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Optimization Energy Management and Audit of Sirri Ngl

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Abstract

The fundamental goal of energy management is to produce goods and prov) 6Âvservices with the least cost and least environmental effect.At the new Sirri Island NGL plant, steam was required to supply heat for process, especially in the reboilers. Boiler feed water was fed from the LP Boiler Feed water Pumps to the LP Package Boilers to produce LP steam at 6.9 bar and 175 °C. It was seems about 44.6 tonnes/hour of steam was required in the plant. Steam will be distributed via a LP Steam Header system to the various users, and steam Condensate will be collected via a Steam Condensate Return header. The returning steam Condensate is partially flashed in the Condensate Storage Drum. At this NGL plant steam heat exchangers network layout is a pure parallel design which implies that each heat exchanger was directly connected to the boiler. These arrange implies that the flow rate of steam needed for the system can be reduced, while maintaining the required duty, simply by changing the layout of the network. Phase change of saturated steam to saturated liquid plays a vital role in the targeting method as well as the design of the network layout. A graphical targeting method and a mathematical model have been developed to obtain the minimum steam flow rate, as well as the network layout. Furthermore, a mathematical model was developed by targeting and designs simultaneously. Results show that about 7% of steam savings in the plant.

Introduction

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme. Bureau of Energy Efficiency 57 3. Energy Management and Audit As per the Energy Conservation Act, 2001, Energy Audit is defined as “the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption”.[1-2] The Neptune Cryogenic Gas Plant has two nominal 300 MMSCFD trains. The prime mover for each of the trains' residue gas re-compressor is a Solar Mars 100 gas turbine. The first train, which was commissioned in February of 2000, utilizes Ortloff's Gas Sub-cooled Process (GSP). The second Neptune train utilizes IPSI's patented Stripping Gas Process [3].

The plant receives a processing fee per the terms and conditions of the gas processing contracts with each inlet owner. The plant processing fee is usually determined in one of three ways: a fixed processing fee, a ‘keep- whole’ contract, or retention of a portion of the produced liquids. A fixed processing fee agreement pays the plant a flat fee based upon the volume of inlet gas. A ‘keep-whole’ contract allows the plant to remove liquids from the gas and pay the supply company based upon the BTU value of the fuel and shrinkage[4].

In addition to processing fees, the plant may receive income from compression, marketing, or pipeline transmission fees. The situation may be complicated further depending upon the terms for fuel allocation and shrinkage. Contractual penalties may also exist for low recovery, insufficient inlet gas flow, low plant inlet suction pressure, high field pressure, high levels of impurities in the inlet or product, and lean inlet gas[5].

Steam is used in Sirri NGL plant for process streams that need to be heated and vaporized such as distillation towers and amine regeneration and also for low pressure flares and thermo compressor ejector in desalination unit. To save on energy costs, heat is initially exchanged between hot and cold process streams via heat exchangers, and then cooling water and Steam are used for the remaining process streams. Pinch Analysis is commonly used in maximizing process-process heat integration, thereby minimizing external utility requirements. Most industries worldwide have adopted Pinch Analysis as the most powerful tool in achieving a design with optimal usage of external utilities. Cooling towers, steam boilers and process-process heat exchangers all form part of a heat exchanger network (HEN).

In the past minimization of the amount of the external steam needed in the system has been accomplished by optimizing the steam boiler, or optimizing each heat exchanger individually. However, in this work it is demonstrated that by optimizing the steam system as one entity instead of individual components, better results are obtained, as was proven Thokozani Majozi [6] and Cardona1 - Gutierrez [7] for heat exchanger network.

Problem Statement

The problem addressed in this paper can be stated as follows, given:

a. The set of heat exchangers in Sirri NGL,
b. The fixed duties of each heat exchanger,

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c. The hot temperature that in bottom of every tower is needed.
d. The limiting data for each heat exchanger, and
e. The minimum driving force ΔTmin for the overall network,

Determine the minimum amount of steam required to satisfy the heat exchanger network, as well as the steam utility network layout without compromising the minimum heat duty requirement.

Methodology

Saturated steam is used first to transfer the latent heat to cold process streams. The resulting saturated liquid is then further used to transfer heat to the remaining cold process streams, together with re-use of hot liquid from other units. The hot utility curve is constructed using the ΔTmin, after which, graphical targeting for the minimum steam flowrate is done. Fig. 1 shows the combination of the saturated steam, saturated liquid and hot utility composite curve on a Temperature vs. Duty diagram. The energy supplied by the saturated steam as well as the saturated liquid is given by Eq. (1).

$$Q = m\,\lambda v + mcp\,\Delta T \quad (1)$$

Where Q is the total energy supplied by the saturated steam and saturated liquid in kW; m is the water flowrate in kg/s; λv is the latent heat of vaporization of the saturated steam in kJ/kg; cp is the specific heat capacity of the water in kJ/kg°C; ΔT is temperature difference in °C.

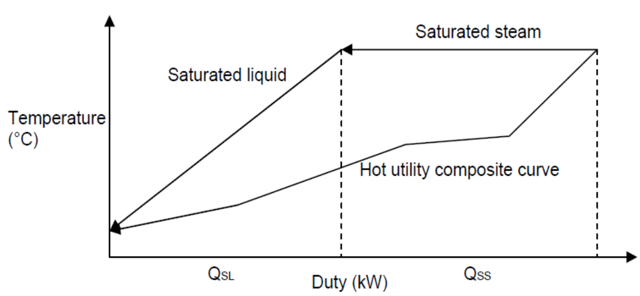

Figure1: targeting using saturated steam as well as saturated liquid.

After the steam target has been set, the heat exchanger network that meets the target is designed. As stated previously, saturated steam and saturated liquid are used as utilities in the HEN. Therefore, the diagram in Fig. 1 can be divided into four regions of interest as shown in Fig. 2. The composite curve divides the diagram into regions 1 and 2. Region 1 is a feasible region since all the utility streams within this region obey the thermal driving forces. Region 2, on the other hand, involves utility streams that violate the thermal driving forces and is, therefore, an infeasible region. The vertical dashed line separates the diagram into regions 3 and 4.

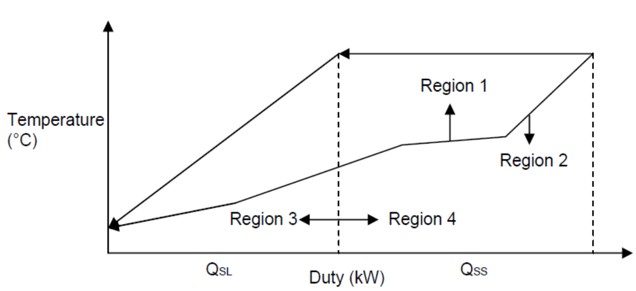

Figure2: The four regions

In region 3, heat transfer takes place through sensible heat whereas in region 4 heat transfers involve latent heat, i.e. phase change. By exploiting the structure of Fig. 2, a HEN that meets the target steam requirement can be developed.
In the region where only saturated steam is required, i.e. region 4, the layout will always be a parallel connection; therefore, one only needs to determine the layout of the rest of the heat exchangers for the saturated liquid region.

In the saturated liquid region the layout can be parallel, series or both. The Temperature vs. Duty diagram gives a visual representation of the targeted solution. However, the diagram does not show the layout of the HEN in the saturated liquid region. A mathematical model is then used to obtain the HEN layout in the saturated liquid region. The mathematical model, which is a linear programming (LP) model, entails mass and energy balances as well as design constraints that should not be violated.

A mathematical model can also be used to target for the minimum steam flowrate, as well as obtain a network layout for targeted value. The model developed for this, takes the form of a mixed integer linear programming (MILP) model. To prove the applicability of the developed methodology, an actual case study will be used.

Sirri NGL steam generation and distribution system and HEN

The utility data is given in Table 1. Saturated steam is provided at 162°C (6.2 bar) with a latent heat capacity of 2081.3 kJ/kg. The specific heat capacity of the resulting saturated liquid is 4.22 kJ/kg°C. The figure temperature vs. duty for Sirri NGL plant HEN shows the results of targeting using saturated steam, as well as saturated liquid.

Table 1: Utility data for the Sirri NGL [3]:

Heat Exchanger	T_{supply}	T_{target}	Duty(KW)
1. Depentanizer	172	150.5	1218
2.Debutanizer	172	130.9	2859
3.Depropanizer	172	128	5313
4.Deethanizer	172	104	6626
5.Condensate Heater	172	110	3382
6.Amin Regenerator	139	120	7503
Total			**26901**

If only saturated steam was used as a hot utility, i.e., assuming a parallel design, the flowrate would be 39.3 t/h. However, by using the methodology described above, the flowrate needed is only 36.5 t/h, reducing the original flowrate by 7%. After targeting for the minimum flowrate, the network layout was obtained by using the LP model.

Whether a heat exchanger should be allowed to split is a decision that rests with the designer, since a split increase the capital cost of the network according to the Table 3. It should be noted however, that by not allowing a split to occur, the flow rate of the steam increases. The MILP model resulted in the same flowrate of 36.5 t/h, although a different network layout was obtained.

Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:

a) Establish energy consumption in the organization
b) Estimate the scope for saving

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a) Identify the most likely (and the easiest areas for attention

b) Identify immediate (especially no-/low-cost) improvements/ savings
c) Set a 'reference point'
d) Identify areas for more detailed study/measurement
e) Preliminary energy audit uses existing, or easily obtained data

Table 2 : Initial calculations for estimating the minimum optimized rate of steam

Heat Exchanger	$Q = m\lambda_v + mc_p \Delta T$
Deethanizer	$Q = m(\lambda_v + c_p \Delta T)$ $m_1 \lambda_v = m_2 (\lambda_v + c_p \Delta T)$ $11337 \times 2081.3 = m_2 (2081.3 + (4.22 \times 68))$ $m_2 = 9963 \frac{kg}{hr}$
Depropanizer	$Q = m(\lambda_v + c_p \Delta T)$ $m_1 \lambda_v = m_2 (\lambda_v + c_p \Delta T)$ $8960 \times 2081.3 = m_2 (2081.3 + (4.22 \times 44))$ $m_2 = 8226 \frac{kg}{hr}$
Debutanizer	$Q = m(\lambda_v + c_p \Delta T)$ $m_1 \lambda_v = m_2 (\lambda_v + c_p \Delta T)$ $7490.6 \times 2081.3 = m_2 (2081.3 + (4.22 \times 41))$ $m_2 = 4423 \frac{kg}{hr}$
Depentanizar	$Q = m(\lambda_v + c_p \Delta T)$ $m_1 \lambda_v = m_2 (\lambda_v + c_p \Delta T)$ $2014 \times 2081.3 = m_2 (2081.3 + (4.22 \times 21.5))$ $m_2 = 1930 \frac{kg}{hr}$
Condensate heater	$Q = m(\lambda_v + c_p \Delta T)$ $m_1 \lambda_v = m_2 (\lambda_v + c_p \Delta T)$ $516.8 \times 2081.3 = m_2 (2081.3 + (4.22 \times 62))$ $m_2 = 459 \frac{kg}{hr}$

Table 3: The relationship of capital cost vs. steam flowrate

Unit	Type of cost function	Investment cost (s\year)
Large package boiler F: steam flowrate (t/h) P: pressure(MPa)	Nonliner Linear(9Mpa)	4954F0.77fp2 Fp2=1.3794-0.5438P+0.1879P2 495384+13861F
Heat recovery boiler Ffg: flue gas flowrate(t/h)	Nonliner liner	941Ffg0.75 6996+211.5Ffg
Steam turbine	Nonliner	$2237Wst^{0.41}$
Wst: power(KW)	Nonliner	$952Wgt^{0.76}$
Gas turbine Weg: power(KW)	Nonliner	$176Weg^{0.49}$
Deaerator F_b: BFW Flowrate(t/h)	Nonliner	$904F_b^{0.62}$

Conclusions

Understanding energy cost is vital factor for awareness creation and saving calculation. In many industries sufficient meters may not be available to measure all the energy used. In such cases, invoices for fuels and electricity will be useful. The annual company balance sheet is the other sources where fuel cost and power are given with production related information.

The following conclusions can be made from the foregoing analysis:

- From the targeting, four regions are encountered, namely the feasible, infeasible, saturated steam and saturated liquid region.
- The heat exchanger layout in the saturated steam region will always be of parallel design.
- The heat exchanger layout in the saturated liquid region can be parallel, series or both.
- An LP model can be used to determine the network layout of the saturated liquid region.
- An MILP model can be used for targeting the minimum steam flowrate, as well as the network layout.

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