Petroleum and Chemical Engineering Department-College of Engineering-Sultan Qaboos University

# Evolutionary Optimization of Acid Gas Removal Process

**Mohammed Thafseer**

## Abstract

Acid gas removal is an important process, especially in the oil and gas industry, to remove acidic gases in the feed to meet environmental regulations and to protect machinery and pipelines. Non-dominated Sorting Genetic Algorithm II (NSGA-II) is used to optimize the process considering objectives where economic, process, environmental, and safety issues are targeted. The process is simulated in ProMax v4.0 and the optimization was carried out using excel-based multi-objective optimization (EMOO). In this study, acid gas removal process using DEPG solvent is optimized considering profit before tax (PBT), global warming potential (GWP), damage index (DI) and exergy destruction of the process as the major objectives. At the same time, the amount of sulfide removed from the feed gas and the amount of methane gas recovered also need to be maximized. The trade-offs that exist are investigated by reviewing the effects of the process variables on the objectives. Sensitivity analysis is carried out on the process which suggests the conditions of the sour gas feed and temperature of the solvent as the most important decision variables. Sulfur removal rate is greatly enhanced at low temperatures and high pressures. Profits depend a lot on the feed flow rate but the same negatively impacts safety and environmental indices. High temperatures and pressures are generally discouraged, unless absolutely necessary, as the increasing damage index values cannot be offset by the gain in the sulfur removal rates. Initially, two-objective cases are considered and the Pareto optimal solutions are obtained. Some of the two-objective cases are then compared with three-objective cases and the findings are reported. The study of the three-objective optimization is more complex, time consuming and challenging. It gives an understanding of the conflicting behavior of three different objectives with respect to the decision variables. Sulfur removal and methane recovery are in direct conflict with each other since the solvent will try to remove both, although at varying rates. High rate of sulfur removal requires a lot of heat and adds to the operating costs, increasing the total heat and leading to a drop in the profits. At the same time, increasing the profits requires high flow rate of the feed. This will increase the flow rate of the exiting gases and lead to high values for the environmental indicators. The damage index values will also be very high when high profits are projected. Exergy destruction increases when high sulfur removal, methane recovery or profits are desired. Also, more exergy destruction occurs when the surrounding temperature is lower due to the larger difference in temperature between system and surroundings. The Pareto-optimal solutions of the optimization and the dependence of the objectives on the different decision variables is provided to the decision makers who can analyze the Pareto-optimal solutions to determine the preferred operating point based on the importance placed on each objective.

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This study adds value to the acid gas removal (AGR) process by considering a variety of conflicting economic, environmental and thermodynamic aspects. The results can be useful to process engineers working in the related field after verifying their process details with this study. To the best of our knowledge, this is the first kind of study on multi-objective optimization of acid gas removal process considering the conflicting objectives used in this study.