New AGE strategies with HIGHSULF

A new member of HIGHSULF™ technologies, called HIGHSULF PLUS™, for improved acid gas enrichment and tail gas treatment performance, is presented by **T.K. Khanmamedov** of TKK Company and **R.H. Weiland** of Optimized Gas Treating, Inc. Prospective applications include shale gas treatment and acid gas enrichment (AGE) in hot climates where it can be difficult to achieve low enough lean amine temperatures using ambient air.

The basic concept of HIGHSULF technology for acid gas enrichment (AGE) and tail gas treating (TGTU) has been discussed in previous issues of *Sulphur (No.s 318, 330 and 342)*. In this article the latest process strategy, HIGHSULF PLUS, is discussed.

The most common processing scheme for AGE is the conventional flowsheet shown in Fig. 1. Low quality acid gas (H_2S, CO_2 plus other trace components) is contacted with selective solvent in the low pressure AGE absorber. This is intended to recover most of the H_2S and reject as much CO_2 as possible. The shortcoming of this scheme is that the acid gas feed itself is fixed by upstream processing; whereas, if it could be made to contain more H_2S, the gas to the SRU would automatically be of higher quality.

The flowsheet shown in Fig. 2 is the simplest implementation of the patented HIGHSULF PLUS process that permits controlling the effective composition of the AGE unit feed gas. The basic principle behind the HIGHSULF PLUS concept is quite straightforward: the higher the H_2S content of the feed gas to the absorber, the higher will be its absorption rate into the solvent. Concomitantly, higher H_2S in the feed means lower CO_2 content so the CO_2 will be absorbed more slowly. Consequently differences between the absorption rates of H_2S and CO_2 are made larger and selectivity is improved. The net result is higher H_2S concentration in the acid gas from the regenerator. The source of the additional H_2S in the absorber feed gas is a recycle stream of regenerator acid gas, and the greater the recycle flow the richer the absorber feed and, therefore, the richer the acid gas ultimately produced.

Depending on the extent to which the HIGHSULF PLUS technology is applied, the combined feed to the AGE absorber can be made richer in H_2S, allowing an even richer SRU feed to be produced.

An important prospective application of HIGHSULF is in gas plants processing shale gas. Cases with very low H_2S/CO_2 ratios in the acid gas from the upstream amine unit are anticipated. This dilute acid gas will need to be enriched before sending it to a downstream SRU. A HIGHSULF PLUS AGE unit could therefore play a major role in shale gas processing facilities.

Fig 1: **Conventional AGE**

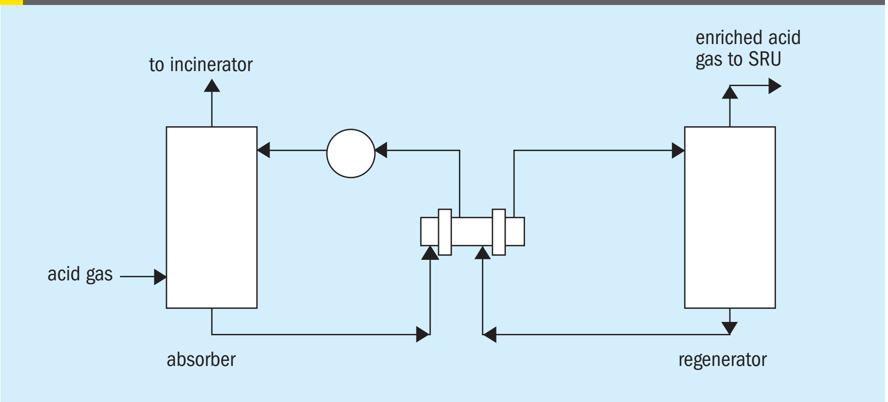


Fig 2: **HIGHSULF PLUS™ with combined feeds**

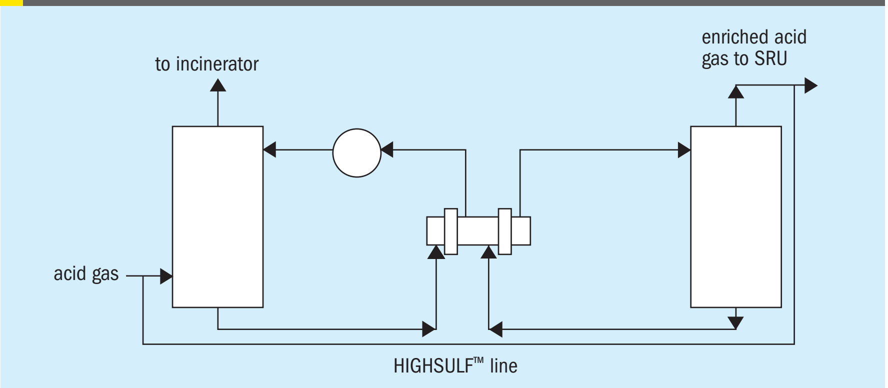
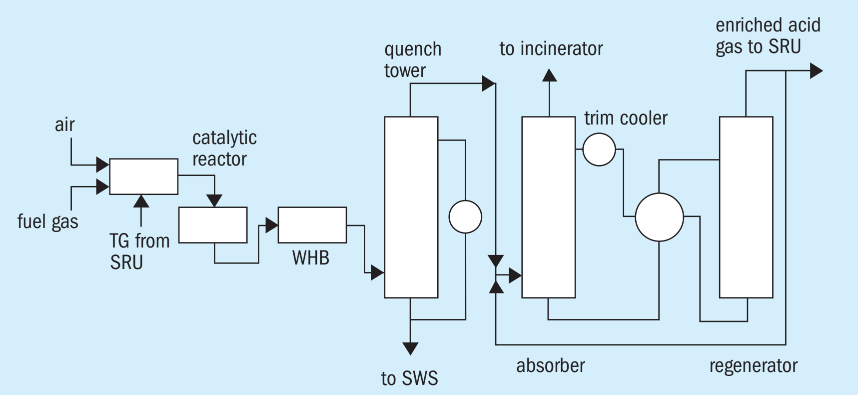


Fig 3: **HIGHSULF PLUS™ tail gas treatment unit** (improved SCOT)



Enriching moderate H_2S acid gas streams

The HIGHSULF PLUS process is analysed by comparison with conventional AGE units through use of a particular case study. Conditions are as follows: a 2.3 MMSCFD acid gas stream coming from a main amine treating unit contains 22.9% H_2S, 73.9 % CO_2, 0.47% of C_1 – C_3, 2.6 % H_2O, 0.07% N_2 and is at 12 psig and 120°F (49°C). This is not usable acid gas for a straight-through sulphur plant, and it can be enriched considerably by treating with MDEA. The solvent is 45 wt-% MDEA at 120°F and at the same constant circulation rate for all cases. The absorber in each case contains the same number of conventional valve trays and each is sized for 70% flood. All regenerators contained the same number of trays with 120°F (49°C) condensers. Reboiler conditions are 15 psig with constant duty. The main constraint applied to all operating schemes was that gas to incineration could not exceed 75 ppmv H_2S. This is a somewhat arbitrary stipulation but it ensures that comparisons are done under identical requirements.

Conventional amine unit vs HIGHSULF PLUS

The conventional scheme (Fig. 1) sets the comparison standard. Under the stated conditions, the ProTreat® simulator predicts that enrichment to 78% H_2S (wet basis) is possible, while sending only 90 ppmv H_2S to incineration by using HIGHSULF PLUS. A conventional MDEA based AGE unit produces acid gas with H_2S concentration as much as 17% lower than HIGHSULF PLUS. Furthermore, the HIGHSULF PLUS™ MDEA-based AGE produces only one-half the H_2S in the overhead of the absorber compared with a regular MDEA based AGE.

Tail gas treating

The patented HIGHSULF strategy can be applied with equal success to the amine section of a tail gas treating unit. The base-case unit is a conventional TGTU using 34 wt-% MDEA. A process flow diagram of the HIGHSULF PLUS TGTU (improved SCOT) is shown in Fig. 3. Its amine section was simulated using ProTreat® under the following conditions: the tail gas is 0.95% H_2S and 3.2% CO_2, balance nitrogen and water, and is flowing at 3 MMSCFD and a pressure of 15.7 psia. Considering the fact that HIGHSULF brings an additional dimension to the amine system, it was interesting to see how high the temperature of the lean amine can be and still have the AGE meet requirements. This aim derived from the well-known fact that fin-fan trim coolers can cause huge problems in the summer time in certain areas such as the Middle East. Results are shown in the tables below. Under these conditions, the treated gas going to incineration was about 114-251 ppmv H_2S for regular and HIGHSULF. The feed to the SRU is simulated to be 82-83 mol-% H_2S for HIGHSULF versus 65 mol-% from a regular unit. Note that for HIGHSULF PLUS the same duty for the lean/rich amine heat exchanger was maintained as for a conventional AGE unit, although the duty of the trim cooler went up slightly while the heat duty of the regenerator overhead condenser was somewhat reduced. The most important result shown in Table 1 is that 140°F of lean amine can be used quite successfully for a TGTU operated with the HIGHSULF PLUS process.

Table 1: **HIGHSULF PLUS TGTU at highest lean amine temperature**

	Regular	HIGHSULF PLUS						
Overhead H_2S, ppmv	114.6	121.4	125.7	131.0	138.1	148.9	182.3	251.1
H_2S in AG, mol-%	65.154	68.943	71.029	73.341	75.889	78.628	81.766	83.428
X-exchanger, MMBtu/hr	3.375	3.36	3.350	3.337	3.318	3.291	3.249	3.222
Trim cooler, MMBtu/hr	-1.259	-1.273	-1.283	-1.296	-1.315	-1.341	-1.382	-1.407
Lean temperature, °F	140	140	140	140	140	140	140	140
Condenser, MMBtu/hr	-1.854	-1.841	-1.829	-1.812	-1.795	-1.767	-1.716	-1.680

Table 2: **HIGHSULF PLUS TGTU at fixed value of trim cooler**

	Regular	HIGHSULF PLUS							
Overhead, H_2S, ppmv	58.56	62.75	65.36	68.55	72.78	78.72	88.49	97.05	117.3
H_2S in AG, mol-%	67.312	70.849	72.793	74.904	77.217	79.733	82.469	83.951	85.535
X-Exchanger, MMBtu/hr	4.236	4.188	4.154	4.11	4.051	3.966	3.829	3.728	3.584
Trim cooler, MMBtu/hr	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22
Lean temperature, °F	100.664	101.981	102.439	103.402	104.667	106.508	109.476	111.659	114.850

It is also instructive to run HIGHSULF PLUS against a regular TGTU for the same tail gas but at fixed value of the trim cooler duty. As shown in Table 2, for given duty of the trim cooler (i.e., an existing cooler) regular TGTU can be run with the lean amine temperature at 100°F. However, with the same trim cooler HIGHSULF PLUS TGTU can be run with the lean amine temperature at 106-114°F (41-46°C) with acceptable H_2S in the absorber overhead. The other important result is reduced duty of lean/rich heat exchanger and most importantly, the H_2S concentration in acid gas to the SRU jumps from 67 mol-% for a regular TGTU to 85 mol-% for HIGHSULF PLUS.

Table 3 summarises the results for HIGHSULF PLUS relative to a conventional MDEA-based TGTU running under otherwise identical conditions. HIGHSULF PLUS shows substantial advantages over a conventional TGTU. It should be pointed out that none of the simulation work done here by using the ProTreat® simulator was for optimised cases. Optimisation will put these advantages in an even brighter light.

Table 3: **Performance figures of regular and HIGHSULF PLUS TGTU**

Technology	Regular TGTU, Generic	HIGHSULF PLUS TGTU
Amine type	MDEA based	MDEA based
Able to meet 200 ppmv H_2S spec?	yes (<100 ppm)	yes (<100 ppm)
Amine concentration, wt-%	34	34
Amine cost per unit mass	1	1
Required inventory volume	1	1
Initial inventory cost	1	1
Amine circulation rate	1	1
Solvent contactor vessel volume	1	1
Solvent regenerator vessel volume	1	1
Regenerator reboiler duty	1	0.90
Regenerator condenser duty	1	0.90
Lean/rich amine exchanger duty	1	0.90
Amine air cooler duty	1	1
Temperature range of lean amine, °F	100	100-140
H_2S concentration in acid gas, mol-%	65-67	78-79
Mass flow of AG stream that recycled to SRU	1	0.45-0.50

Note: Most figures are given relative to generic MDEA

The synergistic effect observed when HIGHSULF PLUS is applied to the amine section of a TGTU reduces the level of H_2S going to the incinerator, increases the H_2S concentration in acid gas and substantially reduces cooling requirements for the lean amine in the trim cooler and the condenser of the regenerator. Allowing the amine section of the TGTU to be run at a higher lean amine temperature makes AGE commercially feasible in higher temperature environments. ■