

**ASPHALT PRODUCTION BY BLENDING BASESTOCKS WITH DEASPHALTER
ROCK**

FIELD OF THE INVENTION

[0001] Asphalt compositions are provided based on combinations of deasphalter rock
5 with lubricating oils, along with methods for forming such asphalt compositions.

BACKGROUND OF THE INVENTION

[0002] One of the goals in maximizing the value of a petroleum feed is to find a
valuable use for as much of the carbon content of the stream as possible. This goal becomes
increasingly difficult to achieve for feeds with higher boiling fractions. For example, some
10 heavy oil fractions are suitable for production of asphalt.

[0003] Asphalt is a viscoelastic semi-solid bituminous material derived from the
distillation residue of crude petroleum. Asphalt may be obtained from a variety of heavy oil
sources including straight run vacuum residue, mixtures of vacuum residue with diluents such
as vacuum tower wash oil, paraffin distillate, aromatic and naphthenic oils and mixtures
15 thereof, oxidized vacuum residues or oxidized mixtures of vacuum residues and diluent oils
and the like. Because it is hydrophobic and has good adhesive and weathering characteristics,
asphalt is widely used as a binder or cement for stone or rock aggregate in pavement
construction (typically only ~5 wt % of the mixture).

[0004] Petroleum feeds that include higher boiling fractions suitable for asphalt
20 production may also be suitable for a deasphalting process, such as propane deasphalting. A
typical deasphalting process results in a higher value fraction suitable for further processing,
such as to form a fuel or lubricant. However, a deasphalting residue is left behind. This
deasphalting residue is sometimes referred to as deasphalter rock. Typically, such a
deasphalting residue is difficult to upgrade to fuels or other lower boiling fractions.
25 Additionally, this type of deasphalting residue may not meet technical specifications for road
paving or other typical asphalt uses. If a suitable use cannot be identified for the deasphalter
residue, it can lower the overall value of the deasphalting process.

[0005] It would be desirable to identify additional methods for forming compositions
using deasphalting residues that allow for substantial incorporation into commercially useful
30 products.

[0006] U.S. Patent 8,993,495 describes upgrading solvent deasphalting residues to
asphalt by combining the desaphalting residue with a heavy oil fraction, such as a distillation

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bottoms fraction. Optionally, an alkyl substituted aromatic sulfonic acid can be added to the resulting asphalt composition to further improve the properties.

[0007] U.S. Patent 5,911,817 and U.S. Patent 5,904,760 describe processes for paving with asphalt that contains mineral lubricating oil base stock. Blends are described that
5 generally contain 50% or more of a conventional asphalt. Re-refined oils are noted as an example of a type of mineral lubricating oil that can be used in an asphalt composition.

[0008] U.S. Patent 6,027,557 describes asphalts formed by blending paraffinic base stocks with conventional asphalts and then oxidizing the resulting blend.

[0009] U.S. Patent Application 2019/0218465 describes block processing

10 configurations for base stock production from deasphalted oil.

SUMMARY OF THE INVENTION

[0010] In an aspect, an asphalt composition is provided. The asphalt composition includes 1.0 wt% to 20 wt% of at least one lubricant base oil, relative to a weight of the asphalt composition. The at least one lubricant base oil can have a viscosity index of 80 or
15 more and/or a kinematic viscosity at 100°C of 5.0 cSt to 32 cSt. Additionally, the asphalt composition includes 80 wt% or more of at least one deasphalter residue, relative to a weight of the asphalt composition. The at least one deasphalter residue can have a penetration at 25°C of 5.0 dmm to 30 dmm and at least one of a) a dynamic viscosity at 60°C of 1000 Pa*sec or more and b) a kinematic viscosity at 135°C of 900 cSt or more. The resulting
20 asphalt composition can have a penetration at 25°C of 35 dmm to 100 dmm and/or a softening point of 43°C to 60°C. Optionally, the asphalt composition can further include 10 wt% or less of vacuum tower bottoms relative to a weight of the asphalt composition.

[0011] In another aspect, a method for making an asphalt composition is provided. The method includes blending 1.0 wt% to 20 wt% of at least one lubricant base oil, relative to a
25 weight of the asphalt composition, with 80 wt% or more of at least one deasphalter residue, relative to a weight of the asphalt composition. The at least one lubricant base oil can have a viscosity index of 80 or more and/or a kinematic viscosity at 100°C of 5.0 cSt to 32 cSt. The at least one deasphalter residue can have a penetration at 25°C of 5.0 dmm to 30 dmm and at least one of a) a dynamic viscosity at 60°C of 1000 Pa*sec or more and b) a kinematic
30 viscosity at 135°C of 900 cSt or more. Additionally, the asphalt composition can have a penetration at 25°C of 35 dmm to 100 dmm and/or a softening point of 43°C to 60°C.

BRIEF DESCRIPTION OF THE DRAWING

[0012] FIG. 1 shows properties of asphalt compositions formed from blends of deasphalter residues with lubricant base oils.

5 [0013] FIG. 2 shows softening point versus penetration at 25°C for various asphalt compositions.

[0014] FIG. 3 shows properties for various asphalt compositions.

[0015] FIG. 4 shows properties for various asphalt compositions.

DETAILED DESCRIPTION OF THE EMBODIMENTS

10 [0016] All numerical values within the detailed description and the claims herein are modified by “about” or “approximately” the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

Overview

15 [0017] In various aspects, asphalt compositions are provided that correspond to blends of lubricating oil base stocks with deasphalter residue. Optionally, a portion of a conventional asphalt fraction (such as a portion of a vacuum distillation bottoms fraction) can be included in a blend. It has unexpectedly been found that lubricating oil base stock can be blended with deasphalter residue to form asphalts that can satisfy the specification for various types of paving and/or roofing asphalts. As a result, lubricating oils can be used as a blend stock for
20 uplift of deasphalter residue to asphalt while reducing, minimizing, or even eliminating the need to blend the deasphalter residue with a conventional vacuum distillation bottoms fraction.

[0018] For refineries that produce multiple products, operation of the refinery requires balancing of the needs for all of the different products being produced. This can include
25 having a commercially viable use or outlet for all of the products produced. For refineries that process heavier crude oil slates, one type of process option that can increase net production of fuels from the refinery is to perform solvent deasphalting on the vacuum distillation bottoms (also referred to as vacuum tower bottoms). Compared to vacuum distillation bottoms, deasphalted oil can be more readily processed in other conventional refinery equipment to
30 increase the total refinery yield of naphtha, distillate fuels, and/or other fuel products.

[0019] Solvent deasphalting, however, also generates deasphalter residue or rock. Conventionally, deasphalter residue can be added to vacuum distillation bottoms to produce

asphalt. However, substantial quantities of vacuum distillation bottoms are needed in order to uplift the deasphalter residue. Thus, if the available quantity of vacuum distillation bottoms is limited, the ability of the refinery to both produce deasphalted oil and uplift the resulting deasphalter residue to asphalt may be constrained.

5 [0020] It has been discovered that relatively small quantities of lubricant base stock can be used to uplift deasphalter rock to form an asphalt composition. In some aspects, the asphalt composition can include deasphalter rock and lubricant base stock, while including a reduced or minimized amount of vacuum distillation bottoms, such as down to substantially no vacuum distillation bottoms. In various aspects, the amount of lubricant base stock in the
10 asphalt composition can correspond to 20 wt% or less, or 15 wt% or less, relative to the weight of the asphalt composition.

[0021] Conventionally, it would not be expected that lubricant base stock could be combined with deasphalter residue to form an asphalt composition without also including a substantial portion of a linking fraction, such as a vacuum distillation bottoms. Due to the
15 highly paraffinic nature of lubricant base stocks, it would be expected conventionally that lubricant base stock and deasphalter residue would be incompatible, so that the resulting composition would be susceptible to phase separation. Additionally or alternately, the presence of paraffinic lubricant base oil would be expected conventionally to lead to problems with satisfying adhesion specifications for the resulting asphalt composition.
20 However, it has been discovered that asphalt compositions that can satisfy various types of roofing asphalt and/or paving asphalt grades can be formed by blending lubricant base stock with deasphalter residue while incorporating a reduced or minimized amount of vacuum distillation bottoms (such as down to substantially no vacuum distillation bottoms).

[0022] In other aspects, asphalt compositions can be formed that include 20 wt% or
25 more of vacuum distillation bottoms (relative to the weight of the asphalt composition) in addition to the deasphalter residue and the lubricant base oil.

Feedstock – Deasphalter Residue and Vacuum Distillation Bottoms

[0023] In various aspects, one component of the asphalt composition is deasphalter residue. In a solvent deasphalting process, a feedstock is processed to form a deasphalted oil
30 and deasphalter residue, sometimes referred to as deasphalter rock.

[0024] In various aspects, vacuum bottoms fraction or a 950°F+ (510°C+) fraction formed by another process (such as a flash fractionation bottoms or a bitumen fraction) can

be deasphalted to form a deasphalted oil. More generally, heavy oils that include at least a portion of asphaltenes can also be used. Such feedstocks suitable can include whole or reduced petroleum crude oils, atmospheric residua feedstocks, and vacuum residua feedstocks.

5 **[0025]** It is noted that one option for defining a boiling range is to use an initial boiling point for a feed and/or a final boiling point for a feed. Another option, which in some instances may provide a more representative description of a feed, is to characterize a feed based on the amount of the feed that boils at one or more temperatures. For example, a “T5” boiling point for a feed is defined as the temperature at which 5 wt % of the feed will boil.

10 Similarly, a “T95” boiling is defined as the temperature at which 95 wt % of the feed will boil.

[0026] A vacuum resid or vacuum bottoms (or other 510°C+) fraction can correspond to a fraction with a T5 distillation point (ASTM D2887, or ASTM D7169 if the fraction will not completely elute from a chromatographic system) of at least about 482°C, or at least
15 510°C, or at least 538°C. Alternatively, a vacuum resid fraction can be characterized based on a T10 distillation point (ASTM D2887 / D7169) of at least about 482°C, or at least 510°C, or at least 538°C.

[0027] Resid (or other 510°C+) fractions can be high in metals. For example, a resid fraction can be high in total nickel, vanadium and iron contents. In an aspect, a resid fraction
20 can contain at least 0.00005 grams of Ni/V/Fe (50 wppm) or at least 0.0002 grams of Ni/V/Fe (200 wppm) per gram of resid, on a total elemental basis of nickel, vanadium and iron. In other aspects, the heavy oil can contain at least 500 wppm of nickel, vanadium, and iron, such as up to 1000 wppm or more.

[0028] Contaminants such as nitrogen and sulfur are typically found in resid (or other
25 510°C+) fractions, often in organically-bound form. Nitrogen content can range from about 50 wppm to about 10,000 wppm elemental nitrogen or more, based on total weight of the resid fraction. Sulfur content can range from 500 wppm to 100,000 wppm elemental sulfur or more, based on total weight of the resid fraction, or from 1000 wppm to 50,000 wppm, or from 1000 wppm to 30,000 wppm.

30 **[0029]** Still another method for characterizing a resid (or other 510°C+) fraction is based on the Conradson carbon residue (CCR) of the feedstock. The Conradson carbon

residue of a resid fraction can be 1.0 wt% to 50 wt%, or 1.0 wt% to 30 wt%, or 5 wt% to 50 wt%, or 5 wt% to 30 wt%, or 10 wt% to 40 wt%, or 20 wt% to 50 wt%.

[0030] Solvent deasphalting is a solvent extraction process. Typical solvents include alkanes or other hydrocarbons containing 3 to 6 carbons per molecule. Examples of suitable solvents include propane, n-butane, isobutene, and n-pentane. Alternatively, other types of solvents may also be suitable, such as supercritical fluids. During solvent deasphalting, a feed portion is mixed with the solvent. Portions of the feed that are soluble in the solvent are then extracted, leaving behind a residue with little or no solubility in the solvent. Typical solvent deasphalting conditions include mixing a feedstock fraction with a solvent in a weight ratio of from 1:2 to 1:10. Typical solvent deasphalting temperatures range from 40°C to 100°C. Typical solvent deasphalting temperatures range from 40°C to 200°C, or 40°C to 150°C, depending on the nature of the feed and the solvent. The pressure during solvent deasphalting can be from about 50 psig (345 kPag) to about 500 psig (3447 kPag).

[0031] The portion of the feedstock that is extracted with the solvent is often referred to as deasphalted oil. The yield of deasphalted oil from a solvent extraction process varies depending on a variety of factors, including the nature of the feedstock, the type of solvent, and the solvent extraction conditions. A lighter molecular weight solvent such as propane will result in a lower yield of deasphalted oil as compared to n-pentane, as fewer components of the heavy oil will be soluble in the shorter chain alkane. However, the deasphalted oil resulting from propane deasphalting is typically of higher quality, resulting in expanded options for use of the deasphalted oil. Under typical deasphalting conditions, increasing the temperature will also usually reduce the yield while increasing the quality of the resulting deasphalted oil.

[0032] In various aspects, the deasphalter residue can correspond to a deasphalter residue formed by performing deasphalting using a C₃ – C₅ deasphalting solvent, such as propane deasphalting, butane deasphalting, pentane deasphalting, or a combination thereof.

[0033] In various aspects, a deasphalter residue can have a penetration at 25°C of 5.0 dmm – 30 dmm, or 5.0 dmm to 25 dmm, or 10 dmm – 30 dmm, or 15 – 30 dmm, or 20 – 30 dmm, or 10 dmm – 25 dmm (EN 1426). This is in contrast to vacuum tower bottoms, which would be expected to have a penetration at 25°C of greater than 30 dmm. Additionally or alternately, a deasphalter residue can have a softening point of 52°C to 65°C, or 54°C to

65°C, or 52°C to 60°C, or 54°C to 60°C (EN 1427). It is noted that the unit “dmm” is equivalent to the unit 0.1 mm or mm/10.

[0034] Deasphalter residue can tend to have different viscosity properties than fractions such as lubricant base oils, vacuum tower bottoms, and/or vacuum gas oils. In some aspects, a deasphalter residue can have a dynamic viscosity at 60°C (EN 12596) of 1000 Pa*sec or more, or 1200 Pa*sec or more, or 1500 Pa*sec or more, or 2000 Pa*sec or more, such as up to 4000 Pa*sec or possibly still higher. Additionally or alternately, a deasphalter residue can have a kinematic viscosity at 135°C of 900 cSt or more, or 1000 cSt or more, or 1100 cSt or more, such as up to 100,000 cSt or possibly still higher. This is in contrast to, for example, vacuum tower bottoms, which would be expected to have a dynamic viscosity at 60°C of less than 1000 Pa*sec and/or a kinematic viscosity at 135°C of less than 900 cSt.

[0035] In various aspects, deasphalter residue can have one or more of the following properties: a density at 15°C of 1.06 g/cm³ to 1.15 g/cm³ (ASTM D792); a sulfur content of 2.5 wt% to 9.0 wt% (ASTM D4294); 0.2 wt% to 1.5 wt% nitrogen (ASTM D5291); and/or 30 wt% to 90 wt % micro-carbon residue, or 40 wt% to 90 wt%, or 51 wt% to 90 wt% (ASTM D189). In some aspects, the deasphalter residue can have a combined content of Ni and V of 250 wppm or more, or 400 wppm or more, or 500 wppm or more, such as up to 1500 wppm or possibly still more. In some aspects, the deasphalter residue can include 90 wt% or more of 565°C+ components, or 92 wt% or more, or 95 wt% or more, such as up to 100 wt%.

Feedstock – Lubricant Base Oil

[0036] In various aspects, deasphalter residue can be blended with lubricant base oil to form an asphalt composition. The lubricant base oil can correspond to any convenient type of substantially paraffinic lubricant base oil. In some aspects, the lubricant base oil can be part of a finished lubricant composition. In some aspects, the lubricant base oil can be part of a used or spent lubricant composition. It is noted that unless otherwise specified, references to a lubricant base oil herein are defined to include either a single lubricant base oil or composition where a plurality of base oils have been blended to form a mixed lubricant base oil composition.

[0037] In various aspects, a lubricant base oil (or a mixture of base oils) can have a kinematic viscosity at 100°C (KV100) of 1.5 cSt to 50 cSt, or 1.5 cSt to 35 cSt, or 1.5 cSt to 15 cSt, or 5.0 cSt to 50 cSt, or 5.0 cSt to 35 cSt, or 16 cSt to 35 cSt (ASTM D445).

Additionally or alternately, a lubricant base oil (or mixture of base oils) can have a kinematic viscosity at 40°C (KV40) of 5.0 cSt to 800 cSt, or 5.0 cSt to 250 cSt, or 25 cSt to 800 cSt, or 25 cSt to 250 cSt. Further additionally or alternately, a lubricant base oil (or a mixture of base oils) can have a viscosity index of 80 to 250, or 80 to 160 or 80 to 135, or 80 to 120, or 90 to 160, or 90 to 135, or 90 to 120, or 100 to 250, or 100 to 160, or 100 to 135, or 120 to 160 (NF ISO 2909).

[0038] In some aspects, a lubricant base oil (or a mixture of base oils) can have a T10 distillation point of 370°C or higher, a T90 distillation point of 565°C or less, or a combination thereof. Additionally or alternately, a lubricant base oil (or a mixture of base oils) can have a pour point of -3°C to -80°C, or -3°C to -60°C (ASTM D97). Further additionally or alternately, a lubricant base oil (or mixture of base oils) can have a density at 15°C of 0.87 g/cm³ – 0.93 g/cm³, or 0.88 g/cm³ – 0.92 g/cm³ (ASTM D4052).

Asphalt Properties

[0039] In some aspects, an asphalt composition can include deasphalter rock and lubricant base oil, while containing a reduced or minimized amount of vacuum distillation bottoms. In such aspects, the asphalt composition can include 1.0 wt% to 20 wt% of lubricant base oil, or 5.0 wt% to 20 wt%, or 8.0 wt% to 20 wt%, or 1.0 wt% to 17 wt%, 2.0 wt% to 17 wt%, or 5.0 wt% to 17 wt%, or 8.0 wt% to 17 wt%, or 11 wt% to 17 wt%, or 1.0 wt% to 13 wt%, or 2.0 wt% to 13 wt%, or 6.0 wt% to 13 wt%, or 1.0 wt% to 5.0 wt%, or 2.0 wt% to 5.0 wt%. The amount of vacuum distillation bottoms can be 15 wt% or less of the asphalt composition, or 10 wt% or less, or 5.0 wt% or less, or 1.0 wt% or less, such as down to having substantially no content (0.1 wt% or less) of vacuum distillation bottoms. The deasphalter residue content can be 65 wt% to 97 wt%, or 70 wt% to 97 wt%, or 80 wt% to 97 wt%, or 65 wt% to 90 wt%, or 70 wt% to 90 wt%. It is noted that other components and/or additives that are different from vacuum distillation bottoms, deasphalter residue, or lubricant base oil, but typically found in asphalt compositions, may also be present in amounts of 10 wt% or less, or 5.0 wt% or less, or 1.5 wt% or less, such as down to having substantially no content of other components or additives (0.1 wt% or less).

[0040] In other aspects, asphalt compositions can be formed that have a higher content of vacuum distillation bottoms. In such aspects, the asphalt composition can include 16 wt% or more of vacuum distillation bottoms, or 20 wt% or more, such as up to 50 wt% or possibly still higher. The asphalt composition can also include 2.0 wt% to 14 wt% of lubricant base

oil, or 5.0 wt% to 14 wt%, or 8.0 wt% to 14 wt%, or 11 wt% to 14 wt%, or 2.0 wt% to 12 wt%, or 5.0 wt% to 12 wt%, or 2.0 wt% to 5.0 wt%. Additionally, the asphalt composition can include 33 wt% to 80 wt% of deasphalter residue, or 40 wt% to 80 wt%, or 50 wt% to 80 wt%, or 40 wt% to 70 wt%, or 50 wt% to 70 wt%. It is noted that other components and/or
5 additives that are different from vacuum distillation bottoms, deasphalter residue, or lubricant base oil, but typically found in asphalt compositions, may also be present in amounts of 10 wt% or less, or 5.0 wt% or less, or 1.5 wt% or less, such as down to having substantially no content of other components or additives (0.1 wt% or less).

[0041] The resulting asphalt composition formed by blending deasphalter residue,
10 lubricant base oil, and optionally vacuum distillation bottoms, can have various properties that may be suitable for satisfying one or more types of asphalt specification.

[0042] In various aspects, the asphalt composition can have a penetration at 25°C of 35 dmm to 70 dmm, or 35 dmm to 60 dmm, or 35 dmm to 50 dmm, or 50 dmm to 70 dmm, or 50 dmm to 60 dmm, or 60 dmm to 70 dmm. In other aspects, the asphalt composition can
15 have a penetration at 25°C of 55 dmm to 100 dmm, or 55 dmm to 80 dmm, or 65 dmm to 100 dmm, or 65 dmm to 80 dmm. In some aspects, the asphalt composition can have a softening point of 43°C to 60°C, or 43°C to 55°C, or 48°C to 60°C, or 50°C to 60°C, or 48°C to 55°C.

[0043] Additionally or alternately, in various aspects, the asphalt composition can have a dynamic viscosity at 60°C (EN 12596) of 90 Pa*sec or more, or 120 Pa*sec or more, or 150
20 Pa*sec or more, or 180 Pa*sec or more, or 225 Pa*sec or more, such as up to 350 Pa*sec or possibly still higher. Further additionally or alternately, the asphalt composition can have a ductility at 10°C of 90 cm or more, or 110 cm or more, or 130 cm or more, such as up to 200 cm or possibly still higher.

[0044] In addition to the above properties, in various aspects, an asphalt composition
25 can have one or more properties that would typically be expected for a commercially viable asphalt composition. In some aspects, an asphalt composition can have a Fraass breaking point (EN 12593) of -5°C to -15°C. In some aspects, an asphalt composition can have a density at 15°C of 1.00 g/cm³ to 1.05 g/cm³. In some aspects, an asphalt composition can have a kinematic viscosity at 135°C of 230 cSt or more, or 370 cSt or more, such as up to 800
30 cSt.

Example 1 – Formation of European Paving Asphalt Compositions

- [0045] A series of deasphalter residue samples were blended with commercially available lubricant base oils to form asphalt compositions. Table 1 shows the properties of the deasphalter residues. Note that for deasphalter residues 1 – 2 (DR1, DR2, DR3), the values shown are measured values. For deasphalter residue 3 (DR3), the values are marked with an asterisk, as these values are calculated from a resulting blended product based on the blend ratio.

Table 1 – Properties of Deasphalter Residues

Tests	Standards	Units	Rock		
			1	2	3
Penetration at 25°C	EN 1426	mm/10	25	29	23*
Softening point	EN 1427	°C	55.8	55.2	56.4*

- 10 [0046] The deasphalter residues were blended with three types of commercially available lubricant base oils. The lubricant base oils corresponded to ExxonMobil AP/E Core™ 150, Core™ 600, and Core™ 2500 base stocks. Table 2 provides some properties for the three types of base oils. The properties in Table 2 include pour point, density at 15°C, kinematic viscosity at 40°C (KV40) and 100°C (KV100), and viscosity index.

Table 2 – Base Oil Properties

Tests	Standards	Units	AP/E Core		
			150	600	2500
Pour point	ASTM D97	°C	-13	-8	-9
Density at 15°C	ASTM D4052	g/mL	0.8864	0.8862	0.9006
Kinematic viscosity @ 40°C	ASTM D445	mm ² /s	31.10	112.4	479.4
Kinematic viscosity @ 100°C	ASTM D445	mm ² /s	5.298	12.07	31.47
Viscosity index	NF ISO 2909	-	102	96	96

- [0047] FIG. 1 shows examples of asphalt compositions that were formed by blending deasphalter residues from Table 1 with base oils from Table 2. In addition to characterization of the blends, FIG. 1 shows examples of specifications for European 35 / 50 paving asphalt, as well as predicted asphalt properties for asphalts made by conventional methods from two types of conventional crudes. For the blends corresponding to asphalt compositions shown in FIG. 1, the blends were made with a target penetration at 25°C between 45 to 50 dmm. This

is on the soft side of the specification for a 35 / 50 paving asphalt. This target was selected because typically an asphalt that can meet specifications at a softer penetration value will also be able to meet specifications at a harder penetration value. For comparison, the predicted asphalt properties were based on a target penetration at 25°C of 47 dmm.

- 5 **[0048]** As shown in FIG. 1, blending deasphalter residue with roughly 4.0 wt% of lubricant base oil, relative to the weight of the composition, resulted in formation of asphalt compositions that could satisfy most or even all of the properties / specifications of a European 35 / 50 paving asphalt according to EN 12591. It is noted that based on the results in FIG. 1, forming asphalts with penetration depths at 25°C of less than 45 dmm may be
10 desirable, as the softening points for all of the asphalts were close to the specification limit of 50°C. It would be expected that forming asphalts with penetrations depths at 25°C of 35 dmm to 45 dmm would result in higher softening points. Forming asphalts with penetration depths at 25°C of 35 dmm to 45 dmm would also assist with lowering the Fraass breaking point values for the resulting asphalt composition, which were close to the specification value of -
15 5°C for all of the asphalt compositions that were formed.

[0049] It is noted that the asphalt compositions formed from deasphalter residue and lubricant base oil had good rutting depth values. The asphalt compositions had rutting depth values of 4.2% or less. This is comparable to some types of commercially available asphalts, and below the typical standard of 7.5% or less.

- 20 **[0050]** Additionally, an unexpected benefit of forming asphalt compositions from a blend of deasphalter residue and lubricant base oil is that the resulting asphalt compositions have good fatigue and thermal performance to relax stress during winter. This is shown, for example, by the BBR S-values and BBR m-values in FIG. 1, along with the positive ΔTC values.

- 25 **[0051]** As a further illustration, FIG. 2 shows softening point versus penetration at 25°C for a number of asphalt compositions that were formed by blending deasphalter residue with lubricant base oil. FIG. 2 also shows the specification boxes for European 35 / 50 paving asphalt and European 50 / 70 paving asphalt. As shown in FIG. 2, 50 / 70 paving asphalt can also be made based on blends of deasphalter residue and lubricant base oil. Similar to the
30 results shown in FIG. 1, selecting harder penetration values at 25°C can be beneficial for achieving a softening point that stays within specification, but this is generally not as significant an issue for 50 / 70 paving asphalts.

[0052] In addition to the results shown in FIG. 1 and FIG. 2, exudation tests were also performed according to EN 13301. During the exudation test, the product was stored for five days at 80°C. The exudation test is a measure of whether an asphalt composition can remain together as a stable material, or alternatively whether lower boiling components (such as lubricant base oil) might phase separate and “exude” from the material. Typically this type of test is used on materials that have softening point values of 85°C or higher. However, the test was used here as a qualitative characterization. During the test, a 35 / 50 paving asphalt made via conventional refinery methods from a conventional feed was also tested as a baseline. During the test, no qualitative difference was observed in the amount of exudation between the conventionally made asphalt and the asphalt compositions formed by blending deasphalter residue with lubricant base oil.

Example 2 – Formation of Additional Asphalt Compositions

[0053] An additional deasphalter residue were used to form asphalt compositions with the lubricant oils shown in Table 2. FIG. 3 shows characterization of asphalt compositions made with either the deasphalter residue and the AP/E Core™ 600 from Table 2, or the deasphalter residue and the AP/E Core™ 150 from Table 2. FIG. 3 also show comparisons with asphalts made at various commercial refineries. For comparison with a specification, the specification for China 60 / 80M asphalt is included in the Tables.

[0054] As shown in FIG. 3, the asphalts made using a blend of deasphalter residue and lubricant base oil offered an excellent degree of quality. The asphalt compositions satisfied the regional specifications in all aspects. Additionally, the asphalts made from a blend of deasphalter residue and lubricant base oil unexpectedly outperformed typical asphalts in certain aspects, such as low temperature ductility, which represents the ability of asphalt to resist against cold cracking failure. Additionally, the relationship between the penetration at 25°C and the dynamic viscosity at 60°C is often an important parameter as it provides information on the asphalt temperature susceptibility character. Having a high dynamic viscosity at 60°C for any given penetration at 25°C is preferred. The blends between de-asphalted rocks and base oils showed an unexpectedly high dynamic viscosity relative to the penetration value at 25°C.

Example 3 – Comparison of Blends With and Without Substantial Vacuum Tower Bottoms Content

[0055] It has been discovered that forming asphalt compositions based on blends of deasphalter residue with lubricant base oil, with only a reduced or minimized content of vacuum tower bottoms, can provide unexpected advantages relative to addition of lubricant base oil to compositions that include a substantial portion of vacuum tower bottoms. To illustrate this comparison, the components shown in Table 3 were used to form asphalt compositions both with and without substantial content of vacuum tower bottoms. In Table 3, DR4 and DR5 are deasphalter residues, VTB A is a vacuum tower bottoms, and C600 refers to another sample of AP/E Core™ 600. DV60 corresponds to dynamic viscosity at 60°C.

Table 3 – Example 3 Blend Components

	DR4	DR5	VTB A	C600
Pen at 25°C (dmm)	15	16	128	
DV60 (Pa sec)	2470	1220	78.3	
Specific Gravity at 15°C (g/L)		1.055	1.028	0.889
KV135 (cSt)		942		
KV100 (cSt)			1898	12
KV40 (cSt)				113

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[0056] The components in Table 3 were used to make the following two asphalt compositions. A first composition was a tertiary blend of 48.5 wt% DR4, 48.5 wt% VTB, and 3.0 wt% C600. A second composition was a binary blend of 91.5 wt% DR5 and 8.5 wt% C600.

15 [0057] FIG. 4 shows the characterization of the resulting asphalt compositions. As shown in FIG. 4, both the tertiary blend (with vacuum tower bottoms) and the binary blend (without vacuum tower bottoms) were able to meet the specifications for a China 60 / 80M paving asphalt grade or an Indonesia 60 / 70I paving asphalt grade. Both blends also show similar aging properties, with the aging properties being comparable to some commercially available asphalts. The rheological properties of DSRo and DSRr for both blends are also able to achieve a high temperature performance grade (HTPG) of 64.

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[0058] For the binary blend, however, in addition to providing comparable values for various properties, the binary blend also provides unexpectedly improved viscosity and

ductility at 10°C. It is noted that for a given penetration value for an asphalt, a higher DV60 value represents a lower tendency for the asphalt to flow, which means that the asphalt has higher stability. A higher ductility means that if the asphalt does flow, the asphalt is less likely to crack. For the binary blend, the underlying deasphalter residue (DR5) had a substantially lower DV60 value than the deasphalter residue used for the tertiary blend (DR4). However, when formulating asphalt compositions to have substantially the same penetration at 25°C, the binary blend provided a higher DV60 value while also having improved ductility. This is an unexpected outcome that was facilitated by using lubricant base oil as a blend component while having a reduced or minimized content of vacuum tower bottoms (such as substantially no vacuum tower bottoms).

Example 4 – Comparison of Blends Based on Vacuum Gas Oil Blend Component

[0059] Asphalt compositions formed based on a blend of deasphalter residue with lubricant base oil also show unexpectedly improved properties relative to blends of deasphalter residue with comparable amounts of vacuum gas oil. Vacuum gas oil corresponds to the feedstock that would typically be used as the starting feed for forming a lubricant base oil. Prior to processing to form a lubricant base oil, vacuum gas oils will have a viscosity index values that are too low for use as a lubricant base oil.

[0060] Table 4 shows the blend components that were used in this example.

Table 4 – Blend Components for Example 4

	DR7	VTB B	C600	VGO
Pen at 25°C (dmm)	15	123		
DV60 (Pa sec)	2470	78.9		
KV100 (cSt)		1898	12	14.9
KV40 (cSt)			113	

[0061] The blend components in Table 4 were used to make a several different types of asphalt compositions. A first series of asphalt compositions corresponded to binary blends of deasphalter residue with lubricant base oil. Table 5 shows the blend compositions and corresponding properties. In Table 5, the weight of the C600 lubricant base oil is shown, with the balance of the composition corresponding to the DR7 deasphalter residue.

Table 5 – Properties of Binary Blends of Deasphalter Residue and Lubricant Base Oil

Wt% C600	Penetration at 25°C (dmm)	Softening point (°C)	DV 60 (Pa sec)	Ductility at 10°C (cm)
9.5	62			130.2
10	68	48.4	230	
11	78	47.2	187	
12	90	45.6	156	

[0062] As shown in Table 5, blends of 8.0 wt% to 15 wt%, or 9.0 wt% to 13.5 wt%, of deasphalter residue with lubricant base oil resulted in asphalt compositions with desirable combinations of penetration at 25°C, softening point, and dynamic viscosity at 60°C. The resulting blends also had high ductility at 10°C. As a comparison, Table 6 shows binary blends of the same deasphalter residue with the vacuum gas oil fraction.

Table 5 – Properties of Binary Blends of Deasphalter Residue and Vacuum Gas Oil

Wt% VGO	Penetration at 25°C (dmm)	Softening point (°C)	DV 60 (Pa sec)	Ductility at 10°C (cm)
12.5	61			60
13	67	48.2	167	
14	76	47.2	141	
15	85	46.4	119	

[0063] As shown in Table 5, marginally more vacuum gas oil was needed to form asphalt compositions with similar values for penetration and softening point relative to the blends in Table 4. However, at comparable values for penetration and softening point, the asphalt compositions in Table 5 had substantially lower values for both dynamic viscosity at 60°C and ductility at 10°C. This is an unexpected difference between using a lubricant base oil and a vacuum gas oil as a blend component for forming an asphalt composition.

Additional Embodiments

[0064] Embodiment 1. An asphalt composition, comprising: 1.0 wt% to 20 wt% of at least one lubricant base oil, relative to a weight of the asphalt composition, the at least one lubricant base oil having a viscosity index of 80 or more and a kinematic viscosity at 100°C

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of 5.0 cSt to 32 cSt; 80 wt% or more of at least one deasphalter residue, relative to a weight of the asphalt composition, the at least one deasphalter residue comprising a penetration at 25°C of 5.0 dmm to 30 dmm and at least one of a) a dynamic viscosity at 60°C of 1000 Pa*sec or more and b) a kinematic viscosity at 135°C of 900 cSt or more, the asphalt
5 composition comprising a penetration at 25°C of 35 dmm to 100 dmm and a softening point of 43°C to 60°C.

[0065] Embodiment 2. The asphalt composition or method of any of the above embodiments, wherein the asphalt composition comprises a ductility at 10°C of 100 cm or more.

10 **[0066]** Embodiment 3. The asphalt composition of Embodiment 1, wherein the asphalt composition comprises a penetration at 25°C of 35 dmm to 70 dmm.

[0067] Embodiment 4. The asphalt composition of any of the above embodiments, wherein the asphalt composition comprises a penetration at 25°C of 55 dmm to 100 dmm.

[0068] Embodiment 5. The asphalt composition of any of the above embodiments,
15 wherein the at least one lubricant base oil comprises a kinematic viscosity at 135°C of 800 cSt or less.

[0069] Embodiment 6. The asphalt composition of any of the above embodiments, wherein the at least one lubricant base oil comprises a pour point of 0°C or less.

[0070] Embodiment 7. The asphalt composition of any of the above embodiments,
20 wherein the asphalt composition comprises 10 wt% or less of vacuum tower bottoms, relative to a weight of the asphalt composition.

[0071] Embodiment 8. The asphalt composition of Embodiment 7, wherein the vacuum tower bottoms have a penetration at 25°C of greater than 30 dmm and a viscosity index of less than 80.

25 **[0072]** Embodiment 9. The asphalt composition of Embodiment 7 or 8, wherein the vacuum tower bottoms comprise a dynamic viscosity at 60°C of less than 1000 Pa*sec, or wherein the vacuum tower bottoms comprise a kinematic viscosity at 135°C of less than 900 cSt, or a combination thereof.

[0073] Embodiment 10. The asphalt composition of any of the above embodiments,
30 wherein the asphalt composition comprises 2.0 wt% to 5.0 wt% of a lubricant base oil, the asphalt composition having a penetration at 25°C of 35 dmm to 70 dmm.

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[0074] Embodiment 11. The asphalt composition of any of the above embodiments, wherein the asphalt composition comprises 8.0 wt% to 17 wt% of a lubricant base oil, the asphalt composition having a penetration at 25°C of 55 dmm to 100 dmm.

[0075] Embodiment 12. The asphalt composition of any of the above embodiments,
5 wherein the at least one deasphalter residue comprises a penetration at 25°C of 10 dmm to 30 dmm, or wherein the asphalt composition comprises a softening point of 48°C to 60°C, or a combination thereof.

[0076] Embodiment 13. A method for making an asphalt composition according to any of the above embodiments, comprising: blending 2.0 wt% to 17 wt% of the at least one
10 lubricant base oil, relative to a weight of the asphalt composition, with 80 wt% or more of the at least one deasphalter residue, relative to a weight of the asphalt composition.

[0077] Embodiment 14. The method of Embodiment 13, further comprising blending 10 wt% or less of vacuum tower bottoms, relative to a weight of the asphalt composition, with the at least one lubricant base oil and the at least one deasphalter residue,

[0078] Additional Embodiment A. A method for making an asphalt composition,
15 comprising: blending 1.0 wt% to 20 wt% of at least one lubricant base oil, relative to a weight of the asphalt composition, with 80 wt% or more of at least one deasphalter residue, relative to a weight of the asphalt composition, the at least one lubricant base oil having a viscosity index of 80 or more and a kinematic viscosity at 100°C of 5.0 cSt to 32 cSt, the at
20 least one deasphalter residue comprising a penetration at 25°C of 5.0 dmm to 30 dmm and at least one of a) a dynamic viscosity at 60°C of 1000 Pa*sec or more and b) a kinematic viscosity at 135°C of 900 cSt or more, the asphalt composition comprising a penetration at 25°C of 35 dmm to 100 dmm and a softening point of 43°C to 60°C.

[0079] While the present invention has been described and illustrated by reference to
25 particular embodiments, those of ordinary skill in the art will appreciate that the invention lends itself to variations not necessarily illustrated herein. For this reason, then, reference should be made solely to the appended claims for purposes of determining the true scope of the present invention.

CLAIMS

1. An asphalt composition, comprising: 1.0 wt% to 20 wt% of at least one lubricant base oil, relative to a weight of the asphalt composition, the at least one lubricant base oil having a viscosity index of 80 or more and a kinematic viscosity at 100°C of 5.0 cSt to 32 cSt; 80 wt% or more of at least one deasphalter residue, relative to a weight of the asphalt composition, the at least one deasphalter residue comprising a penetration at 25°C of 5.0 dmm to 30 dmm and at least one of
 - a) a dynamic viscosity at 60°C of 1000 Pa*sec or more and b) a kinematic viscosity at 135°C of 900 cSt or more, the asphalt composition comprising a penetration at 25°C of 35 dmm to 100 dmm and a softening point of 43°C to 60°C.
2. The asphalt composition of claim 1, wherein the asphalt composition comprises a ductility at 10°C of 100 cm or more.
3. The asphalt composition of claim 1 or 2, wherein the asphalt composition comprises a penetration at 25°C of 35 dmm to 70 dmm.
4. The asphalt composition of claim 1 or 2, wherein the asphalt composition comprises a penetration at 25°C of 55 dmm to 100 dmm.
5. The asphalt composition of any of claims 1 to 4, wherein the at least one lubricant base oil comprises a kinematic viscosity at 135°C of 800 cSt or less.
6. The asphalt composition of any of claims 1 to 5, wherein the at least one lubricant base oil comprises a pour point of 0°C or less.
7. The asphalt composition of any of claims 1 to 6, wherein the asphalt composition comprises 10 wt% or less of vacuum tower bottoms, relative to a weight of the asphalt composition.
8. The asphalt composition of claim 7, wherein the vacuum tower bottoms have a penetration at 25°C of greater than 30 dmm and a viscosity index of less than 80.
9. The asphalt composition of claim 7 or 8, wherein the vacuum tower bottoms comprise a dynamic viscosity at 60°C of less than 1000 Pa*sec, or wherein the vacuum tower bottoms comprise a kinematic viscosity at 135°C of less than 900 cSt, or a combination thereof.

10. The asphalt composition of any of claims 1 to 3 or 5 to 9, wherein the asphalt composition comprises 2.0 wt% to 5.0 wt% of a lubricant base oil, the asphalt composition having a penetration at 25°C of 35 dmm to 70 dmm.

11. The asphalt composition of any of claims 1, 2, or 4 to 9, wherein the asphalt composition comprises 8.0 wt% to 17 wt% of a lubricant base oil, the asphalt composition having a penetration at 25°C of 55 dmm to 100 dmm.

12. The asphalt composition of any of claims 1 to 11, wherein the at least one deasphalter residue comprises a penetration at 25°C of 10 dmm to 30 dmm, or wherein the asphalt composition comprises a softening point of 48°C to 60°C, or a combination thereof.

13. A method for making an asphalt composition according to any of claims 1 to 12, comprising: blending 1.0 wt% to 20 wt% of the at least one lubricant base oil, relative to a weight of the asphalt composition, with 80 wt% or more of the at least one deasphalter residue, relative to a weight of the asphalt composition.

14. The method of claim 13, wherein the method comprises: blending 2.0 wt% to 17 wt% of the at least one lubricant base oil, relative to a weight of the asphalt composition, with 80 wt% or more of the at least one deasphalter residue, relative to a weight of the asphalt composition

15. The method of claim 13 or 14, further comprising blending 10 wt% or less of vacuum tower bottoms, relative to a weight of the asphalt composition, with the at least one lubricant base oil and the at least one deasphalter residue.