R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Computational Energy Sciences

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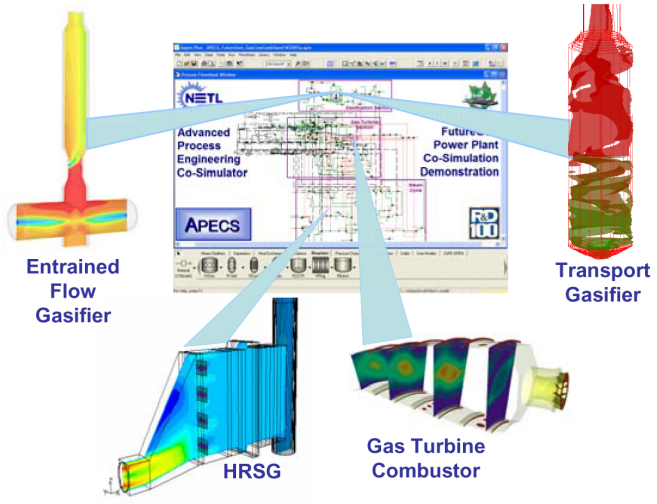
Advanced Process Engineering Co-simulation

Description

The National Energy Technology Laboratory (NETL) and its R&D collaboration partners are developing the Advanced Process Engineering Co-Simulator (APECS) as an innovative software tool that combines process simulation with high-fidelity equipment models based on computational fluid dynamics (CFD). Winner of a 2004 R&D 100 Award and a 2007 Federal Laboratory Consortium (FLC) Excellence in Technology Transfer Award, this powerful co-simulation technology, for the first time, provides the necessary level of detail and accuracy essential for engineers to analyze and optimize the coupled fluid flow, heat and mass transfer, and chemical reactions that drive overall plant performance. Combined with advanced visualization and high-performance computing, APECS offers opportunities for exploiting virtual plant simulation to reduce the time, cost, and technical risk of developing high-efficiency, zero-emission power plants.

FutureGen Power Plant Application

The U.S. Department of Energy's (DOE) $1 billion FutureGen Research Initiative is aimed at creating the world's first coal-fueled, nearly emission-free electricity and hydrogen production power plant. The 275-megawatt FutureGen plant will employ advanced coal gasification technology integrated with combined cycle electricity generation, hydrogen production, and capture and sequestration of carbon dioxide. At NETL, system analysts are evaluating and optimizing potential FutureGen plant configurations using APECS process/CFD co-simulations with detailed CFD models of key equipment items, such as gasifiers, synthesis gas coolers, gas turbines, heat recovery steam generators, and fuel cells.



APECS Co-Simulation of a FutureGen Power Plant

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SECA Fuel Cell Application

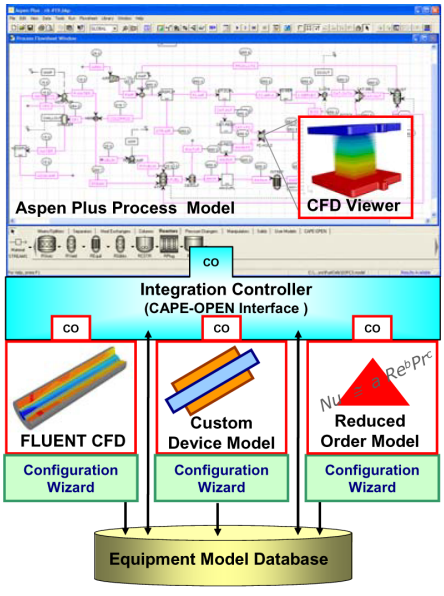
The DOE is sponsoring development of cost-effective, high-volume, fuel cell power systems through its Solid State Energy Conversion Alliance (SECA) program. One large ready-market opportunity for solid oxide fuel cell (SOFC) systems is auxiliary power units (APU) for transportation applications. On-going research at NETL is addressing the need to analyze these systems for low cost, high efficiency, and maximum thermal integration. Using APECS, the overall performance of APU systems can be optimized with respect to the local fluid flow, heat and mass transfer, electrochemical reactions, current transport, and potential field in SOFC stacks simulated using detailed, three-dimensional CFD models.

APECS Benefits

- Helps engineers to better understand and visualize the fluid flow behavior that impacts process design and operation
- Considers detailed equipment models in the context of plant-wide simulations, with recycle loops, heat integration, and water management
- Enables rigorous analysis and optimization of entire plants with respect to CFD-related equipment model parameters
- Eliminates potential for suboptimal designs by using same physical properties and reaction kinetics in the underlying equipment and process models
- Speeds technology development by reducing pilot/demo-scale facility design time and operating campaigns
- Offers opportunities to achieve the aggressive environmental, performance, and economic goals for high-efficiency, zero-emission power plants

APECS Features

- Process industry CAPE-OPEN standard software interfaces for plug-and-play interoperability of unit operation models, physical properties, and reaction kinetics
- Configuration Wizards to prepare equipment models as CAPE-OPEN compliant models for use in process simulation
- Model Database for storing and managing equipment models including CFD models, custom models, and fast reduced-order models (ROMs) based on previously-computed CFD solutions
- Model Selection GUI to browse and select equipment models from the database to associate with blocks instantiated on the process flowsheet
- Model Edit GUI for modifying equipment model parameters and defining flexible and powerful solution strategies
- Integration Controller using a CAPE-OPEN COM/CORBA bridge implementation to enable serial/parallel execution of high-fidelity equipment models on distributed heterogeneous computers
- CFD Viewer to display, within the process simulator, the 2-3D results of CFD simulations conducted as a part of a co-simulation
- Analysis Tools for design specifications, case studies, sensitivity analyses, stochastic simulations, and optimization



APECS Integration Framework