Improving Rectification Technology in Daura Refinery Crude Distillation Units by HYSYS

تطوير تكنولوجيا تصفية النفط في وحدات التكرير باستخدام برنامج المحاكاة HYSYS

Aaed jaber omran , Al.durra Refinary

Abstract

It is well known that the capacity of crude distillation units in any refinery reflects the capacity of the refinery itself, and that is because we consider these units as the first stage and all other units such as vacuum distillation, hydrotreating, reforming, catalytic cracking, and others depend on them. So we devoted our effort to keep these units work with high performance and efficiency.

The purpose of this paper is to develop crude distillation units in Daura refiner, rise their performance level and overcome weak points wherever detected.

Our work here conducted by simulation program (HYSYS) and consists of two stages: Before changing operating conditions, and after changing operating conditions. Each one will be discussed separately later.

This work shows that these old units contain a lot of mistakes because they are working since 1954. These mistakes are concentrated in miss operation due to absence of daily close monitoring to the operation conditions and product specifications related to gap and overlap conditions, and this really affects badly on rectification efficiency.

Introduction

After desalting and dehydration, crude oil is separated into fractions by distillation; the distilled fractions cannot be used directly.

Another reason for complexity is that environmental legislation demands cleaner products by developing novel processes.

Petroleum refining rocesses and operations can be separated into five basic areas:

• *Fractionation* (distillation) is the separation of crude oil in atmospheric and vacuum distillation towers into groups of hydrocarbon compounds of differing boiling-point ranges called "fractions" or "cuts".

• *Conversion Processes* is changing the size and/or structure of hydrocarbon molecules. These processes include**:**

–Decomposition (dividing) by thermal and catalytic cracking;

–Unification (combining) through alkylation and polymerization;

–Alteration (rearranging) with isomerization and catalytic reforming.

• *Treatment Processes :* to prepare hydrocarbon streams for additional processing and to prepare finished products. Treatment may include removal or separation of aromatics and naphthenes, impurities and undesirable contaminants. Treatment may involved chemical or physical separation *e.g.* dissolving, absorption, or precipitation using a variety and combination of processes including desalting, drying, hydrodesulfurizing, solvent refining, sweetening, solvent extraction, and solvent dewaxing.

•*Formulating and Blending* is the process of mixing and combining hydrocarbon fractions, additives, and other components to produce finished products with specific performance properties.

• *Other Refining Operations include*:

–Light-ends recovery;

–Sour-water stripping;

–Solid waste, process-water and wastewater treatment;

–cooling, storage and handling and product movement;

–Hydrogen production;

–Acid and tail-gas treatment;

–And sulfur recovery.

•*Auxiliary Operations and Facilities include*:

–Light steam and power generation;

–Process and fire water systems;

–Flares and relief systems;

–Furnaces and heaters;

–Pumps and valves;

–Supply of steam, air, nitrogen, and other plant gases;

–Alarms and sensors;

–Noise and pollution controls;

–Sampling, testing, and inspecting and laboratory;

–Control room;

–Maintenance;

–Administrative facilities.

Experimental details

In order to perform this work as best as possible and to get real results from the simulation program (HYSYS), we did experi-

Table-1 analysis has been done for crude oil inlet to distillation units for different days and for the distillation products before making any change in operating conditions as shown in the tables (1,2,3,4,5) listed below.

Table-1

TEST	26/11	27/11	30/11
API GRAVITY @ 15.6 °C	35.5	32.9	32.9
SP. GRAVITY @ 15.6 °C	0.8473	0.8555	0.8555
SULFURE CONTENT %W Wt.			
KIN. VISCOSITY Cst.	11.99		17.1
@10 °C			
@21.1 °C	7.85	11.6	113
@ 37.8 °C	5.05		4.8
@ 50.0 °C	3.9	5.0	
Pour Point °C			
R.V.P Kg/cm2	0.45	0.47	0.45
Water & Sediment % Vol.	0.05	0.05	0.05
Salt Content % Wt.	0.0012	0.0006	0.0006
	3.97	4.54	4.S
Asphaltenes Content % Wt.	1.4		1.85
Ash Content % Wt.	0.0070		
Vanadium PPM	23		27.2
Nickel PPM	6		9
KUOP Characterization Factor	12.0		12.0
Distillation			
IBP c			
Rec. @ 50.0 °C	1.5	2.0	2
@ 75.0 °C	4.5	4.0	4
@ 100.0 °C	9.0	9.5	8
@ 125.0 °C	14.0	14	14
@ 150.0 °C	22.5	19.5	19
@ 175.0 °C	29.5	25	24
@ 200.0 °C	36.0	30.5	29
@ 225.0 °C	41.5	36.5	35
@ 250.0 °C	46.5	39.5	39
@ 275.0 °C	50.0	43.5	43
@ 300.0 °C	52	48.0	47
Total Distil. % Vol.	57.0	50.0	49

Table-2

Crude oil API. Gravity @15.6 °C = 31.7			Crude oil Vis.= 7.94		25/11/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	78.1	64.5	48.9	40.1	34.5	17.0
Flash point °C			40.0	76.0	92.0	104.0
Color	+30	+30	+28	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					4.68	22.82 189.8
B.S. & W	0.2% water and sediment					
I.B.P	43	55	138			
10%	52	74	160			
20%	60	80	168			
30%	74	86	174			
40%	78	92	180			
50%	82	100	188			
60%	90	106	196			
70%	98	112	202			
80%	108	120	212			
90%	141	136	222			
E.B.P	152	172	255			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

Table-3

Crude oil API. Gravity @15.6 °C = 34.0			Crude oil Vis.= 5.51		26/11/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	76.5	61.3	52.0	44.2	36.2	18.2
Flash point °C			31.7	60.0	84.0	104.0
Color	+30	+28	+24	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					3.77	16.11 117.07
B.S. & W	0.2% water and sediment					
I.B.P	38	66	142			
10%	50	96	152			
20%	57	105	157			
30%	65	112	162			
40%	73	119	166			
50%	82	125	170			
60%	89	130	174			
70%	96	137	179			
80%	104	144	186			
90%	116	152	199			
E.B.P	142	186	230			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

Table-4

Crude oil API. Gravity @15.6 °C = 32.9			Crude oil Vis.= 7.18		27/11/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	77.1	61.2	49.3	41.3	33.6	17.6
Flash point °C			37.8	68.0	94.0	95.0
Color	+30	+28	+26	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					5.9	18.02 133.86
B.S. & W	0.2% water and sediment					
I.B.P	47	62	140			
10%	58	88	160			
20%	66	94	165			
30%	74	102	170			
40%	82	110	174			
50%	90	118	180			
60%	98	124	186			
70%	110	130	192			
80%	117	138	200			
90%	126	144	212			
E.B.P	158	186	255			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

Table-5

Crude oil API. Gravity @15.6 °C = 33.1			Crude oil Vis.= 6.88		28/11/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	75.3	60.4	49.3	42.0	34.7	17.1
Flash point °C			42.2	70.0	85.0	104.0
Color	+30	+27	+26	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					5.74	18.90 133.98
B.S. & W	0.2% water and sediment					
I.B.P	45	66	147			
10%	54	94	169			
20%	62	102	174			
30%	69	108	180			
40%	76	114	186			
50%	83	120	192			
60%	90	125	198			
70%	100	131	207			
80%	109	138	212			
90%	121	148	222			
E.B.P	150	183	249			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

As we said before in the abstract our experiment consists of two stages:-

1. <u>Stage before changing operating conditions</u>:-

In this stage the following operating conditions system has been used in Daura crude distillation units before the improvement time, as listed in tables (6, 7).

Table-6

Production quantities	
Cdu. No.2	Before (BBL/hr)
Crude oil feed(API=32.7)	800
HN.	60-70
Ker.	70-90
L.G.O.	(60-40) + gland oil
H.G.O.	25
RC.	-

Table-7

Operating conitions	
Cdu. No.2	Before
Top temp. (^{o}F)	200-215
Bottom temp. (^{o}F)	630-640
Upper Reflux draw-off temp. (^{o}F)	250-260
Upper Reflux draw-off quantity. (BBL/hr)	Equal to feed
Lower Reflux (in) temp. (^{o}F)	160-180
Lower Reflux draw-off quantity. (BBL/hr)	33% of feed

Also chromatography analysis for Heavy Naphtha (gasoline) has been done in Daura laboratory before the time of experiment, as shown in the figures (1, 2).

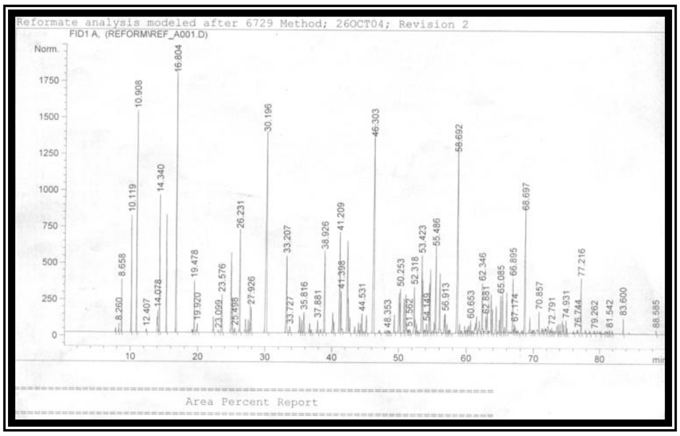

Fig.1

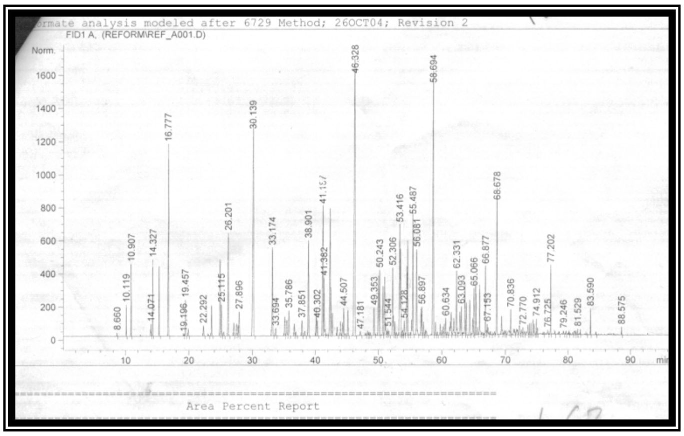

Fig.2

2. Stage after changing operating conditions (Experiment Time):-

In this stage the new operating conditions system has been adopted as we got it from simulation program (HYSYS) and several analyses for all products have been done.

Results

New operating conditions and products analysis tabulated below in tables (8, 9, 10, 11, 12) and distillation curves in figures (4,5,6,7,8,9,10).

Table-8

New product quantities	
Cdu.	After (BBL/hr)
Crude oil feed (API=32.7)	800
HN.	120-130
Ker.	90-115
L.G.O.	105 + gland oil
H.G.O.	Increased
RC.	Decreased

Table-9

New operating condition system	
Cdu.	After
Top temp. (^oF)	226-228
Bottom temp. (^oF)	600-610
Upper Reflux draw-off temp. (^oF)	280-290
Upper Reflux draw-off quantity. (BBL/hr)	85-90% of feed
Lower Reflux (in) temp. (^oF)	240-250
Lower Reflux draw-off quantity. (BBL/hr)	24% of feed

Table-10

Crude oil API. Gravity @15.6 °C = 31.7			Crude oil Vis.= 7.92		02/12/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	77.2	61.6	48.6	41.3	36.0	17.0
Flash point °C			43.3	74.0	86.0	104.0
Color	+30	+28	+27	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					3.02	20.19 170.14
B.S. & W	0.2% water and sediment					
I.B.P	42	64	150			
10%	51	100	165			
20%	60	115	170			
30%	68	125	175			
40%	76	130	180			
50%	86	135	186			
60%	94	140	190			
70%	104	145	200			
80%	112	150	210			
90%	121	160	220			
E.B.P	150	180	248			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

Table-11

Crude oil API. Gravity @15.6 °C = 32.0			Crude oil Vis.= 7.73		03/12/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	77.0	62.7	48.6	39.5	33.2	16.4
Flash point °C			41.1	80.0	90.0	104.0
Color	+30	+28	+26	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					5.48	25.53 241.01
B.S. & W	0.2% water and sediment					
I.B.P	42	60	138			
10%	50	88	160			
20%	56	100	166			
30%	62	108	172			
40%	70	115	180			
50%	78	122	186			
60%	86	130	192			
70%	92	138	200			
80%	102	142	212			
90%	118	150	224			
E.B.P	148	178	252			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

Table-12

Crude oil API. Gravity @15.6 °C = 33.3			Crude oil Vis.= 6.78		04/12/08	
Sample	LN	HN	Ker	Gasoil	Diesel	RC
API. Gravity @15.6 °C	77.6	62.4	50.3	41.5	34.3	17.1
Flash point °C			35.6	86.0	100.0	92.0
Color	+30	+28	+26	0.5		
Doctor test	Ps	Ps	Ps			
R.V.P. @ 37.8 °C						
Pour point °C						
Vis. @ 100 °C @ 50 °C					5.86	26.58 242.36
B.S. & W	0.2% water and sediment					
I.B.P	36	55	140			
10%	48	82	162			
20%	56	90	168			
30%	66	96	172			
40%	75	106	176			
50%	84	114	180			
60%	92	121	185			
70%	100	129	190			
80%	110	138	196			
90%	123	149	206			
E.B.P	156	184	238			
T.D.	96	98	99			
RES.	0.6	0.8	1.0			

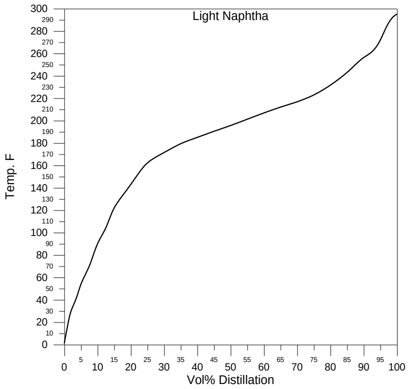

Fig-3

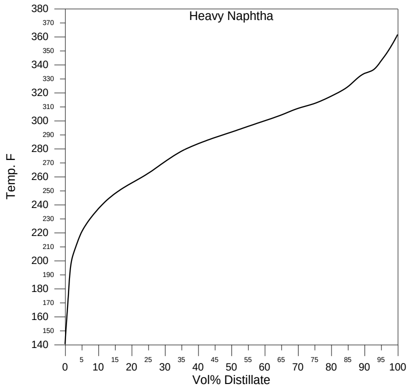

Fig-4

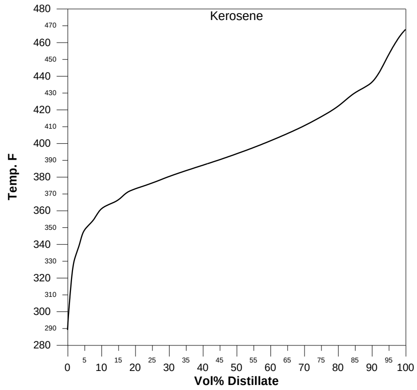

Fig-5

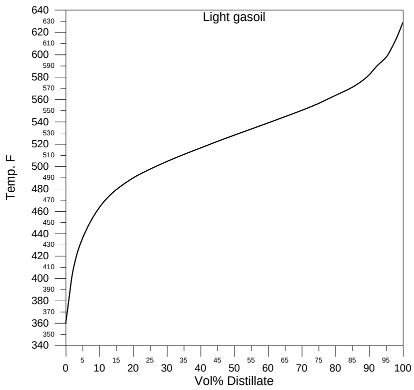

Fig-6

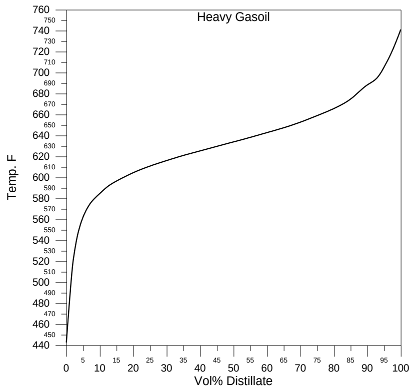

Fig-7

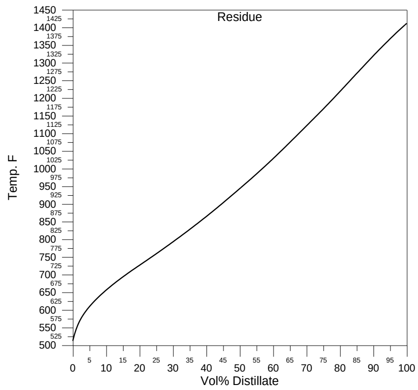

Fig-8

Table-13

%	**M^3/year**	**M^3/year**		
%	Annual increasing	Amount of product after experiment	Amount of product before experiment	Product
100%	82416.534	164833.06	82416.534	HN

Discussion

As a result of experiment the following points have been noticed:-

1. Water accumulation in water separator drum decreased to (90%) and that means no water will be present in the top trays and subsequently corrosion action due to (HCl) will be decreased.
2. End and initial boiling point of heavy naphtha, products and PONA distribution becomes stable despite withdrawing quantity increasing.
3. Decreasing the quantity of reduced crude (RC) despite reducing of furnace outlet temperature from (640 ^{o}F) to (600-620 ^{o}F) and decreasing stripping steam, which means annual fuel saving.
4. Total amount of products after this improvement increased more than (100 bbl/hr) for crude oil with API equal to (32.7).
5. Presence of condensed water in the upper section of the crude distillation tower particularly in the upper reflux trays plays as a water trap and decrease fractionation efficiency, in addition this makes the tower under the risk of high pressure due to water vaporization in case of lack or becoming half or less original quantity of upper reflux.

Now becomes possible to supply reforming unit with heavy naphtha continuously depending on only one unit but it was impossible before the experiment due to low production rate, see table (13).

Conclusion

1. Presence of water condensate in the tower will decrease the fractionation efficiency.
2. Corrosion becomes less in the top section of the distillation tower.
3. Using simulation programs technology can improve the operation process.
4. It is possible to improve operation conditions system for crude distillation units particularly if they are old.

References

1. Simulation program (HYSYS).
2. Donald M. Little/ Catalytic Reforming/ page-25.

الاسم : عائــد جابر عمران طعمة

العنوان الوظيفي : مهندس كيمياوي اقدم

موقع العمل :شركة مصافي الوسط / بغداد

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