

The Practical Problems of Practical Problems

Industrial Perspectives on Teaching Process Design

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UOP

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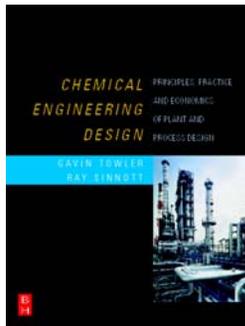
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- **Qualifications & disclaimer**
- **Design in industry**
- **Ways to make design teaching realistic**

- I have managed engineering design groups for over 10 years
- I run UOP's summer intern program
- I used to be on the faculty of Manchester University
- I have been teaching design at Northwestern since 2003 and recently co-authored a book on design



- Having said which, all of the following opinions are entirely my own and do not represent the official policy of UOP, Honeywell, AIChE, CACHE, Elsevier or Northwestern University

Designs For Studies:

- Make-or-buy scenarios
- Competitor analysis
- R&D “what if” designs
- Designs by consultants

Designs That Get Built

- Debottlenecking **30%**
- Revamp/reuse **15%**
- Off-the Shelf plants **10%**
- Licensed designs **20%**
- Clones **20%**
- Commercialization of new technology **5%**

Percentage of all design activity

40%

60%

- **“Cookie cutter” approach reduces technical risk of new plant**
- **Pharmaceuticals & biotechnology:**
 - Time to market and successful scale up are critical
- **Petrochemicals, polymers and fuels:**
 - Scale of investment drives conservative design
- **Well established design rules, clear manuals, proven unit operations and strong vendor relationships make design and EPC phase quicker and lower risk**

- **Debottlenecking and revamp designs require a lot of effort to benchmark current performance**
- **Technical risk of expanding current plant is lower**
- **Obtaining permits can be a large part of the effort**

- **Commercialization of new processes is a relatively rare occurrence in industry**
- **Successful commercialization is even more rare**
 - **First of a kind units often run below design capacity**
 - **Few organizations have deep skill in scale-up and risk mitigation**

- **Revamps, debottlenecking & clones**
 - Need lots of current plant data, which is usually proprietary
- **Standard designs**
 - Manuals are proprietary, design is too “recipe book”
- **Fine chems and pharma**
 - Multi-step syntheses
 - Scale-up from lab data
 - Prices are not easily found
- **All of which has caused many instructors to favor “research” designs**
- **Not necessarily a bad thing if the students learn a few key things**

The safe design and operation of facilities is of paramount importance to every company that is involved in the manufacture of fuels, chemicals and pharmaceuticals!

- **AIChE Code of Ethics:**

- ◆ Members will hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties.

- **Students should understand:**

- **Major safety & environmental legislation**

- ◆ OSHA, TSCA, EPCRA, RCRA, CAA, CWA, EPA, etc.

- **Materials & process hazards**

- ◆ Toxicity, flammability, incompatibility, overpressure, temperature deviations, fires, explosions, loss of containment, noise, MSDS

- **Safety codes and standards**

- ◆ OSHA, NFPA, API, ISA, IEC, etc.

- **Safety analysis methods**

- ◆ HAZOP, FMEA, Quantitative risk analysis

- **Students should be able to identify safety issues in**

- **Their own & others' designs**

- **Plant operations, maintenance, change procedures**

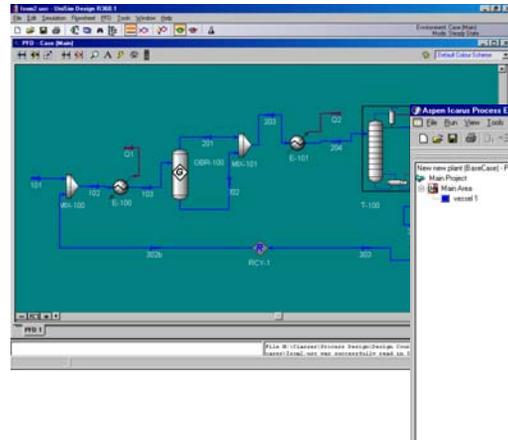
- **Laboratories and research centers**

- **Conformance with codes and standards is a very important professional ethics issue**
- **Students are often not even aware of the existence of design codes**
- **Conformance to code can be a legal requirement or source of liability**
- **Codes are one of the main ways that industry ensures designs meet acceptable safety criteria**
- **Codes should be introduced throughout the curriculum**

- **These days very few problems are solved as pen & paper analytical solutions**
- **There should be way more use of spreadsheets**
 - “Excel: the universal language of engineering”
 - Use spreadsheets for sensitivity analysis
 - Graph results to understand them
 - Don’t just find a number – explore the solution!
- **Use real engineering tools**
 - These are often cheap or even free
 - UniSim, HTFS, FloWizard, Compress, ...
- **Introduce process simulators early and often**
- **Introduce practical design issues throughout the curriculum**

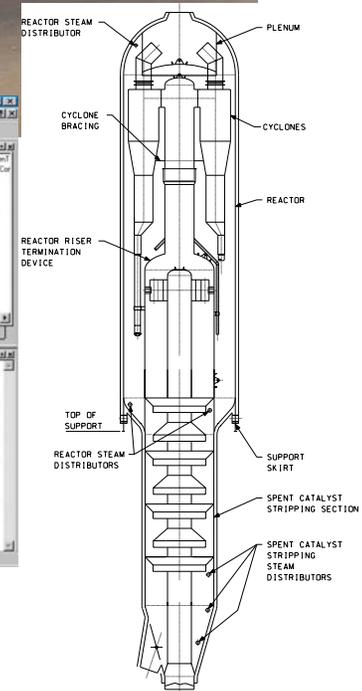
Chemical Engineering Design Supporting Lectures in MS PowerPoint

- 22 presentations with 1170 slides
- Lots of industrial pictures and diagrams (with copyright approval!)
- Step-by-step guides to problem solving using commercial software



Name	Units	Item 1
Shell material	SS304	
Liquid volume	GALLONS	7
Vessel diameter	FEET	10
Vessel tangent to tangent height	FEET	100
Design gauge pressure	PSIG	500
Vacuum design gauge pressure	PSIG	14.7
Design temperature	DEG F	750
Operating temperature	DEG F	650
Skirt height	FEET	66
Vessel leg height	FEET	66
Wind or seismic design	WVS	995
Head volume	PERCENT	24
Number of manholes		2
Allowance for ornaments	PERCENT	10
Minimum thickness	INCHES	
Base material thickness	INCHES	
Corrosion allowance	INCHES	0.125
Number of body flange sets		

ID	Task Name	Duration	Start	Finish	Resource Names
1	Requirements	1 day	Mon 6/14/04	Mon 6/14/04	SNQ[50%],JVC[50%]
2	Prelim process design	4 days	Tue 6/15/04	Fri 6/18/04	LL,SNG[50%],KYDE[50%],MSJ[25%]
3	Simulation Model	5 days	Tue 6/15/04	Mon 6/21/04	LL[50%]
4	FMEA	1 day	Mon 6/21/04	Mon 6/21/04	SNQ,KYDE[50%],LL,N
5	Experimental Program	23 days	Tue 6/15/04	Thu 7/15/04	
6	Electrolysis (at FC)	12 days	Tue 6/15/04	Wed 6/30/04	LN[20%]
7	Delivery of electrolyzer to UOP	1 day	Thu 7/1/04	Thu 7/1/04	
8	Electrolysis (at UOP)	10 days	Fri 7/2/04	Thu 7/15/04	LN[50%],JSH[50%]
9	Hydrolysis (synthetic feed)	5 days	Tue 6/15/04	Mon 6/21/04	RAJ[50%],LL[25%]
10	Hydrolysis (electrolyzed feed)	10 days	Fri 7/2/04	Thu 7/15/04	RAJ[50%],LL[25%]
11	Separation & Peroxide recovery	23 days	Tue 6/15/04	Thu 7/15/04	JSH[50%],LL[25%]
12	Integrated System	48 days	Mon 6/21/04	Fri 8/18/04	
13	Design of integrated system	15 days	Mon 6/21/04	Fri 7/30/04	LL[50%],KYDE[25%],SNQ[25%]
14	Construction of integrated system (2)	5 days	Mon 7/26/04	Fri 7/30/04	RAJ,JSH,N
15	Testing of integrated system	10 days	Mon 8/2/04	Fri 8/13/04	RAJ,JSH,LL[25%]



- **Giving seniors a realistic experience of industrial design is not trivial**
 - **Most industrial problems are hard to simulate in a short time with minimal data and inexperienced engineers**
- **Using real engineering tools requires some set up time, but adds a lot of value**
- **Emphasizing safety, design codes and computation makes the work process more realistic, even if the problem is “researchy”**
- **Industry is really interested in helping universities to do these things better**



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