Removal of Heavy Hydrocarbons from Lean Natural Gas

Dr. Gowri Krishnamurthy and Dr. Yu-Nan Liu

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Unconventional Natural Gas

Natural gas that was difficult or less economical to extract

Source: modified from U.S. Geological Survey Fact Sheet 0113-01
Unconventional Natural Gas

US Natural Gas Production, 1990-2035 (trillion cubic feet per year)

(Source: EIA Annual Energy Outlook 2011)
LNG Process Flow Diagram

Pipeline

Inlet Facility

AGRU, Driers, Hg Removal

NGL, HHC Removal

Precooling

Refrigeration

Liquefaction/Subcooling

Endflash

Fuel

LNG

LNG Storage
Lean Natural Gas: $C_1$ Composition

Lean NG has 5-10% more methane than typical NG.
Lean Natural Gas: Heavy Hydrocarbon (HHC) Composition

HHC may freeze and plug equipment
Lean Natural Gas: Heavy Hydrocarbon (HHC) Composition

HHCs need to be removed prior to cryogenic liquefaction

HHC may freeze and plug equipment
Traditional HHC Removal Techniques

Front-end Natural Gas Liquids (NGL) Extraction

- NGL ~ C$_2$-C$_5$
- Removal of HHC up-stream of pre-cooling/liquefaction in extraction column
Traditional HHC Removal Techniques

Front-end Natural Gas Liquids (NGL) Extraction

- NGL ~ C₂-C₅
- Removal of HHC up-stream of pre-cooling/liquefaction in extraction column

**Pros:**
- Column pressure does not impact Liquefaction pressure
- Ability handle wide feed concentration range
- High recovery of NGL’s, especially C₂

**Cons:**
- High CAPEX
- Lower availability

- Economical at high NGL content
Traditional HHC Removal Techniques

**Integrated Scrub Column**

- Removal of HHC after pre-cooling and prior to liquefaction
- Scrub Column integrated with liquefier
- Pros:
  - Lower CAPEX than Front-end NGL extr.
- Cons:
  - NGL product has significant C$_1$ and may be sent to fractionation, refrigerant make-up, fuel or pipeline
  - Scrub column to be operated at pressure below critical point
- Viable when NGL content is above certain levels
Typical lean NG feeds have insufficient C$_2$-C$_5$ content for traditional HHC removal techniques.
Typical lean NG feeds have insufficient $\text{C}_2$-$\text{C}_5$ content for traditional HHC removal techniques
HHC Removal by Adsorption
Front end HHC removal on Adsorption Bed by Temperature Swing Adsorption (TSA)
HHC Removal by Adsorption
Front end HHC removal on Adsorption Bed by Temperature Swing Adsorption (TSA)

- **Pros:**
  - Does not require C$_2$-C$_5$
  - Operating pressure does not need to be below critical point
  - Can handle limited feed composition variability

- **Cons:**
  - Significant regen byproduct stream (5% - 10%) needs to be dealt with. Often returned to feed, external pipeline or fuel stream
  - Extremely high levels of HHC lead to large beds and regen flow
  - Fewer references for LNG pre-treatment by Adsorption
HHC Removal by Partial Condensation

- Partial Condensation to remove NGL after pre-cooling
- Pros:
  - Needs less C$_2$-C$_5$ than scrub column
- Cons:
  - Only partial removal of C$_5$-C$_8$ components (single equilibrium stage)
  - At high HHC content, significant C$_1$ is lost with NGL
  - Condenser pressure needs to be below critical point
  - Can handle limited amount of feed composition variability before efficiency losses observed
HHC Removal by Adsorption and Partial Condensation Integration

- Combines best features of both, adds CAPEX and complexity
- Does not require C$_2$-C$_5$
- Adsorption removes a portion of HHC
- Partial Condensation removes remaining HHC
- Smaller adsorption unit and regen flow
- High liquefaction pressure and improved efficiency
- Can handle feed variability

Patent Application Filed
Adsorption Considerations

- Adsorbent selection is key
- Prior to HHC removal, H$_2$O and acid gases to be removed
- Multiple parallel adsorption beds may be required
- Regen product gas with HHC needs to be dealt with
- Adsorbent breakthrough measurements performed
  - Adsorbent bed is saturated with component and component begins to be seen at product end
- Adsorption model developed
Adsorption Considerations

![Graph showing molar concentration at product end over adsorption time with breakthrough time indicated for Component A and Component B.]
Summary and Conclusions

• Lean NG feeds are becoming increasingly common
• Typical lean feeds possess
  – High C₁ content
  – Low C₂-C₅ content
  – Tail of HHC to be removed
• Many process technology options exist for successful HHC removal
• No single technology will work for all feed gas compositions
• Important to identify and evaluate appropriate removal technologies early in the project
• Integrated adsorption - partial condensation process is effective for typical lean NG streams

Proper design of HHC removal system is critical for LNG project success!
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Thank you...
tell me more

Please contact the authors if you have any questions.