

STUDYING OF THE EFFECTIVENESS PARAMETERS ON GAS DEHYDRATION PLANT

Kh. Mohamadbeigy

Research Institute of Petroleum Industry Tehran, Iran, P.O. Box 14757-3311

E-mail: mohamadbeigy@ripi.ir

Received December 15, 2007, accepted May 15, 2008

Abstract

Gas dehydration is widely used in natural gas treatment plant as a common process, because water and hydrocarbons can form hydrates, which may block valves and pipelines. Also, water cause corrosion in the gas contains acid components.

Until today, the most popular dehydration technology remains absorption with liquid triethylene glycol.

In this paper present a comprehensive study on gas drying unit and investigate the effectiveness parameters such as glycol flow rate, stages number of absorption tower and stripping gas rate on water content in glycol dehydration units.

Key words: gas dehydration; triethylene glycol;

1. Introduction

Dehydration to dew points below the temperature to which the gas will be subjected will prevent hydrate formation and corrosion from condensed water. The latter consideration is especially important in gas streams containing CO₂ or H₂S where the acid gas components will form an acid with the condensed water.

Absorption dehydration involves the use of a liquid desiccant to remove water vapor from the gas. Although many liquids possess the ability to absorb water from gas, the liquid that is most desirable to use for commercial dehydration purposes should possess the following properties:

- High absorption efficiency.
- Easy and economic regeneration.
- Non-corrosive and non-toxic.
- No operational problems when used in high concentrations.
- No interaction with the hydrocarbon portion of the gas, and no contamination by acid gases.

By far the most common process for dehydrating natural gas is to contact the gas with a hygroscopic liquid such as one of the glycols. The glycols, particularly ethylene glycol (EG), diethylene glycol (DEG), triethylene glycol (TEG), and tetraethylene glycol (T₄EG) come to closest to satisfying these criteria to varying degrees. Water and the glycols show complete mutual solubility in the liquid phase due to hydrogen-oxygen bonds, and their water vapor pressures are very low. One frequently used glycol for dehydration is triethylene glycol, or TEG ^[1, 2].

It can be used an alcohol or one of the glycols as an inhibitor in gas treatment plant. Determination of the amount and concentration of inhibitors and their distribution in different phases are very important for practical purposes and industrial applications. Therefore, in order to determine the required amount and concentration of these inhibitors, several thermodynamic models for hand and rigorous calculations have been developed and incorporated into the computer software.

Most glycol dehydration processes are continuous. That is, gas and glycol flow continuously through a vessel (the "contactor" or "absorber") where they come in contact and the glycol absorbs the water. The glycol flows from the contactor to a "reboiler" (sometimes called "reconcentrator" or "regenerator"¹) where the water is removed or "stripped" from the glycol and is then pumped back to the contactor to complete the cycle. In Figure (1) is shown process flow diagram of Glycol dehydration unit. The glycol solution enters at the top of the Absorber tower and absorbs water as it progresses toward the bottom of the column. A dry gas exits at the top of the contactor and may be used for cooling the incoming lean glycol^[1-2].

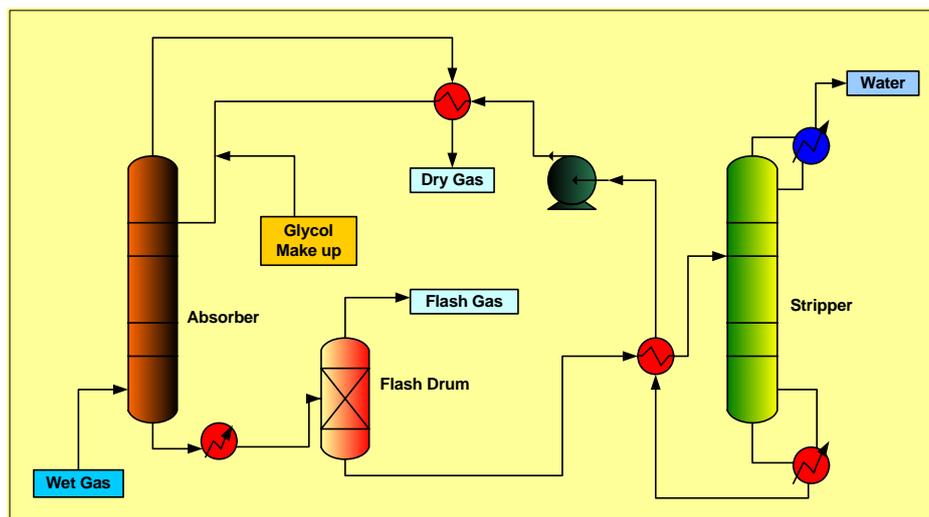


Figure (1): Typical glycol dehydration unit

The rich stream flows to a separator or flash tank where gaseous hydrocarbons that were absorbed along with some of the water in the contactor are liberated and used as fuel. Finally, the glycol flows to the stripper where it is regenerated by boiling off the water and returned to the contactor. For processes requiring gas with very low water dew points, a stripping vapor will most likely be needed to aid the regeneration process.

Glycol system sizing involves specifying the correct contactor diameter and number of trays, which establishes its overall height; selecting a glycol circulation rate and lean glycol concentration; and calculating the reboiler heat duty. The number of trays, glycol circulation rate and lean glycol concentration are all interrelated. For example, the greater the number of trays the lower the circulation rate or lean glycol concentration required^[3-8].

This paper presents an investigation of required parameters for dehydration units design. The results provide an analysis of the dehydration effectiveness at a variety of common operating variables for a typical dehydration facility.

2. Dehydration unit simulation

Table (I) shows the feed specification, which it is used as a sample for simulation and modeling of dehydration unit.

Table (I): Feed Specification

Composition	(% mol)	Composition	(% mol)
Nitrogen	0,10	Propane	1,48
CO ₂	2,84	i-Butane	0,59
H ₂ S	1,55	n-Butane	0,30
Methane	89,89	i-Pentane	0,10
Ethane	3,10	n-Pentane	0,05

Effectiveness parameters such as trays number of absorber, glycol circulation rate and regeneration condition are studied to obtain optimum condition.

In addition to the design parameters listed above, several other factors influence the residual water content of the sales gas. However, often these factors are fixed and cannot normally be changed when optimizing a unit.

First, the temperature of the inlet gas will dictate the total amount of water fed to the unit. Lower plant inlet gas temperatures will require less water to be removed by the glycol. Second, lean glycol temperature at the top of the contactor will affect the water partial pressure at the top stage. Consequently, high glycol temperatures will result in high water content in the overhead gas. However, this temperature is normally no cooler than 5°C above the inlet gas to prevent hydrocarbons in the feed from condensing in the solution. This limit is normally maintained by a gas/glycol exchanger that cools the lean glycol to approximately a 5°C approach using the dry gas.

Other parameters in the plant have limited or no effect on the dry gas water content. The number of equilibrium stages in the regenerator has only a slight effect on the lean glycol purity. Equilibrium at the reboiler temperature and pressure is approached in the reboiler so that additional stages have no effect.

Operating temperature of the lean/rich glycol exchanger only significantly impacts the reboiler heat duty.

3. Modeling results

Figure 2 illustrates the effect of the number of equilibrium contact trays on residual water content using a 85°C reboiler. Increasing the number of trays allows the gas to approach equilibrium with the lean glycol at a lower glycol circulation rate.

Considering a typical glycol circulation rate of approximately 0,06 m³ TEG/kg water removed and a three equilibrium-stage contactor is virtually at equilibrium with the inlet glycol. In a two stage contactor, a circulation rate of 0,1 to 1 m³ TEG/kg water would be required to approach equilibrium. Significantly higher flow rates would still be required when only one ideal stage is used.

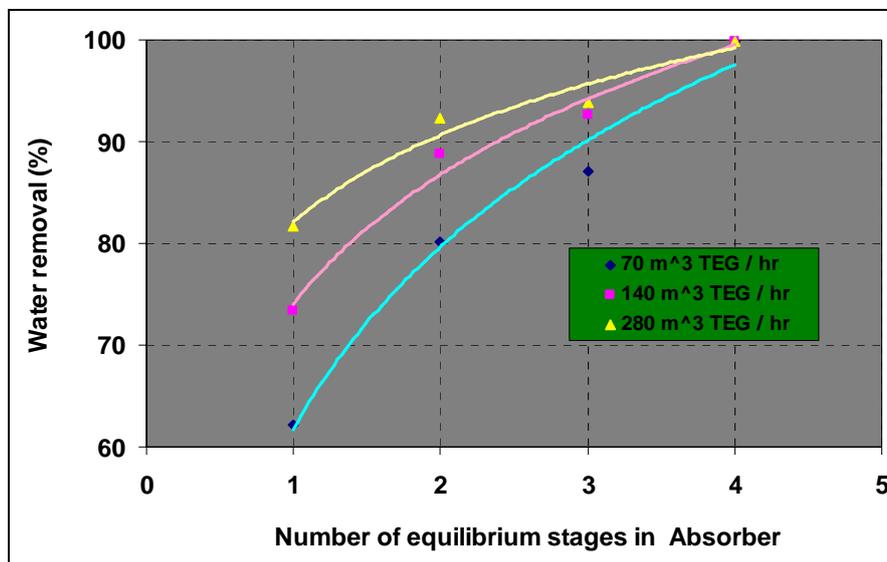


Figure (2): Water removal versus number of equilibrium stages in the contractor

Figure 3 shows the effect of absorber pressure on water removal of gas stream. At a constant temperature the water content of the inlet gas decreases with increasing pressure, thus less water must be removed if the gas is dehydrated at a higher pressure.

In addition, a smaller contactor can be used at high pressure as the actual velocity of the gas is lower, which decreases the required diameter of the contactor.

At lower pressure less wall thickness is required to contain the pressure in a given diameter contactor, therefore, an economic trade-off exists between operating pressure and contactor cost.

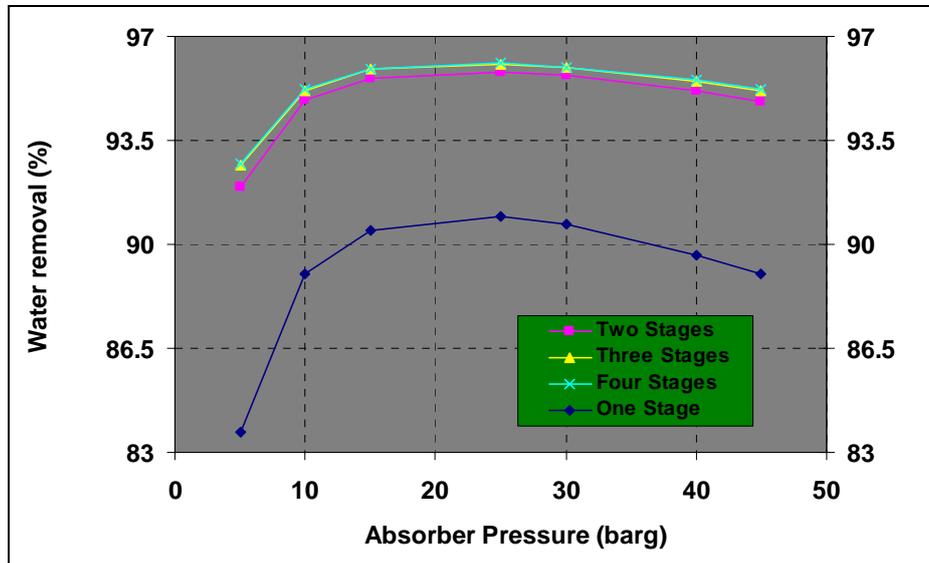


Figure (3): Effect of pressure in the contactor on the water content of gas stream

Figure 4 illustrates the effect of this CO₂ concentration on the dehydrated gas water content. The results indicate that the addition of CO₂ slightly increased the water content about 0,45 kg water/MMscf gas at all glycol circulation rates.

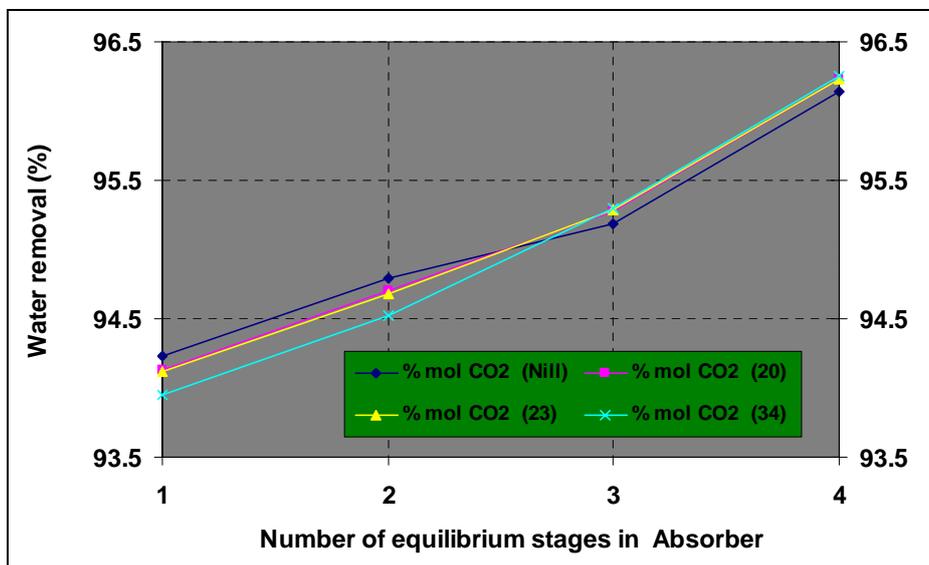


Figure (4): Carbon Dioxide content in gas feed on the water removal

The reboiler temperature influences the overhead water content by changing the purity of the lean glycol.

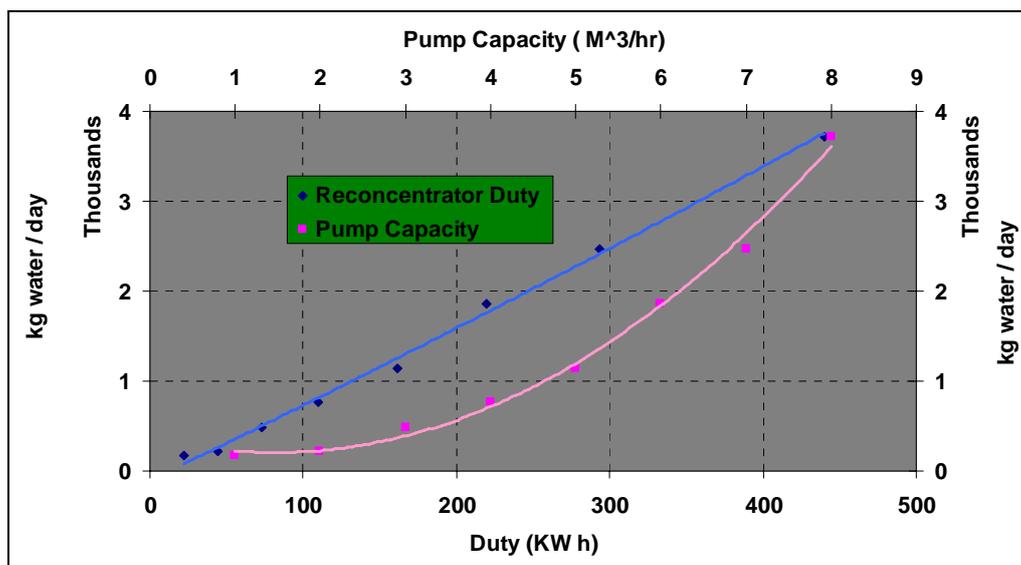


Figure (5): Utility consumption in maximum capacity- kg water/ day removed glycol reconcentrator (Glycol circulation rates: 0,008 (m³ Glycol/kg water removed)

The reboiler duty is then the sum of the sensible heat required to raise the wet glycol to reboiler temperature, the heat required to vaporize the water in the glycol, the heat required for the reflux (which is estimated at 25 to 50% of the heat required to vaporize the water in the glycol) and losses to atmosphere (figure 5).

4. Conclusions

It should be considered a number of alternatives for selecting a method to suppress hydrate formation. In designing dehydration units for natural gas, several critical parameters exist which can be varied to achieve a specified dew point depression.

The process simulation is a suitable tool, which can help to determine optimum condition for maximum efficiency. The effectiveness parameters such as trays number of absorber, glycol circulation rate and operating condition should be investigated for a reliable, available and maintainable plant with economical consideration.

References

- [1] Gas Processors Suppliers Association, Engineering Data Book, 1987.
- [2] Kohl.A and Riesenfeld. F, "Gas Purification", Gulf Publishing Co., Houston, 1985.
- [3] Chorng H. Twu, Vince Tassone, Wayne D. Sim and Suphat Watanasiri, "Advanced equation of state method for modeling TEG–water for glycol gas dehydration Fluid Phase Equilibria", V. 228-229, p. 213-221, 2005.
- [4] Darwisha.N and Hilalb.N, " Sensitivity analysis and faults diagnosis using artificial neural networks in natural gas TEG-dehydration plants", Environmental Modelling & Software, V 19, N 10, PP 957-965, 2007.
- [5] Landreau.B, Amade.J, Doerler.N and Bojey.A, "Gas drying process using glycol, including purification of discharged", us Patent No. 6004380, 1999
- [6] Jou, F. Y., Deshmukh, R. D., Otto, F. D., and Mather, A. E., "Vapor-Liquid Equilibria for Acid Gases and Lower Alkanes in Triethylene Glycol", Fluid Phase Equilibria, V 36, P. 11, 1987.
- [7] Meyers.R.A, "Handbook of Petroleum Refining Processes", McGraw-Hill Professional, third edition, 2003.
- [8] Takahashi.S and Kobayashi.R, "The Water Content and the Solubility of CO₂ in Equilibrium with DEG-Water and TEG-Water Solutions at Feasible Absorption Conditions", Technical Publication TP-9, GPA, 1982.