

Homework #6

Imagine that you have been hired to work at a 100,000 bpd refinery with a 15,000 bpd delayed coker. You've been asked to specify a blend of Ratawi and Brent crude oils to the refinery and the subsequent performance of the coker. See the attached table for the assay data for these crude oils.

1. We would like to process the 1050°F+ vacuum resid as the coker feed. How much of each crude oil should be used so that both the distillation complex & the delayed coker are at capacity?
2. What are the following properties for this blended coker feed:
 - API & specific gravities.
 - Conradson Carbon Residue (CCR).
 - sulfur content.
 - Nickel & vanadium content.
 - Density (lb/ft³) & viscosities (cSt & cP) at 212°F & 275°F.
3. What is the expected yield structure for the coker products:
 - Coke: tons/day; sulfur content; nickel & vanadium content.
 - Light gas: scf/day; composition.
 - Coker gasoline: bpd; sulfur content.
 - Coker gas oil: bpd; sulfur content.

Ratawi 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%		1.7	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
Yield of Cut (wt% of Crude)		2.8	8.0	5.0	7.4	10.6	17.2	15.0	32.9	65.1
Yield of Cut (vol% of Crude)		3.9	9.7	5.8	8.2	11.2	16.9	14.2	28.5	59.6
Gravity, °API	24.5	82.9	57.0	49.3	41.4	33.2	22.1	15.7	3.5	11.2
Specific Gravity	0.9068	0.6601	0.7507	0.7828	0.8182	0.8592	0.9210	0.9615	1.0482	0.9914
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

Brent 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%		3.4	11.3	27.1	37.1	47.1	61.8	78.3	89.8	61.8
Yield at End, vol%		11.3	27.1	37.1	47.1	61.8	78.3	89.8	100.0	100.0
Yield of Cut (wt% of Crude)		6.3	14.4	9.4	9.9	15.1	17.6	12.7	12.3	42.6
Yield of Cut (vol% of Crude)		8.0	15.8	10.0	10.0	14.8	16.5	11.5	10.2	38.2
Gravity, °API	38.5	83.2	54.4	48.2	40.9	35.1	27.9	22.1	10.3	21.1
Specific Gravity	0.8311	0.6591	0.7611	0.7874	0.8210	0.8494	0.8877	0.9212	0.9982	0.9273
Sulfur, wt%	0.43	0.00	0.00	0.01	0.04	0.25	0.57	0.82	1.44	0.90
Mercaptan Sulfur, ppm		3	5	4	4	3	3			
Nitrogen, ppm	1040			0	1	54	736	1910	5376	2423
Hydrogen, wt%	13.3	16.3	14.2	13.9	13.6	13.3	12.7	12.5	10.8	12.1
Viscosity @ 40 °C (104 °F), cSt	3.55			0.954	1.60	4.08	21.2	180	2.17E+05	189
Viscosity @ 50 °C (122 °F), cSt	2.94			0.853	1.37	3.24	14.6	102	51400	107
Viscosity @ 100 °C (212 °F), cSt	1.45		0.382	0.552	0.755	1.39	3.97	15.2	731	16.3
Viscosity @ 135 °C (275 °F), cSt	1.03			0.444	0.565	0.938	2.23	6.79	150	7.31
Freeze Point, °C			-100.000	-68.000	-42.000	-8.000	33.0	52.0		
Freeze Point, °F			-148	-90	-43	17	91	126		
Pour Point, °C	2		-114	-78	-49	-14	29	49	56	33
Pour Point, °F	35		-174	-109	-56	7	85	120	132	92
Smoke Point, mm (ASTM)				28	22	18	15	13		
Aniline Point, °C				53	61	71	83	93		
Aniline Point, °F				127	142	159	182	200		
Total Acid Number, mg KOH/g	0.05			0.0	0.0	0.0	0.0	0.1		
Cetane Index, ASTM D976				37	47	52				
Diesel Index				61	58	56	51	44		
Characterization Factor (K Factor)	12.1	12.8	11.7	11.8	11.8	11.9	12.0	12.1	11.8	11.9
Research Octane Number, Clear		65.2	56.8	43.3						
Motor Octane Number, Clear		63.8	54.7							
Paraffins, vol%		87.5	46.1	42.8	38.5	33.9	26.7	25.3		
Naphthenes, vol%		12.5	40.4	37.2	39.9	41.2	43.1	43.2		
Aromatics, vol%		0.0	13.5	19.9	21.5	24.9	30.2	31.6		
Thiophenes, vol%										
Molecular Weight	209	102	113	143	176	225	317	468	880	418
Gross Heating Value, MM BTU/bbl	5.76	4.82	5.37	5.52	5.70	5.85	6.03	6.18	6.47	6.20
Gross Heating Value, kcal/kg	10990	11580	11210	11140	11030	10940	10760	10660	10290	10620
Gross Heating Value, MJ/kg	46.0	48.5	46.9	46.6	46.2	45.8	45.0	44.6	43.1	44.5
Heptane Asphaltenes, wt%	0.4								3.1	0.9
Micro Carbon Residue, wt%	1.9								15.6	4.5
Ramsbottom Carbon, wt%	1.8								14.8	4.3
Vanadium, ppm	7								58	17
Nickel, ppm	1								11	3
Iron, ppm										