX dollars vs. engineering person-hours.

OSE is the manifestation of model centricity for the process industries, enabling the interdisciplinary collaboration necessary for the engineering and operations community to effectively deploy CAPEX and OPEX investments in an optimal manner.

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