Energy-Related Case Design Studies

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The capstone Senior Design Course offers a unique opportunity to engage students in the areas of energy and fuel production that are of current interest. In this series of three CACHE Design Case Studies developed by Carnegie Melon University, students are required to synthesize new processes that use earlier biomass (vols. 9, 10) or shale gas (vol. 11) as raw material. The case studies provide extensive information and data for the instructor in order to facilitate the assignment of a design project in their design course. Each case study provides background for the corresponding topic (bioethanol and shale gas), course organization, and complete reports by two design groups that include literature review, mass and energy balances, and energy integration and economic evaluation. Slides of the oral presentations by the two design groups are also included. Below are the abstracts for each of the case design studies that can be ordered from: http://cache.org/products-page

CACHE vol. 9: Gasification consists of a partial oxidation of carbon based raw material to generate syngas. The mixture of CO and hydrogen can be used for a wide number of applications, among them the production of second generation of bioethanol. The interesting issue of this path is the number of alternative process flowsheets to produce ethanol, since there are different gasification technologies, reforming modes, CO2 capture methods, and different synthesis paths to ethanol, fermentation or mixed alcohol synthesis. Separation is another major challenge. This case study provides information to guide the students through mass and energy balances and process economics using Matlab and Mathcad process models.

CACHE vol. 10: In this case a different path is used, the biochemical one, to produce bioethanol. Furthermore, the transportation and logistics of biomass is also considered in this project since it has an impact on the plant size. The biochemical route from lignocellulosic raw materials is a second generation process for bioethanol that operates at lower pressures and temperatures. The pretreatment is followed by hydrolysis, fermentation and ethanol dehydration steps. This case study provides information to the instructor to guide the students through mass and energy balances and process economics. The use of Mathcad for process design is also introduced.

CACHE vol. 11: In this case study shale gas and condensates from the wet gas (e.g. ethane) are used as raw material instead of more expensive crude oil to produce aromatics (benzene, toluene, xylene). One of the interesting challenges in the case study is the number of different processes that can be synthesized. Students must first screen different alternative chemical pathways to decide on the specific process. Furthermore, apart from the use of Mathcad or Excel for preliminary process calculations, process simulation using ASPEN-PLUS is used for the detailed mass and energy balances of the plant, while ASPEN-ENERGY ANALYZER is used for energy integration and synthesis of heat exchanger networks.

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