PRJ, Vol. 7 (January 1995); P. 101–106, 3 FIGS, 9 TABLES.

POSSIBILITY OF MANUFACTURING LUBE BASE STOCKS FROM BREGA CRUDE OIL

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إمكانية إنتاج زيوت الأساس من نفط خام البريقة

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تم تقييم إنتاج زيوت الأساس الكامنة في نفط خام البريقة من ناحية النوعية والكمية. فقد تم تحضير المتبقي تحت الضغط الجوي العادي (340+°C) وكذلك تم تقييم هذا المتبقي بهدف إستخدامه في الحصول على زيوت الأساس ذو تصنيفات مختلفة.
وجد أن نسبة المتبقي في نفط خام البريقة بالوزن تحت الضغط الجوي العادي هي 43.00%. كذلك تم تقطير المتبقي إلى عدد تسعة قطفات ذات مدى حراري مختلف وتم تقييم هذه القطفات قبل وبعد عملية نزع الشمع والمواد العطرية وتم أيضاً حساب نسبتها بالوزن في المتبقي من خام البريقة.

ABSTRACT

Lube base stocks production potential of Brega crude oil has been assessed both in terms of quality and quantity. Atmospheric residue (340+°C) of Brega crude oil was prepared and evaluated for manufacturing lube base stocks for different classes. The yield of 340+°C of atmospheric residue was found to be 43.00 wt% on crude oil. The atmospheric residue was further distilled into nine different fractions. The yield and properties of raw cuts, dewaxed cuts and dewaxed and solvent extracted cuts were determined and evaluated for lube base stocks production. Some views on possible utilisation of Brega lube base stocks are also presented.

INTRODUCTION

The finished lubricant contains a base stock, additives to impart certain performance characteristics and may contain a carrier for the additives. Mineral oils have been used as base stock for manufacturing of different types of lubricating oils for a long time and they will probably continue to be used for considerable time to come. The base stock are generally prepared from crude oils. In Libya there is a plant to produce engine oil but the base stock and additives used in this plant to produce engine oils are imported. As a result of this situation an attempt has been made to look into the likely availability of lube base stocks from Libyan crudes both in respect to yield and quality.

This paper presents likely yield potential and available viscosity range of lube base stocks from Brega crude oil. This also presents views on utilisation aspects, based on the current developments in lubricant formulations and application aspects.

EXPERIMENTAL

Experimental work reported herein was carried out using Brega crude oil sample obtained from the field. Physico-chemical data of Brega crude oil are reported in Table 1. Brega crude oil has API 41.2 and having characterisation factor (Kuop) of 12.10.

Preparation of Atmospheric Residue

The atmospheric residue was prepared by distillation of Brega crude oil through a distillation column, which conforming to ASTM D2892 method, for atmospheric distillation to remove naphtha, kerosene

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Table 1. Characteristics of Brega Crude Oil

Test Method	Test Description	Result
ASTM D1298	Specific gravity at 15.6/15.6 °C	0.8194
ASTM D1298	API gravity	41.2
ASTM D1796	Water and sediment content, vol.%	Nil
ASTM 129	Sulphur content, wt.%	0.352
ASTM 97	Pour point ,°C	- 6
ASTM D445	Kinematic viscosity at 37.8 °C, cSt	2.9
IP 143	Asphaltene content, wt.%	0.09
ASTM D189	Conradson carbon residue, wt.%	1.34
ASTM D482	Ash content, wt.%	0.0092
UOP D375	Characterisation factor	12.10
IP 77	Salt content, ppm	23.94
Shell Method	H_2S, ppm	63.92

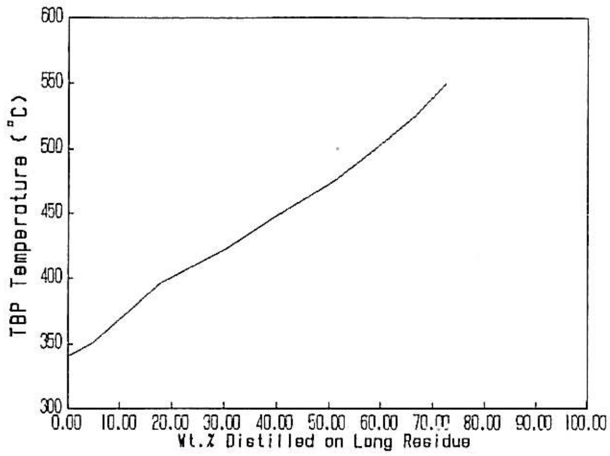

FIG. 1. Composite TBP curve up to 550°C.

Table 2. Yields of Raw and Processed Cuts of Brega Crude Oil

Distillate Cuts Corresponds to Atm. Distillation (ASTM D2892) (°C)	Yield on Atmospheric Residue (wt.%)		
	Raw Cut	Dewaxed Cut	Dewaxed and Solvent Extracted Cut
340 - 351	4.67	3.74	2.25
351 - 396	13.08	10.46	6.38
396 - 422	12.39	9.91	6.10
422 - 450	10.65	8.73	5.95
450 - 475	10.16	8.33	6.09
475 - 500	7.88	6.54	4.71
500 - 525	7.92	6.57	5.09
525 - 550	5.76	4.84	3.48
550+ (Deasphalted Oil)	10.44	8.77	6.58

and gas oil fractions boiling up to 340°C. The left over portion in distillation flask remains as atmospheric residue. The yield of atmospheric residue was found to be 43.00 wt.% on crude oil.

Preparation of Lube Distillate Cuts

The eight distillate cuts ranging from 340 to 550°C and vacuum residue of Brega crude oil were prepared by distillation of atmospheric residue (340+ °C) using a batch distillation apparatus made according to ASTM D1160 method. The position of cuts on composite TBP up to 550°C is shown in Fig. 1. The boiling range and yield of these distillate cuts are presented in Table 2. The properties of distillate cuts are given in Table 3.

Deasphalting of Vacuum Residue

The vacuum residue (550+ °C) was propane deasphalted using a batch four litre capacity extractor at 60°C. The solvent to oil ratio used was 5:1 by volume. The deasphalted oil (DAO) was separated from the solvent initially in the extractor and subsequently by evaporation with a nitrogen purge at 150°C. The yield of oil and asphalt were found 10.44 and 17.01 wt.% on atm. residue, respectively.

Processing of Distillate Cuts and Deasphalted Oil (DAO)

Distillate cuts and deasphalted oil were processed according to the following steps:

Step 1: Dewaxing (to improve the low temperature properties)
Step 2. Solvent extraction (to improve viscosity index and quality)

Table 3. Properties of Raw Distillate Cuts

Distillate Cuts Correspond to Atm. Residue (°C)	Spec. gravity at 15.6°C	API gravity	Kin. Viscosity at 40 °C		Kin. Viscosity at 100 °C		Pour Point (°C)	Total Sulphur, (wt.%)
			(cSt)	(SUS)	(cSt)	(SUS)		
340 - 351	0.8497	35.0	7.22	49.5	2.26	33.7	12	0.220
351 - 396	0.8568	33.7	9.19	56.1	2.44	34.1	18	0.258
396 - 422	0.8729	30.6	14.3	74.6	2.97	36.1	27	0.290
422 - 450	0.8776	29.7	29.9	141	4.75	41.9	39	0.327
450 - 475	0.8973	26.2	-	-	6.10	46.1	42	0.368
475 - 500	0.9056	24.8	-	-	8.10	52.7	45	0.442
500 - 525	0.9117	23.7	-	-	11.1	63.1	48	0.481
525 - 550	0.9139	23.3	-	-	13.9	73.8	51	0.584
550+(Deasphalted Oil)	0.9219	21.9	-	-	46.7	218	63	1.600

The above sequence may be altered during the process design.

Dewaxing

The mixture of methyl ethyl ketone (MEK) and toluene in the ratio of 70:30 percent by volume was used for dewaxing of all distillate cuts. Dewaxing temperature was 12±2°C and the ratio of the solvent to feed was maintained as 3:1 by volume. The chilled solvent was mixed with the preheated feed and cooled to – 12°C with agitation. The mixture was allowed to stand for about 2 hours and then filtered using No. 4 sintered glass filter. The wax cake was washed three times with the solvent and the extract was stripped out of the solvent in a rotary vacuum separator. The wax cake was stripped out from the filter and weighed to determine the yield of the slack wax. The yields of oils after dewaxing and their properties are given in Tables 2 and 4, respectively.

Solvent Extraction

The majority of lubricating oil refining technologies use furfural, phenol and N-methyl-pyrrolidone (NMP) as a solvent. It is generally known that the

Table 4. Properties of Dewaxed Distillate Cuts

Distillate Cuts Correspond to Atm. Residue (°C)	Spec. gravity at 15.6°C	API gravity	Kin. Viscosity at 40 °C		Kin. Viscosity at 100 °C		Viscosity Index	Pour Point (°C)	Total Sulphur, (wt.%)
			(cSt)	(SUS)	(cSt)	(SUS)			
340 - 351	0.8631	32.4	7.99	52.1	2.19	33.5	65	- 6	0.42
351 - 396	0.8717	30.8	10.5	60.5	2.65	35.0	65	- 6	0.47
396 - 422	0.8824	28.7	15.8	80.3	3.29	37.1	58	- 9	0.49
422 - 450	0.8932	26.9	27.5	130	4.69	41.7	80	- 9	0.51
450 - 475	0.8994	25.8	48.3	225	6.32	46.9	70	- 6	0.56
475 - 500	0.9049	24.9	75.8	352	8.73	54.9	84	- 6	0.58
500 - 525	0.9153	23.1	186	859	14.2	74.8	64	- 6	0.72
525 - 550	0.9244	21.6	288	1332	17.7	88.9	54	- 6	0.77
550+(Deasphalted Oil)	0.9353	19.8	358	1658	65.7	306	75	0	0.45

thermal stability of furfural is low, while phenol has undesirable safety and health aspects. NMP is considered more advantageous, for it is nontoxic, its physical and chemical characteristics are more favourable, and it dissolves the aromatics more selectively than either phenol or furfural. The main characteristics [1] of the most widely used solvents: phenol, furfural and NMP are summarised in Table 5.

Table 5. Characteristics of Refining Solvents

Property	Furfural	Phenol	NMP
Molecular weight	96.1	94.1	99.1
Density at 25 °C, kg/l	1.159	1.132	1.027
Boiling point, °C	161.7	181	202
Freezing point, °C	-38.7	40.9	24.4
Flash point, °C (M) (PM)	60 -	- 75	95 -
Heat of evaporation, kJ/kg	450.6	485.3	532.6
Solution characteristics	good	very good	excellent
Selectivity	good	good	very good
Stability	good	very good	excellent
Corrosivity	low	medium	low
Toxicity	mildly	very toxic	nontoxic
Biodegradability	good	good	good
Solubility in water	partial	partial	complete
Azeotrop formation (with water)	yes	yes	no

Keeping all those points into consideration dry NMP was selected as solvent for extraction to improve viscosity index and quality of the base oils. The conditions used for solvent extraction are shown in Table 6. The dewaxed oil (50 ml) and an appropriate amount of NMP solvent were mixed and agitated at 58 ± 1°C for 20 minutes. The mixture was allowed to stand for 30 minutes to settle down. The upper layer (raffinate) containing the product was separated and stripped using initially a rotary vacuum evaporator and subsequently using a stream stripper. GLC analysis of the oil was performed which indicated that the solvent content has been reduced to traces in the base oil. The yield and properties of the oil after solvent extraction are tabulated in Tables 2 and 7, respectively.

Table 6. Conditions Used for Solvent Extraction of Dewaxed Oil

Solvent oil ratio	2 : 1
Temperature, °C	55 - 58
Number of stages	1
Extraction time, min.	20
Settling time, min.	30

Table 7. Properties of Processed (Dewaxed and Solvent Extracted) Distillate Cuts

Distillate Cuts Correspond to Atm. Residue (oC)	Spec. gravity at 15.6°C	API gravity	Kin. Viscosity at 40 °C		Kin. Viscosity at 100 °C		Viscosity Index	Pour Point (°C)	Flash Point, (°C)	Total Sulphur, (wt.%)	Conradson Carbon Residue, (wt.%)
			(cSt)	(SUS)	(cSt)	(SUS)					
340 - 351	0.8434	36.3	7.60	5.07	2.25	33.7	104	- 6	152	0.088	0.0001
351 - 396	0.8528	34.4	10.1	59.2	2.66	35.1	97	- 6	170	0.107	0.0001
396 - 422	0.8618	32.8	15.1	77.6	3.43	37.6	101	- 9	192	0.200	0.0016
422 - 450	0.8695	31.2	25.7	122	4.70	41.7	99	- 9	210	0.247	0.0054
450 - 475	0.8813	29.1	44.4	207	6.56	47.7	98	- 6	226	0.251	0.0123
475 - 500	0.8901	27.5	77.3	358	9.31	56.8	95	- 6	244	0.257	0.0130
500 - 525	0.8923	27.1	109	507	11.6	64.8	93	- 6	270	0.280	0.0155
525 - 550	0.8991	25.9	170	788	15.7	80.7	94	- 6	302	0.291	0.0176

DISCUSSION

The atmospheric residue (340+°C) of Brega crude oil was distilled using a batch distillation apparatus made according to ASTM D1160 method. The eight distillate cuts ranging from 340 to 550°C were prepared and vacuum residue as also collected. The vacuum residue (550+°C) was then propane deasphalted and the oil was separated. It was found to be 10.44 wt.% on atmospheric residue. This oil and eight distillate fractions were subjected to dewaxing and solvent extraction. The plot of cumulative yield of raw, dewaxed and solvent extracted of distillate fractions versus TBP temperature is shown in Fig. 2. The properties of oils obtained after treatment are given in Table 7. The plot of mid wt.% of yield versus kinematic viscosity at 40°C of processed oils is shown in Fig. 3. The yields of different grades of base stocks have been calculated and the cut range corresponds to these yields were calculated and presented in Table 8.

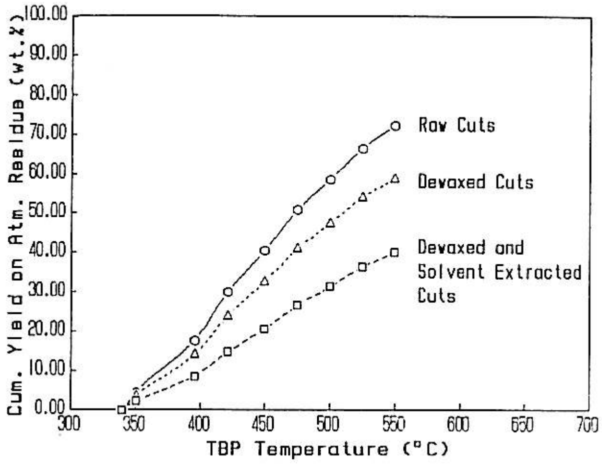

FIG. 2. Yield versus TBP temperature of raw, dewaxed and solvent extracted cuts.

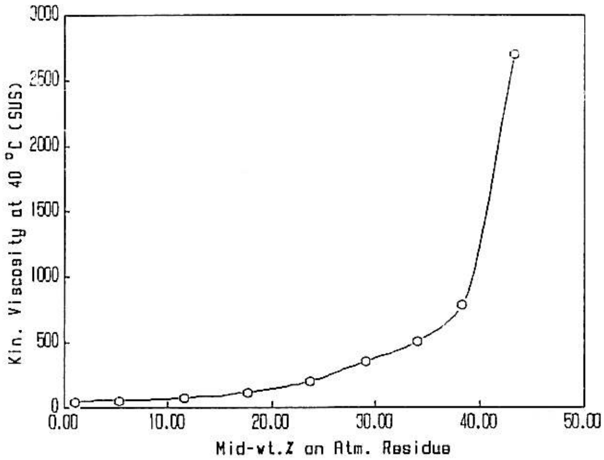

FIG. 3. Kinematic viscosity versus mid wt.% of yield.

Table 8. Distillation Range and Yield of Different Class of Base Oils

Base Oil	Distillation Range (°C)	Yield on Atm. Residue (wt.%)	Yield on Crude oil (wt.%)
Base stock for light lubricants	340 - 430	16.41	7.06
N 150	430 - 456	5.88	2.53
N 250	456 - 478	5.39	2.32
N 500	478 - 550	11.96	5.14
Bright Stock	550+ (Deasphalted oil)	6.45	2.77

All distillate fractions after processing (dewaxing and solvent extraction) had viscosity index between 93 to 104, and pour point −6 to −9°C. The deasphalted oil obtained from vacuum residue after dewaxing and solvent extraction had pour point −3°C. The material balance of the processes showing the yields of lube base stocks, wax content, aromatic content and asphalt content is given in Table 9. The yield of base stock to produce light viscosity range lubricants was found to be 16.41 wt.% on atm. residue (7.06 wt.% on crude oil). Recent reports in the literature [2] indicate that base oils of lower viscosity are required by the automotive sector to meet the need of fuel efficient multigrade oils. However, the volatility of such base oils needs to be carefully controlled to avoid excessive oil consumption. Reports further indicate that friction modifiers have been found to respond best in low viscosity oils.

Table 9. Material Balance of the Process

Product	Yield on 340+°C (wt.%)	Yield on Crude (wt.%)
Base oil for light viscosity lubricants	16.41	7.06
N 150	5.88	2.53
N 250	5.39	2.32
N 500	11.96	5.14
Bright Stock	6.45	2.77
Wax content	15.06	6.48
Aromatic Extract	21.24	9.13
Asphalt	17.01	7.31

The above trends make the situation favourable towards the use of lube base stocks from Brega crude oil, major potential of which is in lower viscosity range. The volatility characteristics of these base oils can be improved by careful control of vacuum unit operation so that oils produced have less low boiling material.

Although it is difficult to make any firm statement on the application aspect of formulated lubricants from Brega lube base stocks in the absence of any performance data, however, it is possible to state that it appears possible to formulate multigrade motor oil like, 20W50, 20W40, 15W40, and alike with low volatility improved oil consumption characteristics, wear protection and deposit control in combination with the following:

(a) By the use of modern additive package of enhanced viscosity increasing power.
(b) By the use of synthetic esters and polyalphaolefins as components in the base oil blend.

CONCLUSIONS

Evaluation results obtained indicate that Brega crude oil is suitable for manufacturing of different grades of lube base stocks. A substantially large amount (16.41 wt.% on atmospheric residue; 7.06 wt.% on crude oil) of the Brega lube base stocks production potential lies in the light viscosity range. Such type of base oils according to the recent trends can be used in the fuel efficient multigrade motor oil formulations along with the proper additive package and synthetic lubricants.

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