PRJ, Vol. 8 (January 1996); P. 67–73, 3 FIGS, 11 TABLES.

Evaluation of Sedra and Hamada Crude Oils for Manufacturing of Lube Base Stocks

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تقييم خام السدرة والحمادة لتصنيع زيوت التزييت الأساسية

أفتخار أحمد ، عادل الطويل و سالم الدباح

تم إجراء عملية تقييم لزيوت الأساس لخامي نفط السدرة والحمادة من ناحية النوعية والكمية حيث تم تحضير وتقييم المتبقى عند الضغط الجوي العادي ($340^{+0}C$) بهدف الحصول على زيوت الأساس ذات التصنيفات المختلفة ، كما تم إجراء عملية تقطير أخرى للمتبقى ($340^{+0}C$) عند الضغط المخلخل والحصول على تسع قطفات لزيوت الأساس ذات مدى حراري مختلف. تم مقارنة خامي السدرة والحمادة من حيث مدى احتوائها على زيوت الأساس من الناحية الكمية والنوعية للقطفات قبل وبعد عملية نزع الشمع والمواد العطرية منها بغرض استخدامها للحصول على زيوت الأساس ، وتعرض هذه الورقة أيضاً إمكانية استخدام زيوت الأساس لخامي السدرة والحمادة.

Abstract *The potential of production of lube base stocks of Sedra and Hamada crude oils has been assessed both in terms of quality and quantity. Atmospheric residua (340^{+}°C) of these crude oils were prepared and evaluated for manufacturing of lube base stocks for different classes. The atmospheric residua (340^{+}°C) of these crude oils were further distilled into nine different fractions. The comparative yield and properties of raw cuts, dewaxed cuts and dewaxed-solvent extracted cuts were determined and evaluated for lube base stocks production. Suggestions of possible use of Sedra and Hamada lube base stocks are also presented.*

INTRODUCTION

The lubricant production in Libya is entirely based on imported lube base oils, bulk of which is in the viscosity range of intermediate (N 150, N 250), heavy (N 500) and bright stocks. As a result of this situation an attempt has been made to look into the likely availability of lube base stocks from Hamada and Sedra crude oils both in respect to yield and quality since these crude oils are processed in Az-Zawiyah refinery.

This paper presents comparative yield potential and available viscosity range of base stocks from Sedra and Hamada crude oils. This work also presents views on utilization aspects, based on the current developments in lubricant formulations and application aspects.

EXPERIMENTAL

Experimental work, reported herein, was carried out using Sedra and Hamada crude oil samples obtained from Az-Zawiyah refinery. Physico-chemical data of these crude oils are reported in Table 1. Sedra crude oil has API gravity 35.6 while Hamada crude oil has 40.0 API gravity. The characterization factors (K_{uop}) of Sedra and Hamada crude oils are 12.20 and 12.25, respectively.

Preparation of Atmospheric Residue

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

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Table 1. Characteristics of Sedra and Hamada crude oils

Test method	*Test description*	*Result*	
		Sedra crude	*Hamada crude*
ASTM D1298	Specific gravity at 15.6/15.6°C	0.8469	0.8249
ASTM D1298	API gravity	35.6	40.0
ASTM D1796	Water and sediment content	0.1	Traces
ASTM D129	Sulphur content	1.52	0.10
ASTM D97	Pour point, °C	3	−6
ASTM D445	Kinematic viscosity at 37.8°C, cSt	5.36	4.63
IP 143	Asphaltene content, wt.%	0.71	0.46
ASTM D189	Conradson carbon residue, wt.%	2.74	2.09
ASTM D482	Ash content, wt.%	Nil	0.0059
UOP 375	Characterisation factor	12.20	12.25
IP 77	Salt content, ppm	Nil	10.74

gas oil fractions boiling up to 340°C. The left over portion in distillation flask remains as atmospheric residue. The yield of atmospheric residue of Sedra and Hamada crude oils were found to be 50.26, and 48.56 wt.% respectively.

Preparation of Lube Distillate Cuts

Eight distillate cuts ranging from 340 to 550°C and vacuum residue of Sedra and Hamada crude oils were prepared by distillation of corresponding atmospheric residue (340^{+}°C) using a batch distillation apparatus made according to ASTM D1160 method. The position of cuts on composite TBP distillation curve 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 of Sedra and Hamada crude oils are given in Table 3 and Table 4, respectively.

Deasphalting of Vacuum Residue

The vacuum residue (550^{+}°C) was propane deasphalted using a batch, four litres capacity extractor at

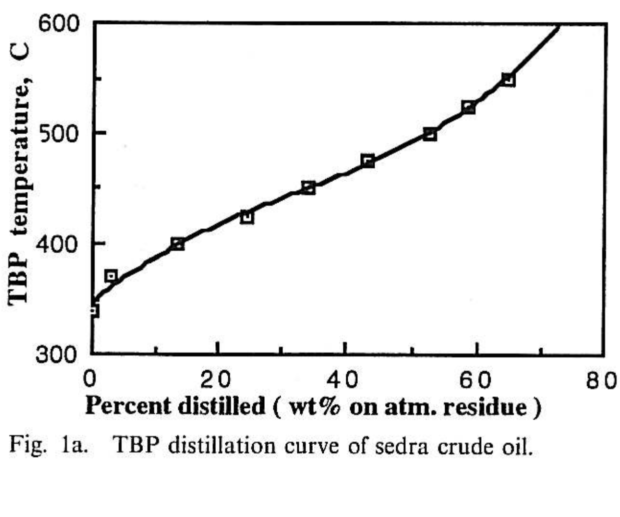

Fig. 1a. TBP distillation curve of sedra crude oil.

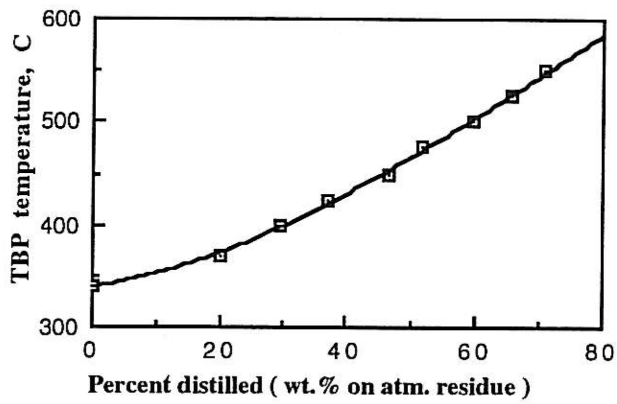

Fig. 1b. TBP distillation curve of Hamada crude oil.

60°C. The ratio of solvent (propane) to oil was used as 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 was found 11.34 and 23.12 wt.% on atm. residue, respectively for Sedra crude oil while the yield of oil and asphalt for Hamada crude oil was found as 8.28 and 20.69 wt.% on atm. residue, respectively.

Processing of Distillate Cuts and Deasphalted Oils (DAO)

Distillate cuts and deasphalted oils 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)

The above sequence may be altered during the process design.

Dewaxing

A mixture of methyl ethyl ketone (MEK) and toluene in the ratio of 70:30 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 are reported in Table 2. The properties of dewaxed oils of Hamada and Sedra are given in Tables 5 and 6, respectively.

Table 2: Yields of raw and processed cuts of Hamada and Sedra crude oils

Hamada crude oil				*Sedra crude oil*			
Distillate cuts correspond to atm. distillation (°C)	*Yield on atm. residue (wt.%)*			*Distillate cuts correspond to atm. distillation (°C)*	*Yield on atm. residue (wt.%)*		
	Raw cut	*Dewaxed cut*	*Dewaxed and solvent extracted cut*		*Raw cut*	*Dewaxed cut*	*Dewaxed and solvent extracted cut*
340–370	20.05	18.97	14.24	340–355	2.87	2.53	1.70
370–400	9.55	8.77	5.61	355–395	10.58	8.88	6.36
400–425	7.35	6.64	4.50	395–421	10.82	9.08	5.66
425–450	9.74	8.72	6.10	421–450	9.63	8.03	5.26
450–475	5.15	4.63	3.28	450–475	9.21	7.70	5.23
475–500	7.72	7.02	5.16	475–500	9.49	8.17	5.49
500–525	6.26	5.68	4.35	500–525	5.77	5.01	3.36
525–550	5.21	4.74	3.74	525–550	6.13	5.33	3.54
550+ (deasphalted oil)	8.28	6.83	5.02	550+ (deasphalted oil)	11.34	9.55	7.36

Table 3. Properties of raw distillate cuts of Hamada crude oil

Distillate cuts correspond to atmospheric distillation (°C)	*Specific gravity at 15.6/15.6 °C*	*API gravity*	*Kin. viscosity at 40°C*		*Kin. viscosity at 100°C*		*Pour point (°C)*	*Total sulphur (wt.%)*
			(cSt)	*(SUS)*	*(cSt)*	*(SUS)*		
340–370	0.8588	33.3	8.47	53.6	2.25	33.7	3	0.25
370–400	0.8698	31.2	12.8	69.0	2.96	36.1	12	0.23
400–425	0.8768	29.9	18.4	91.1	3.67	38.4	21	0.28
425–450	0.8833	28.7	29.4	139	4.69	41.7	27	0.34
450–475	0.8916	27.2	86.0	399	8.88	55.4	36	0.39
475–500	0.9004	25.7	—	—	11.5	64.6	39	0.23
500–525	0.9034	25.1	—	—	13.8	73.2	39	0.28
525–550	0.9118	23.7	—	—	19.6	96.8	42	0.30
550+ (deasphalted oil)	0.9415	18.8	—	—	44.8	210	57	0.50

Table 4. Properties of raw distillate cuts of Sedra crude oil

Distillate cuts correspond to atm. distillation (°C)	*Specific gravity at 15.6/15.6 °C*	*API gravity*	*Kin. viscosity at 40°C*		*Kin. viscosity at 100°C*		*Pour point (°C)*	*Total sulphur (wt.%)*
			(cSt)	*(SUS)*	*(cSt)*	*(SUS)*		
340–355	0.8599	33.1	7.93	51.9	2.28	33.8	12	0.57
355–395	0.8709	31.0	12.1	66.4	2.86	35.7	18	0.60
395–421	0.8788	29.5	15.8	80.6	3.46	37.7	27	0.61
421–450	0.8857	28.3	25.7	122	4.52	41.1	30	0.65
450–475	0.8956	26.5	—	—	6.45	47.3	39	0.69
475–500	0.9075	24.4	—	—	9.31	56.8	42	0.72
500–525	0.9175	22.7	—	—	13.4	71.7	45	0.73
525–550	0.9295	20.7	—	—	21.9	107	51	0.81
550+ (deasphalted oil)	0.9318	20.4	—	—	38.4	181	60	—

Table 5. Properties of dewaxed distillate cuts of Hamada crude oil

Distillate cuts correspond to atm. distillation (°C)	*Specific gravity at 15.6/15.6 °C*	*API gravity*	*Kin. viscosity at 40°C*		*Kin. viscosity at 100°C*		*Viscosity index*	*Pour point (°C)*	*Total sulphur (wt.%)*
			(cSt)	*(SUS)*	*(dSt)*	*(SUS)*			
340–370	0.8580	33.4	7.84	51.5	2.18	33.4	71	−6	0.26
370–400	0.8719	30.8	11.9	65.6	2.74	35.3	50	−6	0.27
400–425	0.8831	28.7	20.6	100	3.78	38.7	45	−6	0.29
425–450	0.8921	27.1	34.7	163	4.97	42.6	44	−6	0.31
450–475	0.8987	25.9	61.8	287	7.04	49.2	57	−6	0.31
475–500	0.9073	24.5	129	598	10.8	62.1	52	−6	0.32
500–525	0.9124	23.6	222	1028	15.3	79.1	56	−9	0.34
525–550	0.9185	22.6	419	1941	21.7	106	49	−6	0.36
550+ (deasphalted oil)	0.9239	21.7	1524	—	54.9	257	78	0	0.73

Table 6. Properties of dewaxed distillate cuts of Sedra crude oil

Distillate cuts correspond to distillation (TBP) (°C)	*Specific gravity at 15.6/15.6 °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)*			
340–355	0.8709	31.0	8.00	52.1	2.21	33.7	72	−6	0.45
355–395	0.8869	28.0	14.0	73.5	2.97	36.4	38	−6	0.54
395–421	0.8949	26.6	20.0	97.8	3.64	38.6	31	−9	0.64
421–450	0.9028	25.2	30.4	143	4.72	42.1	52	−6	0.68
450–475	0.9128	23.5	65.1	302	7.15	49.9	52	−6	0.73
475–500	0.9198	22.3	112	520	9.79	58.9	49	−6	0.81
500–525	0.9258	21.3	191	886	13.1	71.1	39	−9	0.84
525–550	0.9299	20.7	285	1322	17.5	88.6	52	−9	0.88
550+ (deasphalted oil)	0.9317	20.4	1457	6749	51.3	242	72	+3	0.52

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 thermal stability of furfural is low, while phenol has undesirable safety and health aspects. NMP is considered more advantageous, for it is non toxic, its physical and chemical characteristics are more favourable, and it dissolves the aromatics more selectively than either phenol or furfural. The main characteristics of the most widely used solvents: phenol. furfural and NMP are given in earlier publication (Ahmad *et al.*, 1995; Gardos *et al.*, 1982).

Keeping all these points into consideration dry NMP was selected as solvent for extraction to improve viscosity index and quality of the base oil. The conditions used for solvent extraction are shown in Table 7. The dewaxed oil (50 ml) and an appropriate amount of NMP solvent were mixed and agitated at 55 to 58°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, 8 and 9, respectively.

Table 7. 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

DISCUSSION

The atmospheric residua (340$^+$°C) of Hamada and Sedra crude oils was distilled using a batch distillation apparatus made according to ASTM D1160

Table 8. Properties of processed (dewaxed and solvent extracted) distillate cuts of Hamada crude oil

Distillate cuts correspond to atm. distillation (°C)	*Spec. gravity at 15.6/15.6 °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)*					
340–370	0.8371	37.5	7.55	50.6	2.11	33.2	66	−6	164	0.07	0.0225
370–400	0.8537	34.2	12.3	67.1	3.06	36.4	108	−6	180	0.03	0.0270
400–425	0.8607	32.9	21.1	103	4.00	39.5	73	−6	196	0.05	0.0271
425–450	0.8685	31.4	26.5	126	4.66	41.6	87	−6	210	0.11	0.0271
450–475	0.8755	30.1	52.9	246	6.66	48.0	69	−6	232	0.21	0.0273
475–500	0.8830	28.7	93.6	434	9.40	57.1	69	−6	258	0.18	0.0791
500–525	0.8871	28.0	155	718	13.1	70.6	71	−9	282	0.09	0.1026
525–550	0.8908	27.3	257	1191	17.7	88.8	68	−6	292	0.06	0.3427
550+ (deasphalted oil)	0.9076	24.4	994	—	44.1	207	82	0	>300	0.55	0.8529

Table 9. Properties of processed (dewaxed and solvent extracted) distillate cuts of Sedra crude oil

Distillate cuts correspond to atm. distillation (°C)	*Spec. gravity at 15.6/15.6 °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)*					
340–355	0.8548	34.0	8.89	55.0	2.43	34.5	90	−6	166	0.11	0.033
355–395	0.8585	33.3	12.5	67.8	2.85	35.9	57	−9	178	0.14	0.054
395–421	0.8663	31.8	16.5	83.4	3.37	37.7	57	−6	188	0.17	0.089
421–450	0.8745	30.3	20.2	98.7	3.97	39.7	84	−6	218	0.25	0.070
450–475	0.8845	28.5	47.3	220	6.56	48.0	86	−6	231	0.30	0.150
475–500	0.8896	27.6	72.6	337	8.67	55.1	89	−6	250	0.33	0.068
500–525	0.8948	26.6	125	580	11.8	66.2	78	−6	274	0.39	0.064
525–550	0.8976	26.1	176	816	15.1	78.8	83	−6	295	0.45	0.094
550+ (deasphalted oil)	0.9110	23.8	937	4340	43.5	205	85	+3	248	0.42	2.080

method. The eight distillate cuts ranging from 340 to 550°C were prepared and vacuum residue was also collected. The vacuum residue (550^{+}°C) obtained from Hamada crude oil and Sedra crude oil, was then separately propane deasphalted and the oil contents were collected. They were found to be 8.28 wt.% and 11.34 wt.% on atmospheric residue for Hamada and Sedra crude oils, respectively. The deasphalted oil and other distillate fractions were subjected to dewaxing and solvent extraction. The properties of oils obtained after treatment are given in Table 8 for Hamada crude oil and Table 9 for Sedra crude oil. The plot of mid wt.% of yield versus kinematic viscosity at 40°C of processed oils is shown in Fig. 2 and Fig. 3 for Hamada and Sedra crude oils respectively. 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 10.

The distillate fractions after processing (dewaxing and solvent extraction) had viscosity index 66–108 in case of Hamada crude oil and 57 to 90°C in case of Sedra crude oil, and pour point −6 to −9°C in case of both Hamada and Sedra crude oils. The deasphalted oils obtained from vacuum residua after dewaxing and solvent extraction had pour point 0°C in case of Hamada crude oil and +3°C in case of Sedra crude oil. The viscosity index (VI) of processed oils obtained from Hamada and Sedra crude oils are lower than the required in specifications of finished

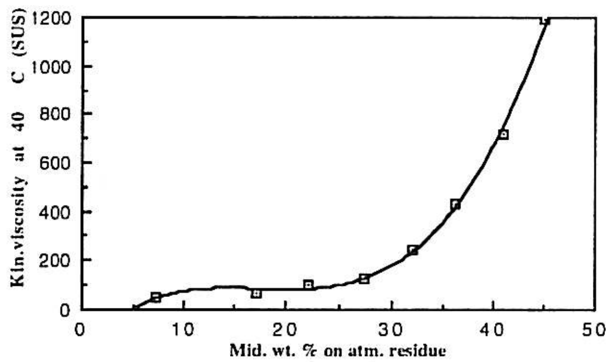

Fig. 2. Kin viscosity versus mid wt.% of yield of processed base oil of hamada crude oil.

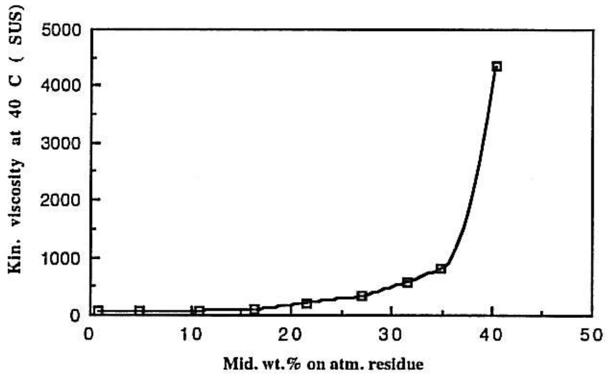

Fig. 3. Kin viscosity versus mid. wt.% of yield of processed base oil of sedra crude oil.

Table 10. 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.%)*	
	Hamada crude	*Sedra crude*	*Hamada crude*	*Sedra crude*	*Hamada crude*	*Sedra crude*
Base stock for light lubricants	340–449	340–442	46.04	31.50	22.36	15.83
N 150	449–466	442–478	2.60	6.60	1.26	3.32
N 250	—	478–505	—	4.50	—	2.26
N 500	466–550	505–550	14.58	8.10	7.08	4.07
Bright stock	550+	550+	5.02	7.36	2.44	3.70

engine oils. Therefore, further processing or addition of a suitable additive of viscosity index improver is required to produce good quality engine oil from these base lube oils. Material balance of the yields of lube base stocks, wax content, aromatic content and asphalt content are given in Table 11. The yields of base stock to produce light viscosity range lubricants were found to be 46.04 wt.% on atm. residue (22.36 wt.% on crude) in case of Hamada crude oil and 31.50 wt.% on atm. residue (15.83 wt.% on crude) in case of Sedra crude oil. Recent reports in the literature (Singh *et al.* 1985) indicate that base oils of lower viscosity are required by the automotive sector to meet the need of fuel efficient multigrade lube oils. However, the volatility of such base oils need to be carefully controlled to avoid excessive oil consumption. These reports further indicate that friction modifiers have been found to respond best in low viscosity oils.

The above trends make the situation favourable towards the use of lube base stocks from Hamada and Sedra crude oils since the major potential of these oils are in lower viscosity range. The volatility

Table 11. Material balance of the process

Product	*Yield on atm. residue (wt.%)*		*Yield on crude (wt.%)*	
	Hamada crude	*Sedra crude*	*Hamada crude*	*Sedra crude*
Base oil for light viscosity lubricants	46.04	31.50	22.36	15.83
N 150	2.60	6.60	1.26	3.32
N 250	—	4.50	—	2.26
N 500	14.58	8.10	7.08	4.07
Bright stock	5.02	7.36	2.44	3.70
Wax content	3.72	8.56	1.81	4.30
Aromaticextract	7.35	9.22	3.57	4.63
Asphalt	20.69	23.12	10.05	11.62

Losses were calculated to be 1.04 wt.% on atm. residue in case of Sedra crude oil.

characteristics of these base oils can be improved by careful control of vacuum unit operation so that produced oils have less low boiling materials.

Although it is difficult to make any firm statement on the application aspect of formulated lubricants from Hamada and Sedra lube base stocks in the absence of any performance data, however, it is possible to state that it appears possible to formulate multigrade oils like 20W50, 20W40, and alike with the combination of the following:

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

CONCLUSIONS

1. Obtained evaluation results indicate that Hamada and Sedra crude oils can be used to produce different grades of lube base stocks but the viscosity index of these base oils was found between 66 to 108 in case of Hamada crude oil and 57 to 90 in case of Sedra crude oil. Therefore, a suitable additive of viscosity index improver is required to produce good quality engine oil from these base lube oils.
2. Production potential of a substantially large amount (46.04 wt.% on atmospheric residue; 22.36 wt.% on crude oil in case of Hamada crude oil and 31.50 wt.% on atmospheric residue; 15.83 wt.% on crude oil in case of Sedra crude oil) of lube base stocks lies in the light viscosity range. Such type of base oils, according to the recent trends, can be used in the formulation of fuel efficient, multigrade motor oil along with the proper additive package and synthetic lubricants.

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