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Modeling and Simulation in HYSYS

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Abstract:

Natural gas is a primary fuel obtained from the earth's crust and it is the mixture of the $C_1 - C_8$ hydrocarbon with some impurities like CO_2 and H_2S. In the chemical industries natural gas is the main feed for the production of different chemical compounds like gasoline, benzene and para xylene and ammonia. Before uses natural gas as feed there is need of pre-treatment. The CO_2 scrubbing process mainly use MDEA solvent to removed CO_2 gas and Glycol in dehydration unit to remove the moisture from the feed. The paper presents the generalized technology of natural gas process plant simulation and optimization in HYSYS software. The main aim is to carrying out plant simulation using HYSYS software. In chemical Industries most of the design and simulation of the chemical flow-sheet work is done in the software. It makes our task easy. It is also helpful for cost estimation of chemical plant.

Keywords: Modeling, Natural gas, HYSYS, Gas Processing, Simulation

1. Introduction

Natural gas is colorless, odorless, mixture of light hydrocarbon.[i] The major component present is methane, with small fraction of the ethane and propane. Crude natural gas also contains light gases such as nitrogen, helium and water in small concentration. It becomes very necessary to remove such impurities from the feed. Otherwise it may degrade the catalyst used in process.[iii]

Table 1. Chemical Composition of Natural Gas

Components	Formula	Typical Mole %	Extreme Mole %
Methane	CH_4	80-95	50-95
Ethane	C2H6	2-5	2-20
Propane	C3H8	1-3	1-12
Butane	C_4H_{10}	0-1	0-4
C5 alkanes+	C_5+	0-1	0-1
CO_2	CO_2	1-5	0-99
Nitrogen	N_2	1-5	0-70
H_2S	H_2S	0-2	0-6
Inert Gases	Traces		

Natural gas is the main feed for many of the chemical which are used for further treatment to produce product. In the market, there are several technologies which are available for the processing of natural gas. We have to select the process based on our process requirement. The technology providers are UOP Honeywell, Haldor Topso, etc. Some of the companies are working on the design of the natural gas plant like LNT Chiyoda, Flour Denial, Linde, etc. The condition is such that in market the requirements of many products have increase and the feed for this material is Natural gas. As a result, the demand of natural gas has increased. Many public and private sectors have started expansion and building new plant of natural gas.

2. Natural Gas Processing

The Natural gas is found from the wellhead it is not in the pure condition. Once the natural gas is separated from crude oil it contains hydrocarbon such as methane, ethane, propane and some impurities like CO_2, H_2S. For the production of quality natural gas various hydrocarbon and impurities has to be removed from the natural gas. The impurities which are separating are not the waste product but they can be purified as they have significant market value. There are various techniques available for the removing of such impurities.[ii]

Table 2. Impurities present in the Natural gas

Name	Formula
Hydrogen Sulphide	H_2S
Carbon Dioxide	CO_2
Water Vapour	H_2O
Sulphur Dioxide	SO_2
Nitrogen Oxides	NO, NO_2
Volatile Organic Compounds	
Volatile Fluorine Compounds	HF, SiF_4

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The actual scenario of purifying the natural gas plant consists of two main units to remove these impurities.

- Acid gas removal unit
- Dehydration unit

2.1 Acid Gas Removal Unit

In the processing of a natural gas, the impurities such as CO_2, H_2S, and sulfur are present which is toxic to the environment. There are various solvents are available in industries to remove these impurities such as MEA (mono ethanolamine), DEA (diethanolamine), and MDEA (Methyldiethanolamine). MDEA is most widely used solvent in the industries, and this solvent is regenerated after the completion of process.

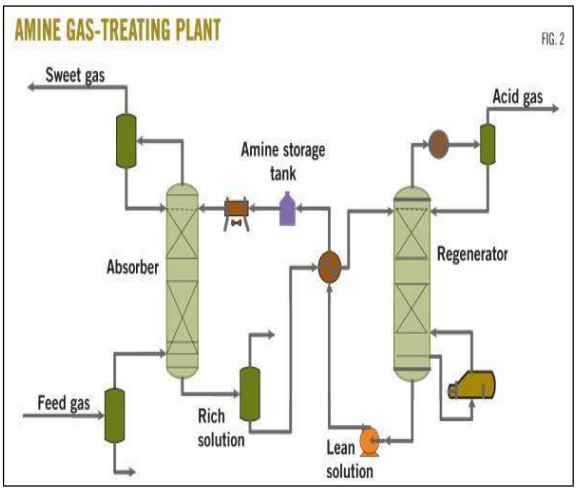

Fig 2.1 Amine gas Treating Unit [iv]

In this process the sour gas enter into absorber and MDEA solvent enter counter currently into the column. Sweet gases are separated from the top of the absorption column. CO_2, H_2S are absorbed into the lean Solvent. Now the rich solvent is going to Regenerator unit. In regenerator section by the action of heat the rich solvent is regenerated and separated from the waste gases. The regenerated solvent is re-circulated back to the absorber for the further processing.

3. Glycol Dehydration Unit

In the dehydration unit as shown in fig. 2.2, water is removed from the wet natural gas by the simple separation method. The treatment consist of the Dehydrating the natural gas, which is usually involves adsorption or absorption. Glycol dehydration is the example of the absorption. In this process liquid desiccants absorbed the water vapors from the gases.

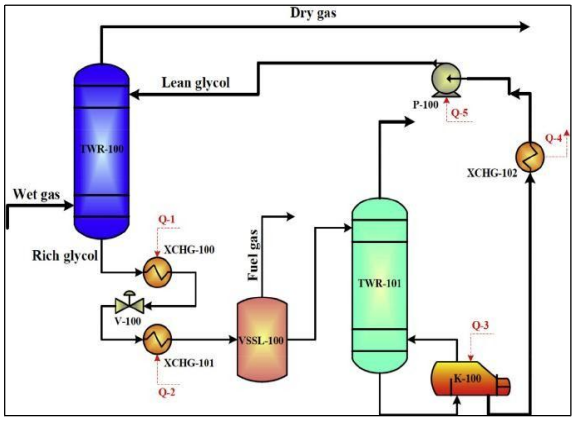

Fig 2.2 Flow sheet of Dehydration Unit[v]

Glycol is the main chemical in this process. It has affinity for the water. And it will absorb the water from the gas stream. From the top of the column the dry gas is removed and the water along with the glycol is going to the stripper, where the glycol get separated from the water.

4. Material Balance of Natural Gas Processing Unit

Here in designing a process plant for production of one million cubic meters per day quality natural gas from Crude Natural Gas.

Table 3. Feed specifications

Composition	Mole %	Wt %
CH_4	57.81	36.62
C_2H_6	19.98	23.73
C_3H_8	11.35	19.77
i- C_4H_{10}	0.96	2.20
N –C_4H_{10}	2.83	6.50
i- C_5H_{12}	0.38	1.08
N-C_5H_{12}	0.55	1.57
C_6H_{14}	0.22	0.75
C_7H_{16}	0.09	0.36
C_8H_{18}	0.04	0.18
CO_2	0.57	0.99
N_2	5.22	5.77
H_2O	0.15	0.11

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H_2S	0.28	0.38

Material Balance is very important data in the designing of chemical plant. Without this data, it is impossible to do the design of plant. From material balance data, we can predict the feed requirements, cost of producing X amount of product, etc.

The law of conservation of mass states that
Mass in - Mass Out = Accumulation

Foremost thing in designing a flow sheet the overall material balance is required over the different units followed with the flow requirement into the inlet stream and outlet product stream.

5. Simulation of the Natural gas Processing Unit

Process simulation is used or the design, analysis and optimization of the process such as chemical plant, chemical processes, environmental systems, power stations, complex manufacturing operations, biological processes, and similar technical functions. The software has to solve the mass and energy balance to find a stable operating point. The goal of a process simulation is to find optimal conditions for an examined process. This is essentially an optimization problem which has to be solved in an iterative process. The model used in the process simulation is the approximation and assumption but it gives the wide range of the temperature and pressure data which is not covered in the real data. Models also allow interpolation and extrapolation - within certain limits - and enable the search for conditions outside the range of known properties.

4.1 Simulation of Acid Gas Removal Unit

Start with the short cut distillation method and Find the number of stages, feed plate location number and the reflux conditions for the distillation column. The separation is based on the concentration of the amine. With increase the solvent concentration. CO_2 and H_2S concentration will go to increase. In the acid gas removal unit simulation, the component and fluid package for the system has been selected. For this unit we have selected amine fluid package. Then after feeding this information a flow sheet is designed in the simulation environment as shown in fig. 4.1

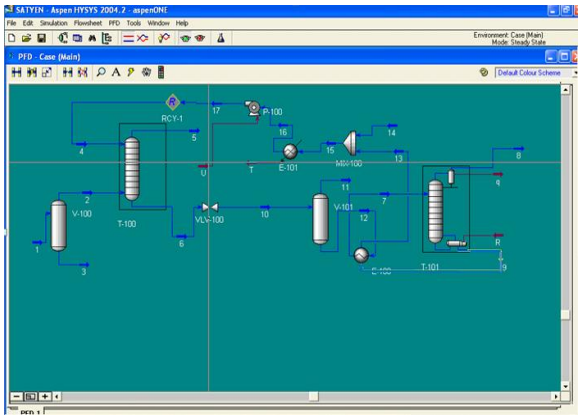

Fig 4.1 Simulated flow sheet of Acid Gas removal Unit

In this simulation process using recycle stream, the amine stream to absorber column. By changing different concentration of amine and different experimental conditions, the best optimized solutions can be derived.

4.2 Simulation of Glycol Dehydration Unit

In the Gycol dehydration unit the glycol Fluid package has been selected. TEG used as an aqueous absorbent to absorb water from gas streams. Before entering to the contactor, the gas is passed through an inlet separator where entrained droplets of liquid are removed from the gas stream.

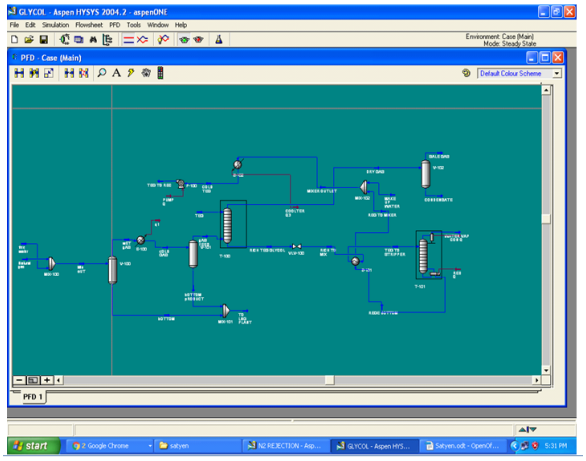

Figure 4.2 Dehydration unit Flow sheet in HYSYS

The simplest way to reduce the water content in the glycol is to introduce stripping gas to the regeneration column. The stripping gas can be nitrogen, recycled natural gas or flash gas. It important to uses inlet gas separator to remove any undesirable impurities such as, solid particulars and liquids. Glycol contactor tower is also important.

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part from the plant which it also need some specifications for example, streams temperature and pressure and the TEG concentration (99% is used).

6. Result

The main aim of this paper is design of process plant using given composition. So, first we decide the process and unit which are required for given product composition. With the help of excel first we make a basic sheet of compositions and flow rate unit wise. This gives the basic idea that about the process. And we get our initial flow rate and composition detail.

For the design of chemical plant HYSYS is most widely used software in industries. We are also using this software for the design and simulation of Acid removal unit and Glycol dehydration unit.

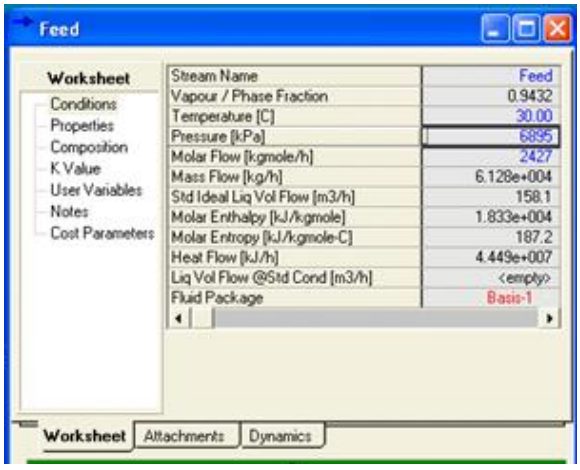

Figure 5.1 Feed Conditions

The feed contain the impurities such as CO_2 & H_2S. Which are separated by using solvent such as MDEA. And we can see the effect of various parameters on the CO_2 absorption. As we increase the concentration of MDEA the absorption of CO2 increase but with that, the cost of solvent is also increase. So we have to consider economical factor and mainly the process industries used 30% wt of MDEA solvent in industries.

Natural gas mainly contains Methane as main component in the feed. Feed enter at 30 c and 2427 mol/h feed flow rate in the acid removal unit. Before that pre – treatment of feed is done.

From result we can see the outlet compositions of the Acid removal unit. Here we can separate CO_2 and H_2S as from feed as per design requirement.

Stream Description	Waste water from separator	
Component	Acid Gas Removal section product Mole	% Mole
CH4	33521.04	0.5801
C2H6	11530.87	0.1995
C3H8	6609.87	0.1144
n-C4H10	559.07	0.0097
i-C4H10	1648.10	0.0285
i-C5H12	221.30	0.0038
n-C5H12	320.30	0.0055
C6H14	128.12	0.0022
C7H16	52.41	0.0009
C8H18	23.29	0.0004
CO2	174.71	0.0030
N2	2981.72	0.0516
H2O	17.47	0.0003
H2S	0.00	0.0000
	57788.28	100.00

Figure 5.2 Composition of Acid gas removal unit

Feed enter into the dehydration unit after removal of moisture using the glycol agent.

	Mole Fractions	Vapour Phase	Liquid Phase
Methane	0.597865	0.597865	0.246287
Ethane	0.199856	0.199856	0.227367
Propane	0.106412	0.106412	0.255445
i-Butane	0.008315	0.008315	0.033814
n-Butane	0.023598	0.023598	0.118590
i-Pentane	0.002691	0.002691	0.023080
n-Pentane	0.003803	0.003803	0.038528
n-Hexane	0.001158	0.001158	0.023061
n-Heptane	0.000333	0.000333	0.012836
n-Octane	0.000096	0.000096	0.007052
CO2	0.000770	0.000770	0.000745
Nitrogen	0.055092	0.055092	0.012068
H2O	0.000011	0.000011	0.0
H2S	0.000000	0.000000	0.0
TEGlycol	0.000001	0.000001	0.001071

Figure 5.3 Composition of Glycol Dehydration Unit

From the above table we can see that the water content is reduced up to 0.01% from the feed and the product is now as per our design composition.

7. Conclusion

In this paper we have tried to simulate the natural gas unit using HYSYS software. For the design and the optimization purpose HYSYS software is widely used in chemical and petrochemical industries. It is helpful for the cost estimation of plant and determining the effect of various parameters in a easy and short time interval. This is also helpful for the comparison of various solvent used in the acid removal unit. We can see the performance of various solvent and select the best solvent as per plant requirement.

In current scenario the process is become more and more complex to optimize the cost parameter. Use of

suitable software is recommended for calculation which reduces the error.

8. Acknowledgements

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