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# Optimizing Energy Consumption and Energy Analysis in KHDS unit of Tehran Oil Refinery

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**ABSTRACT: One of the very unique and convenient and efficient tools and methods for the analysis of wastes is investigating the contribution of irreversibility in various industries of energy analysis method. Energy analysis method is consider as a very efficient way to analyze various industrial units of energy. In the present study, a detailed review will take place about series of production line data of KHDS unit in Tondgooyan oil refinery of Tehran and Studies and analysis of energy and optimizing the energy consumption at the same time will be done. In fact, in this method in order to investigate the amount of works that are converted to useful work, KHDS units are individually evaluated and assessed and in this study, irreversibility and the second law efficiency of the unit is calculated. Energy dissipation calculations show that the amount of irreversibility in KHDS unit is equal to 66/29 MW. The calculations also show that the second law efficiency of KHDS unit is equal to 36.71% and in GHDS unit is equal to 15.71%. Also shift paradigm of the values of irreversibility and the second law efficiency in different discharge input to the unit is drawn. At the end, by examining the several factors which are involved in the irreversible, some improvement and opportunities and suggestions and solutions have been proposed.**

**Keywords**: optimization, energy, energy analysis, KHDS, Tehran

## I. INTRODUCTION

With the increase in energy carrier price and the energy crisis in the early seventies decade and high energy consumption in the industrial sector, energy savings in industry, particularly the chemical and process industries have become essential. Also, due to the high consumption of petrol and discuss about self-sufficiency in petrol production, development and optimization of oil refineries gasoline units is taken into consideration. In this meanwhile, energy efficiency has a great importance in catalytic conversion unit as one of the most important and pervasive petrol units in oil refineries, [2-1]. In the analysis of energy systems based on the First Law of Thermodynamics (energy balance), all forms of energy are assumed to be equal and reduce the quality of energy will not be considered by converting forms of energy. Exergy will be introduce based on first and second law of thermodynamics in relation to the environment as a comprehensive measure of the quality in various forms of energy in the analysis of energy systems. Therefore, Exergy analyze is an efficient method by considering the amount of decreasing energy quality in energy systems and process analysis [5-3]. The main step in the analysis of energy systems is detecting the location and quality of energy loss that occurs with Exergy Analysis. Accordingly, the performance of process equipment and the network of heat exchangers will be assessed and the places with highest exergy destruction will be identified as the process of critical points and the heat exchangers network will be modified according to it [7-5]. Different procedures exists for evaluating a physical or chemical process in terms of energy and energy balance based on the first law of thermodynamics which it can be used for reducing heat loss or gain heat recovery. While that there is no information about the quality of energy loss that occurs in a process. Exergy method will overcome on restrictions in first law of thermodynamics. In this method thermodynamic losses are estimated based on both, first and second law of thermodynamics.

Exergy analysis method will identify the place of energy waste over a process to improve operating conditions in typical processing units or equipment. A unit where Kerosene or fusion naphtha caused by refinery distillation units have crossed these units and its sulfur and nitrate derivatives will be produce under pressure and high temperature in catalyst side and the kerosene purer in terms of sulfur amount. In fact, KHDS unit is more purity of kerosene and its further refining which in routine work of this unit, equipment and various processes is used to achieve this purpose [12-8]. Another unit where light gas oil, heavy gas oil and naphtha from mixture of distillation units will passes this unit and its sulfur and nitrogen compounds will be purified under high temperature and pressure in the presence of catalyst, and a purer gas oil is created in terms of the amount of sulfur, in this unit equipment and processes are used in order to achieve this purpose which the aim of this study is to investigate them.

## II. METHOD OF WORK

In order to review an industrial unit, we can consider the entire map, unit or system as a volume of control, and by having needed information of flows we can do exergy balance on it, thus the overall exergy losses will be achieved. By considering the entire unit as a whole control volume, only the calculation of Exergy flows and what comes out of the industrial unit to its borders will be needed, and the mass exchanges, done work and heat inside are not logged in Exergy balance calculations. In order to do Exergy analyze and obtaining waste work in Exergy analysis of refinery, the method which is used is Exergy balance method. This section explains how to create a thermodynamic model of different oil refining units. The definition of controls' volume carried out for different sectors. These equations includes applying first and second thermodynamics law and Exergy balance for each of these units. With regard to the chemical reaction of sulfur recovery units in this part, calculating the chemical Exergy is required.

**Fig. 1.** The total industrial unit or units and internal systems as the overall control volume.

## III. KHDS UNIT OF TEHRAN OIL REFINERY

The main feed of this unit is Kerosene and naphtha from the mixture of distillation unit and its product as low-sulfur kerosene. To analyze the major sectors in the desalination process and a more detailed description in internal operation process and flow diagram of the process of sweetening, we will focus on the oil refinery process.

**Fig. 2.** Overall control volume model of KHDS unit.

## IV. FLOWS CHARACTERISTICS

Input naphtha flows (flows 1): Naphtha in terms of design with 346000 cubic meters standard per hour and temperature of 21 °C and the pressure of 1063 pounds per square inch and the following chemical analysis will enter to KHDS unit. Naphtha molecular weight will be calculated based on Appendix 1 tables' calculations about 74.18 kg per kilo Joules and its compressibility factor about 89.0.

Consumed electrical power and axial power (flows 2 and 4): Consumed power in KHDS unit consist of two parts. One part of it, is an electrical energy which consumed by Booster pumps, reflux pumps, Amino ventilators and acid ventilators which its information is available in accordance with the attached table 1. The other part of consumed power consists of high-pressure pumps axial power which are consumed by steam turbine and turbine stimulus. This amount is equal to 116.3 MW for design capacity. The Exergy of power consumption is equal to the amount of energy per unit time.

Low pressure steam flow (flow 3): Low pressure steam will be entered to reboilers in order to heat the resuscitation towers with 67,767 kilograms per hour and a temperature of 147 °C and the pressure of 62 pounds per square inch (in terms of design). KHDS unit has four reboilers. The flow of precision tool air (flow 5): Required air of precision tool is consider as an input current, however, its amount is very small.

Output light naphtha flow (flow 6): Output naphtha from KHDS unit in design requirements is entered to dehumidification unit with 213800 kg per hour and a temperature of 38 °C and pressure of 1043 pounds per square inch and chemical analysis.

Molecular weight of light naphtha is calculated based on Appendix 2 table calculations about 30.16 kilograms per kilo Joules and the compressibility factor about 99.0.

## V. THE FLOW OF OUTPUT SULFUR DERIVATIVES

Output sulfur derivatives of KHDS unit will be entered to sulfur recovery unit in design requirements with 39100 standard cubic meters per hour and a temperature of 52 °C and pressure of 22 pounds per square inch and the following chemical analysis. Molecular mass derivatives is based on calculations of Appendix 1 about 05.38 kg per kilo Joules and its compressibility factor is calculated about 99.0, thus the use of gas relations is possible.

Nitrated output flow: Output nitrogen derivatives from KHDS unit is sent in design requirements with 3010 standard cubic meters per hour and at 56 °C and the pressures of 9.88 pounds per square inch and the following chemical analysis towards torches to be burned.

Molecular mass of nitrated derivatives is based on calculations of Tables' Appendix 1 about 37.16 kg Joules and its compressibility factor has been calculated about 99.0, so the use of gas relations is possible.
The flow of output condensate water (Flow 1): Low pressure steam is getting out of unit after the heat transfer to the solution as condensate water about 67767 kg per hour and the heat of 100 °C and the pressure of 14.5 pounds per square inch and is sent towards water and steam units.
Output waste Flow (flow 10): since that discharge current from drains in normal state is not steady, so it has a very little effect on the calculations and won't be entered to calculations.

## VI. EXERGY ANALYSIS WITH A GENERAL APPROACH

According to input and output flows passing from the border of this overall volume control, the Exergy balance will be written. Finally, with regard to the relationship between Exergy' balance, we can substitute this corresponding flow unit and the overall losses unit of Exergy will be derived. In Figure 4-3, the total unit of KHDS is intended as a volume control. According to the input and output streams crossing from the borders of volume control, the Exergy balance equation is obtained as follows:

$$\frac{d}{dt}(EX)_{cv} = \sum_{in-out}(EX_Q) + \sum_{Steam}(EX)_{in} - \sum_{steam}(EX)_{out} + \sum_{in-out} w_{act} - T_0(S_{gen})_{tot}$$

$$0 = 0 + EX_1 + EX_2 + EX_3 + EX_4 - EX_6 - EX_7 - EX_8 - EX_9 - T_0(S_{gen})_{tot}$$

According to the relations (3-3) to (3-8) and the information in Tables and Appendix 1, we can obtain the overall losses Exergy and the overall Exergy efficiency of the units that is:

$$I_{tot} = T_0(\dot{S}_{gen})_{tot} = 29.66\,MW$$

$$(\varepsilon)_{GTU} = 74.6\%$$

Exergy of non-permanent streams can't be seen in calculations of this relationship due to its minimal impact.

## VII. IRREVERSIBILITY CHANGES OF KHDS UNIT

Investigating the effect of the pumps number during unit design is so that by considering the intended cases, that pump has the best efficiency. So any changes that will lead to a displacement of intended operating point during design, will caused the displacement of pump operating point and its efficiency will be drop. It is clear that the displacement of pump function point can be for the reasons such as reducing the capacity of unit (amine reduction in circulation) or increase in the number of pumps in parallel or series forms. In order to investigate the pump change effects on its efficiency, it is necessary to extract the function of pump efficiency in terms of fluid flow passing from it based on the characteristic curve of the pump.

## VIII. CONCLUSION

Day by day increasing the use of energy on one hand and increasing the energy prices on the other hand has doubled the importance of power engineering efficiency and identify the areas of energy waste in various industries, especially in oil and gas industry. In this regard and to explore the areas of power engineering waste and analyzing the wastes and the kinds of analysis methods, different methods have been used for a long time. Conducted studies showed that in all KHDS units and in all circumstances, all three booster pumps are in service (To increase production stable conditions during a sudden stop in each pump this method of decision-making will be applied). It is clear that increasing the number of pumps in service will cause that operating point in each displaced pumps and subsequently reduced pump efficiency and their total power consumption will be increased in compared to design status (two pumps in service). Conducted investigations shows that in KHDS units after oil flow about 250,000 standard cubic meters per hour in all conditions, the four devices amine circulation pumps will be in service. Increasing the number of pumps in service cause that the operating point of each displaced pumps and subsequently the pump efficiency will be reduced and their total steam consumption will be increased compared to the design situation. Thus, applying the design condition, means return the status of four pumps to three pumps would reduce the consumption of stimulus steam turbines of these pumps, and a considerable savings.
1. The efficiency of Thermodynamics second Law (effectiveness): For the unit of KHDS refinery is obtained about 346000 standard cubic meters equal to 64.74%.

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