

ENERGY SAVING IN A GAS PROCESSING PLANT THROUGH APPLICATION OF A MEMBRANE SYSTEM

by

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Abstract

Malaysia is rapidly emerging as a Newly Industrilized Countries (NIC). This shows the rapid pace of industrial programmes currently going on in the country. Even though energy resources in the form of petroleum deposit and hydropower are easily available, it is not too early at this present stage to monitor the energy requirements in industries and develop an efficient energy conservation approach so as to maximize these energy resources. This paper is intended to estimate the energy requirement in a Gas Processing Plant (GPP) having processing capacity of 250 MMSCFD natural gas and to estimate the energy saving that can be generated through the utilization of a Gas Membrane Separation System.

The overall energy requirement for the GPP is estimated to be $1,434 \times 10^{10}$ kJ/day and the estimated energy saving as a result of utilization of a gas Membrane System is 43.7×10^8 kJ/day which is approximately 38.5%. This represents a significant energy saving especially in the long run.

Introduction

Malaysia is emerging as one of the newly industrilized countries (NIC). This status indicates the rapid pace of the industrial development programme currently implemented in Malaysia. Various factors are responsible for the rapid progress of the industry. They are:

- 1) the availability of abundance natural resources such as natural rubber, palm oil, and other agricultural products in which Malaysia is the leading exporter in the world³
- 2) availability of energy sources whether from petroleum reserves or hydropower, and
- 3) availability of skilled and qualified manpower.

* Kertas kerja ini telah dibentang di Seminar Penyelidikan Tenaga, Sirim, pada 16 Februari 1989.

Although energy sources are readily available to meet the demand of our industries, effort must be made to try to conserve this energy and to optimize its usage in various industries especially to ones that are most energy intensive. Table 1 lists the six energy intensive industries in the United States. Petroleum and coal industries have been identified as the highest energy consumer per dollar value added produce (\$VA) followed by metal industries, stone, clay and glass products, chemical and allied products, paper and allied products and food and house-hold products. It is therefore very important at this early stage of our industrilization programme to start auditing industries such as above for its energy requirements and to formulate an energy conservation approaches in order to maximize the use of our energy resources.

Besides hydropower there is a large deposit of natural gas and oil in Malaysia. The total estimated reserve of our natural gas is 52 trillion standard cubic feet (TSCF) and 18 TSCF or 35% is found at offshore Terengganu. To meet the energy requirement in the various industries in Malaysian Peninsular, a Gas Processing Plant (GPP) which has the capacity to process 250 Million Standard Cubic Feet natural gas per day (MMSCFD) was built by Petronas² in Kerteh, Terengganu.

This paper is intended to discuss the present energy requirement of the GPP in Terengganu, and to identify the possible energy saving alternatives either through process integration and modification or through the utilization of membrane gas separation systems.

THE GAS PROCESSING PLANT

Introduction

The Gas Processing Plant built by Petronas² is located in Kerteh, Terengganu and is designed to process 250 MMSCFD natural gas condensate gas from offshore Terengganu and from Terengganu Crude Oil Terminal (TCOT). However this capacity can be increased further to process 1,000 MMSCFD when developed.

The plant is characterized by its high degree of performance and reliliability². Beside its high safety standard the plant also has high recovery factor of 99.6% with minimum losses due to leakage and flaring.

Another interesting feature of this plant is that it can be left on operation at only 5% of the design capacity without significant effect on the product quality. The gas product specifications are given in Table 3.

The Process Flowsheet

Figure 1 shows the process flowsheet of the GPP as given by Reference 2. Basically the plant can be divided into five integrated process units. They are:

- 1) Dew Point Control Unit (DPCU),
- 2) Produce Recovery Unit
- 3) Liquified Petroleum Gas Unit (LGU) for condensate recovery from Terengganu Crude oil Terminal (TCOT)
- 4) Acid Gas Removal Unit (AGRU) and
- 5) Glycol Regeneration Unit

The feed consists of high pressure gas and condensate at 7000 kPa and 27°C coming from the Carigali Slug catcher which is passed through the inlet separator (M101) to remove immediate liquid condensate from the gas stream. The detailed inlet specification and properties are listed in Table 2.

Arriving at the Dew Point Control Unit the gas stream is passed through a J-T expansion valve or through a Turbo Expander (TE) where the pressure and temperature drop 3620 kPa and -27°C respectively in case of J-T valve and 3000 kPa and -44°C respectively for the TE. After removing the condensate in cold separator (M102) the stream is fed into a glycol dehydration unit and acid gas removal unit. Before the sweetened gas is sent for sale it is pressurised back to 3100 kPa (g) using a two-stage compressor (see Table 3 for gas product specifications).

The heavy hydrocarbon condensate from separators (M101, M102, M103) are fed into the fractionation systems consisting the deethanizer, depropanizer, and debutanizer after which it is dried and recovered. Similarly the feed from the Terengganu Crude Oil Terminal (TCOT) is fed into the fractionation systems for recovery of the condensate and treatment of the gas in the Gas Removal Unit.

Energy Requirements

The energy requirement for the GPP is estimated based on the assumption that the plant is running in full capacity i.e. 250 MMSCFD of natural gas and associated gas from the offshore production platforms. It is also assumed that the dehydration unit consists of ethylene glycol injection system and the ethylene glycol regeneration unit, whereas the acid gas removal unit uses the zinc oxide bed to remove the hydrogen sulphide gas and sulphur elements found in the feed mixtures (refer Table 2).

The main energy consumers in the systems are the reboilers for each deethanizer, depropanizer and debutanizer units which use fuel gas obtained from the plant. Compression and pumps works follow the next energy requirement in the plant. The detailed energy requirements for each process instrumentations are given in Reference 3. Last but not least the glycol regeneration unit and the Acid Gas Removal Unit are the next main energy consumer in the plant.

Table 4 shows the energy balance given in each process unit operation keeping in mind that only major equipments are considered³. As shown in Table 4 the total energy requirement for the plants is estimated to be 1.434×10^{10} kJ/Day. This total amount comes from the various process unit operations given.

Energy Saving through Process Integration and Utilization of Membrane Systems

Membrane systems are commercially available for natural gas processing. This include water moisture removal (dehydration) from the gas stream and gas sweetening (removal of CO_2 and H_2S). Gas dehydration using Cellulose Acetate membranes has been reported elsewhere^{4,5} and similarly in the removal of acid gases⁶.

The advantages and benefits of using gas membrane separation systems as compared to the conventional methods also have been given in other paper⁴. However it is good to mention again here that membrane separation systems are particularly superior to the conventional methods especially in terms of low energy requirements. In dehydration of the feed gas the stream is passed through a filter to ensure the removal of debris and hydrocarbon condensate which can affect the performance of the membrane unit. The membrane system is then functioning in removing the water moisture from the stream of natural gas.

The utilization of membrane dehydration unit would therefore eliminate the glycol regeneration unit. Assuming that total dehydration process using membrane unit is possible, then the total energy saving from the process is 2.05×10^8 kJ/Day i.e. the energy that is required in the stripping column (refer Table 5). This comprises of 1.4% of the total energy requirement for the plant.

The major energy saving comes from the utilization of Gas Membrane System in place of the Acid Gas Removal Unit to remove CO_2 and H_2S gases. In case of total replacement of the Acid Gas Removal Unit with Gas Membrane System, it is expected that 53.26×10^8 kJ/day energy could be saved from the plant which is approximately 37.14%. This is after considering 20% the extra energy required for compressor's works in the membrane system.

Membrane Gas Separation System is very simple and easily adapted and integrated into the existing plant flow process without major difficulty and at low installation cost. It is therefore recommended that a Gas Membrane Separation System is installed at the existing plant and be operated concurrently with the existing AGRU. This is to allow testing of the Membrane System Reliability and acquiring operational expertise by the operators. When sufficient testing and operating experienced have been obtained and the economic is favorable then the full function of the gas sweetening process can be carried out using the Gas Membrane Separation System.

Conclusion

The energy requirement for a Gas Processing Plant with capacity of 250 MMSCFD was estimated to be 1.434×10^{10} kJ/Day. The maximum amount of energy saving that can be generated as a result of utilization of a Gas Membrane Separation is 38.5% of the total energy requirement. This is a significant saving of energy especially in the long run.

Reference

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2. Peninsular Gas Utilization Project Stage 1, Petronas Gas Sdn. Bhd., Tingkat 20, Menara Dayabumi, K.L. Malaysia.
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Table 1

Energy Intensive Industries in USA¹

Industry	Energy Requirements in 1980 per \$VA (MBtu/\$VA)
Petroleum and Coal Product	373.55
Primary Metal Industries	212.66
Stone, Clay and glass Products	119.55
Paper and allied products	94.31
Chemical and Allies products	84.02
Food and Kindred products	26.29

Table 2

Typical Feed composition and Properties

Components	Mole %
Methane	80.10
Ethane	7.56
Propane	3.35
I-Butane	0.84
N-Butane	0.90
I-Pentane	0.40
N-Pentane	0.28
Hexane	0.38
Heptane	0.34
Octane	0.33
Nonane	0.21
Decane	0.15
N-decane	0.22
<u>Others</u>	
Nitrogen	0.47
Carbon Dioxide	4.47
Hydrogen Sulphide	30.00 ppmv
<u>Flow conditions</u>	
Flow Rate (Kg/hr)	280,861
Flow Rate (Kg-mole/hr)	12,723
Molecular weight	22.075
Temperature	27°C
Pressure	7000 KPa
Density	69.5 (Kg/M ³)
Mass Flow rate	6741 Tonnes/day
Volumetric Flow Rate	7.22 Million M ³ /day

Table 3

Gas Product Specification³

Products	Specification
Sale Gas	
Gross Calorific Value :	39.1 MJ/SM ³
Hydrogen Dew Point :	10°C Max
Water Dew Point :	10°C Max
Total Sulphur content :	5.7 mg/SM ³ Max
Specific Gravity :	0.7 max
Propane	GPA Standard 2140 - 80
Butane	GPA Standard 2140 - 80
LPG	GPA Standard 2140 - 80

Table 4

Estimated Total Energy Requirement of The Gas Processing Plant

Unit Operations	Energy Requirement (kJ/hr)
Separators	214.00 x 10 ⁶
Acid Gas Removal Unit	277.00 x 10 ⁶
Glycol Regeneration Unit	8.56 x 10 ⁶
Deethanizer	54.51 x 10 ⁶
Depropanizer	33.26 x 10 ⁶
Debutanizer	7.88 x 10 ⁶
Heat Exchanger	4.43 x 10 ⁶
TOTAL	599.64 x 10⁶

Table 5
Estimated Energy Requirement for the GPP
Through Application of Membrane Separation System

Unit Operations	Energy Requirement (kJ/hr)
Separators	214.80×10^6
Deethanizer	54.51×10^6
Depropanizer	33.26×10^6
Debutanizer	7.88×10^6
Heat Exchanger	4.43×10^6
TOTAL	314.88×10^6

