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Original Article

Optimization of operating conditions of distillation columns: an energy saving option in refinery industry

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Abstract

While energy prices continue to climb, it conservation remains the prime concern for process industries. The daily growth of energy consumption throughout the world and the real necessity of providing it, shows that optimization of energy generation and consumption units is an economical and sometimes vital case. Hence, the optimization of a petroleum refinery is aimed towards great production and an increase in quality. In this research, the atmospheric distillation unit of the Iran-Arak-Shazand petroleum refinery was subject to optimization efforts. It was performed by the means of using a simulator with the aim to earn more overhead products. In the next step the optimization results from the simulators were carried out in the real world, at the above mentioned unit. Results demonstrate that the changes in the real operating conditions increase the overhead products with desirable quality. Finally, a net economical balance between the increments of the overhead products and the energy consumption shows an energy saving in this refinery.

Keywords: optimization, energy saving, distillation column, overhead, economical balance, simulator

1. Introduction

The necessity of gasoline imports is a problem faced by many governments throughout the world. Crude refineries operation optimization to gain more products with higher quality could be one of the alternative methods to reach the freedom from gasoline imports. The distillation tower is one of the most energy intensive units in refineries, and is usually very important in revamp and energy optimization. For this objective, the atmospheric distillation unit of the I-A-S Refinery Company was studied for optimization and revamp. The I-A-S Refinery Company with 150,000 bbl/day nominal capacity is one of the largest refineries in Iran. The Ahwaz-Asmary crude field provides the feed of this company (Hosseini, 2006; Yasini *et al.*, 2006). In this refinery the crude is heated up in an exchangers' network with naphtha, heavy diesel, kerosene, light diesel, and waxy diesel, and then goes to desalting vessels. Salt and crude are separated by an electrical field in the desalter and then heated up again in exchange by waxy diesel and fed to a flash drum. In the flash drum the pressure suddenly drops and about seven percent of the liquid vaporized. The liquid comes out from the bottom of the flash drum and heat exchanges with H.V.S and V.B. in the exchangers. Then it is divided in eight passes for heating in a furnace. After earning the required heat in the furnace, crude is mixed with the flash drum overhead product and fed to the atmospheric distillation column flash zone. Hydrocarbon vapors are going up to tray 6 and hydrocarbon liquids are coming down to tray 5. Steam at 4 barg pressure is fed to the bottom of the column i.e. bellow the first

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tray to separate light components existing in the atmospheric residue. Light diesel product is obtained from tray 11 and goes to its striper. Its light hydrocarbons separated with direct steam injection and return to the fourteenth tray of the distillation column. Kerosene is obtained from tray 25 and goes to its striper and its light component return to tray 28. Naphtha is obtained from tray 39 and goes to its striper and its light component return to tray 24. Overhead enters the accumulator after cooled down in an air cooler and condenser. The accumulator output is shared two streams; one of them is reflux and returned to the top of the column. The second one is fed to gasoline stabilizer columns (Hosseini, 2006; Yasini *et al.*, 2006). Because of that, the distillation is one of the highest energy consumer units in refineries; usually this unit is very important in revamp and energy optimization. The use of new equipment and methods like the internal re-boilers (Kister, 1992; Gadalla, 2003; IFP, 2003), new trays (Kister, 1992; IFP, 2003), pumping around and adjusting duties (Kister, 1992; Gadalla, 2003), increasing overhead vapors by decreasing pressure (Herbert, 1999; Kister, 1992; Briones, 1999), and the use of pre-flashes (Herbert, 1999; IFP, 2003) are possible ways of optimization.

In some cases, designers try to increase the efficiency by using the existent equipment with minimum investment. The optimization of the operating conditions in order to get more products with desirable quality and less energy consumption is one of them. To obtain this aim, a try and error method is very expensive and sometimes impossible. Therefore suitable simulators can be used for this goal and by this minimize the errors (Hosseini, 2006; Yasini *et al.*, 2006).

As the distillation tower is one of the largest energy consumer units in a refinery that uses up over fifteen percent of the total energy consumption in a refinery, is very important to address this unit in the revamp and energy optimization procedure (Hosseini, 2006). In this research, the atmospheric distillation column has been modeled and optimized based on the actual operational conditions and data. This has to be noticed that increasing the product output is not the only aim, but also the amount of energy consumption should be considered.

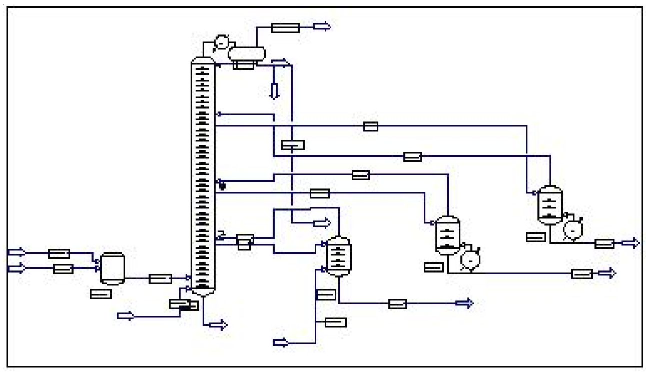

Figure 1. A typically schematic of atmospheric distillation column's simulation by simulator

2. Developing the Models

The atmospheric distillation column with all of its equipment parts of the I-A-S Refinery Company has been simulated by using two simulators, Aspen plus 10.3 and Provision 5.61 (Hosseini, 2006, Yasini *et al.*, 2006). A schematic illustration of these simulations is shown in Figure 1.

At first, the simulator's output has been compared with the real data. A good agreement between the simulator and the real data has been found. A comparison is shown in Table 1 for diesel and kerosene products.

At the next step, for the improvement of the efficiency of the column, first the boundary conditions have been determined and then the models have been optimized to gain more overhead product and less energy consumption. Results are shown in Table 2.

Finally, the optimization results from the simulator have been transferred into real operation. The results are shown in Figure 2 and 3 (Hosseini, 2006). As seen, this optimization improved the product output and reduced the energy consumption.

Table 1. A typically comparison between the simulator software's outputs and real operating data (laboratory's data) (Hosseni, 2006, Yasini *et al.*, 2006)

	IBP°c	5%	10%	30%	50%	70%	90%	95%	FBP°c
					Kerosene				
Operating	165	179	186	196	206	218	234	241	258
Aspen plus	166	182	189	198	206	219	237	245	255
Provision	164	178	183	197	208	219	234	242	250
					Diesel				
Operating	223	250	261	280	295	315	350	367	378
Aspen plus	220	245	252	276	288	312	351	365	377
Provision	219	242	253	277	290	310	346	362	374

Table 2. The optimization's outcome of the models for improvement of efficiency based on the settled important boundary conditions

		Actual	Optimum
Feed Preheat Temp	°C	346.1	345.6
Kerosene Pump Around Temp. Difference	°C	60	73.1
Light Diesel Pump Around Temp. Difference	°C	75	80
Kerosene Pump Around	m^3/hr	455.4	467.1
Light Diesel Pump Around	m^3/hr	250	261
BN Reboiler Temp.	°C	222	229.5
Light Diesel Steam Flow	m^3/hr	1	1
Main Steam Flow	m^3/hr	9.6	8.8
Kerosene Reboiler Temp.	°C	268	270

3. Result and Discussion

As shown in Figure 2 and 3 the results demonstrate that the changes made in real operating condition increased the overhead products with desirable quality. Also shown in Figure 3 are the operating conditions that have been changed during the process based on the optimum models. A net economical balance between the result's increment of overhead products (Figure 2) and the energy consumption (Figure 3) shows an energy saving in the refinery. A real yield has been gained by this optimization.

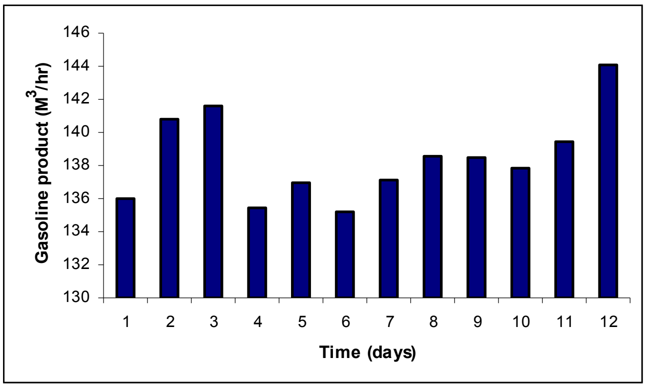

Figure 2. The Increment of heavy straight run gasoline vs. time (day) during optimization process

4. Conclusions

The optimization of the operating conditions of the columns in the distillation units could increase the overhead product with desirable quality and without any change in the equipment itself. The applied method in this work has used the optimization in the environment's steady state simulation. An important point in this project contains the optimization of the operation parameters to maximizing the production of reach fabrication with the view of energy consumption simultaneously. Also the obtained results have been shown that the used mathematical technique for optimization has been written compatible with the proper algorithm.

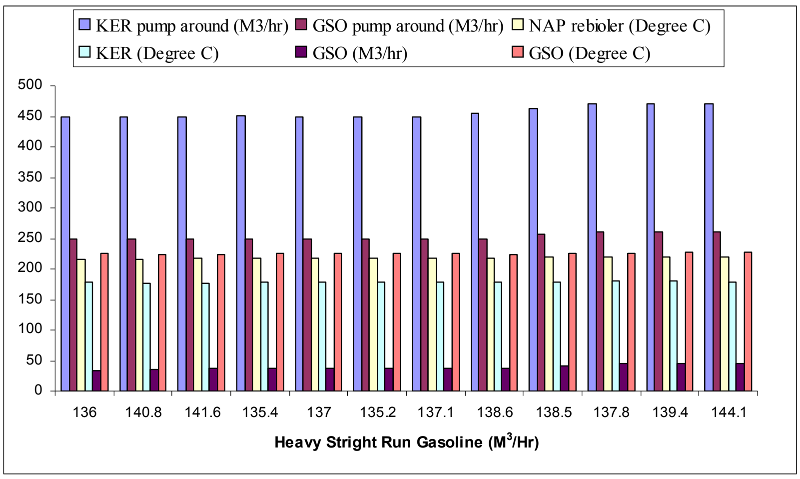

Figure 3. Variations of the key parameters based on simulator's optimization process out come vs. increment of heavy straight line gasoline

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