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Steady State Simulation and Analysis of Crude Distillation Unit at Baiji Refinery

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Abstract

In this research work, the main distillation column of Salahadin 1 refinery in Baiji Refineries is simulated and analyzed using Aspen HYSYS. Kirkuk, Basrah and Ajeel crudes are mixed together (with unknown mixing ratio) to create the feed stream of this unit. The determination of the blending ratio of these streams beside performance analysis of the system using actual plant data to increase the operating capacity are the main objectives of this research work. So, this work is very helpful to the refinery because it can be applicable to manage these blending ratios to obtain desired product quality. Also, this work enables the CDU unit at the refinery to work at full capacity. The validation results show that the system is perfectly simulated with Aspen HYSYS and the mixing ratio of (Ajeel, Basrah, and Kirkuk) crudes are (0.102,0.5, and 0.398) respectively; Furthermore, this study suggested that, it is important to replace the transfer line pipe diameter between the furnace and the distillation column according to the design specifications which enables the operators to rise the feed volumetric flowrate into full capacity.

Keywords: Simulation, Distillation Columns, CDU, Analysis, Aspen HYSYS.

محاكاة وتحليل حالة وحدة تقطير النفط الخام في مصفاة بيجي

الخلاصة:

في هذا البحث، تمت محاكاة عمود التقطير الرئيسي لمصفاة صلاح الدين 1 في مصافي بيجي وتحليله باستخدام Aspen HYSYS. يتم خلط خامات كركوك والبصرة وعجيل معًا (بنسبة خلط غير معروفة) لإنشاء تيار التغذية لهذه الوحدة. إن تحديد نسبة المزج لهذه التيارات إلى جانب تحليل أداء النظام باستخدام بيانات المصنع الفعلية لزيادة القدرة التشغيلية هي الأهداف الرئيسية لهذا العمل البحثي. لذلك، فإن هذا العمل مفيد جدًا للمصفاة لأنه يمكنهم من التحكم بنسب المزج هذه للحصول على جودة المنتج المطلوبة. كما يتيح هذا العمل لوحدة CDU في المصفاة العمل بكامل طاقتها. أظهرت نتائج التحقق أن النظام تمت محاكاته بشكل مثالي مع Aspen HYSYS وأن نسبة خلط خامات (عجيل، البصرة، كركوك) هي (0.102، 0.5، 0.398) على التوالي، علاوة على ذلك اقترحت هذه الدراسة أنه من المهم استبدال قطر أنبوب خط النقل بين الفرن وبرج التقطير وفقًا للمواصفات التصميمية التي تمكن المشغلين من رفع معدل التدفق الحجمي للتغذية إلى السعة الكاملة.

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1. Introduction

Baiji Refinery is the biggest refinery in Iraq and one of the most important crude oil refineries in the Middle East, which consists of four refineries with various capacity, as following: Salahadin 1 Refinery (70,000 BBI/day), Salahadin 2 Refinery (70,000 BBI/day), North Refinery (150,000 BBI/day) and Lube Oil Refinery (250,000 Ton/year).

Our work aims to provide a simulation study of the main crude oil distillation tower in Salahadin 1 Refinery of North oil Refining Company. A comparable study to analyze the column performance and its operating conditions has been done using Aspen HYSYS software.

The main crude oil distillation column is currently unable to work with a full capacity due to the effect of war with ISIS in 2014, so this issue is analyzed to introduce suitable solutions.

It is very difficult to determine the composition and flowrate of products from the unit using simple models or a personal computer because of the significant interaction between the heat and mass transfer processes during the distillation of crude oil as well as changes in the thermodynamic properties of liquid and gas streams that depend on the pressure and temperature [1].

Presently, simulation is among the most effective and time-consuming tools available. It may be used for many different things, including design, performance development, control, and the capacity to predict how a system will behave when one or more operating variables change. Instead of seeking to understand the behavior of the plant or unit by conducting numerous trials, this work can be completed quickly [2].

With its extensive database of different types of equations of state for gases and liquids over a wide variety of pressure and temperature, Aspen HYSYS software is more reliable in design processes and more adaptable in the majority of operational settings. The simulation results of Aspen HYSYS are more realistic and in line with the actual performance of the separation units due to these parameters and characteristics. The application contains a substantial quantity of experimental data in the shape of tables or equations for pure components, solutions, and mixtures [3].

The specifications of the crude oil mixture should be established, along with its specifications, and its constituent parts should be categorized in accordance with a certain range of boiling points in order to execute the simulation [4].

A number of studies employing simulation software have been conducted recently for crude oil distillation columns. Yusof et al. [1] introduce an artificial neural network (ANN) model for a

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crude oil distillation column by using Matlab & Aspen Plus to apply real time optimization. Anitha et al.[2] try different crude mixtures using Aspen plus to obtain more distillate from the crude distillation column, while YIN [3] creates CDU modeling and simulation by Aspen plus to study the impact of various petroleum refining operating conditions on the yield. Several researchers use SIM SCI/PRO II software to study the CDU behavior, Al-Muslim and Dincer [4] analyze the energy and exergy efficiency of crude oil distillation systems while K. Wang et al. [5] study the retrofits and optimization for the light crude oil distillation process and heavy crude oil distillation process with the same software. The ideal work, lost work, and shaft work are examined by Aspen HYSYS for the crude distillation unit of the N'djamena Refining Company (NRC) in the Chadian republic [6]. Shankar N et al. [7] proof that Aspen HYSYS is one of the best simulation tools to simulate and analyze the operation of crude oil refinery. Ibrahim [8] develops a simulation-optimization framework for a crude oil distillation unit using Aspen HYSYS, while Fethi and Ahmed [9] use Aspen HYSYS simulation program to simulate and optimize a crude oil distillation unit of a refinery with the goals of improving the unit's efficiency and examining the effects of changing some parameters on the final products. Ahmed and Abubakar [10] investigate the crude oil distillation unit II of Kaduna refining and petrochemical company KRPC as a case study built in Aspen HYSYS. Jaja et al. [11] use the information from the Port Harcourt Refining Company to optimize the simulated model of the crude distillation unit .As we can see from the previous work, Aspen HYSYS has the majority of the researchers work on the simulation and analysis of crude oil distillation unit.

2. Process Description of CDU

Crude oil is pumping from storage tank with a rate of 333 m^3/hr (460 m^3/hr is the full capacity rate) to heat exchanger trains to exchange heat and to rise the crude oil temperature to about 240 ˚C, then the crude oil is fed to the Furnace 101B. Here, crude oil is heated up to a temperature controlled by the fuel oil/gas to about 338 ˚C and is then fed to the main crude oil distillation Column 101E. The Benzene cut is drowned through the column head together with the stripping steam. The quality of withdrawn benzene cut is controlled by the temperature inside the column head, with the help of the head pump around. The Kerosene Cut is taken from the same point as the head pump around (stage 3), this being mixed with Benzene Cut to perform Light Distillate Cut (The light distillate blend volumetric flowrate does not exceed 120 m^3/hr which are the capacity of hydrotreating unit) which treated in the hydrotreating unit 3302 before separated to

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light and heavy Naphtha beside Naphtha Kerosene in the Redistillation columns. The next drawn off is Light gas oil, this being stripped and fed either for the unit 3303 for hydrogenation (which is not in service) or to the store, after the exchange and further cooling (this stream is stopped right now according to the high carbon content which required further processing to accomplish international carbon content limit). The last side draw is heavy gas oil, this being also stripped, after the heat exchange and cooling it is fed to store with an amount of HGO that is refluxed back to the main distillation column 101E. The reduced crude (RCR) is drowned out through the bottom of the column, this product being fed to the store after the heat exchange with the crude oil and after cooling. Steam is injected at the bottom of the main crude oil distillation column which are used as a stripping method to separate the light ends from the crude oil.

To remove a hot side stream, cool it, and then restore it to the column at a part above the draw off tray, two pumps around (top and intermediate) are used. The pump around functions act as internal condenser to adjust the quality and the temperatures along the distillation columns.

Stripping columns are used to remove entrained light ends from side stream distillate products. Steam is introduced into these columns from below the bottom tray, rises up the tower, and exits at the top of the secondary column along with the light ends stripped out. Just above the side stream draw off tray, the stripped steam with light ends is allowed to enter the main column. The process flow diagram of the main distillation column is presented in Figure (1).

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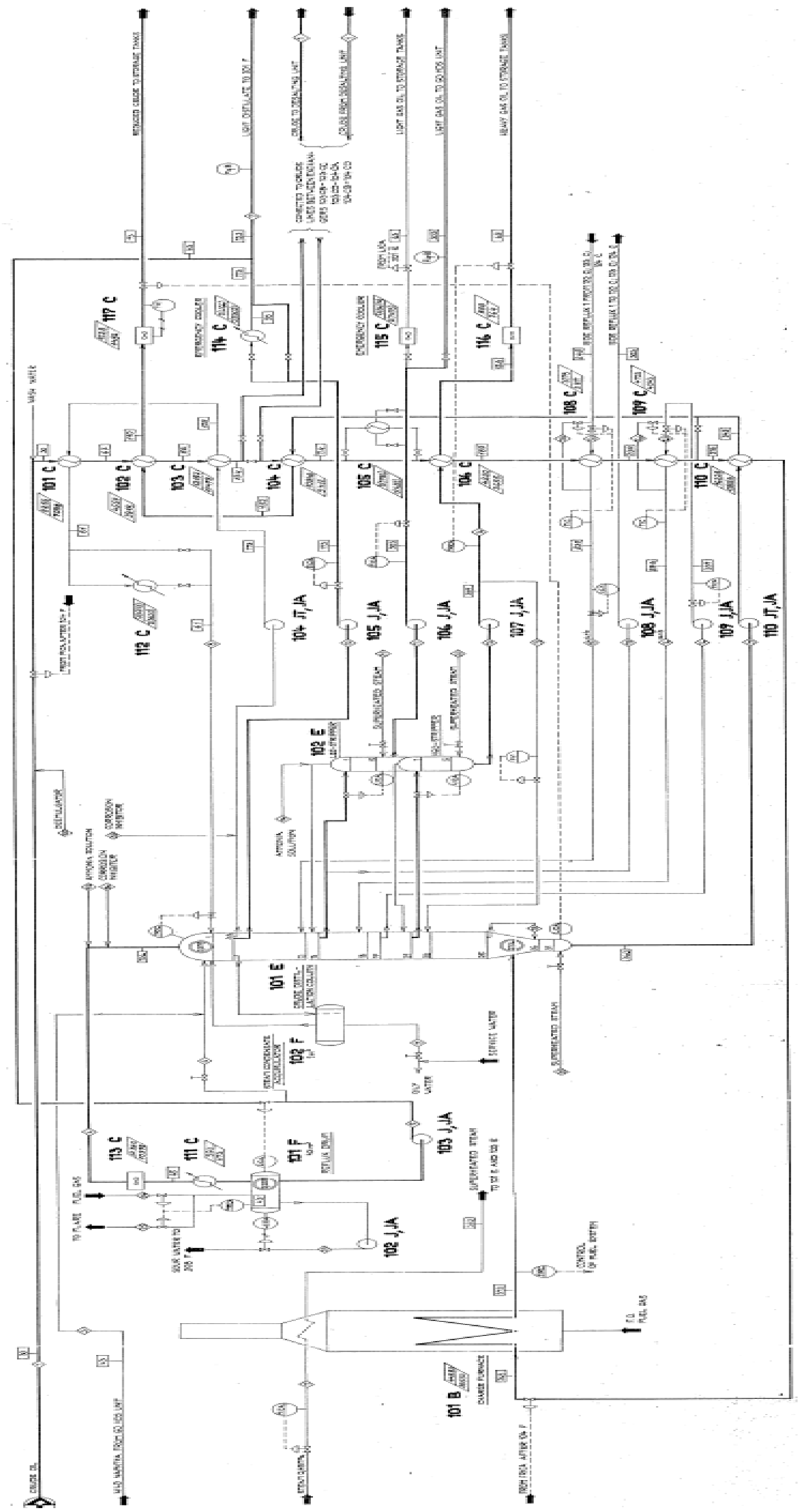

Fig. (1): Process flow diagram of the main crude oil distillation unit.

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3. Steady State Simulation

Aspen HYSYS software has been used to simulate the crude oil distillation unit 101E of Salahaldin1 Refinery in Baiji Refineries. Aspen HYSYS flowsheet of crude oil distillation unit is shown in Figure (2). All necessary data to build ASPEN HYSYS model consist of the actual plant data of North Oil Refining Company: Process flow diagram, piping and instruments diagram, detailed equipment design catalogues and DCS data.

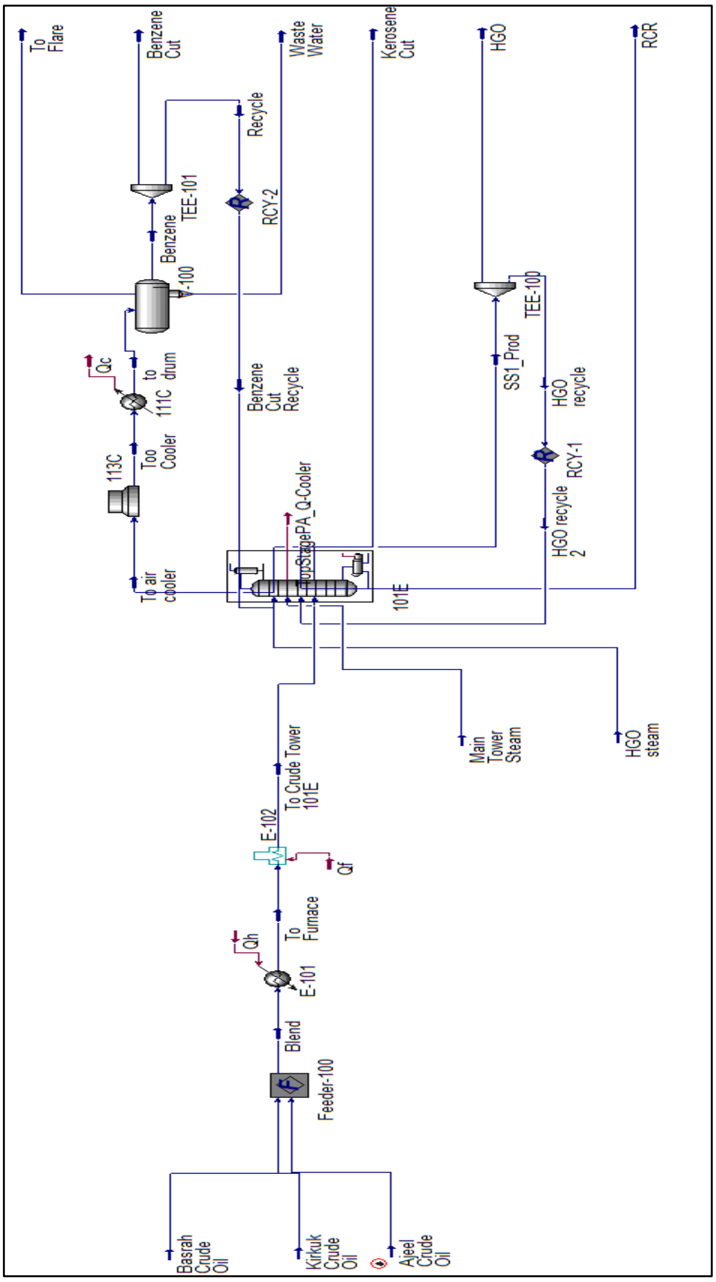

Fig. (2): Aspen HYSYS flowsheet of crude oil distillation unit.

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- ***Input Data and Oil Characterization***

Crude oil in the storage tank which are fed to the refinery units is a blend of three crude oil sources:

- ✓ Kirkuk crude oil
- ✓ Ajeel crude oil
- ✓ Basrah crude oil

Each crude source has its own characteristics, so the final properties of the mixed crude oil that processed in the CDU depend mainly on the blending ratios of these crude assays. Tables (1-3) describe the crude assays of each crude[12].

Table (1) Crude Assay of Kirkuk Crude Oil

Property	Bulk Value
API Gravity @15.6 ˚C	35.15
Liquid Density (kg/m3)	849.08
Kinematic Viscosity (cSt)@ 37.78 (C)	4.10
Kinematic Viscosity (cSt)@ 50 (C)	3.41
Kinematic Viscosity (cSt)@ 98.89 (C)	1.72
Pour Point (C)	10.84
RVP (kPa)	52.73
Watson K	11.56
Distillation Vol @ 1 (%) - TBP	-37.69
Distillation Vol @ 5 (%) - TBP	10.63
Distillation Vol @ 10 (%) - TBP	76.78
Distillation Vol @ 30 (%) - TBP	183.56
Distillation Vol @ 50 (%) - TBP	298.46
Distillation Vol @ 70 (%) - TBP	427.59
Distillation Vol @ 90 (%) - TBP	591.89
Distillation Vol @ 95 (%) - TBP	674.26
Distillation Vol @ 99 (%) - TBP	828.56

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Table (2) Crude Assay of Basra Crude Oil

Property	Bulk Value
API Gravity @15.6 ˚C	24.71
Liquid Density (kg/m3)	905.81
Kinematic Viscosity (cSt)@ 37.78 (C)	21.29
Kinematic Viscosity (cSt)@ 50 (C)	13.87
Kinematic Viscosity (cSt)@ 98.89 (C)	4.27
Pour Point (C)	21.0
RVP (kPa)	45.23
Watson K	11.35
Distillation Vol @ 1 (%) - TBP	-45.53
Distillation Vol @ 5 (%) - TBP	65.15
Distillation Vol @ 10 (%) - TBP	110.06
Distillation Vol @ 30 (%) - TBP	252.57
Distillation Vol @ 50 (%) - TBP	399.91
Distillation Vol @ 70 (%) - TBP	547.81
Distillation @ 90 (%) - TBP	839.09
Distillation Vol @ 95 (%) - TBP	973.42

Table (3) Crude assay of Ajeel Crude Oil

Property	Bulk Value
API Gravity @15.6 ˚C	34.31
Liquid Density (kg/m3)	853.4
Kinematic Viscosity (cSt)@ 37.78 (˚C)	5.00
Kinematic Viscosity (cSt)@ 48.49 (˚C)	4.1
Kinematic Viscosity (cSt)@ 98.89 (˚C)	N.A
PourPoint (C)	-23.33
RVP (kPa)	64.12
Water Content (Vol%)	0.05
Distillation Vol% @ I.B.P	38
Distillation Vol %@ 50 ˚C	1.8
Distillation Vol %@ 75 ˚C	6.00
Distillation Vol %@ 100 ˚C	11.0
Distillation Vol %@ 125 ˚C	17.3
Distillation Vol %@ 150 ˚C	24.5
Distillation Vol %@ 175 ˚C	31.0
Distillation Vol %@ 200 ˚C	37.2

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Distillation Vol %@ 225 ˚C	43.0
Distillation Vol %@250 ˚C	48.3
Distillation Vol %@275 ˚C	53.3
Distillation Vol %@300 ˚C	58.1
Total Distillate Vol%	62
Residue Vol%	37.5
Distillation Losses Vol%	0.5

The staffs of Storage Tanks Department at North Oil Refining Company don't have information related to the crude oil blending fractions since they are receiving a daily amount of blend (Kirkuk and Basrah crudes) with unknown mixing fractions. These quantities will be directed to storage tanks and mixed together with Ajeel crude oil. As a result, a comparable study will be discussed in the next sections to find the mixing ratios of the used crude in Baiji Refineries.

Crude oil passes through a series of heating utilities before it is introduced to the main crude oil distillation column, so the operating parameters for the crude oil since pumping from the storage tanks until reaching the distillation column (unit 101E) are listed in Table (4), furthermore Table (5) shows the pump arounds characteristics. Table (6) describes the operating parameters in the distillation column (unit 101E) and Table (7) presents the steam stripping properties [13].

Table (4) Operating Parameters for The Train Before CDU

Property	Value
Crude oil temperature from storage tank, (˚C)	38
Crude oil pressure from storage tank, (Kpa)	935
Crude oil flowrate, (m3/hr)	333
Crude oil temperature out from Heat Exchangers,(˚C)	240
Crude oil temperature out from Furnace,(˚C)	338

Table (5) Operating Parameters for Pump Arounds

Property	Value
Top pump around average flowrate, (m3/hr)	405.14
Top pump around average Return temperature, (˚C)	76.36
Top pump around draw and return stage	3-1
Intermediate pump around average flowrate, (m3/hr)	209.4
Intermediate pump around average Return temperature, (˚C)	193.23
Intermediate pump around draw and return stage	14-11

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Table (6) Operating Parameters in CDU 101E

Property	Value
Crude oil volumetric flowrate, (m3/hr)	333
Crude oil temperature, (˚C)	338
Crude oil pressure, (Kpa)	140
Number of Trays	31
Feed tray No.	26
Number of Pump around	3 (lower PA now stopped)
Number of Side Strippers	2 (LGO SS not in Service)
Benzene cut average volumetric flowrate , (m3/hr)	50.53
Kerosene cut volumetric flowrate , (m3/hr)	65
HGO volumetric flowrate , (m3/hr)	33
HGO reflux volumetric flowrate, (m3/hr)	10
Top tray average temperature, (˚C)	121.5
Bottom tray average temperature, (˚C)	313.45
Condenser Pressure, (Kpa)	110
Bottom stage average pressure, (Kpa)	126
Condenser average Temperature, (˚C)	40.15

Table (7) Steam stripping properties

Property	Value
Main column stripping steam flowrate, (kg/hr)	2650
HGO stripping steam flowrate, (kg/hr)	730
Stripping steam temperature, (˚C)	365
Stripping steam pressure, (Kpa)	330

4. Results and Discussion

4.1.Crude Oil Blending Fractions

For this simulation case and after the steady state condition is accomplished, the next step is the determination of the real crude oil compositions that feed to the actual crude oil distillation column, through changing of mixing ratios of the previous crudes as mentioned. The actual average plant value of Benzene Cut volumetric flowrate is about 50.53 m^3/hr as mentioned in Table (5). So, the next objective is to achieve this value in steady state condition. Table (8) represents the trial method to determine the mixing ratios until the desired value achieved.

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With a mixing ratio of (0.102, 0.5, and 0.398) for (Ajeel, Basrah, and Kirkuk crude oil respectively), the Benzene Cut volumetric flowrate is accomplished as mentioned in Table (8). So, the volumetric flowrates of Ajeel, Basrah, and Kirkuk crude streams are (33.966, 166.5, and 132.534 m^3/hr respectively).

Table (8) Determination of Real Crude Oils Mixing Ratios

Mixing Ratio			Ajeel Crude Oil Flowrate (m^3/hr)	Basrah Crude Oil Flowrate (m^3/hr)	Kirkuk Crude Oil Flowrate (m^3/hr)	Benzene Cut Production Flowrate (m^3/hr)
Ajeel	Basrah	Kirkuk				
0.2	0.1	0.7	66.6	33.3	233.1	72.94
0.2	0.2	0.6	66.6	66.6	199.8	68.47
0.3	0.2	0.5	99.9	66.6	166.5	73.59
0.2	0.3	0.5	66.6	99.9	166.5	64.07
0.4	0.3	0.3	133.2	99.9	99.9	73.81
0.3	0.4	0.3	99.9	133.2	99.9	64.62
0.4	0.4	0.2	133.2	133.2	66.6	69.23
0.4	0.5	0.1	133.2	166.5	33.3	64.68
0.45	0.4	0.15	149.85	133.2	49.95	71.4
0.4	0.45	0.15	133.2	149.85	49.95	66.95
0.35	0.45	0.2	116.55	149.85	66.6	64.72
0.35	0.35	0.3	116.55	116.55	99.9	69.22
0.3	0.35	0.35	99.9	116.55	116.55	66.85
0.3	0.3	0.4	99.9	99.9	133.2	69.08
0.25	0.35	0.4	83.25	116.55	133.2	64.4
0.2	0.4	0.4	66.6	133.2	133.2	59.72
0.2	0.5	0.3	66.6	166.5	99.9	55.42
0.25	0.45	0.3	83.25	149.85	99.9	60.02
0.2	0.475	0.325	66.6	158.175	108.225	56.49
0.15	0.475	0.375	49.95	158.175	124.875	54
0.125	0.475	0.4	41.625	158.175	133.2	52.74
0.125	0.5	0.375	41.625	166.5	124.875	51.69
0.15	0.5	0.35	49.95	166.5	116.55	52.94
0.115	0.5	0.385	38.295	166.5	128.205	51.19

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0.11	0.5	0.39	36.63	166.5	129.87	50.93
0.1	0.5	0.4	33.3	166.5	133.2	50.43
0.105	0.5	0.395	34.965	166.5	131.535	50.68
0.102	0.5	0.398	33.966	166.5	132.534	50.53

4.2.Operating Capacity Diagnosis

The main crude oil distillation column (unit 101E) is currently operated with about 333 m^3/hr feed flowrate. This operating volumetric flowrate is lower than the design capacity which about 460 m^3/hr. The operators in this unit unable to increase the capacity more than (333) m^3/hr.

This unit is destroyed during the war with ISIS, then the unit is repaired by the effort of North Oil Refining Company staffs. During the maintenance period, some parts of the unit does not repair according to the design specifications. One of these parts is the transfer pipe line of the crude oil between the furnace (unit 101B) and the distillation column (unit 101E). The pipe diameter used in the maintenance is smaller than the design diameter (because the spare parts were not available during the maintenance). Since there is a direct relation between the pipe diameter and the volumetric flowrate, it is suggested to replace this transfer pipe line with another one has a typical design diameter to increase the feed volumetric flowrate and operate the unit with full capacity.

4.3.Column Profiles

One of the most important parameters in the crude oil distillation column is temperature gradient. Since the distillation process depending on physical separations mainly, so temperature is the parameter that separates and justifies the products with the desired purity. Figure (3) shows the simulated temperature profile of CDU (unit 101E) . we see that in this chart the temperatures ascending gradually from top to bottom of the column with nonlinear behavior. These gradients allow the separation of different desired products along the distillation column. At the same time, Table (9) shows the comparison between the simulated temperature profile and available plant temperatures from the column temperature sensors which can be analyzed as follow:

Condenser temperature show a good agreement between simulated and plant date with a value of 40˚C. This value is too important to justify the quality of Benzene Cut which will be sent

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together with Kerosene Cut as a Light Distillate blend for hydrogenation process as mentioned before.

Top stage temperature with a value 121.55 ˚C of real plant data and 122.33 ˚C simulated data show an approximate error value of -0.64 %, which are an excellent indication that overhead product quality is justified perfectly in simulated data as in the real plant data.

Column bottom temperature performs an error value of -1.07 % between plant and simulated data. This error value prove that the simulation case is perfectly represent the crude oil distillation column (unit 101E).

HGO Side Stripper feed from stage 22 with a plant temperature of 269.44 ˚C and 266.4 ˚C of simulated plant data. The error value for this cut about 1.13 % which are an acceptable error deviation value.

Kerosene Cut temperature shows a -17.07 % error deviation. This value is high with comparable to the previous values and must be analyzed.

Since all the top and bottom stages simulated temperatures are identical with plant data except Kerosene Cut value it means there is a problem within the real plant stage. After precise research in the plant documentation with plant troubles and maintenance history, it seen that, the furnace and the main column (unit 101E) are destroyed too many times especially in the last ISIS war in 2014 which affect the quality and sizes of transfer line pipes within the furnace which made further effect on the crude oil heating quality and the crude oil distillation capacity. With that reasons the operator of this unit could not rise the feed flowrate higher than 333 m^3/hr until they satisfy the typical specification as the manufacturer did.

Pressure profile is also an important parameter in crude distillation column due to its reversal relation with temperature. The only available plant data for column pressure are the top and bottom pressures which are identical with simulated data as shown in Table (9). while Figure (4) shows the linear increase in pressures from the top until the bottom of the distillation column. Then, the descending in pressure occurs to show the side stripper pressures.

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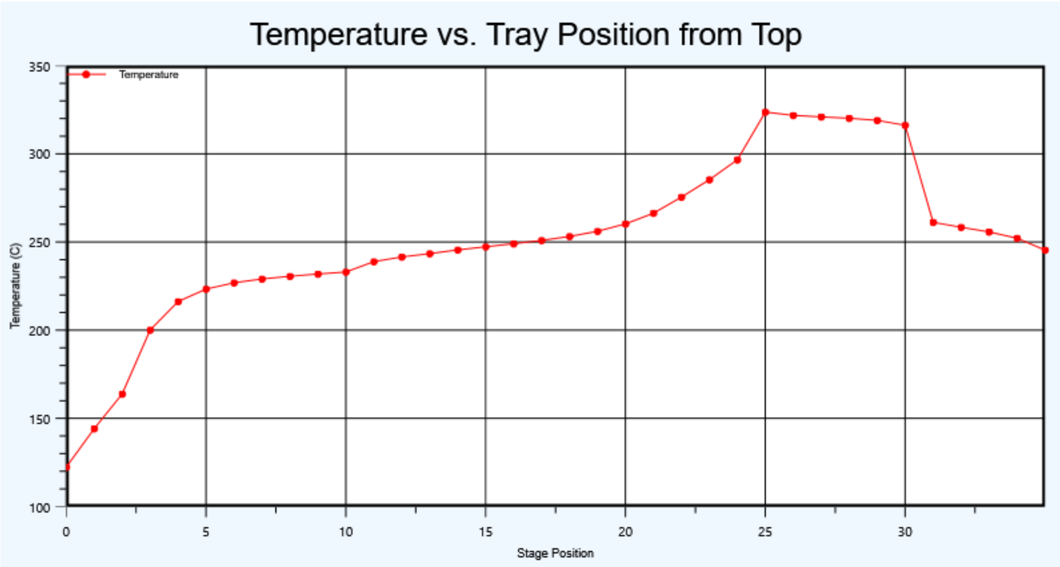

Fig. (3): Temperature profile of crude distillation column and side stripper.

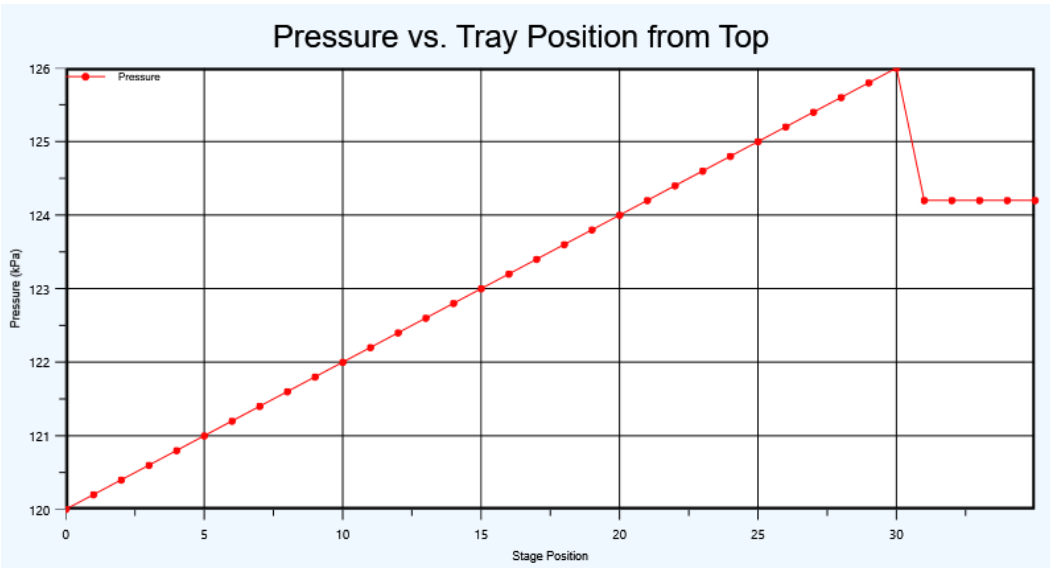

Fig. (4): Pressure profile of crude distillation column and side stripper.

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Table (9) Temperature and Pressure Profile

Stage NO.	Temperature (˚C)	Average Plant Temperature (˚C)	Pressure (KPa)	Average Plant Pressure (KPa)
Condenser	40	40.15	110.00	110.00
1	122.33	121.55	120.00	N/A
2	144.19	N/A	120.20	N/A
3	163.81	139.92	120.40	N/A
4	200.11	N/A	120.60	N/A
5	216.27	N/A	120.80	N/A
6	223.33	N/A	121.00	N/A
7	226.90	N/A	121.20	N/A
8	229.05	N/A	121.40	N/A
9	230.59	N/A	121.60	N/A
10	231.86	N/A	121.80	N/A
11	233.02	N/A	122.00	N/A
12	238.88	N/A	122.20	N/A
13	241.54	N/A	122.40	N/A
14	243.44	N/A	122.60	N/A
15	245.54	N/A	122.80	N/A
16	247.30	N/A	123.00	N/A
17	249.03	N/A	123.20	N/A
18	250.92	N/A	123.40	N/A
19	253.17	N/A	123.60	N/A
20	256.12	N/A	123.80	N/A
21	260.30	N/A	124.00	N/A
22	266.40	269.44	124.20	N/A
23	275.48	N/A	124.40	N/A
24	285.36	N/A	124.60	N/A
25	296.65	N/A	124.80	N/A
26	323.71	N/A	125.00	N/A
27	321.81	N/A	125.20	N/A
28	320.97	N/A	125.40	N/A
29	320.20	N/A	125.60	N/A
30	319.00	N/A	125.80	N/A
31	316.80	313.45	126.00	126.00

4.4.Product Qualities

The ASTM D86 distillation curves for Benzene Cut, Kerosene Cut, and HGO are used in simulation to assess the final products' quality. The 95% ASTM D86 points on these curves, which indicate how different products are from one another, are the most crucial ones. These

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are the temperatures that, in accordance with the particulars of the quantification method, cause 95% of the products to evaporate. The product's quality might be regarded as guaranteed customer satisfaction [14]. Figures (5) to (7) show the ASTM D86 curves for Benzene, Kerosene, and HGO cuts respectively. The net molar liquid flow rate in each stage is shown in Figure (8). In this figure, we notice that the net flow rate is increased in stages between 1-3 and 11-14, this increase occurs because the effect of top and intermediate pump arounds. Nevertheless, the vapor rate is in high level within the stages 1-25 which indicates that the heat exchange is in very good condition, beside the vapor rate in the bottom of distillation column is near the zero rate which indicates that approximately only liquid phase exists in this part of the column.

Figure (9) shows that as the hydrocarbons molecular weight increased, the related light cut density decreased and this are an indication that the light cut presence decreased as the stage number increased according to boiling point range. Light cut (methane, ethane, propane, and butane) shows descending curves in Figure (10) that gives a conclusion of light cuts start to be decreased as the stages dropped down in the column.

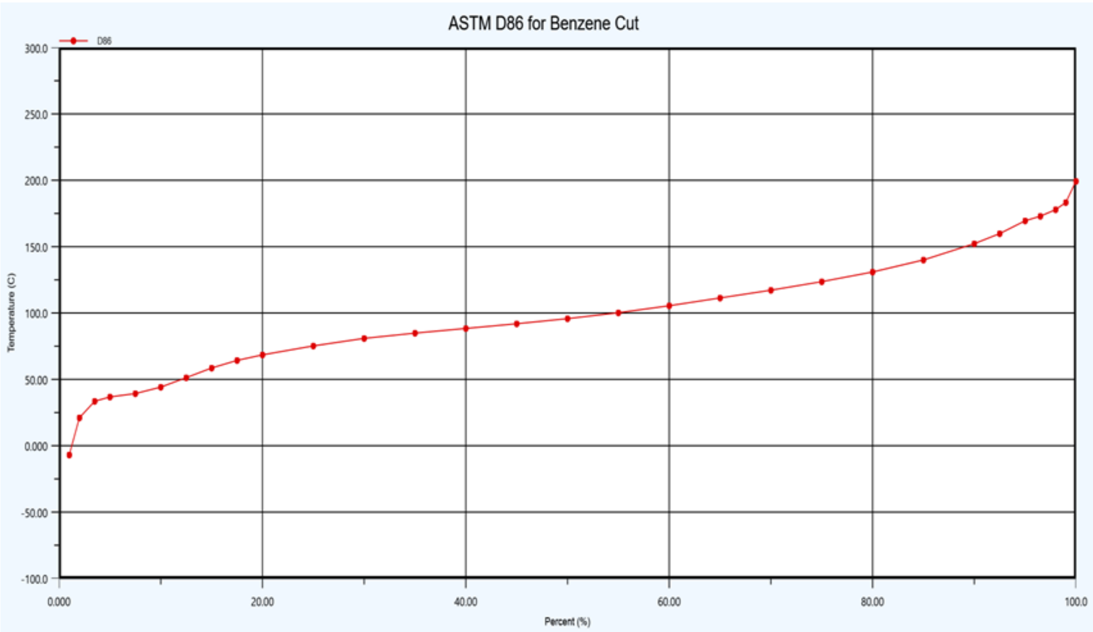

Fig. (5): ASTM D86 for Benzene Cut.

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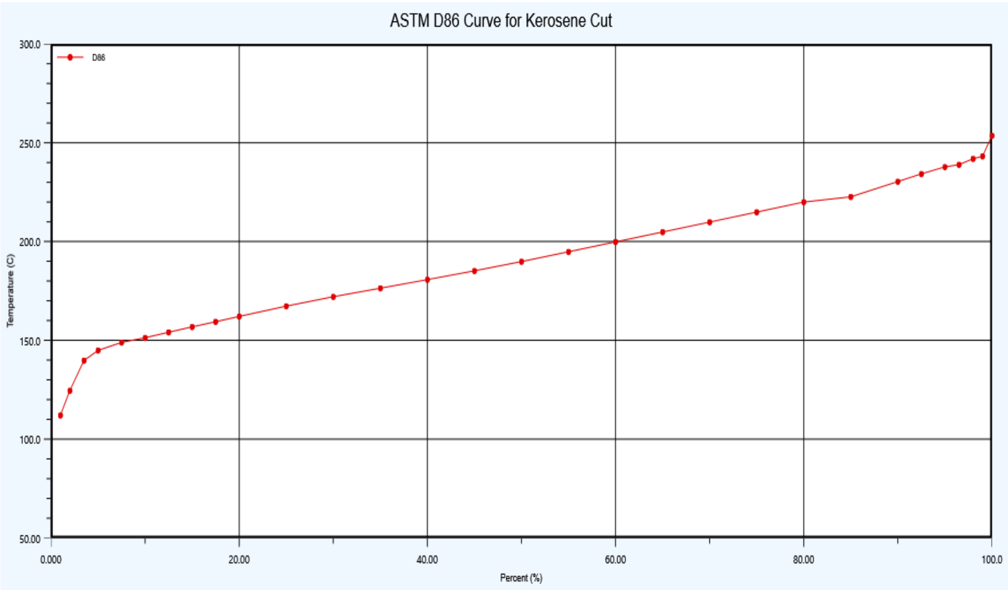

Fig. (6): ASTM D86 for Kerosene Cut.

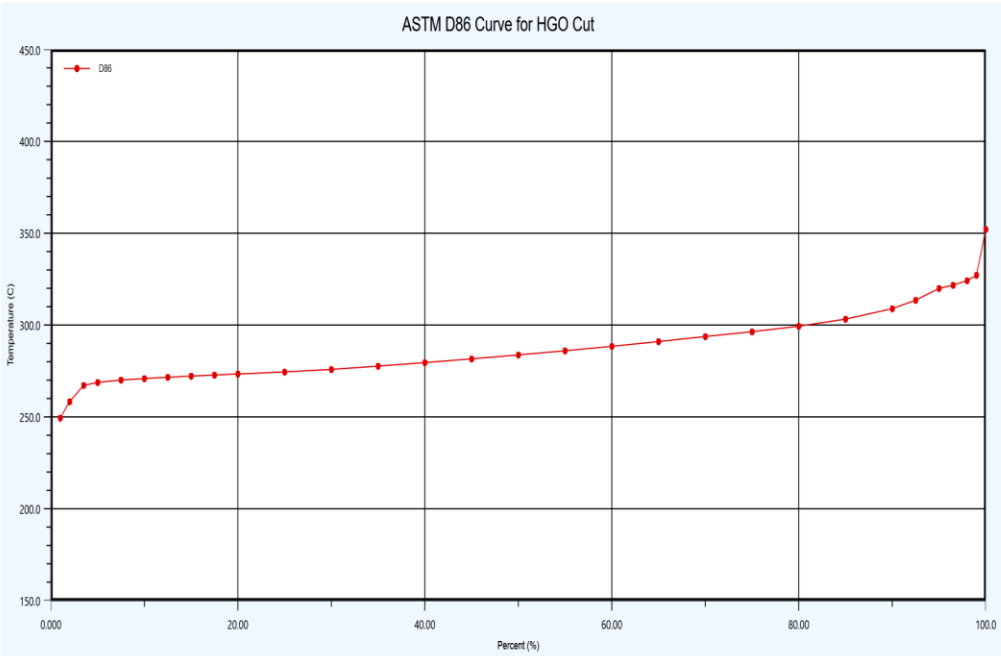

Fig. (7): ASTM D86 for HGO Cut.

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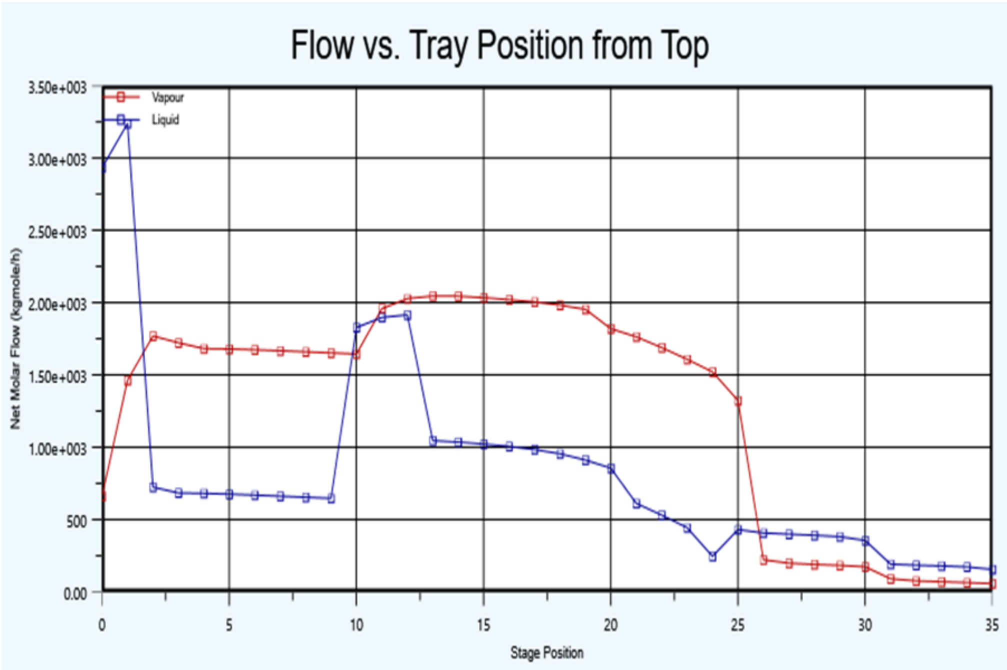

Fig. (8): Net molar flowrate profile.

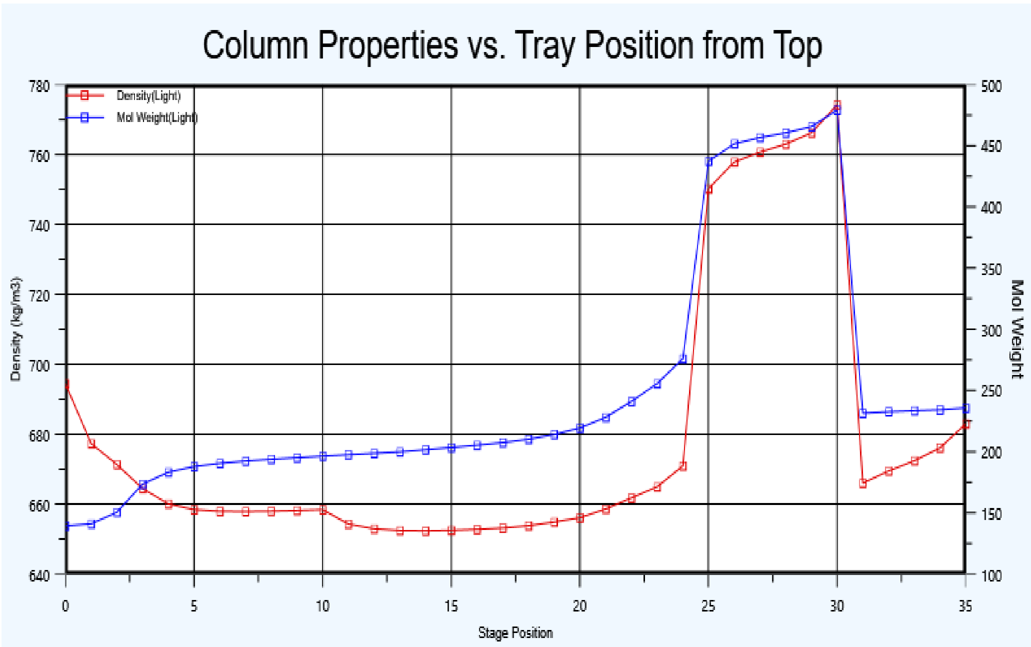

Fig. (9): Molecular weight and density profile.

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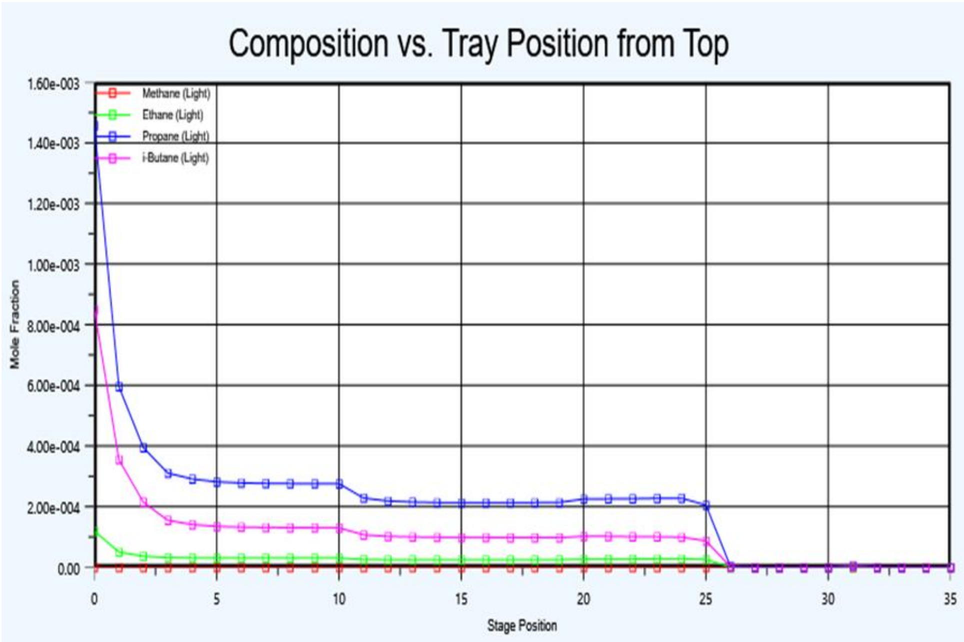

Fig. (10): Light cuts composition profile.

4.5.Results Validation

The Table (10) shows the comparison between actual plant data and simulated data with Aspen HYSYS for both volumetric flow rare and temperature.

Table (10) Comparison Between Plant and Aspen Simulation Data for Volumetric Flowrate and Temperature

Product	Volumetric Flow Rate (m^3/hr)			Temperature (°C)		
	Plant Data	Aspen Simulation	Error %	Plant Data	Aspen Simulation	Error %
Benzene	50.53	50.53	0.00	40.15	40	0.374
Kerosene	65	65	0.00	139.92	163.81	-17.07
HGO SS Feed	33	33	0.00	269.44	266.4	1.13
RCR	N/A	175	N/A	313.45	316.8	-1.07
Off Gas	N/A	7.57	N/A	40.15	40	0.374
Waste Water	N/A	3.25	N/A	40.15	40	0.374

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5. Technical and Economic Feasibility

Based on this simulated study, the CDU unit of the refinery can manage and control the blending ratio of the unit feed so that the quality and quantity of desired products can be controlled. Based on that, the operation of this unit will be improved economically (As the quantity and quality of desired products is improved, the profits of the sales are going up).

Also, this study suggests to replace the transfer pipe line (between furnace and main distillation column) with another one has higher diameter (similar to a typical design diameter) to increase the feed volumetric flowrate and operate this unit with its full capacity. So, the yield of desired products is increased and the profits will be increased too.

In summary, this study helps the North Oil Refining Company to improve the operation of this CDU unit technically and economically.

6. Conclusions

From the present study, Aspen HYSYS steady state simulation of real plant atmospheric distillation column of Salahaldin1 Refinery in Baiji Refineries provides following conclusions:

Crude oil feed of the main distillation column is composed of three crude oil types with the following blending ratio: 0.105, 0.5, and 0.398 for Ajeel, Basrah and Kirkuk crude oils respectively. it is concluded from this blending fractions that Basrah heavy crude oil has the large portions of the crude oil feed. This ratio demonstrates the plan of OIL MINISTRY to get more benefit by refining the heavy crude oil to avoid the consequences of the low prices in the international market if decided to export it abroad. However, these low prices will not recover the costs of extraction, transport and storing.

Steady state simulation gives a brief analysis to help understanding the behavior and operating conditions of crude distillation unit. Temperature profile shows a good agreement with plant data except a deviation appear in stage 3 (stopping tray) with -17.07% error due to the plate design difference using ASPEN HYSYS compared with actual plate design. This issue can be solved using towers design specialized software (KG TOWER) to design this complex tray so it can be used/imported in ASPEN HYSYS for future work.

The maintenance history of the plant indicates that the spare parts used in the transfer pipeline diameter between the furnace (unit 101B) and the crude distillation column (unit 101E) is smaller than the manufacturer specifications (were not available after the War). This is the

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main reason why this column cannot be operated with its full capacity of crude oil volumetric flow rate. So, this study suggested that, it is important to replace the transfer line pipe diameter according to the design specifications which enables the operators to rise the feed volumetric flowrate into full capacity.

This Aspen HYSYS simulation case helps us to understand and analyze the composition of each product in the tower. The result obtained by Aspen HYSYS show a good agreement with plant data, so this simulation software is a useful tool for understanding the crude tower behavior.

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