GAS DEHYDRATION PROCESS BY USING TRIETHYLENE GLYCOL AND SILICA GEL

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I declare that this thesis entitled " Gas Dehydration Process by Using Triethylene Glycol and Silica Gel" is the result of my research except as cited in the references. The thesis has not been accepted for any degree and is not currently submitted in candidate of any other degree.

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Dedicated, in thankful appreciation for support,
encouragement and understanding
to my beloved family and friends.

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ABSTRACT

Gas dehydration is widely used in natural gas treatment plant as a common process, because water and hydrocarbon can form hydrates (ice formation) which may block valve and pipelines. Water also can cause corrosion in the presence of acid gas component in natural gas. Until today, the most popular dehydration process is adsorption and absorption process. The objective of this study was to remove the water content in natural gas for adsorption and absorption process. This study consists of fabricating the lab scale dehydration unit by using PVC-Clear pipe. Two types of desiccant were used in this study which is silica gel for adsorption process and triethylene glycol for absorption process. The various quantity of desiccant was used in this study to get the maximum amount of water content removal from natural gas. In this study, the methods used were designing, fabricating, testing, experimental and analyzing. From the study, the maximum allowable operating pressure for both dehydration unit is 0.3 bar. Furthermore, the higher quantity of desiccant gives the higher amount of water content removal from natural gas. The result also shows that the increasing operating pressure for the process will decrease the water content removal from natural gas for both processes. Lastly, triethylene glycol is a better desiccant compare with silica gel in dehydration process for this study.

ABSTRAK

Penyahhidratan gas adalah digunakan secara meluas dalam loji rawatan gas asli seperti satu proses biasa, kerana air dan hidrokarbon boleh membentuk hidrat (pembentukan ais) yang mungkin menahan injap dan talian paip. Air juga boleh menyebabkan kakisan dalam kehadiran komponen gas asid di dalam gas asli. Sehingga hari ini, proses penyahhidratan paling meluas adalah proses penjerapan dan proses penyerapan. Objektif kajian ini adalah bagi membuang kandungan air dalam gas asli untuk proses penjerapan dan proses penyerapan. Kajian ini mengandungi pemasangan unit pengdehidratan berskala makmal dengan menggunakan paip PVC Clear. Dua jenis bahan pengering telah digunakan dalam kajian ini iaitu gel silika untuk penjerapan proses dan triethylene glycol untuk proses penyerapan. Pelbagai kuantiti bahan pengering telah digunakan dalam kajian ini untuk mendapat jumlah maksimum pembuangan isi air daripada gas asli. Dalam kajian ini, kaedah-kaedah yang digunakan adalah mereka, memasang siap, ujian, eksperimen dan pengkajian. Daripada kajian itu, maksimum tekanan pengendalian dibenarkan untuk kedua-dua unit pengdehidratan adalah 0.3 bar. Tambahan pula, kuantiti lebih tinggi bahan pengering memberi jumlah lebih tinggi pembuangan isi air daripada gas asli. Hasil juga menunjukkan yang tekanan pengendalian bertambah untuk proses akan merosot air pembuangan isi daripada gas asli untuk kedua-dua proses. Akhirnya, triethylene glycol adalah satu perbandingan bahan pengering yang lebih baik bebanding gel silika dalam penyahhidratan proses untuk kajian ini.

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LIST OF ABBREVIATIONS

NG	-	Natural Gas
TEG	-	Triethylene Glycol
CO2	-	Carbon Dioxide
N2	-	Nitrogen
H2S	-	Hydrogen Sulfide
^0C	-	Degree Celsius
^0F	-	Degree Fahrenheit
PVC	-	Polyvinyl Chloride
VCM	-	Vinyl Chloride
MAOP	-	Maximum Allowable Operating Pressure

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Over the past few years, a world shocked about the natural gas prices that have been increasing rapidly. The sky-high natural gas prices have hammered mostly a chemical company where use gas as a fuel and feedstock. Seventeen organization especially chemical company as well as environmental and conservation group had fired off a letter to World congress last week urging a new energy policy to solve the nation's natural gas crisis (1). As a result, companies and trade associations have appealed for government support of more drilling and production as well as greater efficiency. More industrial person thinks or encouraged the congress to do more on drilling activities but an environmental and energy conservation groups have urged in the efficiency of natural gas itself (2).

Natural Gas is a gaseous fossil fuel consisting primarily of methane but including small quantities of ethane, propane, butane, pentane and any heavier hydrocarbon; element sulfur; and sometimes helium and nitrogen (3). Natural gas can be discovered in the wellhead. It comes from the three types of well such as oil wells, condensate wells and gas wells. This gas are exists separate from the oil (free gas) or dissolved in the crude oil (dissolved gas) (4). Before natural gas can be used as a fuel, it must undergo extensive processing to remove almost all materials other than methane. The by-products of that processing include ethane, propane, butanes, pentanes and higher molecular weight hydrocarbons, elemental sulfur, and sometimes helium and nitrogen. To get the higher impurities of methane, there are several process need to be done such as oil and condensate removal, separations of natural gas liquid, sulfur and carbon dioxide removal and water removal.

Natural gas contains many contaminants, of which the most common undesirable impurity is water. Most natural gas will be near water saturation at the temperature and pressure of production. Process that involved removing all the water content in the natural gas can be known as a dehydration process. This dehydration process is needed to reduce the potential for corrosion in the presence of acid gas, hydrate formation, and freezing in the pipeline stream. Water is also removed to meet a water dew point requirement of a sales gas contract specification range from 32.8 to 117 $kg/10^6$ std m^3 (5). The dehydration process can be done into many different types of process. But, only two process that widely use which is an absorption process and adsorption process.

1.2 PROBLEM STATEMENT

Nowadays, natural gas is most valuable source in the world because this source are become decrease follow the year. It is because, natural gas is a very important sources to generate the energy that widely used in commercial, industrial and transportation. But, there was a problem in natural gas that we need to prevent. Under normal production condition, the natural gas is saturated with water vapor. The present of water vapor can cause the corrosion in pipeline when acid gas is present. Process of dehydration is needed to remove the content of water in wet gas. The purposes of dehydration are to prevent gradual plugging of the pipeline by ice formation, to avoid the formation of liquid slugs, to avoid risk of condensation of water in pipeline and to maximize pipeline efficiency (6). There are several method can be used to dehydrate natural gas such as absorption and adsorption process. Silica gel is used in the adsorption process. This process is quite easy because adsorption by silica gel is purely a surface phenomenon. This process can occur in any temperature and pressure. In the absorption process, triethylene glycol (TEG) is used because of their superior dew point depression, operating cost and operation reliable. This process needs a high temperature to give a high water remove. However, the temperature must not drop 5^{o}C from the process temperature because it will cause the feeds to condense (7). The mass of silica gel needs to be review to know how much that water content in the dry gas are removed in the adsorption process and to study the effect of the flow rate of glycol in the absorption process. Also, the surrounding temperature in vessel need to be considered to made the absorption and adsorption process occurs.

1.3 OBJECTIVE

To remove the water component in natural gas by using triethlylene glycol in absorption process and silica gel in adsorption process.

1.4 SCOPE OF RESEARCH WORK

1. To study the effect of quantity triethlylene glycol in the absorption process.
2. To study the effect quantity of silica gel in the adsorption process.
3. To design the lab scale dehydration unit due to maximum allowable operating pressure.
4. To fabricate the lab scale dehydration unit.
5. To analyze the water removal based amount of desiccant before and after process.

CHAPTER 2

LITERATURE RIVIEW

2.1 Natural Gas

Natural gas is a gaseous fossil fuel that commercially produce from oil fields(associated gas) either dissolved or isolated in natural gas fields(non-associated gas) , and in coal beds. Natural gas is not a pure product underground. Since natural gas is not a pure product, when non-associated gas is extracted from a field under supercritical (pressure/temperature) conditions, it may partially condense upon isothermic depressurizing.. The liquids thus formed may get trapped by depositing in the pores of the gas reservoir. One method to deal with this problem is to reinject dried gas free of condensate to maintain the underground pressure and to allow reevaporation and extraction of condensates (8).

Natural gas are produced from the plants and animal decayed and built up in thick layer about millions years ago. This decayed matter from plants and animals is called organic material. Over time, the mud and soil changed to rock, covered the organic material and trapped it beneath the rock. Pressure and heat changed some of this organic material into coal, some into oil (petroleum), and some into natural gas (9).

Methane is primary component in natural gas which is the shortest and lightest hydrocarbon molecule. Natural gas also contain many heavy hydrocarbon such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) and also have other gases such as helium, nitrogen, sulfur, carbon dioxide and water vapor. Natural gas that contains hydrocarbons other than methane is called wet natural gas. Natural gas consisting only of methane is called dry natural gas (10).

Table 2.1 : Component of natural gas

Component	**Typical wt. %**
Methane (CH_4)	70-90
Ethane (C_2H_6)	5-15
Propane (C_3H_8) and Butane (C_4H_{10})	< 5
CO_2, N_2, H_2S, etc.	balance

(source: http://en.wikipedia.org/wiki/Natural_gas, assessed on 13 August 2008)

2.2 Gas Dehydration

Under normal production condition, the natural gas is saturated with water vapor Water vapor components in natural gas can cause many problems especially in the pipeline stream. Process that involved removing the water content can be known as dehydration process. This dehydration process is a important process in operate the natural gas. The purpose of dehydration process is to prevent gradual plugging of the pipeline by ice formation, to avoid the formation of liquid slugs, to avoid risk of condensation of water in pipeline and to maximize pipeline efficiency. Water is also removed to meet a water dew point requirement of a sales gas contract specification range from 32.8 to 117 kg/10^6 std m^3 (11).

There are 4 types of process to remove the water content which is absorption process, adsorption process, gas permeation and refrigeration (12). Compare to 4 processes as state before, only two processes are widely used in the industry which is an absorption and adsorption process.

2.3 Absorption Process

Glycol dehydration is a process removing the water from natural gas by using the glycol solvent. It is the most common and economic means of water removal from these streams. There are many types of glycol that be used in industry but the most commonly and widely used is a triethylene glycol.

For the process, pure triethylene glycol is fed to the top of an absorber where it is contacted with the wet natural gas stream. The glycol removes water from the natural gas by physical absorption and is carried out the bottom of the column. The dry natural gas leaves the top of the absorption column and is fed either to a pipeline system or to a gas plant.

After leaving the absorber, the rich glycol is fed to a flash vessel where hydrocarbon vapors are removed and any liquid hydrocarbons are skimmed from the glycol. This step is necessary as the absorber is typically operated at high pressure and the pressure must be reduced before the regeneration step (13). Due to the composition of the rich glycol, a vapor phase will form when the pressure is lowered having a high hydrocarbon content.

After leaving the flash vessel, the rich glycol is heated in a cross-exchanger and fed to the stripper (also known as a regenerator). The glycol stripper consists of a column, an overhead condenser, and a reboiler. The glycol is thermally regenerated to remove excess water and regain the high glycol purity.

The hot lean glycol is cooled by cross-exchange with rich glycol entering the stripper. It is then fed to a lean pump where its pressure is elevated to that of the glycol absorber. After raising the pressure, the lean solvent is cooled again with a trim cooler before being fed back into the absorber. This trim cooler can either be a cross-exchanger with the dry gas leaving the absorber.

However, there are several operating problems with glycol dehydrators. Suspended foreign matter, such as dirt, scale and iron oxide, may contaminate glycol solutions. Also, overheating of the solutions may produce both low and high boiling decomposition products (14). The resultant sludge may collect on heating surfaces, causing some loss in efficiency or, in severe cases, complete flow stoppage. Liquids in inlet gas may require installation of an efficient separator ahead of the absorber. Foaming of solution may occur with resultant carry-over of liquid

Figure 2.1 shows the flow diagram for dehydration by using triethylene glycol.

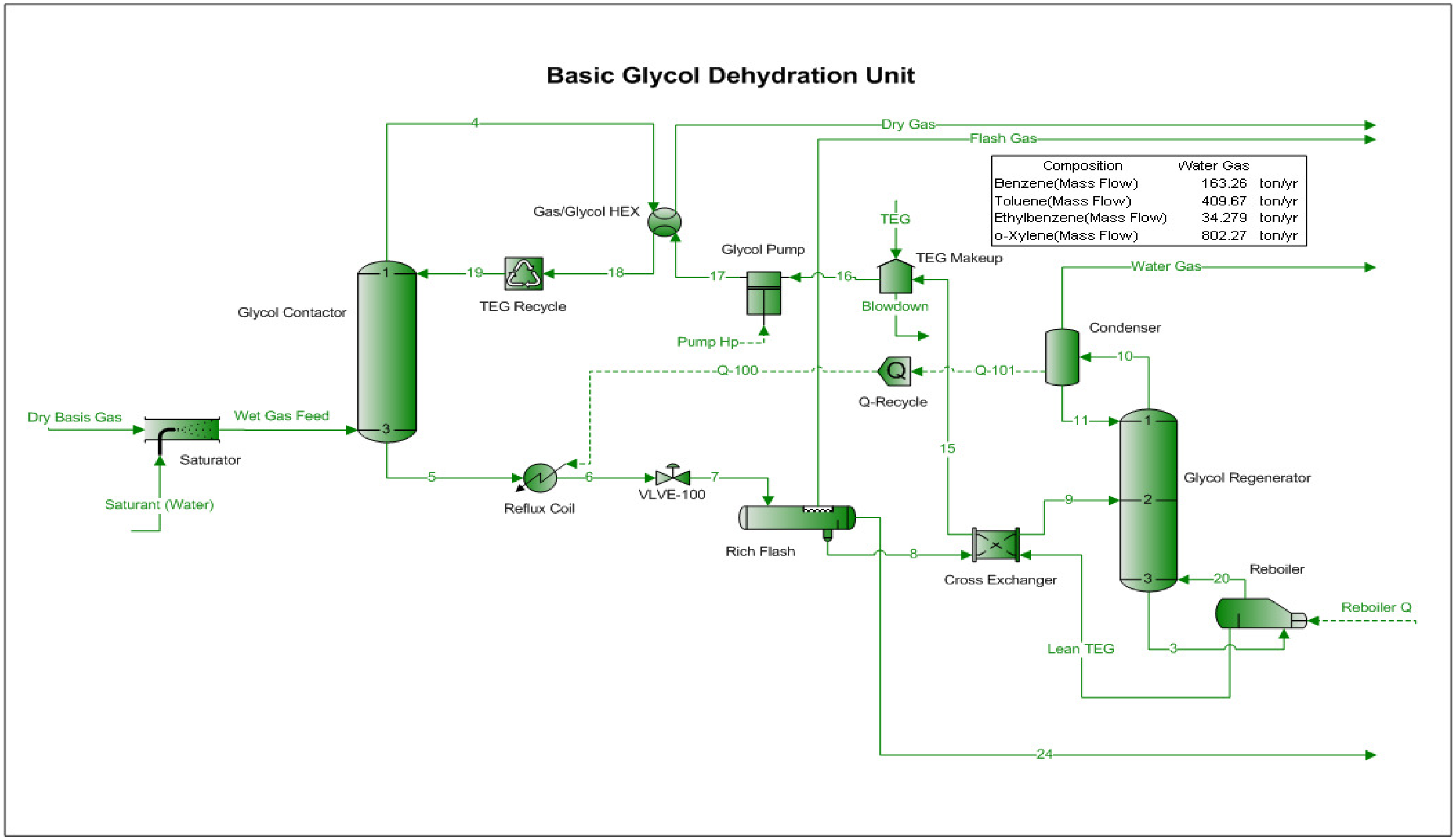

Figure 2.1 : Flow diagram glycol dehydration unit

(source: http://en.wikipedia.org/wiki/Glycol_dehydration, assessed on 15 August 2008)

2.4 Adsorption Process

In this most common configuration, the unit is equipped with two, identical adsorbers, each filled with activated carbon. One adsorber vessel is on-stream in the adsorption mode while the other is off-stream in the regeneration mode. Switching valves automatically alternate the adsorbers between adsorption and regeneration. One adsorber is always on-stream to assure uninterrupted vapor processing capability.

To process the hydrocarbon vapor-air mixture, the mixture first flows up through the on-stream adsorber vessel. There, the activated carbon adsorbs the hydrocarbon vapor, so clean air vents from the bed with minimal hydrocarbon content (15).

Simultaneously, the second adsorber is being regenerated off-line. The carbon bed regeneration uses a combination of high vacuum and purge air stripping to remove previously adsorbed hydrocarbon vapor from the carbon and restore the carbon's ability to adsorb vapor during the next cycle. The liquid ring vacuum pump extracts concentrated hydrocarbon vapor from the carbon bed and discharges it into a three phase separator that separates the vacuum pump seal fluid, the hydrocarbon condensate and the non-condensed hydrocarbon/air vapors.

The seal fluid is pumped from the separator through a seal fluid cooler to remove the heat of compression from the seal fluid. The seal fluid is then returned to the liquid ring pump. In some applications, such as chlorinated hydrocarbon vapor recovery, other types of vacuum generators can be substituted for the standard liquid ring pump to avoid incompatibility of the vapor with the seal fluid required by the liquid ring pump.

Next, hydrocarbon vapor and condensate flow from the separator to an absorber column section that functions as the final recovery device. The hydrocarbon vapor flows up through the absorber packing where it is subsequently recovered by absorption into a liquid hydrocarbon absorbent. The circulating absorbent supplied from storage serves the dual purpose of absorbing the recovered hydrocarbon vapor and cooling the vacuum pump seal fluid. This absorbent is normally the same hydrocarbon liquid that was the original source of the vapor generation. For example, gasoline product from a storage tank is the absorbent fluid in gasoline vapor control applications. The recovered product is simply returned along with the circulating gasoline back to the product storage tank.

A lean absorbent supply pump and a rich absorbent return pump are provided to circulate the required absorbent. A small stream of air and residual vapor exits the top of the absorber column and is recycled to the on stream carbon bed where the residual hydrocarbon vapor is re-adsorbed.