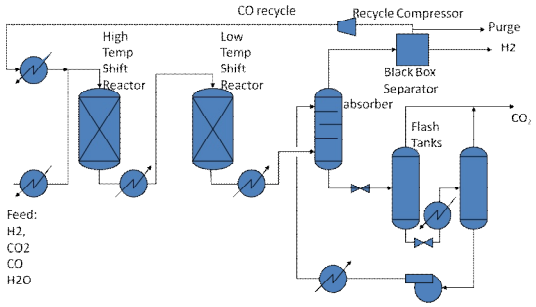
3rd Year Design
Flash System Design



Agenda

- Sizing Separation Vessels
- Flash System Optimization

General - Vessels

- Hold Up Time (at half full)
  - 2 to 32 minutes depending on quality of control for each outgoing stream
  - 5 to 10 minutes is sufficient with modern control systems to handle minor upsets
  - 30 minutes provides a 99% probability that an operator can determine cause of failure
  - Engineering Judgement !

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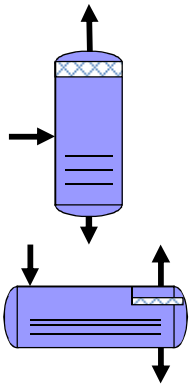
General - Vessels

- Horizontal vs. Vertical
  - Vertical preferred when:
    - small liquid load
    - limited plot space
    - ease of level control is desired



- Horizontal preferred when:
  - large liquid loads are involved, consequently hold-up will set the size
  - three phases are present

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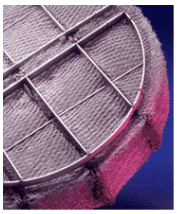
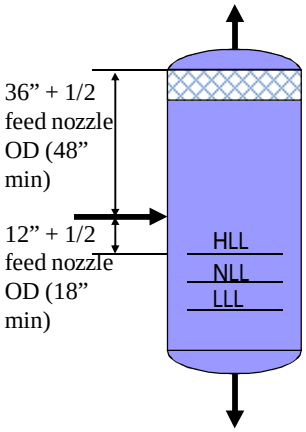
General – Vap / Liq Separators





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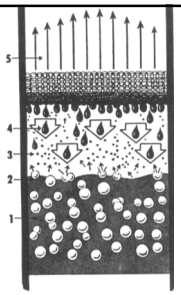
Mesh Separator



General – Vap / Liq Separators

- Liquid levels
  - norm liq level at 50%
  - low liq level at 25%
  - provide low, low liq level for pump shut offs
- Vapour Disengagement (vertical flash vessel)
  - Diameter Calcs; v = m/hr; density = any units

$$V_{allowable} := k \cdot \sqrt{\frac{\rho_L - \rho_v}{\rho_v}}$$

$$V_{design} := (75 \cdot \%) \cdot V_{allowable}$$

$$V_{min} := 10\% \cdot V_{allowable}$$

  - No Mesh k=576; Mesh Separators k=1260 m/hr
- Length to Diameter Ratio - 3 to 5 for Economical Design

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Conflicting Design reqt's

- Quite often the req't to meet the Vapour Vmin gives you a small diameter vessel, when you provide 10 min hold up in a skinny vessel,
  - the vessel ends up being 200 m tall and .1 m in diameter – not a good design
- Prioritize the design requirements
  - Go to Vmin and see what the new size would be
  - Split the vessel into two – a separator on top of a hold up tank.
  - Reduce the hold up time – depending on where you're sending the material
    - Provide more holdup time to pump suctions, less going to another flash tank.

Codes Stds' - ASME

- ASME - American Society of Mechanical Engineers
- Section I - Fired Heaters
- Section VIII - Pressure Vessels
- Other Sections (Plastic / Fiberglass / nuclear)

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Auxiliaries

- Manholes / inspection ports
  - ASME Code has minimum requirements for these based on vessel size - See Section 8 UG-46
- Nozzles - velocities
  - max $v=100/\sqrt{\rho}$, ft/sec
  - min $v= 60/\sqrt{\rho}$, ft/sec
- Non-tangential inlet provides easier level control

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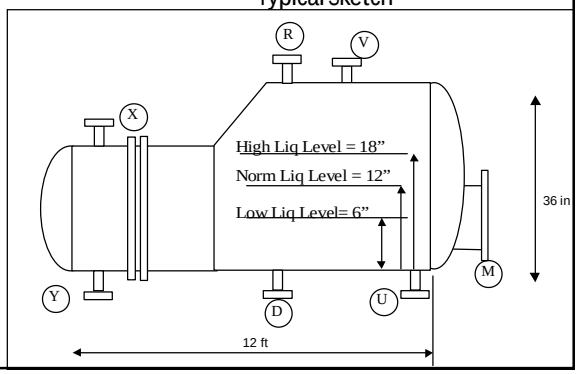
Auxiliaries

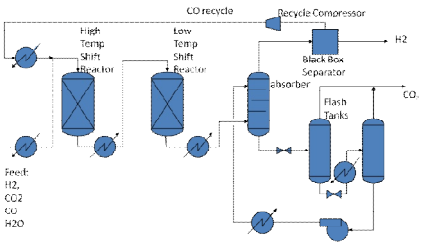
- Thermowells
- Steamouts
- Maintenance blinds
- Drains
- Level Gauges

Typical Sketch



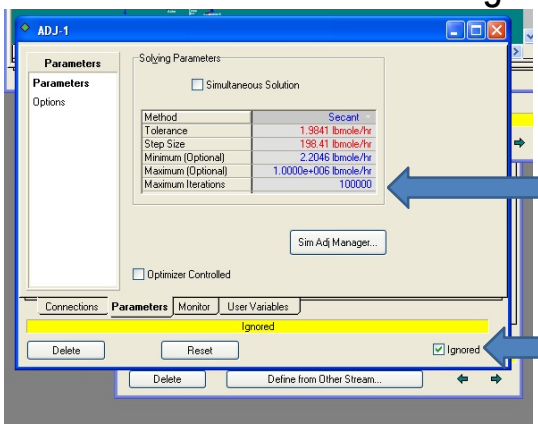
Flash System Optimization

- The optimization of this system will require that you change the simulation.
- It's possible to get the model into a state where it will not converge.
- Here are some pointers:
  - Save OFTEN!!!!
  - The CO2 concentration leaving the Selexol absorber in the gas should be about 0.03 mole fraction.
  - Our system is set up with Selexol temperature of about 86 deg F. The commercial units run about 38 deg F.
  - The reactor dimensions you choose may cause extreme pressure drops. Switch Ergun DP calculation off and manually set to 100 kPa, switch back on after convergence is achieved



Simulation Convergence Problems?

- Use the Ignore option on the adjust if model does not seem to converge



Increase Max # Iterations
To roughly 1e5

Click 'ignore' on temporarily

Cause of the Simulation Instability

- Pertains to Reactor assignment
  - Water starts to condense out with small rectors sizes
- Interesting because this could occur in the plant
  - It's not just an annoyance, it's trying to tell us something! What is it?

Flash System - Design Process

Design Process

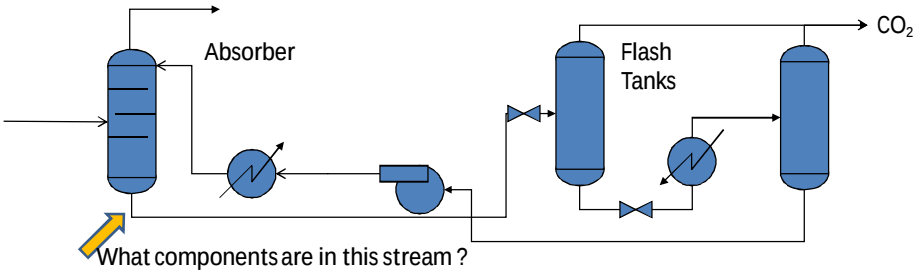
1. Understand the Problem
   - Develop the underlying issues, constraints (i.e. cost, standards, patents, user needs, physical properties, chemical reactions, ..)
   - What is the big picture? – How does the project/process fit in to the business , social, marketing, strategy of the company and society?
2. Generate Alternatives
   - Employ the action of using synthesis and apply engineering science
   - Document with standard engineering documents
3. Analyze the Alternatives and choose the best one
   - Use decision making tools
4. Prepare final design and recommendations
   - Knowing your audience and their needs, presenting the facts and making a recommendation

Step 1

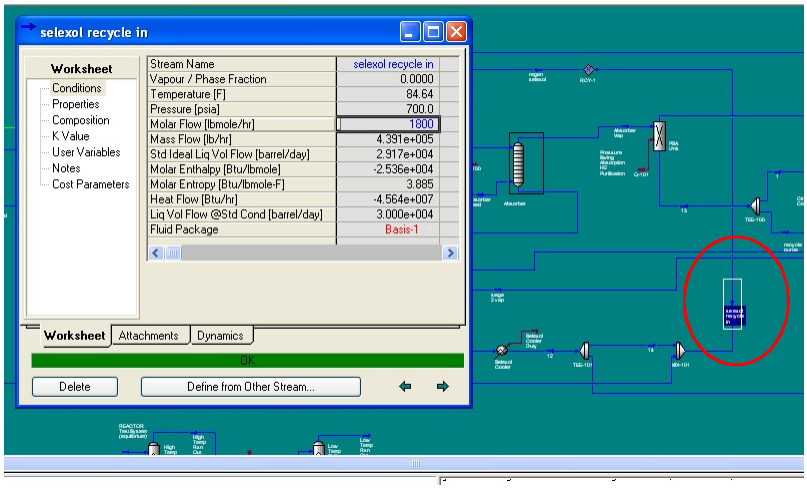
- What are the Business Objectives of the Process?
  1. Make as much money as possible
     - Maximize product, minimize mat'l losses, minimize energy and capital costs
- Objectives of the Engineering Design
  1. Ensure process works and achieves business objective
  2. Ensure process is Safe
  3. Ensure process has low environmental footprint
  4. Maintainable, Operable, Constructable

Flash Optimization

- What you thought you should do…
  - Change some operating pressures and/or number of flash drums
  - Change the Selexol rate
  - Plot a graph to look for capital and operating costs benefits.
- What you should do is Think First & try to predict the answer
  - If I raise the flash pressure what will happen to the H_2?
  - If I raise the flash temperature what will happened to the H_2?
  - What do we really want the H_2 to do?
  - Where is H_2 going?



Change Selexol Circ Rate

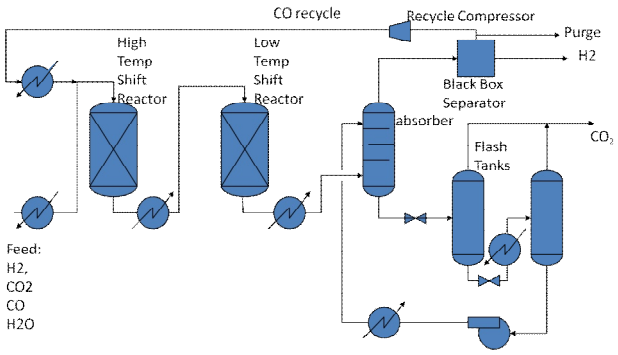


Reach for the Sky

- Like many engineering problems, there is a much larger underlying problem, something only a some creativity can help us solve.
- Are you ready?!

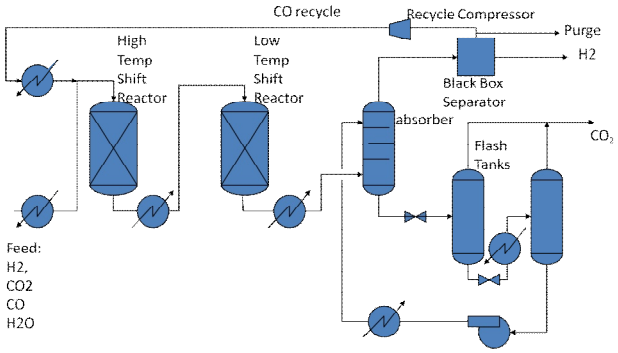
This Design is Lousy

- Is the business objective of maximizing profits being met here?
- Where are the opportunities ?

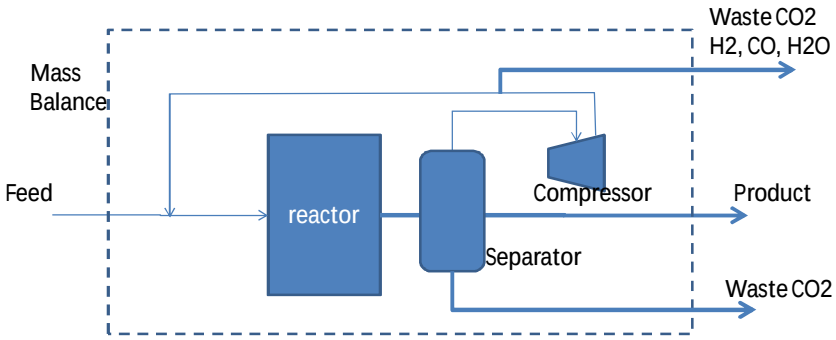


Opportunities

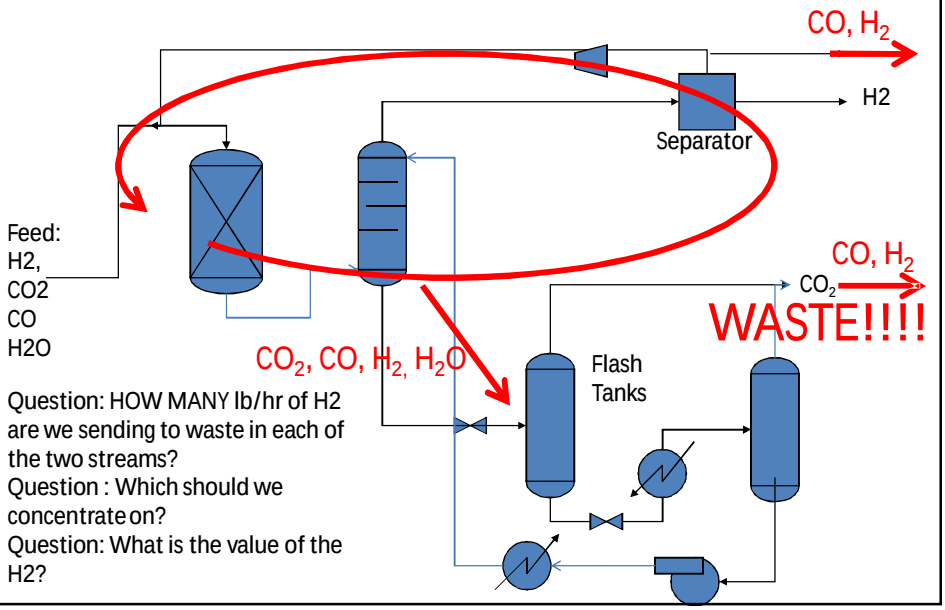
- Our reaction is CO + H2O -> H2 + CO2
  - Where do we have unreacted CO leaving?
  - Where do we have H2 leaving but not in the 'product' stream?
- Where are we using energy and how much?



Simplify to See Waste



Take a Good LOOK!

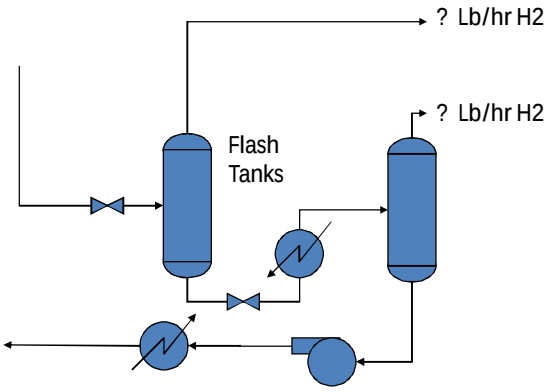


Question: HOW MANY lb/hr of H2 are we sending to waste in each of the two streams?
Question : Which should we concentrate on?
Question: What is the value of the H2?

Step 2

- Develop design alternatives
  - Brainstorm ways to reduce material losses
    - Reduce the amount of 'good' material that gets into the absorption system
    - Increase conversions (larger reactor)
    - Increase reaction selectivity
    - Increase separation efficiency / selectivity
    - More recycle
  - Brainstorm ways to reduce energy use
    - Cross exchange heat
    - This is called "Pinch Technology"

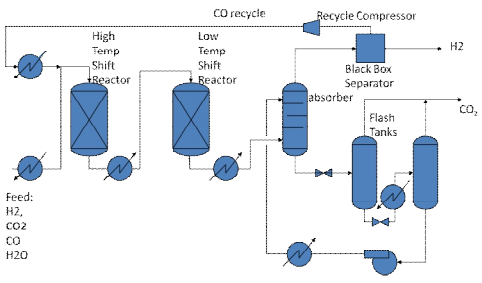
Break it down again



Where can we send it?

Energy Optimization

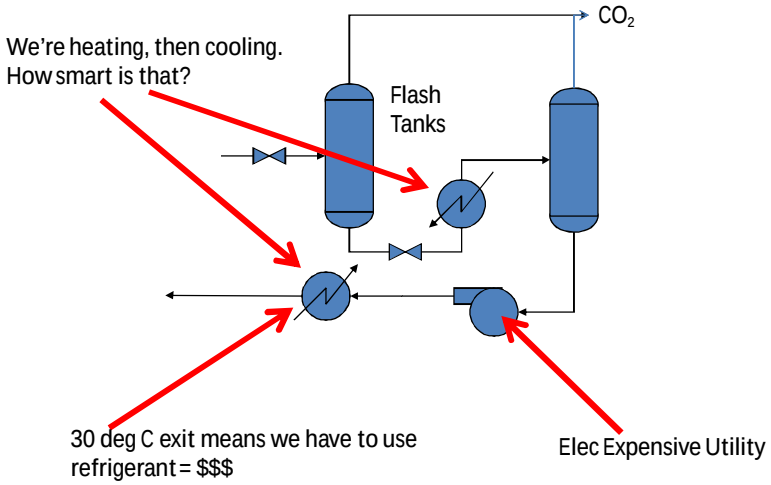
- Look for the low hanging fruit
  - Write down the energy usage on each unit
  - Multiply by the cost of the utility * 3 yrs



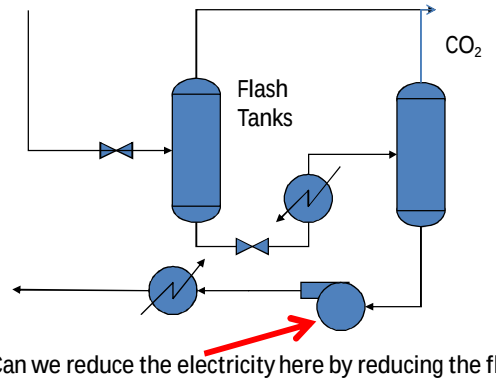
Utility	Pressure	Temperature	$ / GJ
Cooling Tower Water	5 bar(g)	30 °C Return < 45 °C	0.354
Electricity			16.8 $/GJ 0.07 $/kW hr
Refrigerated Water	5 bar(g)	Supply 5 °C, Return ≤ 15°C	4.43
Refrigerant – Mid	5 bar(g)	Supply(liq) -20 °C, Return(vap) -20°C	7.89
Refrigerant – Low Temp	5 bar(g)	Supply(liq) -50 °C, Return(vap) -50°C	13.11
Boiler Feed Water	6 bar(g)	90 °C	
High Pressure Steam	41 bar(g)	Sat'd = 251 °C	9.83
Medium Pressure Steam	11 bar(g)	184 °C	6.87
Low Pressure Steam	6 bar(g)	159 °C	6.08
Natural Gas	4 bar(g)	25 °C	6

Choose a utility that is ideally 10 deg C hotter/colder than exit process, 5 deg C when essential

Energy Optimization



Energy Optimization



Can we reduce the electricity here by reducing the flow rate?
What has to happen to reduce the flow rate of Selexol?

Things you should know

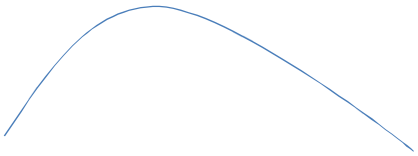
1. Change the flow very slowly – save cases as you go!
2. The CO2 concentration leaving the Selexol absorber in the gas should be about 0.03 mole fraction (less is fine).
3. The industrial systems operate with a Selexol temperature around 38 deg F.

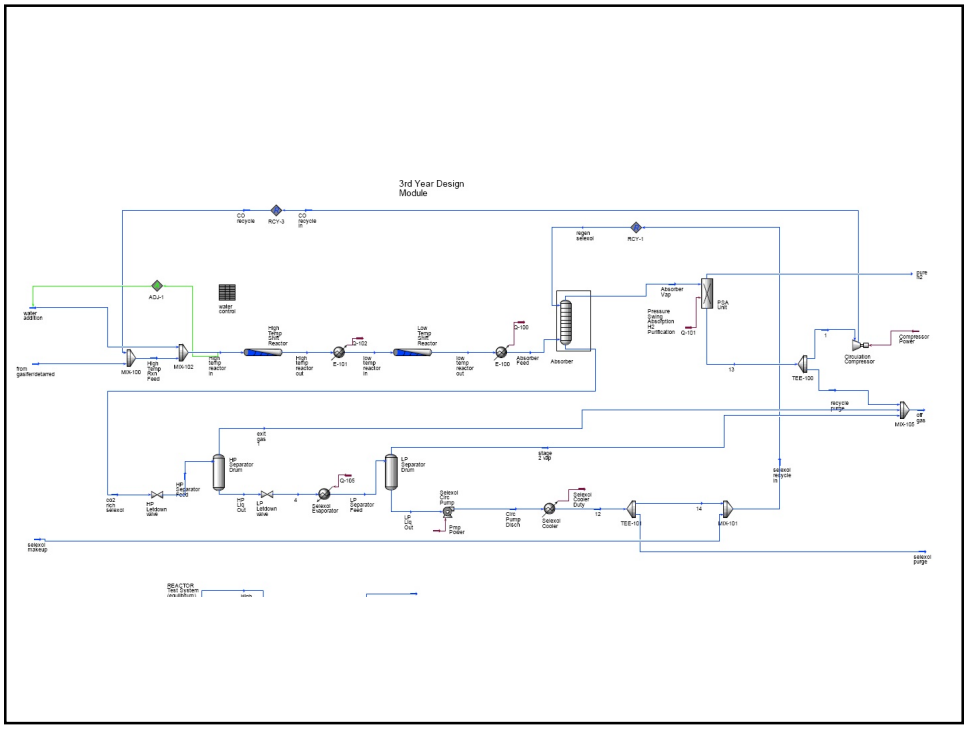
Quick Financial Calcs

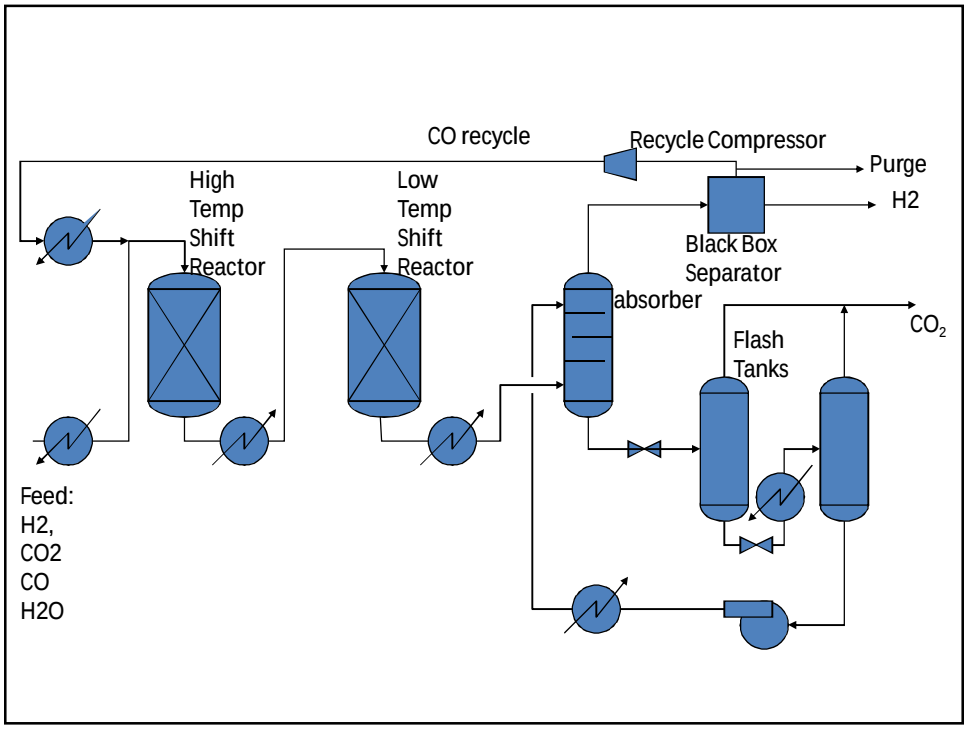
- One way to do quick financial comparisons:

  Profit = 3 yrs Operating Revenue – Capital - 3 yrs Operating costs

  For example




3rd Year Design
Module


CO recycle
Recycle Compressor
Purge
H2
High
Temp
Shift
Reactor
Low
Temp
Shift
Reactor
Black Box
Separator
absorber
Flash
Tanks
CO_2
Feed:
H2,
CO2
CO
H2O