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Energy saving in a crude distillation unit by a preflash implementation

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ABSTRACT

After the 70s energy crisis the revamping of plants designed before this date is very attractive for improving energy recovery and lowering operation costs.

A typical case is the oil refinery plant where an intensive usage of energy takes place and is a promising case for the application of energy saving solutions. In this work we focused our attention to an industrial crude oil distillation unit, evaluating the possibility to modify the feed conditions by installing a preflash drum or a preflash plate column.

Real data plant were collected to obtain a reliable simulation of the unit by means of the software package Aspen Plus 13.0. To characterize the crude oil fed the TBP curve was used. The results obtained were compared with the plant data in terms of flow rate and product quality utilizing the ASTM D-86 curves and a good agreement was obtained. According to the specialized literature the preflash drum/column was placed at the end of the pre-heat train, just before the column furnace.

The furnace is the bottleneck of the plant and with both the preflash devices it is possible to lower its energy consumption. However the energy reduction is associated to the decrease of one kind of distillates (light or middle). The choice of the best preflash device was made according to the production asset of the plant.

1. Introduction

Refineries are among the largest energy consumers in the chemical industries. It was evaluated that the energy requirement for these plants is an amount of fuel equivalent to the 2% of the total crude processed [1]. For this reason there is a continuous interest to identify ways to improve the energy efficiency of the existing plants.

Different solutions were proposed during the years; in the first half of 80s the most popular strategy to increase energy recovery between process fluids was the Pinch method [2], after that other solutions were considered including also the modification of the distillation design. One popular revamping solution is the employing of preflash devices, a drum or a column, to save energy in crude distillation plants following the first indication given by Brugma [3].

The basic idea of a preflash device implementation is to remove the light components of the crude before entering in the furnace. The vapor stream obtained can then be introduced at the furnace outlet or in an appropriate location of the main column. In this way it is possible to reduce the heat duty of the distillation unit and to have also an improvement of the hydraulic performance of the heat exchanger network [4,5].

It is a common opinion [6] that the best preflash location is downstream the desalting process in order to remove, with the light components, also the water carryover that can cause corrosion in the following devices or vaporization in the control valves.

Two main approaches for the preflash implementation have been considered in the literature; the first concerns the impact of the preflash device on the heat exchanger network, and the second is about the impact of this device on the main column performance. In the former category Harbert [4], Feintuch et al. [5] and Yahyaabadi [6,7] made a very clear review of the problem giving useful information to complete the general knowledge about the behavior of the system. Feintuch et al. consider the modification of the preheating crude network to increase the energy recovery; they focus their attention on the maximum utilization of the existing equipment. In particular they consider the hydraulic limitations and the pressure drop of the modified system and observe that the implementation of a preflash drum just downstream the desalter is able to decrease the operative pressure of the heat exchangers between the flash drum and the furnace. Thus no new equipments are necessary to increase the energy savings in the whole heat exchanger network. They also report that this solution is cost effective with a payout period of less than three years. Yahyaabadi [6,7] studies common problems in preheating trains and the best placement of the preflash drum in the preheat train network below the desalter. He finds that the location of the preflash device has only a small effect on the hot and cold utility

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consumptions but it is of great importance on the pressure drop and on the average skin temperature of the furnace. There are also same cases in which it is possible to remove part of the heat exchanger network obtaining additional savings on the operating costs. Recently it is also considered the possibility to employ a preflash system for heavy oils [8], that up to now was not taken into account due to the small amount of vaporization that can be achieved. However also in this case it is possible to eliminate water carryover from the desalter and some lightest components, thus reducing the pressure at the furnace inlet.

The second approach considered is the study of the behavior of the main column when the preflash device is introduced. In this case there are many criticisms about the possibility to achieve a real energy saving. We refer in particular to the meaningful works of Ji and Bagajewicz [9] and of Golden [10]. The former work includes the preflash drum or the preflash column in a design method for the whole system including the main column. They make a detailed analysis explaining the effect of the lightest compounds of the crude, called carrier-effect, in improving the separation of the gas oil fraction and also compared different carrier gases to improve the gas oil yield. In another work [11] the same authors consider the preflash and the main column system integrated with the vacuum column, obtaining that the whole system has an energy request slightly smaller than the base design without the preflash system.

The position of Golden [10] on the performance of the preflash device is more critical. He analyzes many parameters that influence the performance of the main column, like the flash drum temperature, the flashed vapor feed location, the effect of flashed crude entrainment in the vapor stream and the quench effect of the flashed vapor in the main column with a fixed outlet furnace temperature. He made a complete study of the preflash drum theory and reports a revamp case. This case study fails due to a feed lighter than the design case highlighting the necessity to design the preflash system for the light oil processed. Anyway this result can not be considered meaningful of a poor preflash performance. In fact every device has a maximum efficiency in the design operative range, so it is usual that poor performance happens in different situations.

Our study starts by considering a real crude distillation unit (CDU) with high energy consumption due to the high furnace duty, and we aim to evaluate the possibility of energy savings utilizing a preflash device. This problem is different from the previous works already published, because utilizes real plant data and describes how it is possible to obtain a compromise between production and energy savings without changing the main column lay out.

2. Description of the plant

The crude distillation unit is the first separation process that takes place in a refinery plant.

Fig. 1 shows a simplified view of the plant. A 42° API crude, stored at a temperature of about 50 °C, is heated in the first section of the heat exchanger network that utilizes as heating stream the lightest streams from the main column; in this way the crude oil reaches a temperature of about 120 °C and is fed to the desalter to remove inorganic salts, impurities and soluble metals. Then the desalted crude flows through the second section of the heat exchanger network. Due to the great attention on energy integration, by maximizing heat exchanges between the crude oil and the product streams from the main column, the crude can reach a maximum temperature of about 240 °C.

This temperature is still too low to achieve the grade of crude vaporization necessary for the separation in the main column and thus a furnace is always necessary. The temperature of the exiting stream from the furnace is about 345 °C and fuel oil or fuel gas, depending on the refinery availability, is used as energy source. All the heat needed for the separation is given in the furnace, so no reboilers occurs in the main column. The high temperature difference between the inlet and the outlet streams of the furnace and the high flow rate of the crude processed make the furnace as one of the higher energy consumer of the whole refinery. It follows that also the cost of this unit is a meaningful part of the overall production costs.

From the exit of the furnace the heated crude is fed to the main column that is a conventional crude distillation column able to process about 940 m^3/h with the main characteristics summarized as follows:

- a stripping section with few plates below the feed location and a steam stream introduced in the bottom to strip the light components dragged in the liquid;
- four product side withdrawals; that from the top to the bottom, are: heavy naphtha (HN), kerosene (Kero), light gasoil (LGO), heavy gasoil (HGO). The Kero, LGO, HGO streams are steam

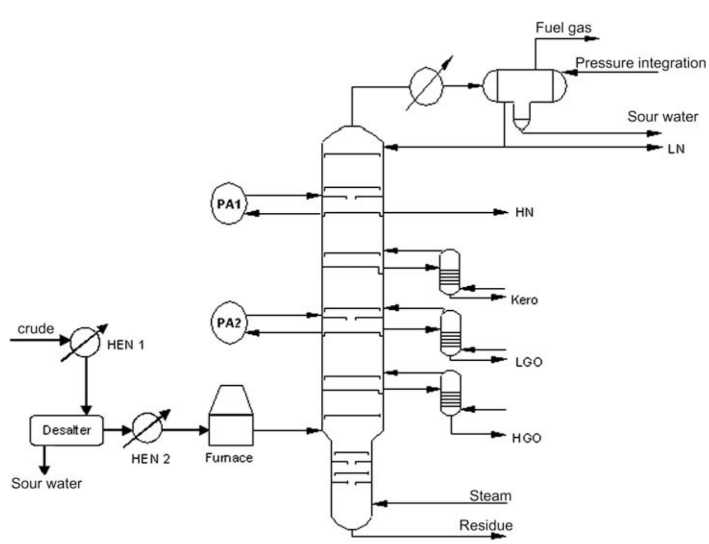

Fig. 1. Crude distillation unit configuration.