INTEROFFICE MEMORANDUM

TO: NEW ENGINEER

FROM: I.M. ANOLDGUY

SUBJECT: CHANGE OF FEEDSTOCK TO CRUDE UNIT

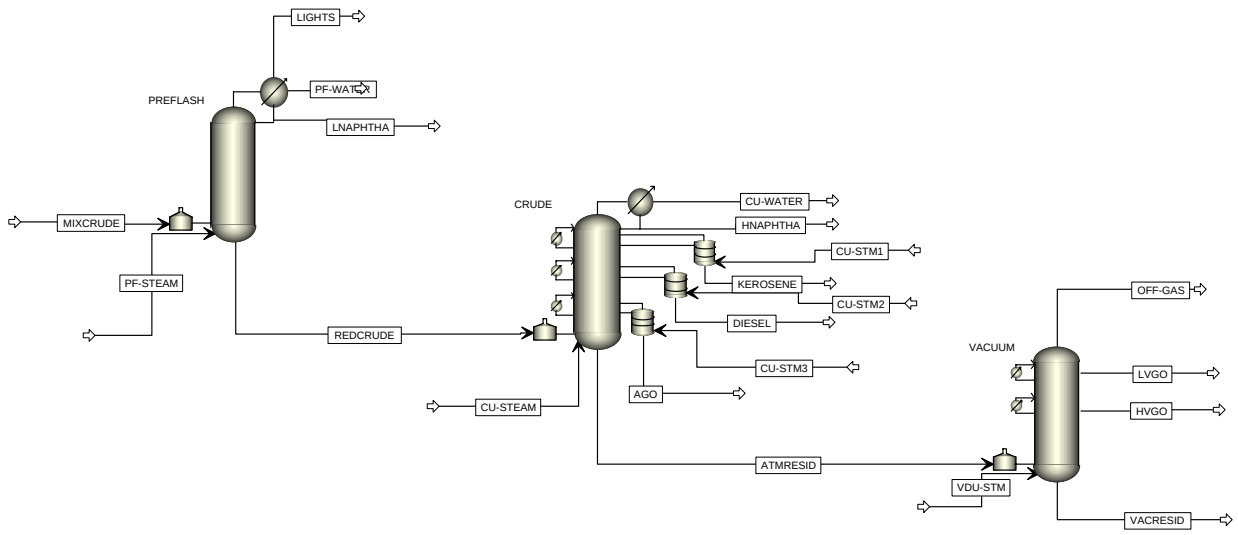
DATE: OCTOBER 12, 2009

We are looking to make a change to our crude unit feed in the near future. Your assignment is to analyze the current crude unit operation and determine the impact of any proposed changes. Depending on the magnitude of these changes we may need to make capital expenditures, so we need to start planning as soon as possible.

The report describing the expected operational changes will be due to me no later than 6:00 PM on Friday, November 13, 2009. I expect a memo report consisting of:

- A one-page Executive Summary describing the problem and summarizing the results.
- An Appendix with any tables, charts, and descriptions of the assumptions made in the simulations to support these results.
- Any Aspen files (in BKP format) used to generate the values in your report.

EXISTING OPERATIONS



You have been using something similar to the existing crude oil operations as a sample problem in your Petroleum Refining class. The preceding figure shows the arrangement of the crude oil separation train: a pre-flash column to separate the light gases (LIGHTS) and Light Naphtha (LNAPHTHA), followed by an atmospheric column with Heavy Naphtha (HNAPHTHA), Kerosene, Diesel, and Atmospheric Gas Oil (AGO) products, followed by a vacuum unit with

Light Vacuum Gas Oil (LVGO), Heavy Vacuum Gas Oil (HVGO), and Vacuum Bottoms (VACRESID) products.

The existing 100,000 bpd crude charge is made up of 20 vol% Oil-1 and 80 vol% Oil-2. The attached Tables 1 & 2 give assay data for these two oils.

The following table gives the important specifications on the products from these distillation columns.

Column	Product	Quality Specification	Adjust
Pre-Flash	Light Gas		
	Light Naphtha	14.0 psi RVP (ASTM) 374°F 90% D86 (dry, vol% basis)	Condenser Temperature Distillate Flow Rate
Atmospheric	Heavy Naphtha	374°F 90% D86 (dry, vol% basis)	Naphtha Draw Rate
	Kerosene		
	Diesel	590°F 90% D86 (dry, vol% basis)	Diesel Draw Rate
	AGO	–	
	Atmospheric Resid		
Vacuum	LVGO		
	HVGO		
	Vac Bottoms		

The following tables give current operating parameters for these distillation columns. ***The available steam is at 60 psi & 400°F.***

Column	Type Operating Parameter	Operating Parameter
Pre-Flash	Total Theoretical Stages	10
	Condenser Type	Partial with water draw
	Reboiler Type	No reboiler, oil & steam feed to bottom stage
	Distillate Rate	15,000 sbdp (est) (Naphtha)
	Pressures	39.7 psi Top Stage 41.7 psi Second Stage 44.7 psi Bottom Stage
	Feed Stages	Crude Charge to Stage 10 (bottom) 5,000 lb/hr steam to Stage 10 (bottom)
	Feed Preheater	Feed Furnace, 550°F & 50 psi outlet
	Liquid Draws	None
	Side Strippers	None
	Pumparounds	None

Column	Type Operating Parameter	Operating Parameter
Atmospheric	Total Theoretical Stages	25
	Condenser Type	Total with water draw
	Reboiler Type	No reboiler, steam feed to bottom stage
	Distillate Rate	13,000 sbdp (est) (Heavy Naphtha)
	Pressures	15.7 psi Top Stage 20.7 psi Second Stage 24.7 psi Bottom Stage
	Feed Stages	Pre-Flash Column Bottoms to Stage 22 (3 above bottom) 12,000 lb/hr steam to Stage 25 (bottom)
	Feed Preheater	Feed Furnace, 3 vol% overflash & 24.18 psi outlet
	Side Strippers	Liquid from Stage 6, vapor to Stage 5; Kerosene side stripper; 11,700 sbpd Liquid from Stage 13, vapor to Stage 12; Diesel side stripper; 16,500 sbpd (est) Liquid from Stage 18, vapor to Stage 17; AGO side stripper; 8,500 sbpd (est)
	Pumparounds	Partial draw from Stage 8 to Stage 6; 49,000 sbpd & 40.0 MMBtu/hr cooling Partial draw from Stage 14 to Stage 13; 11,000 sbpd & 15.0 MMBtu/hr cooling

Column	Type Operating Parameter	Operating Parameter
Kerosene Side Stripper	Total Theoretical Stages	4
	Pressures	
	Feed Stages	Liquid from Atm Column Stage 6 to Top Stage 3,300 lb/hr steam to Bottom Stage

Column	Type Operating Parameter	Operating Parameter
Diesel Side Stripper	Total Theoretical Stages	3
	Pressures	
	Feed Stages	Liquid from Atm Column Stage 13 to Top Stage 1,000 lb/hr steam to Bottom Stage

Column	Type Operating Parameter	Operating Parameter
AGO Side Stripper	Total Theoretical Stages	2
	Pressures	
	Feed Stages	Liquid from Atm Column Stage 18 to Top Stage 800 lb/hr steam to Bottom Stage

Column	Type Operating Parameter	Operating Parameter
Vacuum	Total Theoretical Stages	6
	Condenser Type	None
	Reboiler Type	No reboiler, steam feed to bottom stage
	Pressures	60 mmHg Top Stage 70 mmHg Bottom Stage
	Feed Stages	Atm Column Bottoms to Stage 6 (bottom) 20,000 lb/hr steam to Stage 6 (bottom)
	Feed Preheater	Feed Furnace, 0.6 vol% overflash & 110 mmHg outlet
	Liquid Draws	LVGO from Stage 2; Total Liquid Draw HVGO from Stage 4; 17,000 sbpd
	Pumparounds	Partial draw from Stage 2 to Stage 1; 20,000 sbpd & 28.0 MMBtu/hr cooling (est.); vary duty to control Top Stage to 150°F Partial draw from Stage 4 to Stage 3; 49,000 sbpd & 80.0 MMBtu/hr cooling

Considerations for Aspen Modeling

To perform the Aspen simulations, you must add in the RVP calculation to the report. There are notes on how to do this on a web site[1]. In particular:

1. Add the RVP calculation by going to the Data Browser, click on Properties, Prop-Sets, press the New button, call the property set RVP, and pick RVP-ASTM from the Physical properties list.
2. Add this calculation to the report by going to the Data Browser, click on Setup, Report Options, the Stream tab, click the Property Sets button, and add RVP from the Available property sets list.

NEW POTENTIAL FEEDSTOCK

We have the opportunity to replace Oil-2 with Ratawi (see Table 3). Compare the product rates for the given base case and that with 90% of Oil-2 replaced by Ratawi.

We would like to operate the columns with the same specifications but expect a few difficulties running Ratawi instead of Oil-2. Change the following operating specifications:

- Run the Pre-Flash column's condenser at 150°F, not the RVP of the Light Naphtha stream.

Estimate the light ends analysis for the Ratawi crude (methane, ethane, etc.) so that the Light Ends production and Light Naphtha RVP are properly calculated.

Tabulate & compare the following for these scenarios:

- The gravity and sulfur content for the overall crude charge.
- The production of the Light Gas (scf/day, dry basis).
- The production of Light Naphtha (bpd), the T10 & T90 values (D86 dry basis), RVP (psi), and sulfur content.

[1] http://home.comcast.net/~jjechura/CHEN409/#Extra_Notes

- The production of Heavy Naphtha (bpd), the T10 & T90 values (D86 dry basis), RVP (psi), and sulfur content.
- The production of Kerosene (bpd), the T10 & T90 values (D86 dry basis), and sulfur content.
- The production of Diesel (bpd), the T10 & T90 values (D86 dry basis), and sulfur content.
- The production of AGO, LVGO, & HVGO (bpd), their T10 & T90 values (TBP dry basis), and sulfur content.
- The production of Vac Bottoms (bpd), the T10 value (TBP dry basis), and sulfur content.

Table 1. Assay Data for Oil-1

TBP Analysis		Light Ends Analysis		Properties		
Vol%	**°F**		**Vol Fraction**	**Mid Vol%**	**Gravity**	**wt% Sulfur**
6.8	130	Methane	0.001	2		0.00
10	180	Ethane	0.0015	5	90	0.01
30	418	Propane	0.009	10	68	0.013
50	650	i-Butane	0.004	15	59.7	
62	800	n-Butane	0.016	20	52	0.05
70	903	i-Pentane	0.012	30	42	1.15
76	1000	n-Pentane	0.017	40	35	1.62
90	1255	Total	0.0605	45	32	1.90
				50	28.5	2.15
				60	23	2.54
				70	18	3.00
				80	13.5	3.70
				Bulk	31.4	2.30

Table 2. Assay Data for Oil-2

TBP Analysis		Light Ends Analysis		Properties		
Vol%	**°F**		**Vol Fraction**	**Mid Vol%**	**Gravity**	**wt% Sulfur**
6.5	120	Methane	0.002	2	150	0.00
10	200	Ethane	0.005	5	95	0.01
20	300	Propane	0.005	10	65	0.015
30	400	i-Butane	0.01	20	45	0.056
40	470	n-Butane	0.01	30	40	1.30
50	550	i-Pentane	0.005	40	38	1.70
60	650	n-Pentane	0.0025	45		2.00
70	750	*Total*	0.0395	50	33	2.30
80	850			60	30	2.70
90	1100			70	25	3.20
95	1300			80	20	3.80
98	1475			90	15	
100	1670			95	10	
				98	5	
				Bulk	34.8	2.5

Table 3. Assay Data for Ratawi

	Whole Crude	Light Naphtha	Medium Naphtha	Heavy Naphtha	Kero	Atm Gas Oil	Light VGO	Heavy VGO	Vacuum Resid	Atm Resid
TBP Temp At Start, °C	Start	10	80	150	200	260	340	450	570	340
TBP Temp At End, °C	End	80	150	200	260	340	450	570	End	End
TBP Temp At Start, °F	Start	55	175	300	400	500	650	850	1050	650
TBP Temp At End, °F	End	175	300	400	500	650	850	1050	End	End
Yield at Start, vol%		1.7	5.6	15.3	21.0	29.2	40.4	57.3	71.5	40.4
Yield at End, vol%		5.6	15.3	21.0	29.2	40.4	57.3	71.5	100.0	100.0
Gravity, °API	24.5	82.9	57.0	49.3	41.4	33.2	22.1	15.7	3.5	11.2
Sulfur, wt%	3.88	0.01	0.08	0.33	0.98	2.42	3.50	4.20	6.96	5.41
Mercaptan Sulfur, ppm		274	597	258	72	29	8	0		
Nitrogen, ppm	2066		0	0	1	90	759	1528	5156	3158
Hydrogen, wt%	11.7	16.2	14.3	14.3	13.7	13.0	12.0	11.1	9.2	10.4
Viscosity @ 40 °C (104 °F), cSt	30.5			1.13	1.78	5.87	27.0	272	1.10E+09	4102
Viscosity @ 50 °C (122 °F), cSt	21.5			0.982	1.51	4.40	17.7	143	6.13E+07	1750
Viscosity @ 100 °C (212 °F), cSt	6.19			0.576	0.824	1.59	4.18	17.5	32200	115
Viscosity @ 135 °C (275 °F), cSt	3.52			0.443	0.613	0.996	2.23	7.33	2660	37.9
Freeze Point, °C				-60.000	-38.000	-4.000	27.0			
Freeze Point, °F				-76	-36	25	81			
Pour Point, °C	-23			-68	-41	-6	24	41	40	22
Pour Point, °F	-10			-90	-42	22	76	106	104	72
Smoke Point, mm (ASTM)				28	23	18				
Aniline Point, °C			52	57	61	68	73	78		
Aniline Point, °F			125	135	142	154	164	173		
Total Acid Number, mg KOH/g	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1		
Cetane Index, ASTM D976				43	48	49				
Diesel Index			71	66	59	51	36	27		
Characterization Factor (K Factor)	11.8	12.8	11.8	12.0	11.8	11.8	11.6	11.7	11.5	11.6
Research Octane Number, Clear		68.1	51.0	18.6						
Motor Octane Number, Clear		66.5	48.9							
Paraffins, vol%		85.7	57.7	62.1	46.8	43.5	29.0			
Naphthenes, vol%		14.3	28.6	21.4	32.9	28.2	30.2	30.2		
Aromatics, vol%		0.0	13.7	16.5	20.3	28.3	40.8	38.4		
Thiophenes, vol%										
Molecular Weight	320	102	116	150	177	228	308	456	1080	525
Gross Heating Value, MM BTU/bbl	6.01	4.83	5.32	5.50	5.66	5.83	6.07	6.22	6.44	6.30
Gross Heating Value, kcal/kg	10530	11610	11230	11140	10990	10750	10470	10280	9740	10080
Gross Heating Value, MJ/kg	44.1	48.6	47.0	46.6	46.0	45.0	43.8	43.0	40.8	42.2
Heptane Asphaltenes, wt%	6.1								18.5	9.4
Micro Carbon Residue, wt%	11.3								34.2	17.3
Ramsbottom Carbon, wt%	10.5								32.0	16.2
Vanadium, ppm	47								144	73
Nickel, ppm	22								67	34
Iron, ppm	4								12	6