Removing Sulfur from Natural Gas Midstream

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Sulfur Removal

> A significant portion of natural gas requires the removal of contaminants before it enters the pipeline transportation system
  
  — Midstream cleanup is a major contributor to the total cost of gas production

> New technology for improving the performance and reducing the complexity of current clean up train would be beneficial

> Need to lower the cost of sulfur removal and recovery

> Need for better approaches to meeting environmental regulations for gas processing facilities
Removing Sulfur from Natural Gas Midstream

GTI has technology platforms and expertise in removal of contaminants

- Acid gas removal
- Sulfur recovery
- \( \text{H}_2\text{S} \) scavenging
- Process development supported through lab and field experiments
Sulfur Removal at all Production Levels

**H₂S removal at >25 tons/day**
at processing plant  
– Amine/Claus/SCOT

**Sulfur recovery**  
(medium scale)  
– Liquid redox

**Scavengers for <100 lbs/day**  
Direct injection into gas stream before it reaches processing plant

**GTI Technologies and Capabilities**

**GTI comprehensive one-step sulfur removal process**

**CrystaSulf® Process**

• Available from URS and GTC  
• GTI-patented chemical process that removes H₂S from gas streams and converts it into elemental sulfur using nonaqueous chemistry

• Patented technology  
• Simulation model  
• Testing services
GTI Sulfur Removal: A Flexible Process for Sweetening Natural Gas

Claus Reaction in Liquid Phase
\[ 2 \text{H}_2\text{S} + \text{SO}_2 \rightarrow 3 \text{S}_{\text{liquid}} + 2 \text{H}_2\text{O} \] (Exothermic)

- Inventor: Professor Scott Lynn, University of California, Berkeley
- Typical solvent: DGM (diethylene glycol methyl ether; Dow Dowanol DM™)
- Homogeneous catalyst: 3-pyridyl methanol (less than 1 wt %)
- Reactor Temperature: 250-300 F
- Reactor Pressure: any pressure
**ONGOING WORK**

**Comprehensive Sulfur Removal—Acid Gas Removal, Sulfur Recovery, and Tail Gas Treating in One Step**

**Amine process**
- Acid gas removal process eliminates sulfur from natural gas to achieve permitting levels

**Claus process**
- Sulfur recovery

**SCOT tail gas treating process**
- Clean-up for emissions control
- Recycles remaining sulfur compounds back to Claus system
- CAPEX similar to Claus unit

GTI sulfur removal process can also directly handle $\text{CO}_2$-rich off-gas from amine stripper
Technology Benefits

> Significant economic advantage for GTI sulfur removal process
  - Preliminary process performance and economics suggest a 40% cost savings compared to competing technologies
  - GTI sulfur removal process reduces operating expenditures by 32%

> Cost advantage greatest in high-pressure pipeline systems

> High-pressure sulfur removal can be scaled down to smaller sulfur capacities
Next Steps/Partnering Opportunity

> Design, build, and operate a pilot plant to demonstrate the GTI sulfur removal process for:
  > Amine stripper off-gas (Claus/SCOT replacement)
  > High-pressure natural gas treating (sulfur removal/recovery)

> GTI is interested in partnering with companies to commercialize this technology
What is H$_2$S Scavenging?

> The process of contacting an H$_2$S-laden natural gas stream with special chemicals that react irreversibly with H$_2$S, resulting in a less-toxic solid or sludge-like product

  ─ this approach to reduce contaminants is generally limited to relatively small-capacity removal requirements (<100 lbs/day)
  ─ Higher capacities may be justifiable for certain offshore and temporary applications

> Scavengers can be solids or liquids, and may be utilized in contacting towers

> Liquid scavengers may be sprayed directly into the gas pipeline or gathering system line

> The design process for direct injection of scavengers into a gas stream before it reaches a processing plant is complicated and not universally understood
GTI H₂S Scavenging Research

Industry Needs

> Comply with environmental regulations
> Reduce scavenger consumption and improve H₂S removal

GTI Solutions

> GTI has been deeply involved in H₂S scavenging research and development since the mid-1990s, solving problems and reducing costs for private industrial sponsors

> Our range of services includes engineering consultancy, engineering design software, lab and field testing

  ─ Ability to conduct sophisticated modeling of direct injection scavenging systems and process design of commercial installations

  ─ Large database of direct injection scavenging data from both controlled experiments and industrial applications
GTI H$_2$S Scavenging Technology

> Patented multi-pipe direct injection scavenging technology
  — Flow in multiple pipes to increase scavenger utilization and lower costs
  — Achieve pipeline specification
  — Licensed four applications being used commercially at transmission company storage fields
AVAILABLE FOR PURCHASE ON GTI WEBSITE

GTI H₂S Scavenging Software

GTI Direct-Injection Scavenging software
> Accurately predicts required conditions for direct-injection applications
> Detailed calculations of H₂S removal with triazine scavenger
  > Effects of pipe diameter, flowrate, multi-phase flow, kinetics, stoichiometry, nozzles, heat exchangers, temperature and pressure and other factors
> Validated by oil company majors using large-scale offshore production data

GTI Scavenger CalcBASE® software
> Quick screening of solid and liquid scavengers for tower-based applications to determine most economical approach
> Estimates capital and operating costs for chemicals, ranks vendors based on your gas compositions
GTI H₂S Scavenging Technical Services

Testing Services

- Scavenger capacity
  - Batch and flow loop

- Direct-injection test loops
  - 6- and 2-inch diameter test runs, 250 foot long using field gas – 1,000 psi (70 bar) located in south Texas
  - 3/4- and 1-1/4-inch laboratory test loops (250 foot length) at our headquarters in Des Plaines, Illinois
    - Up to 0.5 MMSCFD, 100 ppmv H₂S in nitrogen, ambient to 250 F, and 50 psi to 1,000 psi

Let GTI help you optimize contaminant removal in a cost-effective way
GTI H₂S Scavenging Consulting

Recent Example:
> Technical consulting for a major oil company with a direct injection scavenger project in Asia concerning the expected performance of a complex pipe arrangement for direct injection

Partnering Opportunity:
> GTI conducts large-scale research, development, and demonstration projects at our facilities or in the field
> GTI can complement or supplement a company’s internal expertise with our specialized technical and knowledge-based services
For More Information

>Howard Meyer  
GTI R&D Director,  
Gas Processing Research  
847/768-0555  
cell: 847/226-0226  
howard.meyer@gastechnology.org