Chemical Process Design: An Enduring Philosophy for a Changing Profession

Richard Turton and Joseph A. Shaeiwitz
Department of Chemical Engineering
West Virginia University
Morgantown, WV 26506

Outline

- What is chemical process design
- Important issues in chemical process design
  - Process understanding
  - New vs. existing processes
  - Life long learning
  - Traditional process engineering
- Big picture and small details
- Critical thinking
- Conclusions

What is Chemical Process Design

the creative process through which new chemical processes are invented, optimized , constructed, and operated.

and

by which existing processes are modified, optimized, and operated

Important Issues in Chemical Process Design

Process understanding

Interconnectivity of Processes

- What happens in one piece of equipment may affect the whole process
- What happens in one process unit may affect the whole plant
- Increasingly complex and integrated plants require extensive understanding
  - intuition and experience
  - advanced modeling

Important Issues in Chemical Process Design

New Process vs Existing Process

- A process is designed once and operated for 15-30+ years – probably never at the design conditions!
- Process engineers are required to design new equipment and also "simulate" existing equipment
- Examples

  – pump curves

  - columns

  - batch processes

Important Issues in Chemical Process Design

Life-long learning

We can't teach everything!

- Life-long learning is a part of any profession (law, medicine, education, etc.)
- Teach-to-learn/teach
- Group projects to expand knowledge base and investigate emerging technologies
- Individual projects to assess individual's understanding

Group Design Projects

- gold production
- formaldehyde and hydrogen peroxide enzymatically from methanol
- formalin production from methanol
- sulfur compounds from waste acid-gas stream tank farm for fuel oil storage
- olefin and alcohol production from wet natural gas production of dimethyl ether
- air separation into oxygen, nitrogen, and argon
- production of silicon compounds production of acrolein
- production of d,l methionine
- maleic anhydride production from n-butane
- acetaldehyde production by ethanol dehydrogenation
- carbon dioxide removal and sequestration from a power plant
- electricity cogeneration with a fuel cell using byproduct hydrogen
- recovering useful products from animal waste
- batch production of amino acids
- cellulosic ethanol production
- methane-syngas-methanol with microprocessing
- Zebra Mussel Control Technology
- Salt Chlorination Device
- Magnetic Refrigerator
- Coated Seeds and Fertilizers
- Transdermal Drug Patch
- Ice Cream Manufacture

http://www.che.cemr.wvu.edu/publications/projects/index.php

Individual Design Projects

- acetone
- acrylic acid
- allyl chloride
- cumene
- phthalic anhydride
- styrene
- dimethyl ether
- ethylene oxide
- drying oil
- maleic anhydride
- MTBE
- ethylbenzene
- formalin
- ethanol

http://www.che.cemr.wvu.edu/publications/projects/index.php

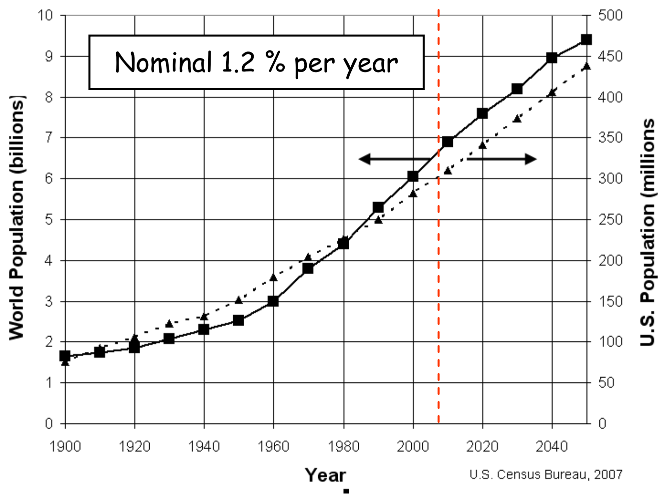
Important Issues in Chemical Process Design

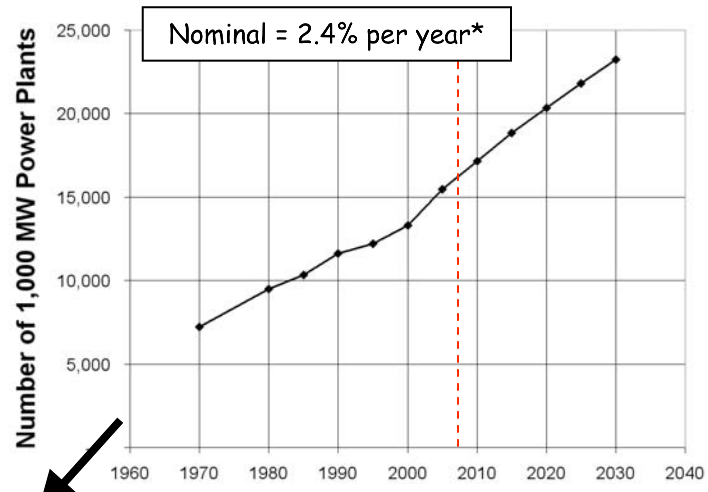
Do we still need traditionally trained process engineers?

- Yes - but not as many as we used to
- Example of EE and Power Engineering
- Energy is important
- Global economy still needs traditional skills

- Emerging technologies also important but bulk chemical production still needs to be managed

Big Picture – Small Details





World wide need is (24,000 – 14,000)/30 = 333 power plants per year

Cost of a 1,000 MW power plant**

NGCC, $554/kW; PC, $1,562/kW (average); IGCC, $1,841/kW (average). With carbon capture, capital costs are: NGCC, $1,172/kW; PC, $2,883/kW (average); IGCC, $2,496/kW (average)

FCI = 390 – 830 $billion/y (wind and nuclear↑)

*** Energy Information Administration - Annual Energy Review 2007**
****Cost and Performance Baseline for Fossil Energy Plants, DOE/NETL-2007/1281**

Big Picture - Small Details

Carbon Capture

Optimization of acid gas removal processes

- **Selexol, Rectisol, Purisol**
- **Amine systems**
- **Emerging processes**

Chemical Looping

Fuel Cells

Coal to liquids

Nuclear

Wind, Solar

Biofuels

Big Picture – Small Details

Process Equipment Details

Pumping Slurries

Designing shift converter

Heat recovery from flue gas

Mechanical design of gasifiers

Thermodynamics (VLE) of complex mixtures

etc.,

Critical Thinking

Differentiate between

- Good science
- Bad science
- "Political" science

Conclusions

- Can't teach everything
- Need both big picture and small detail skills
- Exposure to emerging technology
- Ability to evaluate technology critically and differentiate good science/engineering from politics