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(54) METHOD AND DEVICE FOR SEPARATING ASPHALTENES FROM AN ASPHALTENE-CONTAINING FUEL

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(57) ABSTRACT

A method for separating asphaltenes from an asphaltene-containing fuel, wherein fuel is supplied to a separation unit in which a sub-stream with low-boiling fuel components of the fuel is separated. After separation of the sub-stream the fuel is supplied to a deasphalting unit in which asphaltenes contained in the fuel are separated by a solvent. After the separation of the asphaltenes from the fuel, the solvent is separated therefrom in a solvent recovery unit. The separated solvent is circulated back into the deasphalting unit, and a solvent fraction is obtained from the sub-stream that has been separated from the fuel, which is supplied to the deasphalting unit in addition to the solvent recirculated from the solvent recovery unit. A device is adapted for separating asphaltenes from an asphaltene-containing fuel.

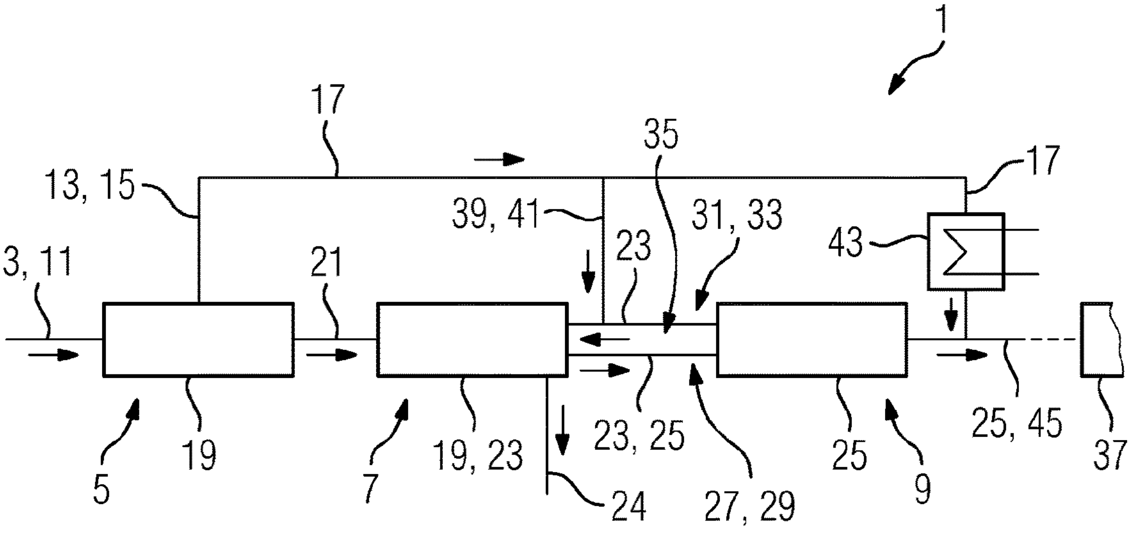

FIG 1

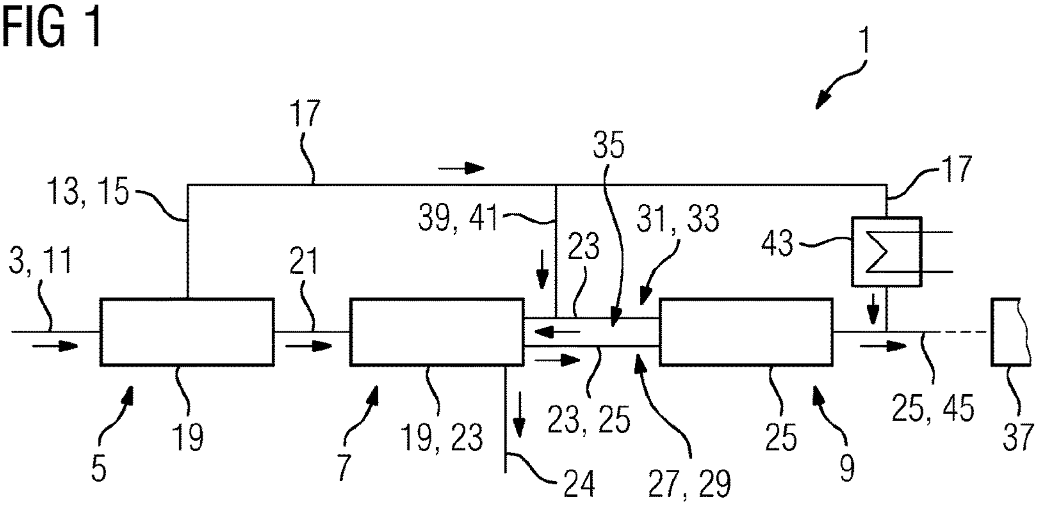
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FIG 2

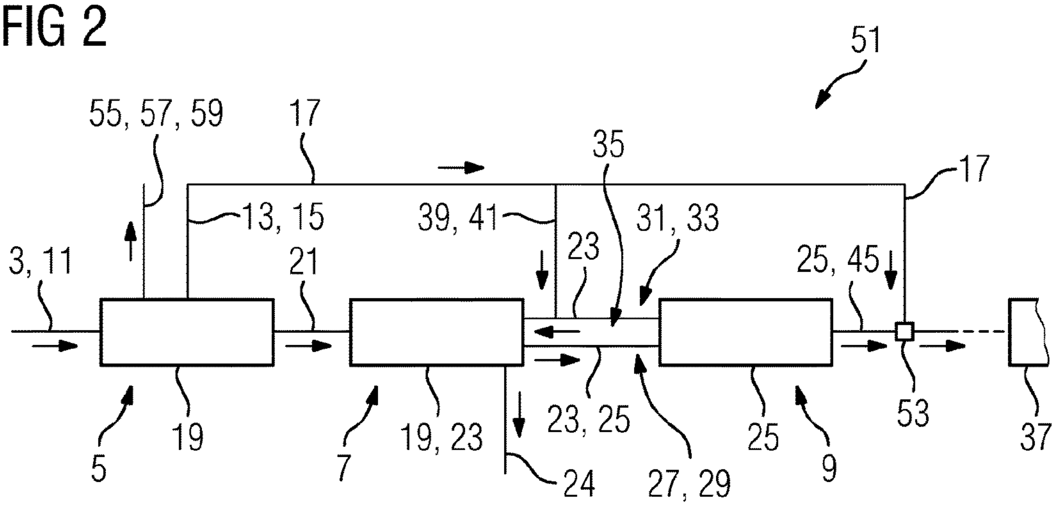
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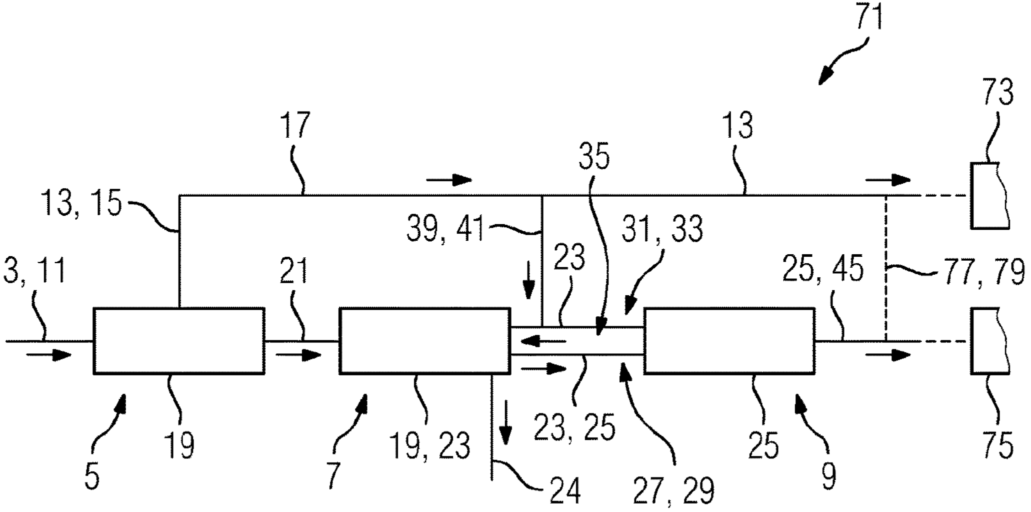
FIG 3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METHOD AND DEVICE FOR SEPARATING ASPHALTENES FROM AN ASPHALTENE-CONTAINING FUEL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the US National Stage of International Application No. PCT/EP2016/058850 filed Apr. 21, 2016, and claims the benefit thereof. The International Application claims the benefit of German Application No. DE 102015210256.4 filed Jun. 3, 2015. All of the applications are incorporated by reference herein in their entirety.

FIELD OF INVENTION

[0002] The invention relates to a method for separating asphaltenes from an asphaltene-containing fuel. The invention further relates to a corresponding device for separating asphaltenes from an asphaltene-containing fuel.

BACKGROUND OF INVENTION

[0003] In energy production, crude and heavy oils are frequently used, which are available as economical fuels for power generation by gas turbines. However, such crude and heavy oils contain asphaltenes, which in turn contain chemically bound heavy metals. On combustion of the oils, heavy metals such as vanadium or nickel are released as metal oxides. The metal oxides form alloys with the metals of the turbine blades, corroding or weakening them.

[0004] Moreover, independently of their metal content, asphaltenes have the property of precipitating as a solid due to major changes in pressure or temperature. These solid asphalt particles can plug lines or fine nozzles of the burner used, causing a lasting detrimental effect on mixture formation in the turbines and thus reducing the efficiency of the turbines. The combustion of crude oils in gas turbines is therefore subject to strict requirements.

[0005] Light crude oils are only suitable to a limited degree for power generation in gas turbines, as modern high-performance turbines tolerate heavy metals such as nickel or vanadium in the fuel only up to limits that are below their concentration in most crude oils. This reason alone is enough to make their use in heavy-metal-sensitive high-performance turbines unfeasible.

[0006] Gas turbines of other classes are also used. It is true that such gas turbines, which are operated at lower temperatures, show lower efficiency levels than heavy-metal-sensitive high-performance turbines. However, they are more tolerant with respect to the heavy metals contained in crude and heavy oils. Nevertheless, these heavy-metal-tolerant or vanadium-insensitive standard turbines require an additive such as a magnesium salt in order to inhibit the above-described corrosive effects of the heavy metals.

[0007] In the use of magnesium salt, which is common as an inhibitor but costly, a high-melting magnesium vanadate forms instead of a low-melting vanadate. In this case, however, there is the risk of crust formation on the turbine blades due to the deposition in layers of the magnesium vanadate. In order to ensure proper functioning of the turbine, the deposits or incrustations must be removed from the turbine blades, which requires regular time and cost-intensive servicing. More particularly, such cleaning involves shutting down the turbine for a period of several hours.

[0008] So-called deasphalting methods are known for separating the asphaltenes and heavy metals from a corresponding crude oil and thus processing the crude oil for combustion in gas turbines. Deasphalting methods are based on extraction of asphaltenes through addition of saturated aliphatic hydrocarbons as precipitants or as solvents for the residual oil components.

[0009] The heavy metals are highly concentrated in the asphaltenes, so that removal of the asphaltenes leads to immediate removal of the heavy metals. By mixing of the crude oil containing asphaltenes and heavy metals with the corresponding solvents, the asphaltenes are precipitated as a solid. The precipitated asphaltenes and the heavy metals simultaneously removed in precipitation of the asphaltenes can then be separated from the crude oil and thus removed from the process.

[0010] However, after deasphalting takes place, the short-chain alkanes preferably used as solvents (deasphalting agents) cannot be completely separated from the purified asphaltene-containing fuel and recirculated to the deasphalting process.

[0011] Common separation methods such as solvent evaporation in correspondingly applied processing units are generally accompanied by losses of the solvent to be separated, as complete separation is either impossible for technical reasons or extremely costly. The unseparated solvent portion thus remains in the stream of the purified asphaltene-containing fuel and is burned together therewith in the gas turbine. An undesirable solvent loss must therefore be accepted.

SUMMARY OF INVENTION

[0012] A first object of the invention is to provide a method that allows, by means of efficient and economical separation of asphaltenes from an asphaltene-containing fuel, the combustion of said fuel in a gas turbine process.

[0013] A second object of the invention is to provide a device by means of which such a method can be correspondingly implemented in an efficient and economical manner.

[0014] The first object is achieved according to the invention by means of a method for separating asphaltenes from an asphaltene-containing fuel, wherein the fuel is supplied to a separation unit, in which a substream comprising low-boiling fuel components is separated from the fuel, wherein the fuel, after separation of the substream, is supplied to a deasphalting unit, in which asphaltenes contained in the fuel are separated by means of a solvent, wherein the solvent, after separation of the asphaltenes from the fuel in a solvent recovery unit, is separated therefrom, wherein the separated solvent is recirculated into the deasphalting unit, and wherein a solvent fraction is obtained from the substream separated from the fuel, which is supplied to the deasphalting unit in addition to the solvent recirculated from the solvent recovery unit.

[0015] In a first step, the invention takes as a point of departure the idea that solvent losses always occur due to the incomplete separation of the solvent used for deasphalting in the continuous process, so that in the worst case, the deasphalting as such cannot take place completely, with the result that the desired purifying action cannot be achieved. Accordingly, subsequent addition of the solvent in the deasphalting process is necessary to compensate for the solvent losses.

[0016] However, because of the sharply higher cost of the solvents compared to asphaltene-containing fuel, this causes the operating costs of asphalting to increase. For example, the operating costs for a benzine fraction with a relatively low production cost of 0.5 €/L for refilling in a configuration of a 1000 MW power plant and an estimated solvent loss of 1%, depending on the asphaltene-containing fuel to be purified, increase by approx. 20 to 60 million €/year. If more specific solvent fractions, such as, for example, a pentane fraction, are required for refilling, the resulting costs would be estimated to be much higher.

[0017] In view of these considerations, in a second step, the invention takes into consideration the composition of the asphaltene-containing fuels to be purified. As an asphaltene-containing fuel, a crude oil is ordinarily used which, in addition to the asphaltenes to be removed, i.e. the highly-condensed aromatic hydrocarbons, primarily also contains a low-molecular fraction of alkanes, alkenes, and cycloalkanes.

[0018] The invention takes advantage of this situation in a third step and recognizes that the asphaltene-containing fuel to be purified is itself useful for obtaining solvents if a solvent fraction is obtained from the asphaltene-containing fuel which is supplied to the deasphalting unit for separation of the asphaltenes from the asphaltene-containing fuel.

[0019] In other words, the invention recognizes that it is possible to compensate for the undesired and inevitable solvent loss by means of targeted treatment of the asphaltene-containing fuel in a simple and cost-effective manner and to essentially completely prevent such loss. In use of short-chain alkanes as solvents or deasphalting agents, subsequent dosing or refilling is completely unnecessary, as suitable amounts of solvents are produced via the asphaltene-containing fuel as such that compensate for the solvent loss.

[0020] The solvents required for deasphalting are thus generated in the process itself, so that the costs for providing the solvents added in the process is reduced to a minimum, and in the ideal case, completely eliminated. The refilling costs that can be avoided by use of the method are in the range of 20 to 60 million €/year in a deasphalting process that is adapted to the requirements of a 1000 MW power plant.

[0021] The solvents required for deasphalting are continuously circulated, i.e. moved in a solvent circuit, between the deasphalting unit and the solvent recovery unit. The circulating solvent is constantly renewed by the supply of the separated solvent fraction to the solvent circuit. Concentration of undesirable auxiliary components and the waste generated therefrom do not occur. The entire process thus eliminates waste streams and produces only a stream of purified fuel that can be supplied to a gas turbine and a stream of separated asphaltenes that can be used, for example, to produce high-quality road asphalt.

[0022] The method can further be carried out under moderate process conditions. Supercritical process conditions and those connected with extremely high costs, more particularly such as those in solvent recovery in the ROSE process, are not necessary.

[0023] The fuel to be purified of asphaltenes is more particularly a crude oil, the main components of which, in addition to the asphaltenes (highly-condensed aromatic hydrocarbons), are primarily alkanes, alkenes, and cycloalkanes. In addition, aliphatic and heterocyclic nitrogen and sulfur compounds also occur.

[0024] Separation of the substream from the asphaltene-containing fuel to be purified takes place in the separation unit. In the present case, the first substream is understood as the low-boiling fraction of the asphaltene-containing fuel, i.e. as the fraction comprising the low-boiling fuel components. This fraction is essentially free of heavy metals such as vanadium and nickel. The substream is advantageously separated from the fuel by distillation.

[0025] In order to obtain the desired solvent fraction from the substream, the solvent fraction is separated by distillation from the substream, with the substream being depleted in this process. In this case, the components best suited for deasphalting are selectively separated from the substream, which corresponds to the total stream of the extracted low-boiling substances, as a distillate. The obtained distillate is added to the solvent circuit between the deasphalting unit and the solvent recovery unit and flows, in addition to the solvent circulated in the circuit, into the deasphalting unit.

[0026] Particularly suitable as solvents for deasphalting are short-chain hydrocarbons such as butane (C_4), pentane (C_5), hexane (C_6), and/or heptane (C_7). Particularly advantageously, butane (C_4), pentane (C_5) and hexane (C_6), also referred to as the C_4-C_6 fraction, are used as solvents. Accordingly, a solvent fraction is advantageously separated from the substream that contains C_4-C_6 carbons.

[0027] In deasphalting, the solvent is used to dissolve soluble components contained in the asphaltene-containing fuel, such as, for example, aliphatics, aromatics, and paraffins. The asphaltene fraction (asphaltenes and heavy meals) contained in the asphaltene-containing fuel is soluble in the solvent used, so that the solvent is used with respect to the asphaltenes as an “anti-solvent”, so to speak.

[0028] In separation of the first substream, a bottom fraction remains, i.e. the fuel that contains the highest-boiling components and more particularly all heavy metals and asphaltenes. The fuel therefore contains high concentrations of asphaltenes and heavy metals. This bottom fraction allows the separation of the asphaltenes and the heavy metals concentrated therein. For this purpose, the fuel is advantageously supplied to the deasphalting unit.

[0029] In this case, the uneven distribution of the heavy metals in the different fractions of these fuels is utilized: most of the heavy metals are contained in the so-called asphaltene fraction, which is defined as the fraction containing the proportion of an oil that is not dissolved by the added alkane on mixing with alkanes, typically propane, butane, pentane, hexane, or heptane. The asphaltenes remain behind as a second phase. This allows the asphaltenes and the heavy metals concentrated therein to be separated, wherein the degree of heavy metal depletion is ordinarily in the range of 50% to 80%.

[0030] The solvent used for deasphalting is provided to the deasphalting unit, originating essentially from the solvent recovery unit. In addition to the recirculated solvent, the solvent fraction obtained from the substream, a fraction that advantageously contains butane (C_4), pentane (C_5), and hexane (C_6), is supplied to the deasphalting unit. In an advantageous embodiment of the invention, the solvent fraction is supplied to the deasphalting unit together with the solvent recirculated from the solvent processing unit. The two streams are correspondingly combined before entering the deasphalting unit.

[0031] After deasphalting, the fuel purified of asphaltenes, i.e. the deasphalted fuel, and the solvent are advantageously supplied to the solvent recovery unit. Here, the solvent is purified and separated from the deasphalted fuel. The solvent is recirculated into the deasphalting process. In addition to the recirculated solvent, the solvent fraction obtained from the first substream is supplied to the deasphalting process.

[0032] The asphaltenes separated from the fuel in the deasphalting unit are advantageously extracted and sent on for further recycling.

[0033] After separation of the solvent, the purified fuel is advantageously supplied to a gas turbine and burned there in order to produce energy. The substream depleted of the solvent fraction is also advantageously supplied to a gas turbine.

[0034] In an advantageous embodiment of the invention, the purified fuel and the depleted substream are combined before being supplied to the gas turbine. For this purpose, the two streams are combined and supplied to the gas turbine together. Combining or mixing of the gaseous extracted stream, i.e. the substream depleted of the solvent fraction, into the liquid fuel stream leaving the solvent recovery unit takes place in an embodiment after prior liquefaction of the substream by condensation. In this case, two liquid streams are combined and supplied to a gas turbine for combustion.

[0035] In a further embodiment, mixing of the substream depleted of the solvent fraction and the liquid fuel stream leaving the solvent recovery unit takes place in a quenching unit. An advantage of such combining lies in the fact that no condenser or supply of a coolant are required. In the quenching unit, the gaseous substream depleted of the solvent fraction is brought into close contact with the liquid purified fuel. In this process, the gas is condensed from the liquid. The condensation heat thus released remains in the liquid mixture, so that the temperature thereof increases slightly.

[0036] Furthermore, the energy previously used for vaporizing the substream, which in condensation would be discharged and thus lost to the system, is retained in the system by quenching. After quenching, the energy remains in the total stream of the fuel resulting from combining of the streams. This fuel stream therefore shows a corresponding slightly higher temperature after quenching than the fuel leaving the solvent recovery unit prior to combining.

[0037] In an alternative embodiment of the invention, the purified fuel and the depleted substream are supplied to different turbines. In this case, a distinction is made between standard turbines having higher heavy metal tolerance (vanadium-insensitive standard turbines) and so-called high-performance turbines having lower heavy metal tolerance (vanadium-sensitive high-performance turbines).

[0038] After separation of the solvent fraction from the first substream, this substream is correspondingly depleted of vanadium. In a particularly advantageous embodiment of the invention, the first substream depleted of the solvent fraction is supplied to a vanadium-sensitive high-performance turbine, where it is used for power generation. This requires no additives, and there is also no risk of turbine damage.

[0039] In other words, the vanadium-free low-boiling fraction, i.e. the substream separated from the fuel in the separation unit, is used not only for obtaining deasphalting agents, i.e. the solvent fraction, but can then also be efficiently used for power generation in a vanadium-sensitive high-performance turbine.

[0040] The purified fuel is advantageously supplied to a vanadium-insensitive, vanadium-tolerant standard turbine. It is true that residues of vanadium and/or heavy metals may be present in this deasphalted fuel. However, the amounts thereof are sufficiently low to allow the fuel to be recovered for power generation by means of a vanadium-insensitive standard turbine.

[0041] In the following, the processing and subsequent use for power generation of an asphaltene-containing fuel are explained. A fuel stream is advantageously separated by distillation before entering a deasphalting unit into a heavy-metal-free fraction of low-boiling substances ("top fraction") and a high-boiling fraction ("bottom fraction") having a high concentration of heavy metals. In this process, the solvent fraction is depleted of the low-boiling substances and supplied to the asphalting process.

[0042] The high-boiling substances, which now contain high concentrations of asphaltenes and heavy metals, are subjected to a deasphalting process using the solvent. In this manner, the heavy metals are removed via the asphaltene fraction. In the process of deasphalting, ⅔ to ¾ of the heavy metals are typically removed, depending on the process conditions. In this case, the portion of heavy metals to be expected in the deasphalted fuel can still be recycled for power generation by means of a vanadium-insensitive standard turbine.

[0043] The processing of an asphaltene-containing total fuel stream of 200 t/h having a content of 30 ppm of metals such as vanadium and nickel respectively is explained by way of example.

		Fuel [t/h]	Vanadium [ppm]
Total fuel stream		200 (100%)	30
Low-boiling substances		150 (75%)	0
High-boiling substances		50 (25%)	120
Of which:	Asphaltenes	6 (12%)	700-800*
	DAO fraction	44 (88%)	36
Fuel utilization (total)		194 (97%)	

*calculated from mass balance

[0044] In separation of the total fuel stream (200 t/h) by distillation, approx. 75% (150 t/h) of the fuel boils off as a vanadium-free, low-boiling top fraction. The remaining 25% (50 t/h) remains in addition to all of the heavy metals and asphaltene as high-boiling substances or as a bottom fraction in the separation unit. After separation of the desired solvent fraction, the 75% of low-boiling substances can be efficiently used for power generation in a vanadium-sensitive high-performance turbine.

[0045] As a result of separation of the low-boiling substream and the concentration of the bottom fraction associated therewith, the high-boiling substances, i.e. the remaining 25% of the fuel, contain a proportion of 12% (6 t/h, corresponds to 3% relative to the total flow) and a concentration of 120 ppm of heavy metals in the "bottom" and are supplied to a deasphalting unit.

[0046] After deasphalting, a deasphalted fuel (DAO fraction) is obtained that is depleted of approx. 70% of its vanadium content. In this case, the asphaltenes (vanadium concentration approx. 700 ppm to 800 ppm) are removed from the fuel. The vanadium content is calculated from the mass balance. Of the initial 25% of the asphaltene-containing fuel, with a heavy metal concentration of 120 ppm, approx. 22% of this mass remains as a deasphalted and demetallized fuel having a vanadium concentration of 36 ppm.

[0047] At 36 ppm, the vanadium content of the deasphalted fuel is therefore only slightly higher than the vanadium content of the starting fuel of 30 ppm, and can still be recovered for power generation via a vanadium-insensitive standard turbine.

[0048] In total, therefore, 97% of the fuel can be selectively utilized, wherein 75% of the fuel is recovered for power generation in a vanadium-sensitive high-performance turbine. The 22% of the fuel remaining after separation of the asphaltenes and most of the heavy metals is processed in a vanadium-insensitive standard turbine. In this manner, one can save almost 75% in additives, and service expenditure drops proportionately.

[0049] The 3% of asphaltenes discharged is advantageously sent on for secondary utilization, i.e. as bitumen as an additive to asphalt in road construction. Moreover, there is the advantageous possibility of subjecting the separated asphaltenes to an "upgrade" in a refinery by means of a blower/coker in order to use them as a construction material.

[0050] Separate power generation with the streams separated in the separation unit and then subjected to different processing can be carried out until the vanadium content in the deasphalted fuel exceeds the economic tolerance level for heavy-metal-tolerant gas turbines.

[0051] Therefore, approx. 75% of the fuel, or the proportion remaining after separation of the solvent fraction of 70% to 72%, is used for high-efficiency power generation in a vanadium-sensitive high-performance turbine. Only the approx. 22% of residual fuel remaining after deasphalting is converted to power with lower efficiency in a vanadium-insensitive standard turbine, with this being possible only because of the relatively favorable vanadium tolerance of these turbines. Overall, therefore, the highest possible energy utilization can be derived from the asphaltene-containing fuel used.

[0052] As fuels containing a high metal content may still contain high proportions of metals despite deasphalting, the invention provides as a further alternative that only so much of the heavy-metal-free top fraction is supplied to the deasphalted fuel so that the financial tolerance limit of the service and additive costs of a vanadium-insensitive standard turbine is not exceeded. For this purpose, only a part of the substream removed from the solvent fraction is combined with the deasphalted fuel prior to entering a vanadium-insensitive standard turbine. The remainder of the heavy-metal-free top fraction is then supplied unchanged to a vanadium-sensitive high-performance turbine.

[0053] In this manner, large proportions of fuels, more particularly light crude oils, can be highly efficiently used for power generation in vanadium-sensitive high-performance turbines without any noteworthy tolerance for heavy metals.

[0054] Furthermore, an economically valuable boiling fraction is advantageously separated from the fuel. An economically valuable boiling fraction refers to a fraction or a substream that contains components which, in commercial exploitation and/or sale, yield revenue that is sharply higher than the heating value of the fuel used. Separation of the boiling fraction advantageously takes place before the asphaltene-containing fuel is supplied to the deasphalting unit. A suitable device for this is the separation unit, in which the substream is extracted to obtain the solvent fraction from the asphaltene-containing fuel. In distillation during this process, which is advantageously carried out, a fraction of "low-boiling substances" is extracted. This fraction is then supplied for further processing, and can then be sold at a profit.

[0055] On the whole, selective separation of an asphaltene-containing fuel into different (sub)streams upstream of deasphalting makes it possible, in a selective manner, to efficiently and economically generate and use the solvents required for the deasphalting process in an ongoing process. In addition, the substreams having different compositions from one another can be selectively utilized in a large-scale power plant operating with multiple turbines.

[0056] In this case, with respect to the fuel fraction containing the high-boiling components, i.e. the bottom, the robustness of a vanadium-insensitive standard turbine is taken advantage of in the best way possible, and the concentration of the asphaltenes in the bottom fraction provides the best possible conditions for the deasphalting process. At the same time, the power generation of the substream comprising the low-boiling components allows the high efficiency of a vanadium-sensitive high-performance turbine to be achieved.

[0057] The second object of the invention is achieved by means of a device for separating asphaltenes from an asphaltene-containing fuel comprising a deasphalting unit for separation of asphaltenes contained in the fuel by means of a solvent and a solvent recovery unit for separation of the solvent from the fuel, wherein the solvent recovery unit for recirculation of the separated solvent is fluidically connected to the deasphalting unit, and comprising a separation unit fluidically connected to the deasphalting unit for separation of a substream comprising low-boiling fuel components from the fuel, wherein the separation unit and the deasphalting unit are fluidically connected to each other such that a solvent fraction obtainable from the substream separated from the fuel, in addition to the solvent recirculated from the solvent recovery unit, can be supplied to the deasphalting unit.

[0058] By means of the fluidic connection of the separation unit and the deasphalting unit, such a device makes it possible to compensate for undesired process-related solvent losses. By means of the obtainable solvent fraction, which can additionally be supplied to the deasphalting unit, costly subsequent dosing or refilling of solvents in the deasphalting process is avoided.

[0059] A discharge line, which is fluidically connected to a supply line of the solvent recovery unit, is advantageously connected to the deasphalting unit. A discharge line is also advantageously connected to the solvent recovery unit. This discharge line is advantageously fluidically connected to a recirculation line of the deasphalting unit.

[0060] The lines connected to one another therefore form a solvent circuit between the deasphalting unit and the solvent recovery unit. The solvent used for deasphalting circulates in this solvent circuit. The solvent fraction obtainable from the substream, in addition to the circulating solvent, can also be supplied via this solvent circuit to the deasphalting unit and thus to the deasphalting process.

[0061] Also advantageously, a discharge line for extraction of the asphaltenes removed from the fuel in the deasphalting process is connected to the deasphalting unit.

[0062] The separation unit is advantageously fluidically connected upstream of the deasphalting unit. In the separation unit, which is advantageously configured as a distillation unit, a substream comprising low-boiling substances is separated from the asphaltene-containing fuel.

[0063] For extraction of the substream, the separation unit is advantageously connected to an extraction line. By means of the extraction line, the substream containing the low-boiling components of the asphaltene-containing fuel is extracted, from which the solvent fraction is obtained. The solvent fraction is extracted from the substream. For extraction of the solvent fraction, a branch line is advantageously connected to the extraction line.

[0064] The branch line is advantageously fluidically connected to a discharge line of the solvent recovery unit. In this manner, a solvent fraction obtainable from the substream can be supplied to the solvent circuit and correspondingly used in the deasphalting unit.

[0065] The separation unit itself is advantageously fluidically connected to a gas turbine. This fluidic connection is advantageously implemented via connection of the extraction line connected to the separation unit with a corresponding inlet to the gas turbine. The substream depleted of the solvent fraction is correspondingly supplied to the gas turbine, where it is burned. The same applies to the fuel freed of asphaltenes and solvents leaving the solvent recovery unit. For combustion of the fuel, the solvent recovery unit is also advantageously fluidically connected to a gas turbine.

[0066] In an advantageous embodiment, the solvent recovery unit and the separation unit are fluidically connected to the same gas turbine. In this case, the substream removed from the solvent fraction and the fuel are advantageously supplied to the turbines as a total flow. For this purpose, the extraction line of the separation unit is advantageously fluidically connected to an extraction line of the solvent recovery unit.

[0067] In an alternative embodiment of the invention, the solvent recovery unit and the separation unit are fluidically coupled to different gas turbines. It is particularly advantageous if the solvent recovery unit is fluidically connected to a vanadium-sensitive high-performance turbine. This possibility arises because the first substream is essentially free of heavy metals, allowing power generation to take place without the addition of additives and possible turbine damage resulting therefrom.

[0068] The purified fuel is advantageously supplied to a vanadium-insensitive standard turbine. For this purpose, the solvent recovery unit is advantageously fluidically connected to a vanadium-insensitive standard turbine. In this case, any heavy metals still remaining in the fuel, because of the sharply higher heavy metal tolerance of vanadium-insensitive standard turbines compared to the vanadium-sensitive high-performance turbine, have no effect on the function thereof.

[0069] In addition to the substream with the low-boiling components, it is also possible in the separation unit to separate an economically valuable boiling fraction from the asphaltene-containing fuel. For extraction of such a fraction, the separation unit is advantageously connected to an extraction line.

[0070] The advantages mentioned for preferred embodiments of the method can be applied mutatis mutandis to corresponding embodiments of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0071] In the following, examples of the invention are explained in further detail with reference to a drawing. The figures are as follows:

[0072] FIG. **1** shows a first device for removing asphaltenes from an asphaltene-containing fuel,

[0073] FIG. **2** shows a second device for removing asphaltenes from an asphaltene-containing fuel, and

[0074] FIG. **3** shows a third device for removing asphaltenes from an asphaltene-containing fuel.

DETAILED DESCRIPTION OF INVENTION

[0075] FIG. **1** shows a device **1** for removing asphaltenes from an asphaltene-containing fuel **3**. The device **1** comprises a separation unit **5**, a deasphalting unit **7** fluidically connected downstream of the separation unit, and a solvent processing unit **9** fluidically coupled to the deasphalting unit **7**.

[0076] A total stream of 200 t/h of an asphaltene-containing fuel **3** is added to the separation unit **5** via a supply line **11**. Inside the separation unit **5**, which in the present case is configured as a distillation unit, a substream **13** comprising low-boiling components **15**, the so-called top fraction, is separated from the fuel **3** and extracted via an extraction line **17** connected to the separation unit **5**. The amount of the extracted top fraction is 75%, which corresponds to a fuel stream of 150 t/h. The top fraction **13** is free of vanadium.

[0077] The fuel **19** containing a high concentration of asphaltenes remains in the separation unit **5**. This consists of the high-boiling substances, which contain 25% (50 t/h) of the fuel **3** and 120 ppm of vanadium.

[0078] The concentrated fuel **19**, which contains 12% (corresponding to a flow of 6 t/h) of asphaltenes, is supplied to the deasphalting unit **7** via a discharge line **21** connected to the separation unit **5**. In this unit, the fuel **19** is purified of asphaltenes and heavy metals. As the heavy metals are removed together with the asphaltenes, on extraction of 6 t of asphaltenes per hour, approx. 700 to 800 ppm of vanadium is simultaneously removed from the fuel **19**.

[0079] For this purpose, a solvent **23** is used which essentially contains butane (C_4), pentane (C_5), and hexane (C_6). In deasphalting, the solvent **23** is used to dissolve soluble components contained in the asphaltene-containing fuel **19**. The asphaltenes contained in the asphaltene-containing fuel **19** are insoluble in the solvent **23** used, so that the solvent **23** constitutes an “anti-solvent” with respect to the asphaltenes.

[0080] The separated asphaltenes and heavy metals are supplied via an extraction line **24** connected to the deasphalting unit **7** for processing not further specified in the present case, followed by utilization in devices accordingly configured for this purpose. The deasphalted fuel **25** (DAO fraction) now still contains 36 ppm of vanadium and is supplied to the solvent recovery unit **9** together with the solvent. For this purpose, a discharge line **27** connected to the deasphalting unit **7** is fluidically connected to a supply line **29** of the solvent recovery unit **9**. In the solvent recovery unit **9**, the solvent **23** is separated from the deasphalted fuel **25** and again recirculated to the deasphalting process.

[0081] For recirculation of the solvent **23**, a discharge line **31** is connected to the solvent recovery unit **9**, which is fluidically connected to a recirculation line **33** of the deasphalting unit **7**. Via these lines **27**, **29**, **31**, **33**, the solvent **23** circulates between the deasphalting unit **7** and the solvent recovery unit **9** in a solvent circuit **35**.

[0082] The separation of the solvent **23** in the solvent recovery unit **9** is generally accompanied by losses. A portion of the solvent content **23** remains in the stream of the purified fuel **25** and is burned together therewith in a gas turbine **37** connected to the solvent recovery unit **9**. This undesired solvent loss must be compensated for.

[0083] The substream **13** comprising low-boiling components **15** separated in the separation unit **5** from the asphaltene-containing fuel **3** is used for this purpose. A solvent fraction **39** is separated by distillation from the substream **13**. In this case, the components best suited for deasphalting are selectively separated from the substream **13**, which corresponds to the total stream of the extracted low-boiling substances, as a distillate. In the present case, a $C_4/C_5/C_6$ fraction **39** is separated from the substream **13**.

[0084] The obtained distillate **39** is added to the solvent circuit **35** between the deasphalting unit **7** and the solvent recovery unit **9** and flows together with the solvent **23** circulated in the circuit **35** into the deasphalting unit **7**. For this purpose, a branch line **41** is connected to the extraction line **17** of the separation unit **3**, said branch line in turn being fluidically connected to the discharge line **31** of the solvent recovery unit **9** or to the recirculation line **33** of the deasphalting unit **7**.

[0085] By adding the solvent fraction **39** to the circulating solvent **23**, it becomes possible to dispense with refilling and thus reduce the costs of providing the solvent **23** required for deasphalting to a minimum.

[0086] Both the solvent recovery unit **9** and the separation unit **3** are fluidically connected to the gas turbine **37**. For this purpose, the gaseous substream **13** depleted of the solvent fraction **39** is combined with the liquid fuel stream **25** leaving the solvent recovery unit **9**. In this case, the gaseous substream **13** is first liquefied prior to this combination, for which purpose a cooler **43** is arranged in the extraction line **17** of the separation unit **5**. Two liquid streams **13**, **25** are therefore combined and then supplied together to the gas turbine **37** for combustion.

[0087] For mixing in of the substream **13** liquefied after condensation, the extraction line **17** of the separation unit **5** is fluidically connected to an extraction line **45** of the solvent recovery unit **9**.

[0088] Overall, by means of the targeted treatment of the asphaltene-containing fuel **3**, the method or the device **1** used to carry it out allows the production of the solvent **23**, **39** required for deasphalting, so that the costs of providing the solvent **23** are reduced to a minimum, and in the ideal case, eliminated entirely.

[0089] FIG. **2** shows a further device **51** for removing asphaltenes from an asphaltene-containing fuel **3**. Here, the device **51** is essentially configured in the same manner as the device **1** according to FIG. **1**.

[0090] The method that can be carried out with the device **51**, and the individual device components, correspond to those of the device **1** according to FIG. **1**. The device **51** therefore also comprises the separation unit **5**, the deasphalting unit **7** fluidically connected downstream of the separation unit, and the solvent processing unit **9** fluidically coupled to the deasphalting unit. Accordingly, the detailed description with reference to FIG. **1** can be applied to the device **51** according to FIG. **2**.

[0091] The essential difference between the two devices **1**, **51** lies in the fact that the substream **13** depleted of the solvent fraction **39** and the fuel **25** purified of asphaltenes and separated from the solvent **23** in the solvent processing unit **9** are combined.

[0092] In the present case, instead of a cooler, such as that used in the device **1** according to FIG. **1**, the device **51** comprises a quenching unit **53**. This quenching unit **53** is arranged in the extraction line **45** of the solvent processing unit **9**. The mixing of the gaseous substream **13** depleted of the solvent fraction **39** and the liquid fuel stream **25** leaving the solvent recovery unit **9** takes place directly in a quenching unit. In the case of such direct combination, no cooler is needed.

[0093] In addition, the separation unit **5** comprises a further extraction line **55**, via which an economically valuable boiling fraction **57**, in the present case comprising aromatic components **59**, is extracted from the asphaltene-containing fuel **3**. This boiling fraction **57** is obtained as an intermediate boiling fraction, wherein the aromatics contained therein are supplied for processing not shown here in further detail and can then be sold at a profit.

[0094] FIG. **3** shows a device **71** that is also used for separating asphaltenes from the asphaltene-containing fuel **3**. In this case as well, the separation unit **5**, the deasphalting unit **7**, and the solvent processing unit **9** are used, so that with respect to the devices **1**, **51**, one can refer to FIGS. **1** and **2**.

[0095] The essential difference from FIGS. **1** and **2** lies in the combustion of the substream **13** and the fuel **25**. In the present case, the purified fuel **25** and the depleted substream **13** are supplied to different turbines **73**, **75**.

[0096] This possibility arises because of the different compositions of the respective streams **13**, **25**. As the substream **13** contains only low-boiling components **15** and no heavy metals or asphaltenes, it can be used for power generation in a vanadium-sensitive high-performance turbine **73**. No additives are required, nor is there any risk of turbine damage.

[0097] In other words, the vanadium-free low-boiling fraction, i.e. the substream **13** separated from the fuel **3** in the separation unit **5**, is used not only for obtaining deasphalting agents, i.e. the solvent fraction **39**, but can then be efficiently used for power generation in a vanadium-sensitive high-performance turbine **73**.

[0098] The purified fuel **25** is supplied to a vanadium-insensitive standard turbine **75**. This deasphalted fuel **25** may still contain residues of vanadium and/or heavy metals. However, the content thereof is sufficiently low to allow the fuel **25** to be recovered for power generation by a vanadium-insensitive standard turbine **75**.

[0099] Such separate power generation with the streams **13**, **25** separated in the separation unit **3** and then subjected to different processing can be carried out until the vanadium content in the deasphalted fuel **25** exceeds the turbine-specific heavy metal tolerance level. If this occurs, it is possible to add a low-boiling portion **77** of the sub stream **13** to the fuel **25** so that the economic tolerance level with respect to servicing and additive costs of the vanadium-insensitive standard turbine **75** is not exceeded.

[0100] Accordingly, the portion **77** of the substream **13** depleted of the solvent fraction **39** is combined with the fuel **25** before it enters the vanadium-insensitive standard turbine **75**. For this purpose, the extraction line **17** of the separation unit **5** and the extraction line **45** of the solvent recovery unit **9** are fluidically connected to each other via a coupling line **79**. This coupling line **79** is shown as an option in FIG. **3** by the broken lines. The residue of the substream **13** remaining after separation of the low-boiling portion **77** is supplied as described above to the vanadium-sensitive high-performance turbine **73**, where it is burned with high efficiency.

[0101] Overall, the separation unit **5** connected upstream of the deasphalting unit **7** and the resulting possibility of selective separation of an asphaltene-containing fuel **3** into different (sub)streams **13**, **25** allow the generation and use in a continuous process, in an efficient and economical manner, of the solvents **23**, **39** required for the deasphalting process.

[0102] In addition, the substreams **13**, **25** having differing compositions can be selectively used in a large-scale power plant operated with multiple turbines, such as a vanadium-sensitive high-performance turbine **73** and a vanadium-insensitive standard turbine **75**.

1.-**21**. (canceled)

22. A method for separating asphaltenes from an asphaltene-containing fuel, the method comprising:

supplying the fuel to a separation unit, in which a substream comprising low-boiling fuel components is separated from the fuel,

supplying the fuel, after separation of the substream, to a deasphalting unit, in which asphaltenes contained in the fuel are separated by a solvent, wherein the solvent, after separation of the asphaltenes from the fuel in a solvent recovery unit, is separated therefrom,

recircuating the separated solvent to the deasphalting unit,

obtaining a solvent fraction from the substream separated from the fuel, which, in addition to the solvent recirculated from the solvent recovery unit, is supplied to the deasphalting unit,

supplying the substream depleted in the separating unit comprising low-boiling fuel components to a high-performance turbine,

supplying the deasphalted fuel purified by the deasphalting unit to a standard turbine, and

when the turbine-specific heavy metal tolerance limit of the vanadium component in the deasphalted fuel in the standard turbine is exceeded, adding low-boiling fuel components to the deasphalted fuel via a coupling line.

23. The method as claimed in claim **22**,

wherein the substream comprising low-boiling fuel components is separated by distillation from the fuel.

24. The method as claimed in claim **22**,

wherein the solvent fraction is separated by distillation from the substream, with the substream being depleted in this process.

25. The method as claimed in claim **22**,

wherein an economically valuable boiling fraction is separated from the fuel.

26. A device for separating asphaltenes from an asphaltene-containing fuel, comprising:

a deasphalting unit for separation of the asphaltenes contained in the fuel by a solvent,

a solvent recovery unit for separation of the solvent from the fuel,

wherein the solvent recovery unit is fluidically connected to the deasphalting unit for recirculation of the separated solvent, and

a separation unit is fluidically connected to the deasphalting unit for separation of a substream comprising low-boiling fuel components from the fuel,

wherein the separation unit and the deasphalting unit are fluidically connected to each other such that a solvent fraction obtainable from the substream separated from the fuel is supplied in addition to the solvent recirculated from the solvent recovery unit to the deasphalting unit,

wherein the separating unit is fluidically connected to a high-performance turbine,

wherein the solvent recovery unit is fluidically connected to a standard turbine, and

a coupling line, wherein when the turbine-specific heavy metal tolerance limit of the vanadium component in the deasphalted fuel for the standard turbine is exceeded, low-boiling fuel components are added to the deasphalted fuel via the coupling line.

27. The device as claimed in claim **26**,

wherein the separation unit is fluidically connected upstream of the deasphalting unit.

28. The device as claimed in claim **26**,

wherein a distillation unit is used as a separation unit.

29. The device as claimed in claim **26**,

wherein an extraction line for extraction of the substream is connected to the separation unit.

30. The device as claimed in claim **29**,

wherein a branch line for extraction of the solvent fraction is connected to the extraction line.

31. The device as claimed in claim **30**,

wherein the branch line is fluidically connected to a discharge line of the solvent recovery unit.

32. The device as claimed in claim **26**,

wherein an extraction line for the extraction of an economically valuable boiling fraction from the fuel is connected to the separation unit.

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