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Amine regeneration used in the treatment of Fuel Gas and LPG

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II. DEDICATES

الحمد لله حبا وشكرا وامتنانا على البدء والختام

.وآخر دعواهم أن الحمد لله رب العالمين

لم تكن رحلة قصيرة ولا الطريق محفوفًا بالتسهيلات، لكنني فعلتها، فالحمد لله الذي يسر البداية وبلغنا النهايات بفضله وكرمه

:بكل حب ومشاعر أهدي ثمرة نجاحي وتخرجي إلى

من قال فيهم الله تعالى (وَقَضَى رَبُّكَ أَلَّا تَعْبُدُوا إِلَّا إِيَّاهُ وَبِالْوَالِدَيْنِ إِحْسَانًا)

أهدي تخرجي إلى الإنسانة العظيمة التي طالما تمنت أن تقر عينيها برؤيتي في يوم كهذا، إلى من جعلت مني فتاة طموحة وسهلت علي الصعاب بدعائها الخفي، إلى القلب الحنون والشمعة التي كانت نورًا لي في الليالي المظلمة التي ساندتني طوال مسيرتي وهونت علي الطريق، **جعفري فتيحة** أمي حفظها الله

إلى من زين اسمي بأجمل الألقاب، إلى من أحمل اسمه بكل فخر، الذي كان دوما بقلبي سندي وقوتي،

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إلى الصديقة الرائعة التي لولا اجتماعنا واتفاقنا الرائع ما كنا أنجزنا هذا العمل، شريكتي في هذه الرحلة الصديقة العزيزة **سعودي رانيا**

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وأخيرًا من قال أنا لها "نالها"، وأنا لها وإن أبت رغما عنها أتيت بها، ما كنت لأفعل لولا توفيق الله، ها هو اليوم العظيم هنا، اليوم الذي سعيت من اجله بعد سنوات شاقة من الدراسة حالمة فيه حتى توالت بمنه وكرمه فرحة التمام، الحمد لله الذي به خيرًا وأملًا إلا وأغرقنا سرورًا وفرحًا ينسيني مشقتي

صغِيِّر نُور الهُدَى

Abstract

In industrial processes, diethanolamine (DEA) is used to absorb carbon dioxide (CO_2) and hydrogen sulfide (H_2S) from natural gases and industrial effluents. It acts by forming reversible reactions with these acidic gases. At the Algerian refinery, DEA is employed in processes for treating liquid hydrocarbons to remove sulfur as per environmental standards. The aim of the Amine Regeneration Unit (ARU) is to provide lean amine to the Fuel Gas Amine Treatment Unit (FGATU) and the caustic Merox unit, while regenerating rich amine from these units. The process efficiency is influenced by operational parameters such as temperature, pressure, H_2S content in the LPG to be treated, DEA concentration used, and the flow rates entering the absorption column.

Dans les processus industriels, la diéthanolamine (DEA) est utilisée pour absorber le dioxyde de carbone (CO_2) et l'hydrogène sulfuré (H_2S) des gaz naturels et des effluents industriels. Elle agit en formant des réactions réversibles avec ces gaz acides. À la raffinerie d'Alger, la DEA est utilisée dans les procédés de traitement des hydrocarbures liquides pour éliminer le soufre selon les normes environnementales requises. L'objectif de l'unité de régénération de l'amine (ARU) est de fournir de l'amine pauvre à l'unité de traitement par amine du fuel gas (FGATU) et à l'unité mérox par caustique, tout en régénérant l'amine riche provenant de ces deux unités. L'efficacité du procédé est influencée par un ensemble de paramètres opératoires tels que la température, la pression, la charge de H_2S dans le GPL à traiter, la concentration de DEA utilisée et les débits d'entrée des flux à la colonne d'absorption.

وكبريتيد الهيدروجين (CO_2) لامتصاص ثاني أكسيد الكربون (DEA) في العمليات الصناعية، يستخدم ثنائي إيثانولامين من الغازات الطبيعية والنفايات الصناعية. يعمل عن طريق تكوين تفاعلات قابلة للانعكاس مع هذه الغازات الحمضية. (H_2S) وفي مصفاة الجزائر العاصمة، تستخدم إدارة مكافحة المخدرات في تجهيز الهيدروكربونات السائلة لإزالة الكبريت وفقا هو توفير الأمين الخالي من الدهون لوحدة معالجة غاز (ARU) للمعايير البيئية المطلوبة. الهدف من وحدة تجديد الأمين ووحدة الميثروكس الكاوية، مع تجديد الأمين الغني من هاتين الوحدتين. تتأثر كفاءة العملية (FGATU) الوقود الأمين في غاز البترول المسال الذي يجب معالجته H_2S بمجموعة من بارامترات التشغيل مثل درجة الحرارة والضغط وحمل المستخدم وتدفقات التدفق إلى عمود الامتصاص DEA وتركيز.

key words **:** DEA ,regeneration ,Absorption,H_2S,GPL, Fuel gas.

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ABREVIATION

(ARU): Amine Regeneration Unit

(CCR) : Continuous catalytic regeneration.

(COS) : carbonyl sulfide

(CO_2) :carbon dioxide

(CS_2) : carbon disulfide

(DEA) : Diethanolamine

(DIPA): Diisopropanolamine

(DGA): Diglycolamine .

(FIC) : flow indicator controller

(FGATU) : Acid Gas Treatment Unit (fuel-gas) with amine

(H_2S) : hydrogen sulfide

(LPG) : liquefied petroleum gas

(MDEA) : Methyldiethanolamine

(MEA) : Monoethanolamine

(NHT) : Naphtha Hydrotreatment

(RFCC) : Residual fluid catalytic cracking

(SRU): Sulphur Recovery Unit

(SWS): Sour Water Stripping Unit

INTRODUCTION

Amines has an important role in treating liquefied petroleum gas (LPG) and fuel gas for desulfurization, a critical process to meet stringent environmental standards for sulfur emissions. Among the commonly used amines, monoethanolamine (MEA), diethanolamine (DEA), and methyldiethanolamine (MDEA) are widely employed due to their specific properties that effectively capture and remove acidic gases such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S).

Diethanolamine (DEA) is an organic compound widely utilized in industries for natural gas and industrial effluent treatment, particularly for absorbing acidic gases like CO_2 and H_2S. DEA is preferred in many applications due to its lower corrosiveness compared to monoethanolamine (MEA) and its ability to handle high-pressure gases with high concentrations of acidic components. The manufacturing process of DEA involves the reaction of ethylene oxide with ammonia, followed by purification to obtain the desired product. DEA is typically in liquid form, and its concentration in solutions used for gas treatment is carefully controlled to prevent excessive corrosion and ensure effective absorption of acidic gases. Proper management of operational parameters such as temperature, pressure, and flow rate is essential to optimize the operation of the regeneration unit and extend the lifespan of the DEA solvent

In gas treatment processes, DEA acts by forming reversible reactions with acidic gases, thereby efficiently capturing them. This capture capability is essential in refineries like Algiers, where DEA is employed to remove sulfur loads from liquid hydrocarbons, ensuring compliance with strict environmental specifications. The desulfurization process with DEA begins with the absorption of acidic gases into a DEA solution. The rich amine solution, now saturated with CO_2 and H_2S, is then routed to a regeneration unit.

The amine regeneration unit (ARU) aims to regenerate the saturated DEA solution by removing the absorbed acidic gases. This regeneration process takes place in a regeneration column where the rich amine solution is heated. The heat releases the captured acidic gases, which are subsequently discharged, typically to a sulfur recovery unit (SRU) or acid flare. The regenerated DEA solution (lean amine) is cooled and returned to the gas treatment cycle. Effective regeneration of DEA is crucial to maintaining the efficiency of the desulfurization process and minimizing operational costs.

My thesis is structured around a general introduction, followed by three chapters about amine and his regeneration process, and a general conclusion.

Chapter 1: I present the location of my internship, focusing on the main facilities it has of the Algiers refinery as well as the sulphur block.

Chapter 2: This chapter begins with a presentation of alcanoamines , addressing the history and its types .

Chapter 3: It is devoted to (DEA) regeneration proces, which is the main subject of this research.

- Finally, the last section is a general conclusion about the regeneration process

This structure aims to provide a clear and comprehensive view of the regeneration amine process at the refinery of algeris .

Chapter one :

The Refinery of Algiers

I. Presentation of the company

I.1 presentation of SONATRACH

Sonatrach is an oil and gas company located in Algeria. The date of its founding was December 31, 1963. It is a major player in the oil sector. SONATRACH is ranked the top company in Africa.[1]

The Sonatrach oil and gas group is engaged in the extraction, processing, pipeline transportation, marketing, and exploration of hydrocarbons and their derivatives.

In addition, Sonatrach is growing its mining, petrochemical, power generating, new and renewable energy, and saltwater desalination operations. [2]

I.2 Presentation of the Algiers Refinery

Constructed in 1959, the refinery in Algiers started operating on April 15, 1964.It covers the needs for necessities like LPG, diesel, gasoline, and more. in addition to the products that form the basis of the petrochemical sector.

95% of the fuel requirements of the Central area of Algeria are met by the 3.6 million tons of Saharan crude oil processed annually by the Algiers refinery.[3]

The refinery installed its RFCC Block for catalytic cracking (associated LPG treatment, acid water treatment, amin regeneration, and Sulphur recovery) and its MS Block for the production of components for the manufacture of gasoline (naphtha hydro processing, CCR reforming, and isomerization) between November 2019 and February 2020

II. Geographical location of the Algiers Refinery

The refinery in Alger is located 5 km south of EL Harrach and 20 km east of Alger, occupying an area of 182 hectares. This location was chosen after a soil study and the discovery of a water tank needed for the supply of cooling systems.

The refinery of Algiers is located in Sidi Arcine in the commune of Barraki, 20 km east of Alger and is located at an altitude of 20 m. The site of the refinery in Algiers occupies a total area of 182 hectares (built and fenced 96 hectares) and is delimited.[4]

III. Objective of the Algiers Refinery

The main task of the Algiers Refinery is to process the crude oil from the Hassi-Messaoud field, as well as the condensate from the Hassi-R'Mel fields. These operations make it possible to obtain different oil cuts for the production of various derivatives such as gasoline, diesel, oil, and many others.

IV. The products of the refinery in Algiers

The refinery has a wide range of products that meet national and international standards which are:

- Commercial butane and propane: used as fuel in gas vehicles & for domestic heating.
- Naphtha (90% gasoline + 10% total solvent): a raw material mostly used in petrochemicals MS Block + exported.
- Lead-free essences and gas-oil: are used in vehicle motors.
- Kerosene: is used as fuel in aviation.
- Heavy fuel is exported feed RFCC Unit.

V. Main units of the Refinery

Sonatrach consists of several units where crude oil is transformed from prime to different finished products:

- Atmospheric distillation unit ″Topping″ (U 100).
- Liquefied gas separation unit "gas-plant" (U 300).
- NHT Naphtha Hydrotreatment Unit (U 500).
- Naphtha Isomerization unit (U 510).
- CCR Catalytic Reforming Unit (U 520).
- RFCC catalytic cracking unit (U 530).
- Block Sulphur section: break down into four units:
- Utilities consists of several units on site; Raw Water Unit, Fire Water unit, Demineralized water unit, The torch... etc.
- Storage Park consisting of 53 cylindrical tanks with a total capacity of 474500 m3 for the storage of the various products and 9 spherical reservoirs with a capability of 15106 m3 to store propane and butane.

- Laboratory the laboratory performs on the various intermediate or finished products a number of conventional tests to control the specifications of the petroleum products according to the standards and to detect anomalies in the operation of the process to optimize the parameters.

VI. Sulphur block section

The sulphur block consists of five units:

- Unit 560-FGATU: Acid Gas Treatment Unit (fuel-gas) with amine
- Unit 600: LPG Treatment Unit with amine
- Unit 580-ARU: Amine Regeneration Unit
- Unit 590-SRU: Sulphur Recovery Unit
- Unit 570-SWS: Sour Water Stripping Unit

Chapter Two:
Alcanolamines

I. Alcanolamines

Several commercial processes are employed to purify light liquid hydrocarbons, with the most common being amine treatment systems, caustic washes, and molecular sieves.

- In case of large quantities of dissolved acid gases, caustic washing may not be the best option due to the cost of caustic soda, challenges in handling waste, and the limited effectiveness of the process in meeting the required quality standards for liquids.
- The disadvantages of molecular sieves are high capital and operating costs, undesirable formation of COS in the presence of H_2S and CO_2, and the inability to achieve the required ppm concentrations in the final products.
- Therefore, amine-based treatment is generally the most cost-effective and technically suitable choice for purifying liquids when significant amounts of CO_2 are present [5]

II. Historically

Bottoms was the first to study amines for gas treatment as early as 1931. His work showed that ethanolamines have a high absorption capacity for acid gases. Triethanolamine was the first amine to be industrially produced and used in early gas treatment units. Other amines were evaluated in this direction as soon as they became industrially feasible, such as diethanolamine (DEA), ethanolamine (MEA), and N-methyldiethanolamine (MDEA), which are known for their greater effectiveness. Disopropylamine (DIPA) was briefly used before being replaced by MDEA. These compounds are derivatives of ammonia in which hydrogen atoms are replaced by an alcohol group (e.g., methanol, ethanol)

The hydroxyl group of alkanoamines increases their solubility in water and reduces the vapor pressure of the aqueous solution. Alkanoamines serve two functions: an amine function that ensures the molecule's basicity and an alcohol function that ensures high solubility of the amine in water.

Amines can be classified into three main families:

- Primary amines: Monoethanolamine (MEA), Diglycolamine (DGA).
- Secondary amines: Diethanolamine (DEA), Diisopropanolamine (DIPA).
- Tertiary amines: Methyldiethanolamine (MDEA).

Hydrogen sulfide (H2S) is more soluble in amines than in hydrocarbons due to their acid-base interaction, making them more suitable for treating acid gases. The high affinity of ethanolamines with H_2S is attributed to the nature of the amine, influenced by their steric hindrance and the degree of nitrogen substitution.

The choice of amine as an absorbent differs mainly based on several characteristics:

- Solubility: It should be highly selective towards the absorbate.
- Low volatility (to avoid being carried away).
- Low viscosity (increased absorption rate, faster flow), as a less viscous solvent is preferred to prevent pressure drop in the pumping device.
- Low corrosiveness to materials.
- Non-flammable and chemically stable.
- Low freezing point.
- Economical price [6].

III. Comparison of the three types of Amines

The choice of process depends on several parameters, with the most important likely being the concentration of acid gases in the feed, the output specifications, the partial pressures, and the selectivity towards a particular component. Amine absorption processes are among the most widespread due to their ability to handle a wide range of acid gas concentrations in the input while meeting stringent output specifications.

III.1 Monoethanolamine (MEA) :

Monorthanolamine (MEA) is a primary amine, the strongest and most basic among others . It can completely remove acid gases from the gas stream. It is always preferred for maximum treatment of gases with low concentrations of CO_2/H_2S and where carbonyl sulfide (COS) and carbon disulfide (CS_2) are not present. It is used with a low-pressure gas stream.These amine have been widely used for many years for acid gas treatment but are now being rapidly replaced by other more efficient amines. It reacts with H_2S according to the following reactions:

$$2\,(R - NH_2) + H_2S \longrightarrow (R - NH3)_2S$$

$$(R - NH_3)_2S + H_2S \longrightarrow 2\,(R - NH_3)\,HS$$

- **Disadvantages:**

— Irreversibly forms reaction products with sulphide carbonyl (COS) and carbon disulfide (CS_2), resulting in excessive loss of solution and an increase in solid products in the circulating solution. These particles cause the formation of foam in the amine solution.

— These are more corrosive and degradable than other amines, especially if the amine concentration exceeds 20% or if the solution is heavily loaded with acid gas. Therefore, the high partial pressure of acid gas limits its capacity.

- It requires high circulation rates and high consumption energy for its regeneration.

III.2 Diethanolamine (DEA)

Diethanolamine (DEA) has replaced Monoethanolamine (MEA) and has become the most widely used gas softener solvent due to its overwhelming advantages compared to MEA.). It can process gases at high pressure with high concentrations of acidic components, in the presence of COS and CS_2, and can also be regenerated when it reacts with carbonyl sulfide (COS) and carbon disulfide (CS_2). Due to fewer corrosion problems and high efficiency in

removing acid gases, it is the predominant chemical used in refineries. It is a secondary amine with lower reactivity and corrosivity than Monoethanolamine (MEA).

DEA is used to treat natural gas, refinery gas effluents, recycle gas from hydrotreating and hydrocracking units, liquefied petroleum gas (LPG), and refinery gas effluents before being sent to the refinery fuel gas system.

$2\ R_2{-}NH + H_2S \longrightarrow (R_2{-}NH_2)_2S$

$(R_2NH_2)_2S + H_2S \longrightarrow 2\ R_2{-}NH_2SH$

- **Advantages**

— Loading up to 0.65 mol of acid gas per mole of DEA can be achieved with fewer operational problems than MEA due to the elimination of degradation products.

— It is a weaker base and less reactive than MEA. Consequently, there are fewer corrosive

— Foaming is reduced due to the absence of degradation and corrosion products.

— It does not degrade upon contact with H_2S, CO_2, or mercaptans.

— Lower circulation rates, reduced energy consumption, and resistance to degradation, as opposed to MEA.

— Under normal operating conditions, DEA decomposition products can be removed fairly easily by activated carbon filtration.

— DEA is much less reactive with carbonyl sulfide (COS) and carbon disulfide (CS_2) than primary amines (MEA), and the reaction products are not corrosive. Therefore, DEA is a better choice for treating gas streams containing carbon disulfide (CS_2) and CO_2.

— It can be used interchangeably for both high and low-pressure applications.

- **Disadvantages**

DEA undergoes many irreversible reactions with CO_2 that form corrosive degradation products. Therefore, DEA may not be the optimal choice for treating gases with high CO_2 content.

III.3 Methyl diethanolamine (MDEA)

MDEA is a good choice for the selective absorption of H_2S in the presence of CO_2. Lower weight percentage solutions are generally used in low-pressure and selective gas applications. Corrosion is much lower even under high acid gas loads . Its main disadvantage is its slow reaction with CO_2. MDEA is used in the purification of gases other than hydrocarbons, such as the products of coal gasification processes and the tail gas treatment section of the Claus

- **Advantages**

— The major advantage of MDEA is its high selectivity for H_2S in the presence of CO_2. Other merits of MDEA include low vapor pressure, lower heat of reaction, and higher resistance to thermal and chemical degradation.

— Due to its low vapor pressure, MDEA can be used at concentrations up to 60% by weight in aqueous solutions without significant evaporation losses.

- **Disadvantages**

— In the presence of oxygen, MDEA forms corrosive acids which, if not removed, can lead to the accumulation of iron sulfide in the system.

— Generally, MDEA is less reactive and may not meet the specifications of the treated product at low gas pressures.

— As a tertiary amine, it cannot directly react with CO_2. When CO_2 dissolves in water, a bicarbonate ion is formed and reacts with MDEA. Consequently, it is less effective for removing CO_2[7] [8] [9].

IV. The uses of amines in the treatment of LPG

The use of amines, such as diethanolamine (DEA), is crucial in the treatment of liquefied petroleum gases (LPG). Their primary function is to remove sulfur compounds, specifically hydrogen sulfide (H_2S) and carbon dioxide (CO_2), from gas streams.

This process is essential to meet stringent environmental regulations and to prevent equipment corrosion. The treatment process involves the absorption of H_2S and CO_2 by the amine solution in an absorption column, where these acidic gases dissolve and react with the amine to form soluble compounds.

The rich amine solution, now containing sulfur compounds, is then heated in a regeneration column to release the acidic gases and regenerate the amine for reuse. The regenerated amine is cooled and recycled back to the absorption column, continuing the purification cycle. The use of DEA in LPG treatment is vital for reducing corrosion risks, ensuring environmental compliance, and improving the quality of the LPG, making it safer and more efficient for end users.

The amine regeneration process allows for efficient recycling, ensuring continuous and economical operation.[10]

V. The use of amines in the treatment of fuel gas

The use of amines in the treatment of fuel gas is essential for removing impurities such as hydrogen sulfide (H_2S) and carbon dioxide (CO_2). This process, known as gas sweetening, ensures that the fuel gas meets environmental standards and reduces corrosion in pipelines and equipment. During the treatment, fuel gas is passed through an absorption column where it comes into contact with an amine solution. The amine reacts with the acidic gases, effectively removing them from the gas stream. The rich amine solution, now containing the absorbed impurities, is then sent to a regeneration unit where it is heated to release the absorbed gases. The regenerated amine is cooled and recycled back into the system for continuous use. This method not only purifies the fuel gas but also enhances its quality and safety for downstream processes and usage.[10]

Chapter three:
Description of processes

VI. Purpose of the unit

The objective of the Aminne Amine Regeneration Unit (ARU) is to provide lean amine to the Fuel Gas Amine Processing Unit (FGATU) and the Caustic Methrox Unit and to regenerate the rich amine from these two units. The circulating amine is a 25% diethanolamine (DEA) solution by weight.

VII. Chemical processes

The rich amine from the FGATU unit (U560) and the Merox unit using caustic (U600) is collected in the rich amine vaporization drum (580-D-001). The rich amine vaporization drum separates entrained liquid or gaseous hydrocarbons from the rich amine. The vaporized hydrocarbon vapors, which also contain H_2S and water vapor, are washed with a small flow of lean amine in the overhead of 580-C-002.

The rich amine from the bottom of 580-D-001 is pumped by the feed pumps of the regenerator (580-P-008-A/B), then sent to the rich/lean amine heat exchanger tube side (580-E-001-A/B). The rich amine is heated and fed to the amine regeneration column (580-C-001) through a flow control valve.

580-C-001 effectively rectifies most of the H_2S from the rich amine, thereby regenerating it into lean amine. The basic chemistry involved in removing H_2S is described below.

Hydrogen sulfide, H_2S or HSH, is a weak acid and ionizes in water to form hydrogen ions and sulfide ions:

$$H_2S + H_2O \quad \Longleftrightarrow \quad H_3O^+ + HS^- \qquad (1)$$

Given that it is a weak acid, only a fraction of H2S ionizes.

Diethanolamine is a weak base and ionizes in water to form amine ions and hydroxyl ions:

$$(HO\ CH_2\ CH_2)_2NH^+\ H_2O \rightarrow (HO\ CH_2\ CH_2)_2NH_2^+ + OH^- \qquad (2)$$

When H2S dissolves in the solution containing amine ions, it reacts to form a weakly bound salt of acid and base.

$$(HO\ CH_2\ CH_2)2NH_2^+ + HS^- \rightarrow (HO\ CH_2\ CH_2)_2NH_2SH \qquad (3)$$

The sulfide ion is then absorbed by the amine solution.

This formation reaction is not complete. As indicated by the arrow, an equilibrium level of hydrogen sulfide remains in the hydrocarbon stream. The overall reaction can be summarized by the following equation:

$$(HO\ CH_2\ CH_2)2NH + H_2S \rightarrow (HO\ CH_2\ CH_2)2NH_2SH \qquad (4)$$

Operating variables are adjusted to favor the reaction to the right of equation (4) in the absorption stage of the process and, conversely, adjusted to favor the reverse reaction in the amine regeneration stage of the process.

It is the reversibility of this reaction that allows solvent regeneration and continuous removal of H_2S through amine treatment.

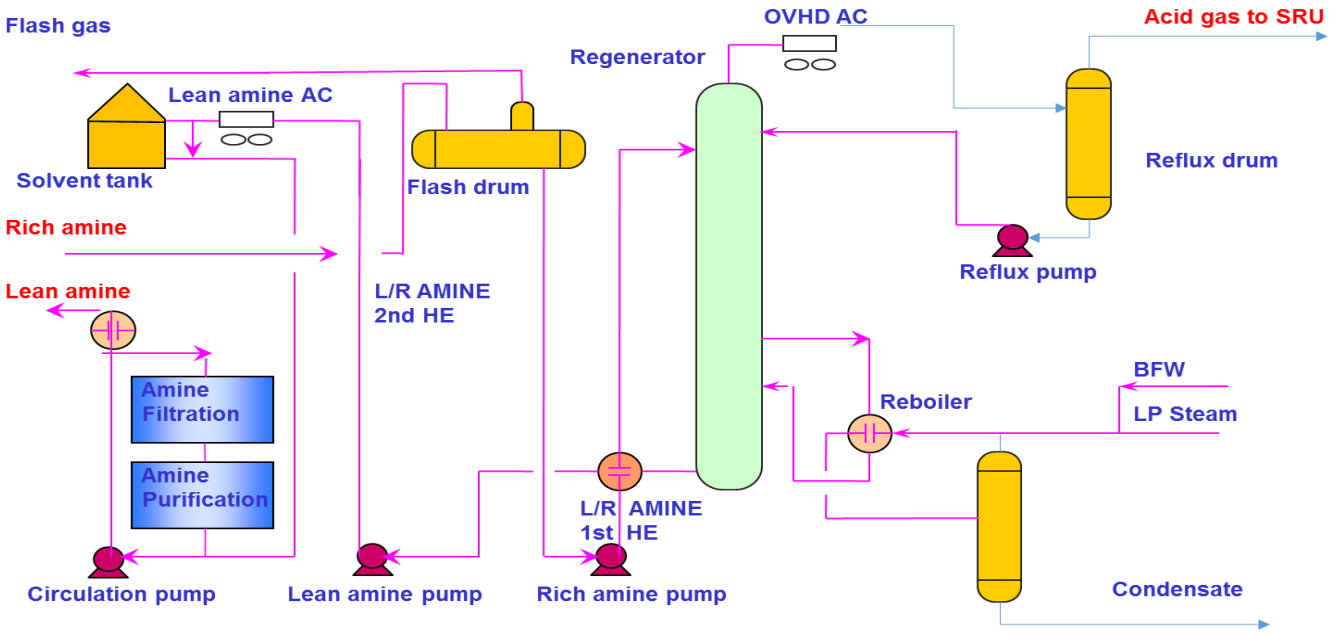


Figure 1: *description of DEA regeneration unit*

VIII. Detailed description of processes

VIII.1 Rich amine vaporization column section

Rich amine from amine from FGATU-560, RFCC Merox unit 600, and future units is directed to the rich amine vaporization column (580-D-001). The rich amine can vaporize within the column to release dissolved gases containing H_2S . The liberated H_2S is re-absorbed by a sidestream of lean amine solution in countercurrent contact with gases released above a packed bed (580-C-002). The vaporization column operates at a pressure of 1.5 kg/cm2g. Vapors from the outlet of 580-C-002 are routed to the acid gas flare or SRU-590 under pressure control within a split-range.

From the rich amine vaporization column (580-D-001), rich amine is pumped by regenerator feed pumps (580-P-008-A/B) under flow control, reset by the vaporization column level control, to the amine regeneration column (580-C-001) after preheating to 100°C in lean/rich amine heat exchangers (580-E-001-A/B).

VIII.2 Amine regeneration section

Feed enters regeneration column (580-C-001) at 21st tray level.

- Column operates at higher pressure of 1.3 kg/cm2g and condenser temperature of 50°C.
- Reflux water enters column at 23rd tray level and descends.
- Prevents DEA losses at the top and ensures H_2S removal.
- Vapors from heater at column base in countercurrent contact with rich amine, removing H_2S/CO_2.

The overhead vapors from the amine regeneration column (580-C-001) are directed to the overhead regeneration condenser (580-EA-001), where most of the water vapors condense and the liquid is separated in the reflux drum of the regenerator (580-D-003). It is then pumped by the reflux pumps of the regenerator (580-P-002-A/B) under flow control. A fixed amount of water is sent as reflux back to the regeneration column.

The level in the reflux drum of the regenerator (580-D-003) is maintained by directing the purge water flow to the acid water stripping unit (SWS-570) under flow control, with reset based on the level control of the reflux drum of the regenerator. Measures have been taken to

inject a corrosion inhibitor at the head of the amine regeneration column and an anti-foam agent at the reflux pump discharge of the regenerator (580-P-002-A/B). Skimming of the bottom of the amine regeneration column and the bottom of the reflux drum of the regenerator is planned.

Heat for the heater is provided by appropriately cooled LP steam, which feeds the column through a boiler-type amine regeneration heater (580-E-002) under flow control reset by the feed flow rate controller to the regeneration column (580-C-001). Condensate from the heater is discharged via a condensate collector operating under level control.

The flow rate ratio controller (580-FFC-0002) is cascaded with the rich amine feed flow rate (580-FIC-0002) and LP steam flow rate (580-FIC-0006). Control of the LP steam temperature to the amine regeneration heater is achieved by superheating the LP steam using feed water to the heater.

Pressure control of the regeneration column is achieved by directing the stripped acid gas mixture to SRU Unit 590 or to the acid flare from the steam outlet of the regenerator reflux drum (580-D-003) under fractional pressure control.

Regenerated lean amine from the bottom of the regeneration column is pumped by the bottom pumps of the regenerator (580-P-003-A/B) to the lean/rich amine heat exchanger (580-E-001-A/B) to exchange heat with the rich amine fluid side and cool it to 77°C. The lean amine is then cooled further to 50°C in the air cooler (580-EA-002), and directed to the lean amine storage tank (580-TK-001) under flow control reset by the regeneration column level control (580-C-001).

Low-pressure condensate is injected into the lean amine line before cooling in 580-E-001-A/B under flow control. The addition of condensate is intended to compensate for water losses in the head section of the amine regenerator.

VIII.3 Lean amine storage tank/ section circulation pump

The lean amine from the regeneration column (580-C-001) is stored in the lean amine storage tank (580-TK-001). This storage tank is of a fixed roof conical type under nitrogen blanket. Its storage capacity is equivalent to the retention of the entire amine circuit in the ARU unit, the Merox unit, interconnection lines between the ARU unit and the Merox unit, and future units. To prevent amine stagnation and the formation of precipitates, an online reservoir is provided with skimming nozzles.

The lean amine at 50°C is pumped by the lean amine pumps (580-P-004-A/B) to the Fuel Gas Amine Treatment Unit (FGATU-560) and the Merox RFCC unit (U600) under temperature control. Part of the lean amine, controlled by flow rate, is used in the gas release scrubbing tower (580-C-002) to absorb H_2S released in the rich amine vaporization drum (580-D-001) before being routed to the Sulfur Recovery Unit (SRU-590) or to the acid flare.

IX. Process variables

A thorough understanding of process variables and their control methods is essential for comprehending stripping systems. To achieve the required performance, it is crucial to provide sufficient heat to the column using a heater and/or increase the feed temperature, allowing the desired products to separate in a countercurrent staged column at a specified pressure with a recirculating heat removal system.

The laws of conservation of heat and mass govern all these operations. Therefore, in any steady-state operation, there is no accumulation of material or energy within the system.

IX.1 Flow rate

The feed rate to the amine regeneration column (580-C-001) is regulated under the control of the level in 580-D-001 in cascade with a flow indicator controller (FIC) for a constant flow control scheme.

IX.2 Temperature

It is important that the DEA solution reaches its boiling point in the heater to ensure adequate regeneration of the solution.

Exessive heater temperature, which is the overall maximum temperature limit, would result in DEA solvent degradation. However, the temperature of the amine regeneration heater (580-E-002) is highly sensitive to the heat input rate. Therefore, the heat input to the regeneration heater is controlled by steam flow rate control according to the rich amine flow rate.

IX.3 Pression

Operating the regeneration column at the lowest possible pressure maintains a low temperature to prevent amine degradation . Degradation occurs due to reactions between the amine and impurities in the solution, resulting in highly corrosive degradation products.

Any variation in operating pressure during normal operation can affect product quality; hence, the pressure in the column is kept constant. Excessive operating pressure in the regenerator would lead to high temperatures in the heater. Prolonged operation of the regenerator at high temperature and pressure would degrade the DEA solvent.

IX.4 Title of DEA solution

The concentration of the amine solution may vary due to losses at the contact points from entrainment, continuous purge of reflux, and water losses in the acid gas to the SRU unit.

Regular samples of the amine solution must be taken to measure the DEA concentration. The title of the amine solution is maintained at 25% by weight of DEA through regular addition of lean amine. If the DEA concentration is too low, operating costs increase and the removal of H_2S at the absorbers becomes less effective. If the DEA concentration is too high, excessive corrosion may occur

GENERAL CONCLUSION

In conclusion, the use of amines in the treatment of gases, such as LPG and fuel gas, plays a very imporatnt role in ensuring environmental compliance and operational safety in industrial processes. Amines, Diethanolamine (DEA) effectively remove harmful impurities such as hydrogen sulfide (H_2S) and carbon dioxide (CO_2) through the process of absorption and regeneration.

Throughout this process, the amine solution absorbs acidic gases from the gas stream in an absorption column, thereby purifying the gas and preventing corrosion in equipment and pipelines. The rich amine solution is then regenerated by heating, releasing the absorbed gases for safe disposal while the purified amine is recycled for reuse.

This cyclic nature of absorption and regeneration ensures the continuous purification of gases, maintaining operational efficiency and meeting stringent environmental standards. By effectively managing parameters such as temperature, pressure, and amine concentration, industries can optimize the performance of their gas treatment processes, contributing to sustainable operations and cleaner emissions.

Overall, the utilization of amines in gas treatment not only enhances the quality and safety of industrial gases but also underscores their essential role in sustainable industrial practices worldwide.

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