Sulfur Recovery
Sulfur Recovery

- The Market
- Investment Cost
- Technology
The Market

- About 700 refineries and about 350 gas field installations are in operation worldwide.
Either you operate a gas field or you are using crude oil as base energy for your plant; in each of these cases:

- purification systems as well as sulfur recovery units are installed on the way from the specific energy source to the products.
The Market

- Decades ago one could really make a lot of profit by selling sulfur.
- Having 2,100 t/d sulfur recovery facilities the plant made a pure daily profit of EUR 250,000 per day only by selling the produced sulfur.
The Market

- In those days sulfur was at about 150 US$/t; one could really speak about sulfur being a cash cow.

- But time changed, sulfur price dropped dramatically to about 25 – 30 US$/t and even less.
The Market

- But although the sulfur price dropped, the sulfur recovery units became more and more important because of very stringent environmental limitations.

- Environmental limitations like decrease of sulfur content in products like Diesel for instance increased the necessity of capacity increases of sulfur recovery units.
The Market

- On average, new sulfur capacities of about 2,000 t/d are installed per year including revamps using technologies like OxyClaus®, increasing the capacities of Claus units by using air and/or oxygen.
**Investment Cost**

- For a 100 t/d two-stage Claus unit, cost is about 9 million EUR.
- Costs for the different process versions and technologies are shown in the following diagram:
OxyClaus® cost savings

Feed
50% H₂S
45% CO₂
1% CH₄
4% H₂O

2 Stage CLAUS Air
317,8 kmol/h Air

Capacity 100 t/d
Cost 100%

2 Stage CLAUS Air + Oxygen
64,7 kmol/h Air
47,2 kmol/h Oxygen

Capacity 100 t/d
Cost 73%

2 Stage CLAUS Air + Oxygen
64,7 kmol/h Air
89,0 kmol/h Oxygen

Capacity 172,8 t/d
Cost 100%
Figure 1 Typical Amine Systems Flow Diagram
Technology

- The Claus process continues to be the most widely used process worldwide for the conversion of $\text{H}_2\text{S}$ to sulfur.
Technology

The requirements to be met by Claus plants are dictated by

- the operating conditions of modern, flexible refineries and natural gas plants and
- increasingly stringent emission control regulations.
One of the most popular emission control regulations is the German TA – Luft, asking for the following minimum requirements for sulfur recovery units (status 2005):

<table>
<thead>
<tr>
<th>Plant capacity t/d Sulfur</th>
<th>S-Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>97%</td>
</tr>
<tr>
<td>20 up to 50</td>
<td>98%</td>
</tr>
<tr>
<td>&gt; 50</td>
<td>99.8%</td>
</tr>
</tbody>
</table>
Claus Process

- Pada proses penyulingan minyak bumi, sulfur bereaksi dengan hidrogen membentuk H₂S.
- Dalam "asam" gas alam (sour natural gas), sulfur ditemukan sebagai H₂S.
- Claus process merupakan proses yang sangat bagus untuk pemisahan sulfur yang terkandung pada gas dan pengolahan kembali sulfur pada H₂S.
Claus Process

- Gas yang mengandung H$_2$S lebih dari 25% sangat sesuai untuk me-recover sulfur dengan Claus Unit.
- Gas-gas ini kemungkinan mengandung hidrogen sianida, hidrokarbon, sulfur dioksida, dan ammonia.
- Gas-gas ini kemudian memasuki gas treatment unit pada proses penyulingan atau pada proses pengolahan gas.
Claus Process

- Gas treatment units seperti *Selexol*, *Rectisol*, *Purisol* dan *amine scrubbers*.
- Hasil dari proses recover sulfur pada claus unit kemudian digunakan untuk pembuatan asam belerang, obat-obatan, kosmetik, pupuk, dan produk karet.
Claus Process

- Reaksi secara keseluruhan:
  \[ 2H_2S + O_2 \rightarrow 2S + 2H_2O \]
- Teknologi claus unit pada umumnya dapat dibagi dua, yaitu:
  - secara termal (pembakaran) dan
  - katalis (penggunaan katalis alumina atau titanium dioksida).
• Gas yang mengandung H₂S diumpankan dengan oksigen kedalam waste heat boiler unit.
• Oksigen ini digunakan untuk mencapai temperature yang dinginkan yaitu sekitar 1562 to 2462 °F (850 to 1350 °C) pada proses pembakaran.

\[ 2\text{H}_2\text{S} + \text{O}_2 \rightarrow 2\text{S} + 2\text{H}_2\text{O} \]

$$2H_2S + O_2 \rightarrow 2S + 2H_2O$$
Setelah didinginkan, kemudian dipanaskan kembali melalui reheater unit.
Pada proses pemanasan ini bertujuan untuk menghilangkan sisa gas yang masih terkandung pada sulfur.
Dari reheater unit lalu menuju katalitik kolom proses.
Katalis yang digunakan adalah Al₂O₃ dengan luas area permukan sekitar 200-300 m²/g.
Hasil reaksinya adalah sebagai berikut:

\[ 2H₂S + O₂ → 2S + 2H₂O \]
Dari reaksi ini diperoleh sulfur yang tidak mengandung gas.
Produk dari reaksi ini menuju sulfur condenser untuk didinginkan dan hasilnya adalah padatan sulfur.

$$2H_2S + O_2 \rightarrow 2S + 2H_2O$$
2H₂S + O₂ → 2S + 2H₂O

- Reaksi yang tak sempurna pada katalitik kolom akan dibawa kembali menuju reheater unit untuk menghilangkan kandungan gas yang masih ada pada sulfur.
- Begitu seterusnya hingga memperoleh sulfur murni tanpa ada kandungan gas-nya.
Jika sulfur yang terbentuk mempunyai konsentrasi yang lebih rendah antara 100-1000 ppmv (parts per million by volume) akan direaksikan kembali dengan oksigen pada reaksi pembakaran membentuk SO$_2$ di-reheater unit.

Reaksinya: $S + O_2 \rightarrow SO_2$

$2H_2S + O_2 \rightarrow 2S + 2H_2O$
Lurgi Claus Process

crude oil $\rightarrow$ petrol

$H_2S$ $\rightarrow$ Claus $\rightarrow$ S
Lurgi Claus Process

- On the way from gaseous, liquid or solid feedstocks to petrol, heating oil or petrochemical products, the feedstocks need to be purified of sulfuric compounds.

- For environmental reasons, these compounds must not be burned off and thus released to the atmosphere.
Consequently, these sulfuric compounds need to be converted to sulfur in a Claus plant.

The Claus process continues to be the most widely used process worldwide for the conversion of $\text{H}_2\text{S}$ to sulfur.
The requirements to be met by Claus plants are dictated by
- the operating conditions of modern, flexible refineries and natural gas plants and
- increasingly stringent emission control regulations.
Lurgi Claus Process

- The highly efficient recovery of elemental sulfur from hydrogen sulfide, carbonyl sulfide, carbon bisulfide, sulfur dioxide or other gaseous sulfur compounds involves four main process steps:
  - partial substoichiometric combustion,
  - catalytic conversion in two or more stages,
  - tail gas cleanup to boost sulfur yield,
  - thermal or catalytic incineration of tail gases.
Lurgi Claus Process

- Advantages of the Lurgi Claus Process
  - Unique burner system including ammonia/RSH destruction
Lurgi Claus Process

\[ 2 \text{H}_2\text{S} + \text{SO}_2 \rightarrow 3 \text{S} + 2 \text{H}_2\text{O} \]
Advantages of the OxyClaus® Process

- Capacity boosting of existing Claus and tail gas units.
- Significant reduction in capital investment when building new Claus and tail gas units.
- Processing of feed gases with both high and low hydrogen sulfide contents (20–100 vol %).
Lurgi OxyClaus® Process

- Advantages of the OxyClaus® Process
  - Flexible processing when handling temporarily high or low amounts of hydrogen sulfide by automatic change over from air to oxygen operation and vice versa.
  - Processing of Claus gases with elevated hydrocarbon contents.
  - Almost complete combustion of ammonia contained in ammonia-laden sour water stripper offgases.
Lurgi OxyClaus® Process

OxyClaus® Process

Lurgi Claus Process

Acid Gas (H₂S Gas)
SWS-Gas
Combustion Chamber
2 (3) Cat. Reactors/Condensers
Incinerator
Stack

Catalytic Stages
Sulfur Recovery Rate
Claus 2 96% - 97%
Claus 3 97% - 98%
A very efficient and low-budget SULFREEN tail gas treatment process is MAXI SULF.

It is basically a one-stage (one adsorber, one regenerator) SULFREEN unit with an open regeneration loop.

The regeneration gas is fed to the adsorber together with the Claus tail gas, whereas in the SULFREEN process the regeneration gas is recycled.
Lurgi MAXI SULF® and SULFREENN®

- With MAXI SULF, yields of up to 98.5 % can be achieved.
- The SULFREENN process is a catalytic tail gas process which has been successfully employed in more than 45 Claus plants.
- This SULFREENN process permits sulfur yields to be boosted to over 99.0 %.
- For even higher yields, a second absorber stage can be added.
Lurgi MAXI SULF® and SULFREEN®

Lurgi Sub-dewpoint Processes

Lurgi Claus Process
Lurgi MAXI SULF® and SULFREEN®

- HYDROSULFREEN®

- If even higher sulfur yields have to be obtained, an additional process stage comprising hydrogenation and hydrolysis with adjustment of the H2S/SO2 ratio to 2 can be installed upstream of the SULFREEN process.

- This concept permits sulfur yields of up to 99.6%.
Advantages of the SULFREEN® Processes

- Continuation of catalytical Claus process
- No chemicals/solvents needed
- Increase of sulfur recovery rate step by step by using existing SULFREEN equipment and only adding additional catalytical stage(s).
Catalytic tail gas processes reach their practical limits when sulfur yields of over 99.9 % are required.

In such a case, hydrogenation and water condensation have to be followed by a (usually) selective chemical absorption process to remove the remaining H₂S and return it to the Claus feed gas.
Lurgi Tail Gas Treating
LTGT®

- Lurgi has built a number of such absorption systems and can offer the necessary references.

- This process combination brings off-gas $\text{H}_2\text{S}$ levels down to 200 ppm prior to thermal incineration.
Lurgi Tail Gas Treating
LTGT®

LTGT®-Lurgi Tail Gas Treatment Technology

Lurgi Claus Process

- Acid Gas (H₂S Gas)
- SWS-Gas
- (Oxygen)
- Air

- Sulfur
- FG

- FG
- Air

- Incinerator
- Stack

- Recovery Rate
  99.9 % +

- Combustion Chamber
- 2 (3) Cat. Reactors/Condensers
- Incinerator
- Stack

- Catalytic Stages
  Claus 2
  Claus 3

- Sulfur Recovery Rate
  96 % - 97 %
  97 % - 98 %

- crude oil → petrol

H₂S → Claus → S
Advantages of Selective Chemical Adsorption (LTGT®)

- Extremely high sulfur recovery rates of more than 99.9 %
- Possibility of using existing solvent regeneration units
- No license fee for LTGT
Sulfur Degassing

- Sulfur Degassing Process AQUISULF®
  - For sulfur degassing, Lurgi uses the AQUISULF process from ELF.
  - Liquid sulfur obtained from H₂S in Claus units necessarily contains dissolved H₂S desorbed during transportation and accumulated in the gaseous phase of tanks.
  - At a certain concentration, it may become explosive and, in any case, is hazardous for operators.
Sulfur Degassing

Sulfur Degassing Process AQUI SULF®

Moreover $\text{H}_2\text{S}$ in liquid sulfur has an adverse effect on the solidity of formed sulfur and particularly on sulfur slate strength.

In order to solve these problems, ELF conducted their own experiments to develop a liquid sulfur degassing process bringing residual $\text{H}_2\text{S}$ down to less than 10 ppm by weight.
Sulfur Degassing

- Advantages of the degassing catalyst
  - Guaranteed $\text{H}_2\text{S}$ level in liquid sulfur of less than 10 ppm by weight
  - Best solubility in sulfur (only small quantities are required)
  - No solid deposits in sulfur
Special Sulfur Concepts

- Emission-free SRU
- Integrated Natural Gas Treating Concept OmniSulf® Advantages
For residual H2S levels below 10 vol. ppm, Lurgi offers a process combination in which the process gases leaving the Claus plant are cooled to temperatures around 125 °C to precipitate the elemental sulfur.

Subsequently,

- the sulfur compounds are hydrolyzed to hydrogen sulfide,
- water is condensed and the gas directed to an absorber stage in the upstream gas purification unit, where its H2S content is reduced to below 10 ppm.
Emission-free SRU

- All sorbents employed in the different absorption stages including the ones for Claus feed supply are jointly regenerated.
- The resulting hydrogen sulfide is returned to the combustion chamber.
- After having been freed of its H₂S load, the gas is routed to the gas turbine, if required via intermediate compressors, or used as stripping gas, resulting in an overall flue gas-free process.
- This makes it an ideal choice for combined cycle power plant applications.
Advantages of Emission-free SRU

- Lower investment cost due to the use of oxygen (OxyClaus®)
- No sulfur emissions from SRU
- Recycle of process gas results in reduction of sulfur emissions to atmosphere in total complex
- Higher efficiency in energy production section in IGCC due to higher gas volume
Emission-free SRU

Lurgi Emission-free SRU Option

- Raw Gas
  - COS Hydrolysis
  - H₂S Removal (Purisol®/MDEA)
  - SRU OxyClaus® Hyrogenation Quench
  - Sulfur Degassing (AQUISULF®)
  - Sulfur Storage & Truck Loading
  - Tall Gas Recompression (Claus Tail Gas)
  - Desulfurized Gas
  - Fuel Gas to Gas Turbine

- Oxygen
  - Combustion Chamber
  - 2 (3) Cat. Reactors/Condensers
  - Incinerator
  - Stack

Acid Gas (H₂S Gas)
- SWS-Gas
- (Oxygen)
- Air
- FG

- Sulfur Product
- Catalytic Stages
- Claus: 2
- Claus: 3
- Sulfur Recovery Rate
- 96% - 97%
- 97% - 98%

Lurgi Claus Process

- Crude oil → petrol
- H₂S → S
Integrated Natural Gas Treating Concept OmniSulf® Advantages

- Single source responsibility
- One licensor
- No interfaces
- Overall guarantees
- A one-stop shop
For natural gas treating, i.e. for gas sweetening and mercaptan removal, Lurgi has developed an innovative concept, the BASF-Lurgi OmniSulf® process.

The first step is an activated MDEA (aMDEA® of BASF) acid gas removal unit removing $\text{H}_2\text{S}$, COS and CO$_2$ to LNG gas quality, producing an acid gas as well as a very small amount of flash gas.
The sweetened natural gas still containing mercaptans, but only little H$_2$S and COS, is routed to a molecular sieve unit. This special molecular sieve unit finally produces the dry, sweet gas according to LNG specification. The batch regeneration of the molecular sieves yields a gas stream containing almost all the mercaptans and a significant amount of hydrocarbons.
Integrated Natural Gas Treating Concept OmniSulf® Advantages

- From this stream, hydrocarbons are recovered in the PURISOL® (Lurgi proprietary physical absorption) process as fuel gas.
- In the PURISOL® solvent regeneration unit, a stream very rich in mercaptans is produced and completely combusted in the Claus unit together with the aMDEA® flash gas, containing mainly hydrocarbons but also some mercaptans as well as some H₂S.
Integrated Natural Gas Treating Concept OmniSulf® Advantages

- The acid gas from the aMDEA® is routed to an acid gas enrichment (AGE) absorber.
- The AGE is part of the Lurgi Tail Gas Treatment (LTGT®) unit and produces a semi-lean gas.
- This semi-lean gas, leaving the absorption column, is routed to the LTGT® unit.
- The solvent used in the LTGT® absorber as well as in the AGE absorber is generic MDEA.
Integrated Natural Gas Treating Concept OmniSulf® Advantages

- This allows for a common regenerator to be used.
- This regenerator produces the acid gas with an enriched amount of H₂S for the Claus unit, which makes the Claus plant (and the whole SRU) smaller and easier to operate than without the AGE unit.
- The gas from the LTGT® is combusted in the incinerator.
Integrated Natural Gas Treating Concept OmniSulf® Advantages
Shell-Paques/ THI OPAQ™ Process

- Penghilangan H₂S dari gas alam yang berikutnya akan diubah menjadi sulfur biasanya menggunakan metode Amine dan metode Claus.
- Proses ini biasanya digunakan untuk pabrik sulfur berskala besar yaitu sebesar 50 ton perhari.
Untuk skala kecil pembuatan sulfur dilakukan dengan proses liquid redox atau alternatif lainnya adalah dengan proses amine yang diikuti dengan insenerasi atau re-injeksi gas asam kedalam sumur kosong.

Metode-metode tersebut memiliki kelebihan dan kekurangan masing-masing.
Untuk sebuah plant gas alam yang tidak terlalu besar dan memiliki kandungan $\text{H}_2\text{S}$ yang relatif tinggi, maka dibutuhkan proses pengolahan yang tepat.

Proses pengolahan itu haruslah aman, biayanya relatif murah, mudah dioperasikan dan berkelanjutan.

Metode tersebut adalah Shell-Paques/THI OPAQ™.
Shell-Paques/ THI OPAQ™ adalah proses bioteknologi untuk menghilangkan H₂S dari gas alam dengan adsorbsi ke dalam mild alkaline,
yang kemudian dilanjutkan dengan oksidasi sulfida menjadi sulfur dengan menggunakan mikroorganisme.
Metode ini memberikan:

- Pengganti liquid redox proses, metode amine, claus recovery, tail gas treatment.
- Penggunaan bahan kimia sedikit.
- High turndown ratio
- Sebagai pengolah gas dan juga pembuatan sulfur
- Kandungan H₂S pada sweet gas dibawah 4 ppm
- Mengkonversi 95-98% H₂S menjadi sulfur
- Tidak ada penggantian biokatalis
Kelebihan metode ini dibandingkan metode claus:
- Tidak ada H$_2$S bebas dimanapun pada proses ini
- Unit operasi aman dan mudah dijalankan
- Tidak menggunakan kontrol loops yang kompleks
- Biaya untuk pelarut relatif murah
Instalasi pertama dari THI OPAQ™ yaitu digunakan untuk menghilangkan H₂S dari

- biogas (CH₄= 80 vol.%, CO₂=18 vol.%, H₂S=2 vol.% @ 30 mbarg) dan

- landfill gas (CH₄=60 vol.%, CO₂=40 vol.%, H₂S=5000 ppmv, @ -50 mbarg) pada tahun 1993.
Sejak itu unit yang sama telah dibuat di Jerman, Inggris, Denmark, Prancis, Spanyol, Italia, India, Chili, dan U.S.A.

Kemudian proses ini berkembang terus dan dapat digunakan secara komersial untuk menghilangkan sulfur di beberapa industri seperti pulp dan kertas, industri kimia dan industri pertambangan.
Main Reactions in the Absorber (at feed gas pressure):

1. H₂S absorption  \(\text{H}_2\text{S} + \text{OH}^- \rightarrow \text{HS}^- + \text{H}_2\text{O}\)  \(\text{OH}^-\) consumption
2. H₂S absorption  \(\text{H}_2\text{S} + \text{CO}_2^2- \rightarrow \text{HS}^- + \text{HCO}_3^-\)
3. CO₂ absorption  \(\text{CO}_2 + \text{OH}^- \rightarrow \text{HCO}_3^-\)  \(\text{OH}^-\) consumption
4. Carbonate formation  \(\text{HCO}_3^- + \text{OH}^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}\)  \(\text{OH}^-\) consumption

Main Reactions in the Bioreactor (at atmospheric pressure):

5. Sulfur production  \(\text{HS}^- + \frac{1}{2} \text{O}_2 \rightarrow \frac{1}{8} \text{S}_8 + \text{OH}^-\)  \(\text{OH}^-\) production
6. Sulfate production  \(\text{HS}^- + 2\text{O}_2 + \text{OH}^- \rightarrow \text{SO}_4^{2-} + \text{H}_2\text{O}\)  \(\text{OH}^-\) consumption
7. Carbonate decomposition  \(\text{CO}_3^{2-} + \text{H}_2\text{O} \rightarrow \text{HCO}_3^- + \text{OH}^-\)  \(\text{OH}^-\) production
8. Bicarbonate decomposition  \(\text{HCO}_3^- \rightarrow \text{CO}_2 + \text{OH}^-\)  \(\text{OH}^-\) production
<table>
<thead>
<tr>
<th>Required SRU-Concept S-Recovery</th>
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<tbody>
<tr>
<td>≥ 97%</td>
</tr>
<tr>
<td>Claus with two catalytical stages</td>
</tr>
<tr>
<td>≥ 98%</td>
</tr>
<tr>
<td>Claus with two catalytical stages plus std. SULFREENER® or Claus with three catalytical stages</td>
</tr>
<tr>
<td>≥ 99.5%</td>
</tr>
<tr>
<td>Claus with two catalytical stages plus HydroSULFREENER®</td>
</tr>
<tr>
<td>≥ 99.9%</td>
</tr>
<tr>
<td>Claus with two catalytical stages plus LTGT®</td>
</tr>
</tbody>
</table>
## Process Highlights

<table>
<thead>
<tr>
<th>Process Highlights</th>
<th>Advantages</th>
<th>Major effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lurgi Claus</strong></td>
<td>■ Unique burner system including ammonia/RSH destruction by separate stoichiometric combustion</td>
<td>■ No plugging of sulfur lines due to ammonia salt formation therefore much better operability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>■ Reduction of operating cost due to safe and efficient performance</td>
</tr>
<tr>
<td><strong>OxyClaus®</strong></td>
<td>■ Decrease of amount of process gas passing through the unit, capacity boosting of Claus and tail gas units</td>
<td>■ Significant reduction in capital investment</td>
</tr>
<tr>
<td></td>
<td>■ Processing of Claus gases with elevated hydrocarbon contents</td>
<td>■ Much better operability of the whole unit</td>
</tr>
<tr>
<td><strong>MaxiSulf®</strong></td>
<td>■ High variety of sub dew point processes aiming at recovery rates of 99.0% up to 99.5%</td>
<td>■ Sub dew point processes are in operational point of view the continuation of the catalytic Claus process</td>
</tr>
<tr>
<td><strong>SULFREEN®</strong></td>
<td>■ No chemicals/solvents used</td>
<td>■ Lower investment cost compared to tail gas units using a solvent</td>
</tr>
<tr>
<td><strong>HydroSULFREEN®</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LTGT®</strong> (Lurgi Tail Gas Treatment)</td>
<td>■ Selective absorption of H₂S versus CO₂ using generic MDEA as solvent</td>
<td>■ Highest recovery rates achievable (Claus+LTGT: 99.9+%</td>
</tr>
<tr>
<td></td>
<td>■ Non corrosive, non degrading, non toxic performance</td>
<td>■ Cost and energy efficient use of solvent</td>
</tr>
</tbody>
</table>
The Lurgi Purisol® process is ideally suited for the selective desulfurization of raw gases from the partial oxidation of heavy oils or from coal gasification.

Raw gases from the partial oxidation of heavy oils or from coal gasification are used as feedstock.
Purisol Process

- Besides H₂, CO₂ and CO, these gases also contain CS₂, H₂S, CO₅ and other impurities such as HCN und NH₃, which have to be removed.

- The clean fuel gas recovered in the Purisol® unit can be used as fuel gas in a down-stream co-generation process, for example.
In the process variant described here, pure sulfur is recovered from the separated sulfur compounds by combining the Purisol® wash with a Claus unit.

In the Purisol® process, N-Methyl-2-Pyrolidone (NMP) is used as physical solvent.
Purisol Process

- The solvent absorbs the undesired components $\text{CS}_2$, $\text{H}_2\text{S}$, $\text{COS}$, $\text{HCN}$, $\text{NH}_3$ as well as $\text{CO}_2$ from the raw gas.

- These components are subsequently desorbed again by reducing the pressure and reboiling the solvent.
As the solubility of $\text{H}_2\text{S}$ is significantly higher than that of $\text{CO}_2$, only very little $\text{CO}_2$ is co-absorbed.

Consequently, Claus gas with particularly high $\text{H}_2\text{S}$ concentrations can be produced.

HCN and higher sulfur compounds are also discharged into the Claus gas.
Purisol Process

- The solubility increases steeply as the temperature decreases.
- For this reason absorption is performed at low temperatures, while high temperatures are used for regeneration.
The simplified process flow diagram illustrates a desulfurization concept for an Integrated Gasification Combined Cycle (IGCC) plant.

Where required, impurities such as HCN or higher sulfur compounds are removed from the cooled raw gas in a pre-wash stage of the absorber.
In the main absorber section, the sulfur compounds, in particular H$_2$S, are removed from the raw gas until reaching the admissible residual concentration.

To this effect, the solvent from the hot regeneration, which has been subsequently cooled, is added at a temperature ranging between ambient temperature and -10°C.
Purisol Process

- Before the desulfurized clean fuel gas leaves the absorber, traces of NMP can be removed in a water wash.

- The solvent from the H$_2$S absorber contains large quantities of H$_2$S and little CO$_2$. 
Purisol Process

- It is relieved to a lower pressure in the bottom section of the reabsorber, whereby CO$_2$ and small quantities of H$_2$S are desorbed.

- The solvent from the hot regeneration in the upper section of the reabsorber immediately reabsorbs the H$_2$S.
As a consequence, sulfur-free gas leaves the reabsorber, which can either be rerouted to the raw gas stream or used as fuel gas.

The solvent from the reabsorber is heated and further flashed in the hot flashing stage.
Purisol Process

- Any $\text{CO}_2$ removed in this stage is returned to the reabsorber.
- The solvent leaving the hot flashing stage is completely regenerated by reboiling in the lower part of the hot regeneration.
Purisol Process

- The H$_2$S-rich gas is then routed to the downstream Claus unit.
- An adequate adjustment of pressures and temperatures allows for extremely high concentrations of H$_2$S.
Purisol Process

- The gas rich in H₂S is processed in a Claus plant and a hydrogenation unit, yielding pure sulfur from H₂S.

- The sulfur compounds produced in the Claus process are converted to H₂S by adding H₂ in the hydrogenating unit.
The exhaust gas from hydrogenation is cooled to condense the water contained in the gas.

The gas is then returned to the reabsorber of the Purisol® unit to be completely desulfurized.
The patented process arrangement presented above describes a zero-emission Claus plant that achieves a sulfur recovery rate of 100%.

The recovery rate of the overall desulfurization plant is thus only dependant on the sulfur concentration in the fuel gas.
Purisol Process

- Since the Purisol® process reduces the sulfur content in the fuel gas to only a few ppm H₂S, a desulfurization efficiency of up to 99.998% can be achieved.
Purisol Process

- If the raw gas contains material quantities of COS, they have to be treated by catalytic hydrolyzation before the H₂S wash.
Purisol Process

- The quantity of fuel gas produced is further boosted by the fact that more \( \text{H}_2 \) and \( \text{CO} \) forms in the Claus plant at high temperatures, than is consumed in the subsequent hydro-genation unit.

- In the same way, the complete \( \text{CO}_2 \) from the raw gas is also utilized in the gas turbine.
Technical Data

Typical consumption figures of a Purisol® unit in an IGCC plant with a raw gas quantity of 19410 kmol/h:

- Power supply: 4,300 kW
- Coolant (temperature gradient 10 K): 1,650 m³/h
Advantages

- Low solvent circulation rate due to high solubility.
- Production of Claus gas with a high $\text{H}_2\text{S}$ concentration.
Advantages

- Exhaust gas volume can be minimized in conjunction with an OxyClaus® process and admixed to the fuel gas in order to prevent emissions.
- No corrosion problems and no risk of plant freezing.
UAS

- Asam Asetat
- Asam Nitrat
- DME (dimetil eter)
- Melamin
- Formaldehida
- Asam Format
- MTBE
- Sulfamic Acid
- Ammonium Nitrat
UAS

Contents:

- Kegunaan
- Proses pembuatan
- Teknologi (*licensor*)
- Pasar
Contents:

- Biaya (Capex, operating cost)
- Harga
- Bonus nilai besar bila sampai ada cashflow dan evaluasi keekonomian (NPV 10%, Pay Back Time 10% dan $irr$) utk pendirian pabrik.
Note:

- Presentasi tanggal 6 (8) Mei dan 13 (15) Mei 2008
- Waktu presentasi 10 - 15 menit
- Full Paper dikumpulkan paling lambat tanggal 3 Juni 2008 (pk. 15.00) melalui ir.sutrasno@ui.edu.