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FEASIBILITY OF REVAMPING OF ATMOSPHERIC TOWER OF REFINERY

Laleh Shirazi[*,1], Ensieh Ganji Babakhani[1], Yahya Zamani[1]

[1] *Gas Division, Research Institute of Petroleum Industry (RIPI), 1485733111, Tehran, Iran,*shirazil@ripi.ir

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Abstract

In this paper, the increasing method of atmospheric distillation tower capacity in a refinery is investigated. For this purpose performance of tower has been simulated. There are two restrictions in increasing of tower capacity called furnace duty and hydrodynamic problems. The first limitation is removed by increasing of entrance temperature of crude oil by Pinch technology. The second problem is solved by adding some pump-around. At the end of this study the increase of a Tehran Refinery's atmospheric distillation tower capacity will be introduced as a case study for one year.

Key Words: Revamping; Tower; Atmospheric; Refinery; Distillation.

1. Introduction

Significant amount of studies have been focused on find a way of increasing production of industrial units according with existing facilities. The reason for this large amount of investigation is due to the fact that none of systems work at its maximum nominal capacity. If problems are solved by different ways, systems will approach to their nominal capacity. The common problems for increasing of systems capacity include:

1) Available energy
2) Ability of systems, equipments and transfer lines for more flow or work in higher temperatures and pressures

In accordance with these problems, there are a lot of problems and limitations in an oil refinery unit which cause systems such as distillation tower don't work at their maximum capacity [1-2]. Main problems related to increase of atmospheric distillation column's capacity in refinery are:

1) Furnace duty
2) Hydrodynamic of tower (Flooding Factor)

It means that, the furnace duty shouldn't be more than designed value and flooding factor of each section of the tower shouldn't be more than 80% [3].

Instructions below are used for solving of these limitations:

A) Removing of furnace restriction of atmospheric tower

Increasing of tower capacity means that the flow rate of crude oil increases in furnace. It needs more duty of furnace to keep operational condition constant, which it may be more than nominal capacity of furnace. There are two solutions for overcoming these problems:

- Changing of furnace structure or using another side-furnace which needs significant amount of costs.
- Increasing of crude oil temperature coming into the furnace. This circumstance causes that despite of increasing in flow rate, temperature of fluid at the outlet of furnace will remain constant. This is possible by changing the arrangement of heat exchanger and modification of their situation by using Pinch Analysis. This solution seems practical and economical.

B) Removing of hydrodynamic problems

With the increasing of column capacity, internal gas stream in the column will be boosted too which causes that flooding factor in tower approaches to the critical level. This means that gas stream fills all distance between each two trays which is resulted that efficiency of tray decreases. Therefore, solving of hydrodynamic problem of tower means control of flooding factor in tower.

In order to control of the flooding factor which means decreasing of gas stream in the column compared with liquid in that, pump-around are used [4-5].

These pumps send a fraction of products to a heat exchanger. This flow is cooled in the heat exchanger and recycled to the column. This cold liquid is poured on gas streams in the tower and condenses them which lead to decreasing of flooding factor in the column. Therefore, without changing the tower diameter, flow rate in tower is increased. Another advantage of pump-around is the facility of heat recovery in the temperature more than condenser temperature [6].

High temperature makes heat recovery easy. The recovered heat is used in exchanger as pre heater of the furnace inlet oil.

It should be noticed that the number of pump-around which added to the tower is limited by these factors:

1) Tower height
2) The location of entrance feed
3) The number of products obtained from the tower
4) Flow rate of feed
5) The heat recovery method used in the column
6) Quality of the products

As mentioned, the distillation tower of the Terhran Refinery is considered as an example which the technique of adding pump-around is investigated in this column [7].

In this tower, the feed is entered from bottom of the tower and three products, Blending Naphta, Kerosine and Light Diesel, are derived from distance between entrance of feed and top of the tower. Therefore, maximum three pump-arounds and minimum one pump-around can be added to the tower. Certainly, the number of pump-around depends on operational conditions of the tower. In usual condition and without increasing of tower capacity, the pump-around is added to the middle stream (Kerosine) [8].

When the capacity is increased, at first one pump-around is added. This pump is added to the stream under the Kerosine. The reason for doing is that the higher temperatures in bottom of the column, which lead to the heat recovery, become considerable more easily. If more increasing of tower capacity is needed, the pump-around should be connected to the stream above the Kerosine. There is a reason for not utilizing the three pump-arounds simultaneously in the same common capacity which is clarified as follow. Briefly advantages and disadvantages of extra pump-around are [9-10]:

1) If two extra pump-arounds are used, less heat is recovered from condenser and the large amount of heat is absorbed from heat exchangers along pump-around. Since the temperature of flow in the bottom of the tower is more than the top of the tower, heat recovery is performed easily. Moreover for constant heat exchanging, small heat exchanging area is needed and it will be economical. These new heat exchangers can be used in preheat network of entered feed to the furnace and furnace duty will be reduced.
2) By using of two pump-arounds, the high increase of capacity will be achieved because:
   - If there is only one pump-around, the capacity cannot be increased more than a specific level because flooding factor in column is increased.
   - Considerable amount of heat is recovered in condenser. Since the temperature at the top of the tower is low, this heat cannot be used in pre heater of entered crude oil to the furnace. Therefore furnace duty can’t be decreased by pre heater.
3) Increasing of the amount of liquid in the tower and decreasing of separation quality are mentioned as demerits of extra pump-around. Adding pump-around causes the quality of product to be changed.

2. Investigation of atmospheric distillation tower of Tehran Refinery as the case study

The atmospheric distillation tower of Tehran Refinery is designed for capacity of 100,000 bbl/day. Feed is entered from the bottom of the tower and the products such as Kerosine, Blending Naphta and Light Diesel are obtained from top of the feed. In usual capacity a pump-around is installed just on Kerosine. The tower capacity was increased up to 140,000 bbl/day and the case was investigated with one or two extra added pumps. It is worth noting that the quality of product is probed not to be far from standard level. Now, we are investigating the effect of extra pump-around on tower efficiency:

Table1 Recovered heat from condenser

Capacity	Recovered heat from condenser (MMBtu/hr)
100,000 bbl/day capacity without extra pump-around	-128
140,000 bbl/day capacity with one extra pump-around	-115.92
140,000 bbl/day capacity with two extra pumps-around	-75.3

The effect of extra pump-around on the amount of recovered heat from condenser has been shown in Table 1. As seen, the amount of recovered heat at 140,000 bbl/day capacity with one extra pump-around is less than that for the capacity 100,000 bbl/day. This is a positive point because as it is mentioned this recovered heat (from condenser) can't be used in preheat exchangers network of entered feed to the furnace.

Table2 The effect of pump-around on flooding factor

	One extra pump-around	Two extra pumps-around
Top of the tower	80.3%	75.2%
Middle of the tower	77%	76.1%
Bottom of the tower	65%	65%

The effect of extra pump-around on flooding factor is shown in Table 2. This table shows that, if two extra pumps-around, added to the first one, the flooding factor of the tower will be decreased so hydrodynamic restriction of the tower will be removed.

Table 3 Heat recovered in the main heat exchangers of the tower

The number of added pumps	1	2
Recovered heat (MMBtu/hr)		
Condenser	-115.92	-75.3
Blending Naphta	-	-31.20
Kerosine	-46.21	-50.27
Light Diesel	-52	-52.3

The amount of recovered heat in the main heat exchangers when one or two extra pumps are added is investigated in Table 3.

The important point is decreasing of recovered heat from condenser and transferring that to lower heat exchangers which explained previously.

Table 4 Comparison of ASTM D86 at 760 mmHg with one and two extra added pumps

Product name	One extra pump-around ASTM D86 (°C)		Two extra pumps-around ASTM D86 (°C)		Standard amount ASTM (°C)	
	5%	95%	5%	95%	5%	95%
Blending Naphta	142.5	173.5	143	176	147	171
Kerosine	176.5	246	177	248	175	242
Light Diesel	254.3	350.5	255.5	351.1	265	366

At the end, the effect of pump-around on quality of product has been shown in Table 4. As expected, with increasing of pump-around, the quality of separation will decreased because increasing the amount of liquid in the tower.

3. Conclusion

Two fundamental problems in increasing of atmospheric distillation tower capacity are tower furnace and its hydrodynamic problems. Furnace duty problem is resolved by increasing the entrance temperature to furnace which is solved by heat exchangers of added pump-around and changing of heat exchangers network. Hydrodynamic restriction is removed by pump-around. Certainly many number of pumps cause products to be far from favorable quality which this problem is ignorable in small amounts.

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