Characteristics of Capstone Design Project

by

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Desired Outcome: Students graduating from the program should have an ability to design and analyze new and existing chemical systems and processes to meet desired needs.

Student learning tasks: Coursework will provide, in most of the courses in the curriculum, some experience in working with open-ended, design-oriented problems and the need to synthesize and innovate in order to reach a solution. The curriculum will include a capstone design course which gives students experience with increasing complex systems and processes...

In my opinion it would be very **beneficial** to introduce non-traditional design projects in the capstone design course. However, the design sequence is intimately related to chemical engineering core courses and many of the concepts utilized in the project are covered in *prior* courses. For this reason, it is important to carefully analyze the background necessary for a non-traditional project before it is assigned as a capstone design project. Based on this analysis, it may be necessary to make *adjustments* to the content of core chemical engineering courses. It would not serve our program well if the design project requires concepts that are *not* covered in the core chemical engineering courses.

The characteristics of a *traditional* design project are listed below:

1. *Development of a process flowsheet*: A typical design project can be divided into three parts (1) feed preparation system, (2) reaction system and (3) separation system. To design each system, there could be seveal *alternatives* and one has to use engineering judgement to decide which alternative to pursue. It is necessary to evaluate if there are sufficient process alternatives for a non-traditional design project.

2. *Thermodynamic and Physical Properties*: Engineering design choices are made based on physical properties of molecules used in the process. These properties are either available in handbooks or websites or can be estimated from mathematical models. This information is typically covered in the thermodynamics and transport phenomenon courses. It is necessary to evaluate if this information is available for molecules used in non-traditional processes.

3. *Mass and Energy Balances*: The process flowsheet shows how various unit operations are interconnected. Mathematical models are utilized for each unit operation to estimate mass and energy balances for producing the desired quantity and quality of the desired product. These models are covered in mass and energy balances, separations, transport phenomenon, and reaction engineering. It is necessary to evaluate if mathematical models are available for unit operations used in non-traditional processes.

4. *Computer-Aided Design*: Most engineering design of traditional chemical engineering processes involves the use of process simulators in the chemical industry. The thermodynamic models developed in the 1960s and 1970s have been very successfully incorporated in process simulators which provide very *accurate* mass and energy balances for process flowsheets. This calculation is necessary for deciding on process alternatives as well as for equipment sizing and costing. We are currently using CHEMCAD in the curriculum which is nicely set-up to handle most traditional process design projects. It is necessary to evaluate its applicability in non-traditional courses.

5. *Equipment Sizing and Costing*: This calculation is typically done using heuristics and empirical equations that are available for most traditional equipment (e.g. heat exchangers, reactors, distillation). This material is currently covered in Transport Phenomena and Design I. It is necessary to evaluate if sizing and costing methods are readily available for non-traditional processes.

6. *Recycle Calculations, Optimization*: In most traditional design projects, the selling price of the desired product is not significantly greater than the cost price and so processes have to be designed cleverly to be optimal (e.g. recycle unreacted material, solvent recovery, energy optimization). This design activity provides a lot of opportunity to test students' engineering ability as well as creativity. It is necessary to evaluate if this issue is important for non-traditional processes (e.g. if the selling price is significantly higher than the cost price, optimization may not be important).

7. *Safety, Ethics and Green Engineering...*: These aspects typically do not involve significant calculations but the issues may be different for different projects. This material is usually covered in Design II and so the content may need to be changed every year depending on the assigned project.