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SIMULATION OF ATMOSPHERIC CRUDE UNIT "BADGER" USING ASPEN PLUS

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Abstract

Primary processing of oil gives fractions such as gas, gasoline, kerosene, gas oil, atmospheric residue, oil fractions and heavy residue. The quantity of each fraction is specified by the composition of oil. The main parts of this process are atmospheric and vacuum distillation preflash crude units.
The object of this work was to make a computer simulation of the atmospheric distillation using Aspen Plus simulator. The feed is preheated in the system of heat exchangers and this part of the process was included in the simulation. The operating parameters were taken from the “Badger” project documentation, which was designed for the oil refinery in Novi Sad. The simulation was performed for a type of crude oil, which is currently in use.
Furthermore, the possibility of running the process under different feed conditions was also checked.

Key words: Aspen Plus; processing of oil; Badger

Introduction

Primary processing of oil gives fractions such as gas, gasoline, kerosene, gas oil, atmospheric residue, oil fractions and heavy residue (these are not final products, they need to pass several refinery processes). The quantity of each fraction is specified by the composition of crude oil. The main parts of this process are the atmospheric and vacuum distillation preflash crude units.

This work is based on the data taken from the project documentation of the atmospheric unit in the oil refinery in Novi Sad, called Badger [1]. This refinery section is very important, because the main characteristics of the fractions, such as viscosity, bubble point, etc. attained from this plant are restitutes during this process. These properties have to be adjusted as well as it is possible because of the further adjustment possibilities and costs.

The aim of this paper was to make a simulation of the atmospheric crude unit Badger using Aspen Plus 11.1 simulation engine provided by Aspen Technology Ltd. [2] in order to test the unit with a crude oil which is currently in use as well as for another type of crude oil whose data were taken from Aspen Plus 11.1 Library and

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documentation from the oil refinery in Novi Sad.

Computer simulation

Thermodynamic property model

A general correlation of the vapor–liquid equilibrium in hydrocarbon mixtures, the thermodynamic model Chao-Seader with Lee-Kesler enthalpy [2], was used in the simulation.

Atmospheric crude unit Badger

The atmospheric crude unit is shown schematically in Fig. 1.

The main part of the process is a distillation column with two side stripers. The column has 22 stages and the stripers have four stages each. In the refinery these two stripers are embedded in a single column. Stripers are needed for elutriation of the desirable fraction from a lighter one. Therefore the steam is introduced in the stripers by streams (6) and (7).

The crude is being preheated in series of heat exchangers using product streams (3, 5, 8, and 9). After the furnace, the feed stream (1) enters the column on the stage 4, numbered from the bottom up. The steam (2) is used for elutriation of the heaviest fraction in the process and it enters the column on the stage 1.

The stream (4) represents reflux, which enters the column on the stage 21. The reflux rate is adjusted in the splitter.

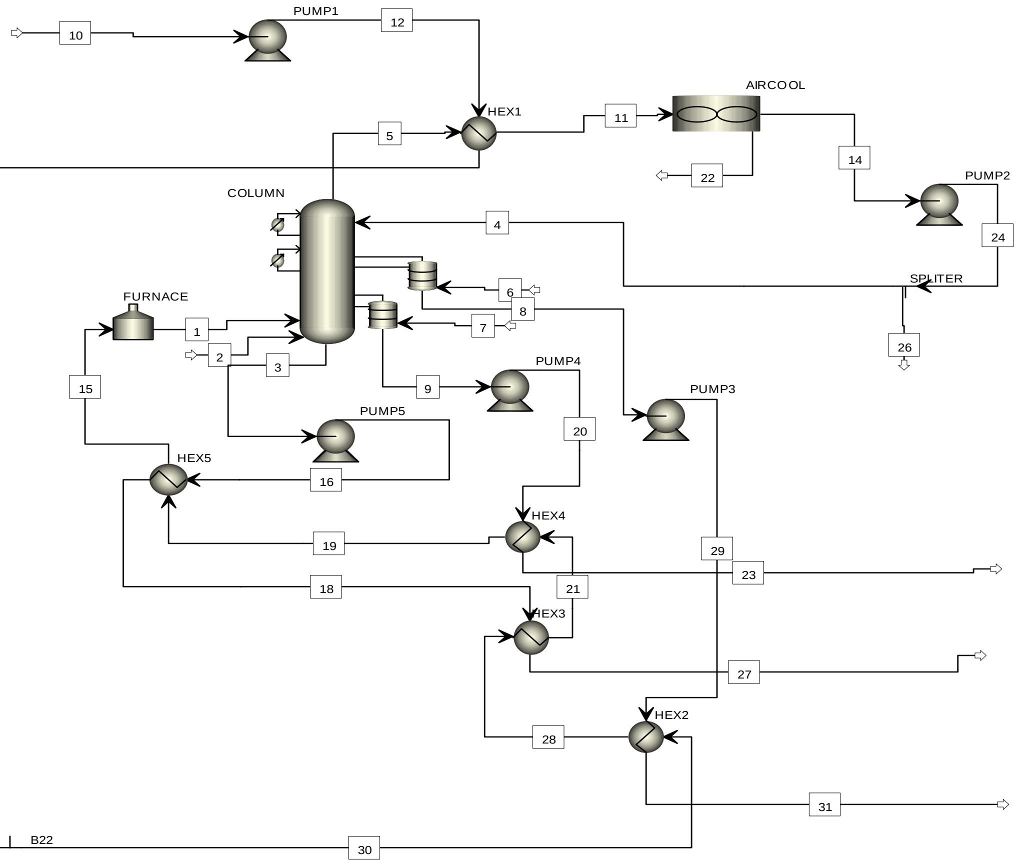

Fig 1. Schematic picture of the atmospheric crude unit.

Beside of these data it is needed to enter the data relative to heat exchangers (such as cold or hot stream inlet or outlet temperature or the heat duty) for the simulation to begin.

The other necessary data are some data concerning the type of the crude oil, which is processed in the Badger unit. These data were taken from the oil refinery in Novi Sad, for VELEBIT type [1], and from Aspen Assay Library, for KIRKUK [2]. KIRKUK is a lighter type of crude oil and it comes from Iraq lodes. VELEBIT is a type of the crude oil that is currently in use and KIRKUK is the crude oil for which the unit is to be tested.

Data are given in Table 1 and in Fig. 2 and Fig. 3 for each type of the crude oil.

Table 1. Data for VELEBIT and KIRKUK crude oil.

type	gasoline	kerosene	gas oil	long residue
VELEBIT	2.6 %	10.7 %	20.1 %	66.6 %
KIRKUK	20 %	17 %	20.5 %	42.5 %

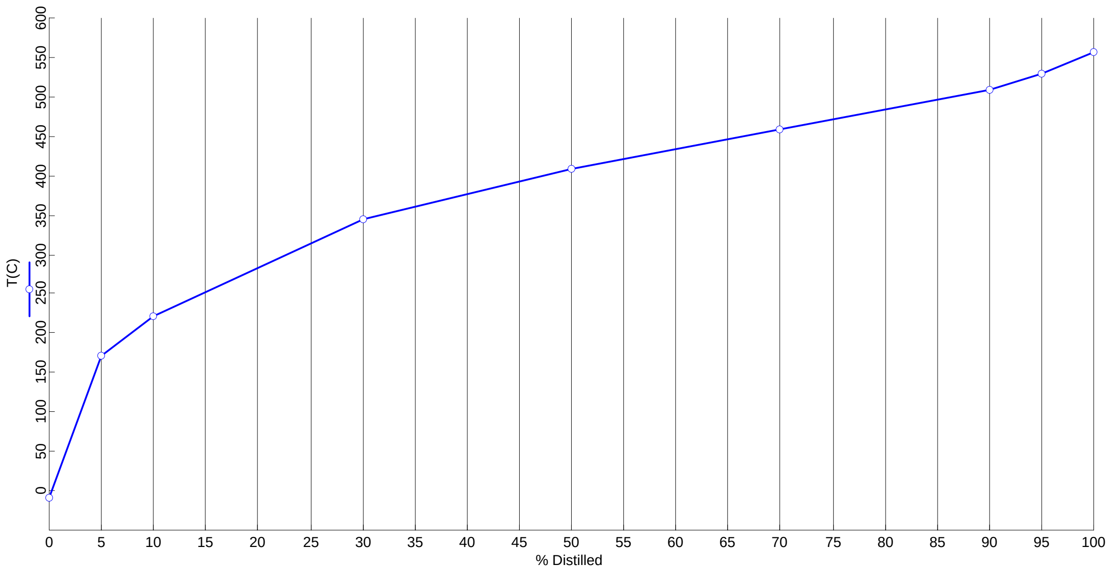

Fig 2. The distillation curve for VELEBIT type of the crude oil.

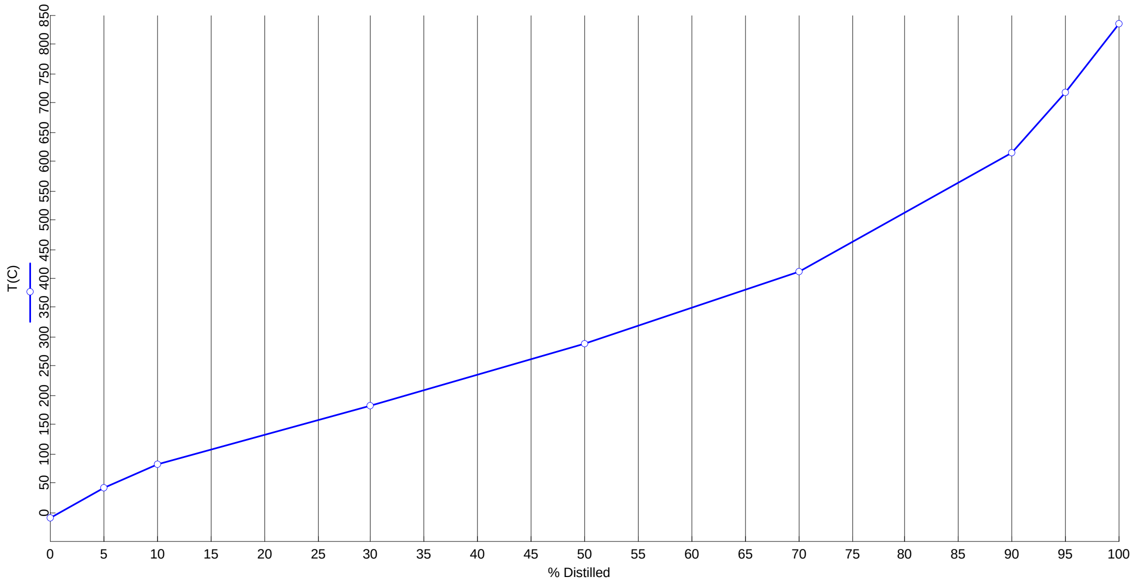

Fig 3. The distillation curve for KIRKUK type of the crude oil.

The most interesting fraction is a lighter one, gasoline, because of its economic importance.

As it can be seen From Fig. 2 and 3, KIRKUK will give bigger amount of light fractions, especially the gasoline fraction. Also, it is possible to see from these figures that at the same temperature KIRKUK type of the crude oil will give bigger amount of the distilled liquid.

The most common fractions are set by TBP cuts [4]:

Light and heavy gasoline:	60-180^{0}C
Kerosene:	180-260^{0}C
Gas oil:	260- 360^{0}C
Residue:	T > 360^{0}C

Column internals data together with the feed stream temperature and pressure are given in Table 2 [1].

Table 2. Column internals and feed stream data

Number of stages	22
Pressure (bar)	1,9- 1,55
Temperature (^{0}C)	350- 138
Feed stream temperature (^{0}C)	372
Feed stream pressure (bar)	1,7

PETRO FRAC unit operation model

PETRO FRAC unit operation model from Aspen Plus model library was used since the actual number of stages had already been known from the project documentation [1]. PETRO FRAC models column configurations consist of a main column with any number of pumparounds and side strippers.

Process limitations

The feed temperature is the most important limitation because at a certain temperature the oil will start to crack and coke will appear in the column, which will result in flooding of the column and collapsing the process.

The column pressure is also a limitation, because of the same reason.

The number of stages was included in limitations, because plant has to be tested as there is.

However, the stage from which were drawn liquid for stripers and stage of return wasn't limitations, so it was tested in purpose of getting more quantity as well as quality of light fraction with regard on composition of gasoline fraction get from VELEBIT crude oil on this plant, BADGER. It was used in case of KIRKUK type of crude oil.

Results and discussions

The first simulation was run with VELEBIT crude oil. The simulation was successfully done, because the matching of the results with the project data was satisfying. The comparison between the project data and the data obtained by the simulation is given in Table 3.

Table 3. The comparison between the project data and the data obtained by the simulation.

	gasoline (kg/h)	kerosene (kg/h)	gas oil (kg/h)	residue (kg/h)
Project documentation	21 460	4 585	8 380	27 690
1st Aspen simulation	22 506	4 585	8 380	27 037

Table 4. Results obtained from the second Aspen simulation.

	gasoline (kg/h)	kerosene (kg/h)	gas oil (kg/h)	residue (kg/h)
2nd Aspen simulation	48 717	3 754	10 010	18 438

Table 5. Results obtained from the fourth Aspen simulation.

	gasoline (kg/h)	kerosene (kg/h)	gas oil (kg/h)	residue (kg/h)
3rd Aspen simulation	49464	3650	9850	18564

These results show that the simulation was successful and it can be used for the description of the process. Therefore, if some of the process parameters are changed the simulation can be used for prediction and adjustment of other parameters.

The simulation was run again with a different crude oil. The KIRKUK type of crude oil was used for the simulation, whose properties were taken according to Assay Data Library in Aspen Plus [2]. Because of the process limitations, mentioned above, no further pressure and temperature adjustment is possible or even necessary. Table 4 shows results of this analysis in terms of the fraction flow rates. Comparing these results to those for the VELEBIT type of crude oil, significant change can be seen. This is obvious because the crude oil composition is different (Table 1) for the two types taken for comparison. The simulation converged successfully again, which drew a conclusion that the distillation unit could be used for this new type of crude oil.

However, as it can be noticed from the TBP gasoline cut, a certain amount of the light fraction did not distilled as gasoline. In order to enlarge the share of the light fraction, as the temperature cannot be increased, in the third simulation the influence of the reflux rate was tested. Since it had no significant influence, another possible solution was to be checked – the location of the stripers. Therefore, in the fourth simulation the side stream withdrawal was shifted one stage down for both stripers. This shifting gave satisfactory composition of the gasoline fraction, the most profitable one. Table 5 shows the results of the fourth simulation.

Aspen Plus can be successfully used to simulate the atmospheric crude unit Badger with the existing project parameters for the crude oil VELEBIT.

What is more important is the fact that this unit can be used for a different crude oil, such as the KIRKUK crude oil, with not so significant changes in basic operating parameters. These changes were in accordance to the main process limitations and unit capability.

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