Increase crude unit capacity through better integration

In revamp projects, better energy integration provides more benefits with less capital investment and lower operating costs

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Pinch analysis and process integration techniques are established methods to increase process heat recovery, thereby limiting overall plant energy requirements. Pinch analysis proceeds in two basic steps: 1) targeting possible energy savings, and 2) developing design based on pinch principles to achieve the identified targets. To attain the defined targets, changes to the heat exchanger network (HEN) may be extensive and complicated. Such excessive changes may lead to extremely high costs and hamper the feasibility of the project.

In regions where refining profit margins are low, revamp projects requiring very high capital investment cannot be justified. Therefore, minimizing modifications becomes critical to justify such projects economically.

Case study. In this example, a study was conducted regarding the expansion of a refinery crude distillation unit (CDU). The targeted CDU capacity was 20% more than the current operating capacity. The unit was already operating at 30% over the original design capacity. Some modifications were done previously in the heat exchanger network to improve heat recovery. Previous attempts for further expansions with traditional solutions, such as adding a new preheat train, were not successful due to high capital costs.

Maximizing energy opportunities. Most heat exchangers are already low minimum approach temperatures; thus, there is little scope to increase the heat duty of the existing exchangers by merely adding surface area or intensifying heat transfer. Also, the sequence of heat exchangers is thermodynamically correct with higher-temperature hot streams providing heat to crude at higher temperature.

The project goal was to achieve the required throughput targets with minimal modifications in the existing equipment and piping. It was very critical to the project to minimize capital investment and keep the modifications simple.

Since the primary objective of this study was debottlenecking issues rather than energy conservation, an increase in furnace load within its limits was considered to minimize modifications.

Crude preheat train. The primary focus of this study was the crude preheat train. To minimize necessary modifications, the crude preheat train was divided into three sections for analysis. The preheat train heat exchangers were installed in groups that were placed at considerable distances. These groups formed the basis to divide the crude preheat train in different sections for this evaluation, as shown in Fig. 1.

The first section is between the crude surge drum and the desalter. The second section is the area between the desalter and the flash drum, and the third section is between the flash drum and the heater. Once each section was defined, the section was analyzed beginning with the third section (between the flash drum and furnace).

An iterative procedure was adopted. The first step was to analyze each section separately, and then analyze the whole train collectively. In the analysis of the whole preheat train, the thermal sequence of the exchangers, i.e., heating crude at higher temperatures using higher temperature stream was investigated and changes were made accordingly. Only the major heat exchangers with high heat duties were considered in the retrofit, as minor heat exchangers would not yield much benefit.

The heat duty was added not by conventional methods of installing new shells, but by replacing the tube bundles with twisted-tube bundles as well as by adding new shells with twisted

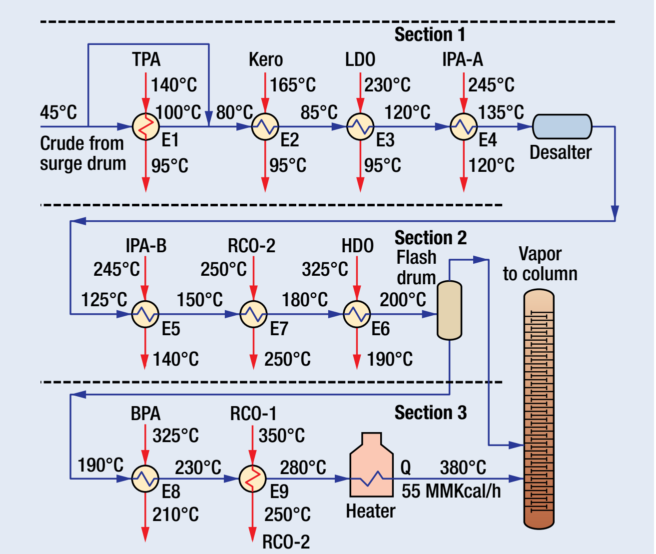

FIG. 1 Original crude preheat train for the case study refinery.

tube bundles where needed. The units with high-performance tube bundles can help reduce or, in some cases, eliminate the need of more exchanger shells. Furthermore, the increased duty was achieved by maintaining a reasonable approach temperature. Fig. 2 shows the overall procedure for the study.

Section 3, between the furnace and the flash drum being the most critical, was analyzed first. This section has two exchangers. These heat exchangers already had low minimum approach temperatures; there was not much scope to add more duty to the heat exchangers by any means. Therefore, to have higher approach temperatures and to create scope for additional heat duty or recovery, the crude stream between the flash drum and furnace was split. Now, the two exchangers in this segment are in parallel rather than in series. The stream splitting provided two benefits:

1. An increase in approach temperatures
2. Improvement in pressure drop performance on the cold side of the heat exchangers from lower crude oil flow.

Since the approach temperature has increased due to splitting, adding duty to the heat exchangers enabled better energy recovery in the crude preheat train. Around 20% additional duty was achieved with reasonable approach temperatures through heat transfer intensification and additional area. The splitting in Section 2 was proposed due to the same reason.

Heat from one of the product streams is used in two exchangers located in two separate sections successively, 3 followed 2. Now that more heat will be recovered and streams' temperatures are lower than two of the streams in Section 2, it us recommended to be used in Section 1. Also, two streams from section 1 shall be used in Section 2, while one of them shall be used in Section 1 successively. These modifications would correct the thermal profile of the preheat train.

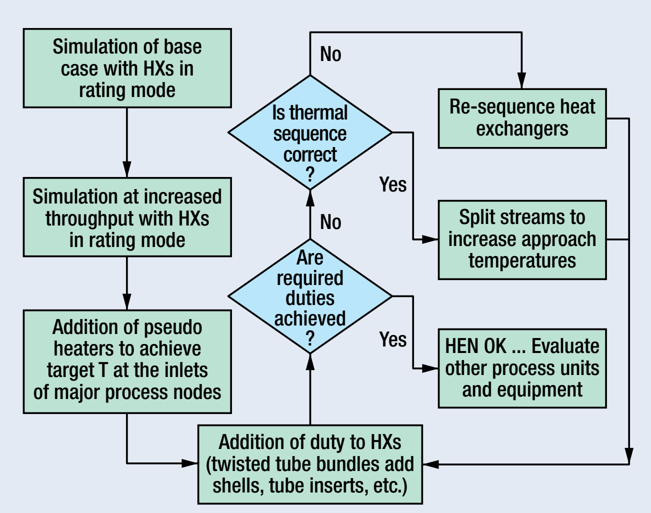

FIG. 2 Logic tree to analyze possible heat duty improvements for the crude preheat train.

Benefits. For this project, the recommended changes will improve the unit's economics greatly, as more crude (20% extra) will be processed for the same energy cost. This is a direct benefit for the refiner. The capital investment for the final design will be much lower as compared to the conventional expansion solution.

The final proposed structure design was not very different from the original. No additional heat exchanger units (matches) were proposed. Only additional shells were needed to some of the exchangers instead of a new preheat train. Also, the layout of heat exchangers was kept consistent with the original design; no exchangers were moved between the sections. Therefore, due to the simplicity of the design, this project will have better operability and safety implications, as well as economic feasibility. The environmental impact from these modifications is also positive, as the ratio of flue gases to production capacity will greatly be reduced. **HP**

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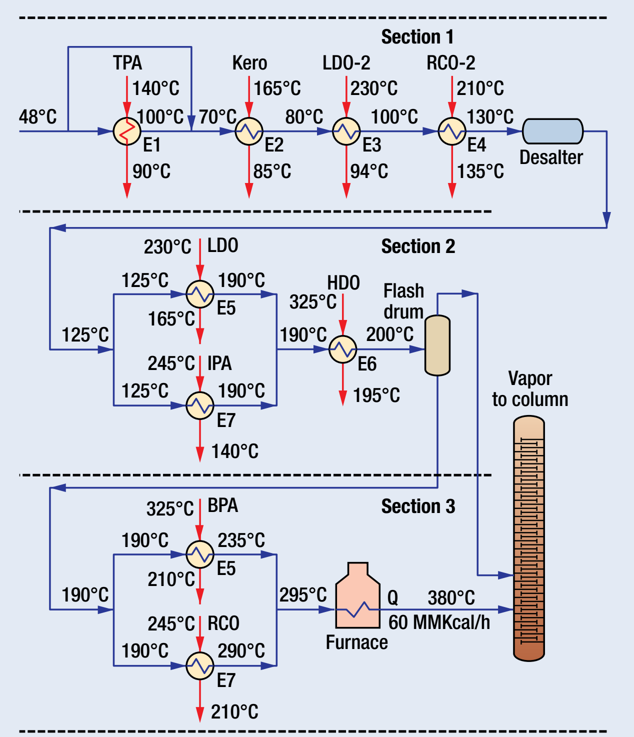

FIG. 3 Proposed revamp of the crude unit preheat train to conserve energy and increase processing capacity by 20% with minimal capital investment.