CHEMICAL ENGINEERING TRANSACTIONS Volume 18, 2009
Editor Jiří Klemeš

DOI: 10.3303/CET0918021

Energy Management of Gas Separation Plant by Energy Auditing Program

Natapat Wongsarnpigoon[1*], Kitipat Siemanond[1,3*], Yuti Chaleoysamai[1], Rungroj Chuvaree [2]

The Petroleum and Petrochemical College, Chulalongkorn University[1]
Soi Chulalongkorn 12, Phayathai Road, Pathumwan, Bangkok 10330, Thailand
PTT Public Company Limited[2]
Center for Petroleum, Petrochemical, and Advance Materials [3]
*Corresponding authors: kitipat.s@chula.ac.th

Due to energy losses in petroleum and petrochemical plants, energy loss analysis needs to be applied for energy saving. A gas separation plant (GSP) in Thailand is a case study for this research work. Two types of energy sources consumed in this GSP, fuel gas and electricity, will be measured and analyzed for identifying energy losses at several energy-consuming areas; acid gas and water-removal unit, refrigeration area, and fractionation area by energy-auditing program. For acid gas and water-removal areas, and refrigeration areas, energy audit program can calculate daily energy consumption of the utility-exchangers and waste-heat- recovery unit using hot oil as heating media and fuel gas as fuel. For the fractionation area including demethanizer, deethanizer and depropanizer, the column targeting is used for analysis of energy-loss by separation.

1. Introduction

The increase of energy cost in petrochemical industry is major effort to reduce energy requirements and utilities costs. Gas separation plant consumes electricity and fuel gas as energy source and natural gas was fractionated by demethanizer, deethanizer, and depropanizer to produce five products; methane, ethane, propane, liquefied petroleum gas (LPG), and natural gasoline (NGL). To achieve the purpose of energy consumption reduction, the energy loss analysis is considered by developing energy audits program for utility exchangers in plant. In this work, column targeting is used to analyze the energy loss for distillation columns. The column grand composite curve (CGCC) is useful for representation of temperature-enthalpy. The calculation procedure for the CGCC involves determination of the net enthalpy deficit at each stage by generating envelopes from either the condenser end (top-down approach) or the reboiler end (bottom-up approach) by Dhole and Linnhoff (1993) and Shenoy (1995).

Please cite this article as: Wongsarnpigoon N., Siemanond K., Chaleoysamai Y. and Chuvaree R., (2009), Energy management of gas separation plant by energy auditing program, Chemical Engineering Transactions, 18, 141-146 DOI: 10.3303/CET0918021

2. Energy loss analysis by energy audits program

The energy audit program is developed for monitoring energy consumption by hot oil of the following areas in the gas separation plant; acid gas removal, water-removal, refrigeration and fractionation areas, as shown in Figure 1. The program receives the actual data through distributed control system (DCS) and plant information system (PIMS). After that the program will calculate the energy consumption by hot oil of utilities exchangers and report in daily or monthly data, as shown in Figure 2-4.

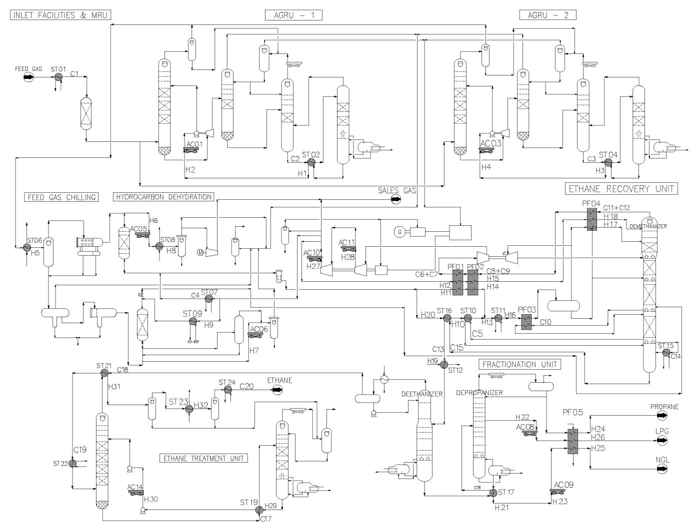

Figure 1. Process flow diagram of gas separation plant.

The measured data of GSP consist of flow rate, temperature inlet-outlet and density.

The energy consumption by hot oil can be calculated by equation (1);

$$\text{Energy demand hot oil} = FCp\,\Delta T. \quad (1)$$

Where,

F = Flow rate of hot oil, Cp = Heat capacity of hot oil, ΔT = Temp out – Temp in

The energy consumption by fuel gas can be calculated by equation (2);

$$\text{Energy loss} = \text{Energy supply}_{fuelgas} - \text{Energy demand}_{hot\ oil} \quad (2)$$

Where,

Energy consumption by fuel gas = (fuel gas flow rate)(heat combustion of fuel gas),*

Where,

*Heat of combustion of fuel gas = sum[(low heating value)i*Xi],*

X_i is mole fraction of each fuel gas component.

After implementing the equeations to program, the daily or monthly energy consumption can be reported, as shown in Figure 2 and 3.

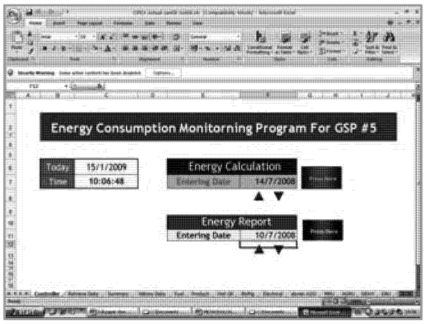

Figure 2. Energy monitoring program

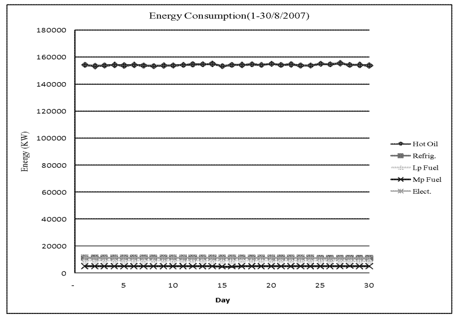

Figure 3. Energy consumption chart.

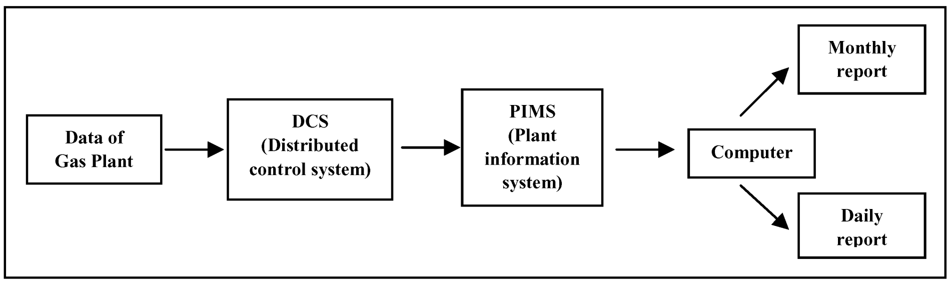

Figure 4 Energy monitoring system

For the energy loss analysis, the energy loss can be calculated by this equation,

Energy loss = Actual energy consumption – Standard energy consumption.

The standard energy consumption comes from simulated gas separation plant which was compared with the actual energy consumption.

3.Energy loss analysis by distillation column targeting

For reducing the energy consumption of demethanizer, deethanizer and depropanizer, column targeting is used for analyzing energy loss.

3.1Demethanizer

Demethanizer column consists of six trays and four packed beds in side the column. However in the simulation step, 20 trays were used to represent these packed beds. This section is a low temperture process (the cryogenics process) dominated by the shaftwork of compressor in refrigerant system. This column has no condenser duty and less reboiler loads; furthurmore, this column is a complex column having many feed streams. It also contains chimey trays which collect liquid from between packed beds and function as a collector device for ethier feeding distributor and liquid drawing from the column. Figure 5 and 6 shows the thermal profile of demethanizer column or CGCC and demethanizer diagram.

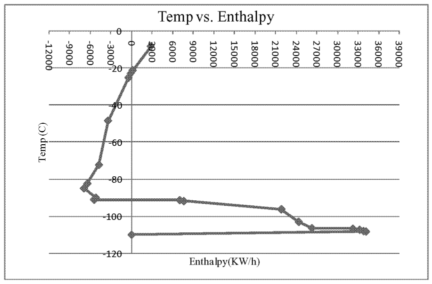

Figure 5. CGCC of Demethanizer(temp. vs enthalpy)

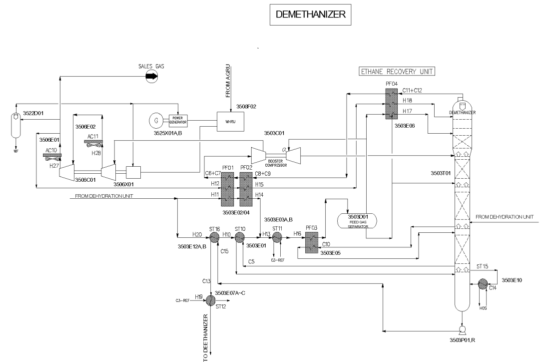

Figure 6. Demethanizer

From Figure 5 and 6, the energy consumption of demethanizer is around 3,000 KW for the reboiler duty, there is no energy loss by separation to reduce energy loads of the column.

3.2Deethanizer

This column has 40 trays with feed at tray no.12; the duty of reboiler and partial condenser are shown in Figure 8, the CGCC of deethanizer with only one pinch point at stage 12 and temperature around 35.9 deg C. The energy loss gap is observed around 2,600 KW which implies an improper existing reflux ratio (R=1.73). This can be modified by reflux modification.

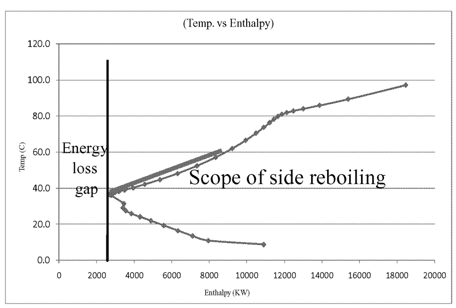

Figure 7. Energy loss gap and scope of side reboiling.

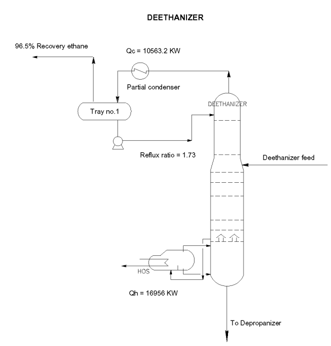

Figure 8. Deethanizer.

After reducing reflux ratio to R = 0.7, the energy consumption of reboiler and condenser duty can be saved to 7.72% as shown in Table 2. However, the ethane recovery drops to 86.1% so R=1.54 is might be the optimum reflux ratio. Another modification is the scope of side reboiling as shown in Figure 7, side reboiling can be used by using hot stream with temperature of 107.13 C, this hot process is used to heated the deethanizer as a side reboiler, resulting in reducing main reboiler and air cooler duty as shown in Table 3.

Table 2. Results of reducing reflux ratio of deethanizer.

Reflux Ratio	Ethane recovery (%)	Duty Reboiler (KW)	Duty Condenser (KW)	Qh & Qc Saving	
				KW	%
1.73(Existing)	96.5	16,956.60	11,563.20		
1.6	96.5	16,486.20	11,539.90	256.12	0.94
1.54	96.3	15,942.70	11,266.58	1,013.90	3.72
1.45	95.6	15,759.32	11,157.40	1,603.50	5.62
0.7	86.1	13,023.22	11,109.65	2,105.65	7.72

Table 3. Results of side-reboiling of deethanizer at tray 33.

	Deethanizer	Air cooler no.1
Utility Saving (KW)	5,237.90	5,275.20
Utility Saving (%)	30.77	43.14

3.3Depropanizer

Depropanizer consists of 98 stages with feed tray no.51th and use both of reboiler and partial condenser as shown in Figure 10. The reflux ratio is around 3.13 moreover there are 2 side draws at tray no.23 (LPG) and tray no.89 (i-pentane). Heat duties of reboiler and condenser are around 8,900KW and 10,700 KW respectively. The CGCC of depropanizer shows the pinch point at temperature around 86 C, as shown in Figure 9. There is energy loss gap around 1,000 KW. The results of reflux modification is shown in Table 4, this shows reflux ratio can save energy loss in depropanizer and the proper reflux is R = 2.80.

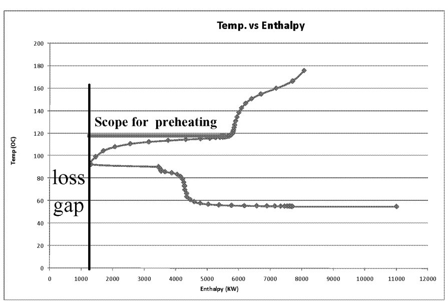

Figure 9. Scope of Feed Preheating.

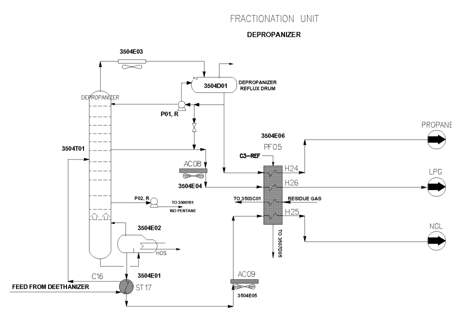

Figure 10. Depropanizer.

Furthermore, after reducing reflux ratio, feed preheating is observed in Figure-9 by using hot process stream with temperature of 100.49 C, this hot stream is used to heat feed of depropanizer to 90 C resulting in reducing main reboiler duty and air cooler duty as shown in Table 5.

Table 4. Result of reflux modification of depropanizer.

Reflux Ratio	Ethane recovery (%)	Duty Reboiler (KW)	Duty Condenser (KW)	Qh & Qc Saving	
				KW	%
3.13	99.93	8900	10,700		
3.02	99.82	8600	10,700	300	3.37
2.96	99.75	8400	10,700	500	5.62
2.88	99.63	8200	10,700	700	7.87
2.80	99.57	8000	10,700	900	10.11

Table 5. Result of feed preheating.

	Depropanizer	Air cooler no.2
Utility Saving (KW)	2,633.00	2,643.70
Utility Saving (%)	15.89	25.55

Conclusions

1. **Energy loss analysis by energy auditing program**

The energy-loss monitoring program can audit the energy usage of utility exchangers in GSP.

2. **Energy loss analysis by distillation column targeting**

For demethanizer, there is no scope for energy loss reduction. For reflux modification, deethanizer reflux ratio of 0.7 is the most energy saving but %ethane recovery drops to 88.6%. Another modification is a side reboiling, this is used to help reducing the main reboiler duty in deethanizer for 30.77% and 43.14% for air cooler no.1. For depropanizer, reflux ratio of 2.80 is the most energy saving and feed preheating is used to help reducing the main reboiler duty in depropanizer for 15.89% and 25.55% for air cooler no.2.

Acknowledgements

The authors wish to thank Dr. Rungroj Chuvaree and Mr. Supachai Laorrattanasak for their helpful work on details of gas plant. Finally, we would like to thank PTT Public Company Limited, Government Budget, Assoc. Prof. Anuvat Sirivat, Conductive and Electroactive Polymers Research Unit, and Center for Petroleum, Petrochemical, and Advance Materials for funding support.

References

Dhole, V. R., & Linnhoff, B. (1993). Distillation column targets. *Computers & Chemical Engineering*, 17 (5:6), 549–560.

Bandyopadhyay, S., Malik, R. K., & Shenoy, U. V. (1998). Temperature–enthalpy curve for energy targeting of distillation columns. *Computers & Chemical Engineering*, 22 (12), 1733–1744.

Shenoy, U. V. (1995). *Heat exchanger network synthesis*: *process optimization by energy and resource analysis*. Houston: Gulf Publishing.