

Method for treating heavy fuel oil

The present invention relates to a method for on-ship processing of heavy oil, for use as a fuel, especially
5 for a diesel engine.

According to the online encyclopedia WIKIPEDIA and in the context of this application, a "heavy oil" (heavy fuel oil, HFO) is a residue oil from distillation or
10 from cracking plants in mineral oil processing, and serves as a fuel for large diesel engines, as used, for example, on ships and for steam locomotives with oil firing or in power plants for power generation. The international trade designation of such an oil is:
15 marine (residual) fuel oil (MFO); the US term Bunker C is sometimes also used.

It is known that heavy oils - especially in order to comply with ISO 8217 - before being combusted in diesel
20 engines or in other units, can be processed directly on board ships by clarification to remove solids - in particular abrasive heavy fines removable from the heavy oil by sedimentation or in a centrifugal field and having a given minimum diameter D (depending on the
25 respective internal combustion engine, for example: $D = 10 \mu\text{m}$; called catalyst fines or cat fines hereinafter, especially aluminum (compounds) or silicon (compounds), for example Si or SiO_2) - and a removal of an aqueous phase. The proportion of the so-called abrasive
30 catalyst fines in the heavy oil for processing as starting material in the prior art and also in the process according to the invention should if at all possible already be below an upper limit of below 60 mg/kg (ppm). Then this content of catalyst fines is to
35 be distinctly lowered, especially in order that the abrasives do not damage the diesel engine. According to specifications from diesel constructors, in this regard, even markedly lower upper limits of 20 ppm or

even 15 ppm or 10 ppm or even 5 ppm should be complied with. This is to be achievable in particular on board ships with a minimum level of complexity.

- 5 A known system for processing heavy oil on board ships is shown in fig. 2.

Heavy oil OIL1 which is to be processed and flows in through a conduit 101 (here with a valve 102 connected
10 therein) from a tank, which is not shown, and has a starting temperature T0 is first freed of coarse solids in a soil trap 103 such as a sieve. Then the heavy oil is passed with a pump 104 through a heat exchanger 105 in which it is heated to a temperature of up to 98°.

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The heated heavy oil is passed out of the heat exchanger 105 through a conduit section 106 into a centrifuge, a three-phase separator 107 here, in which a soil/water phase W is separated from the heavy oil
20 and flows away through an outlet 108, and in which it is cleaned to free it of a solid phase S which contains the abrasive catalyst fines and which is removed via an outlet 109. The processed heavy oil phase - the "clean oil" - OIL2 is passed out of the separator 107 through
25 an outlet 110 for further use. It can be passed here into an intermediate tank (not shown here) or fed directly to combustion in a diesel engine. The heat exchanger 104 is preferably fed with thermal oil or saturated or hot steam (also referred to hereinafter as
30 "HS") as thermal energy-releasing medium, from which the thermal energy serves to heat the heavy oil in countercurrent.

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This method is to be improved further.

Solving this problem is the object of the invention.

The invention achieves this object by a method having the features of claim 1 and of the further independent claim 11.

5 The at least intermittent or permanent increase in the separation temperature according to claim 1 increases the separation efficiency. In this way, lower catalyst fines contents and, at the higher temperatures of more than 100°C or more than 105°C or more than 110°C or
10 even more than 115°C, even lower catalyst fines contents in each case can be achieved in the clean oil.

An additional particularly advantageous feature is the optional heating in two stages. Firstly, in this way,
15 the increase in the temperature to the very high separation temperature need not be effected until immediately before the actual separating operation. In addition, the multistage and especially two-stage heating of the heavy oil for processing allows the
20 "clean oil" which has been heated to the separation temperature and conducted out of the at least one centrifuge, especially the (three-phase) separator, to be utilized for flow through a heat exchanger in order to release heat in countercurrent to the "feed fuel" to
25 be cleaned, in order to heat it to a first temperature T₁, but one which is still lower than the separation temperature T₂. This reduces the amount of heat needed overall for heating of the heavy oil to the separation temperature T₂, and keeps the clean oil temperature in
30 the downstream pipelines below the temperature T₂ of otherwise possibly more than 100°C.

The invention of claim 11 additionally achieves optimized closed-loop control of a generic method but
35 also of a method of the invention as claimed in any of claims 1 to 10.

Thus provided is an advantageous method as claimed in any of the preceding claims or method for on-ship processing of heavy oil which is to be utilized as fuel for a diesel engine, having the following steps: a) providing heavy oil (OIL1) for processing; b) passing the heavy oil (OIL1) provided and for processing from step a), especially using at least one pump, onward into a centrifuge, with heating of the heavy oil for processing before it reaches the centrifuge to a separation temperature of - preferably - more than 98°C, and c) separating an aqueous phase and a sludge phase from a clean oil phase (OIL2) in the centrifuge, also with performance of one or more of the following steps d) to f) : d) the catalyst fines content (Cat Fines IN) in the incoming heavy oil for processing - especially prior to heating - is determined with a sensor device, e) the catalyst fines content (Cat Fines OUT) in the outgoing cleaned or processed clean oil is determined with the or a second sensor device, f) the catalyst fines content(s) determined from step d) and/or e) is/are used as process variable(s) in a closed-loop control process and the process variable(s) determined are used with a closed-loop control device for closed-loop control especially of the separation temperature T2 and/or the throughput of the pump.

Preference is given to using the following as process variables:

- current fuel consumption of the engines,
- current fuel level in a clean oil tank,
- catalyst fines content in the incoming or outgoing heavy oil and/or clean oil and/or current service tank overflow rate.

Further advantageous configurations are the subject of the dependent claims.

The invention is described in more detail by working examples with the figures which follow. The figures show:

- 5 Fig. 1 a plant of the invention for processing heavy oil;
- Fig. 2 an already known plant for processing heavy oil;
- 10 Fig. 3 a tank arrangement for storing heavy oils; and
- Fig. 4 a tank arrangement for storing heavy oils
- 15 having an overflow-dependent closed-loop pump control system.

In the plant in fig. 1, heavy oil OIL1 for processing, which flows in through a conduit 1 (here with a valve 2 connected therein) from a tank HT1, is first preferably

20 freed of coarse solids in a soil trap 3 such as a sieve.

Then the heavy oil OIL1 for processing - preferably

25 with the aid of a pump 4 - is passed from a tank T1 in which it has a starting temperature T_0 of, for example, 40° to 60°C through a first heating device, especially a first heat exchanger 5A, in which it is heated to a first temperature $T_1 > T_0$, higher relative to the

30 starting temperature, of preferably less than 95° , especially 60° to 80°C .

The heavy oil heated to the first temperature T_1 is passed from the first heating device, especially the

35 first heat exchanger 5A, through a conduit section 6 into a second heating device, preferably a second heat exchanger 5B, in which it is heated at least intermittently or permanently to an even higher second

temperature T2 compared to the first elevated temperature T1. This temperature T2 is greater than 98°C, preferably greater than 100°C, especially greater than 105°C and preferably even greater than 110°C.

5 Separation temperatures of up to 125° seem advisable at present, particular preference being given to the range between 100° and 115°C, since the apparatus complexity can still be controlled efficiently within this range, but, on the other hand, particularly good separation
10 results are achieved in terms of the removal of catalyst fines.

The heavy oil OIL1 heated to the second temperature T2 is passed out of the second heat exchanger 5B directly
15 into at least one centrifuge, here a three-phase separator 7, in which a soil/water phase W is separated from the heavy oil and flows away through an outlet 8, and in which it is cleaned to free it of a solid phase S which is removed via an outlet 9. The clarifying to
20 remove solids and the separation of the water phase from the oil phase can also be effected in two series-connected centrifuges (clarifier and phase separator). According to fig. 2, in addition, a process water supply P is provided in the separator 7.

25 Preferably, the oil takes only a very short time from passing out of the 2nd heat exchanger until it enters the centrifuge, in order that it is passed or passes directly from the second heating device, the second
30 heat exchanger 5B here, into the centrifuge, a three-phase separator 107 here. What is advantageous about this procedure is that the heavy oil, before reaching the centrifuge, cannot lose heat, or cannot do so to any degree of practical relevance, which would detract
35 from the processing operation.

The processed heavy oil phase - called OIL2 or synonymously also "clean oil" hereinafter - is passed

out of the separator 7 through the outlet 10 for further use.

Preferably, the clean oil, before being introduced into a tank or into an internal combustion engine, is first used as thermal energy-releasing medium in the first heat exchanger 5A, i.e. passed through it, in order to release thermal energy to the incoming heavy oil for processing.

In this way, heavy oil leaving the separator 7 is advantageously used to heat the heavy oil in the first heat exchanger 5A to the first temperature T1 and, on the other hand, to cool down the heated clean oil, such that it is especially storable in a simpler manner. The recovery of energy distinctly increases the economic viability of the processing method, since the energy consumption for heating the heavy oil to the separation temperature is lowered overall. In the second heat exchanger 5B, the thermal energy-releasing medium used may especially be saturated or hot steam HT or another suitable medium, with which it is then merely necessary to heat the heavy oil from the first temperature T1 to the second temperature T2.

Until an adequate operating temperature of the heat exchangers is attained, it is possible at first, in the course of startup, also to pass heavy oil for processing in circulation for a while through the two heat exchangers 5A and 5B and then back into the tank T1 (indicated by the conduit 13 and the two-way valve 14).

It is advantageous, in the incoming heavy oil for processing - for example prior to heating - to use a sensor device 11 to take measurements of the catalyst fines content in the dirty oil for processing coming into the separator (Cat Fines IN). Preferably,

measurements of the catalyst fines content (Cat Fines IN) are additionally also made in the outgoing cleaned or processed clean oil - for example directly in the clean oil running out of the separator - with the same
5 sensor device 11 or with a second sensor device 12. In this case, the proportion of fines having a mean diameter below a limit (especially less than 10 μm) can be determined, for example. These measures need not be effected directly in real time. Instead, it is also
10 possible to take samples (for example at intervals of a few hours in each case) which are then analyzed with a suitable sensor system - as commercially available in principle - for the catalyst fines content.

15 The measurements determined are then advantageously passed to a computer unit, not shown here, which is utilized as (closed-loop) control device for control of the plant shown in fig. 1 and which is used for closed-loop control especially of the separation temperature
20 T1 and/or the throughput with the pump 4 using the process variables determined. The closed-loop control can be effected as described above or, alternatively, optionally also in real time with online measurements of the catalyst fines content.

25 In this way, the processing method can be controlled precisely.

Closed-loop control variables used may especially be
30 the catalyst fines content mentioned, which is to be kept below a setpoint value, the current fuel consumption of the internal combustion engine as process variable and/or the actual level in a clean oil tank.

35 It is thus possible in a very efficient manner by the process of the invention, in a simple manner, to adapt the separation efficiency to the current fuel quality

(catalyst fines content or "cat fines content" in the heavy oil for processing according to the defined limit) and to the current mode of engine operation.

- 5 A reduction in the throughput increases the separation efficiency. In addition, the electrical energy consumption is also reduced when the feed pump speed is reduced.
- 10 It is therefore advantageous to assign a control device, especially a frequency converter, to the pump 4, in order to be able to alter the feed pump speed in a simple manner, preferably under closed-loop control.
- 15 In this way, in a simple manner, the throughput in the processing method can be used for closed-loop control as a function of one or more of the following measurement parameters or process variables:
- b) of the current fuel consumption of the engines
 - 20 c) of the current fuel level in a clean oil tank
 - d) of the present catalyst fines content ("cat fines content" in the clean oil outlet).

The - at least intermittent - increase in the

25 separation temperature to more than 98°C described improves the separation efficiency and enables the attainment of very low catalyst fines contents. The proportion of abrasive catalyst fines can be lowered in a simple manner below limits defined by engine

30 manufacturers, which may also be well below 20 ppm or even below 15 ppm or 10 ppm or lower. With a further increase in temperature, the result of the separating operation is improved further, although the apparatus demands are lower at temperatures up to 115°C than for

35 even higher temperatures.

It is particularly advantageous to heat the heavy oil, preferably in two or more stages, to the separation

temperature T2 of more than 98°, especially more than 100°C or 105°C or more, and to undertake the separating operation at this separation temperature T2. The multitude of stages increases economic viability

5 further, since it is possible to recover energy. But it is also conceivable to warm or to heat the heavy oil directly to the separation temperature T2 in just a single heating device.

10 The way in which the method of the invention works is illustrated in more detail with reference to the results of an illustrative test conducted on board a ship.

15 This involved making measurements, on board a ship equipped with a plant of the type according to fig. 2, of the catalyst fines content in the incoming dirty oil for processing running into the separator (Cat Fines IN) and in the clean oil running out of the separator
20 (cat fines OUT):

Measurement number	Flow rate [L/h]	Separation temperature [°C]	Cat fines [ppm] IN	Cat fines [ppm] OUT	Efficiency [%]
1	7800	98	19	11	42
2	7800	105	21	6	71
3	2000	97	23	7	70
4	2000	110	23	3	90

Table 1

25 As can be seen, the measures of the high separation temperature of the heavy oil of more than 100°C, especially more than 103°C, more preferably 105°C to 110°C, and, in addition - if necessary and possible - lowering of the throughput, achieve very good results
30 in terms of low fines or cat fines contents.

Fig. 3 shows a particularly advantageous tank arrangement having several tanks connected in a particularly advantageous manner to one another and to the plant of fig. 2. In fig. 3, the heat exchangers and
5 further details from fig. 1 were not included in the drawing to improve clarity.

Two settling tanks ST1, ST2 are provided here, and two service tanks ST3, ST4, into which either clean oil
10 OIL2 or else heavy oil OIL1 for processing can be introduced as required. The conduit 10 therefore branches into all these tanks ST1 to ST4.

The tanks ST1 to ST4 also each have at least one
15 outlet. These outlets can each be opened with valves V1 to V4 in the desired manner. All the outlets also open into the inlet 1 in fig. 2. This arrangement can be managed in a particularly flexible manner and gives options for storage of oils of various quality and also
20 for pre-processing of oils which have been stored in the tanks for a long period by first "circulating" the oil from the tanks, then "pre-processing" the oil, for example, at a lower temperature up to 98°C, and then passing it back into the same tank.

25 The working example of fig. 4 corresponds substantially to that from fig. 3, but has been supplemented with an overflow-dependent closed-loop pump control system. For this purpose, service tanks ST3 and ST4 have at least
30 one overflow conduit 201, 202 to the service tanks ST1 and ST2.

These overflow conduits 201, 202 should preferably be disposed in the lower region of the service tanks ST3
35 and ST4, in order to be able to recycle any possible sediments into the service tanks ST1 and ST2.

Flow indicators FIC are connected within each of the overflow conduits. These are connected to a closed-loop control device 203 which uses the flow rate into the overflow conduits here as the only process variable or
5 as one of the process variables that it advantageously uses as well takes into account in the closed-loop control of the pump 204.

The throughput of a pump 104 is subject to closed-loop
10 control via a flow indicator 203 connected within the overflow conduits.

Claims

1. A method for on-ship processing of heavy oil which is to be utilized as fuel, especially for a diesel engine, having the following steps:
 - a) providing heavy oil (OIL1) for processing;
 - b) passing the heavy oil (OIL1) provided and for processing from step a) using at least one pump (4) onward into a centrifuge (7), with heating of the heavy oil for processing before it reaches the centrifuge (7), at least intermittently or permanently, to a separation temperature T2 of more than 98°C, and
 - c) separating an aqueous phase (W) and a sludge phase (S) from a clean oil phase (OIL2) in the centrifuge (7).
2. The method as claimed in claim 1, characterized in that one condition for the intermittent heating of the heavy oil for processing to the separation temperature T2 from step b) is that the content of catalyst fines (cat fines content) that can be separated in the centrifugal field exceeds a first upper limit in the incoming heavy oil for processing and/or a respective second upper limit in the outgoing clean oil.
3. The method as claimed in claim 1 or 2, characterized in that the heating in step c) is effected in a single step.
4. The method as claimed in claim 1 or 2, characterized in that the heating in step c) is effected in at least two component steps c1) and c2).

5. The method as claimed in claim 4, characterized in that the heavy oil OIL1 for processing is passed in component step c1) through a first heating device, especially a first heat exchanger (5A), in which it is heated to a first temperature T1, and in that the heavy oil for processing is then passed in the second component step c2) into a second heating device, preferably a second heat exchanger (5B), in which it is heated to a second temperature T2 which is higher compared to the first temperature and is the separation temperature.

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6. The method as claimed in any of the preceding claims, characterized in that the heavy oil for processing is passed into the centrifuge immediately after the attainment of the separation temperature T2.

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7. The method as claimed in any of the preceding claims, characterized in that thermal energy from the clean oil (OIL2) running out of the centrifuge is utilized to heat the heavy oil (OIL1) for processing.

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8. The method as claimed in any of the preceding claims, characterized in that the thermal energy from the clean oil (OIL2) running out of the centrifuge is released in the first heat exchanger (5A) to the heavy oil (OIL1) for processing, in order to heat it to the first temperature T1.

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9. The method as claimed in any of the preceding claims, characterized in that the separation temperature T2 is greater than 100°C, especially greater than 105°C and especially preferably greater than 110°C.

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10. The method as claimed in any of the preceding claims, characterized in that the feed output of the pump (4) is adjustable.
- 5 11. The method as claimed in any of the preceding claims or method for on-ship processing of heavy oil which is to be utilized as fuel for a diesel engine, having the following steps:
- a) providing heavy oil (OIL1) for processing;
 - 10 b) passing the heavy oil (OIL1) provided and for processing from step a), especially using at least one pump (4), onward into a centrifuge (7), with heating of the heavy oil for processing before it reaches the
 - 15 centrifuge (7) to a separation temperature of - preferably - more than 98°C, and
 - c) separating an aqueous phase (W) and a sludge phase (S) from a clean oil phase (OIL2) in the centrifuge (7),
 - 20 characterized in that one or more of the following steps are also performed:
 - d) the catalyst fines content (Cat Fines IN) in the incoming heavy oil for processing -
 - 25 especially prior to heating - is determined with a sensor device (11),
 - e) the catalyst fines content (Cat Fines OUT) in the outgoing cleaned or processed clean oil is determined with the or a second
 - 30 sensor device (12),
 - f) the catalyst fines content(s) determined from step d) and/or e) is/are used as process variable(s) in a closed-loop control process and the process variable(s)
 - 35 determined are used for closed-loop control especially of the separation temperature T2 and/or the throughput of the pump (4).

12. The method as claimed in claim 11, characterized in that the following are used as process variables:

- current fuel consumption of the engines,
- 5 - current fuel level in a clean oil tank,
- catalyst fines content in the incoming or outgoing heavy oil and/or clean oil and/or
- current service tank overflow rate.