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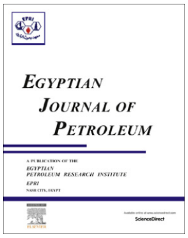

FULL LENGTH ARTICLE

Application of energy management coupled with fuel switching on a hydrotreater unit

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Abstract In the last decades, saving energy and protecting environment became the most important topics for search and survey. The energy engineer for any chemical process is obliged by restrictions of "Kyoto Protocol" for limitation of carbon dioxide emissions from fuel combustion, so he does his best to reduce utility consumption and thus reduce gas emission. Proper designing of the heat exchanger network (HEN) for any process is an effective and successful method to minimize utility consumption and therefore minimize gas emission (mainly carbon gases (CO_2) and sulfur gases (SO_x)). Fuel switching coupled with energy targeting achieved the least gas emission. In this work we choose a hydrotreater unit of a petroleum refinery as a case study due to its effective role and its obvious consumption of utility. We applied the methodology of energy targeting through HEN design (using pinch technology) at several values of mean temperature difference ($\Delta T_{\min}$); where the maximum percentage of energy saving was 37% for hot and cold utility which directly leads to percentage reduction of gas emission by 29% for CO_2 and 17% for SO_x. Switching fuel oil to other types of fuel realized gas emission reduction percentage where the maximum reduction established was through natural gas fuel type and reached 54% for CO_2 and 90% for SO_x. Comparison between existing design and the optimum $\Delta T_{\min}$ HEN led to few modifications with the least added capital cost for the hydrotreater existing design to revamp it through four scenarios; the first one depended on fuel switching to natural gas while the second one switched fuel to diesel oil, in the third scenario we applied heat integration only and the fourth one used both of heat integration and fuel switching in a parallel way.

1. Introduction

The change in the atmospheric air quality is strongly related to the emissions of gases from chemical processes and power generation plants. The combustion of fossil fuel by the chemical process industries and power plants contributes greatly to the emissions of carbon dioxide, as well as nitrogen oxides, sulfur oxides and particulates. The relationship between energy

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Nomenclature

CP	heat capacity flow rate (MJ/h °C)
HEN	heat exchanger network
HENS	heat exchanger network synthesis
HENs	heat exchanger networks
H	heat transfer coefficient (MJ/m^2 °C)
MER	maximum energy recovery
PDM	the pinch design method
M_{pol}	mass flow rate of pollutant (kg/h)
NHV	fuel net heating value (kJ/kg)
Q_{fuel}	heat duty from fuel (kW)
Q_{proc}	process heat duty (kW)
T_o	ambient temperature (°C)
T_s	supply temperature (°C)
T_{STACK}	stack temperature (°C)
T_{in}	inlet temperature of stream (°C)
T_{out}	outlet temperature of stream (°C)
T_{TFT}	theoretical flame temperature (°C)
ΔT_{min}	minimum approach temperature difference (°C)
β	mass percentage of the pollutant in non-oxide form (dimensionless)
ϕ	the ratio of the molar mass of the oxidized form to the non-oxidized form of the pollutant (dimensionless)
η_{furn}	furnace efficiency (dimensionless)

efficiency and flue gas emissions is clear [1]. Many approaches have been proposed to control and/or reduce the greenhouse gas emissions, such as carbon capture, fuel switching, CO_2 storage, and process integration. Among all approaches, improvements in efficient use of energy and changes in fuel selection appear to be most straight forward as well as financially feasible [2]. The more inefficiency in our use of energy, the more fuel we burn and hence the greater are the flue gas emissions [3].

In the past three decades, extensive efforts have been made in the fields of energy integration and energy recovery technologies due to the steadily increasing of energy cost and shortage of energy resources. A heat recovery system consisting of a set of heat exchangers can be treated as a heat exchanger network (HEN), which is widely used in process industries such as gas processing and petrochemical industries [4].

Over the past decade, the pinch analysis technique and mathematical programing approaches have been widely adopted to achieve energy consumption reduction by achieving optimal heat exchanger network (HEN) [2,5]. The most important methods used in designing of HEN are mathematical programing assignment problem methods [6–8] and thermodynamic-based methods [9–15]. Some recent methods have appeared for designing of HEN such as genetic algorithm [16,17], genetic/simulated annealing algorithm [18–21] and tabu search procedure [22].

The pinch design method (PDM) is the most complete thermodynamic method which realized the optimality conditions of the HEN design step by step. It has a track record of worldwide industrial applications that resulted in energy savings of 15–45%. Basics, applications, and benefits of pinch technology are given in Linnhoff et al. [12] see also [http://www.cheresource.com].

The petroleum refining industry uses the largest quantity of premium fuels in the industrial sector. Removal of sulfur is essential for protecting the catalyst in subsequent processes (such as catalytic reforming) and for meeting product specifications for certain "mid-barrel" distillate fuels. Hydrotreating is the most widely used treating process in today's refineries [23]. Hydrotreater unit, removes sulfur, nitrogen and metal contaminants, but it needs about 19% of refinery energy consumption [24]. Improving energy efficiency for this unit is an attractive opportunity for cost and gas emission reductions [25].

In this work, application of energy management by designing the maximum energy recovery (MER) heat exchanger network of a hydrotreater unit coupled with fuel switching can

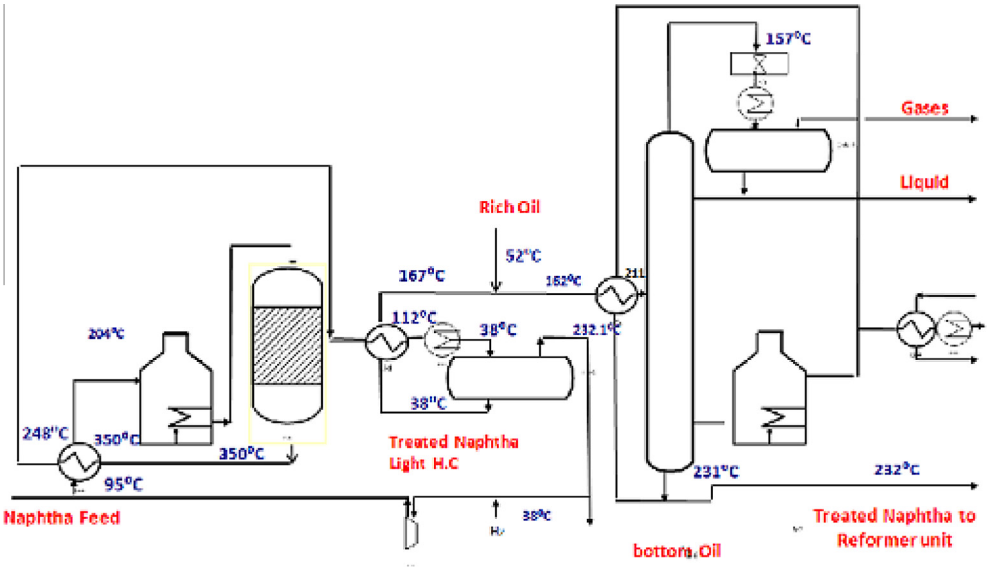

Figure 1 Flowsheet of the existing hydrotreater unit.