# The Using of Mixing Amines in an Industrial Gas Sweetening Plant

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*Abstract*—Natural gas is defined as gas obtained from a natural underground reservoir.

It generally contains a large quantity of methane along with heavier hydrocarbons such as ethane, propane, isobutene, normal butane; also in the raw state it often contains a considerable amount of non hydrocarbons, such as nitrogen and the acid gases (carbon dioxide and hydrogen sulfide).

The acid gases must be removed from natural gas before use.

One of the processes witch are use in the industry to remove the acid gases from natural gas is the use of alkanolamine process.

In this present paper, a simulation study for an industrial gas sweetening plant has been investigated.

The aim of the study is to investigate the effect of using mixing amines as solvent on the gas treatment process using the software Hysys.

*Keywords*—Natural gas, alkanolamine process, gas sweetening plant, simulation, mixing amines

## I. INTRODUCTION

THERE are many treating processes available for removal of acid gases from natural gas.

These processes include Chemical solvents, Physical solvents, Adsorption Processes Hybrid solvents and Physical separation (Membrane) [11].

The chemical solvents and physical solvents or combination of these two have been used extensively in existing base load LNG facilities.

In the past few years, mixed amine solvents for the removal of acid gases have received increased attention. In most cases, the mixtures contain MDEA as the base amine with the addition of one or two more reactive amines such as MEA or DEA.

These amine mixtures have been called a variety of names including formulated amines and MDEA based amines.

Historically, MDEA has been recognized primarily for its ability to selectively absorb $H_2S$ from a gas while leaving large amounts of $CO_2$ in the gas. The selective absorption characteristics of MDEA have been widely reported in the literature [1-9].

MDEA's selective absorption ability is due to its relatively slow reaction rate with $CO_2$. Until the last few years, MDEA has not been associated with cases where the removal of large amounts of $CO_2$ is desired [10].

Today, computer-aided process simulation is nearly universally recognized as an essential tool in the process industries.

Indeed, simulation software plays a key role in: process Development to study process alternatives, assess feasibility, preliminary economics, interpret pilot-plant data, process design to optimize hardware and flow sheets, estimate equipment, operating cost, investigate feedstock flexibility, and plant operation to reduce energy use, increase yield and improve pollution control[11].

In the present paper, the use of amine mixtures employing methyldiethanolamine (MDEA), and diethanolamine (DEA) have been investigated for a variety of cases using a process simulation program Hysys.

## II. HYSYS SIMULATION OF AMINE PROCESS

### A. Description of Process Equipment

For the acid gases removal units the following is a brief description of the major equipment necessary for successful simulation of amine unit to meet the LNG specifications and to operate environmental acceptable units.

The function of the inlet separator is to remove the entrained liquid amine carried over with the gas from the pipeline/slug catcher before getting to the absorber.

The contactor allows counter-current flow of lean amine from the top and sour gas from the bottom.

The rich amine is flow to the bottom while the sweet gas is collected at the top for further processing.

The throttling valve is used to expand the rich amine coming from the high pressure contactor; this is done by lowering gas pressure before entering the flash tank.

The gas from the throttling valve is flashed to remove the hydrocarbons components carried along with the rich amine, this unit serves as a recovery unit for hydrocarbons, and horizontal flash tank is used to prevent foaming.

The rich/lean exchanger is a heat conservation device where hot lean solvent preheats cooler rich solvent.

Air-cooled forced draft with automatic louvers for temperature control.

Cold climate service may require air recirculation and/or preheat media on fans/coils.

Condenser tubes should be made of stainless steel, as this is a wet, acid gas environment and sloped to the outlet side [11].

The reflux accumulator is vessel separates the reflux water and water saturated acid gases.

The water is pumped back to the still and the acid gases are directed to vent, incinerator, or sulfur recovery unit.

Solvent reboiler is either a direct-fired fire tube type or cabin heater, or indirect hot oil or steam heated unit.

The lean amine solvent from the re-boiler through amine-amine heat exchanger is further cool here before entering the absorber again.

The reflux and booster centrifugal pump is installed to maintain the recycle lean solvent at the desired operating pressure of the absorber.

The main circulation pump choice depends upon contactor operating pressure and solvent flow rates [1].

### B. Hysys Simulation Procedures

The first step is to select the appropriate fluid package; here amine fluid package model is selected.

The component selection window is open by selecting view in the component-list as in Fig. 1.
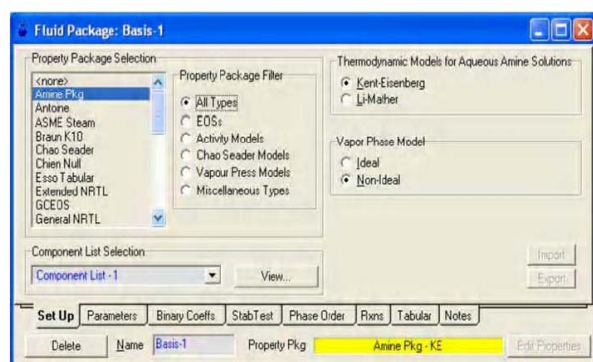


Fig. 1 Fluid Package Basis (Amine fluid Package)

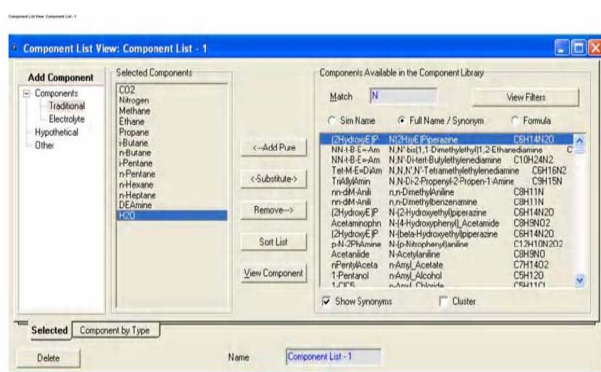Fig. 2 shows dialog window is use for components selection:



Fig. 2 Component selection windows

After selecting the component of the fluid, the simulation environment can enter where the process flow diagram is built.

Amine process flow diagram simulation environment is shown in Fig. 3.
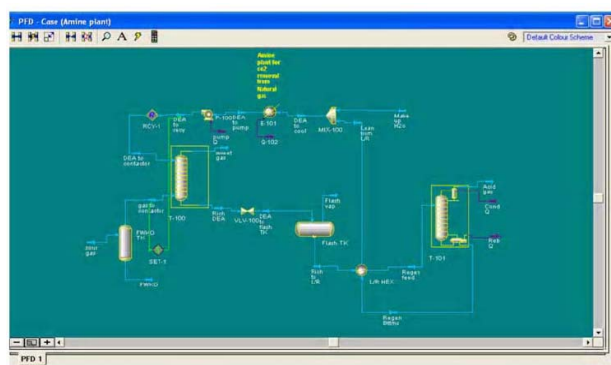


Fig. 3 Un-simulated Amine Process Flow Diagrams

Other streams specifications made are DEA to Contactor temperature pressure and flow rate, make up water temperature and DEA to recycle temperature, the regenerated feed out of the amine-amine heat exchanger.

One of the rigorous tasks is the convergence of the absorber and the regenerator, to converge the absorber top and bottom temperature and pressure was specified and run, as in Fig. 4.

The regenerator is converged by specifying the condenser and re-boiler pressure, the reflux ratio and the vent rate, the column is then run, as in Fig. 5.
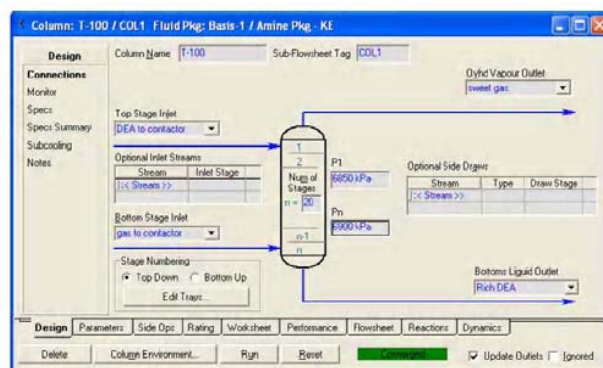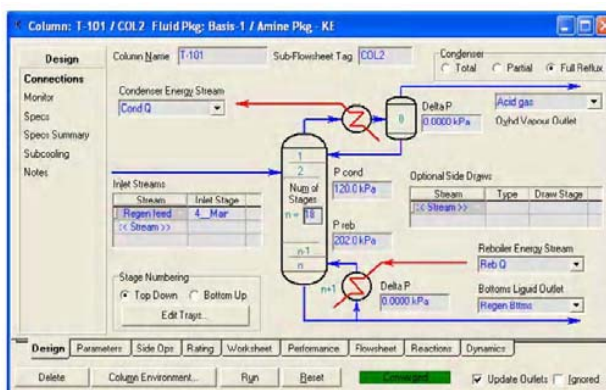


Fig. 4 Converged window of the Absorber



Fig. 5 Converged windows for regenerator unit

With the convergence of the absorber and the regenerator units a complete amine simulation for the base case was established as shown in Fig. 6.
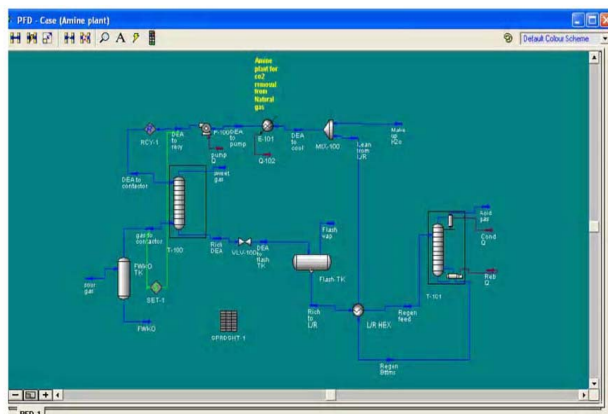


Fig. 6 Complete Simulations Unit

## III. RESULTS AND DISCUSSION

The aim of the study is to investigate the effect of using mixing amines (methyldiethanolamine (MDEA) and diethanolamine (DEA)) on the natural gas treatment process using the process simulation program Hysys.

As a simulation result shows the fig.7 the effect of different percent of mixing amines upon the amount of $CO_2$ in mol fraction in the absorber column in different circulation rate, the 40%MDEA with 10% DEA, 30%MDEA with 10 % DEA and 40%MDEA with 5% DEA are the best result in the absorption processes of $CO_2$ from the natural gas.
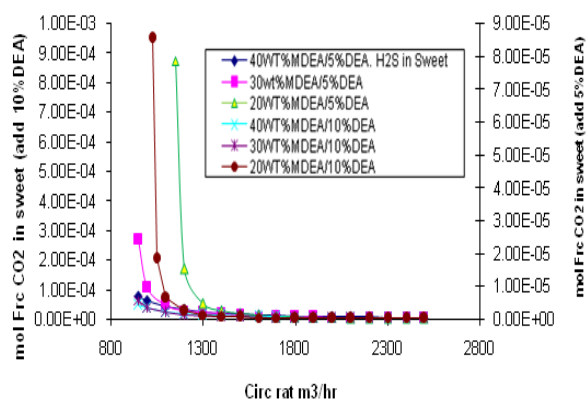.



Fig.7 The effect of different percent of mixing amines upon the amount of $CO_2$ in the absorber column in different circulation rate

Fig. 8 shows the effect of different percent of mixing amines upon the amount of $H_2S$ in mol fraction in the absorber column in different circulation rate, as shown the 30%MDEA with 10% DEA, 40%MDEA with 5 % DEA and 40%MDEA with 10 % DEA are the best result in the absorption processes of $H_2S$ from the natural gas.
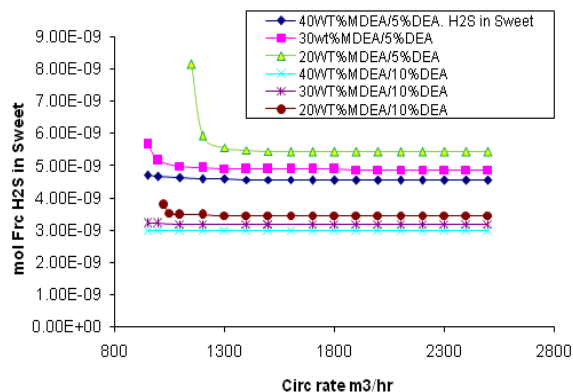


Fig. 8 The effect of different percent of mixing amines upon the amount of $H_2S$ in the absorber column in different circulation rate

Fig. 9 shows the effect of different percent of mixing amines and different percent of MDEA upon the amount of $CO_2$ in the regeneration column in different circulation rate.

The 40%MDEA with 5% DEA has better result comparing with the 40%MDEA without mixing, and the 30% MDEA with 5% DEA has better result comparing with the 50% MDEA without mixing.
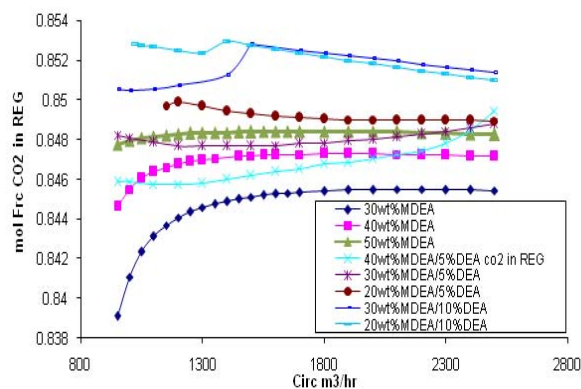


Fig. 9 The effect of different percent of mixing amines and different percent of MDEA upon the amount of $CO_2$ in the regeneration column in different circulation rate

In Fig. 10 is the effect of different percent of mixing amines and different percent of MDEA upon the amount of $H_2S$ in the regeneration column in different circulation rate.

The 30%MDEA so as the 40% MDEA with 5 % DEA have the largest amount of $H_2S$, and as shown in the fig.10 the 30% MDEA with 5 % DEA gives the same result as 50% MDEA without mixing.

Fig. 11 shows the effect of different percent of mixing amines and different percent of DEA upon the amount of $CO_2$ in the sweet gas in different circulation rate, as shown after the circulation rate up to 1300 $m^3/hr$ the amount of $CO_2$ in the sweet gas will be the same.

In Fig. 12 is the effect of different percent of mixing amines and different percent of DEA upon the amount of $H_2S$ in the sweet gas in different circulation rate.

The 20%MDEA with 10% DEA, 30% MDEA with 10 % DEA and the 40% MDEA with 10 % DEA have the lowers amount of $H_2S$ in the sweet gas comparing with different percent of DEA without mixing.

In Fig. 13 is the effect of circulation rate upon the temperature of rich amine in different percent of mixing amines and different percent of MDEA, the temperature of rich amine decrease with increase the circulation rate in all different percent of mixing amines and different percent of MDEA.

The effect of circulation rate upon the reboilre temperature in different percent of mixing amines and different percent of MDEA is shown in fig.14, as result shows the fig.14 that the reboilre temperature was constant in the 20%MDEA with 10 % DEA and in the 30%MDEA, 40%MDEA and in the 50%MDEA, otherwise the reboilre temperature increase with increase the circulation rate in all different percent of mixing amines.
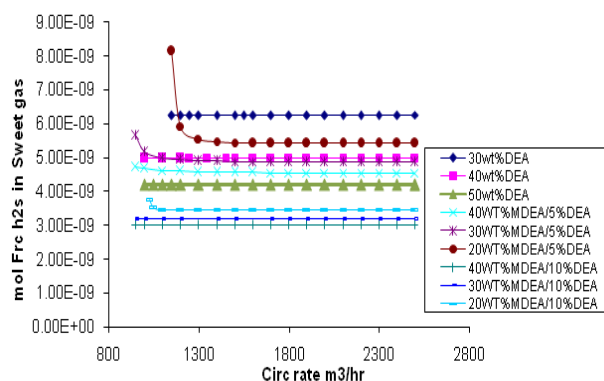


Fig. 12 The effect of different percent of mixing amines and different percent of DEA upon the amount of $H_2S$ in the sweet gas in different circulation rate
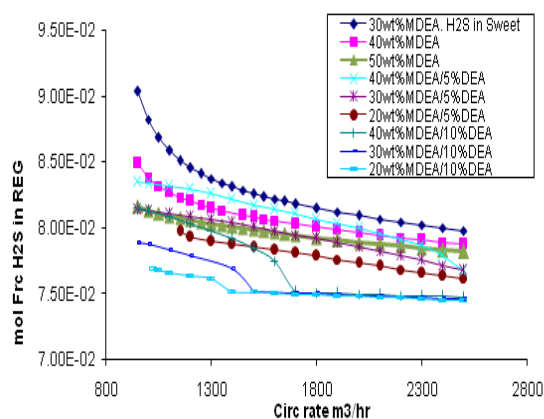


Fig. 10 The effect of different percent of mixing amines and different percent of MDEA upon the amount of $H_2S$ in the regeneration column in different circulation rate
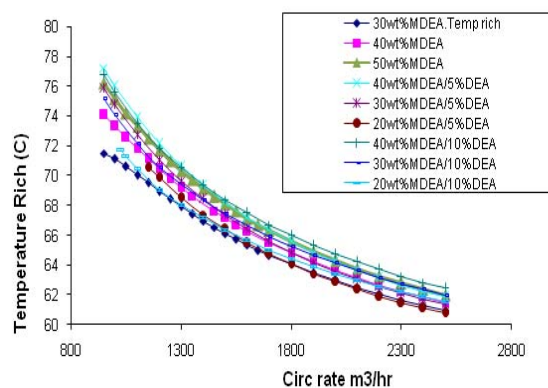


Fig. 13 The effect of circulation rate upon the temperature of rich amine in different percent of mixing amines and different percent of MDEA
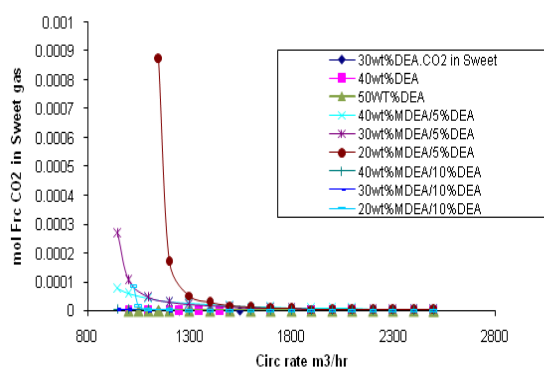


Fig. 11 The effect of different percent of mixing amines and different percent of DEA upon the amount of $CO_2$ in the sweet gas in different circulation rate
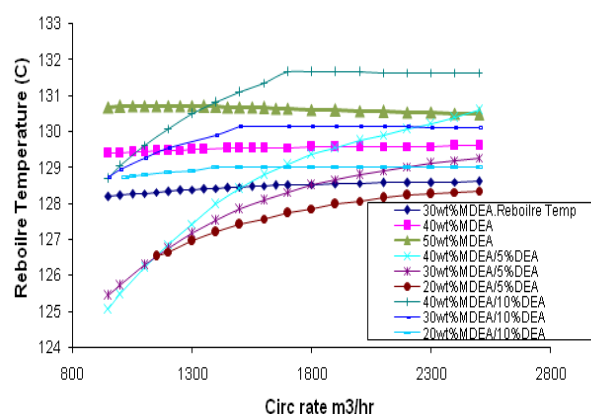


Fig. 14 The effect of circulation rate upon the reboilre temperature in different percent of mixing amines and different percent of MDEA
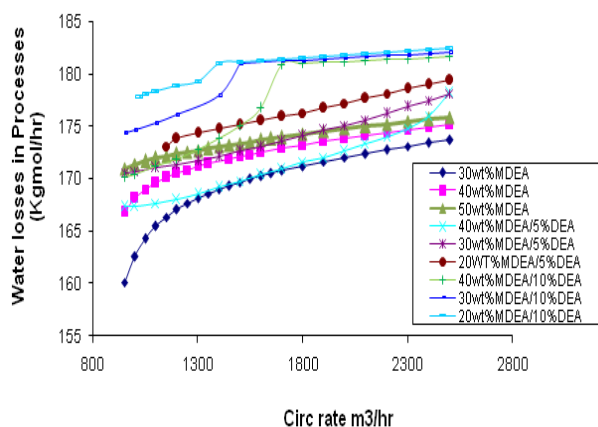
Fig. 15 The effect of circulation rate upon the water losses in different percent of mixing amines and different percent of MDEA

Fig. 15 shows the effect of circulation rate upon the water losses in different percent of mixing amines and different percent of MDEA, as shown the water losses increase with increase the circulation rate in all different percent of mixing amines and different percent of MDEA.

The 40% MDEA with 5% DEA has lower water losses in all different circulation rates comparing with the 40% MDEA and 50% MDEA without mixing.

## IV. CONCLUSION

The principle investigation was directed to study the effect of using mixing amines (methyldiethanolamine (MDEA), and diethanolamine (DEA)) as solvent on the gas treatment process using the software Hysys.

In all cases, the mixtures were containing methyldiethanol amine (MDEA) as the base amine with the addition of diethanolamine (DEA).

The simulation results show that, the 40%MDEA with 10% DEA, 30% MDEA with 10 % DEA and 40% MDEA with 5% DEA were the best result in the absorption processes of $CO_2$ from the natural gas.

And the 30%MDEA with 10% DEA, 40%MDEA with 5 % DEA and 40%MDEA with 10 % DEA were the best result in the absorption processes of $H_2S$ from the natural gas comparing with other mixing amines.

The 20%MDEA with 10% DEA, 30% MDEA with 10 % DEA and the 40% MDEA with 10 % DEA have the lowers amount of $H_2S$ in the sweet gas comparing with different percent of DEA without mixing.

The temperature of rich amine decrease with increase the circulation rate in all different percent of mixing amines and different percent of MDEA without mixing.

The reboilre temperature was constant in the 20%MDEA with 10 % DEA and in the 30%MDEA, 40%MDEA and in the 50%MDEA, otherwise the reboilre temperature increase with increase the circulation rate in all different percent of mixing amines.

The water losses increase with increase the circulation rate in all different percent of mixing amines and different percent of MDEA.

The 40% MDEA with 5% DEA has lower water losses in all different circulation rates comparing with the 40% MDEA and 50% MDEA without mixing.

And The 30% MDEA with 5% DEA has the same water losses comparing with 40% MDEA and 50% MDEA without mixing, otherwise the 40% MDEA with 10% DEA, 30% MDEA with 10% DEA and the 20% MDEA with 10% DEA have more water losses comparing with the 30% MDEA, the 40% MDEA and the 50% MDEA without mixing.

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