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FULL LENGTH ARTICLE

Theoretical effect of concentration, circulation rate, stages, pressure and temperature of single amine and amine mixture solvents on gas sweetening performance

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Abstract This simulation experiment performed by Aspen Hysys is about theoretical investigation of gas sweetening performance of single amine solvents MEA[1], MDEA[2], DEA[3], DGA[4], DIPA[5] and mixed amine solvents DGA–MEA, DEA–MDEA and SULFOLANE[6]–MDEA. Sweet gas having very high percentage of methane is produced by MEA (95.36%), DGA–MEA (95.37%), DEA–MDEA (95.51%) and SULFOLANE–MDEA (95.10%) and DGA (93.76%) shows lowest performance. DGA, SULFOLANE–MDEA, MDEA remove H_2S at a lower circulation rate and DEA, DIPA need higher but satisfactory circulation rate. Increasing stage number shows positive effect on DEA, DIPA and SULFOLANE–MDEA. Pressure change has no significant effect. Temperature increase and methane percentage are negatively correlated for all solvents (except low circulating DIPA). With temperature increase H_2S composition increases for DEA–MDEA, DGA–MEA; CO_2 increases for DEA–MDEA, DGA–MEA and high circulating SULFOLANE–MDEA.

1. Introduction

Sour gas is a fossil fuel coming from gas wells containing methane, ethane and other hydrocarbons as well as oxygen, nitrogen, water carbon-di-oxide and hydrogen sulfide. The raw gas that comes from underground gas wells directly is referred as sour gas because of the presence of H_2S or both H_2S and CO_2. If H_2S is present in NG then it causes severe corrosion to pipelines, turbines, compressors and other equipment. H_2S is also a poisonous chemical, if it is exposed to environment for leakage it will cause harm to humans and animals in the surroundings. On the other hand, NG having high amounts of CO_2 is low efficient to be burned and CO_2 is also responsible for corrosion in pipeline because it forms carbonic acid by reacting with water vapor [1]. So reducing H_2S and CO_2 is a compulsory case for natural gas treatment process. In a gas treatment plant gas stream undergoes two major

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Table 1 Composition of Sour Gas (collected from laboratory of Chemical Engineering Department, BUET).

Name of the component	Composition
Methane	0.863413
Ethane	0.039246
Propane	0.008830
i-Butane	0.000748
n-Butane	0.000467
n-Pentane	0.000491
n-Hexane	0.000280
H_2O	0.046721
N_2	0.001766
CO_2	0.020377
H_2S	0.017661

treatment processes, the first process is sweetening where the amount of H_2S and CO_2 is reduced and amine or amine mixture is used for gas sweetening process and the other one is dehydration process to decrease water content. Maximum allowable limit of natural gas stream for H_2S is 4 ppm and for CO_2 is 2% [2].

2. Amine and amine mixtures

Choice of suitable solvent for gas sweetening depends on several criteria. Capability of removing H_2S and CO_2, pickup rate of hydrocarbons, heat requirement of solvent regeneration, vapor pressure, foaming, selectivity, thermal stability, corrosive nature, cost, availability etc. are considered during designing of a gas sweetening unit [3]. In this simulation experiment MEA, MDEA, DIPA, DEA, DGA, SULFOLANE–MDEA blend, DGA–MEA blend and DEA–MDEA blend are used as sweetening solvent. Primary amine MEA, the oldest in modern gas sweetening plants is used having concentrations between 10% and 20% (wt), the used concentration of DGA is between 50% and 65% (wt), DEA is between 25% and 35% (wt), MDEA is between 30% and 50% (wt), DIPA is between 30% and 40% (wt), SULFOLANE–MDEA is between 40–35% and 40–40% (wt), DGA–MEA is between 10–15% and 5–20% (wt) and DEA–MDEA is between 25–10% and 35–15% (wt) [3][4].

Chemical reactions for MEA and DGA are (R refers to amine) [3]-

$$RNH_2 + H_2S = RNH_3HS$$

$$RNH_2 + H_2O + CO_2 = RNH_3HCO_3$$

Chemical reactions for DEA are

$$R_2NH + H_2S = R_2NH_2HS$$

$$2R_2NH + CO_2 = R_2NCOOR_2NH_2$$

Chemical reactions for MDEA and DIPA are

$$R_2NCH_3 + H_2S = R_2NHCH_3HS$$

$$R_2NCH_3 + CO_2 + H_2O = R_2NHCH_3HCO_3$$

3. Fluid package

Aspen Hysys has initiated a new fluid package for amine system in a gas processing plant from 8.3 version named Acid Gas, but this fluid package can be applied only on some components. For MEA, MDEA, DEA, DGA, DIPA and SULFOLANE–MDEA mixer Acid Gas is used. In other three cases, for DGA–MEA blend, DEA–MDEA mixture and MEA; NRTL fluid package is used. The simulation systems where Acid Gas fluid package is used generally take much longer time to converge than NRTL, and also in Acid Gas fluid packaged systems for low circulation rates take two or three hundred iterations to converge, on the contrary less than 50 iterations is enough for any amount of circulation rate in NRTL systems.

4. Experiment

In this simulation experiment it is considered that two sour gas streams come from two gas wells. From one well 25 MMSCFD (1245 kml/h) sour gas enters in the separator at

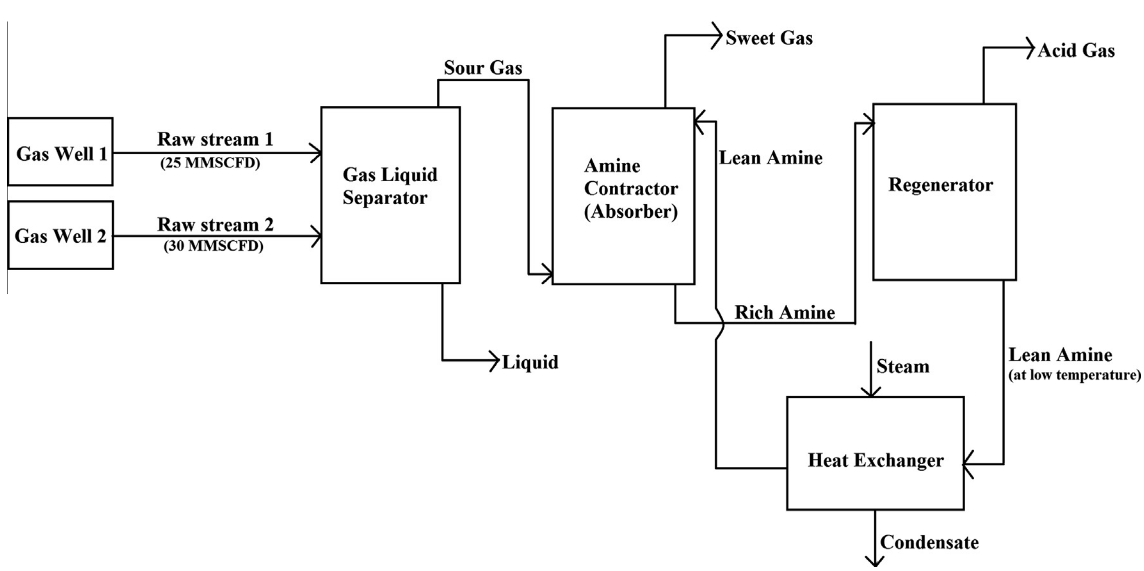

Figure 1 Simplified flow-chart of gas sweetening unit.