

Homework #8

Imagine that you have been hired to work at a 150,000 bpd refinery processing Hibernia crude oil. It has been proposed to “slump” the Vacuum Tower – i.e., adjust the cut point between the HVGO & Vacuum Resid. You’ve been asked to estimate the difference in performance for the FCCU and Delayed Coker.

We want to compare operations for two cases:

- The Base Case will have a cut point similar to the crude oil assay. The 500 – 1050°F material (Atm Gas Oil, Light VGO, & Heavy VGO) will go to the FCCU. The 1050°F+ material (i.e., the Vacuum Resid) will be fed to the Delayed Coker.
- For the Slumped Case we will make the cut between the HVGO & the Vacuum Resid at 950°F. The 500 – 950°F material (Atm Gas Oil, Light VGO, and the 850-950°F portion of the HVGO) will go to the FCCU. The 950°F+ material (i.e., the 950-1050°F portion of the Heavy VGO & the Vacuum Resid) will be fed to the Delayed Coker.

To prepare for the Slumped Case calculations:

1. What is the incremental vol% yield of the 850-950°F portion of the HVGO? What is its API gravity of this fraction?¹ What is the specific gravity? What is the Watson K Factor?²
2. What is the incremental vol% yield of the 950-1050°F portion of the HVGO? What is its API gravity of this fraction?¹ What is the specific gravity?

For the Base Case:

3. For the coker:
 - What is the feed rate (bpd & ton/day)?
 - What are the feed properties (API gravity & CCR)?
 - How much Coker Gasoline will be produced (bpd)?
 - How much Coke will be produced (ton/day)?
4. For the FCCU operating at 70% conversion:
 - What is the feed rate (bpd & ton/day)?
 - What are the feed properties (API gravity & Watson K factor)?³
 - How much Cat Gasoline will be produced (bpd)?
 - How much Coke will be produced (ton/day)?

For the Slumped Case:

5. Calculate the same values for the coker as in #3.
6. Calculate similar values for the FCCU as in #4. However, estimate the conversion to produce the same amount of coke (in ton/day) as in the Base Case. What is this conversion?

¹ Use interpolation of the API gravity vs yield in the original crude oil assay.

² Approximate the mean average boiling point with the boiling point at the middle of the increment.

³ Use the approximate weight blending rule for the Watson K factor.

Hibernia Crude Oil – Summary of Major Cuts

	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%		1.6	7.3	21.3	30.9	41.6	56.7	74.3	86.6	56.7
Yield at End, vol%		7.3	21.3	30.9	41.6	56.7	74.3	86.6	100.0	100.0
Yield of Cut (wt% of Crude)		4.5	12.6	8.9	10.4	15.1	18.4	13.3	15.6	47.3
Yield of Cut (vol% of Crude)		5.7	14.0	9.6	10.7	15.1	17.6	12.3	13.4	43.3
Gravity, °API	35.9	81.0	53.9	48.6	40.7	35.2	28.1	22.8	13.0	21.6
Specific Gravity	0.8454	0.6660	0.7632	0.7857	0.8218	0.8489	0.8868	0.9168	0.9791	0.9240
Sulfur, wt%	0.34	0.00	0.00	0.01	0.02	0.15	0.40	0.53	1.07	0.66
Mercaptan Sulfur, ppm		1	2	2	3	3	3			
Nitrogen, ppm	1035		0	1	1	51	710	1837	4186	2170
Hydrogen, wt%		16.1	15.9	15.4	14.6	14.0	13.2	12.5		
Viscosity @ 40 °C (104 °F), cSt	5.09			1.07	1.74	4.06	16.9	168	69661	257
Viscosity @ 50 °C (122 °F), cSt	3.55			0.938	1.47	3.26	12.2	93.8	20100	141
Viscosity @ 100 °C (212 °F), cSt	1.04			0.563	0.797	1.46	3.84	13.6	465	19.1
Viscosity @ 135 °C (275 °F), cSt	0.610			0.438	0.591	0.994	2.27	6.03	110	8.21
Freeze Point, °C				-58.000	-31.000	2.00	45.0			
Freeze Point, °F				-72	-23	36	113			
Pour Point, °C	13		-87	-60	-34	-1	34	51	35	29
Pour Point, °F	55		-125	-76	-29	31	93	124	95	84
Smoke Point, mm (ASTM)				25	20	17	15			
Aniline Point, °C				52	60	71	86	98		
Aniline Point, °F				125	140	160	187	208		
Total Acid Number, mg KOH/g	0.11	0.0	0.0	0.0	0.0	0.0	0.1	0.2		
Cetane Index, ASTM D976				37	46	52				
Diesel Index				61	57	56	52	48		
Characterization Factor (K Factor)	11.6	12.7	11.6	11.8	11.8	11.9	12.0	12.2	12.0	12.0
Research Octane Number, Clear		64.8	56.4	34.2						
Motor Octane Number, Clear		63.0								
Paraffins, vol%		83.1	48.1	51.2	46.9	40.0	30.6			
Naphthenes, vol%		16.9	35.2	30.4	31.8	33.0	36.1			
Aromatics, vol%		0.0	16.7	18.4	21.2	27.0	33.3			
Thiophenes, vol%										
Molecular Weight	233	103	112	143	176	227	326	471	824	436
Gross Heating Value, MM BTU/bbl	5.81	4.86	5.38	5.52	5.71	5.85	6.03	6.18	6.42	6.20
Gross Heating Value, kcal/kg	10900	11580	11190	11140	11050	10940	10800	10690	10390	10660
Gross Heating Value, MJ/kg	45.6	48.5	46.8	46.6	46.2	45.8	45.2	44.7	43.5	44.6
Heptane Asphaltenes, wt%	0.9								5.6	1.9
Micro Carbon Residue, wt%	1.2								8.0	2.6
Ramsbottom Carbon, wt%	1.2								7.6	2.5
Vanadium, ppm	1								6	2
Nickel, ppm	1								6	2
Iron, ppm										