ThioSolv, LLC's SWAATS Process

A Low-Cost Alternative for increasing SRU Capacity

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SWAATS Process

SWAATS was developed to process sour water stripper gas by converting the ammonia and hydrogen sulfide to ammonium thiosulfate. It can also be applied to

- Process amine acid gas
- Capture SO_2 from oxidized Claus tail gas or an extraction process
- Provide backup (redundancy) for Claus
- Remove H_2S from sour hydrocarbon gas or CO_2

$$6\,NH_3 + 4\,SO_2 + 2\,H_2S + H_2O \Longrightarrow 3\,(NH_4)_2S_2O_3$$

Ammonium Thiosulfate

ATS

- Produced as 60% aqueous solution
- Low toxicity, no H_2S emissions
- NFPA placard 0, 0, 0
- Density 1.34 (limits capacity of tanks designed for 1.0)
- Colorless to pale yellow
- Nearly odorless

Its fertilizer description is nominally 12N - 0 - 0 – 26S

Effects of SWSG on Claus Gas Flow Rates

Below show the effects of ***SWSG*** on the air demand and gas flow rates on the operation of the Claus.

AAG Claus Reaction

H_2S	+	O_2	+	N_2	==>	H_2O	+	N_2	+	S	**Gas Flow**
1		0.5		1.9		1		1.9		1	2.9
NH_3	+	O_2	+	N_2	==>	H_2O	+	N_2			
1		0.75		2.8		1.5		3.3			4.8
H_2O					==>	H_2O					
1						1					1.0
Total											**8.7**

SWSG creates 3 times as much gas traffic in the Claus as pure AAG

Consumes capacity and is problematic on-air control

Required 2 ½ times as much air to process SWSG as AAG

Effect on Current Operation

The following illustrations show how ThioSolv's SWAATS process can be added to an existing sulfur recovery system to expand capacity and improve operation.

Examples show typical flow rates of sulfur in [tpd] in the streams of an existing operation recovering 100 tpd of sulfur by Claus plus amine-based tail gas treating.

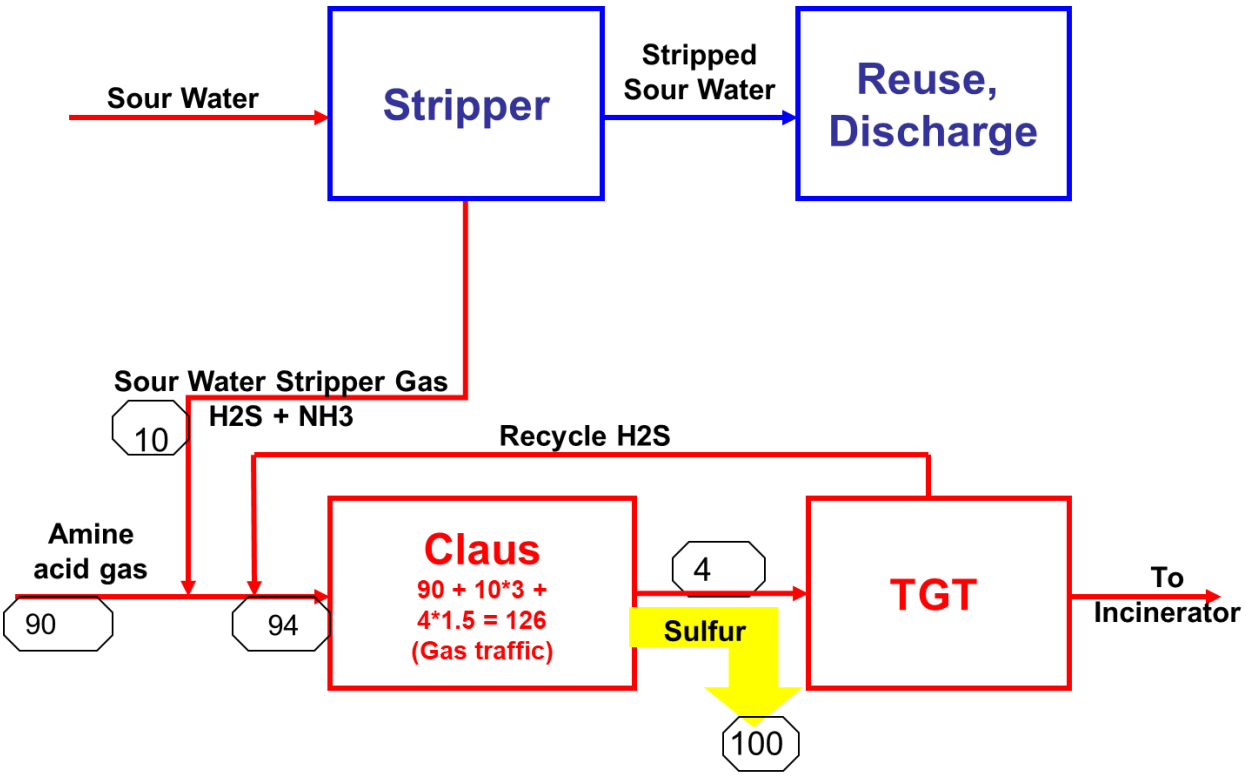
The example assumes 10% of total sulfur produced reaches the SRU via the sour water stripper gas. Actual may range from slightly less than 10 to over 40%.

Rates in actual units depend on presence of hydrocarbons, CO2, and inert gasses.

Factors affecting the fraction of total S that is in the SWSG are:

- N in crude
- Depth of HDS
- LCO included in treated diesel
- Extent of cat feed hydrotreating

Conventional SWS + TGT

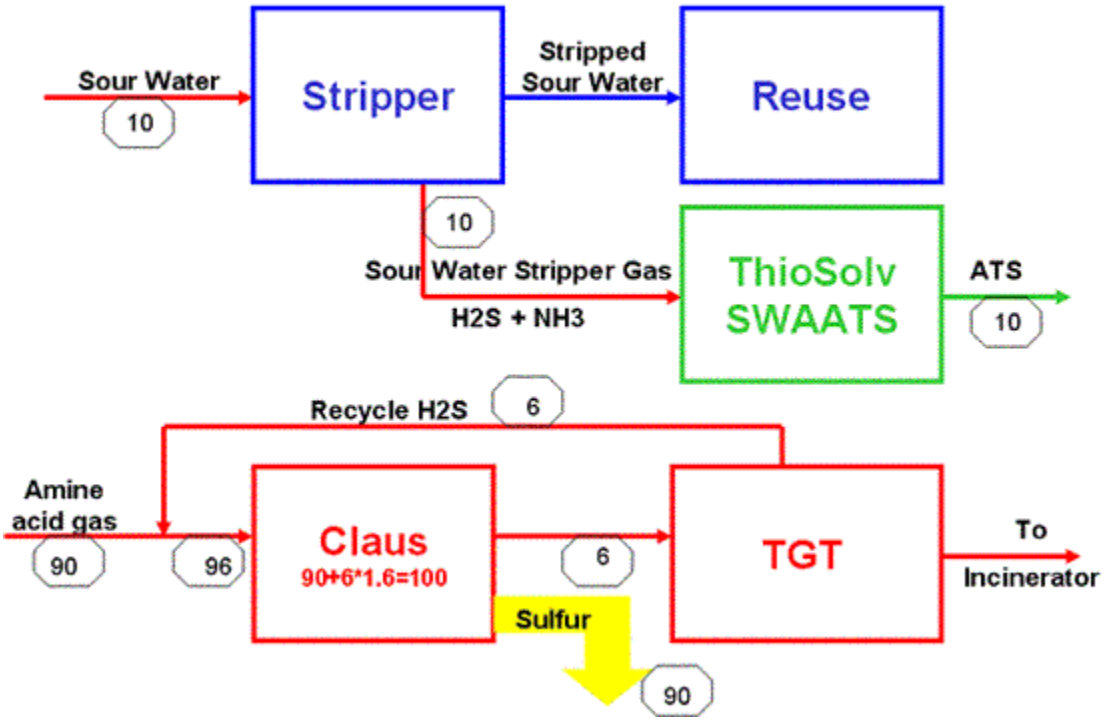


Notes Tons of S

Conventional Sour Water Stripper, SWAATS + Tail Gas Treater

- Assumes ten percent of S reaches SRU via SWS. Actuals range from 8% to 40%.
- Solubility of H_2S in water is low, but reaction with ammonia forms highly soluble NH_4HS. Therefore, the mol ratio of N to S in sour water is about 1.
- Best ammonia destruction in Claus is achieved under oxidizing conditions, requiring that the H_2S in SWSG fed to a Claus train not exceed 1/3 of the total H_2S fed.
- Variation in the rate or composition of SWSG to Claus challenges control of the air rate.
- When O_2 is deficient, ammonia salts and coke plug the catalyst.
- When O_2 is in excess, the SO_2 formed exceeds stoichiometric demand, increasing cost of chemical reduction in the TGT and sometimes breaking through into the quench and amine scrubbers. Increases formation of SO_3.
- Calculate Claus capacity in terms of equivalent AAG S rate. Recycle H_2S from TGT produces about 1.6 times as much gas because it contains about as much CO_2 as H_2S. AAG eq = 126 tpd

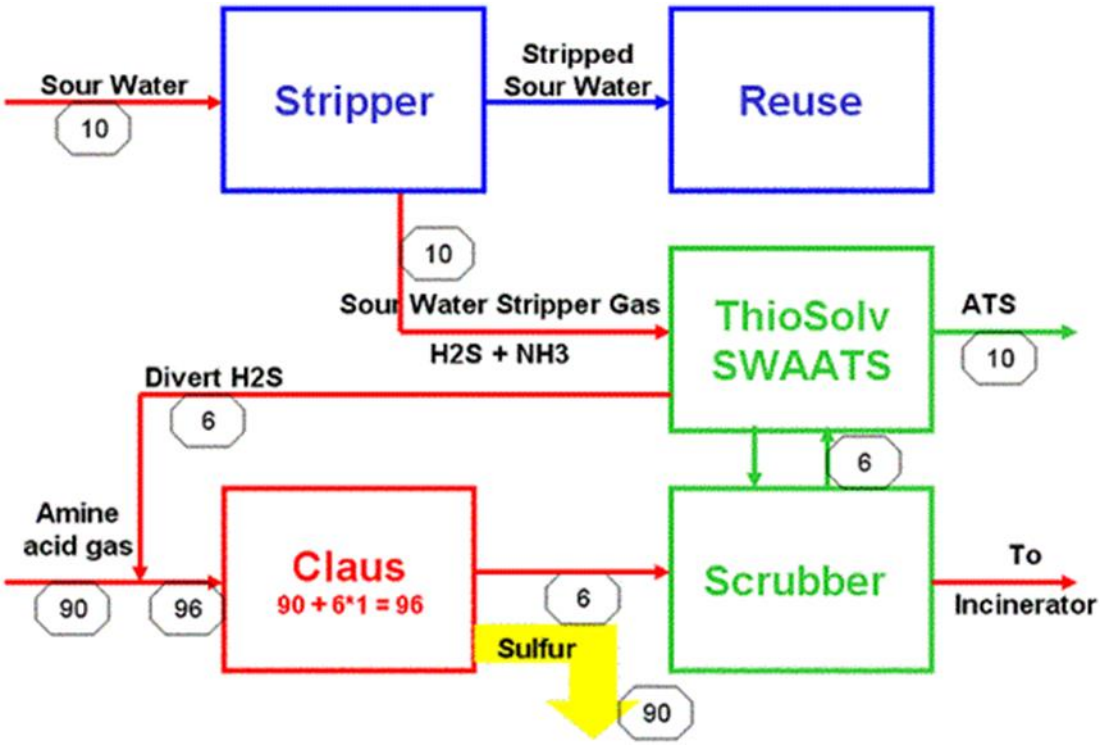
Sour Water Stripper + ThioSolv SWAATS



Claus and TG Scrubber converted to SWAATS

- Diverting the SWSG to ATS reduces the load on Claus and TGT. Note that AAG equivalent capacity used is 100 tpd, a reduction of 26 tpd.
- Eliminating NH_3 from Claus feed reduces upsets and extends life of catalyst.
- Lower gas rate through TGT can reduce emission of SO_2.

Sour Water Stripper + ThioSolv SWAATS as TG Scrubber



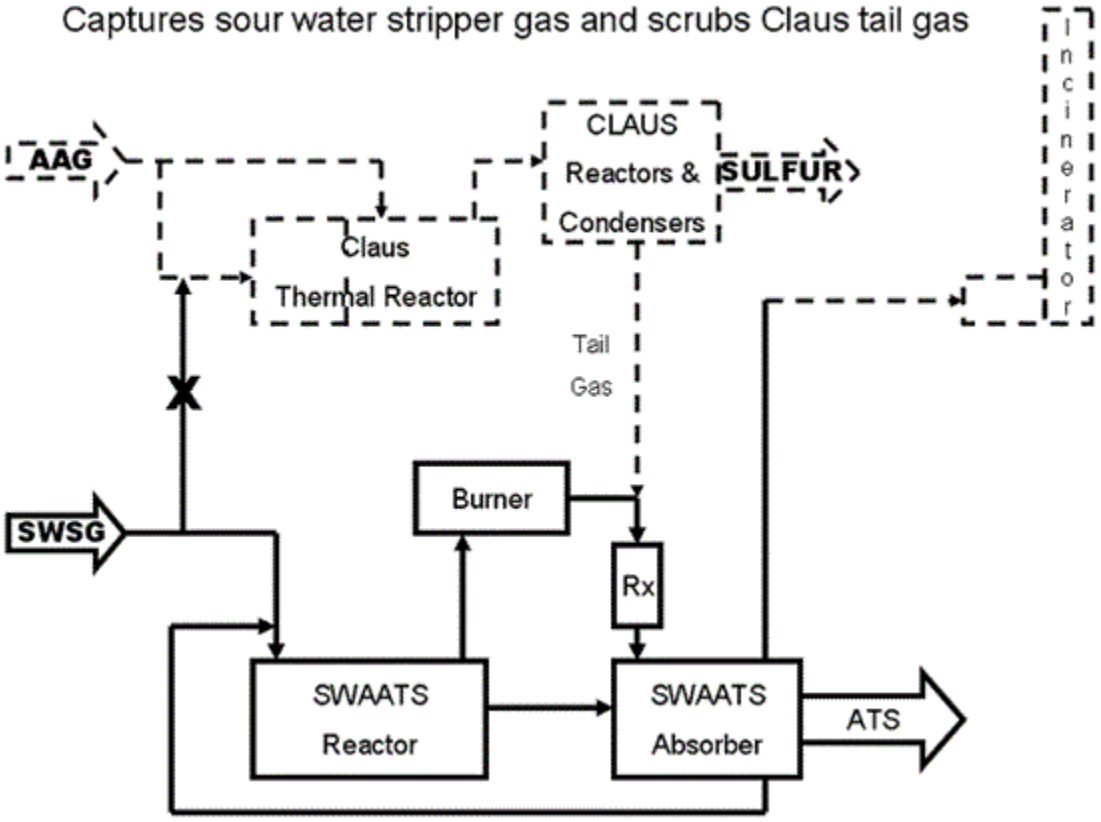
Expanding the ATS chemistry to scrub Claus tailgas:

- diverts H_2S from ATS to Claus feed equal to S in tail gas.
- lowers the multiplier on "recycle" H_2S by reducing CO_2

Results are:

- small reduction in AAG equivalent load on Claus.
- reduced [SO_2] in incinerator stack.

SWAATS Process Block Flow Diagram



- Tail gas from SWAATS contains no H_2S and low SO_2. It is shown directed to incineration only because Claus tail gas may contain CO from incomplete combustion in thermal reactor. The CO content is lower than from SCOT, which forms some CO in the burner that generates reducing gas and reheats the tailgas. Reheat in SWAATS is by combustion of H_2S or fuel in excess air, adding no CO to the tail gas.