Preserving FCC Throughput

Overcoming System Cooling Limits by Alternative Approach

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Recognize "how continuous process industry (CPI) works"

Regulatory compliance costs: Biggest challenge is always the government regulatory compliance theme, noted Greg Goff. For example, 0.5% sulfur bunker fuel regulation by 2020 will result in a lot of additional desulfurization capacity upstream and downstream from FCCU. There will probably be surplus high sulfur fuel oil in the long term.

Sharper unit performance: Refining industry more receptive to adapting and implementing a variety of capabilities to achieve sharper unit performance, from remote sensing to temporary use of heat and mass transfer systems to increase LPG, propylene, downstream alkylate, etc.

Export opportunities vs declining domestic demand: U.S. market oversupplied with many refined products, but over 1.1 million bpd of gasoline and 1.4 million bpd of distillate are now being exported, primarily to Latin America, alkylate & other high octane components to Asia, etc., (according to Andrew Lipow, president of Lipow Oil Associates as of Jan 2017).

CPI Industry to date is composed of:

•Owners/operators

•Large, well established engineering construction companies

•E&C's that follow a predictable sequence of project steps, including:

Conceptual study

Process design

Detailed engineering

Procurement

Field construction, etc…

•Project completion cycle is typically 12 to 18 months with costs varying widely

**"Nimbleness, agility & development of multiple cash flow schemes in a very demanding regulatory environment is necessary" in the CPI industry going forward*

*Tesoro CEO Greg Goff, while speaking at CERAWeek in Houston on March 7, 2017.

Preserving FCC Throughput

A fresh approach to overcoming limitations

KEY Takeaways

1. Assemble the written process concept in a *rapid* fashion
2. *Identify* and *Mobilize* equipment to accommodate process and plot needs
3. Operations, Performance, and Flexibility

Fresh Approach to Overcoming FCC/System Cooling Limits
Assembling the plan

- Project best practices
  - API RP 750
  - OSHA 29 CFR 1910.119
  - MOC, PHA, HAZOP, PSSR
- Teamwork: Successful implementation depends, in large part, on cooperation between owner/operator staff and contractor personnel designing the change

Resolving process constraints based on application of best practices & assessment of economic trade-offs must be balanced against plant engineering staff's time & talent working on immediate operational issues, monitoring & reporting requirements, etc.

Fresh Approach to Overcoming FCC/System Cooling Limits

Assembling the plan

Comparison of modification methods *(from "New approach to revamps", Hydrocarbon Processing, 2005)

Aspect of Revamp	New approach	Traditional
Definition of basis	As thorough as time and inputs permit	As thorough as time and inputs permit
Evaluation of solutions	Process study, utilizing characteristics of available equipment	Process study, generally with no limits on modifications
Selection of preferred solution	Cost and benefit; schedule has little impact	Cost, schedule, and benefit
Design effort	Fast – track design, performed at site, teaming with owner	design performed at contractor's remote offices
Design approach	Design based on characteristics of available equipment	Design assumes equipment, bulks to be acquired
Design review	Full review, consistent with current best practices	Full review, consistent with current best practices

Fresh Approach to Overcoming FCC/System Cooling Limits
Identify & Mobilize Equipment

Comparison of modification methods *(from "New approach to revamps", Hydrocarbon Processing, 2005)		
Aspect of Revamp	**New approach**	**Traditional**
Procurement	Not applicable; leased equipment and bulks ready to ship	Acquire equipment and bulks per the project commercial framework
Construction	Modular assemblies are fitted together with a minimum labor	Traditional, labor – intensive installation
Commissioning, startup	Modules have been pre–tested; systems are checked for integrity	Check all equipment and systems

Fresh Approach to Overcoming FCC/System Cooling Limits
Operations , Performance, and Flexibility

- **Flexibility/ Nimbleness**
  - Modular equipment allows owners to derive benefits from opportunities that were not traditionally available
  - A seasonal limitation may allow for modular equipment to be removed during unused periods of the year
- **Cooperation of Staff**
  - “Foreign” equipment operating with a process block
  - Plant operations trained to level of detail needed
- **Performance**
  - Reliability enhanced with fleet of “like” units
  - A revamp can be a complex undertaking where significant effort is made to anticipate consequences of the change. Leverage the ability to quickly make further modifications (add or change equipment from a readily available inventory)
  - Consider strategy allowing for owner to commercially test (in a cost & schedule efficient method) concepts whose results are not well predicted.

FCC Case Histories

Resolving system cooling limitations

Main air blower (MAB)
Wet gas compressor (WGC)
Fuel gas system (LPG recovery)

Primary Limitations:

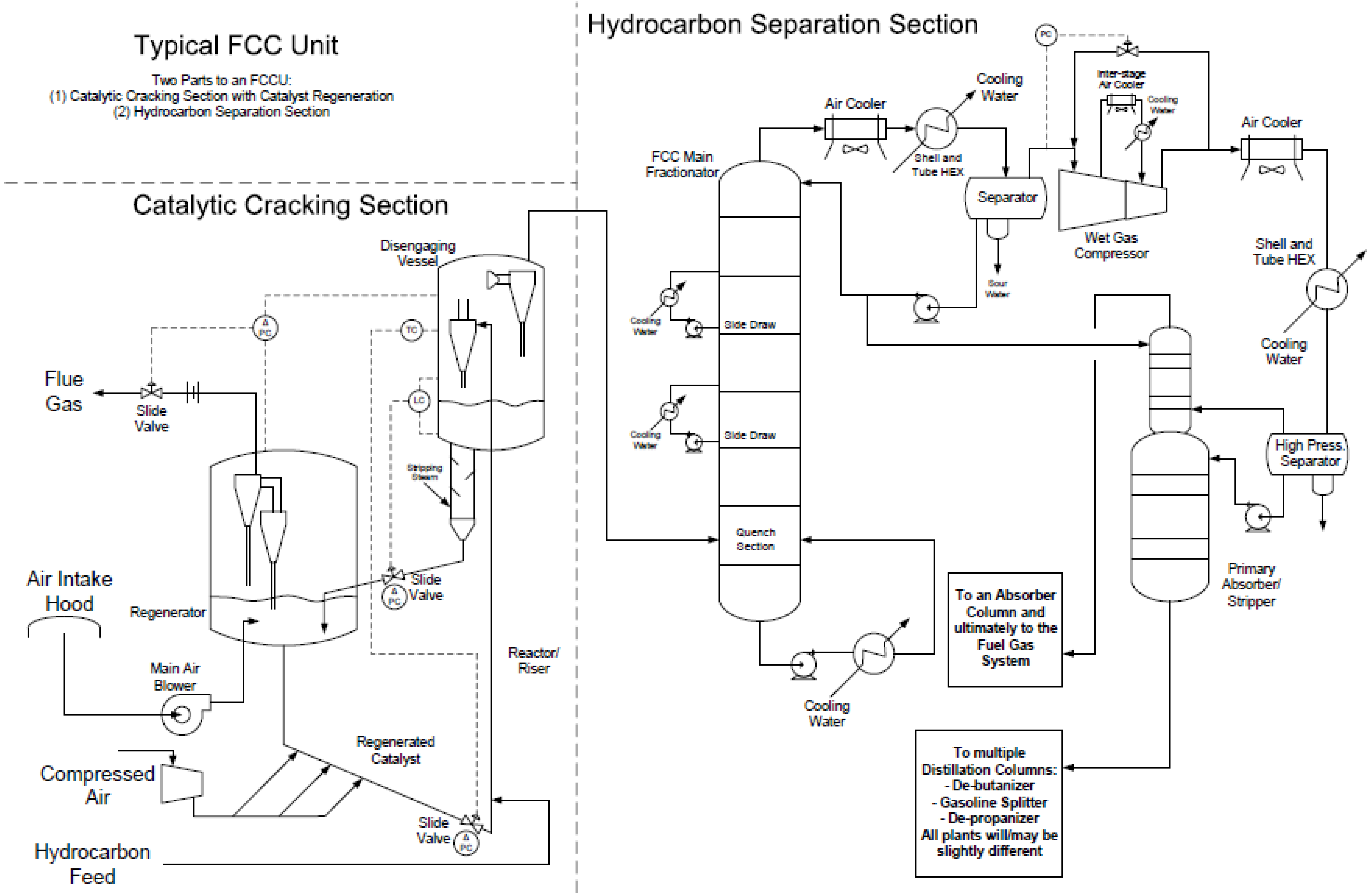
- •High ambient temperatures
- •Regen catalyst coke burn
- •Reduced mass air/O_2
- •Pressure relief valve limits
- •Lean oil absorption inefficiencies.

Solutions Methodology

- •Assemble the plan
- •Identify the equipment
- •Mobilize the equipment
- •Implementation & operations

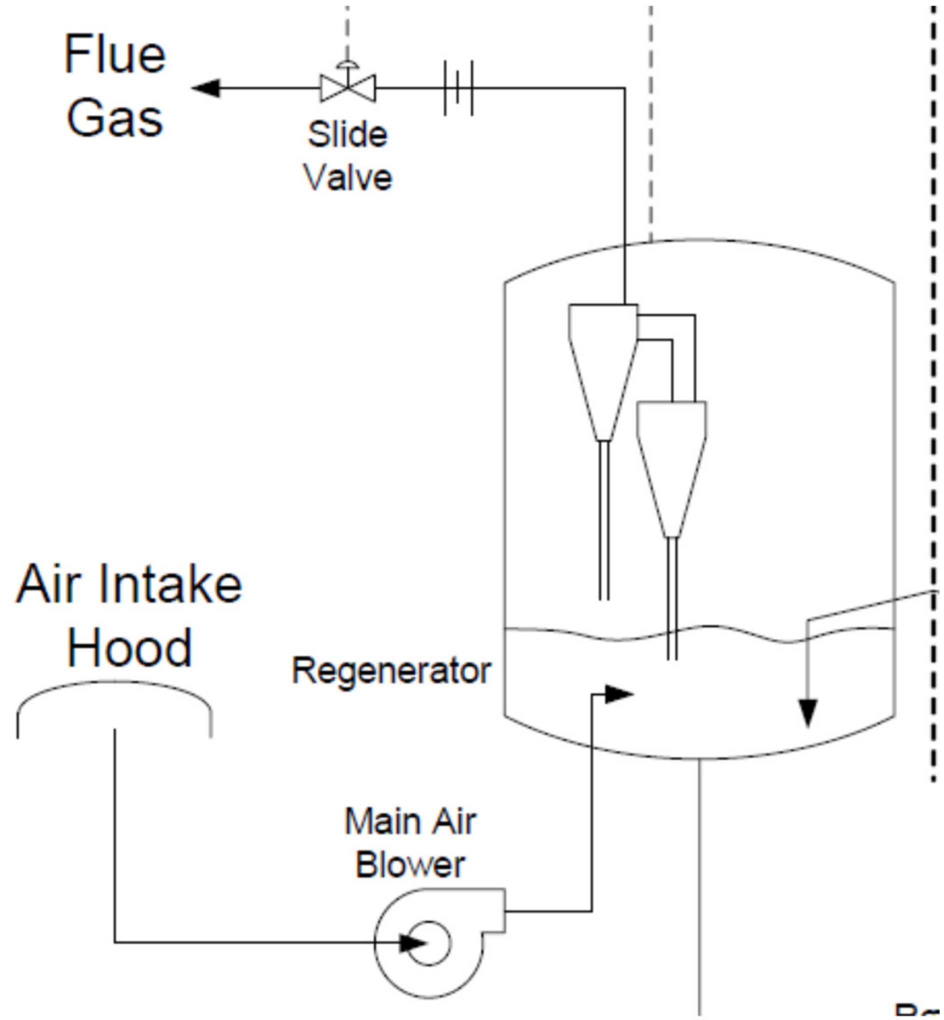
Typical FCC Unit

Two Parts to an FCCU:
(1) Catalytic Cracking Section with Catalyst Regeneration
(2) Hydrocarbon Separation Section



Case Study: Central US Refiner
FCCU is MAB limited during peak summer time gasoline demand

- Refiner risked cutting FCC feed during peak gasoline demand
- As ambient air temp increases, air to MAB becomes less dense, reducing percentage of O_2 to regenerator for coke burn-off
- MAB is a volumetric machine; can only process a certain volume/mass of air per time period



MAB Case Study

Pain points:

•Reduced mass air/O_2 rates through MAB (air temp could reach 105°F)

Solutions & objectives:

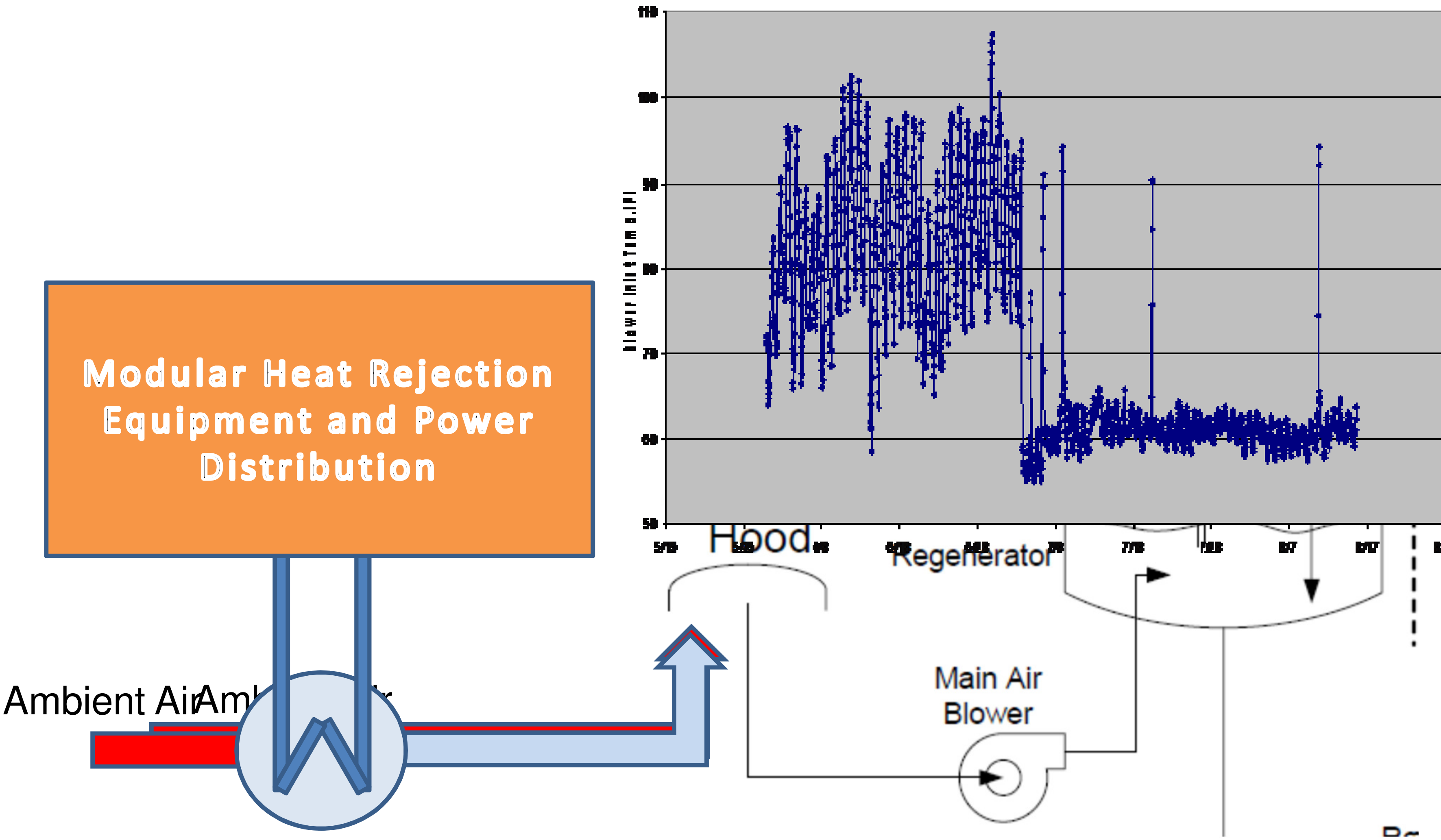
- Study and Document Concept with readily available equipment
- Minimize downtime for installation
- Seasonal need, Equipment not needed year-round

Results:

- Engineered temporary cooling solution based on mechanical refrigeration to chill MAB inlet air from 105°F down to 60°F
- Chilled (by 40°F), higher density air with higher percentage O_2 preserves coke burn-off
- O_2 supply increased 7% based on constant volume supply
  - ROT: Every 5 degree temperature reduction to MAB inlet air resulted in a 1% increase in capacity.

MAB Case Study

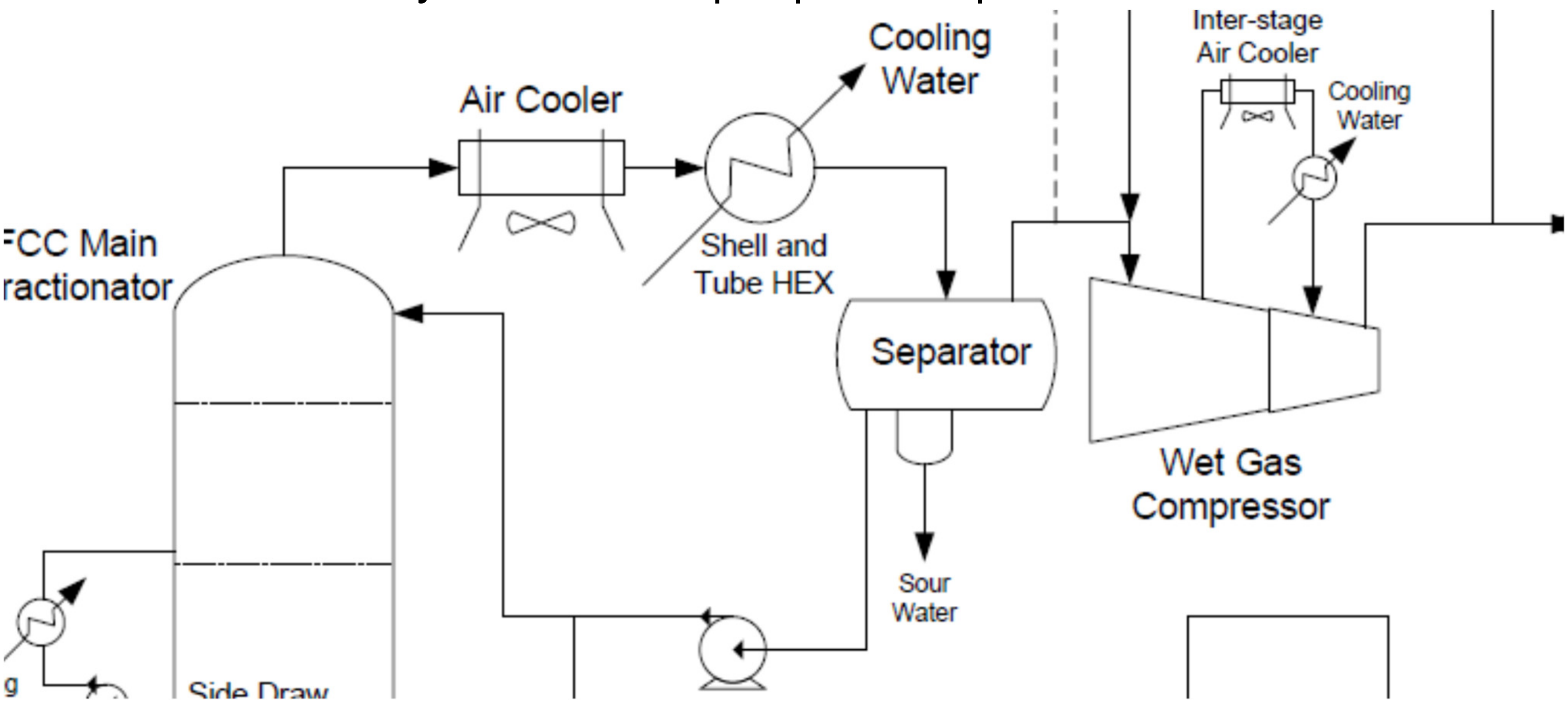
Maximize FCC throughput against hard constraints



Case Study: Mid-West US Refiner

FCCU is WGC or Main Frac OVHD limited during peak summer time gasoline demand

- Refiner risked cutting FCC feed during peak gasoline demand
- As OVHD temp increases, composition trends heavier and volumetric traffic increases in OVHD system
- WGC is a volumetric machine; can only process a certain volume/mass of hydrocarbon vapor per time period



Main Fractionation Case Study

Pain points:

- FCCU typically scaled back during on WGC compressor capacity
- This limitation would be aggravated due to incidence of fouling

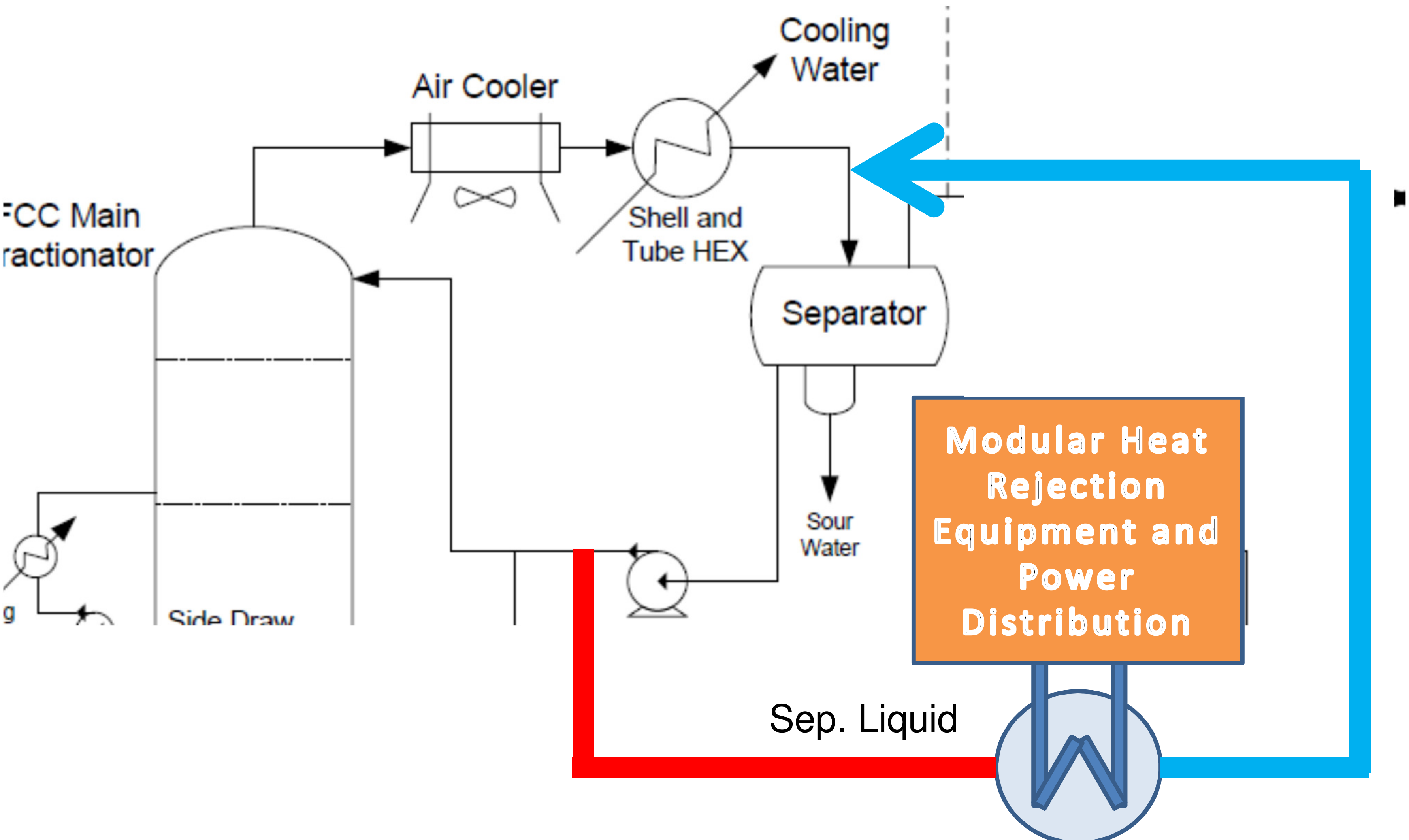
Solutions & objectives:

- Study OVHD system and Document Concept with readily available equipment
- Minimize downtime for installation
- Seasonal need, Equipment not needed year-round

Results:

- Began study early in the year, one week effort, quick agreement
- Equipment delivered to site allowed for hard pipe fabrication
- Engineered temporary cooling solution based on mechanical refrigeration for incremental removal of heat from OVHD
- Observed a decrease in off-gas production
- Refiner able to operate at desired conditions

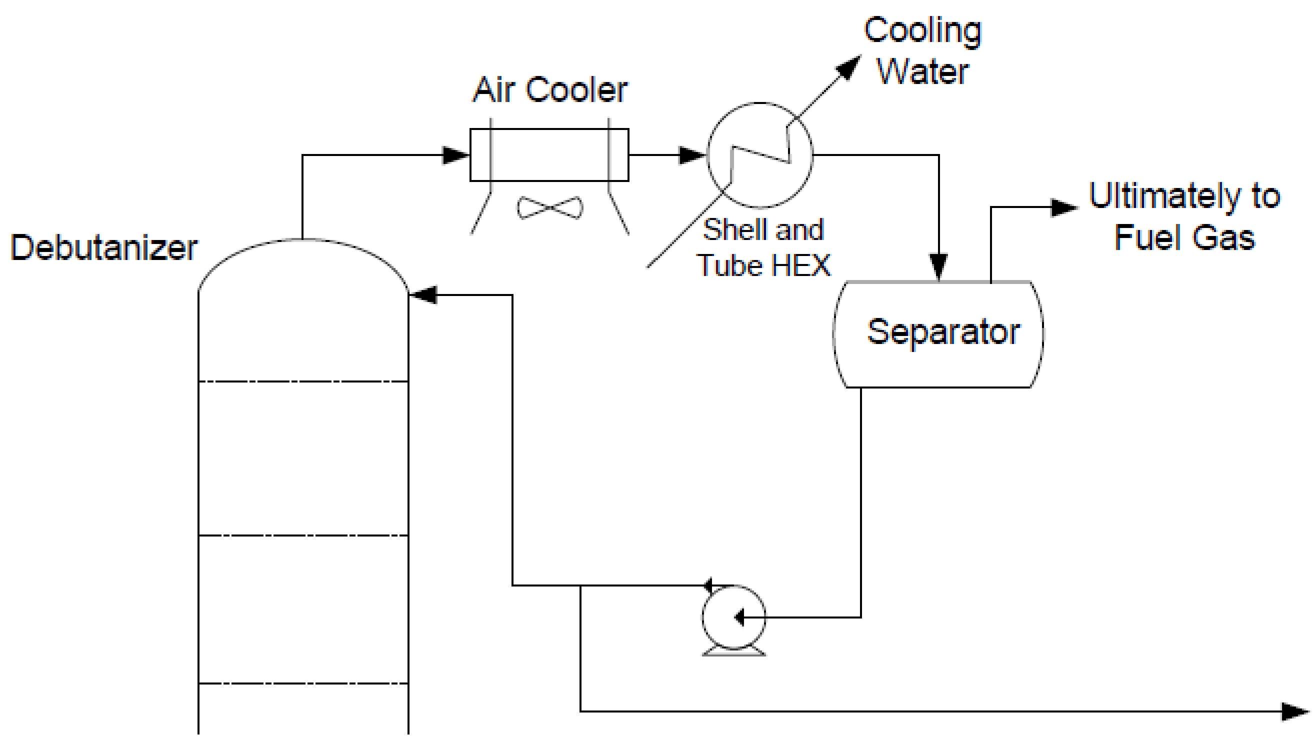
WGC Case Study
Main Fractionator Overhead System



Case Study: Canadian Refiner

Excess Fuel Gas Make in the Recovery Section

- Refiner made modifications within the processing units
- Multiple sources of Fuel Gas were identified
- Rich, LPG range material impacted balance



Recovery Section Case Study

Pain points:

- Rich, LPG range material impacted Fuel Gas balance

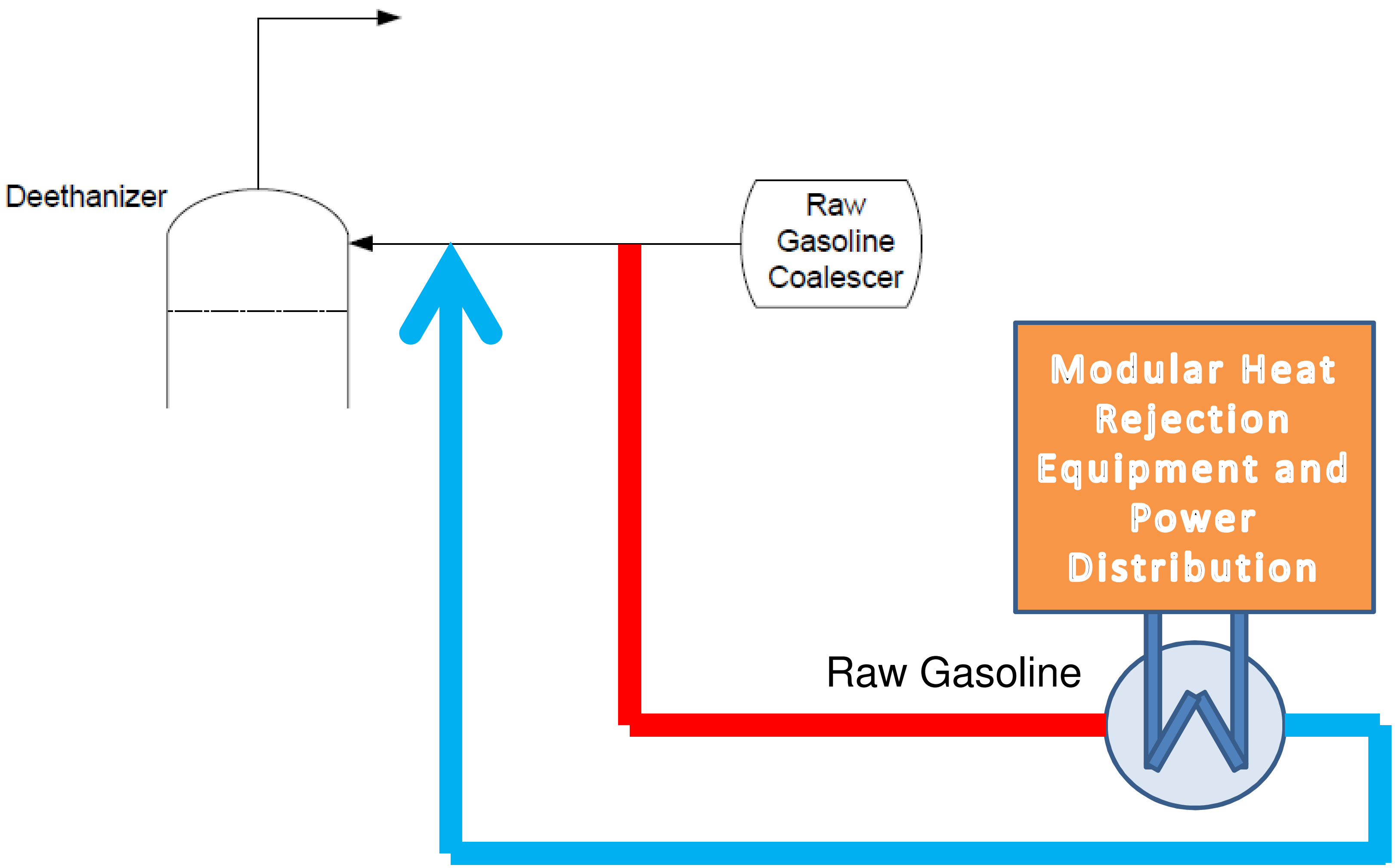
Solutions & objectives:

- Study OVHD system and Document Concept with readily available equipment
- Minimize downtime for installation
- Seasonal need, Equipment not needed year-round

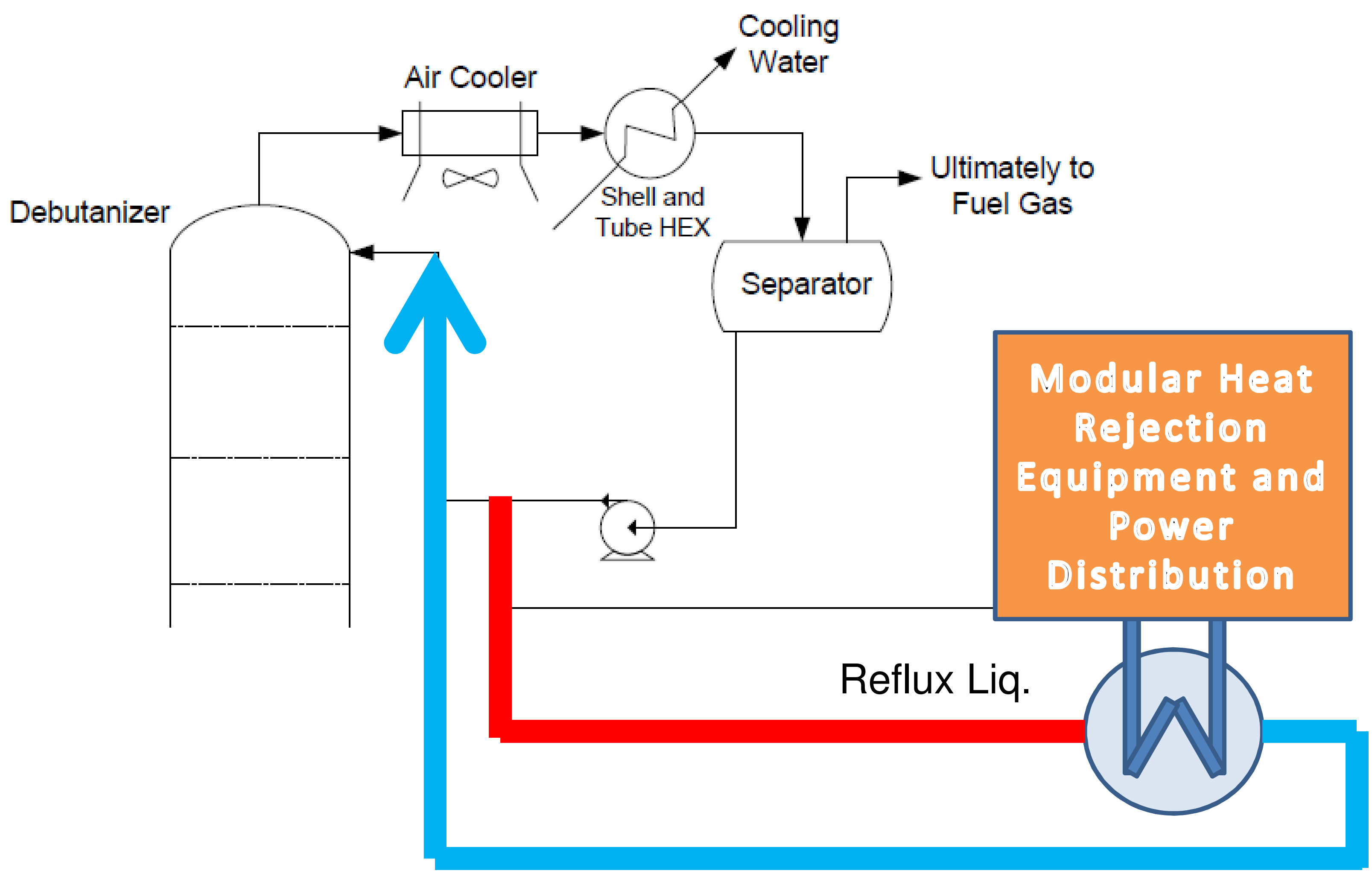
Results:

- Began study early in the year, one week effort, quick agreement
- Equipment delivered to site allowed for hard pipe fabrication
- Engineered temporary cooling solution based on mechanical refrigeration for incremental removal of heat
- Observed a decrease in off-gas production by ~10%
- Stable operation of deethanizer/absorber

LPG recovery



Optimizing C_4 Recovery



Conclusion
Overcoming constraints, bottlenecks & capturing marginal value

- Refiners are pushing units to maximize production during summertime demand
- Warmer ambient temperatures can curtail/prevent summer production targets
- Cooling water circuits become warmer due to higher wet bulb temperatures
- Every plant heat exchanger using cooling water is affected, including FCC HEXs
- FCCU MAB or WGC limits are aggravated by summertime ambient temps
- FCCU Recovery Section efficiency affected because their fractionators typically use a combination of cooling water and fin-fans to condense OVHD vapors
- Without a capital project, these limits can be overcome by applying the approach presented here with readily available equipment

Glossary

The Author: Michael Karlin is Engineering Manager with Aggreko Process Services (www.aggreko.com/northamerica), a provider of temporary solutions to a broad spectrum of industries. His professional career with Aggreko includes engineering solutions to enhance process efficiencies, notably to the nuclear power and petroleum refining industries, and field-installation and operations. Mr. Karlin has a B.Sc. in chemical engineering from Texas A&M University and is a registered Professional Engineer in the state of Texas.