INFLUENCE OF HYDROCARBON COMPOSITIONS OF THE HYDROCRACKING FEEDSTOCKS ON THE HYDROCRACKED PRODUCTS OF LUBRICANT BASE STOCK AND MIDDLE DISTILLATE

by

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ABSTRACT

An experiment has been carried out to study to influence of hydrocarbon composition of the hydrocracking feedstocks on the hydrocracked products of lubricant base stock and middle distillate with bi-functional catalyst. The operating conditions are; temperature: from 400° to 420°C pressure: from 100 kg/cm² and H_2/HC ratio: 1000 lt/lt using a Catatest unit, operated with a contineous system. Experimental data show that the high content of paraffin hydrocarbon in the hydrocracked feedstock tends to increase the viscosity index of lubricant base stock, smoke point of kerosene and diesel index of gas oil products.

I. INTRODUCTION

Hydrocracking of heavy petroleum fractions converts the undersirable hydrocarbons and other compounds, contained in the original feedstock into hydrocarbon distillates possesing properties which make them suitable for blending into lubricant base stock or fuels. (1)

Hydrocracking catalysts are bi-functional, containing both hydrogenating and cracking sites. The best choice of catalysts for a specific objective requires a particular balance between these two functions.(4)

Mechanism of hydrocracking process is the formation of the carbonium ion as an intermediate molecule, which then gives the final products, characterized by a mayority of branched paraffin isomers and the virtual absense of small fragments (methane and ethane). (2)

The kinetic of hydrocracking process gretly depend on the operating conditions, such as hydrocarbon composition of feedstock, type of catalyst, pressure, temperature, hydrogen-hydrogen ratio. (5)

The versatility of hydrocracking process with respect to the variety of feedstock characteristics gives rise to an interesting case to study: i.e. the feasibility of obtaining lube base stock and fuel oil from Minas Waxy Residue, because the high wax content of the latter respresents the point of difficulty when the conventional process is to be used. (6)

In order to gain more data on the hydrocracking process, an experiment has been carried out to study the influence of hydrocarbon composition of the hydrocracking feedstocks: i.e. Nonparaffinic vacum distillate, paraffinic vacuum distillate and wax on the performance of hydrocracked products: i.e. lubricant base stock, middle distillate and naphtha with the operating conditions: Temperature from 400° to 420°C, Pressure: 100 kg/cm² and H_2/HC ratio: 1000 lt/lt using bi-functional catalysts. A Catalytic activity test unit operated in a continuous system was used in this experiment.

Gas and liquid product samples were taken from gas and liquid samples respectively. Liquid product was fractionated to get the following cut IBP–80°C, 80°–150°C, 150°–250°C, 250°–380°C and >380°C.

II. EXPERIMENTAL

Nonparaffinic (NPVD) and paraffinic vacuum distillates (PVD) having boiling range 350°–550°C and wax has been used as feedstock at this experiment. The electrolytic hydrogen has been purified from oxygen compound by passing this hydrogen into Deoxo catalyst and then followed by drying in the molecular sieve. The purified hydrogen has a pu-

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rity 99,5% volume. Bi-functional catalyst is the type commonly employed in hydrocracking process of heavy distillate.

The hydrocracking of vacuum distillate was carried out in a catalytic activity test unit which can be operated in continuous system (Fig. 1). The volume and inside diameter of reactor are 220 cc and 19 mm respectively. The reactor temperature is regulated automatically.

80 cc of the catalyst was charged to the reactor and the catatest unit brought to the operating pressure with hydrogen. The reactor wax was then heated to about 250°C and kept at this temperature for two hours, while hydrogen was recirculated at desired rate. The feed pump was then started and the operating conditions was carefully adjusted in this pretest period. After the density of the product become constant, the pretest period liquid product was removed; then a test run of ten hours was carried out.

Gas and liquid product samples were taken from gas and liquid samples respectively and these products were then analysed.

Liquid products were fractionated to get the following cuts: IBP-80°C, 80°–150°C, 250°–380°C, where by distillation apparatus; with the 30 theoritically plate, operated by 4/1 reflux ratio, was used.

The 380°C bottom product was defined as unconverted feedstock of vacuum distillate. Yield of feedstock conversion and cut fractions are determined in percent weight. Hydrocarbon composition of cut: 80°C–150°C was analysed in percent volume. Smoke point of cut 150°C–250°C; and diesel index of cut 250°C–380°C were determined.

III. RESULTS AND DISCUSSION

Experimental data of hydrocracking of nonparaffinic vacuum distillate, paraffinic distillate and wax are shown in Figures: 2, 3, 4, 5, 6, 7 and 8.

These experimental data will be discussed in two following topics :

- Distribution of hydrocracked products
- Characteristic of hydrocracked products

A. Distribution of hydrocracked products

By increasing of the operating temperature from 400°C to 420°C it was observed as follows :

a. Conversion of the three feedstocks increase i.e.: from 33.02 to 62.80; from 43.01 to 63.00 and 9.20 to 52.50% by weight NPVD, PVD and wax feedstocks respectively.

b. Yield of lubricant base stock products decrease, i.e. from 55.06 to 35.03 and from 25.10 to 20.20 for NPVD and PVD feedstock respectively. Wax feedstock produces an optimal yield of this lubricant base stock products i.e. 28.02% by weight at ± 25.10% by weight of feedstock conversion. And the selectivity of these lubricant base stocks products at ± 50% by weight of feedstock conversion, are 0.82; 0.48 and 0.52 for NPVD, PVD and wax feedstocks respectively.

c. Yield of middle distillate (i.e. kerosene and gas oil products) increase i.e. from 28.03 to 51.04 and from 38.000 to 55.07; NPVD and PVD feedstock respectively. At ± 50% by weight of feedstock conversion, the selectivity of the middle distillate are 0.86; 0.90 and 0.80 for NPVD, PVD and wax feedstocks respectively.

d. Yield on naphtha products increase: i.e. from 2.00 to 8.00 and from 1.00 to 6.00 by weight to NPVD and PVD feedstocks respectively.

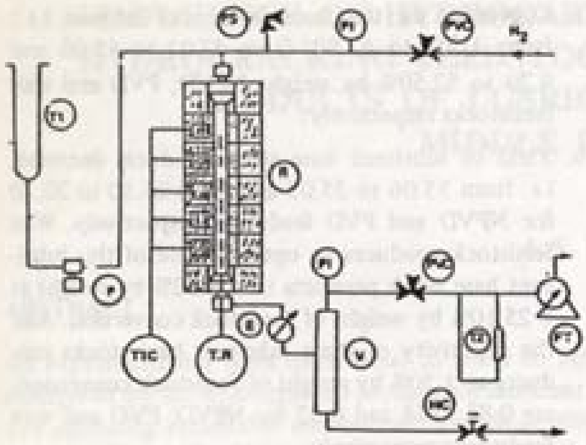
B. Characteristic of hydrocracked products

By rising the operating temperature from: 400°C to 420°C, it was obtained as follows :

a. Viscosity index of the lubricant base stock product increase from 109 to 128 for NPVD feedstocks, but the PVD and wax feedstocks have an optimal viscosity index of the lubricant base stock products i.e. 140 and 157 respectively.

b. Diesel index of gas oil products increases i.e. from 42 to 55 and from 69 to 79 for NPVD feedstocks respectively. At ± 50% by weight of feedstock conversion, the diesel index of gas oil product are: 50; 75 and 88 for NPVD, PVD and wax feedstocks respectively.

c. Smoke point of kerosine products increase i.e. from 15 to 18 and from 18 to 20 mm for NPVD and PVD feedstocks respectively. At ± 50% by weight of feedstock conversion, the smoke point of kerosine product are: 17; 19 and 34 for NPVD, PVD and wax feedstocks respectively.
(N + 2A)content of naphtha products decrease i.e. from 86.80 to 73.90 and from 78.20 to 59.70%



E – Condensar
FT – Gas meter
P – Pump
PVC – Pressure regulator
PI – Pressure gauge
PS – Pressure safety valve
R – Contact tube
T1 – Batch
T2 – Sample
TIC – Temperature regulator
TR – Temperature recorder
V – Separator

Figure 1

Catatest unit.

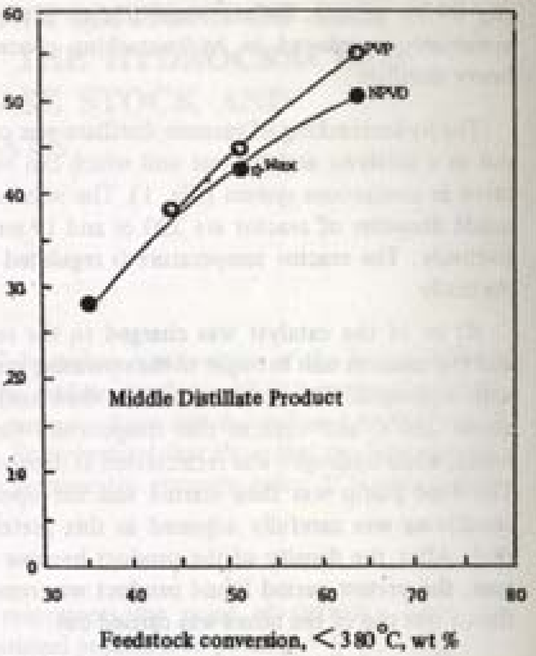


Figure 3.

A plot of yield of middle distillate product against feedstock conversion

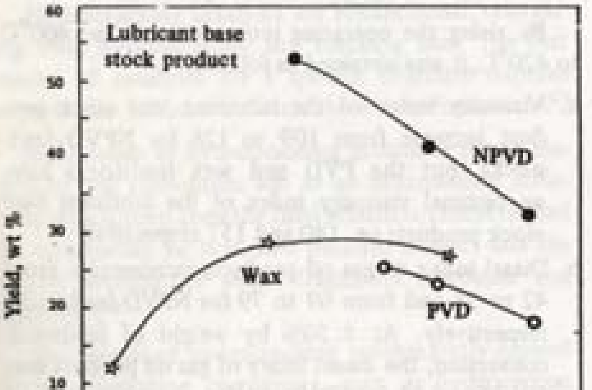


Figure 2

A plot of yield of lubricant base stock product against feedstock conversion

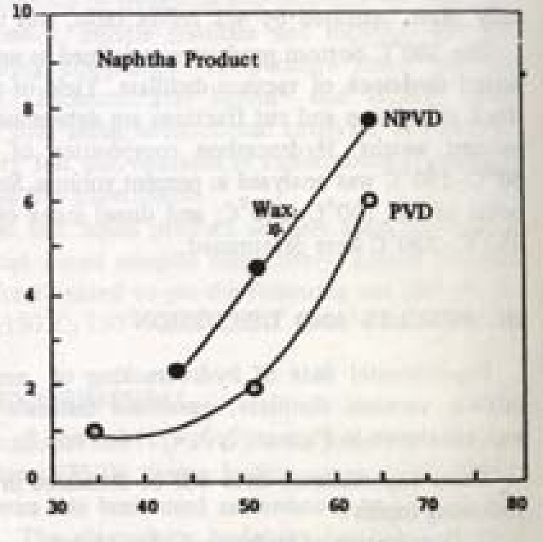


Figure 4.

A plot of yield of naphtha product against feedstock conversion by volume for NPVD and PVD feedstocks respectively. At ± 50% by weight of feedstock conversion, the (N + 2A) contents of naphtha products are 74.10; 64.3 and 41.8% by volume for NPVD, PVD and wax feedstocks respectively.

High quality of lubricant base stock and middle distillate obtained from paraffinic feedstock, it is suggested that the structure of the feedstock used appears also to influence the degree of braching and of ring in the hydrocracked products. (3)

For production of lubricant base stock product propably the most important reaction in conventional hydrocracking is as follows. (7)

1. **For NPVD feedstock**

   The partial hydrogenation of polycyclic aromatic rings, followed by rapid splitting of the saturated rings to form substituted less condenced aromatic rings.

2. **For PVD feedstock**

   The splitting of multiring naphthene into di/mono ring naphthenic structures.

3. **For wax feedstock**

   Direct isomerization and cyclization of paraffin to high iso paraffins and high branched naphthenic ring.

As cyclic type feedstock largely give cyclic type hydrocracked products and paraffinic type feedstocks give paraffinic type hydrocracked products. Thus the type of middle distillate and naphtha products, made directly by hydrocraking in influence to significant extent by the type feedstock used in the process.

IV. CONCLUSION

By increasing the operating temperature the conversion rate of NPVD, PVD and wax feedstocks, the quality of the middle distillate products will increase.

At the operating conditions: Temperature: 400°C, Pressure: 100 kg/cm^2 and H_2/HC ratio, the feedstock conversions are 51.2; 50.5% by wt for NPVD, PVD and wax respectively. At ± 50% by wt of feedstock conversion, the performance of hydrocracked product for NPVD, PVD and wax feedstocks is obtained as follows :

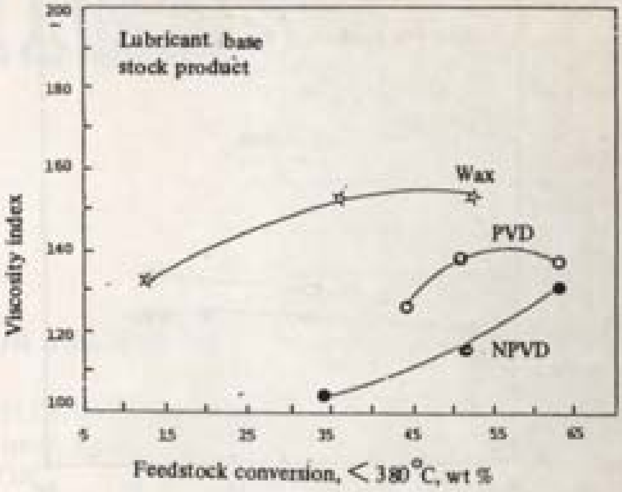


Figure 5

A plot of viscosity index of lubricant base stock against feedstock conversion

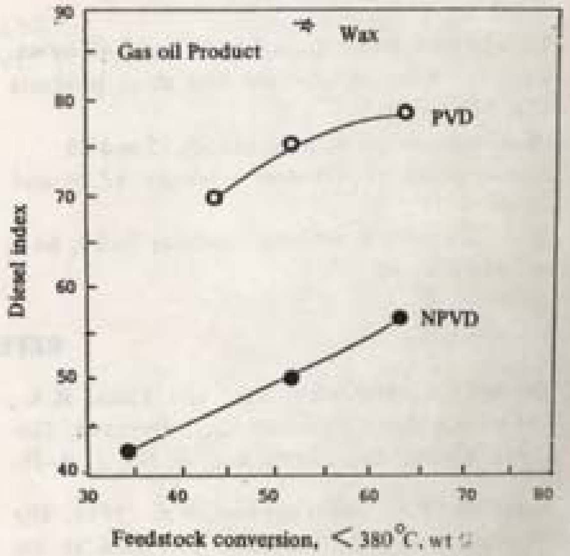


Figure 6

A plot of diesel index of gas oil product against feedstock conversion

- Yield of lubricant base stock products 42.5; 24.4 and 28.02% by wt.
- Yield of middle distillate products 43.1; 45.2 and 42.5% by wt.

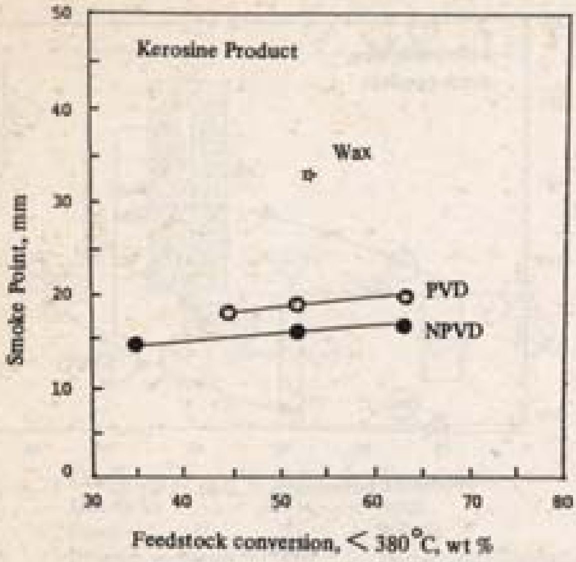


Figure 7

A plot of smoke point of kerosine product against feedstock conversion

- Yield of naphtha products 4.5; 2.1 and 5.4% by wt.
- Viscosity index of lubricant base stock products 128; 140 and 157.
- Diesel index of gas oil products 50, 75 and 88.
- Smoke point of kerosine products 17,19 and 34 mm.
- (N + 2A) content naphtha products 74.10, 64.3 and 41.8% by vol.

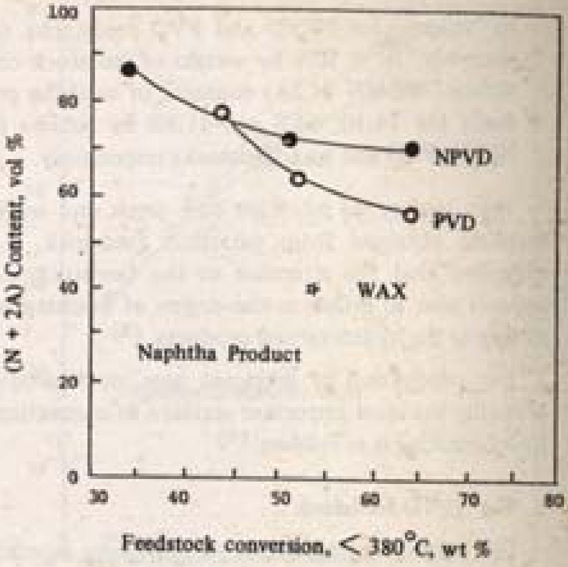


Figure 8

A plot of (N + 2A) content of naphtha product against feedstock conversion

Base on the experimental data, it suggested that cyclic type feedstock largely give cyclic type hydrocraked products and paraffinic type feedstocks give paraffinic type hydrocracked products.

Optimal operating conditions can certainly be achieved by variation of other parameters, H_2/HC ratio and the type of the catalyst.

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