Benzene Reduction

Frontier Cowboys

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Overview

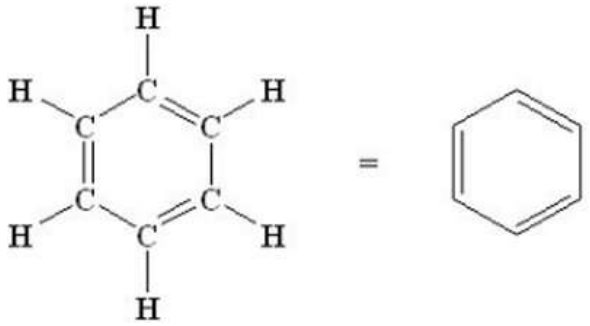
- MSATII Regulations
- Scope of Work
- Process Simulator
- Naphtha Splitter
- Reformer
- Alkylation Unit
- HAZOP
- Octane Number
- Results
- Economics

EPA Regulations

- New regulation from EPA concerning refineries
  - Mobile Source Air Toxics (MSATII)
  - Gasoline pool purity specification (small refineries)
  - 0.62% (v/v) by 2015

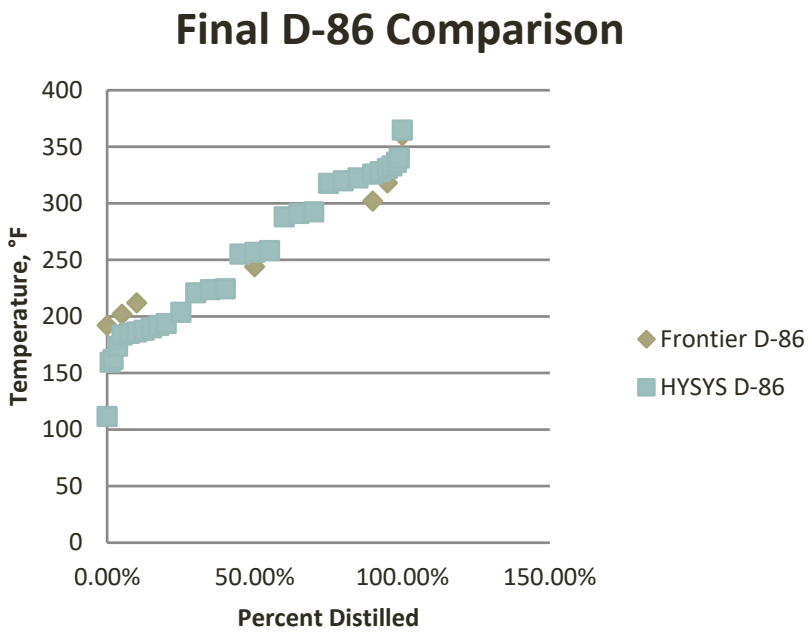
Scope of Work

- Develop an economical BZ reduction solution
  - Gasoline pool must meet purity spec
  - Economics
    - Hydrogenation
    - Marketing
    - ➔ **Alkylation**



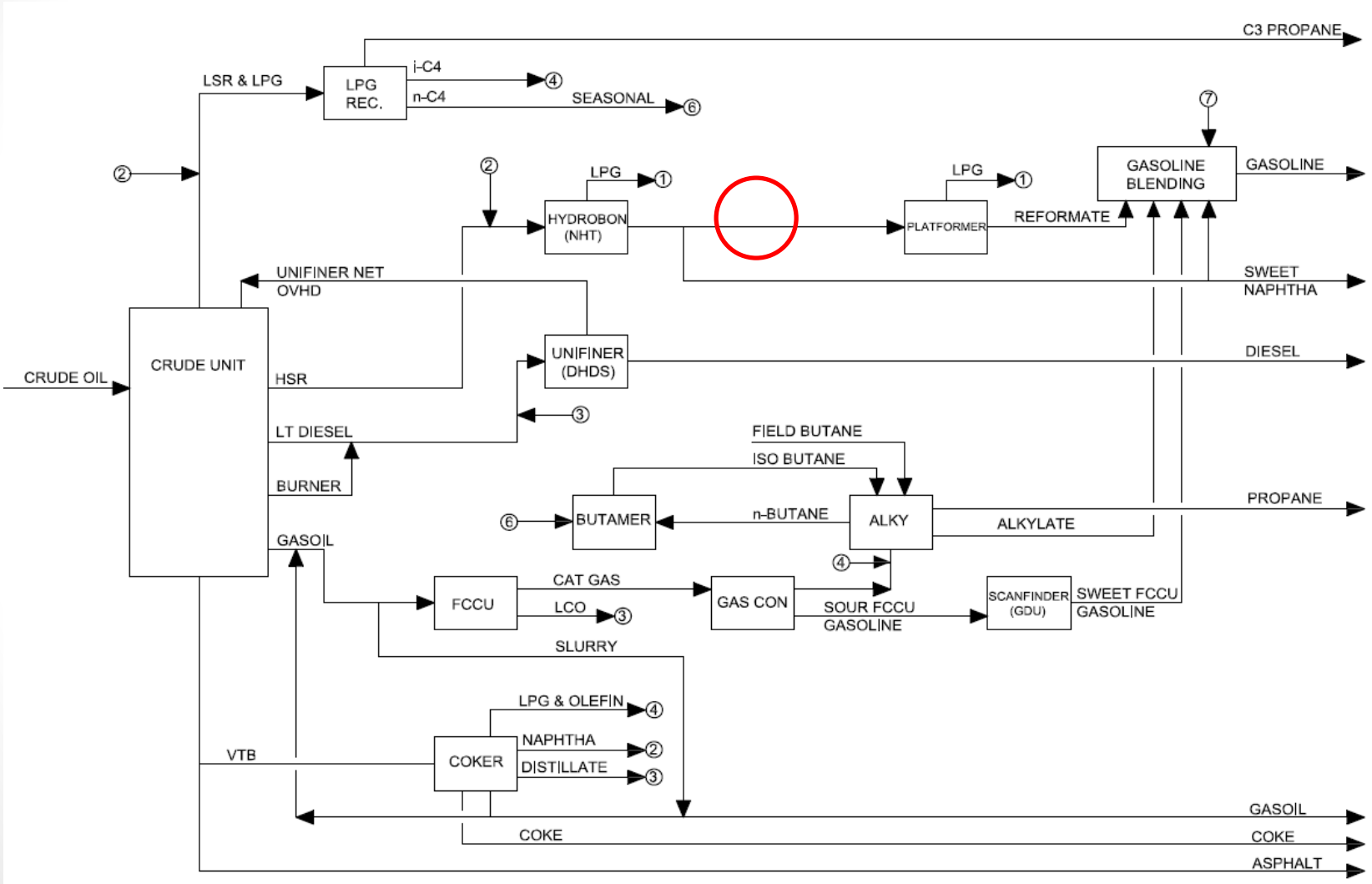
Process Simulator

- HYSYS simulator
- Rigorous component entry
- SRK equation of state

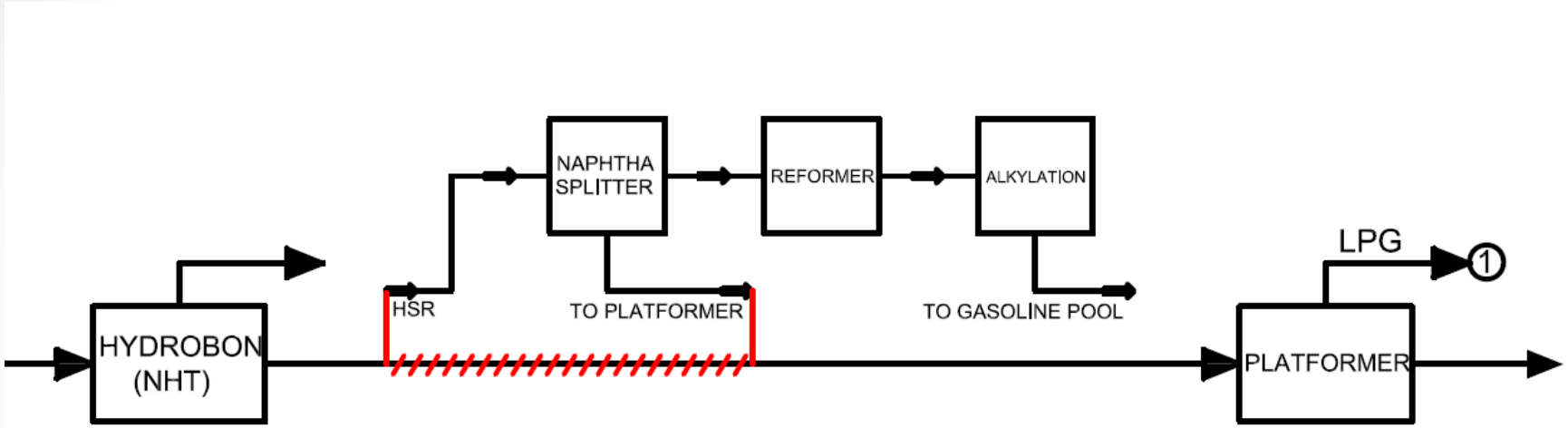


An *ASTM D-86* curve is generated by measuring the temperature at which a certain volume percent of a hydrocarbon mixture boils. This can be seen by "Percent Distilled" on the x-axis (independent variable) and "Temperature, °F" on the y-axis (dependent variable).

Oil Refining 101

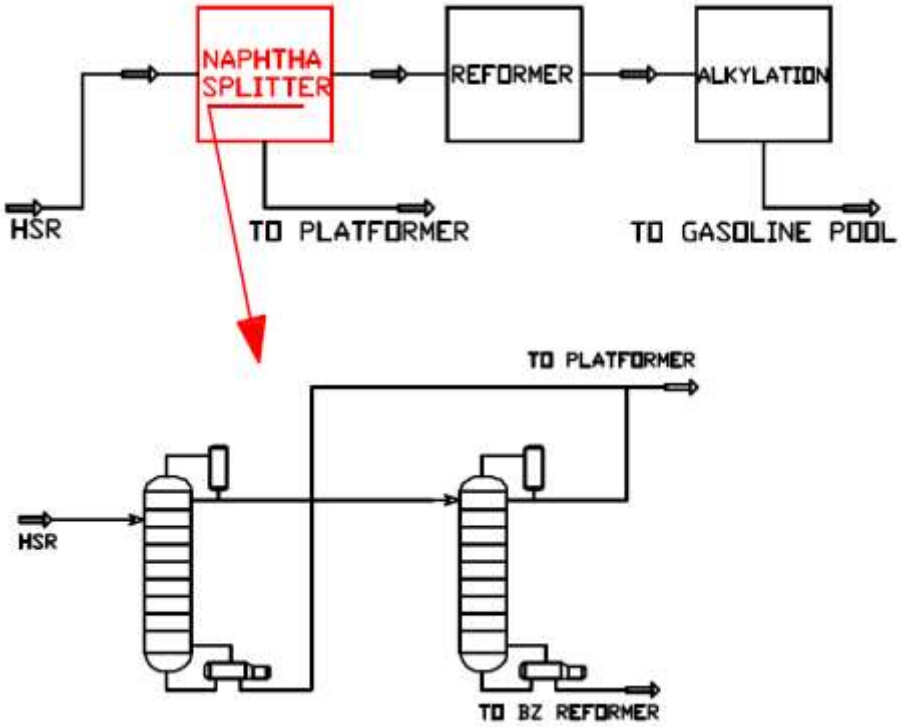


Process Overview



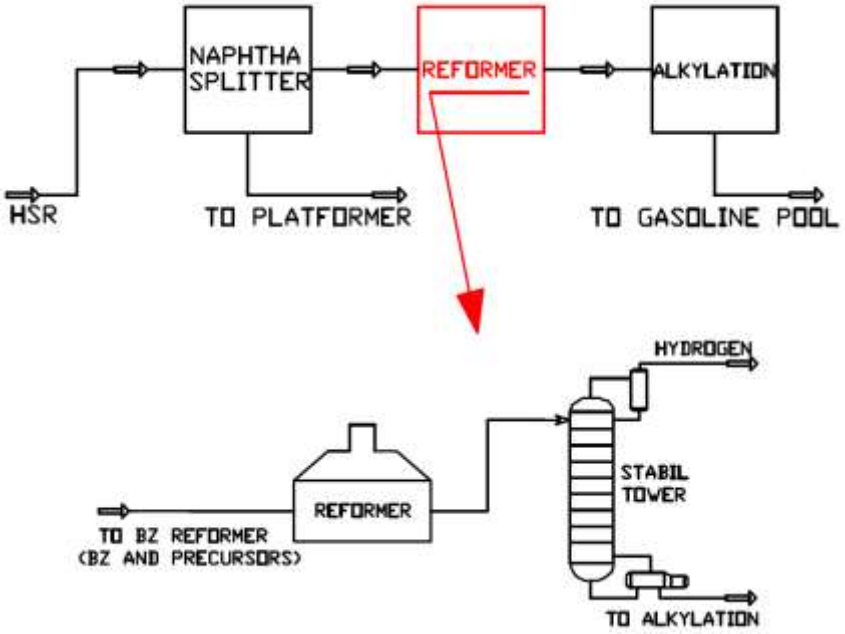
Naphtha Splitter

- First tower
  - 45 stage tower
  - Achieves 98% purity
- Second tower
  - 65 stage tower
  - Achieves 99% purity
- Overhead to Platformer
- Bottoms to [new] reformer



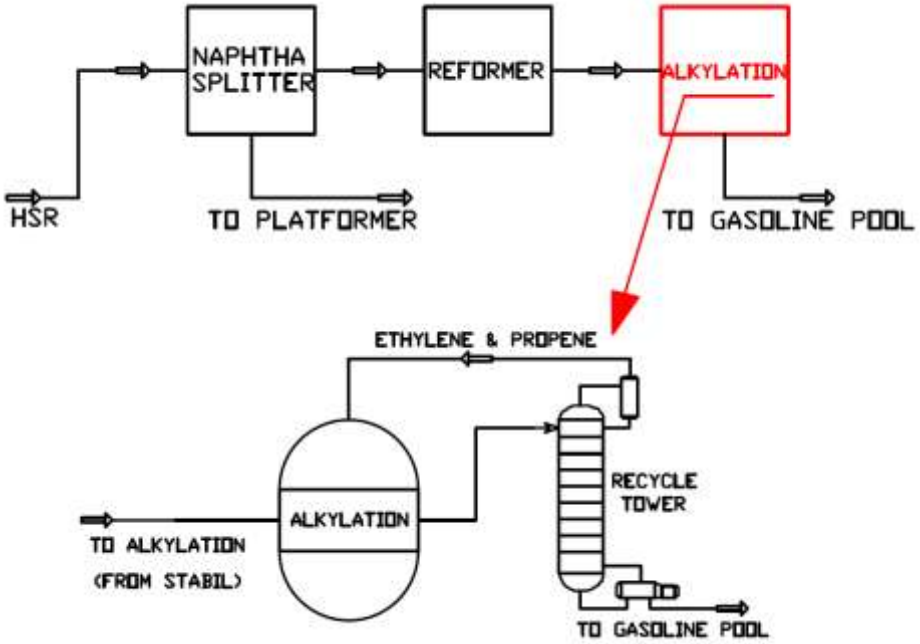
Reformer

- Cracks H_2 off of precursors
  - 4.30 MMCFD H_2 produced
  - Solves H_2 loss problem
    - Eliminates need for H_2 plant
- Higher purity BZ stream to alkylation unit
  - Higher octane product
    - Eliminates need for toluene add-in
- Expensive now, cheaper later



Alkylation Unit

- Refromer effluent sent to alkylation unit
- Reacted with ethylene and propene
- Benzene alkylated to high octane ethyl and propylbenzene
- Light olefins recycled
- High octane stream sent to gasoline pool



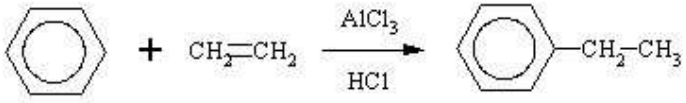
Alkylation

Advantages

- High benzene conversion
- Upgrades BZ to usable gasoline blend stock
- Does not require hydrogen
- Increases gasoline pool octane rating
- Reduction of RVP
- No reduction in pool volume

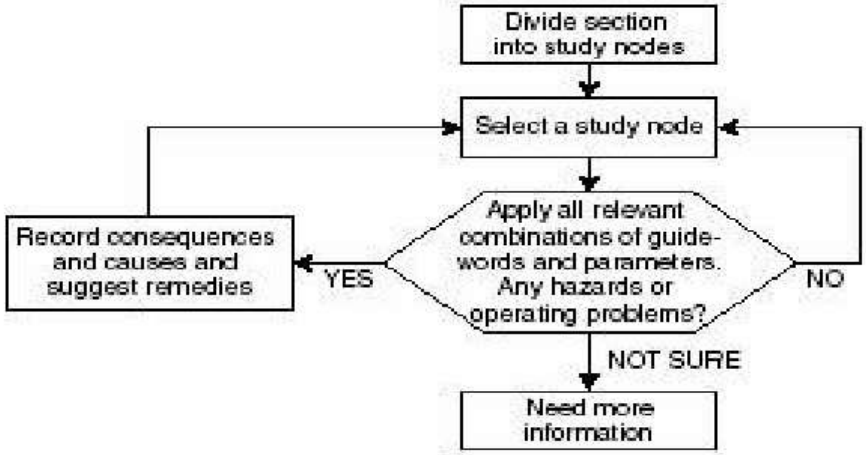
Concerns

- Light olefin source
- Impact on other unit operations



HAZOP Considerations

- Nodes (Big picture)
  - Naphtha splitter
  - Reformer
  - Alkylation unit



- Hazards
  - Fluctuation: More, Less
    - Temperature
    - Pressure
    - Flow

Octane Number: Calculations

- A New Non-Linear Calculation Method of 'Isomerisation' Gasoline Research Octane Number Based on Gas Chromatographic Data by N. Nikolaoua, C.E. Papadopoulosa, I.A. Gagliasb, K.G. Pitarakisc

- $RON = \sum_{i=1}^{N} K_i RON_i y_i$

- $K_i = \frac{RON_i}{BRON_i} \frac{\sum_{i=1}^{N} y_i BRON_i}{\sum_{i=1}^{N} y_i RON_i}$

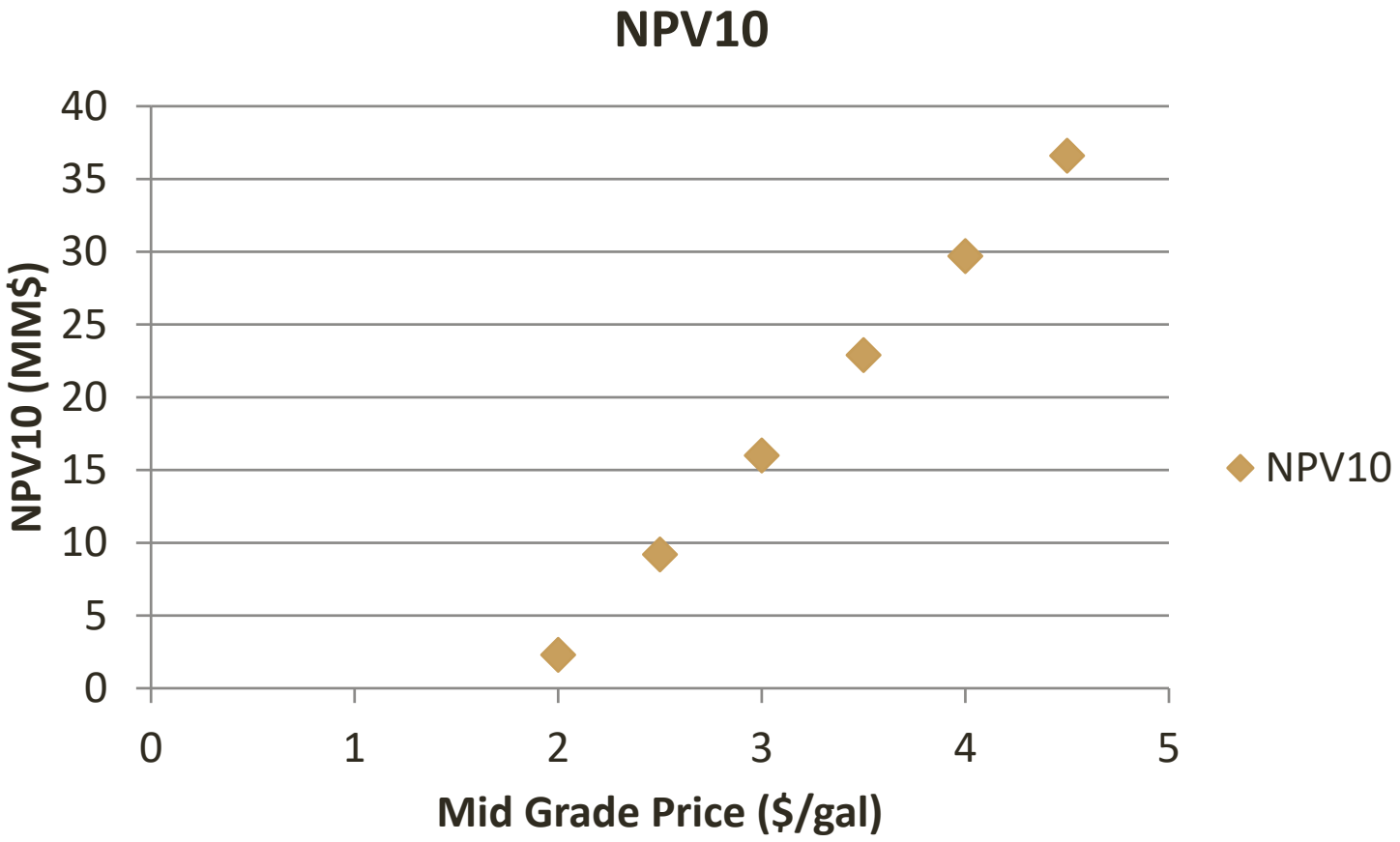
Economics

Benzene Pool Concentration	0.97%	
Benzene EPA Fine	3.13	MM$
Increase in octane	3.72	MM$
Increase in production	13.64	MM$

Economics

IRR	29.72%	
NPV 0	88.5	MM$
NPV 10	28.4	MM$

Sensitivity Analysis



Summary

- Naphtha splitter
  - Remove benzene and precursors
- Reform precursors
  - H_2 generation
  - Higher purity benzene
- Alkylate benzene
  - High octane blendstock

Acknowledgements

- Thank You!
  - Clinton H. Butcher, PE
    - Technical Service Engineer
  - Steven L. Reynolds, PE
    - Sr. Optimization Engineer

Work Distribution

- **Jordan:** Naphtha splitter simulation, naphtha splitter base case section, reformer and stabilizer simulation
- **Kyle:** Naphtha splitter simulation, reformer and stabilizer simulation, reformer and stabilizer base case section, saturation alternate solution
- **Ben:** Redesign and optimize Alkylation unit in HYSYS, chose appropriate catalyst, and find capital costs of Alkylation unit
- **Robert:** Redesign and optimize Alkylation unit in HYSYS, find capital costs of Alkylation unit, calculate octane number of product and work on entire project economic analysis
- **Dylan:** Process simulator, physical properties, naphtha splitter simulation, hydrogen loss, risk management, safety and OSHA requirements, AutoCAD drawings

Questions?