Cut time-to-market for coal-to-liquid energy projects

30 August, 2012 John Immelman 0 comments

Coal miners in, or considering, coal-to-liquid (CTL) energy production need to make decisions on the most suitable liquefaction process, estimate the associated capital costs, and predict the return-on-investment (ROI) for the stakeholders.

Projects owned by Ambre Energy, Syngas, New Hope Coal, Altona Energy, Linc Energy, Coalworks, and others, are all in progress in Australia, but time-to-market, and R&D costs are concerns.

[*Pictured alongside is the Sasol Secunda CTL plant which supplies 30 percent of South Africa's fuel requirement (image courtesy Sasol, Media Club South Africa).*]

The volatility of the coal price, unpredictability of coal demand, and ongoing search for alternative energy sources, has encouraged many Australian coal miners to explore new and complementary coal mining processes.

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The best known is the coal seam gas (CSG) non-renewable energy source which has recently attracted extensive negative publicity, mainly because it is seriously invasive on the mines' neighbouring farming land, and not particularly environmentally friendly.

The coal-to-liquid (CTL) process, in most instances, means that existing coal mines can convert coal into synthetic crude oil for further refining into diesel and other fuels, adding revenue and economic sustainability to the miner.

CTL processes

There are three recognised basic processes for the liquefaction of coal: Direct Coal Liquifaction (DCL) and Indirect Coal Liquifaction (ICL), and a hybrid of the two.

As with all process plants there are also many variations of these processes used in industry.

Which basic model is selected depends on many factors, the most critical being feedstock coal quality (lignite, sub-bituminous, bituminous, or other low ranked coals), yield required, final product (diesel or high octane fuels), and capital costs.

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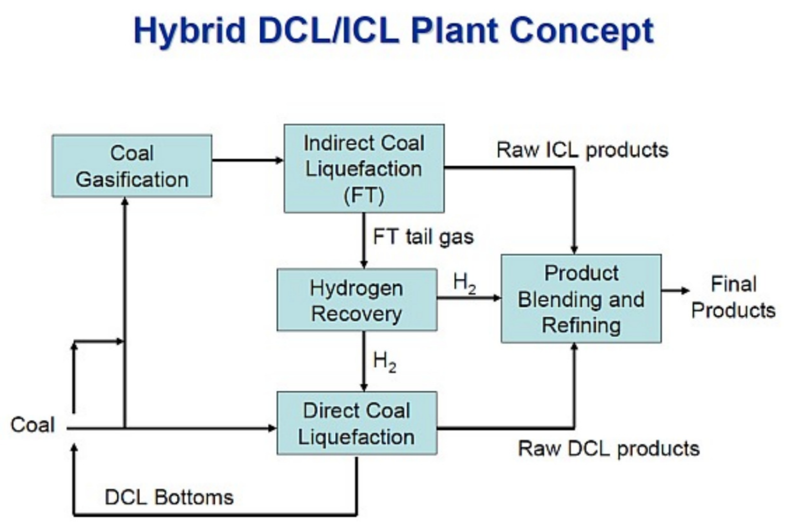

This hybrid liquifaction process map shows the significance of the gasifier (image courtesy DOE/NETL).

What is common and most crucial to the efficiency to all CTL processes, and their variations, is the gasification phase.

One of the most common gasification designs is the Integrated Gasification Combined-Cycle (IGCC) plant. Since the plants represent investments of hundreds of millions of dollars it is essential to leverage advanced technology to identify optimal process configurations.

This will also help to design equipment that will run reliably and safely, as well as develop very accurate cost estimates to ensure that the right decisions are made early in the design lifecycle.

The simulation solution

According to Steven Kratsis (pictured here), director of area sales for AspenTech Australia, "recent advances in engineering software and the relentless progress of Moore's law have made it possible to simulate large scale processes such as IGCC plants at increasingly higher levels of fidelity."

Decision makers, or champions, need to consider the challenges of simulating IGCC and other large-scale integrated processes.

Today's simulators, such as our Aspen Plus, allow users to break the process down into hierarchical sections. Each hierarchy captures an area in the plant, such as an air separation unit or the power island.

The hierarchical sections are connected by the 'boundary streams', representing the material, heat, electricity, or shaft work flowing from one section of the plant to another section.

Hierarchical models can also be used as containers for complex equipment models. For example, gasifier models may be assembled from combinations of ideal reactor blocks, furnace models, mixers, and splitters.

Building these reactor models in a hierarchy container allows the model developer to package the entire structure as a reusable template. The resulting templates can be inserted into a process model just like any of the built-in unit operation models.

Hierarchies improve the usability of these complex simulations by organizing the models into a sensible structure. In addition, hierarchies make the models easier to maintain since an entire section of a process can be updated by importing a single object into an existing simulation case.

Advances in simulation

At AspenTech, improvements in computer hardware and software have allowed process engineers to significantly increase the scope of the process included inside a single simulation case.

Specifically, equation-oriented and hybrid (mixed EO-SM) simulation allows our users to carry out wide-scale process optimisations of entire plants.

Simulating and optimising the whole process using an integrated plant model allows process engineers to avoid time-consuming manual work reconciling designs spread across multiple case files.

More importantly, optimising a process using an integrated model ensures that the resulting designs capture the true plant-wide optimum instead of a local optimum

Advances in design

The gasifier is the core of the IGCC plant. It is essential to design the gasifier properly to ensure high energy efficiency and good process economics.

Engineers can apply computational fluid dynamics (CFD) tools to optimise equipment design to identify and eliminate dead zones, hot spots, and other potential operability problems.

These types of CFD models can also be used to characterise equipment performance over a range of operating conditions to improve predictions of efficiency and performance under various scenarios.

Although CFD models are very powerful, they have high computational requirements. As a result, the CFD models have been used primarily in isolation to design key equipment.

Recent work led by the US Department of Energy's National Engineering Technology Labs (DOE/NETL) shows great promise for improving this situation.

A number of organisations working together under the NETL-sponsored Advanced Power and Energy Co-Simulation (APECS) project are developing methods of converting rigorous models (including CFD models) to reduced order models (ROMs), which in turn can be used in the context of an integrated plant process simulation model.

Advanced mathematical modelling techniques, such as neural networks and principle component analysis (PCA) are used to perform data regression against simulation results from the high-order models. The models are fitted to complex equations which capture the essence of the equipment behaviour.

The ROMs are much less computationally intensive than the original high-order models, so they can work inside simulators to help predict the global optimum operating conditions.

NEDO (New Energy and Industrial Development Organisation - Japan), installed a pilot plant for brown (low ranked) coal liquifaction at Morwell in Victoria in the late 80s, but after some years they could not achieve the desired yield.

“Using the latest simulation tools to adjust the processes, NEDO estimates that the cost of production could be reduced by 24 percent, making such a plant viable,” maintains Kratsis.

Role of AspenTech tools

Since all mines have different grades of coal across their landscape, step one is to select the location of the optimum coal source.

Using Aspen Plus, the miner can enter the properties (moisture, carbon content etc) of a coal sample, and then model the gasification process to determine the syngas output, and the yield. This process is repeated until the best site is identified.

The next step is actual design. Detailed first-principle gasifier models have also been developed using equation-oriented modelling tools such as Aspen Custom Modeller (ACM).

These models, which capture rate-limited reactions, mass- and heat-transfer, can be used to optimise the steady-state operating conditions and the equipment designs.

Such models can also be used to study process dynamics, to test control schemes, and to identify the best start-up and shutdown procedures for these plants. These custom models can be plugged directly into the steady-state simulation environments (such as Aspen Plus) to examine the process as a whole.

Process simulation models can be used to predict the mass and energy balances and key equipment sizes for IGCC plants.

These results can be used together with rigorous cost modelling software, such as Aspen Icarus Process Evaluator (IPE) and Aspen Process Economic Analyser (APEA), to carry out detailed economic evaluations of various process configurations and scenarios.

Rigorous cost modelling provides the accuracy needed to make the right investment decisions and to reduce the risks of cost overruns.

Further, these tools allow estimators to carry out detailed economic analysis of various scenarios such as future escalation in coal production costs, and fuel price changes.

Conclusion

There are a number of excellent technologies available today to help guide decision making with respect to process selection, feedstock selection, process configuration, and detailed equipment design.

Coal miners who leverage these technologies most effectively to develop the most economical and reliable IGCC plants will come out the winners in the competitive race to produce synfuels using the CTL process.

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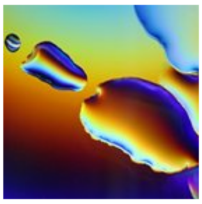

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