PROCESS OF REDUCING VISCOSITY OF HEAVY CRUDE OIL BY REMOVAL OF ASPHALTENE USING A PRECIPITATING AGENT

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Related U.S. Application Data

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ABSTRACT

A process and system for reducing the viscosity of heavy and extra heavy crude oils, and more particularly to a process for reducing the viscosity of heavy and extra heavy crude oils by means of total or partial oil deasphalting using a precipitating agent in order to obtain an upgraded crude oil of lower viscosity that can be pumped without the use of diluents. The upgrading also includes a reduction in metals and sulfur associated with asphaltene removal. The process consists of relatively simple equipment such as static mixers and stirred tanks and operation temperature is low and pressure is moderate.
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RELATED APPLICATION

[0001] The present application claims the benefit of U.S. Provisional Application No. 61/622,197, filed Apr. 10, 2012, which is incorporated herein in its entirety by reference.

FIELD OF THE INVENTION

[0002] The invention is generally directed to reducing the viscosity of heavy and extra heavy crude oils, and more particularly to a process for reducing the viscosity of heavy and extra heavy crude oils by means of total or partial oil deasphalting using a precipitating agent in order to obtain an upgraded crude oil of lower viscosity that can be pumped without the use of diluents. The upgrading also includes a reduction in metals and sulfur associated with asphaltene removal. The process consists of relatively simple equipment such as static mixers and stirred tanks and operation temperature is low and pressure is moderate.

BACKGROUND OF THE INVENTION

[0003] Crude oil contains four different hydrocarbons including paraffins, napthenes, aromatics, and asphaltenes. Paraffins, or alkanes, are saturated hydrocarbons that consist only of hydrogen and carbon atoms, having the general formula CnH2n+2. All bonds are single bonds, and the carbon atoms are not joined in cyclic structures but instead form a simple chain. They make up from about 15 to about 60% of crude oil, and on average about 30%. Resins or napthenes, otherwise known as cycloalkanes, are alkanes that have one or more rings of carbon atoms in the chemical structure of their molecules. They make up from about 30 to about 60% of crude oil, and on average about 49%. Aromatics, or arenes, are hydrocarbons with alternating double and single bonds between carbon atoms forming rings. Aromatics make up from about 3 to about 30% of crude oil, and on average about 15.5%.

[0004] Asphaltenes consist primarily of carbon, hydrogen, nitrogen, oxygen, and sulfur, as well as trace amounts of vanadium and nickel. The C:H ratio is approximately 1:1.2, depending on the asphaltene source. Asphaltenes are defined operationally as the n-heptane (C7H16)-insoluble, toluene (C7H8Cl3)-soluble component of a carbonaceous material such as crude oil, and are the sticky, black, highly viscous residue of distillation processes. They make up the remainder of crude oil, and on average from about 3 to about 10% of the crude oil; however heavy oils can contain 10% or more, with a high C:H ratio. Due to the aggregation of asphaltenes, they are the most significant contributor to the viscosity of crude oil affecting its viscosity.

[0005] Light crude oil is liquid petroleum that has low viscosity, low specific gravity, and high API (American Petroleum Institute) gravity due to the presence of a high proportion of light hydrocarbon fractions. API gravity is calculated by dividing 141.5 by the fluid’s specific gravity and subtracting 131.5. The New York Mercantile Exchange (NYMEX) defines light crude oil for domestic U.S. oil as having an API gravity between 37° API (840 kg/m³) and 42° API (816 kg/m³), while it defines light crude oil for non-U.S. oil as being between 23° API (865 kg/m³) and 42° API (816 kg/m³).

The National Energy Board of Canada defines light crude oil as having a density less than 875.7 kg/m³ (more than 30.1° API). The Mexican state oil company, Pemex, defines light crude oil as being between 27° API (893 kg/m³) and 38° API (853 kg/m³).

[0006] Unlike light crude oil, heavy crude oils are generally not pumpable due to the high viscosity. Therefore, it is advantageous to remove the higher viscosity products, i.e. asphaltenes, in order to pump the remaining, lighter deasphalted crude oil. Light crude oil is also desired over heavy crude oil because it receives a higher price than heavy crude oil on commodity markets because it produces a higher percentage of gasoline and diesel fuel when converted into products by an oil refinery.

[0007] One method of decreasing the viscosity of heavy crude oil is via a deasphalting process. Deasphalting is a well-known process that uses extraction towers and usually propane as a solvent as depicted in a number of references including, for example, U.S. Pat. Nos. 2,121,517; 2,192,253; and 2,081,473. Other solvents used are gasoline, as described in U.S. Pat. No. 2,101,338, asphalts as described in U.S. Pat. No. 4,592,831, mixtures of propane with H2S or CO2 as described in U.S. Pat. No. 4,191,639, acetone mixtures as described in U.S. Pat. Nos. 3,975,396, among others. The list is not exhaustive but shows that many types of solvents have been used.

[0008] The use of extraction towers is common to almost all processes, as shown in the descriptions of several commercial processes such as LEDA, Demex, MDS, ROSE and Solvaha (Speight, J.G., The Chemistry and technology of petroleum, 4ed, CRC Press, Boca Raton, 2007). The majority of these processes requires high temperatures and pressures, and often operates at super-critical conditions. Those processes also operate at higher solvent to crude oil volume fraction of 2:1 to 10:1 by volume as stated in many patents, such as, for example, U.S. Pat. Nos. 2,101,308; 2,152,253; 2,337,448; 2,367,671; 2,850,431; 2,940,920; 3,159,571; 3,364,138; 4,101,415; 4,548,711; 4,290,880, and more specifically normally in the 4:1 to 8:1 volume range. One specific process to produce fluid catalytic cracking (FCC) feedstock can use lower range solvent to crude oil ratios between 1:1 to 4:1 by volume, as described in U.S. Pat. No. 5,000,838, but in this process, the solvent recovery is not complete.

[0009] The principle in all the asphaltenes precipitating processes from asphaltene containing mixtures, such as crude oils, is the insolubility of asphaltenes in low alkane carbon solvents (propane to heptane) and other solvents and mixtures. This is because the asphaltene molecules are polar and insoluble in non-polar paraffin, being less soluble in the least molecular weight paraffin (propane) and more soluble in heptanes. The solvent type is related to the yield and quality of the upgraded oil (hereinafter “UO”). In general, a process with propane gives lower yields of UO, but of better quality regarding lighter density and lower metals content. In some cases, the solvent is subjected to special operating conditions, which changes the solubility and its precipitating power. By changing the operating conditions, different products are obtained as UO, resins and asphaltenes, as described in U.S. Pat. No. 4,290,880.

[0010] Most of the deasphalting processes use settling vessels for the separation of asphaltenes, while in some cases, hydrocyclones or centrifuges are suggested, as described in, for example, U.S. Pat. Nos. 3,159,571; and 4,572,781. These technologies aid at precipitating the smaller particles sus-
pended in the UO. However, many of these processes are complex, and are not adequately adapted for oilfield operations.

[0011] An alternative method for transporting or pumping otherwise unworkable, high viscosity heavy crude oil is via the use of diluents. Diluents are diluting agents that thin, or reduce the viscosity of a fluid to which it is added. For example, diluents are added to and blended with the heavy crude oil at the oilfield. The lower viscosity solution is then pumped, trucked, and/or transported to a refinery, storage facility, or other desired location, where the solution is broken to separate the crude oil from the diluent. The diluent is then pipelined or otherwise transported back for reuse. However, this process requires additional process steps, such as returning the diluent, that can be costly. Also, available diluents, such as naphtha, are becoming increasingly unavailable.

[0012] Therefore, there remains a need to make the process simpler and readily adaptable to oilfield operations, and that does not require large amounts of additives, such as diluents.

SUMMARY OF THE INVENTION

[0013] Embodiments of the present invention described many of the drawbacks inherent in the processes described above. Embodiments are directed to a process that reduces heavy and extra heavy crude oil viscosity by partial or total demetallization of such crude oils producing a high yield of the partially or totally demetallized product at the oilfield. The process can significantly reduce, or in a best-case scenario, completely eliminate the use of diluents for pipeline transport of crude oil. Furthermore, the process is designed so that it can be readily implemented in oilfield operations sites requiring moderate pressures and temperatures.

[0014] The present invention includes a process that uses a low precipitant/crude oil ratio, such as, for example, a 2:1 in volume ratio or less, and a 1.5:1 in weight ratio or less, and more particularly about 1:1, as compared to ratios of 8:1 in weight or more of the prior art, to produce upgraded oil with a viscosity suitable for pumping at ambient temperatures, while maximizing upgraded oil yield, such as, for example, about 90% or greater volumetric recuperation, and more particularly about 94% or greater. The process also produces a reduction in metal and sulfur content of the upgraded oil obtained related to the asphaltene removal. The upgraded oil also has an API gravity at least about three degrees or more greater than an API gravity of the heavy crude oil.

[0015] In this process, precipitant and crude oil come into intimate contact with a static mixer arrangement, at temperatures below 80°C (176°F) and pressures between 40 and 60 psig. The crude oil/precipitant stream is then taken to an agitated tank for further mixing and for ensuring sufficient residence time in order to improve solid precipitation. The agitated tank content is then drained out of the tank using suitable equipment that forces it to flow into a high gravity field device (a hydro-cyclone or a centrifuge). There, the crude oil/precipitant stream is separated into two currents: a solid free stream and high solid content slurry which still contains some upgraded oil and precipitant. The solid free stream is fed to a flash separator that recovers the precipitant to be reused, and produces the upgraded oil.

[0016] The high solid content stream goes to a “washing” section where the solids are washed to recuperate the liquid that remains occluded in them. This step is critical to increase the volumetric yield of the process. The washed product goes to a high gravitational force separator (centrifuge) where two streams are obtained: one rich in solids (asphaltene) that goes to a dryer where the remaining precipitant is recuperated, and a second current comprising, or alternatively consisting of, dry solids that can be used for power generation (combustion) or other purposes. The second stream is a liquid that contains some crude oil and precipitant that goes to the flash unit to recover the lighter precipitant and to produce the upgraded oil, which is mixed with the oil obtained in the first separator. In the flash unit, the precipitant remaining in the upgraded oil is adjusted to further reduce viscosity, if required.

[0017] The precipitant used in this process is a light fraction of crude oil, like light gasoline, that reduces asphaltene solubility in the crude oil and that can optionally contain some additives (paraffinic, aromatic or oxygenated compounds) that enhance the performance of the process as required. The formulation of the precipitant is such that it fits the type of crude being treated, as well as the required quality and yield.

[0018] An alternative embodiment of this process includes a battery of static mixers that blends the extra heavy and heavy crude oil feeds with the stream that leaves the washing section. In this case, the precipitant enters the washing section, which consists of a stirred tank and a centrifuge or hydro-cyclones; the solid stream of the centrifuge goes to a dryer where solids are obtained as a product and precipitant is recovered. The liquid stream of the centrifuge goes to the static mixers where it combines with crude oil as mentioned. The crude oil and precipitant blend that exits the static mixers goes to an agitated tank to provide for residence time and then to a separator (hydro-cyclones or centrifuge) where the liquid stream goes to a flash separator where the precipitant is recuperated while the bottom stream goes to a steam stripper to recover the last traces of solvent (if required). From the bottom of the stripper, upgraded crude oil is obtained. The heavy stream of the separator goes to the washing section or stirred tank where precipitant and make-up precipitant are introduced. From there the combined stream goes to the washing section centrifuge.

[0019] The above summary of the various representative embodiments of the invention is not intended to describe each illustrated embodiment or every implementation of the invention. Rather, the embodiments are chosen and described so that others skilled in the art can appreciate and understand the principles and practices of the invention. The figures and the detailed description that follow more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention can be completely understood in consideration of the following detailed description of various embodiments of the invention in connection with the accompanying drawings, in which:

[0021] FIG. 1 is a diagram showing in a schematic way the main stages of the process of upgrading the crude oil for transport in pipelines, according to an embodiment of the invention.

[0022] FIG. 2 shows a diagram of a modified version of the process for upgrading crude oil for pipeline transport.

[0023] While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is to not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all
modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION

[0024] Referring to FIG. 1, a process 1000 is shown in which crude oil (1) is blended with a feed precipitant (2) in a set of static mixers (3). The feed crude oil (1) generally comprises a kinematic viscosity (dynamic viscosity divided by fluid density) of about 2400 centistokes (cSt) or more. Optionally, water has been removed from the crude oil before being introduced into process 1000. The crude oil (1) is at a temperature range of 50 to 100°C (122 to 212°F), with pressures lower than 60 psig and the volumetric precipitant to oil volume ratio is in a range from about 1 to 1 to about 1 to 2, including for example, 1.25:1 and 1.5:1, depending on density differences. The weight ratio of crude oil to precipitant (or solvent) can comprise about 1:1.

[0025] Once blended, the crude oil/precipitant mix is introduced to a stirred tank (4) to allow for some residence time and growth of the precipitated particles. The use of light precipitant with relatively low boiling points (FBP less than 140°C or 284°F) helps in the separation and precipitation of asphaltene. The asphaltene are generally present in the agitated tank (4) as suspended particles and nano-colloids. From the tank (4), the mixture goes through line (5) to a separator set (6). The separator (6) uses inertial forces to separate the solid particles from the liquid upgraded crude oil. The separator (6) can comprise, for example, one or more hydrocyclones or centrifuges. Precipitant is present in both streams.

[0026] From the separator set (6) the liquid exits through line 7 to a “flash” separator or distillation tower (8) to recuperate the precipitant from the upgraded oil. The “flash” separator (8) operates at a pressure slightly higher than atmospheric and temperatures capable of recuperating most of the precipitant. If needed, the flash tower or separator (8) operation can be adjusted so that a convenient amount of precipitant remains in the upgraded oil, to further reduce viscosity as required or desired.

[0027] The precipitant leaves the flash through line 9 to be cooled down in condensers (not shown) exiting at 35-55°C (95-131°F) and then goes through line 17 to a solvent tank (18). From tank (18), the precipitant goes through line 19 to line 2 and is recycled and mixed with crude oil (1).

[0028] Referring back to the flash separator (8), the bottom of the flash drum goes through line 20 into an optional steam stripper (21) that operates to recuperate traces of precipitant left in the upgraded oil, if required or desired. The recuperated precipitant plus steam mix leave the stripper (21) through line 24, where the mix is condensed (not shown) and the water and precipitant are separated in a drum (not shown). The recuperated precipitant goes through line 17 where it mixes with the precipitant from line 9 of the flash separator 8, and the combined currents return to the solvent tank (18) as described above. From the precipitant tank (18), the solvent transits line 19 into line 2 and it is finally mixed with crude oil (1).

[0029] Referring back to the stripper (21), vapor, in the form of steam, enters the stripper (21) through line 23. The product of the stripper (21) is the lower viscosity upgraded oil, which exits through line 22. Typically, the kinematic viscosity (dynamic viscosity divided by the density of the fluid) is equal to or less than about 700 centistokes (cSt). The yield of crude oil in the upgraded oil is about 92% or greater in volume. It has been observed that the initial viscosity of the crude oil feed (1) is independent from, and does not affect, the yield of upgraded oil.

[0030] The liquid/solid stream, or oil slurry containing the asphaltene that leaves the first separator (6) through line 10 goes to an agitated tank (11) where it is very well mixed or washed with precipitant at low shear rates fed from recycle stream 19 through line 25 with a volumetric flow similar to the one used in the first contact in the static mixers (3). The mixture of the oil slurry and the precipitant leaves the agitated tank (11) through line 12 to a centrifugal separator (13) that operates between 1000 to 6000 g/s. The combination of the tank (11) and separator (13) make up the washing unit of the process, and is shown in FIG. 1 inside a dashed box.

[0031] Two streams leave the separator (13) including a liquid stream with precipitant and crude oil (14) that goes to the flash separator (8) to recuperate the precipitant and the upgraded oil as described above, and a solid stream (15) saturated with precipitant that goes to a dryer (16) to recuperate the precipitant through line 17, where the precipitant is condensed and recycled as described above with respect to line 17. A dry stream (26), containing mostly asphaltene (26), can be used to produce energy, such as by firing at the oilfield site, or for other purposes.

[0032] Additionally, or optionally, precipitant make-up or additives are introduced, as needed, such as at start-up, through line 27 that combines with recycled precipitant 19 at line 2, where it ultimately mixes with the crude oil in line 1.

[0033] Referring now to FIG. 2, in an alternative embodiment, a process 2000 includes a crude oil feed (50) mixed with a recycled current (51) that contains precipitant and deasphalted crude oil recuperated in the washing section exiting the separator (52). This mixture goes through a static mixers battery (53) and then enters a stirred tank (54) to allow for residence time. From there, the liquid-solid mixture exits through line (55) to end in a separation unit (56), which can comprise a battery of hydro-cyclones or centrifuges.

[0034] Two streams leave the separator (56); one liquid stream (57) goes to a flash separator unit or distillation tower (58) where the solvent (i.e. light precipitant) leaves through line 59 to precipitant tank (60). The heavy fraction or oil slurry leaves the separator (56) through line 61 to the wash tank (62) of a wash unit shown in dotted lines, where it is washed with precipitant from precipitant tank 60 via line 71. From the wash tank (62) the stream exits through line (63) to the separator (52) of the wash unit. The separator (52) discharges the liquid recycled current (51) that goes to blending with the crude oil as aforementioned.

[0035] The slurry or heavy fraction leaves the separator (52) through line 64 to the dryer (65). The dryer output consists of two currents: stream 66, which is the solid product comprising mainly asphaltene, similar to line 26 of FIG. 1; and stream (67), which is recuperated precipitant. This recuperated precipitant is condensed (condensing section not shown) and sent to a precipitant tank (60) where it is blended with recuperated precipitant (59) from flash unit or distillation tower (58) and fed via line 71 to wash tank (62) as described above.

[0036] The bottom of the flash tower (58) leaves through line 68 to an optional stripper (69) where the current 68 containing crude oil and precipitant is stripped with steam (70). From the bottom of the stripper the upgraded oil (72) is obtained. The recuperated precipitant plus steam leave the stripper through line 74 where it is condensed and the water
and solvent separated in a drum (not shown). The precipitant is sent through line 59 to precipitant tank 60.

Additionally, or optionally, precipitant make-up or additives are introduced, as needed, such as into wash agitated tank 62, through line 76.

Similar to the process 1000 of FIG. 1, the kinematic viscosity (dynamic viscosity divided by the density of the fluid) of the upgraded oil at 72 is equal to or less than about 700 centistokes (cSt). The yield of crude oil in the upgraded oil is about 92% or greater in volume. It has been observed that the initial viscosity of the crude oil feed (50) is independent from, and does not affect, the yield of upgrade oil. Furthermore, the ratio of precipitant to crude oil at the feed of process 2000 is also similar to process 1000 of FIG. 1, and can comprise, for example, a volumetric precipitant to oil volume ratio is in a range from about 1 to 1 to about 1 to 2, including for example, 1.25:1 and 1:5:1, depending on density differences. The weight ratio of crude oil to precipitant (or solvent) can comprise about 1:1.

In embodiments of the invention, the precipitant can comprise, for example, a light or natural gasoline. The precipitant's precipitating properties can be modified using optional additives such as light paraffinic hydrocarbons (pentane, hexane and heptanes, for example) or oxygenated hydrocarbons (such as pentanol, butanol, light ketones) that can be added through line 27 in FIG. 1, or line 76 in FIG. 2. The formulation of the final precipitant is a function of the type of crude oil and the level of deasphalting required in the process to reach a low enough upgraded oil viscosity for pipe transportation and the highest yield possible. Also the vapor pressure of the solvent or precipitant must be such as to allow an easy separation in the flash columns or distillation column of the processes.

In both processes, the stripper is used to recuperate traces of solvent from the upgraded product; however, depending on the user’s needs, the stripper could be omitted from the process.

**EXAMPLE**

In this example the process 1000 shown in FIG. 1 is followed:

100 g of Quifa crude oil from Colombia, whose characteristics are shown in table 1, is treated with a 100 g of a light gasoline as precipitant (Flash Boiling Point 260°C and 81.1° API) in a precipitant/crude oil ratio of 1/1 in weight percent. The Quifa and precipitant are well mixed and are separated in a centrifuge (at 4000 g’s). Two streams are produced, a light stream of 141.1 g which contains precipitant and partially deasphalted upgraded oil. This stream is subjected to a flash separation to recover precipitant and separate the upgraded oil. The other stream is 58.9 g of slurry that contains precipitant and a heavy solids fraction. This heavy fraction is subjected to a washing operation with 100 g of precipitant in an agitated tank.

The washed product is separated in a centrifuge at 4000 g’s and two streams are obtained: a slurry stream of 40.8 g rich in asphaltene (18.0%), very little crude oil (6.5%) and precipitant (75.5%) and a liquid stream of 118.1 g that contains washed crude oil (20.3%) and solvent (79.7%). The slurry stream is dried and 10 g of solids are obtained and 30.8 g of precipitant are recuperated. The liquid stream goes to the flash tower, where it is mixed with the liquid stream from the first centrifuge. From the flash unit, 169.1 g of the precipitant is recuperated and 90.0 g of upgraded oil are obtained as a product (characteristics shown in table 1).

<table>
<thead>
<tr>
<th>Characteristics of Quifa crude oil and of upgraded oil</th>
<th>Quifa Crude Oil</th>
<th>Upgraded Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>API gravity</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Viscosity (cP @ 30°C)</td>
<td>2400</td>
<td>650</td>
</tr>
<tr>
<td>V (ppm)</td>
<td>119</td>
<td>24</td>
</tr>
<tr>
<td>Ni (ppm)</td>
<td>53</td>
<td>7</td>
</tr>
<tr>
<td>Yield (% wt)</td>
<td>N/A</td>
<td>90</td>
</tr>
</tbody>
</table>

As demonstrated by this example, the process has a very high yield of product (90.0% wt) and a volumetric recuperation of 92%. There is also a substantial reduction in metals.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and described in detail. It is understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of reducing a viscosity of heavy and extra heavy crude oils at an oilfield site by partially removing asphaltenes to produce a pumpable upgraded oil, the method comprising:
   - combining a heavy or extra heavy crude oil and a feed precipitant, wherein a volumetric precipitant to crude oil ratio is in a range from about 1 to about 2;
   - precipitating and separating asphaltenes from the combination crude oil and precipitant;
   - separating the precipitated asphaltenes to form an oil slurry comprising the asphaltenes and precipitant, and a liquid stream comprising precipitant and a remaining volume of the crude oil; and
   - separating the liquid stream to produce the upgraded oil and a first precipitant stream, wherein a yield of upgraded oil is about 90% by weight or more with respect to the heavy or extra heavy crude oil.

2. The method of claim 1, further comprising:
   - washing the oil slurry with additional precipitant;
   - separating the washed oil slurry to produce an asphaltenes stream and a second precipitant stream; and
   - drying the asphaltenes stream to produce a solid asphaltene product, and a third precipitant stream.

3. The method of claim 2, wherein at least one of the first, second, and third precipitant streams is recycled as feed precipitant.

4. The method of claim 2, wherein at least one of the first, second, and third precipitant streams is recycled as additional precipitant to wash the oil slurry.

5. The method of claim 2, wherein the second precipitant is combined with the liquid stream before separation of the liquid stream.

6. The method of claim 1, wherein the heavy or extra heavy crude oil and precipitant is combined using static mixers.

7. The method of claim 6, wherein the crude oil and precipitant are combined at temperatures of about 80° C. (176° F.) or below, and pressures between 40 and 60 psig to maximize asphaltene precipitation.
8. The method of claim 1, wherein the step of precipitation utilizes one or more stirred or agitated tanks to induce asphaltene precipitation, or to remove crude oil occluded in the precipitated asphaltene particles.

9. The method of claim 1, wherein the oil slurry and liquid stream are separated in a separation vessel comprising hydrocyclones or centrifuges, wherein the precipitation of small solid asphaltene particles is induced by inertial forces many times the gravitational force, which operates to reduce residence time in the separation vessel.

10. The method of claim 2, wherein the asphaltene stream is dried by dryers.

11. The method of claim 1, wherein the first precipitant stream is separated from the upgraded oil using a flash separator or distillation tower.

12. The method of claim 1, further comprising:
   stripping the upgraded oil by stream stripping to produce stripped upgraded oil and a fourth precipitant stream.

13. The method of claim 12, wherein the fourth precipitant stream is recycled as feed precipitant.

14. The method of claim 12, wherein the stripped upgraded oil has a higher viscosity than the unstripped upgraded oil due to the removal of precipitant.

15. The method of claim 1, wherein a volumetric yield of the upgraded oil is greater than 92% with respect to the heavy or extra heavy crude oil.

16. The method of claim 1, wherein the upgraded oil exiting the process has less than 5% by weight of light component depending on a target viscosity of the upgraded oil.

17. The method of claim 1, wherein the upgraded oil has a higher API gravity compared to heavy or extra heavy crude oil, wherein a difference in API gravity comprises at least 3 API gravity units.

18. The method of claim 1, wherein the upgraded oil comprises a significant reduction of metals and sulfur from crude oil.

19. The method of claim 2, wherein a precipitant loss in the dried, solid asphaltene product is less than 1% by weight.

20. The method of claim 1, wherein the feed precipitant comprises a light gasoline or natural gasoline.

21. The method of claim 1, wherein the feed precipitant comprises a solvent and one or more additives formulated according to a chemical makeup of the heavy or extra heavy crude oil.

22. The method of claim 21, wherein the one or more additives are selected from the group consisting of light paraffinic hydrocarbons or oxygenated hydrocarbons.