Effect of solvent concentration on the energy demand of an absorption-based natural gas sweetening plant

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Abstract

Fossil fuel-based hydrocarbons are a primary energy source for current civilization. They account nowadays for 83% of global energy consumption, and they are forecasted to account for 75% by 2035. Being 30% less pollutant than oil, demand for natural gas is expected to rise by nearly 1.8% per annum for the next couple of decades. However, 40% of the world’s natural or associated gas reserves currently identified as remaining to be produced have high acid gas content [1, 2].

From an industrial point of view, it is well established that chemical absorption with alkanol-amines is the most mature technology for reducing CO₂ content in gas flows. Yet, this process is still facing some serious drawbacks, chiefly due to the high energy demand. Moreover, the presence of volatile pollutants such as BTEX (Benzene, Toluene, Ethyl-Benzene and Xylene), which are common in sour gas reservoirs, may add even more stringent constraints; besides their toxicity, these compounds have strong affinity to amine solutions and might be drifted along to the regeneration unit and vented to the atmosphere [3]. Their emissions need to be controlled, frequently by incineration, which further increases the energy penalty of the absorption process.

The use of MDEA/DEA blend is a practical solution for reducing both regeneration energy and solvent thermal degradation. Many papers studied the optimal composition corresponding to the lowest energy demand at the reboiler [4]. This work focuses on the use of MDEA/DEA for natural gas sweetening in a wider framework, taking into account supplemental heat required to satisfy the constraint related to BTEX emissions.

Methodology

First, the Vapor Liquid Equilibrium predictions of Aspen_HYSYS-V9 fluid packages were compared to experimental measurements gathered from the literature [5, 6]. The model of Li-Mather was therefore selected and used for the simulation of an industrial scale acid gas removal unit. The predictions of the model were then compared to plant data: The relative error of CO₂ content in sweet gas was 2.15% whereas the errors of tray temperatures inside absorption and regeneration columns were respectively 2.14% and 5.10%.

Building upon the validated model, the impact of solvent composition on the required solvent flow rate, hydrocarbon loss as well as energy consumption was investigated. The results were considered into a single cost function.
Results

We have found that the solvent concentration is a key variable to satisfy both environmental and technical constraints. For a fixed CO₂ molar content of 2% ± 0.01% in the sweet gas flow, the minimum energy cost for the BETX-free case was estimated at 10.16$/ton CO₂ captured. The presence of BTEX entailed an average increase of 30%.

Also, the optimum was found to be influenced by the number of constraints: Figure 2 shows the COST/COST_{min} as a function of amine fraction for three cases; the simple case, where only reboiler duty is taken into account, the No-BTEX case which includes amine and hydrocarbon losses, and finally the BTEX case which further includes the energy required for incineration. The respective optimums were estimated at 45%, 40% and 60% amine mass fraction.

Figure 3 summarizes the relative effect of solvent concentration on different process variables; the details of each, as well as the contributions to the overall energy demand will be presented with more details in the final paper.

As a conclusion, the results show that the presence of BTEX in feed gas results in a considerable increase of energy demand and imposes new optimal solvent composition. Special attention should hence be given to the presence of such compounds at early stages of the design.

![Fig. 1 Process flowsheet](image)

![Fig. 2 Impact of amine concentration on overall energy cost,](image)

![Fig. 3 Overview of the impact of amine concentration on the plant performance,](image)
References