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Natural Gas Acid Gas Removal and Sulfur Recovery

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Abstract

Natural gas is generally defined as a naturally occurring mixture of gases containing both hydrocarbon and nonhydrocarbon gases. The hydrocarbon components are methane and a small amount of higher hydrocarbons. The nonhydrocarbon components are mainly the acid gases hydrogen sulfide (H_2S) and carbon dioxide (CO_2) along with other sulfur species such as mercaptans (RSH), organic sulfides (RSR), and carbonyl sulfide (COS). Nitrogen (N_2) and helium (He) can also be found in some natural gas fields. Natural gas must be purified before it is liquefied, sold, or transported to commercial gas pipelines due to toxicity and corrosion-forming components. H_2S is highly toxic in nature. The acid gases H_2S and CO_2 both form weak corrosive acids in the presence of small amounts of water that can lead to first corrosion and later rupture and fire in pipelines. CO_2 is usually a burden during transportation of natural gas over long distances. CO_2 removal from natural gas increases the heating value of the natural gas as well as reduces its greenhouse gas content. Separation of methane from other major components contributes to significant savings in the transport of raw materials over long distances, as well as savings from technical difficulties such as corrosion and potential pipeline rupture.

Natural gas processing projects are facing challenges due to stringent sales gas specifications and increasingly impure natural gas. CO_2, H_2S, N_2, He, COS, water, mercaptans, and organic sulfides need to be removed from natural gas prior to its liquefaction or sales. This report addresses the technology review and process economics of removing acid gases H_2S and CO_2 from raw natural gas and the subsequent conversion of H_2S to sulfur for sale. This report also gives an overview of conventional treating technologies, gas sweetening solvents, and the latest treating technologies for CO_2 removal, mainly using absorption processes.

This report presents the comparative technoeconomic evaluation for different feedstock with varying CO_2 and H_2S composition in the feed natural gas, by using two different type of solvents as mentioned below.

To illustrate the process economics of acid gas removal and sulfur recovery, we selected the following two modules. For Module-1, nine cases have been evaluated and compared, and for Module-2, three cases have been evaluated and compared. These cases have different sour gas feedstock natural gas composition by varying CO_2 and H_2S concentration. Following are the two type of modules that have been evaluated:

- Module-1: Acid gas removal from natural gas using MDEA and piperazine amine solvents, Claus sulfur recovery, and tail gas treatment using MDEA amine sweetening solvent

- Module-2: Acid gas removal from natural gas using Shell's Sulfinol®-X solvents, Claus sulfur recovery, and tail gas treatment using MDEA amine sweetening solvent

In these modules, each case has different H_2S and CO_2 concentrations in the feedstock raw natural gas. For different cases, CO_2 molar concentration is varies between 5%, 12%, and 20%, and H_2S molar concentration varies between 2%, 6%, and 10% in raw natural gas feedstock. For Module-1, nine cases, and for Module-2, three cases have been technoeconomically evaluated and compared for different combinations of H_2S, CO_2 concentration in the feedstock. For these different feedstock raw natural gas compositions, CAPEX and net production cost graphs has been prepared and results discussed for removal of acid gases from raw natural gas feed.

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