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APPENDICES

Appendix A True Boiling Point Curve Result

Table A1 True boiling point temperature vs. recovery percent of previous crude (LK1) that was obtain from Sim-dist GC data

Reocovery (%)	True boilng point temperture (°C) brought from Sim-Dist GC data						
	Run 1	Run 2	Run 3	Run 4	Run 5	Average	SD
0	95.3	91.8	90.3	90.2	98.1	93.1	3.5
5	112.4	109.5	106.7	106.0	120.6	111.0	5.9
10	143.7	138.8	135.1	153.9	151.6	144.6	8.1
20	190.6	182.8	177.1	181.0	198.0	185.9	8.4
30	225.8	216.7	210.3	215.1	233.3	220.2	9.2
50	281.6	270.5	262.7	268.8	286.9	274.1	9.9
70	345.0	337.7	329.1	329.8	347.5	337.8	8.5
80	376.6	372.9	359.6	359.4	376.9	369.1	8.9
90	414.1	415.7	400.9	395.7	411.0	407.5	8.7
100	487.0	491.5	466.9	457.9	483.9	477.4	14.4

Table A2 True boiling point temperature vs. recovery percent of new crude (LK2) that was obtain from Sim-dist GC data

Reocovery (%)	True boilng point temperture (°C) brought from Sim-Dist GC data						
	Run 1	Run 2	Run 3	Run 4	Run 5	Average	SD
0	77.4	75.3	77.8	75.2	77.5	76.6	1.3
5	80.3	77.1	81.7	76.5	81.2	79.4	2.4
10	105.5	101.8	106.9	100.5	105.5	104.0	2.7
20	143.4	139.1	145.0	136.6	142.1	141.2	3.4
30	176.2	172.4	177.7	168.7	174.6	173.9	3.5
50	241.8	240.5	242.0	235.5	240.5	240.1	2.6
70	318.1	312.9	317.7	306.0	309.9	312.9	5.2
80	357.6	351.9	355.7	339.8	345.5	350.1	7.4
90	407.3	402.8	402.4	383.6	390.1	397.2	9.9
100	485.5	487.3	479.2	451.4	454.3	471.5	17.4

Appendix B Hydrocarbon Solvent Effect

Table B1 Pour point of new crude was treated by pentane following new methodology (based on 80°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
2.5	1	0.6248	25.0179	25.5	26.0	0.5
	2	0.6249	25.0287	26.0		
	3	0.6257	25.0216	26.5		
5	1	1.2524	25.0478	20.5	20.8	0.3
	2	1.2515	25.0635	21.0		
	3	1.2515	25.0419	20.8		
7.5	1	1.8785	25.0159	17.5	18.0	0.5
	2	1.8790	25.0001	18.5		
	3	1.8768	25.1690	18.0		

Table B2 Pour point of new crude was treated by hexane following new methodology (based on 80°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
2.5	1	0.6303	25.0039	25.8	24.8	0.9
	2	0.6279	25.0787	24.2		
	3	0.6392	25.3155	24.5		
5	1	1.2584	25.0263	19.5	19.2	0.3
	2	1.2528	25.011	19.0		
	3	1.2595	25.0125	19.0		
7.5	1	1.8789	25.0302	16.5	16.7	0.3
	2	1.8764	25.0318	17.0		
	3	1.8887	26.3241	16.5		

Table B3 Pour point of new crude was treated by heptane following new methodology (based on 80°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
2.5	1	0.6254	25.0011	24.5	24.8	0.3
	2	0.6271	25.0295	25.0		
	3	0.6261	25.0176	25.0		
5	1	1.2591	25.0161	17.5	17.7	0.3
	2	1.2501	25.2408	18.0		
	3	1.2541	25.0211	17.5		
7.5	1	1.8761	25.2817	16.5	16.7	0.3
	2	1.8765	25.1251	16.5		
	3	1.8751	25.1072	17.0		

Table B4 Pour point of new crude was treated by heptane following new methodology (based on 60°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
1	1	0.2577	25.0088	32.5	32.3	0.3
	2	0.2588	25.0164	32.0		
	3	0.2561	25.0117	32.5		
2.5	1	0.6280	25.0208	31.0	30.7	0.3
	2	0.6328	25.0601	30.5		
	3	0.6277	25.0185	30.5		
5	1	1.2540	25.0375	28.5	29.2	0.6
	2	1.2543	25.0393	29.5		
	3	1.2567	25.0287	29.5		
7.5	1	2.0261	25.0117	29.0	28.8	0.3
	2	2.0379	25.0045	29.0		
	3	2.0285	25.0188	28.5		
10	1	2.7800	25.0168	28.0	28.0	0.0
	2	2.7776	25.0445	28.0		
	3	2.7857	25.0121	28.0		

Table B5 Pour point of new crude was treated by toluene following new methodology (based on 60°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
1	1	0.2572	25.0189	30.5	30.6	0.2
	2	0.2559	25.0049	30.8		
	3	0.2563	25.0127	30.5		
2.5	1	0.6491	25.0248	29.5	29.3	0.3
	2	0.6436	25.0547	29.0		
	3	0.6441	25.0271	29.5		
5	1	1.3253	25.0872	27.8	28.0	0.2
	2	1.3158	25.0393	28.2		
	3	1.3207	25.0148	28.0		
7.5	1	2.0458	25.0437	27.8	27.3	0.5
	2	2.0311	25.0214	27.0		
	3	2.0311	25.0079	27.0		
10	1	2.7923	25.0205	26.5	26.7	0.3
	2	2.7794	25.0408	26.5		
	3	2.7736	25.0119	27.0		

Table B6 Pour point of new crude was treated by o-xylene following new methodology (based on 60°C)

Concentration (% wt/wt)	Run	Solvent wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
1	1	0.2595	25.0110	31.0	31.2	0.3
	2	0.2564	25.0299	31.0		
	3	0.2557	25.0126	31.5		
2.5	1	0.6561	25.0123	29.0	29.3	0.3
	2	0.6412	25.0257	29.5		
	3	0.6426	25.0207	29.5		
5	1	1.3125	25.0227	28.0	28.3	0.3
	2	1.3167	25.0662	28.5		
	3	1.3224	25.0134	28.5		
7.5	1	2.0290	25.0224	28.0	28.2	0.3
	2	2.0311	25.0629	28.5		
	3	2.0217	25.0155	28.0		
10	1	2.7815	25.0141	26.8	26.9	0.1
	2	2.7815	25.0594	27.0		
	3	2.7826	25.0173	27.0		

Appendix C Single Polymer Effect

Table C1 Pour point of new crude was treated by PMAO (solid phase) following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
100	1	0.0027	25.0503	32.5	32.3	0.3
	2	0.0026	25.0117	32.0		
	3	0.0026	25.0201	32.5		
200	1	0.0052	25.0302	31.0	31.2	0.3
	2	0.0053	25.0172	31.5		
	3	0.0052	25.0118	31.0		
400	1	0.0102	25.0059	31.0	31.2	0.3
	2	0.0103	25.0722	31.0		
	3	0.0107	25.0054	31.5		
600	1	0.0148	25.0072	31.5	31.7	0.3
	2	0.0154	25.0305	31.5		
	3	0.0151	25.1164	32.0		
800	1	0.0209	25.1125	31.0	31.5	0.5
	2	0.0198	25.0269	31.5		
	3	0.0208	25.2315	32.0		
1000	1	0.0248	25.0081	32.0	32.5	0.5
	2	0.0253	25.0057	33.0		
	3	0.0252	25.0078	32.5		

Table C2 Pour point of new crude was treated by POMA following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
100	1	0.0116	25.0057	32.5	32.8	0.3
	2	0.0104	25.0188	32.8		
	3	0.0122	25.0071	33.0		
200	1	0.0230	25.0063	31.5	31.8	0.3
	2	0.0214	25.0171	32.0		
	3	0.0205	25.0236	32.0		
400	1	0.0463	25.0095	32.0	32.2	0.3
	2	0.0405	25.0436	32.5		
	3	0.0417	25.0113	32.0		
600	1	0.0652	25.0367	32.5	32.0	0.5
	2	0.0661	25.0271	32.0		
	3	0.0657	25.0109	31.5		
800	1	0.0881	25.0017	32.0	31.7	0.3
	2	0.0866	25.0197	31.5		
	3	0.0875	25.0201	31.5		
1000	1	0.1003	25.0374	32.0	32.2	0.3
	2	0.1109	25.0134	32.0		
	3	0.1096	25.0211	32.5		

Table C3 Pour point of new crude was treated by PEBAMA (solid phase) following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
100	1	0.0027	25.0373	31.5	31.5	0.0
	2	0.0024	25.0163	31.5		
	3	0.0026	25.0156	31.5		
200	1	0.0054	25.0218	30.5	30.5	0.0
	2	0.0053	25.0149	30.5		
	3	0.0052	25.0331	30.5		
400	1	0.0107	25.0276	30.0	31.2	1.0
	2	0.0094	25.0113	31.5		
	3	0.0104	25.0069	32.0		
600	1	0.0153	25.3909	31.5	31.8	0.3
	2	0.0151	25.0232	32.0		
	3	0.0155	25.0673	32.0		
800	1	0.0207	25.0779	30.5	31.2	0.6
	2	0.0203	25.0266	31.5		
	3	0.0205	25.0203	31.5		
1000	1	0.0249	25.0266	31.5	31.5	0.0
	2	0.0255	25.0117	31.5		
	3	0.0253	25.0066	31.5		

Table C4 Pour point of new crude was treated by PMAO that diluted in toluene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
100	1	0.0167	25.0242	32.0	32.0	0.0
	2	0.0163	25.0012	32.0		
	3	0.0165	25.1770	32.0		
200	1	0.0303	25.1014	30.0	30.7	0.6
	2	0.0332	25.0012	31.0		
	3	0.0331	25.0000	31.0		
400	1	0.0629	25.0036	31.5	31.2	0.3
	2	0.0641	25.0538	31.0		
	3	0.0709	25.0478	31.0		
600	1	0.0917	25.0047	31.5	31.1	0.8
	2	0.1002	25.1249	31.5		
	3	0.0908	25.0389	30.2		
800	1	0.1287	25.0013	30.5	30.8	0.3
	2	0.1216	25.0059	31.0		
	3	0.1379	25.0238	31.0		
1000	1	0.1552	25.0593	32.0	32.2	0.3
	2	0.1586	25.0988	32.0		
	3	0.1593	25.0004	32.5		

Table C5 Pour point of new crude was treated by PMAO that diluted in o-xylene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (oC)	Pour Point Average (oC)	SD of Pour Point (oC)
100	1	0.0159	25.0397	31.5	31.9	0.5
	2	0.0150	25.0587	31.8		
	3	0.0150	25.0265	32.5		
200	1	0.0313	25.0167	31.5	31.3	0.3
	2	0.0302	25.0043	31.5		
	3	0.0307	25.0325	31.0		
400	1	0.0614	25.0031	30.8	30.9	0.1
	2	0.0615	25.0296	31.0		
	3	0.0619	25.0263	31.0		
600	1	0.0912	25.3036	31.0	31.2	0.3
	2	0.0959	25.0902	31.0		
	3	0.0922	25.0707	31.5		
800	1	0.1223	25.0241	30.5	30.2	0.3
	2	0.1247	25.0204	30.0		
	3	0.1227	25.0194	30.0		
1000	1	0.1503	25.0206	32.5	31.5	0.9
	2	0.1518	25.0148	31.0		
	3	0.1502	25.0462	31.0		

Table C6 Pour point of new crude was treated by EVA 40 % vinyl acetate content that diluted in toluene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
100	1	0.0156	25.0129	31.5	31.7	0.3
	2	0.0152	25.0476	32.0		
	3	0.0153	25.0107	31.5		
200	1	0.0319	25.0112	32.0	31.8	0.3
	2	0.0313	25.0705	32.0		
	3	0.0296	24.9958	31.5		
400	1	0.0619	25.0406	28.0	27.7	0.6
	2	0.0614	25.0085	27.0		
	3	0.0603	25.0097	28.0		
600	1	0.0913	25.0121	26.5	26.5	1.0
	2	0.0911	25.8620	27.5		
	3	0.0907	25.0085	25.5		
800	1	0.1219	25.0227	23.0	23.5	0.5
	2	0.1211	25.0060	23.5		
	3	0.1214	25.0425	24.0		
1000	1	0.1562	25.0023	18.0	17.2	1.0
	2	0.1582	25.0062	16.0		
	3	0.1573	25.0599	17.5		
2000	1	0.3004	25.0065	13.0	13.4	0.5
	2	0.3018	25.0274	13.2		
	3	0.3022	25.0164	14.0		

Table C7 Pour point of new crude was treated by EVA 33 % vinyl acetate content that diluted in toluene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
100	1	0.0273	25.0172	30.2	29.9	0.4
	2	0.0280	25.0329	29.5		
	3	0.0278	25.0177	30.0		
200	1	0.0571	25.0120	27.0	27.3	0.6
	2	0.0557	25.0246	27.0		
	3	0.0564	25.0199	28.0		
400	1	0.1161	25.0264	20.0	21.2	1.3
	2	0.1091	25.0109	22.5		
	3	0.1097	25.0136	21.0		
600	1	0.1673	25.0283	21.0	21.2	0.3
	2	0.1673	25.0217	21.0		
	3	0.1678	25.0293	21.5		
800	1	0.2220	25.0129	22.0	21.9	0.4
	2	0.2227	25.0228	21.5		
	3	0.2196	25.0342	22.2		
1000	1	0.2780	25.0156	17.5	18.6	1.5
	2	0.2836	25.0192	18.0		
	3	0.2751	25.2751	20.3		

Table C8 Pour point of new crude was treated by EVA 25 % vinyl acetate content that diluted in toluene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
100	1	0.0147	25.0215	27.0	26.7	0.5774
	2	0.0156	25.0264	26.0		
	3	0.0150	25.0251	27.0		
200	1	0.0327	25.0012	21.5	21.7	0.7638
	2	0.0298	25.0258	21.0		
	3	0.0300	25.0085	22.5		
400	1	0.0604	25.0081	20.0	20.3	0.2887
	2	0.0623	25.0138	20.5		
	3	0.0610	25.0293	20.5		
600	1	0.0907	25.0149	21.5	21.7	0.7638
	2	0.0917	25.0168	21.0		
	3	0.0922	25.0084	22.5		
800	1	0.1203	25.0195	22.0	21.7	0.2887
	2	0.1230	25.0309	21.5		
	3	0.1238	25.0247	21.5		
1000	1	0.1537	25.0158	22.5	22.5	0.5000
	2	0.1519	25.0632	22.0		
	3	0.1541	25.0148	23.0		

Table C9 Pour point of new crude was treated by EVA 18 % vinyl acetate content that diluted in toluene following new methodology (based on 60°C)

Concentration (ppm)	Run	Ihibitor wt. (g)	Crude oil wt. (g)	Pour Point (°C)	Pour Point Average (°C)	SD of Pour Point (°C)
100	1	0.0276	25.0191	28.5	27.9	0.7
	2	0.0277	25.0070	28.0		
	3	0.0272	25.0105	27.2		
200	1	0.0549	25.0138	28.0	28.2	0.3
	2	0.0511	25.0298	28.5		
	3	0.0558	25.0092	28.0		
400	1	0.1101	25.0236	25.0	24.8	0.3
	2	0.1108	25.0255	24.5		
	3	0.1124	25.0186	24.8		
600	1	0.1660	25.0226	29.0	28.2	0.8
	2	0.1658	25.0006	27.5		
	3	0.1646	24.9911	28.0		
800	1	0.2205	25.0405	31.5	30.8	0.6
	2	0.2199	25.0123	30.5		
	3	0.2206	25.0235	30.5		
1000	1	0.2747	25.0019	31.0	31.3	0.3
	2	0.2752	25.0165	31.5		
	3	0.2760	25.0089	31.5		

Appendix D Calculation of Disposal Cost Correlation

The company loses money to clean wax in the tank wagon tank. The cost can be categorized into 2 parts, i.e. treatment coat and opportunity loss cost. The cost calculation is based on the information provided by the company.

Information provided by the company

A.) Steam of cleaning ROB in RTW = 20,000 Baht/unit.
1 unit produced wax-sludge average = 3 ton of wax-sludge.

B.) Wax-sludge produced from RTW produced = 190 ton/month.
Disposal cost of 3 wax-sludge by tracks is free of charge.

C.) Water treatment for oil contaminated waste water 35 ton/month @ 3,000 Baht/ton of contaminated waste water.

D.) Rail transportation cost = 320 Baht/1,000 litre.

E.) Sale of ROB as crude = 26.58 US$/bbl.

Total disposal cost calculation per month = [steam cost] + [water treatment cost] + [rail transportation cost] + [loss of income from sale ROB as crude]

Correlation of total cost calculation per ton of wax sludge

Steam cost = [20,000 Baht/Unit]*[1/3 ton of wax-sludge]
= 6,666.7 Baht/ton of wax-sludge

Water treatment cost = [35 ton/month]/[3,000 Baht/ton]*[190 ton/month]
= 552.6 Baht/ton of wax-sludge

Rail transport cost = [320 Baht/1,000 liter]*[159 liter/bbl.]
[1 bbl./0.1272 ton]/1,000

= 400 Baht/ton of wax-sludge

Loss of income sale ROB as crude = $\frac{[26.58\ US\$/bbl.]*[41.03\ US\$/Baht]}{[1\ bbl./0.1272\ bbl.]}$

= 8573.7 Baht/ton of wax-sludge

From all parameter can be find the correlation between total disposal and ROB percent as

Total disposal cost (Baht) = [6,666.7 + 552.6 + 400 + 8573.7]*(ton of ROB)

Total disposal cost (Baht) = 16193*(ton of ROB)

We can be rewrite in term of changing of total disposal cost with changing of amount of ton of ROB that is,

Δ Total disposal cost (Baht) = 16193*(Δ ton of ROB)

Appendix E Calculation of Total Disposal Cost per Year

The company loses money to clean wax in the tank wagon tank. The cost can be categorized into 2 parts, i.e. treatment coat and opportunity loss cost. The cost calculation is based on the information provided by the company.

Information provided by the company

A.) Steam of cleaning ROB in RTW = 20,000 Baht/unit.
1 unit produced wax-sludge average = 3 ton of wax-sludge.

B.) Wax-sludge produced from RTW produced = 190 ton/month.
Disposal cost of 3.wax-sludge by tracks is free of charge.

C.) Water treatment for oil contaminated waste water 35 ton/month @ 3,000 Baht/ton of contaminated waste water.

D.) Rail transportation cost = 320 Baht/1,000 litre.

E.) Sale of ROB as crude = 26.58 US$/bbl.

The calculated was based on following,

1. 1 month of operation
2. Specific gravity of crude = 0.8
3. Conversion 1 bbl. = 159 liter
   = 0.1272 ton of crude (sp.gr = 0.8)
4. 1 US$ = 41.03 Baht (USD50 Selling rate of Bangkok Bank)

Treatment cost consists of steam cost (A) and water treatment cost (B).

The calculation of Steam cost = [20,000 Baht/Unit]*[1/3 ton of wax-sludge]
= 6,667 Baht/ton of wax-sludge
= [6,667 Baht/ton of wax-sludge]*[190 ton/month]
= 126,667 Baht/month

The calculation of water treatment cost = [35 ton/month]*[3,000 Baht/month]
= 105,000 Baht/month

Opportunity loss cost

Two kinds of opportunity loss, the loss of the wagon tank volume while the wagon rent is fully paid, due to ROB and the loss of money to sale ROB as crude oil.

Rail transportation cost

Amount of wax-sludge per month = [190 ton/month]/[1 bbl./0.1272 ton]*[159 liter/bbl.]

= 273,500 liter/month

= [273,500 liter/month]*[320 Baht/1,000 liter]

= 76,000 Baht/month

Sale ROB as crude oil

Amount of ROB per month = [190 ton/month]/[1 bbl./0.1272 ton]

= 1,493.7 bbl./month

loss of income from sale ROB as crude = [1,493,7 bbl./month]*[26.58 US$./bbl.]*[41.03 Baht/US$]

= 1,629,007 Baht/month

Total disposal cost calculation per month = [steam cost] + [water treatment cost]
+ [rail transportation cost]
+ [loss of income from sale ROB as crude]

= 126,667 + 105,000 + 76,000 + 1,629,007

= 3,076,674 Baht/month

= 36,920,085 Baht/year

≈ 36.9 million Baht/year

CURRICULUM VITAE

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