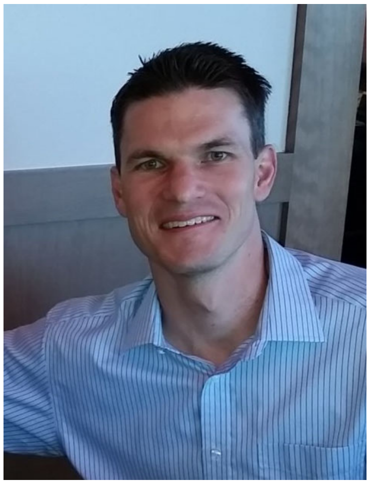
Ty Carlson

BYU ChE Honored Alumnus 2018



- B.S. ChE BYU – 2006
- Mission to Hungary Budapest
- Joined Valero – 2006
  - Met wife there (Benicia, CA)
  - 3 kids
- Process engineer
  - crude, hydrotreating, hydrogen, hydrocracking, and cogeneration units
- Planning and economics at refinery
- Regional planning engineer (headquarters in San Antonio)
  - focused on optimizing and aligning commercial and operational activities
  - MBA from UT San Antonio
- Planning and Optimization Manager
  - (Wilmington refinery near Long Beach) over the FCC and Alkylation units.

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Next Week

Monday – Combustion Reactions

Wednesday – Exam Review

Exam 1

- Take-home
- Closed book, but one page of notes (one-sided)
- Passed out in class on Wednesday (Sept 29)
- Due Monday in class (9 am, Oct. 4)
- 3-hr time limit (must be consecutive)
- Practice Exam is now on Learning Suite
- TA help session in class on Friday (Oct. 1)

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Road Map

DOF for Reacting Systems (Finish Ch. 4)

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Non-Ideal Gases (Ch. 5)

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Multiple Phases (Vapor-Liquid) (Ch. 6)

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Exam 2

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Energy Balances (Ch. 7-9)

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Exam 3 → Case Study

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Review

$$n_i = n_{i,0} + \nu_i \xi$$

- What does the subscript “i” represent?
- What does the subscript “0” represent?

$$n_{A,final} = n_{A,initial} + \nu_A \xi$$

- How does this equation relate to the general balance equation?

$$accum = in - out + gen - cons$$

$$out = in + gen - cons$$

- What is ν_i?
- What about multiple reactions?

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Class 11
Multiple Reactions, Multiple Units

- Conversion & Excess Reactant (Review)
- Extent of Reaction (Review)
- Recommendations & Cautions (repeat)
- Definitions
  - Recycle
  - Purge
- Examples

Conversion & Excess Reactant

- Definition of conversion

$$X_A = \frac{n_{A,0} - n_A}{n_{A,0}}$$

- $n_{A,0}$ ALWAYS defined based on inlet stream
- Definition of Excess Reactant

$$\%excess = \frac{n_{A,0} - n_{A,stoich}}{n_{A,stoich}}$$

- $n_{A,stoich}$ ALWAYS defined based on inlet stream
  - **not based on conversion of limiting reactant**
  - Example: if 80% of limiting reactant is converted, the % excess is still computed as if 100% was converted

Extent of Reaction

- Moles reacted for a given reaction (normalized)
- Example: Carbon Tetrachloride Production

$CS_2 + 3Cl_2$	$\rightarrow S_2Cl_2 + CCl_4$	ξ_1
$CS_2 + S_2Cl_2$	$\rightarrow 6S + CCl_4$	ξ_2
$6S + 3C$	$\rightarrow 3CS_2$	ξ_3

- Write expressions for n_{CCl4}, n_{Cl2}, and n_{CS2} in terms of ξ's

$n_{CCl4} = n_{CCl4,0} + \xi_1 + \xi_2$

$n_{Cl2} = n_{Cl2,0} - 3\xi_1$

$n_{CS2} = n_{CS2,0} - \xi_1 - \xi_2 + 3\,\xi_3$

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Cautions

- If no reactions occur in the subunit, use the DOF for non-reacting systems
- If reactions occur in the block, you must use the DOF for reacting systems

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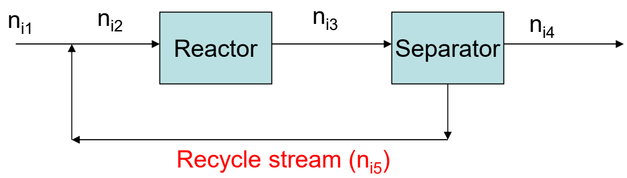
Definitions - Recycle

- Overall Conversion = $(n_{i1}-n_{i4})/n_{i1}$
- Single Pass Conversion = $(n_{i2}-n_{i3})/n_{i2}$



- Note that $X_{overall} > X_{single\ pass}$
- Also, $\xi_{single\ pass} = \xi_{overall}$
  - ✓moles reacted are the same

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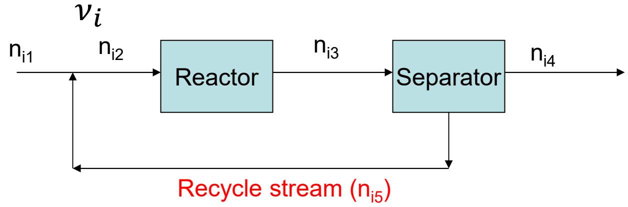
Relationship between X and ξ

- Single Pass Conversion $(X_{sp}) = \frac{n_{i2}-n_{i3}}{n_{i2}}$
- $\xi = \frac{n_{i3}-n_{i2}}{\nu_i}$



- Therefore, $X_{sp} = \frac{-\xi}{\nu \cdot n_{i2}}$
  - If you know X_{sp} and ξ you can get n_{i2}

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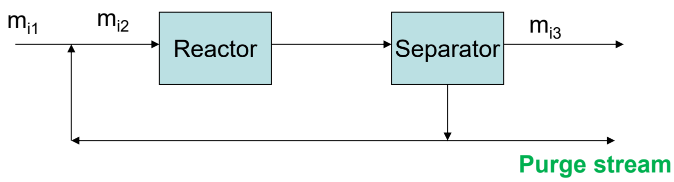
Definitions - Purge

- Recycle can result in buildup of unwanted species
- Purge streams are used to release a small portion of the recycle stream
- Purge streams usually have small flow rates compared to main flow rates
- Unwanted species therefore have a path for release
  - Otherwise you get buildup of trace species which may cause deposit buildup or corrosion in tubes



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Examples

A. Multiple Species, Elements

B. Multiple Units

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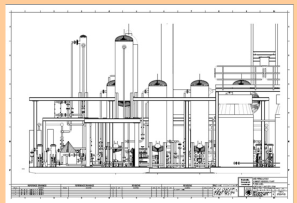
Problem 4-71 (4-52 in 3rd Ed.)
(Multiple Reactions, Elements)

Ore

Basis: m_1 = 1000 kg ore
x_{CaF2} = 0.96
x_{SiO2} = 0.04



$n_{CaF2(s)}$
$n_{SiO2(s)}$
n_{H2SO4}
n_{H2O}
n_{CaSO4}
Wanted n_{HF}
n_{H2SiF6}

Aq. Sulfuric Acid

m_2 = ?
x_{H2SO4} = 0.93
x_{H2O} = 0.07

Assume that the undissolved ore has the same composition as the original ore

CaF_2(s) + H_2SO_4(l) => $CaSO_4$(diss) + 2HF(l)

6HF(l) + SiO_2(aq) => H_2SiF_6(s) + $2H_2O$(l)

15% excess Aq. Sulfuric Acid
95% of ore reacts

Find all unknowns, and check

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DOF with Element Balances
Balances:
- Ca
- Si
- F
- S
- H

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Show Excel File

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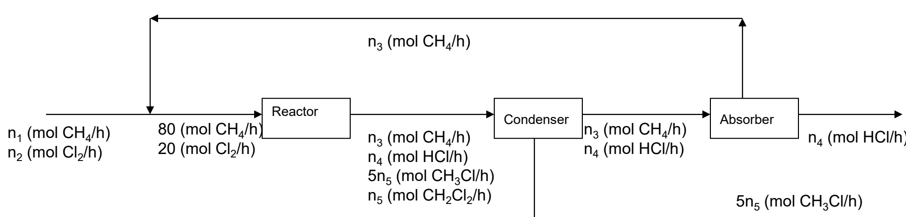
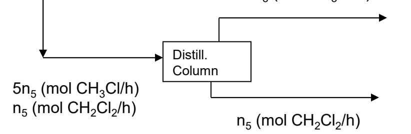
DOF Practice

(Problem 4-77, 4-58 in 3rd Ed.)

Do the DOF on each subunit





6 MORE VOLUNTEERS!

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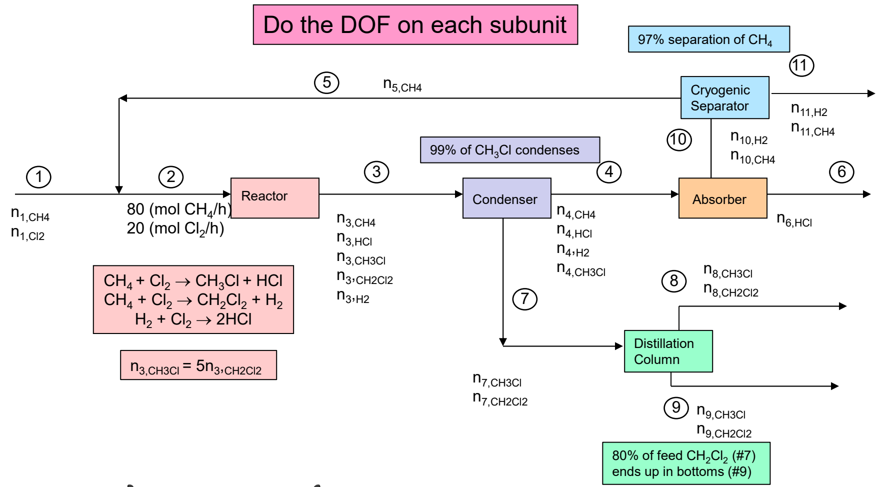
DOF Practice

Do the DOF on each subunit



7 MORE VOLUNTEERS!

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My Answers

Unit	Unknown variables	#U	ξ's	BE	OE	DOF
Mixer	$n_{1,CH4}, n_{1,Cl2}, n_{5,CH4}$	3	-	2	0	1
Reactor	$n_{3,CH4}, n_{3,HCl}, n_{3,CH3Cl}, n_{3,CH2Cl2}, n_{3,H2}$	5	3	6	1	1
Condenser	$n_{3,CH4}, n_{3,HCl}, n_{3,CH3Cl}, n_{3,CH2Cl2}, n_{3,H2}$ $n_{4,CH4}, n_{4,HCl}, n_{4,H2}, n_{4,CH3Cl},$ $n_{7,CH3Cl}, n_{7,CH2Cl2}$	11	-	5	1	5
Absorber	$n_{4,CH4}, n_{4,HCl}, n_{4,H2}, n_{4,CH3Cl}$ $n_{6,HCl}, n_{10,H2}, n_{10,CH4}$	7	-	4	0	3
Dist Column	$n_{7,CH3Cl}, n_{7,CH2Cl2}, n_{8,CH3Cl}, n_{8,CH2Cl2},$ $n_{9,CH3Cl}, n_{9,CH2Cl2}$	6	-	2	1	3
Separator	$n_{10,H2}, n_{10,CH4}, n_{11,H2}, n_{11,CH4}, n_{5,CH4}$	5	-	2	1	2
Overall	$n_{1,CH4}, n_{1,Cl2}, n_{11,H2}, n_{11,CH4}, n_{6,HCl},$ $n_{8,CH3Cl}, n_{8,CH2Cl2}, n_{9,CH3Cl}, n_{9,CH2Cl2}$	9	3	6 $CH_4, Cl_2, H_2, HCl, CH_3Cl, CH_2Cl_2$	0	6

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