COMPARATIVE STUDY OF GAS DEHYDRATION TECHNIQUES

PRESENTED BY:

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CERTIFICATION

This is to certify that this research work was carried out by OSARO OSATOHANMWEN FRANKLIN of the Department of Petroleum Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria in accordance with the rules and regulations of the University in partial fulfilment for the award of Bachelors' Degree (BEng.) in Petroleum Engineering.

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DEDICATION

I dedicate this project to God Almighty for the grace and ability to carry out this research work, also to my family, whose unwavering support and encouragement have been my guiding light throughout this journey, most specifically my mum Mrs joy osaro, words aren't enough to appreciate you for your efforts. Your belief in my abilities has been a constant source of motivation, and I am deeply grateful for the sacrifices you've made to help me reach this milestone.

I also dedicate this work to all my lecturers, my Head Of Department (Engr) Dr. S.A. Igbinere, who is also my project supervisor, who have imparted knowledge, challenged me to grow, and instilled in me a passion for learning. Your guidance has been invaluable in shaping my academic and personal development, also to all my friends who have stood by my side, providing camaraderie and a shoulder to lean on during the ups and downs of university life. Your friendship has enriched my experience and made this journey memorable.

This project is a culmination of the collective support, encouragement, and inspiration I have received from my loved ones and mentors. Thank you for being a part of this chapter in my academic journey.

ACKNOWLEDGMENT

I would like to express my heartfelt gratitude to all those who have contributed to the successful completion of this project.

First and foremost, I want to acknowledge my supervisor, Engr.(Dr). S.A igbinere for his guidance, patience, and valuable insights throughout the project. Your expertise, dedication, and insightful feedback have been instrumental in shaping the direction and quality of this research. Your mentorship extended beyond the academic realm, enriching my overall learning experience. Thank you for the support and encouragement.

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CHAPTER ONE

INTRODUCTION

Background of study

Natural gas, which can be found in conventional natural gas reservoirs as non-associated gas (NAG), associated gas (AG), or gas condensation products, is a combustible gaseous combination of gaseous hydrocarbons, very light liquid hydrocarbons, free water, water vapor, and other undesirable non-hydrocarbon gaseous and solid components.

Water or water vapor is eliminated from the streams of natural gas through the process of natural gas dehydration. Production, handling, and transportation of natural gas are hampered by the presence of water that is free in the gas. Therefore, it is imperative to eliminate a large portion moisture as feasible from the gas stream.

While there are a number of ways to dehydrate natural gas, the following are the most widely used ones:

(1) Process of Adsorption;

(2) Process of Absorption

ADSORPTION

This is the process by which solid elements known as desiccants, which draw in and retain water vapor molecules within themselves by adhesive actions, remove water from the gas stream. Activated alumina, activated bauxite, silica gel, silica-based beads, membranes, and molecular sieves are a few of the solid desiccant kinds that are utilized.

ABSORBTION

This is the procedure wherein a liquid desiccant comes into direct contact with the gas stream to eliminate or absorb water or water vapor. Since they closely resemble the qualities required for commercial applications, glycols have shown to be among the most effective liquid desiccants in use today. The gas industry is an essential part of Nigeria's economy, and the glycol that has absorbed the water is renewed and reintroduce into the dehydration cycle for additional water extraction.

STATEMENTS OF THE PROBLEMS

Gas dehydration is a common process in gas treatment plants because water in the presence of acidic elements in natural gas is capable of causing

corrosion; water also reacts with hydrocarbons and produces hydrates, which can plug valves and pipelines. When natural gas is dehydrated using tri-ethylene glycol, an important quantity of glycol may be lost during the absorption process, and a significant amount of volatile organic compounds may be released during regeneration. This could be due to plant engineering flaws or operational issues. An excessive level of glycol loss could lower the performance of the dehydration process, which would raise the cost of dehydrating the gas. The resulting emissions of volatile organic compounds (VOCs) may also cause regulatory bodies to express concern.

OBJECTIVE;This project compares the performance, operational factors, and efficiency of the adsorption and absorption processes in gas dehydration machines. This study will offer important insights into the best gas dehydration process selection for particular industrial applications by performing a thorough analysis.

(2) To examine and assess the body of research on methods for gas dehydration, including adsorption and absorption processes.

(3) To determine which method or methods are best suited for a given gas composition and set of operational parameters.

(4) To offer suggestions for improving the chosen dehydration method(s) in light of the study's conclusions.

SCOPE OF STUDY

1. Natural gas dehydration via TEG utilization.

2. Natural gas dehydration by molecular sieve.

2. Examining the variables that influence the regeneration of glycol.

3. Examining the factors that affect dehydration in the adsorption and absorption processes

4. A comparative analysis of several gas dehydration methods, focusing on the adsorption and absorption processes, to ascertain the most successful and economical way to extract water vapor from natural gas. evaluating the dehydration processes' effectiveness, energy usage, affordability, and environmental impact.

CHAPTER TWO

LITERATURE REVIEW

Gas dehydration is an essential procedure in several fields, such as the petrochemical, natural gas transmission, and oil and gas production sectors. Natural gas's effectiveness, efficiency, and downstream equipment may all suffer from its moisture content. To determine the best and most efficient procedures for removing moisture, a comparative analysis of gas dehydration processes is necessary.

1. Prevention of hydrate formation: Gas dehydration prevent hydrate formation by removing water vapor from the natural gas. Natural gas can contain significant amounts of water vapor, and when the gas is transported at high pressures and low temperatures, hydrates can form. These hydrates are ice-like solids that can block flow lines, pipelines, and equipment, leading to flow disruptions and potential safety hazards.

2. Corrosion prevention: Water vapor in natural gas can react with steel pipelines and equipment, causing corrosion. Corrosion not only affects the integrity of the infrastructure but also poses safety risks. By dehydrating gas, the water content is reduced, minimizing the potential for corrosion.

3. Prevention of liquid drop-out: When gas is cooled or depressurized, the water vapor can condense into liquid droplets. These liquid droplets can cause erosion and damage to pipelines, valves, and other equipment. Dehydrating the gas effectively removes water vapor, minimizing the risk of liquid drop-out and associated issues.

4. Enhanced gas quality: Water vapor in natural gas can affect the gas' heating value and overall quality. By dehydrating the gas, the water content is reduced, resulting in a cleaner gas with improved caloric value.

5. Environmental considerations: Water vapor in natural gas can contribute to the formation of greenhouse gases such as methane. Dehydration reduces the water content, minimizing the potential environmental impact.

DIFFERENT GAS DEHYDRATION TECHNIQUE

There are several different techniques used for gas dehydration in the oil and gas industry. Example include: Adsorption process, Absorption process, Refrigeration dehydration, Membrane dehydration. The choice of technique often depends on factors such as the specific requirements of the gas stream, capacity needs, and economic considerations. But, I will be limiting this project to two of the common process_ Adsorption process and Absorption process.

ABSORPTION PROCESS

The oil and gas industry uses the dependable absorption technique extensively for gas dehydration. To extract water vapor from a gas stream, a liquid desiccant is used in the procedure. It is frequently utilized for extensive gas dehydration applications in the oil and gas sector.

During the absorption process, a liquid desiccant—typically a solution of glycol—is introduced into contact with the gas stream within a tower or vessel. The desiccant absorbs the water vapor from the gas because of its strong affinity for water molecules.

The liquid absorbs and holds onto the water vapor in the gas as it travels through the tower and comes into touch with the desiccant. Next, the dry gas is divided.

PROCESS OPERATION OF ABSORPTION

Through an entrance, the gas stream that contains free water vapor or water and pollutants like carbon dioxide (CO2) and hydrogen sulfide (H2S) enters the contactor. Simultaneously delivered into the contactor is the TEG (TriEthyleneGlycol) solution, which serves as a solvent for dehydration and impurity removal. In a glycol contactor (tray column or packet bed), absorption is carried out by an opposite current of moist gas, typically between 20 and 35 degrees Celsius, and triethylene glycol (TEG). The

countercurrent flow is intended to maximize contact between the liquid glycol and the wet gas, which will help the TEG solution absorb contaminants and water vapor.

After being enriched (by H2O), TEG exits the contactor through the bottom, passes through a flash and heat exchanger, and enters a reboiler.

REGENERATING ENRICH GLYCOL

The process of purging impurities and water vapor from glycol after it has been utilized in natural gas dehydration systems is sometimes referred to as "regenerating glycol." Water and other contaminants cause the glycol to get saturated, which lowers its effectiveness. The glycol is usually heated in a reboiler to remove impurities and water in order to regenerate the glycol.

The following steps are involved in the regeneration process:

1. Glycol Circulation: From the absorber unit to the reboiler, the glycol is circulated.

2. Heating: The water and contaminants evaporate when the glycol is heated to a high temperature in the reboiler, usually between 400 and 500°F (200 and 260°C).

3. Vapor Separation: A demister or separation system is used to remove the vaporized water and contaminants from the glycol. After the water and contaminants have been separated.

4. Cooling: The regenerated glycol is then cooled before returning to the absorber unit.

5. Monitoring and Adjusting: The system is monitored to ensure the glycol has been sufficiently regenerated and meets the required specifications. Any necessary adjustments are made to the regeneration process as needed.

Regenerating glycol in the reboiler helps to maintain the efficiency and effectiveness of natural gas dehydration systems, ensuring optimal water removal from the gas streams.

CHOICE OF DIFFERENT GLYCOL

Several glycols that are frequently utilized for gas dehydration include:

1. Ethylene Glycol (MEG): Because it works well to extract water from gas streams, MEG is a glycol that is frequently used for gas dehydration. It can reach low dew points and has a strong liking for water. Its cost is comparatively higher than that of other glycols, and there may be some toxicity issues.

2. Diethylene Glycol (DEG): Another glycol that's frequently utilized for gas dehydration is DEG. It is generally less poisonous and has water-removal characteristics comparable to MEG. When cost and toxicity are significant considerations, DEG is frequently chosen over MEG.

3. Triethylene glycol (TEG): In the oil and gas sector, particularly in natural gas processing facilities, TEG is frequently utilized for gas dehydration. TEG is renowned for its capacity to manage significant gas flow rates and for its effective water removal characteristics. This type of glycol is more costly than DEG but comparatively less harmful than MEG. The absorption process will be illustrated using this type of glycol as a case study.

4. Tetraethylene Glycol (TTEG): Though less frequently utilized, TTEG may be a viable substitute for DEG or TEG, contingent upon certain process needs. It is comparatively less poisonous and has good water removal properties.

ADSORPTION PROCESS

Usually, a bed of desiccant material, such as activated alumina or a molecular sieve, is passed through the gas mixture, which could contain water vapor. Because of their strong affinity for water molecules, these substances are well suited to efficiently adsorb and extract water from the gas stream. Water

molecules from a gas mixture are selectively adsorbed onto a solid adsorbent material in the adsorption process used for gas dehydration.

Water molecules can more easily be adsorbed onto the desiccant bed thanks to its precise pore size and surface chemistry. The desiccant material and the water molecules come into contact as the gas mixture passes through the bed.

Because the water molecules have great attraction to one another,

The four main steps of the adsorption process are usually as follows: the adsorbate is transported to the adsorbent surface, it attaches itself to the surface, it accumulates and forms a monolayer or multilayer, and it reaches equilibrium between the adsorbate in the bulk phase and the adsorbate on the solid surface.

Water molecules gradually saturate the desiccant material, reducing both its adsorption capacity and efficacy in removing water vapor. To reinstate the desiccant's adsorption capacity, a regeneration phase is consequently necessary.

Regenerating an adsorption process is cleaning the adsorbent material of the contaminants or molecules that have been adsorbed so that it can be utilized again in later cycles. The particular procedures needed to regenerate an adsorption process are as follows:

1. Determine the right regeneration technique and the type of adsorbent material being employed. Certain regeneration strategies, such as solvent, pressure swing, or heat regeneration, may be necessary for a certain adsorbent.

2. Heat the adsorbent material to a temperature that desorbs the adsorbed molecules or contaminants if thermal regeneration is necessary. The qualities of the adsorbent and the pollutants to be eliminated will determine the regeneration temperature. To avoid thermal shock, a stepped temperature profile or gradual heating may be required.

3. If pressure swing regeneration is utilized, change the pressure to alternate between cycles of adsorption and desorption. Lower the pressure during the desorption cycle to liberate the molecules that have been adsorbed. It is possible to gather and manage the desorbed gases properly.

4. Regenerating the adsorbent with a particular solvent that desorbs the molecules adsorbed is known as solvent regeneration. The pollutants and the adsorbent will

determine which solvent is best. The right separation methods can be used to extract the desorbed molecules from the solvent.

5. To make sure the appropriate degree of regeneration is attained, monitor the desorption process using appropriate techniques, such as online analysis or recurring sampling.

6. Reassemble the adsorption system or reload the adsorbent material into it after the regeneration process is finished.

7. Carry out any required tests or analysis to confirm that the adsorbent's adsorption capability has been restored and the regeneration was successful.

8. Record the regeneration procedure and count the regeneration cycles in order to assess the performance and service life of the absorbent

Major types of adsorbents in use

Molecular sieve zeolites, polymeric adsorbents, alumina, silica gel, activated carbon, sieve carbon, and sieve carbon. A small number of adsorbents, like some zeolites, are naturally occurring, while the majority, like activated carbons, are produced. Every material has unique properties, including pore structure, porosity, and adsorbing surface nature.

Adsorbents may have pore diameters that are dispersed throughout the solid. The three broad categories of pore sizes are as follows: macropores have "diamaters" greater than 50 nm, mesopores (sometimes called transitional pores) have "diameters" between 2 and 50 nm, and micropores have "diameters" less than 2 nm.

Several adsorbent substances, including silica gels, carbons, and aluminas, are amorphous and comprise intricate webs of interconnected macropores, mesopores, and micropores. Zeolitic adsorbents, on the other hand, have precisely defined pores.

The choice of adsorption material depends on several factors, including:

1. Adsorbate: When choosing a material, one of the most important considerations is the kind of molecules or contaminants that will be adsorbed. The affinities of various adsorption materials for various adsorbate types vary. For instance, zeolites are frequently employed to adsorb gasses and tiny molecules, while activated carbon works well to adsorb organic substances.

2. Adsorption Capacity: The greatest quantity of adsorbate that a material can store is referred to as its adsorption capacity. When working with high contaminant concentrations or requiring lengthy adsorption cycles, this issue becomes even

more crucial. In these situations, materials with a high adsorption capability are favored.

3. Selectivity: The capacity of an adsorption medium to adsorb particular molecules or contaminants more readily than others is referred to as selectivity.

4. Stability: An additional important factor to take into account is the adsorption material's stability. Adverse operating conditions, including high temperatures or corrosive environments, are present in certain applications. Materials that are resistant to these circumstances without suffering appreciable deterioration are favored in such circumstances.

5. Regenerability: Sustainability and cost-effectiveness depend on the adsorption material's capacity to regenerate. While certain materials may need to be replaced after just one use, others can be recycled and used repeatedly. It is crucial to take into account the regeneration capability and technique since certain materials may lose their structural integrity or efficacy throughout the regeneration process.

6. Cost: The cost of the adsorption material is an essential factor in the selection process. The material should be economically feasible for the desired application. The cost may vary depending on factors such as availability, production methods, and demand.

7. Handling and Operational Considerations: Ease of handling, compatibility with the system, and operational requirements also play a role in material selection. Factors such as particle size, packing behavior, and pressure drop should be considered based on the specific application and system design.

Adsorption therefore is often commonly used in other industries beside gas dehydration. It can be used in water treatment, catalysis, and separation techniques. It is also utilized in technologies like activated carbon filters, which adsorb impurities from air or water, and in pharmaceuticals, where adsorption is employed to remove contaminants or impurities during the manufacturing process.But in oil and gas industry adsorption process is considered to have the following advantages:

1. Selectivity: The process of adsorption is quite selective. It has the ability to eliminate particular impurities or pollutants from a mixture while retaining the

desired ingredients. Adsorption is a useful technique for separation and purification procedures because of its selectivity.

2. High efficiency: Adsorption techniques frequently remove pollutants with a high degree of effectiveness. This is so that a high surface area-to-volume ratio, which is typical of adsorption, can accommodate a large number of adsorption sites. These sites have a high efficiency of separation or purification because they can effectively adsorb and remove impurities from the mixture.

3. Versatility: Adsorption is an adaptable method with a wide range of uses. It is helpful for purifying water and air because it may be used in both liquid and gas phases. Additionally, adsorption can be utilized to eliminate a variety of pollutants, such as heavy metals, chemical compounds, and volatile organic compounds (VOCs).

4. Adsorbent regeneration: The adsorbent utilized in the adsorption procedure can frequently be recycled and utilized again. As a result, the process is more cost-effective and efficient overall. Regeneration is the process of removing the impurities that have been absorbed from the adsorbent so that it can be utilized again.

5. Operational simplicity: Adsorption processes are often low maintenance and easy to run. They don't need a lot of training or complicated machinery.

This simplicity of operation contributes to their efficiency and ease of implementation in various industries.

6. Environmental friendliness: Adsorption processes are often considered environmentally friendly compared to other purification or separation techniques. They do not generate harmful byproducts or waste streams and can effectively remove pollutants from the environment, contributing to sustainable development.

Despite all this advantages, adsorption process have high operational cost and high investment.

CHAPTER THREE

METHODOLOGY

PROCESS SIMULATION

Overview

The project's input data, absorption model, and process simulation are all shown in this section. Aspen HYSYS was the simulation program that was used. Because Aspen HYSYS has every dehydration unit required for natural gas dehydration, it was chosen. It was also selected due to its broad application range in hydrocarbon and water temperature and pressure. For this project, ASPEN HYSYS version 2006.5 was utilized, and the Peng-Robinson equation was the absorption model. The thermodynamic behavior of the TEG water system is represented by the Peng-Robinson equation of state. Peng-Robinson equation of state is also selected as the best model for process computation. This is due to the fact that it works well in systems that handle a variety of hydrocarbon and water components.

This can be attributed to its suitability for managing systems that include water and hydrocarbons under a variety of pressure and temperature conditions. All the unit operators needed in a gas dehydration plant are also included in the HYSYS simulation program. The heat exchanger, pump,

separator, absorber, and flash drum are all present. These unit operators can all be configured to operate similarly to the gas dehydration plant.

TEG Contactor

The Glycol package, designed specifically for glycol dehydration, is the fluid package that Aspen HYSYS used for simulation. Through sophisticated mixing procedures, this thermodynamic package combines the Two-Sim-Tassone (TST) EoS with a NRTL activity coefficient model. It is a more accurate representation of compressibility than other techniques such as the Redlich−Kwong equation of states (including the modified version developed by Soave).

Design presumptions

When creating the design model, the following presumptions were made:

i) Each tray experiences mass transfer;

ii) The regenerator is well-lagged, so heat losses are minimal.

iii) The liquid-phase related gases that are connected to the rich TEG are taken into account.

iv) There are two components in the regenerator's feed: TEG and (water plus gases).

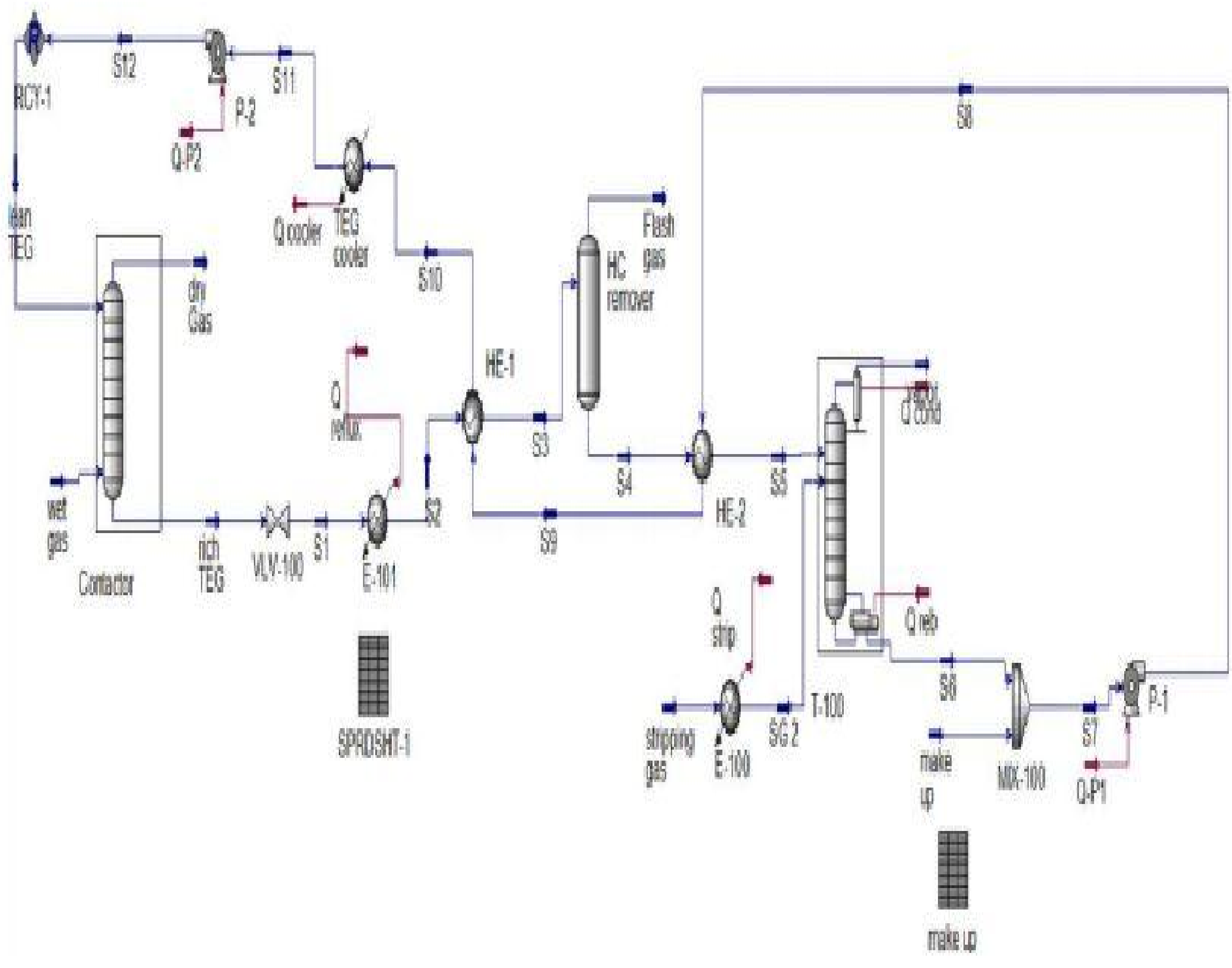
v) An average value is assumed, and the impact of changes in the total molar flow rate is disregarded.

vi) Raoult's law is used to define the equilibrium relationship between vapour and liquid.

Because of its strong hygroscopicity, low volatility, and good thermal stability, TEG is the most often used solvent for absorption.

An absorption column is used in the process at first in order to extract water from the gas stream. After that, the stream of water-enriched glycol goes through a regeneration process that starts with separating it from the hydrocarbon mixture it contains in an expansion vessel. Utilizing alternators to heat the stream of water-rich glycol (rich TEG),

, it enters a distillation column where the glycol is separated from the water by means of a stripping gas (methane). Finally, the pure glycol returns to the absorption column in order to repeat the whole process.


RCY-1
S12
P-2
S11
Q-P2
lean TEG
Q cooler
TEG cooler
S10
dry Gas
wet gas
Contactor
rich TEG
VLV-100
S1
E-101
S2
Q reflux
HE-1
S3
HC remover
Flash gas
S4
HE-2
S9
S5
S8
Q cond
Q reb
Q strip
stripping gas
E-100
SG 2
T-100
S6
make up
MIX-100
S7
P-1
Q-P1
SPRDSHT-1

It is essential to define the main properties and composition in each material stream. Some of the main properties are pressure, temperature, composition and molar flow rate. These properties are the main parameters for this study.

INPUT DATA

The input data used for this study is from azaloye gas field in iran

WET GAS	
COMPONENTS	MOLE FRACTION
WATER	0.0007
CO_2	0.025
N_2	0.005
CH_4	0.80
C_2H_6	0.090
C_3H_8	0.05
i-C_4H_{10}	0.0050
n-C_4H_{10}	0.010

$i\text{-}C_5H_{12}$	0.0025
$n\text{-}C_6H_{14}$	0.0025
Flow rate(*m³/hr*)	1120.00
Pressure(bar)	52
Temperature(^{O}C)	54
TRAYS.	3

Distillation column	
COMPNENTS MOLE FRACTION	
TEG	1.00
FLOW RATE(*Kmol/hr*)	104.6
Pressure(*bar*)	1.27
TEMPERATURE	100_204
Trays	3

Water content in dry gas: TEG has a higher purity as it reaches the suction column, which traps more water and lowers its content in the dry gas.

flow: More TEG is carried to the peak product and thus higher stripping gas supply to the distillation column causes more losses while lowering TEG flow into the suction column. The flow of TEG lean should, in theory, be constant as the amount of TEG lost is also replaced.

Reflux: The amount of reflux rises as more stripping gas enters the distillation column. This is explained by the mass balance, which states that more mixture will liquefy and rise to the surface as reflux.

Heat exchanger-1 Duty: For the first heat exchanger, the temperatures of streams S2, S3, and S9 are known, given the Qreflux load and heat load for the second heat exchanger. As a result, the HE-1 heat exchanger becomes charged, allowing the current temperature of s10 to be determined. A higher stripping gas flow causes the flow to decrease, which lowers the load.

Heat exchanger-2 Duty: The amount that enters determines the alternator's load based on the temperatures of streams S4 and S5. Raising the temperature lowers the quantity of "rich TEG" that exits the absorption column and the amount of pure TEG. Consequently, there must be a decrease in the load on the second heat exchanger (HE-2).

Boiler: Because more material is entering the column and needs to be heated, the boiler load increases.

Condenser: Like the boiler, a higher required load will be needed for a bigger amount to be liquefied.

Glycol Cooler: The condenser in a chain follows the path taken by the two alternators, so with the load decreasing based on the molar flow and known current temperatures of S10 and S11.

First Pump: The mass-molar flow through it and the pressure differential determine how much power is needed. The power is decreased, just like in other processing devices.

2nd Pump: The power is retained fixed because the pressure disparity is constant and the molar flow does not alter enormously. It is noticed that for stripping gas supply 20 kmol / h, greater TEG purity is obtained than that of the standard. For purposes of energy economy, values near to 20 kmol /h are tested, in order to offer the lowest practicable quantity, while achieving the specification. By repetitive test processes, this amount is achieved at 19 kmol/h and the water content of the gas after the absorption column is 29.34 ppm.

ADSORPTION

Adsorption fundamentals

Two types of adsorption

▪ Chemisorption

• Chemical interaction between adsorbate and adsorbent

• May not be completely reversible

▪ Physical adsorption

•Only physical interaction between adsorbate and adsorbent

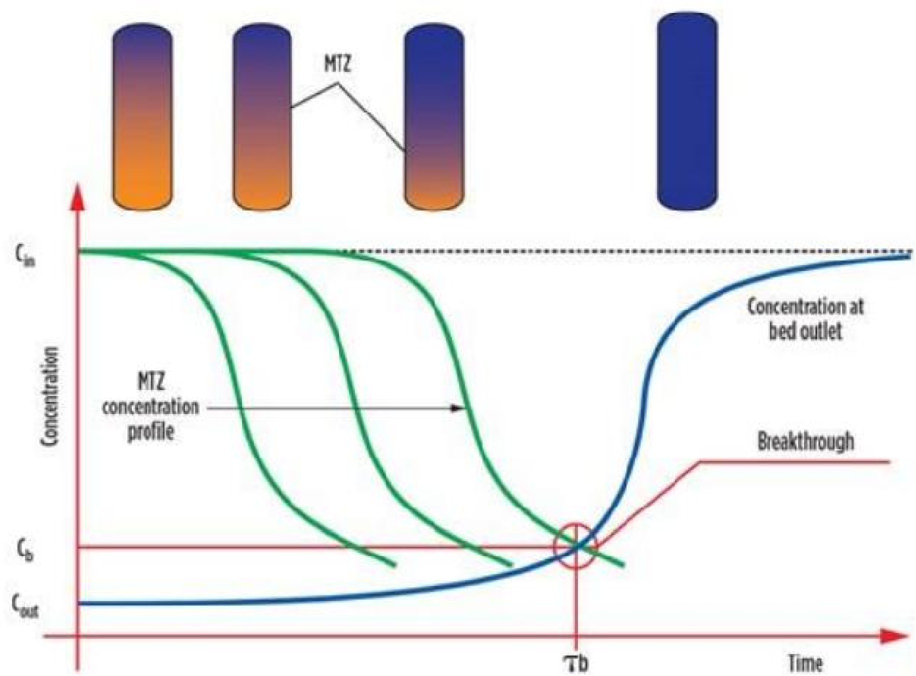
• Completely reversible

$-\Delta H_{Chem} >> -\Delta H_{Phys}$

We are restricting our research for this project to physical adsorption.

The van der Waals interactions between water and the surface of a solid desiccant, which is usually housed in fixed-bed columns, are the foundation of this family of technologies. It is feasible to dry natural gas to less than 0.01 ppm as a result of these interactions. Chemical bonds are stronger than van der Waals bonds. These bonds are loosened by the increased kinetic energy of the adsorbed molecules during heating, allowing water to be separated from the sorbent. When the sorbent runs out, this phenomena is employed to replenish it. Fresh desiccant quickly becomes water-saturated as it comes into contact with the wet natural gas, creating a mass transfer zone (saturation front).

The bed is saturated above the mass transfer zone, meaning that the water concentration in the gas passing through the upper side of the mass transfer zone stays constant and the "wet" sorbent is in equilibrium with the wet incoming gas. In this region, there is no more adsorption. The desiccant is in contact with dry gas below the mass transfer zone, which keeps it fresh. The green line in the graphic below illustrates how the water content decreases within the mass transfer zone from the entrance concentration, Cin, to the new adsorbent's equilibrium value. It is emphasized that the length of the bed engaged in the absorber process at time τ can be viewed as the mass transfer zone.



As time passes, the mass transfer zone moves downward through the bed until it reaches the bottom of the column. At this point the entire bed has become water-saturated, and the adsorption process comes to an end. In time, the water dewpoint at the tower outlet draws an “S” curve, known as the breakthrough curve, represented by the blue line with diagram above. When the water concentration at the bed outlet touches the (Cb, τb) point (the water dewpoint corresponding to the gas specification) on the breakthrough curve, the fixed bed is considered exhausted.

It is then excluded from the production cycle and regenerated. In industrial practice, the end of the production cycle is not set by the analytical measurement of water dewpoint in the treated gas; rather, it is set by a predetermined time τ .

Regenerating process.

The most popular physical adsorbents are those that can be replenished during the process, including silica gel and molecular sieves. As a result, the dehydration procedure entails cyclic batch operation, which entails regeneration after the bed has been loaded with water through adsorption. The batch stages must be switched across several columns, each running at a separate stage, to ensure continuous operation. This means that before another column is completely filled during adsorption, the regeneration of the first column must be completed.

In order to release the components that were collected, the bed is heated during regeneration. Next, the column is cooled to make it ready for adsorption once more. Usually, to do both, some of the dry gas stream is diverted and circulated through the regeneration loop. The propelling power for reintroducing the gas utilized for regeneration into the wet gas production stream is usually a compressor. The regeneration gas is heated to a high temperature for the heating stage. The heating stage is stopped by turning off the heater once the entire column has reached the appropriate end temperature.

After that, the column is cooled by the cold regeneration gas, getting it ready for the next adsorption cycle. This process is known as temperature swing adsorption, or TSA. Pressure swing adsorption (PSA) is an additional technique for achieving regeneration through pressure changes. Combining the two methods (TSA and PSA) seems to be a viable future option for NG adsorption dehydration. We are currently investigating this idea. The continuity of the entire system is ensured by the synchronization of the columns. While the other tower is in the adsorption state, one is currently undergoing regeneration. When the adsorption tower runs out of energy, the previously regenerated tower can swiftly enter the manufacturing cycle.

After a bed has been heated, typically at 170°C–260°C, it is cooled to 30°C–40°C to make it fresh again. Therefore, a regeneration cycle includes both heating and cooling stages.

To make a bed fresh again, it is cooled to between 30 and 40 degrees after it has been heated, usually to between 170 and 260 degrees. Thus, there are heating and cooling phases in a regeneration cycle.

In the setup of the process. As regeneration gas, a slipstream—roughly 10%–20% of the raw gas—is utilized. Regeneration gas is removed upstream of the control valve and reinjected into the adsorption circuit downstream of the control valve to provide the driving force required to circulate the gas through the regeneration loop. This control valve provides the overall driving force for the circulation of regeneration gas.

This process arrangement's main drawback is the comparatively large pressure difference between the raw gas and the dry gas, which necessitates using more energy when the

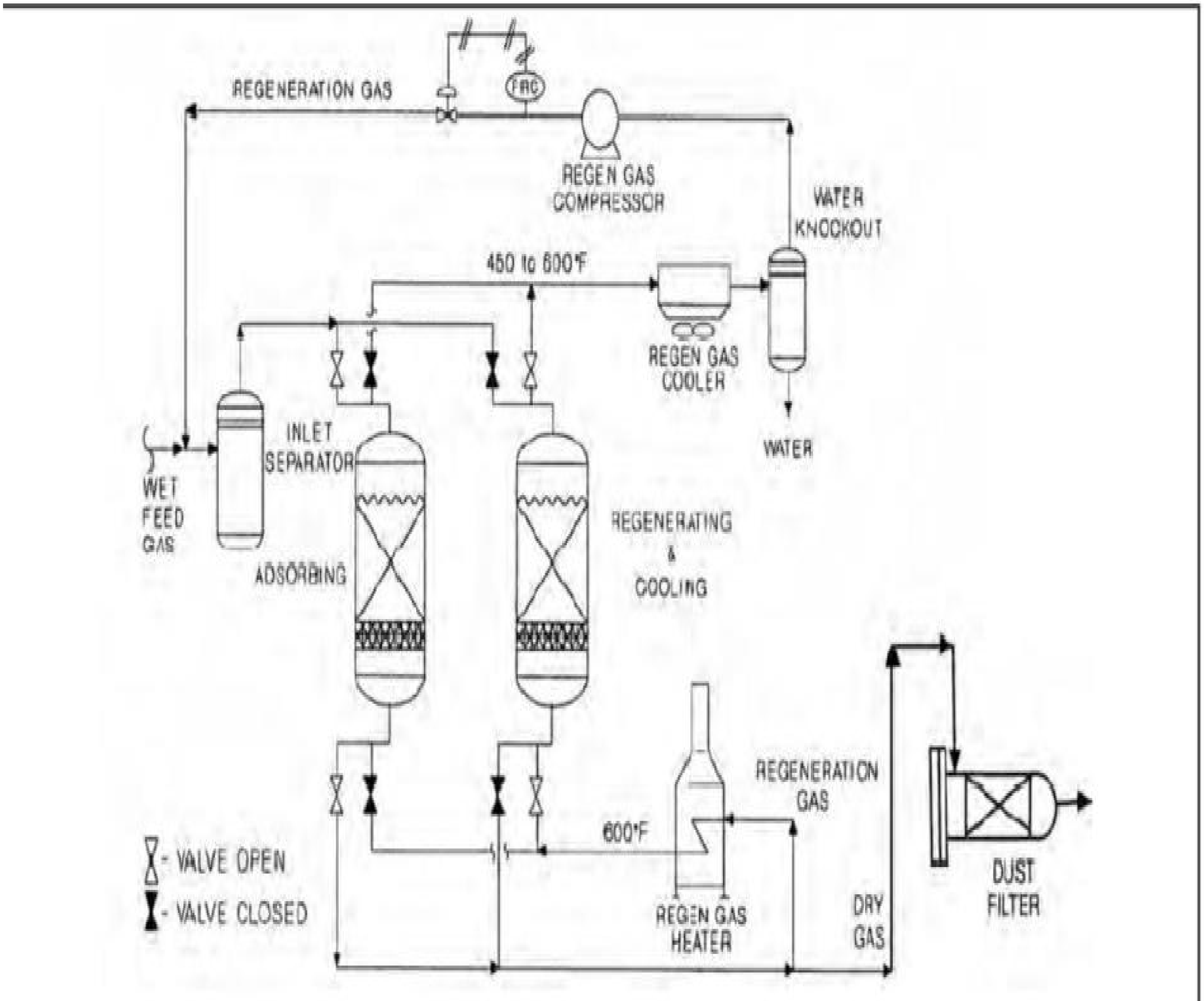
dry gas, which requires an increasing energy consumption when the dry gas must be compressed. In such cases, the pressure drop can be minimized by inserting a recycle compressor in the regeneration loop.

ADSORBER

Molecular sieves, silica gel, and activated alumina are the most popular sorbents for drying natural gas. The most affordable sorbent agent for drying natural gas to -70°C is activated alumina. The co-adsorption of hydrocarbons, which lowers the water load and reduces production, and the rehydration caused by extremely high temperatures interaction with wet gas throughout the regeneration phase are the main drawbacks of activated alumina.

Because silica gel has a high water adsorption capacity and the ability to adsorb C+ components, it can be used to remove gasoline and water from natural gas at the same time.

With silica gel, one can get a water dewpoint of between –55°C and –60°C. Synthetic zeolites, or metal aluminosilicates, with three-dimensional crystalline structures that have uniformly sized interconnecting cavities divided by similarly uniform but narrower apertures, can also be used in molecular sieves. Natural gas can be dried using molecular sieves to a dewpoint of less than -100°C. These materials can therefore be used to dry the raw gas meant for applications involving cryogenic hydrocarbon recovery.



ADSORPTION PROCESS CYCLE

A slipstream of dry gas is used to feed the recycle compressor in the process arrangement depicted in the above graphic. In alternative setups, it circulates the moist gas that comes out of the three-phase separator. During the cooling cycle, dry gas does not partially rehydrate the bed and is more successful at eliminating water from the bed.

The regeneration gas is fed to the base of the tower for heating and cooling, as seen in the above diagram. Using wet gas as regeneration gas causes the bottom portion of the regenerated bed to absorb a tiny amount of water throughout the cooling cycle, as figure 23 illustrates. When dry gas is utilized for the upflow regeneration pattern, there is no water pickup. In this instance, the bed's bottom the bed is always contacted by dry gas, and the result is a more efficient regeneration step. A similar effect can be attained with the downward regeneration pattern, in which the regeneration gas flows from the top to the bottom of the tower.

Every tower experiences periodic temperature swings, which cause some sorbent beads to break over time and produce powder and fines. These solid materials have the potential to interfere with downstream processes and the regeneration loop's gas cooler. In order to remove solid materials (such as rust and pipe scales) and any free water that the gas may have entrained, mechanical filters must additionally be fitted on the gas dehydration unit's outlet sides and upstream of the gas cooler. It is necessary to remove the solid materials because they clog the sorbent bed and increase pressure drop along its length. Coalescer filters are required to eliminate free water since it breaks and powders the sorbent.

Lastly, it is important to remember that an operational labor schedule is used to determine the cycle duration of an adsorption process, leading to typical cycles of eight, twelve, sixteen, and twenty-four hours. In terms of equipment sizing and desiccant charge, shorter cycle lengths are more cost-effective; nevertheless, operating expenses could be greater because of more frequent valve operation and a shorter desiccant life, which requires more frequent replacement.

The main drawback of this process setup is the comparatively large pressure drop that occurs between the dry gas and the raw gas, necessitating higher energy usage when the dry gas needs to be compressed. When this occurs, adding a recycle compressor to the regeneration loop can reduce the pressure loss.

CHAPTER FOUR

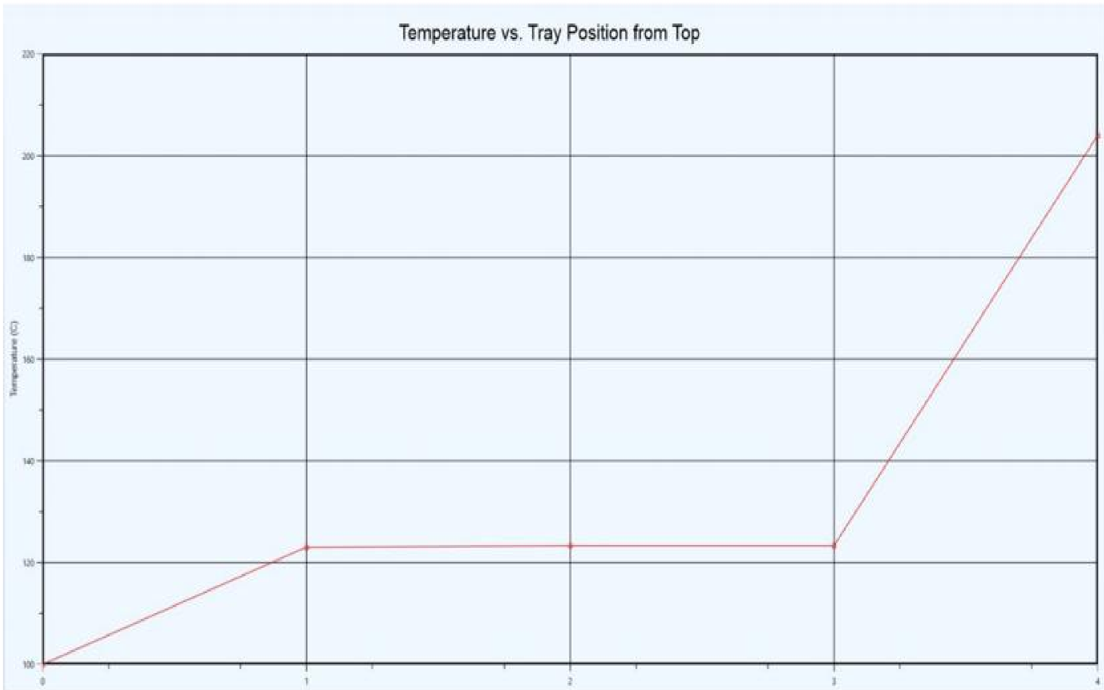
Statement of results

ABSORPTION

Simulation results with stripping gas flow as design variable.

The following tables is obtained by keeping the operating pressure of the regenerator constant and changing the supply of the stripping gas. In this case the design variable is the supply of stripping gas.

Striping gas flow (kmol/j)	%WT Lean TEG purity	Ppm(mole) Water in dey gas	Lean TEG (kmol/h)	TEG Loss %	Reflux (Kmol/h)
0	91.58	50.39	37.95	0.003	238×10^{-2}
10	92.79	41.8	37.46	0.012	211×10^{-2}
20	95.17	27.54	36.52	0.023	305×10^{-2}
30	96.4	20.46	36.06	0.032	3.93×10^{-2}



The TEG molar fraction falls and the water equivalent rises as we proceed from top to bottom. This makes sense because the supply gas stream's water is absorbed by TEG. Since TEG is the heaviest component, it makes sense that its concentration will increase as we proceed from top to bottom.

Because it is the lightest component in the column, its concentration is continuously dropping, in contrast to that of water. Furthermore, the vapor pressure of triethylene glycol stays nearly constant in column disks even if it varies with temperature. Although there may be variations in the vapor pressure along the regenerator, the outcomes remain unaffected.

It is evident from the following diagram that the absorption effect is responsible for the lower temperature at the bottom of the column. Starting at the top and working down to the bottom, the software indicates that the first tray's temperature is 31.52 oC, the second tray's is 27.48 oC, and the third tray's is 26.42 oC. According to the comparative analysis, absorption is: i. a simple and affordable form of rejuvenation.

ii. It is not poisonous or corrosive.

iii. operational issues when utilised in excess.

iv. no contact with the hydrocarbon component of the gas; absence of acid gas pollution.

However,

i. TEG in the reboiler foams, and with time it degrades into a “black mud

ii.BTEX emissions (the acronym stands for benzene, toluene, ethylbenzene and xylenes)

in the flash gases and in the reboiler vent are a further disadvantage.

iii.TEG also has a problem with sulfur, and with gas contaminated with higher hydrocarbons.

EFFICIENCY OF ADSORPTION

Water molecules are bonded to the surface of a solid substance known as an adsorbent during the process of adsorption. Adsorption efficiency is contingent upon various elements, including the concentration and physical characteristics of the contaminants, as well as the adsorbent's surface area, porosity, and chemical composition. The adsorption efficiency can be improved by increasing the adsorbent's surface area and porosity. Efficiency can also be increased by adjusting the working parameters, such as temperature, pressure, and contact duration.

Since adsorption depends on the physical interactions of pollutants with the adsorbent surface, it is generally more effective than absorption in the removal of low-concentration liquids, particularly volatile organic compounds (VOCs).

Adsorption frequently has a lesser effectiveness than absorption, despite the fact that it might be useful in some situations. This is due to the possibility

that the adsorbed material will only interact with the solid material's surface, which will reduce the amount that can be adsorbed.

CHAPTER FIVE

Conclusion

Finally, a number of findings from the comparative analysis of gas dehydration techniques are presented. The choice of technique is influenced by a number of parameters, including as the desired dryness level, the type of the gas, cost effectiveness, and environmental impact. Each approach has pros and cons of its own. Absorption is employed when little attention is paid to the output stream's water content and when little cash is needed for operational expenditures. In situations where bone dry NG is necessary, adsorption is employed. While a wealth of literature exists regarding process simulation and parameter optimization for the natural gas dehydration process, very little of it focuses on optimizing the process overall to minimize energy consumption overall, equipment capital and operating costs, carbon emissions, and other environmental factors while imposing restrictions on lean solvent concentration (TEG purity), water removal efficiency (specifications), stripping gas flow, and TEG losses and consumption. There is a need for a more comprehensive strategy.

to further optimize and integrate the traditional natural gas dehydration process using triethylene glycol as a solvent.

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