

**USED MOTOR OIL DISTILLATION RESIDUE PROCESSING THROUGH
SUPERCRITICAL SOLVENT DEASPHALTING FOR LUBE OIL PRODUCTION**

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application having Serial No. 63/517,411 filed on August 3, 2023 which is incorporated by reference herein.

Field of the Invention

[0002] The present invention relates to processing residue oil through a supercritical deasphalting process to produce lube oil deasphalted oil quality and a residual or pitch.

Background

[0003] Used motor oil distillation residue (UMOR) including vacuum tower asphalt extender (VTAE), also referred to as re-refined engine oil bottoms (REOB) and like products sourced from commercial hydrocarbon products such as generator oil, lubricant oils, engine oils etc... are generally considered to be non-distillable residuum from the recycling of used oil via atmospheric distillation followed by vacuum distillation. Because distillation is not considered to be an option, the main use for these oils is as blending agents in fuel and in paving grade binders to achieve low temperature properties. Similarly, residue of virgin crude oil (VC) produced from atmospheric or vacuum distillation processes cannot typically be used as a commercial product. Instead, the VC is typically a blending component rather than being sold in consumer markets as hydrocarbon products..

[0004] While these uses of residue oil from distillation of used motor oil allow for some level of recycling of the material, they are low value utilizations of this material.

SUMMARY OF THE INVENTION

[0005] Exemplary embodiments of used motor oil distillation residue processing through supercritical solvent deasphalting for lube oil production can substantially obviate one or more of the problems due to limitations and disadvantages of the related art.

[0006] Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0007] In examples, provided is a process including feeding oil including a used motor oil distillation residue to an asphaltene separator; feeding a solvent to the asphaltene separator to achieve a solvent to oil ratio of 10:1 to 15:1 in the asphaltene separator; and causing the used motor oil distillation residue to at least partially combine with the solvent while the solvent is above supercritical pressure, wherein, a bottoms effluent of the asphaltene separator may include pitch, and an overhead of the asphaltene separator may include a deasphalted oil.

[0008] In examples, the supercritical solvent may include propane, butane, isobutane, or any mixtures thereof.

[0009] In examples, the process may include maintaining the solvent in the asphaltene separator at a temperature that is below the critical temperature of the solvent.

[0010] In examples, the process may include feeding the oil that may include the used motor oil distillation residue to the asphaltene separator as a mixture of the oil and of the solvent. In examples, the mixture of oil and of the solvent may include a solvent to oil ratio of 0.5:1 to 15:1.

[0011] In examples, feeding the supercritical solvent may include supplying solvent separately from the oil.

[0012] In examples, the process may include feeding the mixture of oil may include used motor oil distillation residue and solvent at a first stage of the asphaltene separator and feeding the supercritical solvent at a second stage of the asphaltene separator, wherein the first stage is at a higher position in the asphaltene separator than the second stage.

[0013] In examples, the process may include feeding the supercritical solvent to achieve a solvent to oil ratio of 12:1.

[0014] In examples, the process may include maintaining the solvent temperature in the asphaltene separator at a temperature below the critical temperature of the solvent.

[0015] In examples, the process may include mixing the residue virgin crude oil (VC) with the used motor oil distillation residue to form a mixed feed of used motor oil distillation residue and VC to be fed to the asphaltene separator. In examples, the mixed feed of used motor oil distillation residue and VC may include a ratio of VC to used motor oil distillation residue of about 70 to 30. In examples, the ratio of solvent to the oil in the asphaltene separator may be 13:1.

[0016] In examples, the process may include maintaining the solvent temperature in the asphaltene separator at a temperature that is below the critical temperature of the solvent.

[0017] In examples, the process may include heating the materials inside the asphaltene separator in a zone that is between an extraction packing and a coalescing plate packing.

[0018] In examples, the process may include maintaining the asphaltene separator at a pressure that is greater than about 4.2 MPa.

[0019] In examples, provided is a process including feeding a used motor oil distillation residue to an asphaltene separator; feeding a solvent to the asphaltene separator; and causing the used motor oil distillation residue to at least partially combine with the solvent while the solvent is above its supercritical pressure, wherein, a bottoms effluent of the asphaltene separator may include pitch, and an overhead of the asphaltene separator may include a deasphalted oil.

[0020] In examples, provided is a process including feeding an oil mixture that may include a residue virgin crude oil (VC) and a used motor oil distillation residue in a ratio of 70:30 to an asphaltene separator; feeding a solvent to the asphaltene separator; causing the oil mixture to at least partially combine with the solvent while the solvent is above its supercritical pressure; and wherein a bottoms effluent of the asphaltene separator may include pitch, and an overhead of the asphaltene separator may include a deasphalted oil.

[0021] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0023] In the drawings:

[0024] FIG. 1 illustrates a diagram of a process in which a UMOR residue oil feed and a solvent are provided to an asphaltene separator to yield DAO and pitch.

[0025] FIG. 2 illustrates a diagram of a process in which an asphaltene separator receives a solvent and a mixture of UMOR and VC to yield DAO and pitch.

[0026] FIG. 3 illustrates an example of a simplified plant system diagram that may be used for the deasphalting process of UMOR residue oil using a solvent.

[0027] FIG. 4 illustrates another example plant system diagram that may be used for the deasphalting process of UMOR residue oil using a solvent.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0028] Reference will now be made in detail to an embodiment of the present invention, example of which is illustrated in the accompanying drawings.

[0029] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which the inventions belong. All patents, patent applications, published applications and publications, websites and other published materials referred to throughout the entire disclosure herein, unless noted otherwise, are incorporated by reference in their entirety. Where there is a plurality of definitions for terms herein, those in this section prevail. Where reference is made to a URL or other such identifier or address, it is understood that such identifiers can change and information on the internet can

come and go, but equivalent information can be found by searching the internet. Reference thereto evidences the availability and public dissemination of such information.

[0030] As used herein, the singular forms “a”, “an” and “the” include plural referents unless the context clearly dictates otherwise.

[0031] The terms first, second, third, etc. as used herein can describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer, or section. Terms such as “first”, “second”, and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the example embodiments.

[0032] As used herein, ranges and quantities can be expressed as “about” a particular value or range. “About” also includes the exact amount. Hence “about 5 percent” means about 5 percent in addition to 5 percent. The term “about” means within typical experimental error for the application or purpose intended.

[0033] As used herein, “and/or” includes any and all combinations of one or more of the associated listed items.

[0034] As used herein, a “combination” refers to any association between two items or among more than two items. The association can be spatial or refer to the use of the two or more items for a common purpose.

[0035] As used herein, “comprising” and “comprises” are to be interpreted to mean “including but not limited to” and “includes but not limited to”, respectively.

[0036] As used herein, “optional” or “optionally” means that the subsequently described event or circumstance does or does not occur, and that the description includes instances where the event or circumstance occurs and instances where it does not. For example, an optional

component in a system means that the component may be present or may not be present in the system.

[0037] As used herein, “substantially” means “being largely but not wholly that which is specified.”

[0038] Used motor oil distillation residue (UMOR) for purposes of this disclosure refers a non-distillable residuum from the recycling of used oil sourced from commercial hydrocarbon products such as generator oil, lubricant oils, engine oils and the like. In examples, UMOR may include one or more residues from commercial hydrocarbons such as asphalt flux, asphalt blowdown, engine oil residue (EOR), re-refined heavy vacuum distillation bottoms (RHVDB), re-refined heavy vacuum distillation oil (RHVDO), re-refined engine oil bottoms (REOB), re-refined vacuum tower bottoms (RVTB), vacuum tower bottom (VTB), vacuum tower asphalt binder (VTAB), vacuum tower asphalt extender (VTAE), waste engine oil residue (WEOR), waste oil distillation bottoms (WODB) and like materials. In examples, the UMOR may include VTAE obtained by the atmospheric distillation followed by the vacuum distillation of used motor oil. In examples, UMOR may include about the remaining 10-12wt% residual after the atmospheric distillation and vacuum distillation processes of used motor oil. For example, used motor oil may be collected from various sources. That used motor oil, i.e. 100% used motor oil, may be processed via atmospheric distillation where about the lightest 5%-10% content is distilled out. The residual from the atmospheric distillation may be then processed via vacuum distillation that may distill out an additional 75%-85wt% of the feed. The leftover residual of the vacuum distillation or UMOR may thus include about 10-12wt% of the originally collected used motor oil. A use for UMOR can be as #6 fuel oil blending component. Also, having a high BTU content residual oil, #6 fuel oil is suitable to power waterborne vessels and for other marine industry use. Although useful, these applications of UMOR may not extract the most value from the material.

[0039] Similarly, residue of virgin crude oil (VC) for purposes of this disclosure refers to be the bottom of the barrel residue from a vacuum distillation or atmospheric distillation of when distilling virgin crude oil. VC is often used as a blending component for residual fuel oil or asphalt.

[0040] In examples, the process and/or system as described, may be able to extract products from used motor oil distillation residue (UMOR), or a mixture of UMOR and VC. In example, the products extracted from UMOR and/or a mixture of UMOR and VC by the process and/or system described herein may be more valuable and/or more desirable than the use of UMOR and/or a mixture of UMOR and VC as a blending component or as fuel. In examples, the process and/or system as described may be able to extract lube oil deasphalted oil quality (DAO). In examples, the process and system as described may produce a residual product, referred to as pitch, that may meet road bitumen properties components. In examples, the process and system as described, may be able to process UMOR and/or a mixture of UMOR and VC to produce both DAO and pitch product that meets road bitumen properties.

[0041] In examples, a process and system to deasphalt used motor oil distillation residue (UMOR) is described. In examples, described is a process and system to extract DAO from UMOR. In examples, described is a process and system to extract pitch that may meet road bitumen properties components from UMOR. In examples, UMOR may include VTAE. In examples, UMOR may be mixed with VC. In examples, the process and system as described may incorporate a residuum oil supercritical extraction process. In examples, the process as described herein may be carried out employing a ROSE[®] solvent deasphalting system as made available by KBR, Inc.

[0042] In examples, as illustrated in the process diagram of FIG. 1, a process 100 may include a solvent feed 102 from a solvent source 104 and UMOR feed 106 from a UMOR source 108. In examples, the solvent feed 102 and the UMOR feed 106 may be directed to an asphaltene separator 110. In examples, the solvent and the UMOR may combine in the asphaltene separator 110. In examples, an overhead product 112 of the asphaltene separator 110 may include DAO. In examples, a bottoms product 114 of the asphaltene separator 110 may include pitch. In examples, the pitch may be used as a bitumen component.

[0043] In examples, the solvent may be a solvent at near supercritical condition used in the asphaltene separator. In examples, the ratio of solvent to UMOR in the asphaltene separator may be about 10 to 1 or higher. In examples, the ratio of solvent to UMOR in the asphaltene separator may be no greater than about 15 to 1. In examples, the ratio of solvent to UMOR in the asphaltene separator may be in the range of about 10 to 1 to about 15 to 1. In examples,

the ratio of solvent to UMOR in the asphaltene separator may be 10 to 1, 11 to 1, 12 to 1, 13 to 1, 14 to 1, or 15 to 1.

[0044] In examples, as shown in the diagram of FIG. 1, the solvent feed 102 and the UMOR feed 106 may be introduced to the asphaltene separator 110 as separate feeds. In examples, the UMOR feed 106 and of the solvent feed 102 may be provided at different locations or stages of the asphaltene separator 110. In examples, a UMOR feed 106 may be provided at a higher stage of asphaltene separator 110 than the solvent feed 102.

[0045] In examples, at least a portion of the solvent may be fed to the asphaltene separator together with the UMOR. For example, the UMOR feed may include solvent at a ratio of standard volume of solvent to standard volume of UMOR of about 0.5:1 to 15:1.

[0046] In examples, the UMOR feed may include solvent at a ratio of standard volume of solvent to standard volume of UMOR of about 0.5:1 to about 2:1. In examples, the UMOR feed may include solvent at a ratio of solvent to UMOR of about 1:1.

[0047] In examples, all of the solvent may be fed to the asphaltene separator together with the UMOR. In examples, the UMOR feed 106 and the solvent feed 102 may be combined before being fed to the asphaltene separator 110. In examples, the combined UMOR feed 106 and solvent feed 102 may include a ratio of solvent to UMOR of about 10:1 to about 15:1. In examples, at least a portion of the solvent or the whole solvent may be provided by a separate solvent feed. In examples, a separate solvent feed may be provided that includes only solvent or a solvent solution.

[0048] In examples, the recovery yield rate of DAO from an overhead 112 of the asphaltene separator 110 for a deasphalting process and/or system as described herein may be in the range of at least about 30% of the feed, in examples, the recovery yield rate of DAO may range from about 30% to about 70%, for example about 30%, 40%, 50%, 60%, 70%, or in the range of 50% to 70%, or in the range from about 60% to 70%, or in the range from about 65% to 70%. In examples, the remainder may include a bottoms pitch product.

[0049] In examples, the overhead and/or bottoms of the asphaltene separator may undergo further processing and/or purification. For example, the overhead effluent may be processed through one or more separation steps to separate DAO from solvent. In examples, the separated

solvent may be recycled to the asphaltene separator. In examples, separated DAO may be used or further processed as may be desired.

[0050] In examples, the UMOR may be mixed with VC. In examples, the UMOR may include VTAE and be mixed with VC. FIG. 2 illustrates an example of a process diagram similar to that of FIG. 1 but wherein the UMOR feed is mixed with VC. As shown, process diagram 200 may include a UMOR source 202 and a VC source 204. In examples, a UMOR feed 206 from UMOR source 202 may be mixed with a VC feed 208 from VC source 204 to form a mixed oil feed 210. In examples, any mix ratios of VC and UMOR may be used. In examples, the ratio of VC to UMOR in the mixed oil feed 210 may be at least about 2:1. In examples, the mixed oil feed may include about 70% VC and 30% UMOR. The mixed oil feed 210 may be directed to an asphaltene separator 212.

[0051] A solvent feed 214 from a solvent source 216 may also be fed to asphaltene separator 212. As described earlier with reference to FIG. 1, mixed oil feed 210 may also include at least a portion of the solvent. In examples, the mixed oil feed 210 may include a standard volume of solvent to standard volume of mixed oil ratio ranging from about 0.5:1 to about 2:1. In examples, the mixed oil feed may include solvent at a ratio of solvent to mixed oil of about 1:1. In examples, the mixed oil feed may include all of the solvent to be fed to the separator. In examples, the solvent feed 214 and the mixed oil feed 210 may be combined prior to being fed to the asphaltene separator 212. In examples, the combined mixed oil feed 210 and solvent feed 214 include a ratio of solvent to mixed oil of about 10:1 to about 15:1.

[0052] In examples, the solvent from feed 214 may combine with the mixed oil feed 210 in the asphaltene separator 212. From the asphaltene separator 212, an overhead product 218 and a bottoms product 220 may be obtained. In examples, the overhead product 218 may include DAO. In examples, the bottoms product 220 may include pitch product. In examples, the pitch product may be one that may be used as a bitumen component.

[0053] The techniques and systems described herein may be implemented in several ways. Example implementations are provided below with reference to the figures.

[0054] FIG. 3 illustrates an example of a simplified plant system diagram 300 that may be used for the process described herein.

[0055] As shown in FIG. 3, the process and system 300 may include a oil feed 302 and a solvent feed 304. In examples, the oil feed 302 may include UMOR, or a combination of UMOR and VC. In examples, the oil feed 302 may include UMOR and be substantially free of VC. In examples, the oil feed 302 may include a mixture of VTAE and VC. In examples, as previously described, the ratio of VC to UMOR in the oil feed 302 may be 2:1 or higher. In examples, an oil feed 302 may include oil that may include 70% VC and 30% UMOR. In examples, the oil feed may be provided as a liquid solution when heated. In examples, the oil feed may include up to about 1wt% solids. In examples, the oil feed may have a specific gravity of about 0.93 to about 0.95. In examples, the oil feed may include an ash content of about 4wt% to about 6wt%.

[0056] In examples, the oil feed 302 may include solvent. In examples, solvent present in oil feed 302 may be the same or different from the solvent provided in solvent feed 304. In examples, the solvent in oil feed 302 may be the same as the solvent provided by solvent feed 304. In examples, the ratio of standard volume of solvent to standard volume of oil in the oil feed may be in the range of 0.5:1 to 15:1. In examples, the ratio of solvent to oil as described herein should be understood as the ratio of solvent in the oil feed to the total oil in the oil feed, where the total oil includes the total UMOR and VC that may be present in the oil feed.

[0057] In examples, the ratio of standard volume of solvent to standard volume of oil in the oil feed may be in the range of 0.5:1 to 2:1. In examples, the ratio of solvent to oil in the oil feed may be 1:1.

[0058] In examples, oil feed 302 and solvent feed 304 may be fully mixed prior to being fed to the asphaltene extractor 306. In examples, the oil feed 302 and solvent feed 304 may be mixed to produce a single feed to the asphaltene extractor 306. In examples, the oil feed 302 and solvent feed 304 may be mixed to produce a single feed in which the ratio of solvent to oil ranges from about 10:1 to about 15:1.

[0059] In examples, the oil feed may be fed to the asphaltene separator 306 at a temperature of about 100°C to about 70°C (210 F to 160 F) and a pressure of about 4.1 MPa to about 4.41 MPa (600 to 640 psi).

[0060] In examples, the flow rate of the oil feed 302 may be adjusted as desired. In examples, the flow rate may be low such as about 0.5 BPSD to about 1 BPSD. In examples, the flow rate may be high as such as about 500 BPSD to about 10,000 BPSD. In examples, the range of oil feed 302 may vary from about 0.5 BPSD to 10,000 BPSD. Other flow rates may also be possible. In examples, the flow rate of the oil feed 302 and/or the flow rate of the solvent feed 304 may be controlled to obtain a total solvent to oil ratio in the asphaltene extractor 306 that may be about 10:1 to about 15:1. In examples, the solvent to oil ratio in the asphaltene extractor 306 is maintained at about 12:1. In examples, the solvent to oil ratio in the asphaltene extractor 306 is maintained at about 13:1.

[0061] In examples, the oil feed 302 and the solvent feed 304 may be directed to an asphaltene separator 306. In examples, the oil feed 302 and the solvent feed 304 may be fed at the same or different stages of the asphaltene separator 306. In examples, as shown, the oil feed 302 may be fed at a stage of asphaltene separator 306 that may be higher than the stage of the asphaltene separator 306 where the solvent feed 304 may be fed. In examples, when referring to stages, “higher than” is meant to indicate the vertical placement. Thus, a first stage described as being higher than a second stage is meant to indicate that the first stage is physically above or closer to a top portion of the column or separator than the second stage which is physically below or closer to a bottom portion of the column or separator.

[0062] In examples, the solvent feed 304 may include a solvent may include or be propane, butane, isobutane, or any mixtures thereof. In examples, the solvent may be fed to the asphaltene separator 306 at a temperature of about 54°C to about 95°C (129 F to 203 F) and a pressure of about 4.1 MPa to about 4.41 MPa (600 psi to 640 psi).

[0063] In examples, the asphaltene separator 306 may operate at a temperature ranging from about 54 °C to about 95 °C. In examples, an operating temperature below 54°C may result in fouling, while a temperature above 95°C may result in precipitation of the oil.

[0064] In examples, the solvent provided to asphaltene separator 306 may be such that at the operating temperature and pressure of the asphaltene separator 306, the solvent may reach close to supercritical conditions. In examples, the solvent may be maintained at near supercritical conditions while inside the asphaltene separator 306. In examples, the asphaltene separator 306 may operate to maintain the solvent just above its critical pressure. In examples, the

asphaltene separator 306 may operate to maintain the solvent below its critical temperature. In examples, the asphaltene separator 306 may operate at a temperature to maintain the solvent at a temperature that is just below its critical temperature, for example, about 10 to 20 degrees below its critical temperature. In examples, the solvent may include propane and the asphaltene separator 306 may be operated at a temperature ranging from about 70°C to about 85°C. In examples, the asphaltene separator may be operated at a pressure above 4.2 MPa, i.e. above the critical pressure of propane. For example, the asphaltene separator 306 may operate at a pressure of 4.25 MPa to about 4.6 MPa. In examples, the asphaltene separator 306 may operate at a pressure of about 4.25 MPa, 4.30 MPa, 4.35 MPa, 4.40 MPa, 4.45 MPa, 4.50 MPa, 4.55 MPa, 4.60 MPa, or within any range defined by any two of these examples. Other operating temperatures and pressures are also within the scope of this disclosure to maintain the solvent in near to supercritical conditions while inside the asphaltene separator.

[0065] In examples, the asphaltene separator 306 may include two or more stages. In examples, the asphaltene separator 306 may include two stages, three stages, or more than three stages. In examples, the asphaltene separator 306 may include column packing. Different suitable packing may be used. In examples, asphaltene separator 306 may include one or more packing sections 320a, 320b, etc.... In examples, the packing of a packing section 320 may be coalescing plate packing. In examples, the coalescing plate packing may include structured packing. In examples, the packing may be extraction packing. In examples, the extraction packing may include structured packing. Combinations thereof may also be possible. In examples, asphaltene separator 306 may include coalescing plate packing 322 at a top portion. In examples, oil feed 302 may be introduced below a coalescing plate packing section of asphaltene separator 306. In examples, asphaltene separator 306 may include an extraction packing 324 at a lower portion thereof. In examples, oil feed 302 may be introduced above the extraction packing section of asphaltene separator 306. In examples, the solvent feed 304 may be introduced below the extraction packing section of asphaltene separator 306. In examples, the solvent feed 304 may be combined with oil feed 302 prior to being fed to asphaltene separator 306.

[0066] In examples, the extraction packing 324 of asphaltene separator 306 may have a bulk density that ranges from 144 Kg/m³ to about 256 Kg/m³ (9 lbs/ft³ to about 16 lbs/ft³). In examples, the surface area of the extraction packing 324 may range from about 42 m²/m³ to

about $65.6 \text{ m}^2/\text{m}^3$ ($13 \text{ ft}^2/\text{ft}^3$ to about $20 \text{ ft}^2/\text{ft}^3$). Other types of packing may also be used. In examples, the coalescing plate packing as generally referenced herein for the asphaltene separator 306 as well as the DAO separator 312 may exhibit a higher bulk density and/or surface area than the extraction packing 324. In examples, the coalescing plate packing 322 of asphaltene separator and/or DAO separator may be configured to have a height equivalent to a theoretical plate (HETP) value ranging from about 160 mm to about 2300 mm as determined by atmospheric pressure distillation systems with low relative volatility and generally acceptable liquid/vapor distribution. In examples, the coalescing plate packing 322 may exhibit any suitable nominal inclination angle, for example, 45° or 60° .

[0067] In examples, a heated reflux zone 326 may be present in asphaltene separator 306. In examples, a heated reflux zone may include one or more heating units. In examples, the heating units may be external heating units, blankets, steam pipes or any combination thereof. In examples, the heated reflux zone may be configured to introduce heat to increase the temperature of the material passing through the reflux zone by about 8°C to about 14°C . In examples, the temperature increase may be a gradual across the length of the reflux zone. In examples, a heated reflux zone 326 may be provided between two or more packing sections 320a and 320b in asphaltene separator 306. In examples, a heated reflux zone 326 may be provided above an extraction packing section 324 of asphaltene separator 306 and below a coalescing plate packing section 322 of separator 306.

[0068] In examples, the asphaltene separator 306 may include any suitable internal diameter. In examples, the internal diameter of asphaltene separator 306 may range from about 1.5 meters to about 6 meters.

[0069] In examples, the bottoms 308 of asphaltene separator 306 may include oil pitch. In examples, the overhead 310 of the asphaltene separator may include a stream comprising DAO.

[0070] In examples, overhead 310 may optionally be directed to a DAO separator 312. In examples, a DAO separator 312 may include a system configured to increase the temperature of the solution fed to the DAO separator 312 to a point above the solvent critical temperature. In examples, in DAO separator 312, the solvent may be at supercritical conditions. In examples, in DAO separator 312 the solvent may be above both supercritical temperature and supercritical pressure. In examples, at such conditions the solubility of the DAO in the solvent

decreases. In examples, at the solvent critical temperature the DAO may become virtually insoluble in the solvent. In examples, this may allow for separation of DAO from solvent with the solvent being recovered as overhead and the DAO as bottoms product.

[0071] In examples, DAO separator may include packing in a packing section 328. In examples, packing in DAO separator may include coalescing plate packing. In examples, the coalescing plate packing may include structured packing. In examples, the feed to DAO separator 312 may be below the coalescing plate packing. In examples, DAO separator 312 may be configured to separate solvent from DAO. In examples, DAO separator 312 may include a DAO separator bottoms 314 comprising DAO. In examples, DAO separator 312 may include a DAO separator overhead 316. In examples, the DAO separator overhead 316 may include solvent. In examples, DAO separator overhead 316 may include only solvent. In examples, DAO separator overhead 316 may include solvent at a concentration of at least 100%.

[0072] In examples, the solvent from DAO separator overhead 316 may be recycled via a recycle line 318. In examples, recycling may include storing in a solvent tank for later use and/or directly feeding the solvent to asphaltene separator 306. In examples, a combination of both may be implemented. In examples, recycle to the asphaltene separator 306 may be by a third separate feed to asphaltene separator 306, by mixing with solvent feed 304, by mixing with oil feed 302, or any combination thereof.

[0073] FIG. 4 illustrates a diagram of another example of a plant system 400 that may be used for the process described herein.

[0074] In examples, plant system 400 may include a feed system 402. In examples, feed system 402 may include an oil source 404. In examples, the feed system 402 may include a mixer 406. In examples, feed system 402 may include an oil feed 408. In examples, feed system 402 may include a solvent circulation pump 410. In examples, feed system 402 may include a solvent feed 412.

[0075] In examples, as previously described, oil source 404 may include UMOR, or a combination of UMOR and VC. In examples, oil source 404 may include a mixture of VC and UMOR at a ratio of 2:1 or greater. In examples, oil source 404 may include an oil mixture of

70% VC and 30% UMOR. In examples, additional oil or non-oil components may be included in oil source 404.

[0076] As shown, in examples, oil source 404 may supply UMOR and/or UMOR combined with VC to mixer 406. In examples, mixer 406 may also receive diluting solvent. For example, at least a first portion of solvent from solvent circulation pump 410 may be used as dilution solvent feed 414 and directed to mixer 406. In examples, mixer 406 dilutes the UMOR or UMOR and VC mix from oil source 404 by combining the UMOR or UMOR and VC mix from oil source 404 with dilution solvent feed 414 from solvent circulation pump 410 to form an oil-solvent feed 408. In examples, oil-solvent feed 408 may have a solvent to oil ratio ranging from about 0.5:1 to 15:1 based on standard volume of solvent and of premixed oil source.

[0077] In examples, oil-solvent feed 408 may have a first portion of solvent with a solvent to oil ratio ranging from about 0.5:1 to 2:1 based on standard volume of solvent and of premixed oil source. In examples, the ratio is 1:1. In examples, a second portion of solvent from solvent circulation pump 410 may be used as separator solvent feed 412.

[0078] In examples, all of the solvent from solvent circulation pump 410 may be mixed with UMOR and/or UMOR and VC in mixer 406. In examples, the oil-solvent feed 408 may include all the solvent intended to be fed to the asphaltene separator 416. In examples, the oil-solvent feed 408 may have a solvent to oil ratio ranging from about 10:1 to about 15:1 based on standard volume of solvent and of premixed oil source.

[0079] In examples, oil-solvent feed 408 and separator solvent feed 412 may be directed to asphaltene separator 416. In examples, asphaltene separator 416 may be as previously described with reference to FIG. 3.

[0080] In examples, oil-solvent feed 408 and separator solvent feed 412 may be inputted into asphaltene separator 416 at the same or different stage of asphaltene separator 416. In examples, the oil-solvent feed 408 will include all of the solvent to be fed to the asphaltene separator 416. In examples, the separator solvent feed 412 would be absent and/or shut off. In examples, as shown, the oil-solvent feed 408 may be fed into the asphaltene separator 416 at a higher stage than the separator solvent feed 412. In examples, oil-solvent feed 408 may enter

a top distributor of the asphaltene separator 416. In examples, separator solvent feed 412 may enter a bottom distributor of the asphaltene separator 416.

[0081] In examples, in the asphaltene separator 416, the solvent may contact the UMOR in counter current flow across a bed of separator packing. In examples, the solvent in the asphaltene separator 416 may act as an extraction solvent. In examples, the packing may include a fouling refractive extraction packing.

[0082] In examples, the total solvent flowing through asphaltene separator 414 (i.e., solvent from dilution solvent feed 414 that is mixed in the oil-solvent feed 408 plus any solvent from separator solvent feed 412 if present) may be about 10 to about 15 standard volumes of solvent per standard volume of oil.

[0083] In examples, the asphaltene separator 416 is configured to operate at conditions that result in the solvent reaching near supercritical conditions. In examples, at these conditions, the pitch may be insoluble in the solvent and thus may drop out of solution. In examples, in this manner, the pitch may flow down and exit with the bottoms 418 of the asphaltene separator 416 on interface level control. In examples, some dissolved solvent may also exit with the bottoms 418 of the vessel as part of a pitch-solvent solution. In examples, bottoms 418 may be directed to flow to one or more flash and stripping sections 420 and 422 to recover the solvent from the pitch product 424.

[0084] The pitch-solvent solution from the asphaltene separator 416 may be heated by a pitch flash heater 456 and fed to the pitch flash drum 420 on liquid interface level control from the asphaltene separator 416. In examples, the feed temperature of the pitch flash drum 420 may be controlled by adjusting the heating medium to the pitch flash heater 456. In examples, sufficient heat may be added to the system to maintain the recommended recovery temperature which may be selected to provide efficient solvent recovery in the pitch flash drum 420 and downstream pitch stripper 422. In examples, at the pitch flash drum 420, the pressure may be reduced to cause most or a substantial portion of the solvent to flash overhead. In examples, the solvent overhead of pitch flash drum 420 may be directed to condenser 458 and then into solvent surge drum 452 for temporary storage prior to being recycled via solvent recycle pump 450.

[0085] In examples, the pitch and remaining solvent from pitch flash drum 420 may be fed to the pitch stripper 422 on liquid level control from the pitch flash drum 420. In examples, at pitch stripper 422, the pressure may be reduced again to cause additional and/or most of the remaining solvent to flash overhead.

[0086] In examples, in the pitch stripper 422, the pitch product may be contacted with dry superheated low pressure stripping steam to strip the additional and/or remaining solvent to reduce the solvent content in the bottom product stream. In examples, the stripping steam may enter the pitch stripper 422 below the bottom tray on flow control. In examples, the flow rate in pitch stripper 422 may be set for efficient stripping.

[0087] In examples, the overhead solvent from pitch stripper 422 may be directed to a solvent condenser 460 and then a solvent compressor 462. In examples, solvent condenser 460 may be configured to cool solvent vapors from pitch stripper 422 and/or DAO stripper 442. In examples, solvent compressor 462 may be configured to compress the cooled solvent vapors output from solvent condenser 460. In examples, solvent effluent from solvent compressor 462 may be directed to condenser 458 and then solvent surge drum 452 before being recycled via solvent recycle pump 450.

[0088] In examples, a solvent and DAO solution with the majority of the solvent from the asphaltene separator 416 may exit with the overhead 426 of the asphaltene separator 416.

[0089] In examples, DAO yield may be effectively controlled by the operating temperature of the asphaltene separator 416. For example, higher operating temperatures may lead to less DAO product extracted by overhead 426. In examples, lower operating temperatures may lead to increased DAO in the overhead 426. In examples, the operating temperature of the asphaltene separator 416 may affect the quality of the DAO. For example, at lower temperature the DAO product in overhead 426 may be of a poorer quality.

[0090] In examples, the extraction temperature in asphaltene separator 416 may be controlled mainly by controlling the conditions of the solvent feed 412. Accordingly, in examples, the DAO yield may be controlled by controlling the temperature of the solvent that is fed into the asphaltene separator 416.

[0091] In examples, the overhead 426 may be further processed. In examples, the overhead 426 may be used as DAO separator feed 428 to a DAO separator 430. In examples, the DAO separator feed 428 may be heated prior to being fed to DAO separator 430. In examples, DAO separator feed 428 may be heated to reach supercritical solvent recovery conditions before entering the DAO separator 430. In examples, the DAO separator feed 428 may be heated via a ROSE heat exchanger 432. In examples, ROSE heat exchanger 432 may be configured to exchange heat between recovered solvent 434 and DAO separator feed 428. In examples, DAO separator feed 428 may be heated or further heated by a pre-heater 436.

[0092] In examples, the DAO separator 430 may be set up and operated as previously described with reference to FIG. 3. In examples, the DAO separator 430 operating conditions may be set to achieve the required density difference needed for good separation. In examples, the DAO separator 430 may be operated to induce a supercritical phase separation. In examples, by increasing the temperature of the solvent above its critical temperature may benefit from the solvent's low-density properties in this region. In examples, as the temperature of the solvent increases above the critical point of the solvent, the density of the solvent significantly decreases to values approaching that of dense gases. In examples, at the higher temperature, the DAO may be less soluble and/or virtually insoluble in the solvent. In examples, the low density of the solvent and the insolubility of the DAO can lead to a phase separation. In examples, at least about 90% of the solvent from the solvent-plus-DAO stream that makes up the DAO separator feed 428 may be recovered by supercritical phase separation in the DAO separator 430.

[0093] In examples, the temperature of separation in the DAO separator 430 may be controlled by adjusting heating medium flow on temperature control to pre-heater 436. In examples, the pressure in the DAO separator 430 may be maintained by adjusting the flow of recycle solvent 448 on pressure control to the high-pressure system from recycle solvent pump 450.

[0094] In examples, a DAO-solvent solution with less than about one standard volume of dissolved solvent per standard volume of DAO product may be withdrawn from the bottoms 438 of the DAO separator 430 on interface level control. In examples, the DAO-solvent solution of bottoms 438 may be directed to a DAO flash drum and DAO stripping sections 440 and 442 to recover additional solvent and output DAO 444.

[0095] In examples, the DAO-solvent solution from the bottoms 438 of the DAO separator 430 discharged on liquid level control from the DAO separator 430. In examples, sufficient heat may be present in the system to maintain the recommended recovery temperature which is selected to provide efficient solvent recovery in the flash drum and downstream stripper. At the flash drum, the pressure may be reduced and most of the solvent flashes overhead. In examples, solvent flashed overhead at DAO flash drum 440 may be directed to condenser 458 for cooling and then to solvent surge drum 452 prior to being recycled by solvent recycle pump 450.

[0096] In examples, the DAO and remaining solvent stream from the flash drum may be fed to the DAO stripper 442 on liquid level control from the flash drum. At the DAO stripper 442, the pressure may be reduced again to cause additional solvent or most of the remaining solvent to flash overhead.

[0097] In examples, in DAO stripper 442, the DAO may be contacted with superheated low pressure (LP) stripping steam in the DAO stripper 442 to strip the remaining solvent to reduce the solvent content in the product stream. In examples, the stripping steam may be superheated in a steam heater (not shown). In examples, stripping steam may be fed to the DAO stripper 442 below the bottom tray on flow control. The flow rate of the steam in the DAO stripper 442 may be adjusted for efficient stripping.

[0098] In examples, the overhead solvent from DAO stripper 442 may be directed to a condenser 460 and then a solvent compressor 462. In examples, solvent effluent from solvent compressor 462 may be directed to condenser 458 and then solvent surge drum 452 before being recycled via solvent recycle pump 450.

[0099] In examples, an overhead of DAO separator 430 may include recovered solvent 434 at supercritical conditions. In examples, the recovered solvent 434 may supply circulating solvent 446. In examples, circulating solvent 446 may be directed to solvent circulation pump 410 and fed to asphaltene separator 416.

[00100] In examples, heat may be recovered from the recovered solvent 434 at heat exchanger 432. In examples, the recovered solvent 434 may additionally be cooled in a solvent trim cooler 454 prior to becoming circulating solvent 446. In examples, a solvent trim cooler

454 may use coolant such as cooling water to cool the solvent to a relatively low temperature as may be desirable for extraction control in the asphaltene separator 416. In examples, an optional bypass around the cooler (not shown) may be employed to help control the temperature for the lower section of the asphaltene separator 416.

[00101] In examples, the recycle solvent 448 from a recycle solvent pump 450 may combine with circulating solvent 446 just upstream of the suction of the solvent circulation pump 410. In examples, the pressure of the DAO separator 430 may control the flow of recycle solvent 448 from the solvent surge drum 452 to replenish the solvent that was removed from the circulating solvent 446 stream along with the products as solvent carry-under from the combined separator bottoms.

[00102] In examples, the combined recycle solvent 448 and the circulating solvent 446 may enter the solvent circulation pump 410 which may be configured to boost the pressure of solvent flow sufficiently to flow to the asphaltene separator 416. In examples, the solvent circulation pump 410 may provide the solvent flow needed for solvent-to-oil ratio control in the asphaltene separator 416. In examples, the solvent circulation pump 410 may provide the pump head that may be required to make up for the hydraulic pressure drop in the circulating solvent 446 loop. In examples, total solvent flow may be measured at the discharge of the solvent circulation pump 410. In examples, the total solvent flow may be used to control the solvent-to oil ratio in the asphaltene separator 416 and/or the amount of solvent entering the bottom distributor of the asphaltene separator 416. In examples, total solvent flow may be manually adjusted to the unit feed to achieve the desired solvent-to-oil ratio in the asphaltene separator 416.

[00103] Processing of UMOR or UMOR mixed with VC with solvent deasphalting as described can be a refining process for regenerating UMOR or UMOR and VC into high-quality base oil. The solvent deasphalting process may remove impurities, such as pitch from used motor oil “bottom-of the barrel” portion to result in a high-quality base oil that can be used as a feedstock for producing new lubricants. In examples, rejected used motor oil “bottom-of the barrel” viscosity modifiers and impurities could be blended to road bitumen product by upgrading pitch molecules from conventional VC, with viscosity modifiers co-polymers from UMOR source.

[00104] In examples, the process and system as described may be used to produce DAO that could meet Bright Stock Lube Oil quality. In examples, the DAO resulting from the process described herein may exhibit a specific gravity ranging from 0.86 to about 0.87.

[00105] In examples, the pitch that results from the process described herein may be used as a bitumen additive. In examples, the bitumen may be road grade. In examples, the pitch may have a specific gravity of 1.00 to 1.07. In examples, the pitch may have a solid content of about 2.0wt% to 3.0wt%. In examples, the pitch may exhibit a ring and ball softening point of about 95°C to about 125°C.

[00106] In examples, the systems described herein may include one or more control systems, sensors, and other standard components that allows for the control and operation thereof.

[00107] In examples, although not shown, the systems described herein may include one or more sensors as generally employed in the art. In examples, sensors may be used to monitor the operation of the systems described. Non-limiting examples of one or more sensors may include temperature sensors, pressure sensors, flow meters, and other like sensors.

[00108] In examples, although not shown, the one or more control systems may include one or more controllers and/or other suitable computing devices may be employed to control one or more of portions of systems described herein. Controllers may include one or more processors and memory communicatively coupled with each other. In the illustrated example, a memory may be used to store logic instructions to operate and/or control and/or monitor the operation of the described process or system. In examples, the controllers may include or be coupled to input/output devices such as monitors, keyboards, speakers, microphones, computer mouse and the like. In examples, the one or more controllers may also include one or more communication components such as transceivers or like structure to enable wired and/or wireless communication. In examples, this may allow for remote operation of one or more systems described herein.

[00109] In examples, memory associated with the one or more controllers and/or other suitable computing devices may be non-transitory computer-readable media. The memory may store an operating system and one or more software applications, instructions, programs, and/or data to implement the methods described herein and the functions attributed to the various

systems. In various implementations, the memory may be implemented using any suitable memory technology, such as static random-access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory capable of storing information. The controls systems may include any number of logical, programmatic, and physical components.

[00110] Logic instructions may include one or more software modules and/or other sufficient information for autonomous operation, safety procedures, and routine maintenance processes. Any operation of the described system may be implemented in hardware, software, or a combination thereof. In the context of software, operations represent computer-executable instructions stored on one or more computer-readable storage media that, when executed by one or more processors, perform the recited operations. Generally, computer-executable instructions include routines, programs, objects, components, data structures, and the like that perform one or more functions or implement particular abstract data types.

[00111] It will be apparent to those skilled in the art that various modifications and variation can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A process comprising:
feeding oil comprising a used motor oil distillation residue to an asphaltene separator;
feeding a solvent to the asphaltene separator to achieve a solvent to oil ratio of 10:1 to 15:1 in the asphaltene separator; and
causing the used motor oil distillation residue to at least partially combine with the solvent while the solvent is above supercritical pressure,
wherein,
a bottoms effluent of the asphaltene separator comprises pitch, and
an overhead of the asphaltene separator comprises a deasphalted oil.
2. The process of claim 1, wherein the supercritical solvent comprises propane, butane, isobutane, or any mixtures thereof.
3. The process of claim 1, further comprising maintaining the solvent in the asphaltene separator at a temperature that is below the critical temperature of the solvent.
4. The process of claim 1, further comprises feeding the oil comprising the used motor oil distillation residue to the asphaltene separator as a mixture of the oil and of the solvent.
5. The process of claim 4, wherein the mixture of oil and of the solvent comprises a solvent to oil ratio of 0.5:1 to 15:1.

6. The process of claim 4, wherein feeding the supercritical solvent comprises supplying solvent separately from the oil.
7. The process of claim 6, further comprising feeding the mixture of oil comprising used motor oil distillation residue and solvent at a first stage of the asphaltene separator and feeding the supercritical solvent at a second stage of the asphaltene separator, wherein the first stage is at a higher position in the asphaltene separator than the second stage.
8. The process of claim 1, further comprising feeding the supercritical solvent to achieve a solvent to oil ratio of 12:1.
9. The process of claim 8, further comprising maintaining the solvent temperature in the asphaltene separator at a temperature below the critical temperature of the solvent.
10. The process of claim 1, further comprising mixing the residue virgin crude oil (VC) with the used motor oil distillation residue to form a mixed feed of used motor oil distillation residue and VC to be fed to the asphaltene separator.
11. The process of claim 10, wherein the mixed feed of used motor oil distillation residue and VC comprises a ratio of VC to used motor oil distillation residue of about 70 to 30.
12. The process of claim 10, wherein the ratio of solvent to the oil in the asphaltene separator is 13:1.

13. The process of claim 12, further comprising maintaining the solvent temperature in the asphaltene separator at a temperature that is below the critical temperature of the solvent.
14. The process of claim 10, further comprising heating the materials inside the asphaltene separator in a zone that is between an extraction packing and a coalescing plate packing.
15. The process of claim 1, further comprising maintaining the asphaltene separator at a pressure that is greater than about 4.2 MPa.
16. A process comprising:
feeding a used motor oil distillation residue to an asphaltene separator;
feeding a solvent to the asphaltene separator; and
causing the used motor oil distillation residue to at least partially combine with the solvent while the solvent is above its supercritical pressure,
wherein,
a bottoms effluent of the asphaltene separator comprises pitch, and
an overhead of the asphaltene separator comprises a deasphalted oil.
17. A process comprising:
feeding an oil mixture comprising a residue virgin crude oil (VC) and a used motor oil distillation residue in a ratio of 70:30 to an asphaltene separator;
feeding a solvent to the asphaltene separator;
causing the oil mixture to at least partially combine with the solvent while the solvent is above its supercritical pressure; and
wherein

a bottoms effluent of the asphaltene separator comprises pitch, and
an overhead of the asphaltene separator comprises a deasphalted oil.