ENCLOSURE (B) 16

PART III

STUDIES ON HYDROCRACKING OF OHA GAS OIL

by

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SUMMARY

The hydrocracking of Oha gas oil over catalyst No. 6 ($NiO-MoO_3$-Active clay) was studied in a continuous pilot plant. Studies were made under reaction conditions of 200 kg/cm^2, space velocities of 0.46, 0.69 and 0.92 and temperature range from 360 to 420°C. The yield of aviation gasoline at 400°C was 75.3%, and at 420°C was 81.2%. The octane number of these gasolines was 92 (with 0.1% lead).

It was concluded that this catalyst had excellent activity for hydrocracking of Oha gas oil.

I. INTRODUCTION

A. History of Project

Many autoclave tests had been made since 1935, in search of good catalysts for hydrocracking mineral oils, and it was reported that catalyst No. 6, ($NiO-MoO_3$-active clay) had the best activity for this purpose. This project was initiated to confirm the effectiveness of this catalyst and to obtain specific data on the hydrocracking of Oha gas oil in a continuous pilot plant.

B. Key Research Personnel Working on Project

Chem. Eng. Lt. Comdr.	K. MITSUI
Chem. Eng. Lieut.	A. MORITA
Chem. Eng. Lieut.	U. SATO
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II. DETAILED DESCRIPTION

Pilot plant and test procedures used in this investigation have been described previously in the report "Studies on Hydrocracking of High Temperature Tar".

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A. Raw Materials

Gas oil obtained from Oha crude was used as a feed stock.[1] Its properties are as follows:

Table XXIV(B)16

Density (d_4^{20})	0.832
Distillation (°C)	
I.B.P.	154°C
10%	177
20%	183
30%	188.5
40%	195.5
50%	202
60%	209
70%	218
80%	231
90%	250
F.B.P.	298
Ultimate Analysis	
Unsaturated HC (Vol%)	2.0
Aromatic HC (Vol%)	13.7
Saturated HC (Vol%)	84.3
Aniline Point of Saturated HC (°C)	65.2
Content of Sulphur (Vol%)	0.08

Catalyst No. 6 was prepared in The Third Naval Fuel Depot. It consisted of $NiO-MoO_3$ and active clay (1:3:3 by weight). Its physical properties were as follows:

Tablet Diameter	6.7mm (Average)
Tablet Height	20.0mm (Average)
Density	1.74
Weight per unit volume	915 kg/m^3

8.75 liters of this catalyst were packed in each reaction chamber.

Hydrogen with purity of 99.5% was prepared by electrolysis of water.

B. Results

Experimental data are summarized in Tables XXV(B)16-XXIX(B)16 incl.

A plot of data showing the relation between reaction temperature and yield of aviation gasoline is given in Figure 2(B)16.

The yield of aviation gasoline was only 10% at the reaction temperature of 370°C but above 370°C, the yield rapidly increased until it reached 80% at 420°C. Variation of space velocity had little effect on the yield.

The relation between reaction temperature and properties of aviation gasoline is given in Figure 3(B)16.

It is seen that variation in reaction temperature had little effect on these properties.

III. CONCLUSIONS

A. Catalyst No. 6 was excellent for manufacture of aviation gasoline by continuous hydrocracking of Oha gas oil.

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B. The optimum reaction temperature for a S.V. of 0.5 was 400°C, and for S.V. of 1.0, 420°C. The yields of aviation gasoline for these cases were 75.3 vol% and 65.5%, respectively.

C. Properties of the hydrocracked residual oil differed from the residual product of thermal cracking, its density being lower, and its aniline point higher. On the basis of other experiments it is known that the former could easily be hydrocracked to aviation gasoline.

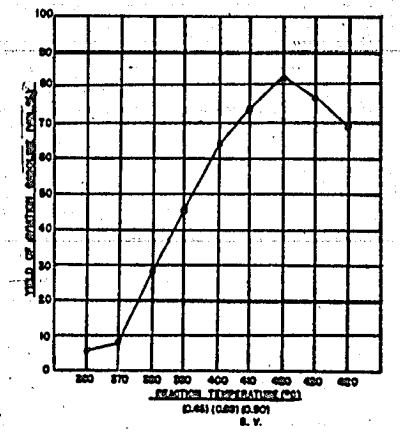

Figure 2(B)16

RELATION BETWEEN REACTION TEMPERATURE AND YIELD OF AVIATION GASOLINE

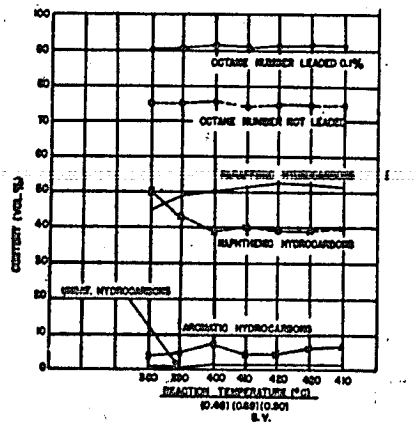

Figure 3(B)16

RELATION BETWEEN REACTION TEMPERATURE AND PROPERTIES OF AVIATION GASOLINE

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Table XXV(B)16
REACTION CONDITIONS AND YIELD

		Run Number								
		1	2	3	4	5	6	7	8	9
Reaction Press. (kg/cm^2)		200	200	200	200	200	200	200	200	200
Reaction Temp. (^oC)		360	370	380	390	400	410	420	420	420
S. V.		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.69	0.92
Run Period (hr)		6	6	6	6	6	12	24	12	12
Oil Charged	(lit)	47.8	47.9	47.9	48.0	48.1	95.3	190.2	140.3	190.8
	(kg)	39.8	39.9	39.9	40.0	40.1	79.0	158.0	116.4	158.2
	(lit/hr)	7.98	7.98	7.98	8.0	8.0	7.94	8.0	11.7	15.9
Product	(kg)	38.4	40.6	36.2	39.8	42.5	66.5	136.0	95.7	136.2
	(lit)	47.0	49.9	46.6	51.2	57.1	91.4	189.5	131.7	183.5
H_2 Charged (m^3)		42.9	41.4	41.6	41.2	40.5	93.4	176.3	141.3	167.3
Residual Gas (m^3)		30.2	29.0	32.4	29.0	26.3	54.5	104.2		
Yield of Product	(vol%)	98.2	104.0	97.2	106.5	118.5	96.0	99.3	94.0	96.2
	(wt%)	95.6	100.2	90.6	99.5	105.0	84.0	86.1	82.0	86.0
H_2 Consumption	(wt%)	2.86	2.71	2.06	2.63	2.88	4.3	4.07		

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Table XXVI(B)16
PROPERTIES OF PRODUCTS

		Run Number								
		1	2	3	4	5	6	7	8	9
Density	d_4^{20}	0.817	0.812	0.781	0.777	0.743	0.727	0.718	0.727	0.738
Fractional Distillation	I.B.P. (°C)	72.5	71	60	50	44.5	40.5	32	32.5	35
	10% (°C)	161.5	158.5	110	86	67.5	60	52	54.5	59
	20% (°C)	174	171.5	138	109	84	74	68	68.5	77.5
	30% (°C)	180.5	180	155.5	127	99.5	90	83.5	81.5	94.5
	40% (°C)	185	187	166	144	114.5	102	96	94.5	110
	50% (°C)	193	190.5	175	156.5	128	111	106.5	109.5	127
	60% (°C)	202	198.5	182.5	170	143.5	124	120	125	143
	70% (°C)	209.5	206.5	191	180.5	160.5	144	135	145	159
	80% (°C)	220	219	202	192	177	167	153.5	166	177.5
	90% (°C)	243	238	215	207.5	198.5	192.5	186	190	201.5
	97% (°C)	270	260	246	239	234				
	F.B.P. (°C)	277	265	251	247	238	228	235	231	240.5
	Total Distilled (vol%)	98.5	97.5	98.5	98	98	96	96	97.5	96.5
	Residue (vol%)	0.7	1.3	0.7	0.8	1	0.5	0.7	0.3	0.7
	Loss (vol%)	0.8	1.2	0.8	1.2	1	3.5	3.3	2.2	2.8
Four Point Method (%)	-80 (°C)	1.5	2.8	7.0	15.8	21.3	24.0	27.5	28.5	21.5
	-105 (°C)	2.7	4.0	14.0	24.3	36.0	43.5	48.5	46.5	38.5
	-150 (°C)	7.5	10.0	28.3	42.0	58.3	73.5	78.0	74.0	64.5
	-170 (°C)	19.5	24.0	43.3	56.3	69.3	82.0	85.0	82.0	76.0
Yield of Aviation Gasoline (vol%)		5.4	8.0	28.0	46.7	63.7	74.4	81.9	77.8	68.1

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Table XXVII(B)16
PROPERTIES OF RESIDUAL GASES

	Run Number								
	1	2	3	4	5	6	7	8	9
CO_2 (vol%)	0	0	0	0	0	0	0	0	0
O_2 (vol%)	0	0	0	0	0	0	0	0	0
C_nH_{2n} (vol%)	0.3	0.2	0.3	0.3	0.2	0.5	0.3	0.5	0.6
CO (vol%)	0.1	0.1	0	0.1	0.1	0.3	0.1	0.1	0.1
H_2 (vol%)	95.6	91.7	92.7	92.6	90.7	92.2	89.4	92.4	92.3
C_nH_{2n+2} (vol%)	0.9	1.9	1.9	0.5	1.9	2.9	4.3	1.9	4.9
N_2 (vol%)	3.1	6.1	5.1	5.5	6.4	4.1	5.4	5.1	2.1
n	1.5	1.0	1.5	1.0	1.5	1.0	1.4	1.0	1.0

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Table XXVIII(B)16
PROPERTIES OF AVIATION GASOLINE

		Run Number						
		3	4	5	6	7	8	9
Density	d_4^{20}	0.723	0.718	0.707	0.705	0.703	0.702	0.708
Fractional Distillation	I.B.P. (°C)	39	37	37	37.5	34	34.5	37
	10% (°C)	62	60	54.5	56.5	53	52	52
	20% (°C)	75.5	72	66	66.5	63	62.5	64
	30% (°C)	85	82	76	75.5	72.5	71.5	73.5
	40% (°C)	93	91.5	85	83	81.5	80	83
	50% (°C)	102.5	98.5	92.5	92.5	90	90	92
	60% (°C)	110	107	99.5	100	99	98.5	100.5
	70% (°C)	118.5	116	108.5	108	107.5	107	110
	80% (°C)	130	130	119	117	117	119	122
	90% (°C)	148	140	137	130	131	135	141
	97% (°C)	172	170	160	160	159	159	163
	F.B.P. (°C)	180	173	164	174	167.5	165.5	168
	Total Distilled (vol%)	98.5	98	98.5	97.5	97.4	97.2	97.5
	Residue (vol%)	0.5	0.7	0.4	0.4	0.3	0.6	0.6
	Loss (vol%)	1.0	1.3	1.1	2.1	2.3	2.2	1.9
Sum of 10%, 50% and 90% P. (°C)		312.5	298.5	284.0	279.0	273.0	277.0	285.0
Analysis	Unsaturated HC (vol%)	1.0	1.0	2.0	2.0	2.0	1.5	1.5
	Aromatic HC (vol%)	3.0	5.9	7.8	4.9	4.9	6.0	6.8
	Naphthenic HC (vol%)	50.2	43.4	39.1	40.3	39.4	39.2	39.7
	Paraffinic HC (vol%)	45.8	49.7	51.1	52.8	53.7	53.3	52.0
Octane Number	Clear	75.6	75.5	76.1	74.0	74.5	74.5	74.5
	With 0.1% Lead	90.6	91.0	92.0	91.6	92.0	92.2	92.0

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Table XXIX(B)16
PROPERTIES OF TOPPED OILS

		Run Number						
		3	4	5	6	7	8	9
Density	d_4^{20}	0.813	0.810	0.804	0.804	0.804	0.808	0.812
Fractional Distillation	I.B.P. (°C)	151	148	145	151	151	149	153
	10% (°C)	166	168	160	165	165.5	164	168.5
	50% (°C)	184	186	180	179.5	180	181	184.5
	90% (°C)	224	223	216	215	213	216.5	220.5
	F.B.P. (°C)	261	263	251	256	256	253	250.5
Analysis	Unsaturated HC (vol%)				0	1.3	2.0	0.5
	Aromatic HC (vol%)				7.0	7.9	8.8	9.0
	Saturated HC (vol%)				73.0	90.8	89.2	90.5
	Aniline Point (°C)				62.5	63.0	63.6	63.8