School of Engineering

Chemical and Petroleum Engineering Department

Petroleum Refining Engineering (CHEN 462) & Process Dynamic and Control (CHEN 482)

Instructor: Dr. Sara Faiz

Project

This project is collaborative project that integrate skills and knowledge obtain in two chemical engineering courses (CHEN 462 & CHEN 482).

Students are required to select one of the crude oil feedstock data provided in the following appendix to design one of the following refinery processes in a group consist of two members:

1. Crude Distillation Unit (CDU) (Team A: Ruwda & Khalid)
2. Fluid Catalytic Cracking (FCC) (Team B: Mohammed & Tasnim)

The report must consist of the following:

- The main hypotheses and design steps (Material & Energy balance)
- Design specification
- Design standards and constrains
- Design of control system (including dynamic model, selection of controller, identifying type of control loop and system block diagram)
- Steps for optimization
- Operation procedures
- Expected products

Submission deadline of the final report and presentation is May 6, 2022

Appendix A

Arabian medium, Saudi Arabia

Crude
Gravity, °API: 30.8
Sulfur, wt %: 2.40
Pour point, °F.: +5
RVP, psi: 3.2
Viscosity
Kin. cSt @ 70° F.: 16.2
Kin. cSt @ 100° F.: 9.41

Light naphtha
Range, °FVT: 68-212
Yield, vol %: 8.9
Gravity, °API: 77.7
Sulfur, wt %: 0.043

RVP, psi: 7.9
Paraffins, vol %: 85.3
Naphthenes, vol %: 12.3
Aromatics, vol %: 2.4
RON, clear 54.5

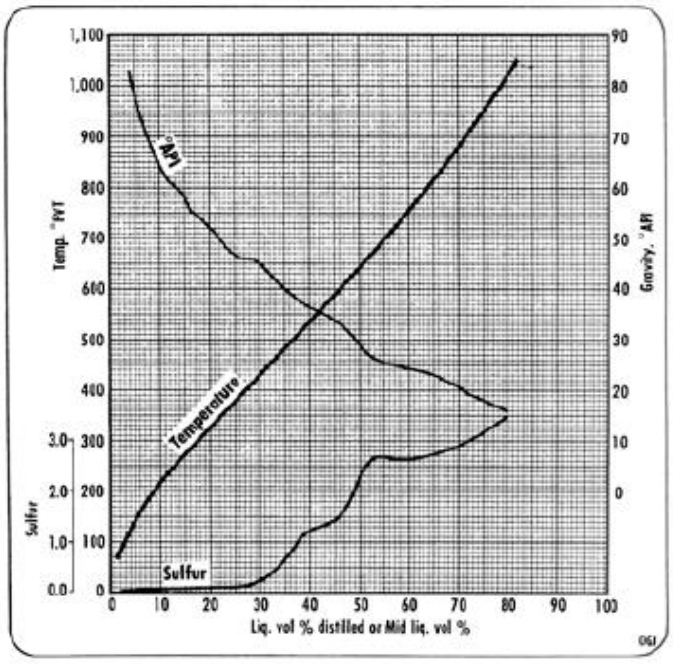
Heavy naphtha
Range, °FVT: 212-302
Yield, vol %: 7.7
Gravity, °API: 59.1
Sulfur, wt %: 0.050
Paraffins, vol %: 68.5
Naphthenes, vol %: 18.7
Aromatics, vol %: 12.7

Kerosine
Range, °FVT: 302-455
Yield, vol %: 14.5
Gravity, °API: 48.0
Sulfur, wt %: 0.14
Paraffins, vol %:
Naphthenes, vol %:
Aromatics, vol %: 20.6
Freeze point, °F: −62
Smoke point, mm: 23
Luminometer No.: 52
Aniline point, °F.: 136
Viscosity
Kin., cSt @ −30° F.: 5.10
Kin., cSt @ 100° F.: 1.13

Light gas oil
Range, °FVT: 455-650
Yield, vol %: 18.1
Gravity, °API: 36.0
Sulfur, wt %: 1.24
Pour point, F.: 15
Aniline point, °F.: 157
Viscosity
Kin., cSt @ 100° F.: 3.53
Kin., cSt @ 210° F.: 1.32

Heavy gas oil
Range, °FVT: 650-1,049
Yield, vol %: 30.9
Gravity, °API: 21.9
Sulfur, wt %: 2.91
Pour point, °F.: 100
Aniline point, °F.: 176
Viscosity
Kin., cSt @ 100° F.: 49.2
Kin., cSt @ 210° F.: 6.40

Arabian medium



Residual oil
Range, °FVT: 650+
Yield, vol %: 49.6
Gravity, °API: 15.0
Sulfur, wt %: 3.90
Pour point, °F.: 55
Con carbon, wt %: 9.9
Viscosity
Kin., cSt @ 100° F.: 850
Kin., cSt @ 210° F.: 36.0

Residual oil
Range, °FVT: 1,049+
Yield, vol %: 18.7
Gravity, °API: 4.9
Sulfur, wt %: 5.35
Pour point, °F.: 115

Con carbon, wt %: 23.3
Viscosity
Kin., cSt @ 210° F.: 3,847
Furor, sec @ 275° F.: 226
Metals
Vanadium, ppm: 96
Nickel, ppm: 32
Iron, ppm: 30

Appendix B

Kuwait crude, Kuwait

Crude
Gravity, °API: 31.2
Sulfur, wt %: 2.50
Viscosity, SUS at 100° F.: 58.7
Pour point, °F.: 0
C4 and lighter, vol %: 2.46
Reid vapor pressure, lb.: 5.4
Vanadium, ppm: 31
Nickel, ppm: 9.6
Con. carbon residue, wt %: 5.3
Salt, lb/1,000 bbl: 3
ASTM, 50% point, °F.: >590

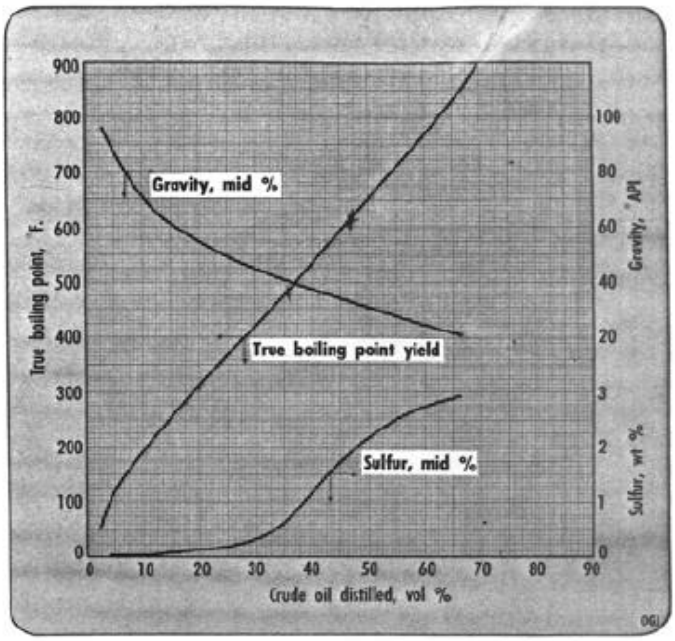
Light naphthas
TBP range, °F.: IBP-140*
Yield, vol %: 5.49
Gravity, °API: 94.6
Sulfur, wt %: 0.01
Paraffins, vol %: 98.5
Naphthenes, vol %: 1.4
Aromatics, vol % 0.1
Res. octane, clear: 78.5
Res. octane, +3 ml TEL: 92.0
ASTM, 50% point, °F.: 96

Light naphthas
TBP range, °F.: 140-170
Yield, vol %: 1.85
Gravity, °API: 78.2
Sulfur, wt %: 0.02
Paraffins, vol %: 86.2
Naphthenes, vol %: 12.5
Aromatics, vol %: 1.3
Res. octane, clear: 58.8
Res. octane, +3 ml TEL: 76.3
ASTM, 50% point, °F.: 156

Heavy naphtha
TBP range, °F.: 170-310
Yield, vol %: 12.03
Gravity, °API: 62.2
Sulfur, wt %: 0.02
Paraffins, vol %: 67.9
Naphthenes, vol %: 22.1
Aromatics, vol %: 10.0
Aniline point, °F.: 132.8
ASTM, 50% point, °F.: 244

Kerosine
TBP range, °F.: 310-520
Yield, vol %: 18.20
Gravity, °API: 45.9
Sulfur, wt %: 0.28
Aromatics, vol %: 19.5
Freezing point, °F.: −46
Aniline point, °F.: 143
Cetane Index: 52.3
Smoke point (ASTM), mm: 24
ASTM, 50% point, °F.: 403

Kuwait crude



Light gas oil
TBP range, °F.: 520-680
Yield, vol %: 14.11
Gravity, °API: 33.7
Viscosity, SUS at 100° F.: 41.3
Sulfur, wt %: 1.66
Pour point, °F.: +20
Diesel index: 53.6
Cetane index: 55
ASTM, 50% point, °F.: 573

Heavy gas oil
TBP to EFV range, °F.: 680-1,000
Yield, vol %: 26.59
Gravity, °API: 21.7
Viscosity, SUS at 210° F.: 53.9
Sulfur, wt %: 2.91
Nitrogen (total), ppm: 950
Pour point, °F.: +100
Aniline point, °F.: 178
Vanadium, ppm: 0.4
Nickel, ppm: 0.1
ASTM, 50% point, °F.: 850

Residual oils
TBP or EFV, °F.: 680+
Yield, vol %: 47.53
Gravity, °API: 14.0
Viscosity, SUS at 210° F.: 267
Sulfur, wt %: 4.14
Con. carbon residue, wt %: 9.37
Pour point, °F.: +70
Vanadium, ppm: 59
Nickel, ppm: 18

*Does not include uncondensed gases of 0.79 vol % to crude.

Appendix C

Murban, Abu Dhabi

Crude
Gravity, °API: 39.4
Sulfur, wt %: 0.74

Rvp, psi: 5
Pour point, °C.: −15
Wax content, wt %: 8.0
Vis., cSt @ 21° C.: 5.0
Salt content, lb/1,000 bbl: <5
V/Ni, ppm: 0.8/0.58

Straight-run gasoline
Range, °C.: C_5-75
Yield, vol %: 6.78
Gravity, °API: 82.2
Sulfur, wt %: 0.012
Rvp, psi: 10.1
RON, clear: 69
RON + 0.5 ml TEL/liter: 84

Naphtha
Range, °C.: 75-175
Yield, vol %: 21.22
Gravity, °API: 56.9
Sulfur wt %: 0.013
Paraffins, wt %: 63
Naphthenes, wt %: 20
Aromatics, wt %: 17
Aniline point, °C.: 51.3

Kerosine

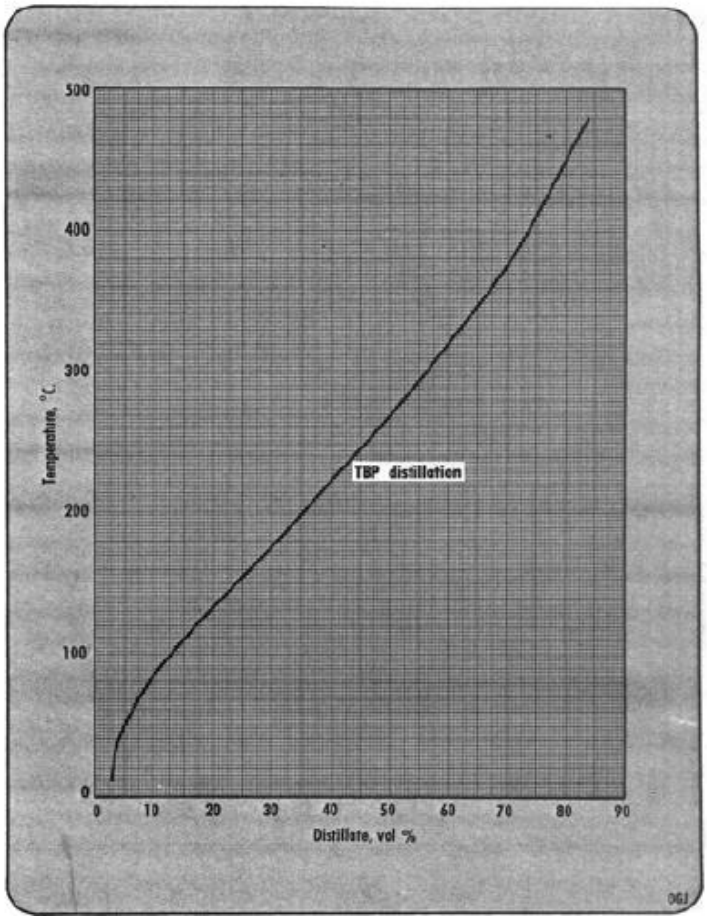
Range, °C.: 175-250
Yield, vol %: 16.14
Gravity, °API: 45.4
Sulfur, wt %: 0.058
Aniline point, °C.: 61.8
Diesel index: 65
Smoke point, mm: 24

Freezing point, °C.: −43
Vis., cSt @ 20° C.: 1.8

Gas oil
Range, °C.: 250-300
Yield, vol %: 10.40
Gravity, °API: 37.8
Sulfur, wt %: 0.47
Diesel index: 59
Cetane index: 54
Pour point, °C.: −18
Vis., cSt @ 20° C.: 4.2

Gas oil
Range, °C.: 300-350
Yield, vol %: 9.24
Gravity, °API: 33.6
Sulfur, wt %: 1.06
Diesel index: 58
Wax content, wt %: 17.5
Pour point, °C.: +4
Vis., cSt @ 20° C.: 9.5

Murban



Residual oil
Range, °C.: 350+
Yield, vol %: 34.51
Gravity, °API: 22.6
Sulfur, wt %: 1.49
Pour point, °C.: +35
Wax content, wt %: 19.5
Conradson carbon, wt %: 3.6
Vis., cSt @ 37.8° C.: 104
V/Ni, ppm 2/2

Project Data Sheet

CDU Data Sheet

Table 1. Properties of Crude Oil

Sample type	Density of crude oil	Specific Gravity	Wax content	Pour point	Total acid number (TAN)	water content	sulfur content	Asphalting content
	Density @15C°	S.G	Wax content%	Pour point C°	TAN mg KoH/g	Water content wt%	sulfur content wt%	Asphalting content wt%
Dar blend	913.6	914.5	19.28	39	4.47	0.4	0.1272	0.12
Fulla light	881.3	882.1	21.68	12	0.35	3.0	0.0813	0.1
Sargas	927.8	928.6	20.99	12	1.64	0.05	0.1227	0.08
Nile blend	878.4	872.9	29.95	30	0.66	0.20	0.0745	0.14
B.of fulla+staroil	836.3	836.9	36.88	42	0.12	2.8	0.0885	0.04

Table 2. The Kinematic viscosity

Sample type	k. Viscosity @50C°	k. Viscosity @60C°	k. Viscosity @70C°
Dar blend	440.5	233.4	139.8
Fulla light	32.54	21.34	16.06
Sargas	499.4	278.7	170.6
Nile blend	39.03	25.06	17.88
B.of fulla+staroil	12.97	7.761	6.696

Table 3. Crude oil & products properties

Stream	Mass flow Kg/h	Temp. °C	Cp Kj/kg.°C	Latent heat Kj/kg
Feed crude	312500.00	365	1.861	
Naphtha	20281.25	123	2.38	262.838
Kerosene	26093.75	170	2.68	232.600
Light diesel	45437.5	260	2.8	209.340
Heavy diesel	11593.75	340	2.88	198.240
Residue	208468.75	355	3.2	

FCC Unit data sheet

No.	Item	
1	1st regen big ring air flow	1577
2	1st regen small ring air flow	313
3	Cat cooler air flow	97.4
4	2nd regen air flow	752
5	Transfer air from 1st regen to 2nd regen flow.	513
6	Degaser air flow	8.8
7	1st regen flue gas outlet temp ℃	647.4
8	2nd regen flue gas outlet temp, ℃	699.1
9	1st regen dense phase temp ℃	674
10	2nd regen dense phase temp, ℃	716.6
11	Main air temp. ℃	202
12	Boost air temp ℃	262
13	Injection steam temp to reaction, ℃	281
14	Atomization steam for fresh feed ,t/h	4.95
15	Atomization steam for fresh feed ,t/h	4.87
16	Atomization steam for fresh feed ,t/h	4.94
17	Atomization steam for fresh feed ,t/h	1.79
18	Atomization steam for recycle oil ,t/h	1.38
19	Atomization steam for recycle oil ,t/h	1.36
20	Lifting dry gas for riser, nm^3/h	–
21	Lifting steam for riser, t/h	0.613
22	Striping steam for settler, t/h	0.531
23	Striping steam for settler, t/h	1.08
24	Striping steam for settler, t/h	1.02
25	Striping steam for settler, t/h	4.96
26	Striping steam for settler, t/h	1.1
27	Settler bottom outlet temp ℃	513
28	Settler top outlet temp ℃	463

29	1.0 MPa steam temp, ℃	263
30	3.6 MPa steam temp, ℃	432
31	Cat cooler blowdown quantity,t/h	2. 74
32	Cat from cat cooler temp,℃	448. 8
33	Cat cooler generated steam flow, t/h	48. 14
34	Cat cooler generated steam temp,℃	246. 2
35	Cat cooler feed water flow,t/h	50. 88
36	Cat cooler feed water temp,℃	189. 7
37	Fresh feed flow t/h	74. 14
38	Fresh feed flow t/h	73. 8
39	Fresh feed flow t/h	72. 7
40	Recycle oil flow t/h	12. 43
41	Recycle oil flow t/h	11. 2
42	Slurry oil flow t/h	-
43	Tops oil flow t/h	15. 7
44	Feed oil entering reactor temp,℃	205
45	Recycle oil entering reactor temp,℃	325
46	Recycle slurry entering reactor temp,℃	347
47	Thriller oil entering reactor temperature, ℃	45
48	Stabilized gasoline, t/h	93/120
49	LPG off-unit, t/h	34//36
50	Diesel off-unit	48/54
51	Slurry off-unit	3. 16
52	Dry gas off-unit	14. 43
53	Dry gas to boiler	353
54	1st regen top press,MPa	0. 257
55	2nd regen top press,MPa	0. 26
56	Reactor top press,MPa	0. 214
57	Dry gas off-unit press,MPa	0. 878
58	Dry gas off-unit temp ºC	34

59	Dry gas to boiler press,MPa	0. 032
60	temp of dry gas to boiler oC	36
61	Top reflux outlet temp,℃	11
62	Cold reflux inlet temp,℃	45
63	Cold reflux flow,t/h	40
64	Top reflux outlet temp,℃	142
65	Top reflux inlet temp,℃	83
66	Top reflux flow,t/h	426
67	1st reflux outlet temp,℃	262
68	1st reflux inlet temp,℃	191
69	1st reflux flow,t/h	279
70	2nd reflux outlet temp,℃	323
71	2nd reflux inlet temp,℃	257
72	2nd reflux flow,t/h	204
73	Lean absorb oil from column outlet temp,℃	217
74	Rich absorb oil from column inlet temp ,℃	131
75	Lean absorb oil from column flow ,t/h	36
76	Fractionator bottom stiring steam flow,t/h	1. 26
77	Light diesel stripping steam flow,t/h	0. 45
78	Heavy diesel stripping steam flow ,t/h	1. 08
79	Light diesel drawing temp,℃	190
80	Heavy diesel flow	48
81	Heavy diesel drawing temp,℃	218
82	Recycle oil return column flow	54
83	Recycle oil return column temp,℃	359
84	Upper return slurry flow	173
85	Upper return slurry temp,℃	286
86	Bottom return slurry flow	480
87	Bottom return slurry temp,℃	286
88	Slurry out of column temp,℃	347
89	Oil and gas temp below 1st column trap ,℃	359

American University of Ras Al Khaimah

الجامعة الأمريكية في رأس الخيمة

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Department of Chemical and Petroleum Engineering

Chemical Engineering Program

Petroleum Refining Engineering (CHEN 462) & Chemical Process Dynamic and Control (CHEN 482)

Project Evaluation Rubrics

Name/ID:

Rubric	Student Project Assessment Criteria	Excellent (5)	Very good (4)	Good (3)	Medium (2)	Unsatisfactory (1)
Research skills	Identify the problem [1]					
	Ability to address potential conceptual constraints [2]					
	Collect & Analyse data with supporting methodology and generate results [6]					
	Present conclusions and applications of research findings [3]					
Interdisciplinary Curriculum	Identify & Discuss problem from multiple perspectives [6]					
	Link the theoretical to the practical applications [1]					
Entrepreneurship	Acquire new knowledge in the area of chemical engineering processes [7]					
	Apply critical and creative thinking to design selected process [2 & 6]					
	Verify the use of moderate chemical engineering research tool or software [7]					
Communicate effectively	Uses logical organizational pattern which enhances understanding [3]					
	Identify and cite credible sources [3]					
	Delivers effective oral presentations on technical topics [3]					
Total (60 Marks)						