

Energy Optimization of Ilam Gas Refinery Unit 100 by using HYSYS Refinery Software

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Abstract

Optimization can be defined as the use of the specific methods to determine the most effective and economical solution to a problem in a process. Optimization is one of the most important decision-making tools in the industry. Optimization uses the effective quantity methods by choosing the best answer or solution among the possible solutions. Of course, computers and the related software have made the necessary calculations feasible with the least cost. In this paper, an energy optimization has been done for condensations stabilization unit of Ilam gas refinery (IGTP). At first, the stabilization unit has been simulated and examined in the environment of the commercial HYSYS Refinery software by taking into account all the details. Then, it has been defined by using integration techniques and scenario processing facilities with the purpose of losing Electricity consumption. Again, the presented scenario was defined in the software. The obtained results from the simulation reveal that in case of using feed stream as the energy integration factor (for cooling) and using heat exchanger Instead of the present air conditioner, 1/1 Mega Watt electric power will be saved in addition to the omission air conditioner 1060/1360 AC (this equipment is currently being used for cooling) and the reduction of operating costs amounted to be more than \$ 522,240 a year.

Keywords: Air Conditioner, Energy Efficiency, Energy Integration, Gas Refinery, Heat Exchanger

1. Introduction

Heat integration is a method for minimizing the energy consumption based on thermodynamic equations. This objective can be obtained by Optimization of heat recovery systems, energy supply methods and operating conditions. This technology is also known as heat integration, energy integration or pinch technology integration. Pinch technology is a heat exchanger network design ensures minimal energy consumption in designing heat technology. Exergy analysis benefits from the first and second laws of thermodynamics in order to calculate the Exergy flow in the system and determine the non-optimized components. But, unfortunately, these methods do not provide a practical solution to prevent Exergy losses.

On the other, Pinch technology is a generic approach to design processes with a capability to target the largest possible correction before the final design and simulation. But the disadvantage of this approach becomes apparent when it is used in power generation systems. Therefore, a new method was developed to overcome the weaknesses of these two aforementioned methods which is called combinational analysis of the pinch and Exergy (Figure 1)¹⁻³.

Therefore, in designing the production and consumption systems, pinch technology power was not applied alone, so a secondary tool should be used to strengthen it. In conclusion, the combinational analysis method of the pinch and Exergy can be realized. In this method, the Exergy Combinational Curves (ECC) and Exergy General Combinational Curves (EGCC) are used to analyze the systems.

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Thus, by converting the temperature axis to the Carnot factor ($\eta_c = 1 - T_0/T$), Exergy Combinational Curves was plotted, then by using ECC the Exergy General Combinational Curves was plotted. The area between two combinational curves is proportional to the Exergy loss in the heat exchangers network⁴.

The starting point of the integration process to reduce energy consumption is in 1980. From 1990 onwards, the methods for its industrial applications such as the total annual costs, the unit application and the flexibility of the unit have been developed. Today, social estimations such as the environment and nutrition have become an indivisible part in the integration process. The main reason for achieving the advantages of the integration processes, in fact, is matters that close us to System Requirements. Most units in industries have very complicated internal interconnections including advanced Components; thus, because of these matters, we are closing to the unit basic needs. Undoubtedly, local researches are very effective in the conclusion of optimization. In the level of heat integration, process integration can determine optimization level of the heat recovery which is compatible with the exchanger network design in terms of the least cost of equipments. In the heat and Tolen level, process integration can determine the amount of optimum loading, consumption level, steam production and also conditions of combining heat and power systems. In the proper economic and thermodynamic optimization, one can choose appropriate heat pump in the process integration by using graphical diagrams and systematic methods. Regarding unit production increase, the integration process can be used in eliminating bottlenecks to increase production capacity^{5-9,11}. As an obvious example, consider an energy system which has a limited mass flow rate during the process. In many plants of the oil refining when the furnace is working at its maximum capacity, such matter can be seen. Integration process is also very effective in avoiding investing in the supportive units by using optimum heat recovery in the process. Regarding the topic of unit operations, handling and flexibility of the unit have indicated that very often the main dissipation is in the internal connections of the process equipments parts. Integration process has a very much focus on the process structure. Compatibility of the methods of critical tools for finding dissipations is associated with the operation of the unit. For example, it is possible that flexibility of the unit is obtained through the installation of additional

equipments and parts larger than the major unit requirements. In this case, the integration process can be used to identify the place of additional investment in order to determine effective flexible capital. In the Environment and Sustainable Development, Integration Process offers systematic approaches in order to reduce capital, government regulations and the expectations of society. Reducing emissions of pollutants and wastes are examples of its benefits (it means to reduce water consumption). Finally, we can say that the results of the integration process increase our information about the key elements and the subordinates in the unit^{7,8}. Heat integration is a method for minimizing the energy consumption based on thermodynamic equations. This objective can be achieved by optimization of heat recovery systems, process energy supplying methods and that's operating conditions. This technology is also known as heat integration, energy integration or pinch technology integration^{9,10}. Pinch technology ensures at least minimal energy consumption in designing heat exchangers network. Exergy analysis benefits from the first and second laws of thermodynamics in order to calculate the Exergy flow in the system and to determine non-optimized components. But, unfortunately, this method does not provide any practical solution to prevent losses of Exergy. On the other hand, Pinch technology is a generic approach in designing processes which has the ability to target the largest possible correction before final designing and simulation. But, when this approach is used in power generation systems, its drawback becomes apparent. Therefore, a new method was developed to overcome the weaknesses of these two aforementioned methods which is called combines the pinch combinational and Exergy analysis⁹.

2. Processing Performance of the Stabilization Unit

In this unit, not stabilized condensates (the combination in Table 1) with an intensity of 5214 barrels per day, and the pressure of 1035 kpa and the temperature of 8/4 °C before entering the stabilizer tower T-1330/1030, first enter the heat exchanger shell - tube E-1320/1020, and exchange heat with the output product of Re-boiler (Figure 2). In this conversion, the condensates flow temperature will increase to 26 °C. The condensates in two-phase form enter from the top of the tower T-1330/1030 and then the consolidated operations are carried out during 15 trays

(regardless of Re-boiler). The T-1330/1030 tower is essentially an exclusion pillar which excludes the light structures existing in the condensates flow from the top of the tower, and as shown in Figure 3, the temperature rises from top to bottom in the tower. The overhead vapor with temperature of 55/35 °C containing significant amounts of hydrogen sulfide is sent to the compression unit. The lower section of the tower contains a Re-boiler (heat exchanger E-1340/1040) that its required heat is provided by the medium pressure steam (MPS) with 4125 kg intensity per hour. Output product from the bottom of the tower 1330/1030-T is stabilized condensates temperature which is sent to the heat exchanger before the tower with temperature of 9/176 °C and exchanges heat with the feed. During this exchange, the heat of flow temperature of the stabilized condensate decreases to 2/157 °C. The product finally stabilized in the air conditioner AC-1360/1060 which its consuming power is kw-h 1088 and is made cold to 2/80 °C¹⁰.

3. Result

3.1 Energy Optimization of Unit Stabilization

In order to optimize stabilization unit of gas condensate of Ilam Gas Refinery, this unit should be simulated in commercial HYSYS Refinery software. This study focuses on reducing the use of air conditioner and electric AC-1360/1060 it is. According to the integration of energy concept (using processing facilities to provide cooling or heat requirements and reducing direct energies use), the FEED GAS flow entry to gas condensate stabilization unit has a very good operating conditions (low temperature and high flow rate) to provide cooling process needs for cooling low product flow of stabilization tower T-1330/1030.

There should be two conditions to use FEED GAS flow to lose flow temperature of condensates product:

1. FEED GAS flow temperature is lower than the temperature of the output flow from the air conditioner 1360/1060-AC (2/80 °C).
2. FEED GAS flow rate be far more than the input flow to the air conditioner AC-1060- (kmole / h 8/187). According to processing information¹³, FEED GAS flow temperature is 3/18 °C and its flow rate is 11954 k mole/h which is consequently has two afore mentioned conditions. Moreover,

FEED GAS flow can be used as the integration factor in which FEED GAS flow at first exchanges heat with condensates flow before getting into a three-phase separator V-1310/1010 with 3/18 °C temperature in the heat exchanger IE (This adapter is used instead of air conditioner AC-1360/1060) and then is sent to exchanger V-1310/1010. As a result of heat exchanging between cold flow (FEED GAS flow) and hot flow (condensates product), the FEED GAS temperature increases from 3/18 °C to 6/25 °C and gas condensates temperature decreases from 2/157 °C to 1/1 80 °C without using electricity and air conditioner (Figure 4).

Table 1. Combining input condensates¹⁰

Component	Mole Fraction	Component	Mole Frac
H ₂ O	0.0002	C ₈ H ₁₈	0.148353
N ₂	0.0	C ₉ H ₂₀	0.065512
H ₂ S	0.048566	C ₁₀ H ₂₂	0.041070
CO ₂	0.015352	C ₁₁ H ₂₄	0.017630
CH ₄	0.072023	C ₁₂ H ₂₆	0.037364
C ₂ H ₆	0.052089	CH ₄ S	0.008645
C ₃ H ₈	0.071321	C ₂ H ₆ S	0.000427
i-C ₄ H ₁₀	0.031554	C ₃ H ₈ S	0.000036
n-C ₄ H ₁₀	0.065311	C ₅ H ₁₂ S	0.000008
i-C ₅ H ₁₂	0.048282	COS	0.000072
n-C ₅ H ₁₂	0.053391	M-E-Sulfide	0.000043
C ₆ H ₁₄	0.101473	DiMethyl Sulfide	0.003379
C ₇ H ₁₆	0.117901	CS ₂	0.0

4. Conclusion

In this paper, energy optimization was done for unit 100 of Ilam Gas Refinery. Initially, unit 100 was simulated by using commercial software HYSYS Refinery and thermodynamic package Peng-Robinson in a stable state and advanced mode. Then, using the concept of energy integration, two conditions were expressed to use the processing flows:

1. FEED GAS flow temperature should be lower than the temperature of the output flow from the air conditioner 1360/1060-AC (2/80 °C).
2. FEED GAS flow rate should be far more than the input flow to the air conditioner AC -1060- (kmole/h 8/187).

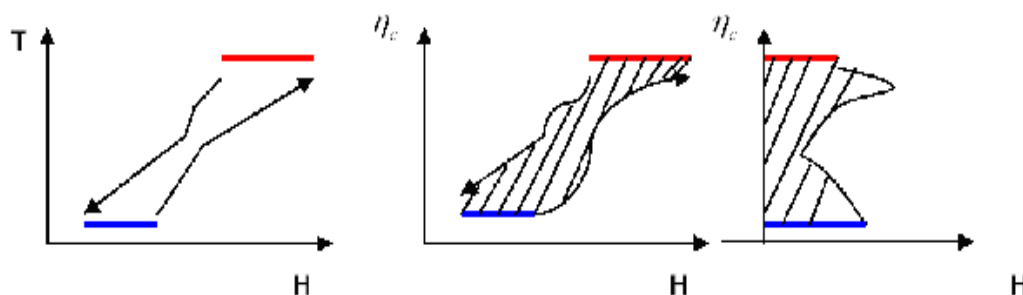


Figure 1. Combinational curves of Pinch and Energy.

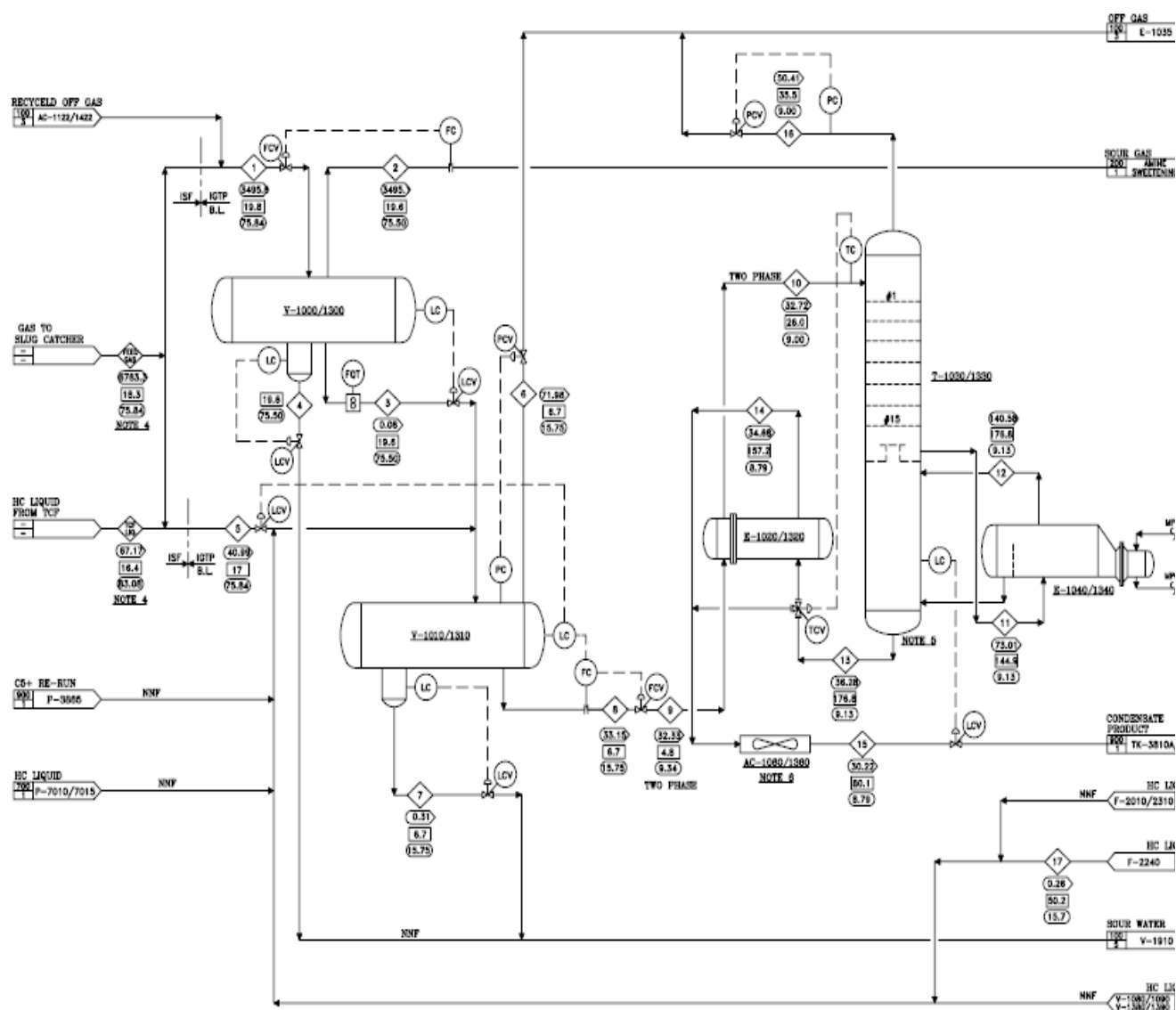


Figure 2. Plot of the condensates stabilization unit of Ilam Gas Refinery.

The diagram illustrates a distillation column system with the following components and flow paths:

- Distillation Column (T-1030/1330):** A vertical column with three trays labeled 1, 8, and 15.
 - Tray 1: Top section with an overhead vapor outlet.
 - Tray 8: Middle section with a vapor outlet labeled "vap".
 - Tray 15: Bottom section with a liquid outlet labeled "To Reboiler".
- Reboiler and Condenser (E-1040/1340):** A horizontal vessel connected to the bottom of the column.
 - Receives liquid from Tray 15.
 - Has two control loops: MPS (Manipulated Process Signal) and MPC (Manipulated Control Signal).
 - Outputs vapor to Tray 8 and liquid to the feed gas inlet.
- Feed Gas Inlet:** A vertical vessel receiving liquid from the reboiler.
 - Outputs liquid to the condenser E-1020/1320.
- Condenser (E-1020/1320):** A horizontal vessel.
 - Receives liquid from the feed gas inlet.
 - Has a condensate inlet and a return line.
- Integration Exchanger:** A horizontal vessel.
 - Receives liquid from the condenser's return line.
 - Outputs liquid back to the top of the distillation column (Tray 1).
 - Has a condensate product outlet.

flow in heat exchanger IE (instead air conditioner AC-1360/1060-is used) and then it is sent to separator V 1310/1010. As a result of heat exchanging between cold flow (FEED GAS flow) and hot flow (condensates product), the FEED GAS temperature increases from 3/18 °C to 6/25 °C and gas condensates temperature decreases from 2/157 °C to 1/1 80 °C without using electricity and air conditioner. Simulation results reveal that using the feed flow as the energy integration factor (for cooling) and using heat exchanger (Integration

Exchanger) instead of the current air conditioner, 1/1 mega Watt electric power will be saved in addition to deleting the air conditioner AC-1360/1060 (these equipments are currently used for cooling) and reducing operating costs amounted to \$ 522,240 per year.

5. References

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