Technical Article

Unlocking Profitable Biofuel Opportunities with Process Simulation

Biofuel market has witnessed significant growth in recent years on account of rising environmental awareness and strong demand from automotive sector. Stringent government regulations resulted into growing demand for biofuel. This is anticipated to boost the demand for bioethanol, states a recent report. The increasing demand for biofuel will certainly need profitable processes. Following article discusses these opportunities and challenges associated with the biofuel production processes.

As the demand for lower carbon emission fuels increases, resourceful design of biofuel processes, such as biodiesel, bioethanol, syngas, and biogas derived from biomass feedstocks such as corn, sugarcane, algae, and cellulosic sources etc. is unlocking opportunities for more attractive and profitable endeavours. Combustible biofuels offer a nearly carbon neutral alternative within the existing oil and gas energy infrastructure and for these reasons among others, they are attracting continuing investment interest. Recently, an influx of low cost natural gas and tight shale oil in the US has altered the economic benchmark for biofuels, putting pressure on process engineers to arrive at optimised designs. Designing biofuel processing plant configurations with an advanced flowsheet simulator that incorporates economic, energy, and heat exchanger design analyses, to optimise processes for energy use and cost, can not only produce better designs but also in shorter period of time.

Several design challenges arise with the development of biofuel processing plants, the foremost being the proof of techno-feasibility and profitability, prior to detailed design, to attract capital investment. Other challenges include the rapid pace of process innovations, resulting from the exploration of alternative crops and cellulosic ethanol, and the pressure to optimise feedstock selection and ensure flexibility in plant design to accommodate change. To further secure profitability, many processes must also incorporate the production of profit-making by-products including animal feeds and chemicals.

Process simulation is used to design entire biofuel processes

From processing the feed and controlling the final product to equipment selection and costing, process simulation is used to design entire biofuel processes from research and development to conceptual design to engineering and procurement.

By designing a fully developed process model in a process simulator, users can compare and screen solutions that support more profitable and flexible biofuel plant designs. Advancements in biofuel processing, such as those seen in feedstock pre-treatment, transformation (i.e. hydrolysisis, saccharification, and fermentation), ethanol dehydration, gasification of biomass, and transesterification of triglycerides, can be conceptually designed in a flowsheet simulator. Users can benefit from visualising and optimising the entire process, rather than the individual steps. The design can be modularised, to explore impact of substitution of different units and technologies in the overall process schema. Using consistent and reliable property data from a database, such as the comprehensive and always advancing NIST database available in select simulators, increases model validity. Furthermore, process simulation allows for optimisation studies to find the optimal operating conditions while considering process constraints like product water content or vessel temperature. Users also have the opportunity to test different feedstocks and feedstock blends in the same plant configuration. With these options, higher quality models, that can forecast scale-up and economics, can be developed, dismissing fears of solutions lacking techno-feasibility.

Process simulation has been used to model chemical processes for the last 30 years and has been providing model-centric integrated solutions for many process industry sectors. To date, users have used models for corn-starch plants, dry and wet mill corn-to-ethanol processes, cellulose-to-ethanol processes, as well as biomass gasification processes. Additionally, process simulation is widely used for designing important ethanol activities such as hydrolysis, saccharification, fermentation, distillation and dehydration, co-products recovery, and pH control. With the integration of solids modelling capabilities into flowsheet simulators, users can now more rigorously model equipment used to process solids feeds, such as crushers and mills, and the equipment used to model liquid/solid separation, such as centrifugation and drying.

There are many process simulators on the market today, and depending on the vendor, the user may be able to take advantage of integrated process engineering tools when designing biofuel processes. These integrated tools bring energy optimisation, rigorous exchanger design and rating, and cost estimation tools into process simulation environment. With integrated energy optimisation software, users can increase heat recovery by evaluating exchanger networks and minimise operating costs by effectively evaluating the different utility types by cost effectiveness. With rigorous exchanger design and rating tools integrated into the process simulator, users can size and rate an exchanger from the flowsheet, utilise the design to increase flowsheet accuracy, and also check the exchanger for operational risks and warnings such as vibration, fouling, and excessive operating temperature and pressure. With integrated economic evaluation tools, users can compare alternative process designs in less time and also view the impact of operational decisions on the overall operating cost the process. The unique opportunity to use these types of analyses earlier in the design process can translate to more profitable design.

Pan Pacific Technologies, a sustainable energy consultancy run by Dr Eric Dunlop, used Aspen Plus to develop various models for biological processes to evaluate the technical and commercial feasibility of carbon-to-algal-biomass conversion integrated with downstream biodiesel production[1]. Through innovative use of aspenONE solutions, Pan Pacific Technologies was able to accurately solve the biological physical properties challenge, and successfully produce an Aspen Plus model with results matching laboratory and industry data. With this baseline case, they further used the model, the energy balance, and the link to AspenTech's estimating system to understand scale-up constraints and the key economics of the process. The resulting model was validated and accepted by the DOE's NAABB Consortium.

The Brazilian Bioethanol Science and Technology Laboratory (CTBE), a research centre based out of Brazil, used Aspen Plus to design and scale up a sugarcane refinery to assess different routes for biofuel production[2]. CTBE considered first and second generation ethanol plants, sweet sorghum as a feed, and butanol as a product, and compared economics, social, and environmental factors. Using aspenONE Engineering, CTBE was able to find the best configuration for return on investment.

In addition to the number of biofuel models developed by experts at Aspen Technology, the National Renewable Energy Laboratory (NREL) has a collection of biofuel processing models developed in Aspen Plus that are available to the public[3]. With this existing know-how as to modelling all of the processes involved in biofuel production, users can have a starting point when designing new processes.

By using innovative software simulation, organisations that are even in the early R&D stage or technology demonstration phase, can develop innovative biofuel process designs that are not only more techno-feasible, but also in a shorter amount of time, with rigorous process results that demonstrate both the engineering viability and the economic opportunity of a new process or feedstock. ■

The resourceful design of biofuel processes unlocks opportunities for more profitable endeavours

References

1. Dr. Eric Dunlop, Pan Pacific Technologies, 3rd International Conference on Algal Biomass, Biofuels and Bioproducts, Toronto, 2013.
2. Tassia L. Junqueira, CTBE, AspenTech OPTIMIZE, Boston, MA, May 2013
3. National Renewable Energy Laboratory, NREL Biorefinery Analysis Process Models.

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