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A Competitive study for the behaviors' of two amines of acid gas Removals in normal natural gas processing

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A B S T R A C T

Natural gas is the most significant and common fossil fuel in the present time. However, because the natural gas exists normaly in deep underground reservoirs, it may contain several non- hydrocarbon components such as, hydrogen sulphide and carbon dioxide in the processing route. These impurities cause several technical problems mainly; corrosion and environmental pollution. Gulf of Suez Gas Plant (GOS) is operated by the Gulf of Suez Petroleum Company (GUPCO) since1983 in Red Sea region in Egypt. This plant used Di Ethanol Amine (DEA) for sweetening process, and it has received a huge amount of natural gas having a content of acid gas over than the design conditions 300 Part Per Million (PPM), which lead to corrosion issue and shutdown of the amine unit causing the losses in productions. And recommended to study and simulate another type of amine chemicals ,that can be used for sweetening to meet concentrations of H_2S in sweet gas was about 4 PPM[1-3]. This study aims to simulate GOS gas sweetening process by using aspen hysy V,12 program and focuses on using amine solutions for example; Mono Ethanol Amine (MEA) and Piperazine (PZ) . The novel process can be reduced chemical consumption by doing preparatory calculations.The impacts of feed flow rate, feed pressure, acid gas content (CO_2 and H_2S) in feed, and the cost of chemical based on mass flow rate were investigated. In certain ranges of feed flow rates, pressures, and acid gas concentrations. MEA process is less expensive than an independent PZ process. And it is expected to provide low-cost technology for capturing H_2S and CO_2 from wet natural gas.The optimization found that the use of MEA (32 weight%) may be considered the most recommended process.

Keywords:

Natural gas processing, Acid gas removal, Sensitivity analysis, Amine solutions, Process simulation.

1. Introduction

Natural gas is an imperative part on the planet's inventory of energy. It is the most important source of energy BUT "it is not the cleanest source of energy". In ingestion section to move it from the gas stream to the fluid stream catalyzed by a synthetic response [4]. GUPCO is considered as the main source of fuel for upper Egypt region, where, GUPCO Liquifed Petroleum Gas (LPG) plant is currently treating acid gas by DEA solutions. There

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spite of its significance, notwithstanding, there are numerous confusions about its imperativeness since the word 'gas' itself has a wide range of employments. H_2S is a noxious and very destructive compound existent in flammable gas escaped its well and going to the cycle plant. Seaward and inland plants need to eliminate H_2S, where regulations characterize as far as possible to be 4 PPM. By time, different strategies for eliminating H_2S have been evaluated all around the world and the business is continuously intending to perform better and more effective improving constantly to limit the costs for the cycle.

Many cycles have been explored, yet the concentration in current time has been to foster an improving interaction utilizing various types of adsorption and ingestion strategies. Two center regions are in an overall use while creating gas-improving strategies; dry adsorption and wet absorption.

The dry adsorption is normally non-regenerative strategy and comprises of a channel where H_2S is adsorbed .These channels must be in this manner changed consistently to get the vital cleaning.

The wet assimilation, then again is regularly a regenerative cycle where a fluid stream lead to respond with H_2S in an

for the examination of both CO_2 and H_2S in the exit gas stream while maintaining an acceptable limit of it .

is a plan to change the chemical of amine solution due to corrosion problems and foaming problem from DEA to another chemical amine.

To explore the petroleum gas improving all unique utilized strategies ought to be recorded [5]. Research about significant gear for the most utilized strategies ought to be made, to have the option to make a point-by-point model for the cycle [6]. One cycle was picked and assessed completely to assess the productivity of that particular cleaning technique [7]. The point of the current review is to mimic the area of gas improving to play out a model by the HYSYS program .Consequently to the most proficient interaction, which had been distinguished, a financial viewpoint is to be performed, to get that they picked model is reasonable to be utilized.

As a result, the primary goal of this study was to look into the simultaneous **absorption** rates of CO_2 and H_2S from their pressured gas streams into **absorption** solvents for the first time. In addition, we report the using of commercially available MEA as a superior option to replace the previously widely investigated DEA. To explore the removal of CO_2 and H_2S at the same time, a change to the prior simulation setup was required to allow

2.1. Specifications for the models and process simulation description

The creation of the gas stream shown is in table 2.1, while the interaction s' methodology is displayed in fig. 2.1.

2. Process description of the existing gas plant

The operating conditions of the rich acid gas feed to the unit are ; (1) Flow rate 12 Million Standard Cubic Feet Per Day (MMSCFD), (2) feed gas temperature 41°C,(3) feed gas pressure 49 kg/cm² and centralization of H_2S feed to contactor is 600 PPM; table (2.1) illustrated the conformation of feed natural gas in the rich case to the amine unit.

The corrosive gas enters the contactor from bottom, while the amine arrangement from its top. The amine made to be reused by going the stream through a mixer where it was mixed with a makeup stream of water.

Components	**Molar flow (MMSCFD)**	**Mole fraction**	**components**	**Molar flow (MMSCFD)**	**Mole fraction**
H_2O	0.0000	0.0000	I-butane	0.0855	0.0071
CO_2	0.0588	0.0049	N-butane	0.1780	0.0148
H_2S	0.0072	0.0006	I-pentane	0.0485	0.0040
Methane	9.6503	0.8042	N-pentane	0.0411	0.0034
Ethane	1.2559	0.1047	Nitrogen	0.0806	0.0067
Propane	0.5646	0.0471	N-hexane	0.0295	0.0025

Table 2.1 Composition of feed natural gas

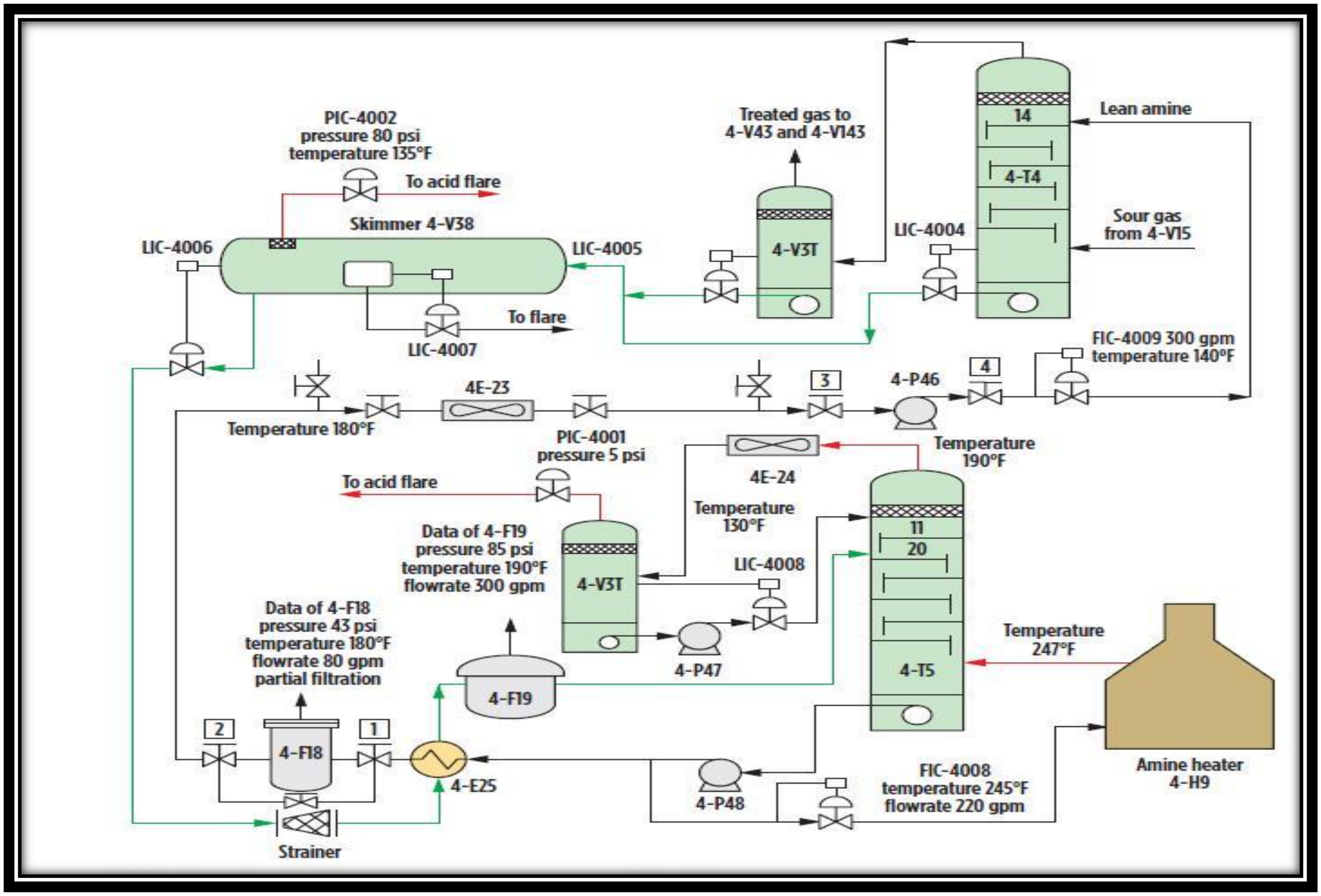


Fig.2. 1 The actual amine unit process flow diagram [8].

A greater amount of the amine solution might be added to the blender to guarantee the ideal structure of it for gas improving. A supporter pumps raises the pressure to 47 bars, which is the activity pressure of the contactor. A heat exchanger introduced to cool the amine solution for the ideal activity temperature 47.3 °C. The quantity of stages utilized for the contactor was 24-valve plate, internal diameter 4.5 ft., bottom temperature 46 °C and for the desorber was 22-valve plate, internal diameter 5.5 ft. Moreover, bottom temperature 120 °C. In addition, Reboiler temperature is 120 °C. The improved gas from the tower directed to the line transportation framework to be Directed to a blaze tank, where the stream warmed determined to streak out the vast majority of the substance of hydrocarbons in the stream. The amine solution then, at that point, prompted a refining tower (stripper), where the stream cleaned from H_2S to similar level as the improved the gas. The recuperated amine then, at that point, added with water to the blender, to reuse for the new improving interaction cycle.

2.2. Content of H_2S in the sweetened gas

Legislations give maximum content of H_2S in sweetened natural gas to be 4 PPM [9].The two bay streams are subsequently; the feed gas and lean amine. The temperature moved to chilling region for conveyance and further handling. The base fluid is

2.3. Data acquisition

To modelize a sensible gas improving interaction(whose object is to eliminate CO_2 and H_2S in a flammable gas stream) a predetermined substance of CO_2 must be available, in the event that not, the utilization of the improving specialist gave is to be low and can not be assessed in itis productivity or stream [10]. The usual acceptent substance of CO_2 in an untreated petroleum gas is characterized to be inside 4 to 5 mole percent [11]. So the substance of CO_2 in the gas stream is laid out to be as 0.0049 mole percentage. Water is consequently to be added to the amine solution for guarantee a greater surface for the fluid stage [12].When a gas stream is added to, an absorption fragment with a for the most part high stream rate, the looking at proportion of amine will be fairly low [13]. In the event that no water is added, It will be impossible to ensure good contact between gas and fluid, which will cause the improving system to be less productive, water is along these lines regularly amounted to 75-mole rate while performing gas sweetening[14].

The propensity affirmed by the utilization of the amine bundle in the HYSYS program intended to be explicit for displaying gas ingestion; where real recreations could not proceed with its run without a specific water content in the stream [15]. The assimilation interaction happens in a segment, introduced with a specific determined number of and pressure for the framework were subsequently researched previously; here it is depicted that the temperature of the amine-water stream ought to be somewhere around five degrees hotter than the corrosive gas stream in the assimilation segment to stay away from parts of the natural gas to gather into the fluid amine stream[16]. The activity at pressure of the contactor tower was found to be around 49 bar, which is normally accepted for the absorption column.

3. Results of steady state simulation and process optimization

To assess the effectiveness of gas improving, a few instances of treatments were displayed in the HYSYS. The interest for all recreations is that the substance of H_2S must be under 4 PPM, to match the determinations for the perfect gas. Two cases were displayed to explore the effectiveness of plate and packed tower and to assess the thermodynamic models. The amine treatment agents chosen, were MEA and PZ. For all cases, the amine packages (acid gas cleaning) in the modelling will be used [17].

3.1. Chemical absorption by amines

Determination of a proper dissolvable for gas improving relies upon different conditions,the generally significant of which are:capacity of eliminating H_2S and CO_2, pickup level of hydrocarbons, heat necessity of dissolvable recovery, vapour pressure, frothing, selectivity, thermal stability, destructive nature, cost, accessibility and others.[18]. In this simulation experiment amines and amine blends were used stages. The mass equilibrium utilized is McCabe-Thiele model.

as sweetening solvents.

Chemical reactions for MEA

$RNH_2+H_2SR \rightarrow NH_3HS$ (3.1)

$RNH_2+H_2O+CO_2R \rightarrow NH_3HCO_3$ (3.2)

Chemical reactions for PZ

$R_2NCH_3+H_2SR \rightarrow 2NHCH_3HS$ (3.3)

$R_2NCH_3+CO_2+H_2OR \rightarrow 2NHCH_3HCO_3$ (3.4)

3.2. Process optimization

The requirments of this upgrade work is to focus on the effect of using various types of amines and amine blends on the amine plant execution. Thusly, improvement region will apply various amines with predictable obsession that can be achieved by entering to re-enacement apparatuse and changing bitter gas stream associations.

Utilizing (32 weight. %) of various amine and amine mixes for GUPCO gas improving plant by keeping up with some activity conditions for example (acrid gas stream, pressure and temperature) and (lean amine temperature and pressure). Then, at that point, the outcomes ought to be recorded for H_2S and CO_2 in sweet gas stream.

3.2.1.1. Parametric sensitivity analysis and HYSYS modeling using MEA

In a table 3.1 it is clear that H_2S composition of sweet gas is 4.508e-004 PPM, recovery for removed H_2S from sweet gas is 100% and for acid gas (H_2S and CO_2)is 100% also, the amine strength taken is (32weight %). Percentage and regenerated steam required for regenerator is 307.4 Tonne/day. Moreover, total flow rate required 170 barrel/day and the total **MEA** mass flow required is 366.5774 kilogram/hour (kg/h) thus the given the composition of sweet gas by mole fraction for methane is 0.806 and for ethane is 0.1049. In addition, operating conditions of rich amine stream is P=48.03 kg/ cm^2 and temperature is 39.27 °C. As, shown in table (3.1).

3.2.1.2. Economic visibility for MEA

The following items give a summary for the data obtained by the HYSYS program analysis so as to be able to discuss their comparative importance with respect to the amine treatment process for the Egyptian natural gas; taking into consideration that ,the mass flow rate required from **MEA** is 366.5 Kg/h. showed in fig 3.1. In addition, the dollar currency is to be equalized by sixteen Egyptian pounds for all imports and exports trade (as the precise by the Egyptian authority in time)

	value	unit		value	unit
Reboiler Duty	6.495e+006	kcal/h	Lean Amine Temperature	48	°C
Regenerator Steam	307.4	Tonne/d	H_2S Composition (ppm) in feed gas	599.6	
Acid gas Loading in regen bottom	1.381e-003		Feed Gas Flowrate	12	MMSCFD
Acid Gas Loading in acid stream	8.537e+014		H_2S Composition (ppm) in sweet gas	4.508e-004	
Acid gas Loading in regen feed	0.5495		H_2S Composition(ppm) in acid gas	9.603e+004	
Regenerator Feed Temper-ature	104.4	°C	H_2S Composition(ppm) in regen bottom	0.7344	
Regenerator Reflux Ratio (mole basis)	161.1		H_2S Composition(ppm) in regen feed	7083	
Amine Strength	32.00	Weight. %	Recovery of amine unit for H_2S	100	%
Amine Recirculation Rate	170.0	barrel/day	Recovery of amine unit(H_2S&CO_2)	100	%

Table 3.1 MEA unit dashboard

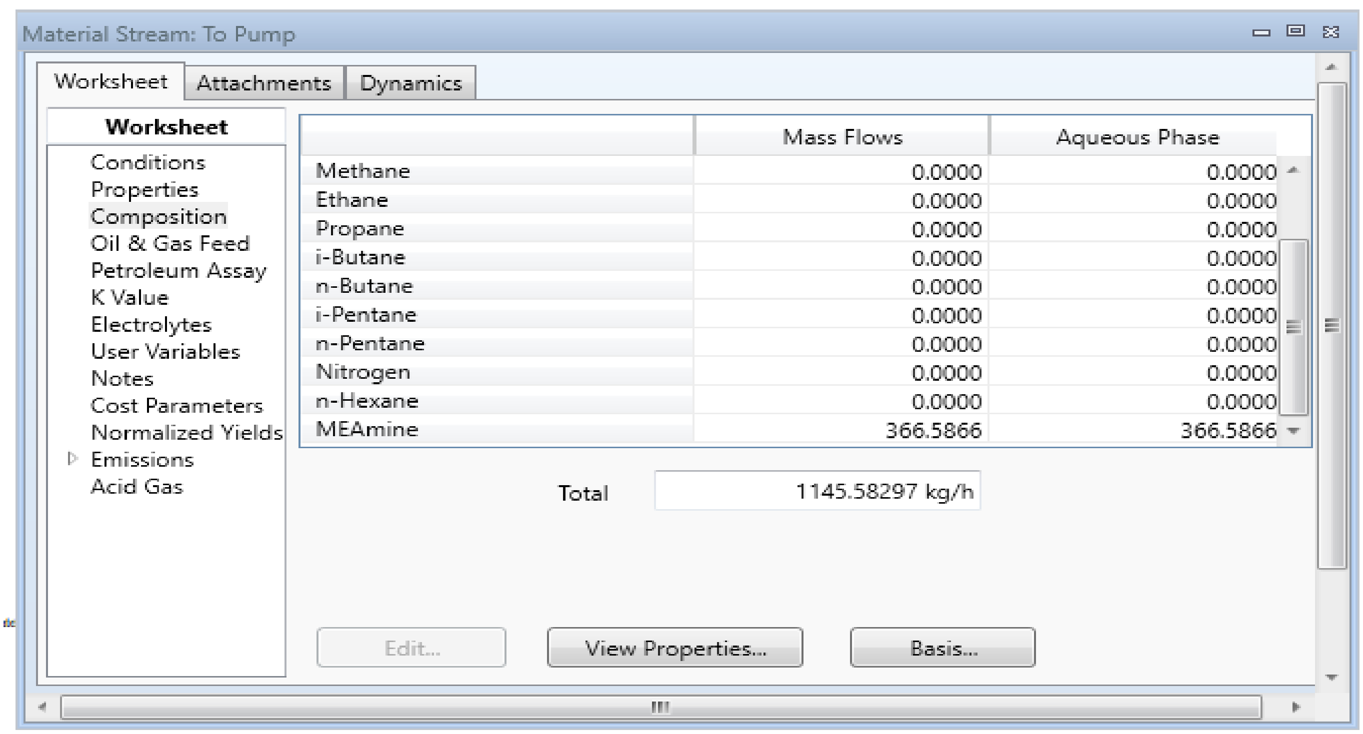


Fig.3. 1 mass flow rate for MEA

*Recovery for removed H_2S from sweet gas is 100% and for both removed (H_2S, CO_2) is 100% also.

* Average price of the Chemical used MEA=2 USD/kg.

* The total mass flow required for MEA is= 366.5 kg/h.

* Cost of chemical =2*16*366.5*24= 281,472 L.E/d.

3.2.2.1. Parametric sensitivity analysis and HYSYS modeling using PZ

Table 3.2 shows the dashboard for treatments by the **PZ** activators. It can be seen that the H_2S composition in the sweet gas is 1.872e-002 PPM. The recovery for the removed of H_2S is 100 %, same as that for the recovery of both H_2S and CO_2. The amine strength taken is (32 weight%) and regenerator steam is 307.4 Tonne/day.

Moreover, the total **PZ** mass flow required is 357.3 kg/h. to give a recovery of 100 % for the expulsion of both H_2S and CO_2. Investigation of the factors of PZ process illustrate that: the concentrations of methane and ethane in sweet gas stream in mole fraction. Show that composition of methane is 0.8059 and for ethane is 0.1049. In addition, the operating conditions of rich amine is P= 48.03 kg/ cm² and temperature T =39.03 c° and total mass flow required from total solutions is =165 barrel/day to remove 100% acid gas As, shown in table (3.2).

	value	unit		value	unit
Reboiler Duty	6.493e+006	kcal/h	Lean Amine Temperature	48.00	°C
Regenerator Steam	307.4	Tonne/d	H_2S Composition (ppm) in feed gas	599.6	
Acid gas Loading in regen bottom	1.93e-003		Feed Gas Flowrate	12.00	MMSCFD
Acid Gas Loading in acid stream	7.734e+015		H_2S Composition (ppm) in sweet gas	1.872e-002	
Acid gas Loading in regen feed	0.7949		H_2S Composition(ppm) in acid gas	9.680e+004	
Regenerator Feed Tem-perature	104.4	°C	H_2S Composition(ppm) in regen bottom	1.876	
Regenerator Reflux Ratio (mole basis)	162.4		H_2S Composition(ppm) in regen feed	7525	
Amine Strength	32.00	Weight %	Recovery of amine unit for H_2S	100	%
Amine Recirculation Rate	165	barrel/day	Recovery of amine unit(H_2S&CO_2)	100	%

Table 3.2 PZ unit dashboard

3.2.2.2. Economic visibility for PZ

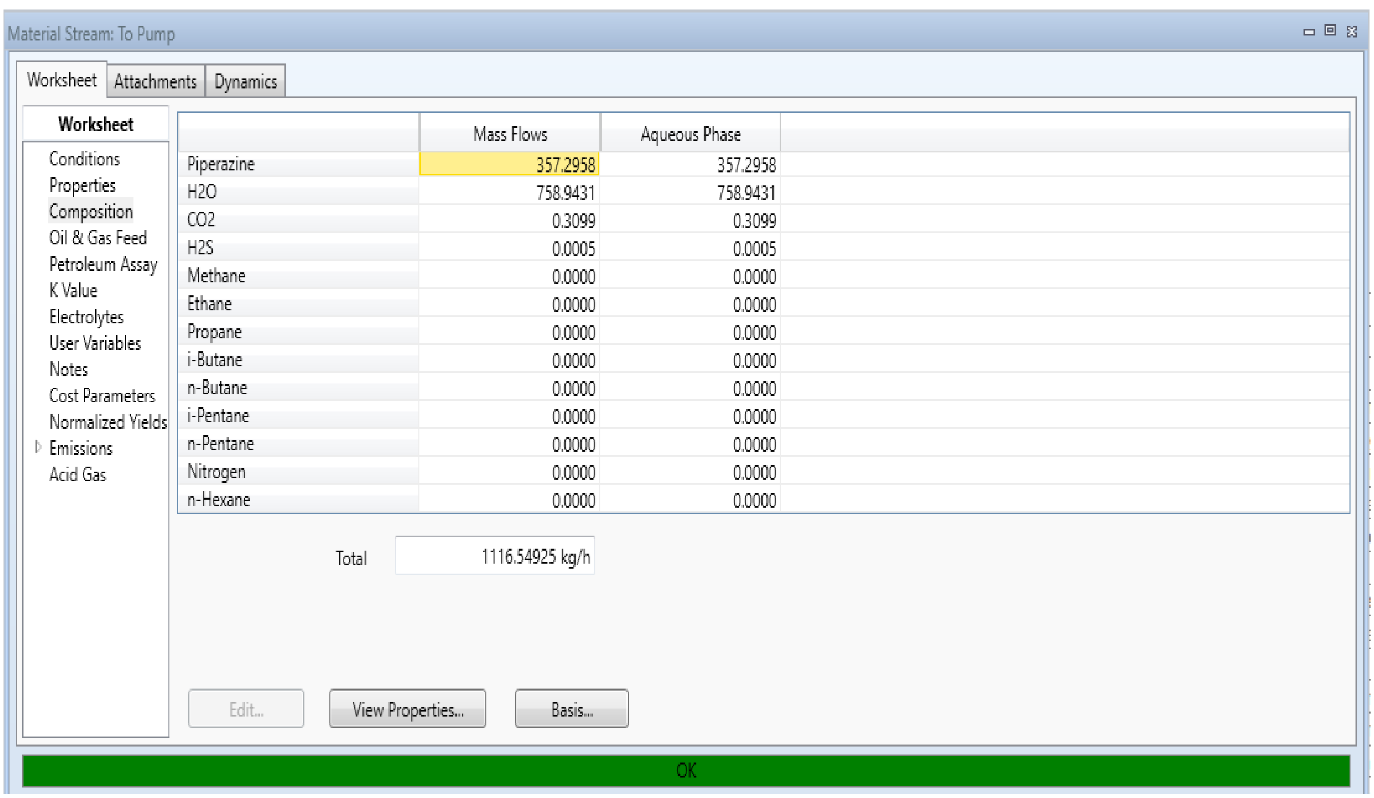
The following items provide a summary of the data obtained through the HYSYS programme analyses so that their relative importance can be discussed in relation to the amine treatment process for Egyptian natural gas; taking into consedration that the mass flow rate required from **PZ** is 357.3 Kg/h., as shown in fig 3.2. In addition, for all imports and exports, the dollar currency will be equalised by sixteen Egyptian pounds (as the precise by the Egyptian authority in time)

*Recovery for removed H_2S from sweet gas is 100% and for both removed (H_2S, CO_2) is 100%.

* Average price of Chemical Used PZ=7 USD/Kg.

* The total mass flow required from PZ is= 357.3 kg/h.

*Cost of Chemical =7*16*357.3*24= 960,422L.E/d.



	Mass Flows	Aqueous Phase
Piperazine	357.2958	357.2958
H2O	758.9431	758.9431
CO2	0.3099	0.3099
H2S	0.0005	0.0005
Methane	0.0000	0.0000
Ethane	0.0000	0.0000
Propane	0.0000	0.0000
i-Butane	0.0000	0.0000
n-Butane	0.0000	0.0000
i-Pentane	0.0000	0.0000
n-Pentane	0.0000	0.0000
Nitrogen	0.0000	0.0000
n-Hexane	0.0000	0.0000

Fig.3. 2 mass flow rate for PZ

4. Conclusions

In an end, this work-study is accomplished by GUPCO gas sweetining plant computations and mimicked the interaction by utilizing Aspen HYSYS .it can contend that GUPCO gas contains high measure of corrosive gases. Anyway this issue can be settled by the current gas cleaning plant, by changing the sort of amine to obtain best outcomes with low working expense. Also, reenactment work accomplished high corrosive evacuation that make the gas meet gas pipeline determinations for practically amine type and mixes. Two cases are reenacted with similar number of stages and at similar concentrations for chemicals to have the option to assess the productivity of the worked amines. It cauld be contended that (32 weight

%) MEA with 170 barrel/day flow rate accomplished ideal gas expulsion and outlet natural gas stream has meet gas pipeline particulars. In addition, amine process likewise upgraded by applying a few amine types and mixes. Besides, different interaction boundaries analyzed for example; reboiler duty, regenerator steam and acid gas evacuation moreover economic calculations done to determine the cost of chemicals required and that founded the MEA is cheapper than PZ. It can contend that utilizing MEA (32 weight %) is suggested for process than PZ. Other reagents are thus required to be tested using the same procedure.The most efficent for the quality of the produced gas ,it will also be much accepted to have also the best lower level of payments for acid gas recovery , as perspected in other proceding reserches [19-20].

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