Distillation Column Design

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Purpose

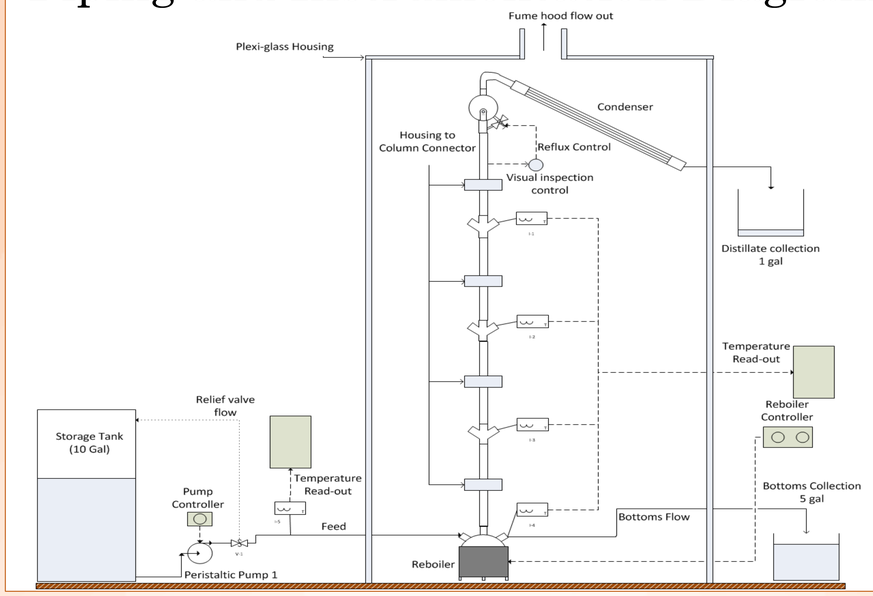
Produce a distillation column with equipment set and documentation that will be put to use by OSU CHE students. $100,000 can be saved by constructing it ourselves.

Distillation Background

Distillation is a common unit operation used in industry to separate mixtures. Distillation takes advantage of component volatility differences. As vapor moves up the column it passes through several stages where it is condensed and then vaporized again. After each stage, the concentration of the more volatile component increases.

Source: http://upload.wikimedia.org/wikipedia/commons/thumb/c/cc/Colonne_distillazione.jpg/250px-Colonne_distillazione.jpg

Piping and Instrumentation Diagram



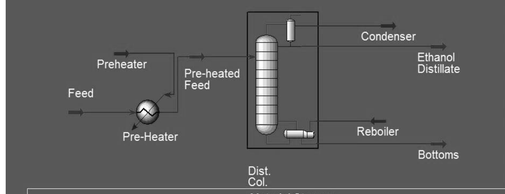
University Bench-Mark

University	Cont. vs. Batch	Packing vs. Trays	Size	System	Measuring Techniques
Utah	Cont.	Both	H: 8.2' ; D: 3.8'	EtOH/H20,H20/IPA	RI, Density
UW	Batch w/Reflux	Trays	H: 10'	EtoOH/H20	GC
MIT	Cont./Batch	Both	H: 4.9' ; D: 3.8'	MeOH/H2O	Density
OkSU	Cont. w/ reflux	Trays	D: 3"	MeOH/H2O	RI, Density
CU	NA	Trays	H: 5'	Propanol/Iso-prop.	MS
WSU	Cont.	Trays	H: 13' ; D: 4"	EtOH/H2O	Density
UT	Cont. w/Reflux	Trays	10' x 15' x20'	EtOH/H2O	GC

Material and Energy Balances (HYSYS)

Compositions

	Feed	Pre-heated Feed	Ethanol Distillate	Bottoms
Comp Mole Frac (Ethanol)	0.1000	0.1000	0.3944	0.0284
Comp Mole Frac (H2O)	0.9000	0.9000	0.6056	0.9716



Energy Streams

		Preheater	Reboiler	Condenser
Heat Flow	kJ/h	0.0000	789.5	451.3

Dist. Col.

Convergence	Converged	
Number of Trays	12.00	
Reflux Ratio	0.5000	
Vessel Pressure Drop (Condenser)	0.0000	kPa
Vessel Pressure Drop (Reboiler)	<empty>	kPa

Material Streams

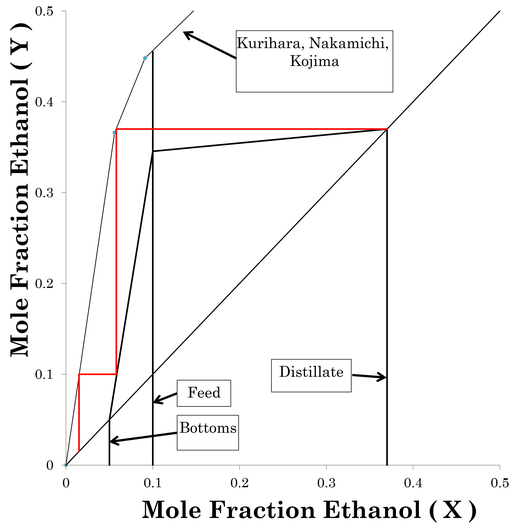
		Feed	Pre-heated Feed	Ethanol Distillate	Bottoms
Vapour Fraction		0.0000	0.0000	0.0000	0.0000
Temperature	C	20.00	20.00	80.60	93.65
Pressure	kPa	101.3	101.3	101.3	101.3
Molar Flow	kgmole/h	3.842e-002	3.842e-002	7.516e-003	3.091e-002
Mass Flow	kg/h	0.8000	0.8000	0.2186	0.5814
Liquid Volume Flow	m3/h	8.466e-004	8.466e-004	2.537e-004	5.929e-004
Heat Flow	kJ/h	-1.094e+004	-1.094e+004	-2076	-8634

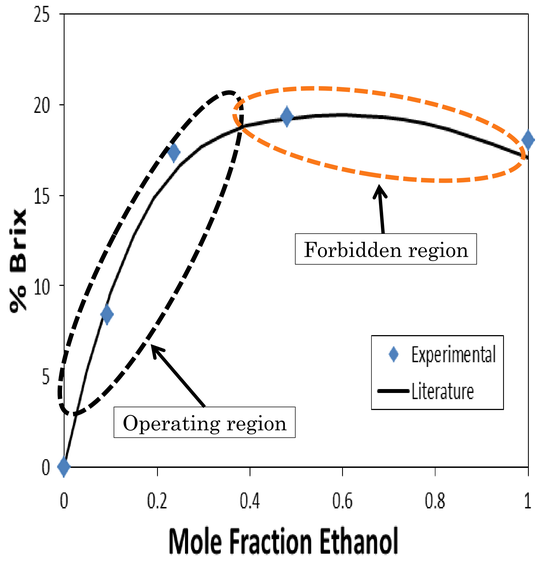
- Feed flow, F, 14 ml/min
- Reboiler duty, Q_R, 220 W
- Condenser duty, Q_C, 125 W
- Heat loss from the column walls, Q_{loss}, 30 W (no insulation)
- Distillate flow, D, 4 ml/min
- Bottoms flow, B, 10 ml/min
- Composition of ethanol in feed, x_F, 10 mole%
- Composition of ethanol in distillate, x_D, ~ 39 mole%
- Reflux ratio, R, 0.5 (conservative estimate)
- Number of trays, N, 12

Assumptions and Constraints

- Experiments are limited to two 3 hour lab periods
  - The column needs to reach steady state in approximately 30 minutes
- There must be a measurable difference (~30 mole %) between distillate and inlet compositions
- Students need to be able to change some parameter(s) (e.g, inlet flow rate, inlet temperature, etc.) and determine how effects the process

McCabe-Thiele Diagram





Future work

- Assemble the column
- Run the distillation system to determine HETP (Height of a Theoretical Transfer Plate)
- Document standard operating procedures and expected experimental results (e.g, flow rates, feed and reboiler temperatures, etc.)
- Detailed notes for T.A.s (e.g, turn on before lab)

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