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Natural Gas dehydration methods-Challenges and fixes

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ABSTRACT

Natural gas dehydration is a crucial process in the energy industry, ensuring pipeline quality gas that meets stringent specifications for transmission and distribution. This research examines key technologies employed in natural gas dehydration, including glycol absorption, desiccant adsorption, solvent salt adsorption, chemical cooling, and hydrate suppression. Among these, glycol absorption remains the most widely used method, particularly in large-scale gas processing operations. However, it faces significant challenges such as emissions, glycol losses, and degradation, particularly in Nigeria's gas fields and storage facilities, impacting operational efficiency and environmental compliance. Desiccant adsorption offers high dehydration efficiency, achieving very low water dew points, but requires effective regeneration strategies and is often limited to specific applications due to cost and complexity. Other methods like solvent salt adsorption, chemical cooling, and hydrate suppression have niche applications but are less prevalent for mainstream gas dehydration. This study focuses on optimizing glycol absorption systems, addressing prevalent issues, and proposing practical solutions to enhance gas processing performance. It details the technology's process flow, operational challenges, and potential fixes for improving dehydration efficiency, reducing emissions, and minimizing losses. Key aspects like glycol circulation rates, regeneration systems, and contamination management are analyzed to provide a comprehensive understanding of the process.

Keywords:
TEG, MEG, DEG, Natural Gas, Dehydration.

INTRODUCTION

Natural gas dehydration is a critical process in the gas industry, ensuring that gas meets pipeline specifications and preventing issues like hydrate formation, corrosion, and freezing. With increasing demand for cleaner energy, optimizing dehydration processes is crucial for efficiency, safety, and environmental compliance. This work explores common dehydration methods, key challenges, and practical fixes to enhance gas processing operations. Natural gas dehydration is a critical process in the gas industry, ensuring that gas meets pipeline specifications and preventing issues like hydrate formation, corrosion, and freezing.

Natural gas dehydration is a critical process in Nigeria's gas industry, ensuring that gas meets stringent pipeline specifications and preventing operational issues like hydrate formation, corrosion, and freezing. With Nigeria's vast gas reserves, growing LNG exports, and increasing domestic demand, efficient dehydration is pivotal for maintaining product quality, safety, and environmental compliance. Nigeria's gas fields, often located in challenging environments like swamps, foothills, and remote areas, face unique dehydration challenges including foaming, glycol losses, BTEX emissions, and water disposal issues, impacting operational efficiency and environmental footprint. This research explores common dehydration methods used in Nigeria (glycol dehydration, solid desiccants), highlights country-specific challenges, and proposes practical fixes to enhance gas processing performance, reduce environmental impact, and optimize production costs. The findings aim to contribute to Nigeria's gas industry efficiency, safety, and sustainability goals.

Natural gas dehydration is a critical process in the energy industry, ensuring pipeline quality gas and preventing hydrate formation (Kidnay & Parrish, 2006). Glycol absorption is a widely used method, but faces challenges like emissions and losses (Arubi & Duru, 2008). Alternative methods like desiccant adsorption and membrane separation offer advantages, but have limitations (Netusil & Ditl, 2011).In Nigeria, gas dehydration efficiency is impacted by mechanical particles and glycol losses, reducing economic gains (Anyadiegwu et al., 2014). Enhancing absorption methods with additives or alternative technologies can improve efficiency (Okafor & Evwierhurhoma, 2020). The retardation method (US 2002/0053285 A1) offers a simple, low-cost solution for salt reduction and gas purification (Hassanpour et al., 2020).

Natural gas dehydration involves removing water vapor to meet pipeline specifications, preventing issues like hydrate formation, corrosion, and ice plugs. Common methods include:

1. Glycol absorption (e.g., TEG)
2. Adsorption using solid desiccants (e.g., silica gel, molecular sieves)
3. Solvent/salt absorption
4. Chemical cooling and hydrate suppression

Dehydration is crucial before gas delivery, preventing:

1. Hydrate plugs and corrosion in pipelines
2. Energy losses and reduced pipeline efficiency
3. Need for frequent water separation
4. Lower heat output in wet gas

Benefits of dehydration:

1. Enhanced gas quality and heat output
2. Reduced pipeline operational issues
3. Lower energy consumption in transport

MATERIALS AND METHODS

Glycol dehydration is a widely used method for removing water vapor from natural gas. Four glycols are commonly employed: Monoethylene Glycol (MEG), Diethylene Glycol (DEG), Triethylene Glycol (TEG), and Tetraethylene Glycol (T4EG).

Table 1 outlines their properties.

Glycol	Molecular Weight	Boiling Point	Typical Uses
MEG	62.1	197.3	(Hydrate Inhibition)
TEG	150.2	287.4	Dehydration(Most Common)
DEG	106.1	244.8	(Dehydration)
T4EG	194.2	327.3	Dehydration (High Temp.app)

TEG is the most commonly used glycol due to its favorable properties, while MEG is typically used for hydrate inhibition rather than dehydration. Understanding glycol properties is crucial for optimizing dehydration processes and addressing challenges like glycol losses and BTEX emissions.

RESULTS

Glycol Dehydration Practices in Nigeria

In Nigeria, Diethylene Glycol (DEG) is widely used for natural gas dehydration (~1200 tons/year). Triethylene Glycol (TEG) is also suitable, while Tetraethylene Glycol (T4EG) is less common due to higher regeneration energy needs.

Table 2: Glycol Suitability for Natural Gas

Glycol	Suitability for Dehydration	Reason
DEG	Widely Used	Efficient Regeneration
TEG	Commonly Used	Favorable Properties
T4EG	Rarely Used	High Energy Consumption

Process Overview:

A typical glycol dehydration unit (Fig. 1) involves absorption, regeneration, and recycling. Units vary despite similar core processes.

Challenges & Fixes Link:

a. Challenges: Energy efficiency, glycol losses, equipment differences
b. Fixes: Optimize regeneration, use efficient glycols (DEG/TEG), customize units for site needs

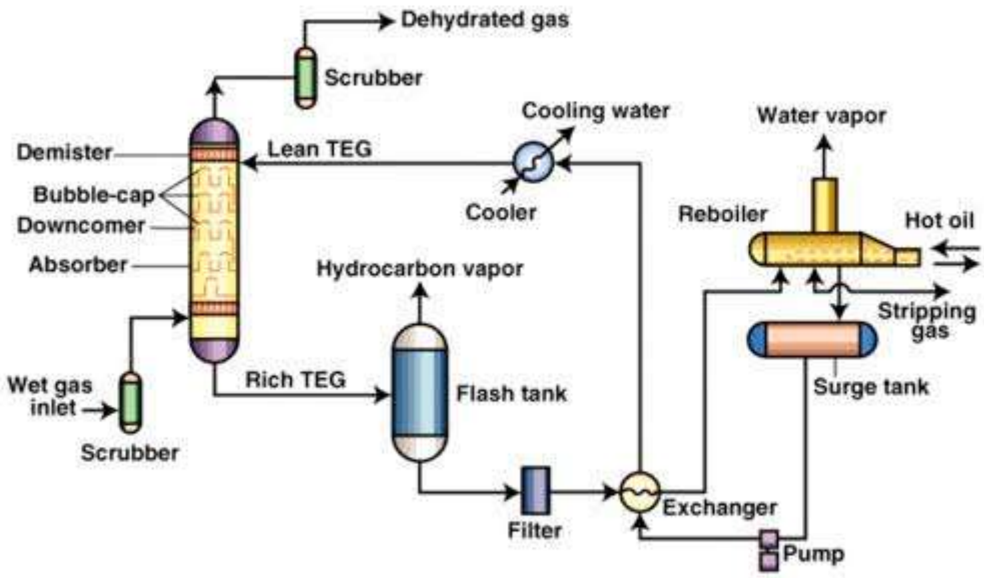

Figure 1: Schematic drawing of the glycol dehydration process equipment

Solid Adsorption Methods- Alternative Dehydration

Though less common for pipeline gas dehydration, solid adsorbents are used in specific conditions. Common adsorbents include:

1. Silica gel
2. Zeolites (molecular sieves)
3. Activated alumina

Challenges & Fixes:

a. Challenges: High regeneration energy, adsorbent degradation, bed replacement costs
b. Fixes: Optimize regeneration cycles, use robust adsorbents, apply in niche cases (e.g., remote sites, stringent specs)

Solid Adsorption Process: Dual-Tower Operation

Fig. 2 illustrates the dual-tower setup for natural gas dehydration using solid adsorbents (silica gel, zeolites, alumina). Two towers alternate between adsorption and regeneration for continuous operation.

Process Details:

1. Adsorption Phase: Wet gas flows through Tower 1, water adsorbs onto the solid medium.
2. Saturation & Switch: After several hours, Tower 1 is saturated. Gas flow switches to Tower 2.
3. Regeneration Phase: Tower 1 is regenerated by heating with a slipstream of gas, stripping off water. It's then cooled before switching back.

Challenges & Fixes in Nigerian

a. Challenge: High energy for regeneration, complex operation.
b. Fixes: Optimize cycle times, use waste heat, apply in remote sites where glycol units face logistics issues

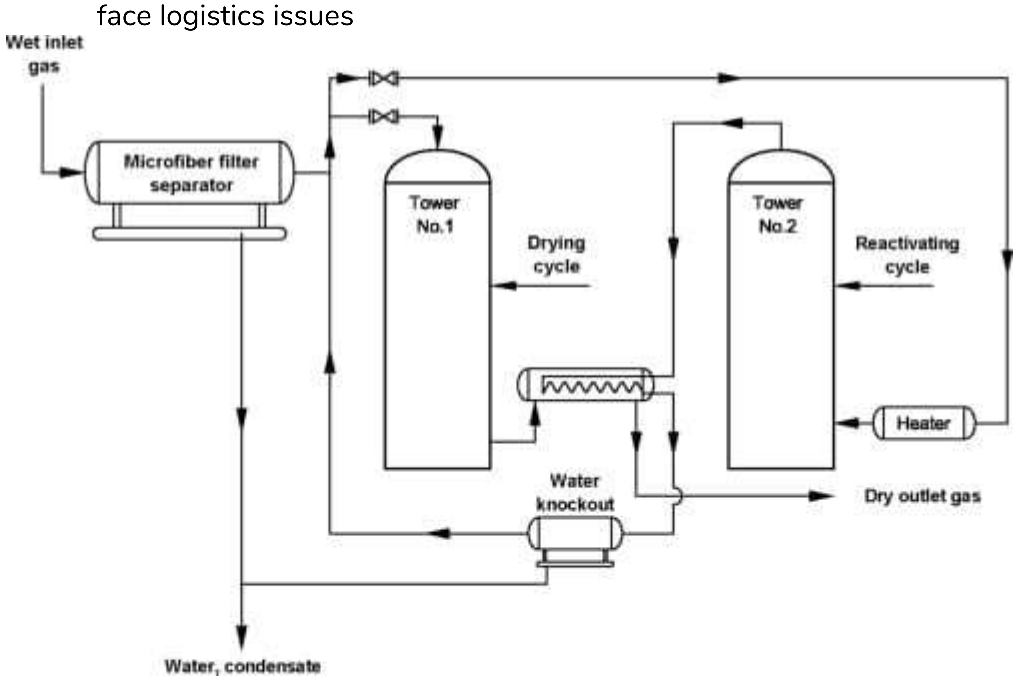

Figure 2: Adsorption process flow diagram for solid desiccants

Liquid Desiccant Dehydration- Calcium Chloride Process

Calcium chloride ($CaCl_2$) is used as a liquid desiccant, absorbing water vapor and forming brine, which is removed.

Advantages of Modern CaCl2 Desiccants:

1. Hard, non-porous structure prevents water ingress
2. Low permeability maintains shape during hydration
3. Consistent flow efficiency as degradation occurs on surface only

This process is useful for specific gas conditions, offering an alternative to glycol and solid adsorption methods. The modern formulation of CaCl2 desiccants enhances performance and durability. Fig. 1 illustrates an improved gas dehydration system using liquid desiccant dryers (e.g., Calcium Chloride).

1. Wet gas enters the bottom of a vertical vessel, passing through diffusion baffles for even flow distribution.
2. Gas contacts the desiccant bed, where water vapor is absorbed, hydrating the desiccant.
3. Collected water dissolves the desiccant salts ("dehumidification"), forming a brine that's removed.
4. Desiccant dosage depends on formulation and dilution factor for efficient water removal

Refrigeration in Gas Processing: Dual Dew Point Control

In gas plants, refrigeration cools process streams, serving a dual purpose:

1. Hydrocarbon Dew Point Control: Prevents liquid dropout in pipelines by condensing heavier hydrocarbons.
2. Water Dew Point Control: Ensures residual gas meets specs for consumer use (Fig. 3).

Why It Matters:

a. Prevents hydrates, corrosion, and pipeline issues.
b. Optimizes gas quality for sales/transport.

Challenges: Energy intensity, refrigerant management, equipment costs.
Fixes: Use efficient cycles (e.g., Joule-Thomson), integrate with dehydration units, optimize refrigerant blends

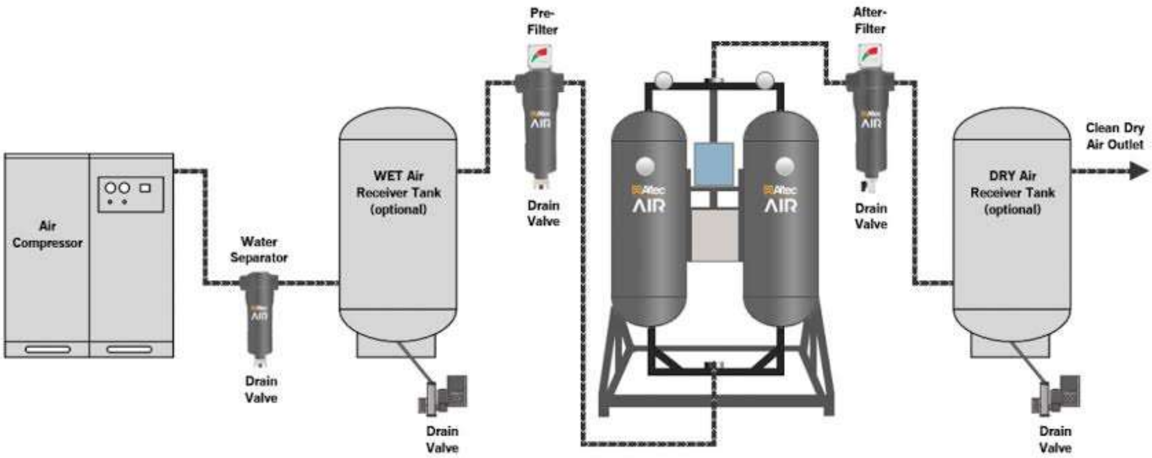

Figure. 3. Multi-stage desiccant dryer process flow diagram

Fig. 4 illustrates typical refrigeration equipment for natural gas cooling. The heat exchanger uses gas mixing to cool incoming gas; e.g., propane coolers chill gas to a set low temperature.

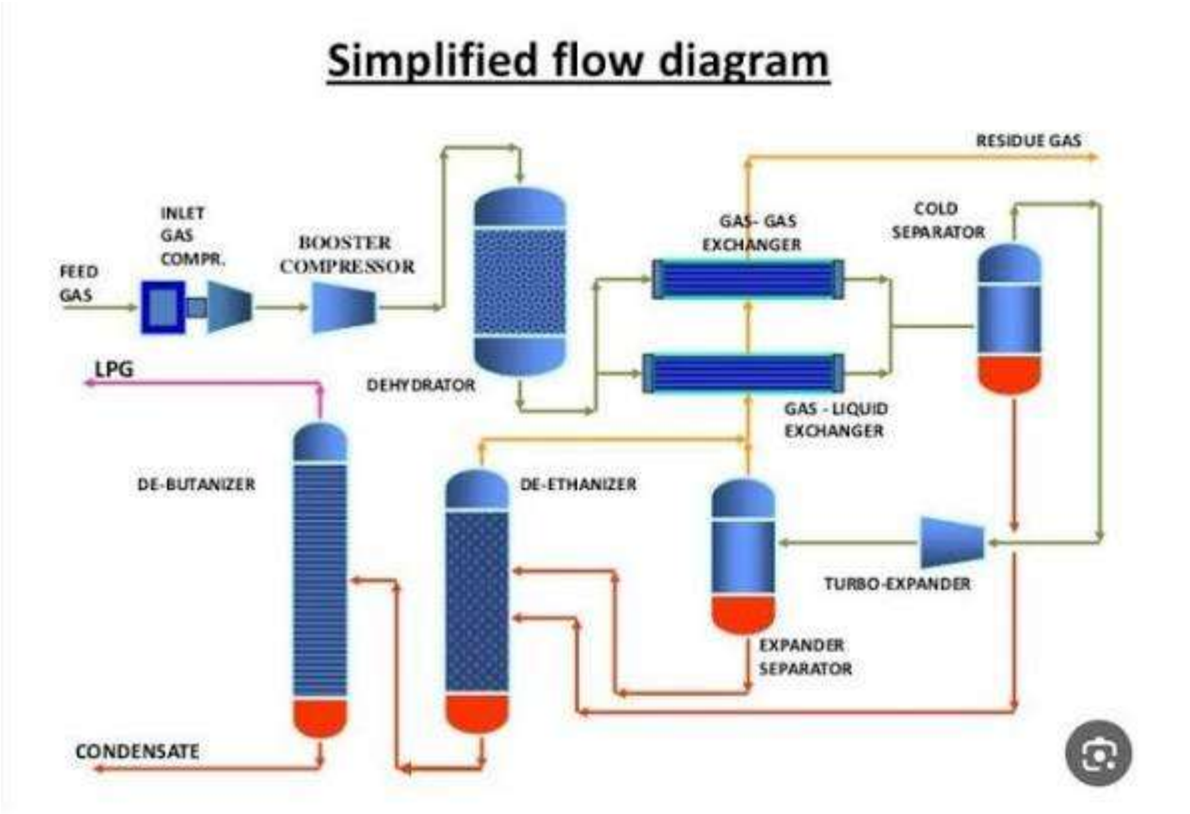

Figure 4: Process diagram for controlling product dew point in a refrigeration unit

Dehydration of extracted gas uses methods discussed earlier, with glycol absorption being common in Nigeria.

Process Setup (Fig. 5):

a. Antidirectional Device: 3 absorbers in series with solution collectors (1), pumps (4), and coolers (3).
b. Flow: Absorbent flows counter-current to gas, enhancing water uptake.

Recirculation Absorption-Desorption (Fig. 6):

a. Purpose: Maximize liquid saturation and cleanly separate absorbed components.
b. Components: Absorbers (1), collectors (2), pumps (3), coolers (4), heat exchanger (5), desorption column (6).
c. Flow: Gas enters first column; liquid contacts gas counter-currently

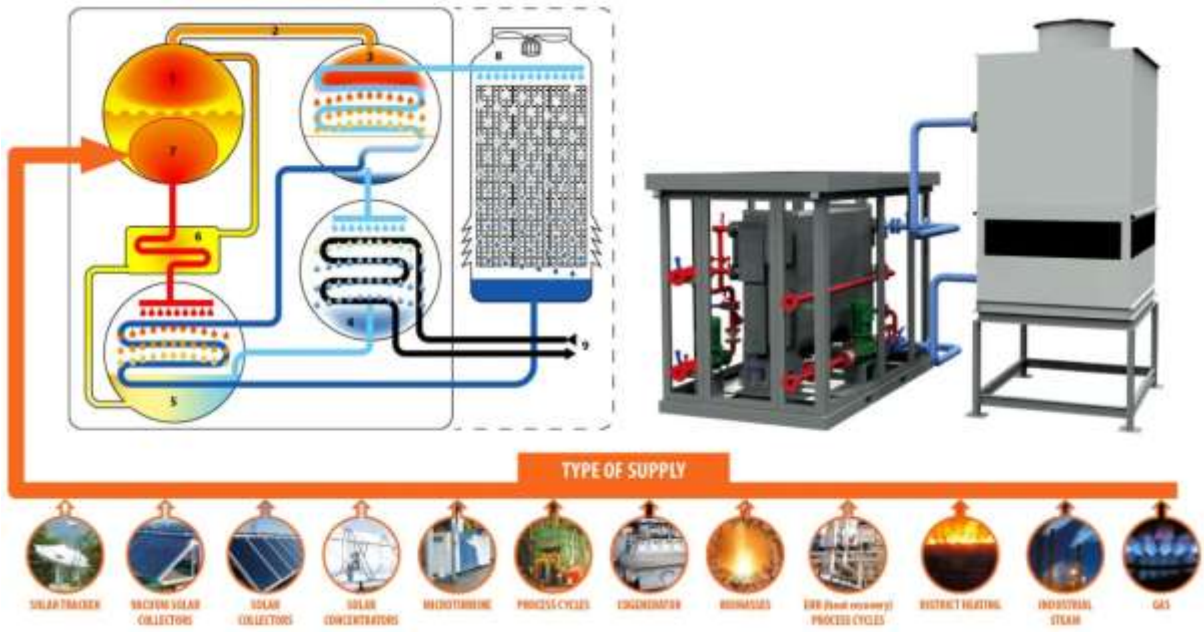

Figure 5: Counter-flow absorption unit schematic

Process Flow in Multi-Column Absorption

In this setup, fluid moves in a limited cycle:

a. Partially treated gas flows from 1st to 2nd column.
b. Liquid also cycles in each column.
c. When solution concentration hits a threshold in column 2, it's transferred to column 1 (Fig. 6).

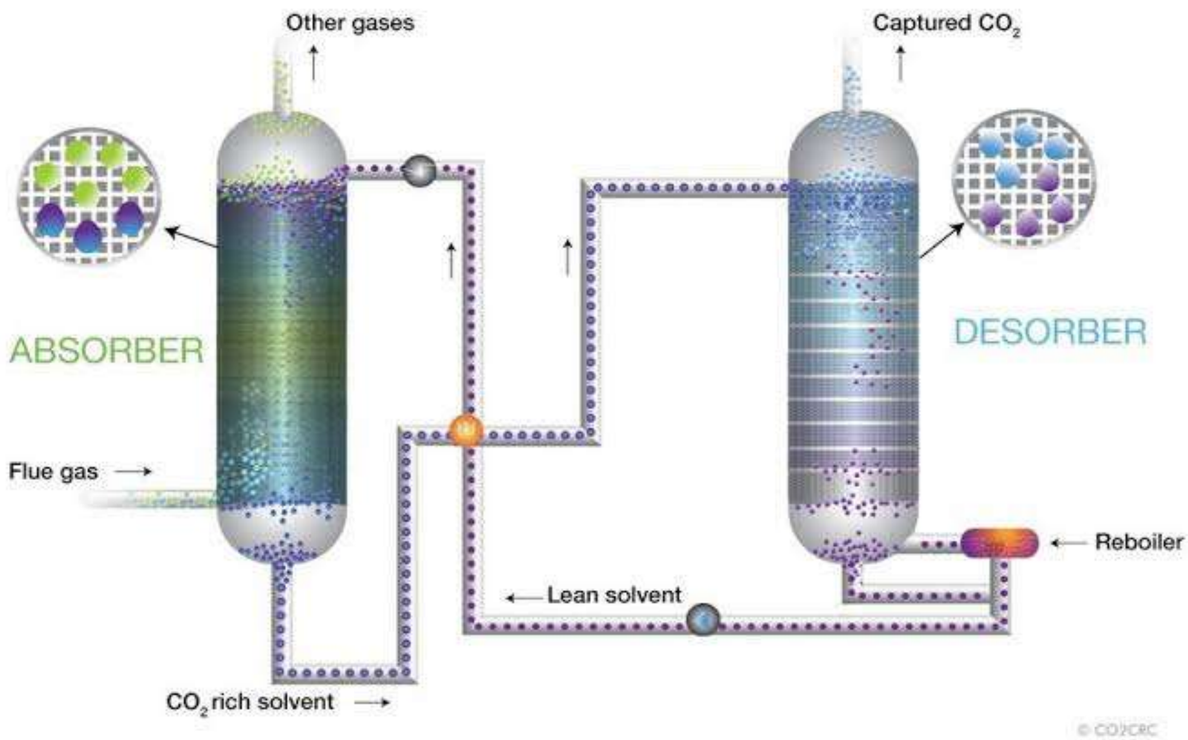

Figure 6: Recirculation absorption-desorption unit layout

A key issue with current setups is ignoring salt & mechanical particles exiting with extracted gas, affecting efficiency & equipment.

Discussion

Challenges of High Salt Content in Gas

Nigeria's Bonny Gas field faces issues due to high salt content:

1. Cost spikes in gas drying.
2. Glycol degradation reduces regeneration efficiency.
3. Equipment damage → repairs & rebuilds hike costs.
4. Stranded gas with high salt content.
5. Energy drain: Salt buildup in desorbers raises power use

Proposed Fix: Use retardation methods or salt-tolerant glycols, optimize desorption temps, and integrate salt removal units.

Ion Exchange Desalination for Natural Gas Dehydration.

This method tackles salt-related challenges in gas dehydration via ion exchange:

a. Gas from reservoir (1) flows through cationite (4) → removes cations (Na^+)
b. Then anionite (6) → removes anions (Cl^-)
c. Desalinated gas exits via pipe (8).

Continuous Process:

a. Saturated cationite (4) switches to backup (5); regenerated with H_2SO_4
b. Anionite (6) regenerated with NaOH
c. Wastewater discharged (10)

Key Benefits for Natural Gas Dehydration:

a. Adapts to varying salt types in gas wells/storage
b. Boosts DEG efficiency & equipment lifespan (Fig. 7 integration)
c. Mitigates salt buildup issues in recirculation absorption-desorption units

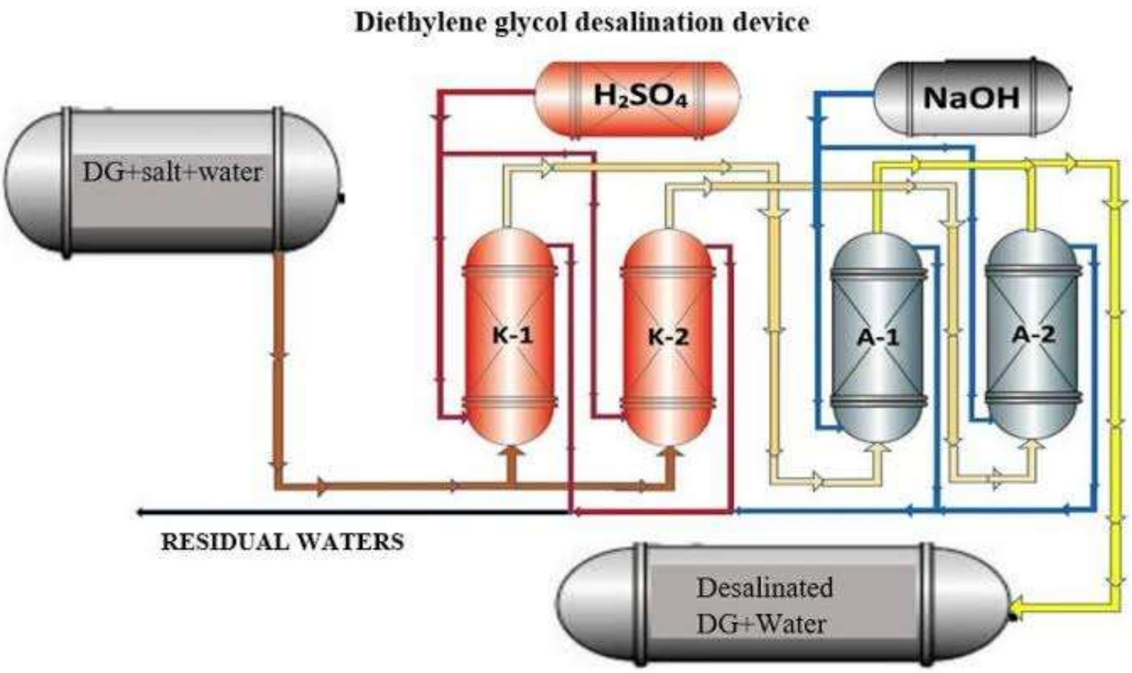

Figure 7: DEG solution desalination unit using retardation

Membrane Dehydration Process for Natural Gas Treatment

The membrane dehydration process, as outlined in United States Patent No. US 2002/0053285 A1, utilizes a membrane separator (20) to remove moisture from wet gas streams. Here's a detailed breakdown of the process: The wet gas is introduced through line

(21) into the membrane separator (20), which is equipped with a membrane (22) and a porous membrane support (23). The membrane support has pores (24) that allow water molecules (25) to pass through from the gas side to the solution side (26) of the membrane separator.

The membrane (22) is designed with micropores that selectively permit water molecules from the gas to pass through while blocking other gas molecules. As the moist gas flows upward against the potassium formate solution on the opposite side of the membrane, moisture is transferred from the gas through the porous support and membrane. The potassium formate solution, which is diluted due to moisture absorption, is then sent through line (32) to a regenerator (29). The regenerator removes excess water from the solution, returning a concentrated stream through line (30) for reuse in the membrane separator.

The dry gas, now depleted of moisture, is recovered through line (27) for further use or transmission. The removed water is either vented through (31) or stored for other applications. The regenerator (29) can be a reboiler, another membrane separator, or a cavitation pump, offering flexibility in the dehydration process. This membrane dehydration method effectively removes water vapor from natural gas, making it suitable for various industrial applications.

Key Components:

a. Membrane separator (20)
b. Membrane (22)
c. Porous membrane support (23)
d. Potassium formate solution
e. Regenerator (29)

Process Advantages:

a. Efficient moisture removal
b. Selective permeability of the membrane
c. Flexible regeneration options
d. Suitable for natural gas treatment

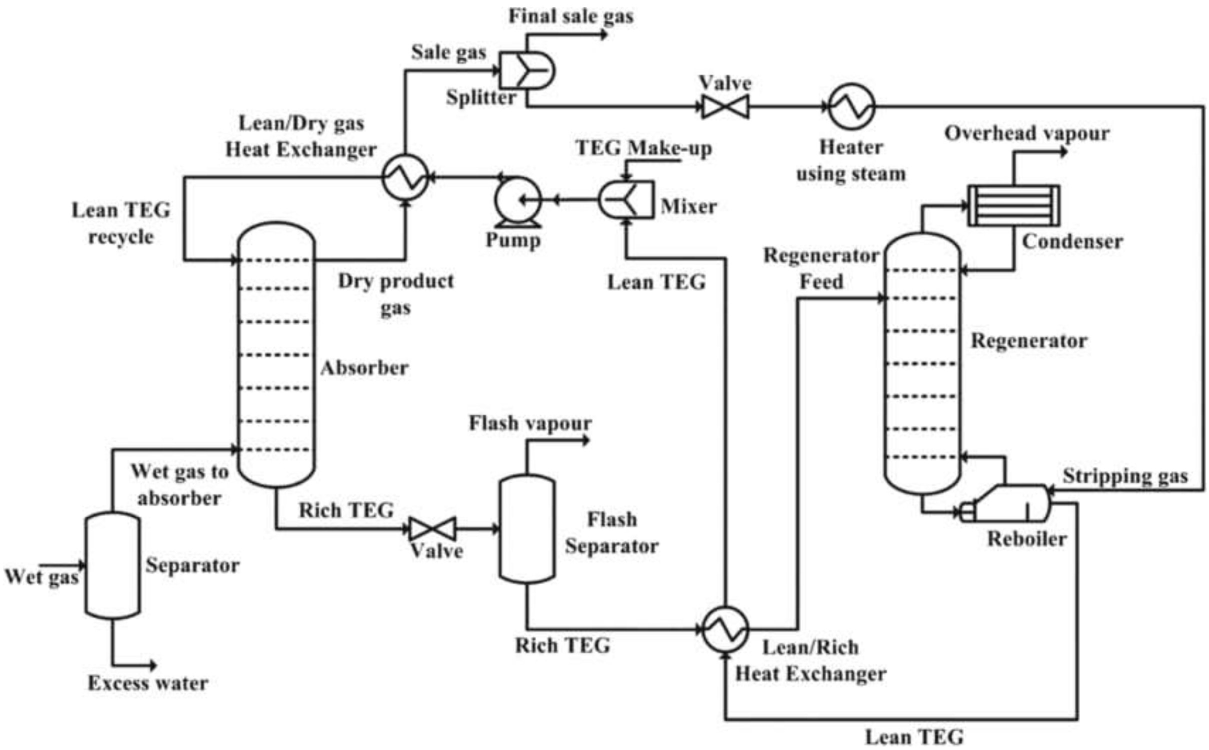

Figure 8: Membrane-Based Gas Dehydration System

CONCLUSION

In Nigeria's Gas fields, dehydration efficiency is impacted by mechanical particles and glycol losses, reducing economic gains. Enhancing absorption methods with additives can help. The retardation method (US 2002/0053285 A1) offers a simple, low-cost solution for salt reduction and gas purification. Though productivity differs from absorption, it complements existing processes, enabling better utilization of residual gases, reducing maintenance, and extending equipment life. Implementing this alongside absorption can optimize gas processing, addressing local challenges and boosting efficiency. This approach suits Nigeria's needs, balancing simplicity, cost, and purification effectiveness

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