Amoco Activities

4.1 Indirect wax catalytic cracking

FCC pilot plant runs were successful with feedstock containing both 20 wt.% and 40 wt.% purified Fischer-Tropsch (F-T) wax (FL-2443) from the La Porte slurry reactor that were blended with a Whiting combined FCC feed (FL-2312). The catalyst was equilibrium FCC catalyst from Conoco, Vektor 50, (F-9804). Initial runs with the wax blends were plagued with excessive presure build-up due to plugging of the injector nozzle with coke. The coking appeared to be caused by the composition of the wax and not by the iron catalyst fines. The injector nozzle on AU-79L was bored out from 0.02" to 0.04" and the pilot plant ran successfully. The results of the FCC runs are shown in Table 4-1.

The incremental value of products obtained from cracking the LaPorte FT wax dissolved in gas oil is worth approximately $3 per barrel more than the products from gas oil cracking. This stems primarily from the larger yields of naphtha and valuable light olefins. The incremental wax naphtha yields were 82 vol.% for the 40% blend and 75% for the 20% blends versus 62% for the gas oil. The incremental C_4+ light olefins yield was 18 wt% for the both wax blends versus 10 wt% for the gas oil. The incremental calculation indicates that the cycle oil obtained from the Fischer-Tropsch wax is very light and very little decanted oil is produced. Decanted oil is becoming difficult to sell and often has to be recracked.

4.2 Indirect wax hydrocracking

Hydrocracking experiments were commenced in a one-inch fixed-bed pilot plant (AU-18) operated on a once-through basis at 1250 psi and using a hydrogen flow rate of 9 to 11 MSCFB and a 2 stage catalyst bed. The petroleum feed is FL-2350 and the purified F-T wax is FL-2443. The properties of the feed are listed in Table 4-2. The temperature of the reactor bed will be adjusted to achieve 77 wt% conversion (where conversion is defined as the amount of feed converted into 380°F - boiling material). A 25 wt% wax blend will then be run and the temperatures adjusted to reach 77% conversion and then a 50 wt% wax blend followed by a temperature adjustment.

Amoco Activities

Table 4-1 - Indirect Wax Catalytic Cracking Yields

Incremental Yields And Octane Numbers For Cracking Fischer-Tropsch Wax In Gas Oil.					
AU-79L				Incremental Yields For F-T Wax	
Test No.	464-02	465-01	466-01		
Wax, wt.%	0	20	40	20	40
Weight Percent Yields	Wt.%	Wt.%	Wt.%	Wt.%	Wt.%
H2S	0.41	0.31	0.14	0.00	0.00
H2	0.09	0.09	0.11	0.09	0.14
C1	0.63	0.65	0.62	0.73	0.61
C2=	0.54	0.53	0.51	0.49	0.47
C2	0.47	0.46	0.41	0.42	0.32
C3=	4.04	4.58	5.01	6.74	6.47
C3	0.82	0.80	0.75	0.72	0.65
IC4	3.17	3.39	3.47	4.27	3.92
NC4	0.69	0.71	0.75	0.79	0.84
Total C4 Paraffins	3.86	4.10	4.22	5.06	4.76
IC4=	1.32	1.64	1.98	2.92	2.97
1-C4=	1.27	1.47	1.67	2.27	2.27
CC4=	1.19	1.41	1.66	2.29	2.37
TC4=	1.55	1.84	2.14	3.00	3.03
Total C4 Olefins	5.33	6.36	7.45	10.48	10.63
I-C5	3.45	3.95	4.32	5.95	5.63
Cyclo-C5	0.03	0.03	0.02	0.03	0.01
NC5	0.50	0.59	0.68	0.95	0.95
Total C5 Saturates	3.98	4.57	5.02	6.93	6.58
1-C5=	0.35	0.44	0.56	0.80	0.88
Cyclo-C5=	0.07	0.08	0.07	0.12	0.07
C&T-2-C5=	1.34	1.70	2.02	3.14	3.04
2M-2-C4=	1.60	2.01	2.48	3.65	3.80
2M-1-C4=	1.32	1.62	2.07	2.82	3.20
C5==	0.02	0.03	0.04	0.07	0.07
Total C5 Unsaturates	4.70	5.88	7.24	10.60	11.05
C6/430	43.03	42.18	44.08	38.78	45.42
C5/430	51.70	52.64	56.35	56.40	63.33
430+	28.44	25.73	20.69	14.89	9.07
Coke	3.68	3.76	3.75	4.08	3.86
Sum Of Components	100.02	100.00	100.00	100.01	100.00
Volumetric Data					
C5-430 vol.% Yield	61.56	64.22	69.6	74.86	81.66
C6-430 vol.% Yield	49.41	49.5	52.34	49.86	56.74
430+	24.72	22.83	19.39	15.27	11.4
Adj. C5-430 API	56	59.5	61.8	77.7	71.7
Adj. C6-430 API	49.3	52.3	54.3	71.1	64.3
Adj. 430+ API	5.4	7.4	15.1	30.1	66.5
Adj. RON	88.2	87.9	87.5	86.9	86.7
Adj. MON	79.6	79.4	79.4	78.7	79.2
(R+M)/2	83.9	83.65	83.45	82.8	82.9
Conversion, vol.%	74.19	-	75.77	84.73	88.61

Amoco Activities

Table 4-2 - Feed Properties of FL-2350, Hydrocracker petroleum feed

Gravity, API	23.4
N, ppm	334
S, wt%	--
Simulated Distillation	
IBP (°F)	169
5 wt%	361
10 wt%	409
20 wt%	452
30 wt%	482
40 wt%	506
50 wt%	530
60 wt%	559
70 wt%	586
80 wt%	617
90 wt%	651
95 wt%	679
99 wt%	729
FBP (°F)	748
6.3 wt%	380° naphtha fraction
Ca (wt% aromatic carbon)	47.1
C	88.79%
H	10.55%

M.W. Kellogg Activities

5.1 Direct Heavy Distillate Catalytic Cracking

Microactivity Tests (MAT)

MAT testing of as-is and hydrotreated POC-1 heavy distillates , plus a petroleum-derived gas oil supplied by Amoco, as potential feedstocks to an FCC unit was completed in January. In general, these results showed that all of these coal liquids are good gasoline producers with the maximum gasoline yield being increased from 52 to 65 wt% by very severe hydrotreating. Yield improvement was found to be linear function of the increase in feed hydrogen content.

The coal liquids do not behave as typical petroleum feeds and follow a different conversion-severity model. This behavior and the low coke make are probably due to the fact that 2 ring aromatic nuclei are stable and pass into the cycle oil. The end points of these feeds are too low to accommodate appreciable material with larger aromatic clusters.

Liquid product from the MAT run with each feed that had maximum potential gasoline yield was analyzed by the PIANO method. Products from 3 runs were also analyzed by the GCOCTANE method. These analyses show the extent of octane number change caused by hydrotreating.

Heat balance calculations were made for each feed. Due to the low coke make with coal liquids the conversion required for heat balance was well past the optimum needed for gasoline production. Cracking at the same conditions as needed to heat balance the petroleum feed, however, gave maximum high value product yields while requiring some heat input to the regenerator. These conditions are more representative of those the feed would see when blended with petroleum materials.

Pilot Plant Testing

Three runs were made in Kellogg's FCC1 pilot plant on a DL1-derived feedstock and a petroleum-blending feedstock.

The feedstocks were:

Kellogg I.D.	SwRI I.D.	Description
F-9819	FL-2312-F	Amoco Heavy Vacuum Gas Oil
F-9820	FL-2440	Direct Coal Liquid Distillate

The catalyst used in these tests was equilibrium Vektor-50 (Kellogg I.D. F-9804) with an MAT activity of about 66.

M.W. Kellogg Activities

The first run fed 100% vacuum gas oil and was used to set the operating condition for the two subsequent runs. The riser was targeted for isothermal operation at about 980 F. Catalyst-to-oil ratio was adjusted until the coke yield reached about 5 wt%. Table 5-1 summarizes the key operating conditions for all three runs.

The second run fed 100% coal liquid heavy distillate. The third run employed a blend comprised of 33.6 wt% F-9819 and 66.4 wt% F-9820 (about 33.3 vol% coal liquid heavy distillate). Table 5-2 lists the yields from all three runs. Conversions were all in the 73-74 wt% range. Notably, the calculated weighted averages of the product yields from the first two runs, which used the neat feeds, essentially equalled those yields found in the third run with the blended feed.

Summary

Table 5-3 compares the results from the MAT program with results from the pilot plant runs. The agreement is quite good considering the marked differences between the method of liquid-catalyst contacting which occurs in the two devices but is typical of Kellogg's experience with petroleum-derived materials in similar testing.

M.W. Kellogg Activities

Table 5-1 FCC Pilot Plant Operating Conditions

FEEDSTOCK:	F-9819	F-9820	F-9819/9820
CATALYST:	F-9804	F-9804	F-9804
RUN NUMBER:	H-2006-1	H-2006-2	H-2006-3
OIL FEED RATE , GRAM/HR	1794	1808	1814
CATALYST RATE , LB/HR	48.1	48.6	48.0
CATALYST/OIL RATIO	12.2	12.2	12.0
MATERIAL BALANCE:			
CLOSURE, WT%	98.50	98.49	98.46
GASOLINE, WT%	50.52	55.17	51.01
CONVERSION, WT%	74.13	74.20	73.18
COKE YIELD, WT%	4.90	3.27	4.32
GASOLINE SELECTIVITY, W/W	0.68	0.74	0.70
RISER OUTLET PRESSURE , PSIG	35.0	35.0	35.0
TEMPERATURES, F:			
OIL PREHEAT	212	212	214
CATALYST INLET	1265	1253	1252
RISER PROFILE, FT			
0.58 (MIXING ZONE)	983	985	982
5.47	983	986	982
9.22	978	982	978
17.10	988	992	988
19.18	981	985	981
22.87	989	993	989
26.12	991	995	990
28.13	976	981	977
RISER AVERAGE	984	987	983

M.W. Kellogg Activities

Table 5-2 Product Yield Spectrum
Normalized, Basis Fresh Feed, Wt. %

FEEDSTOCK	F-9819	F-9820	F-9819/9820	WEIGHTED
CATALYST:	F-9804	F-9804	F-9804	AVERAGE
RUN NUMBER:	H-2006-1	H-2006-2	H-2006-3	(CALC'D)
COMPONENT-WT %				
H2S	0.00	0.00	0.00	0.00
H2	0.14	0.16	0.16	0.15
CH4	1.29	0.73	1.07	1.10
C2H4	0.76	0.51	0.65	0.68
C2H6	1.15	0.63	0.95	0.98
C3H6	5.04	4.10	4.71	4.73
C3H8	0.95	1.08	0.98	0.99
C4H6	0.02	0.02	0.02	0.02
1-C4H8	0.72	0.62	0.70	0.69
I-C4H8	1.82	0.64	1.36	1.43
T-2-C4H8	1.43	1.08	1.35	1.31
C-2-C4H8	1.06	0.82	0.98	0.98
IC4H10	2.86	3.32	3.24	3.01
NC4H10	1.47	2.05	1.68	1.66
C5+ IN GAS	4.79	4.12	4.49	4.57
IBP-430 F	45.73	51.05	46.52	47.50
430-650 F	19.75	22.65	21.77	20.72
650+ F	6.12	3.15	5.05	5.13
COKE	4.90	3.27	4.32	4.36
TOTAL	100.00	100.00	100.00	100.00

M.W. Kellogg Activities

Table 5-2 Product Yield Spectrum (continued)

SUMMARY				
TOTAL C2 & LIGHTER	3.34	2.03	2.83	2.90
TOTAL C3'S	5.99	5.18	5.69	5.72
TOTAL C4'S	9.38	8.55	9.33	9.10
TOTAL GASOLINE	50.52	55.17	51.01	52.07
TOTAL CYCLE OIL	25.87	25.80	26.82	25.85
COKE	4.90	3.27	4.32	4.36
CONVERSION	74.13	74.20	73.18	74.15

Table 5-3 Comparison of Pilot Plant and MAT Results

FEED DESCRIP-TION	PETROLEUM		SEV. HT COAL LIQUID		67/33 BLEND	50/50 BLEND
FEED, F-NUMBER	9819	9821	9820	9823	9819/9820	9821/9823
YIELDS, WT%	P.P	MAT	P.P.	MAT	P. P.	MAT
TOTAL C2 & LIGHTER	3.3	3.9	2.0	2.4	2.8	3.4
TOTAL C3'S	6.0	6.7	5.2	5.0	5.7	6.3
TOTAL C4'S	9.4	9.0	8.6	6.6	9.3	8.5
TOTAL GASOLINE	50.5	49.3	55.2	54.3	51.0	51.7
TOTAL CYCLE OIL	25.9	26.1	25.8	28.0	26.8	26.1
COKE	4.9	4.9	3.3	3.6	4.3	4.1
CONVERSION	74.1	73.9	74.2	72.0	73.2	73.9
CAT/OIL	12.2	6.54	12.2	6.54	12.0	6.54

NOTES:
1) ALL RUNS WERE MADE WITH CAT/OIL SET TO PRODUCE 4.9 WT% COKE WITH PETROLEUM FEED
2) RUNS MADE AT 980 F +/- 5 F.
3) MAT DATA ARE EXTRAPOLATIONS; PILOT PLANT DATA ARE ACTUAL RUN YIELDS

Section 6

Project Management

6.1 Plans

6.2 Reports and Schedules

The milestone schedule and status for the Basic Program and Option 1 is shown in Figure 6-1.

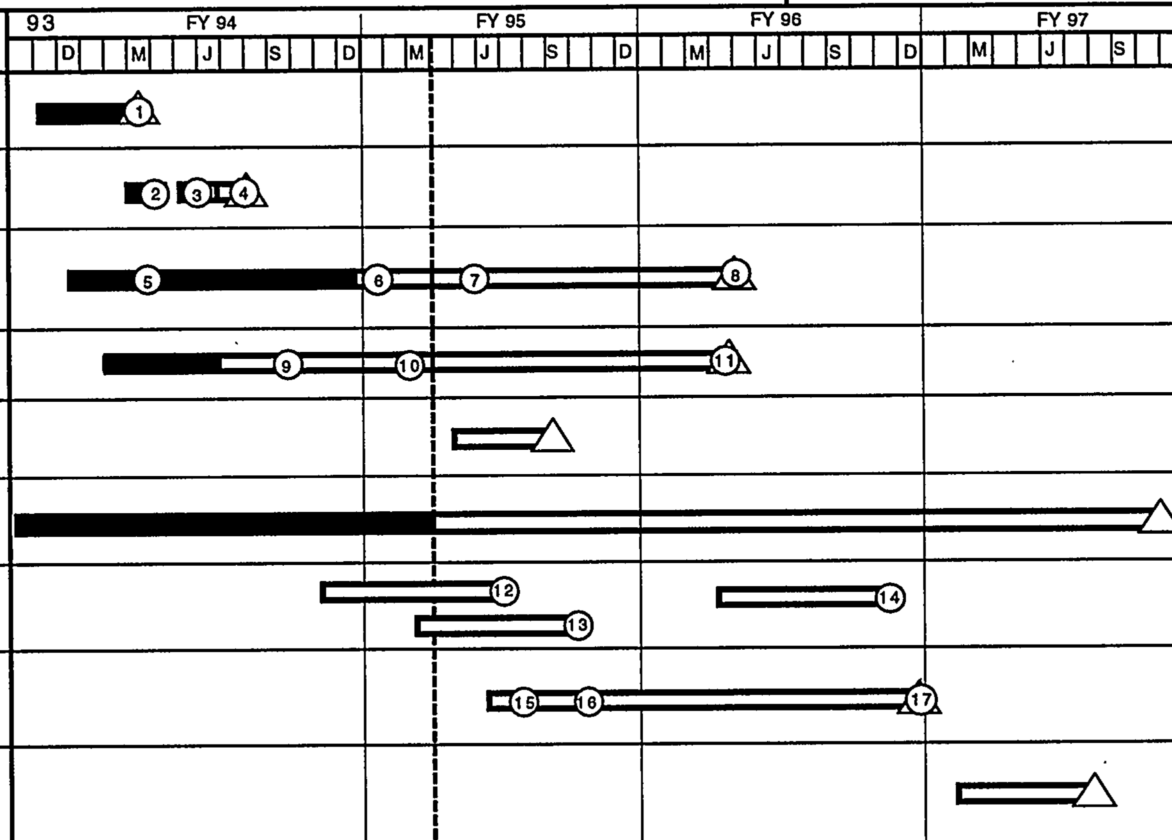
DOE F1332.3
(11.84)

FORM APPROVED
OMB NO 1901.1400

Figure 6-1
Milestone Schedule for Basic Program & Option 1

☐ PLAN ■ STATUS REPORT

1. TITLE Refining and End Use Study of Coal Liquids	2. REPORTING PERIOD 12/19/94 to 3/25/95	3. IDENTIFICATION NUMBER DE-RP22-93PC91029
4. PARTICIPANT NAME AND ADDRESS	Bechtel Corporation 50 Beale Street San Francisco, CA 94105	5. START DATE 11/1/93 6. COMPLETION DATE 9/30/97



7. ELEMENT CODE	8. REPORTING ELEMENT	10. PERCENT COMPLETE a. Plan	b. Actual
Task 1	Project Work Plan	100	100
Task 2	Feed Characterization	100	38
Task 3	Linear Programming (LP) Analysis	81	69
Task 4	Pilot Plant Analysis	63	21
Task 5	Option 1 Work Plan	0	0
Task 6	Administration Task	36	36
Option I Task 1	Pilot Plant Analysis (Produce Fuels)	27	0
Option 1 Task 2	Characterization, Blending, and Testing	0	0
Option 1 Task 3	Economic Study	0	0

1 Submit final Project Work Plan
2 Characterize DL1 liquid
3 Characterize IL liquid
4 Characterize DL2 liquid
5 Develop LP model
6 Conduct final DL1 LP runs
7 Conduct final IL LP runs
8 Conduct final DL2 runs
9 Conduct DL1 pilot plant tests
10 Conduct IL pilot plant tests
11 Conduct DL2 pilot plant tests
12 Production runs for DL1
13 Production runs for IL
14 Production runs for DL2
15 ASTM tests for DL1
16 ASTM tests for IL
17 ASTM tests for DL2

11. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE
Cliff Love 5/8/95