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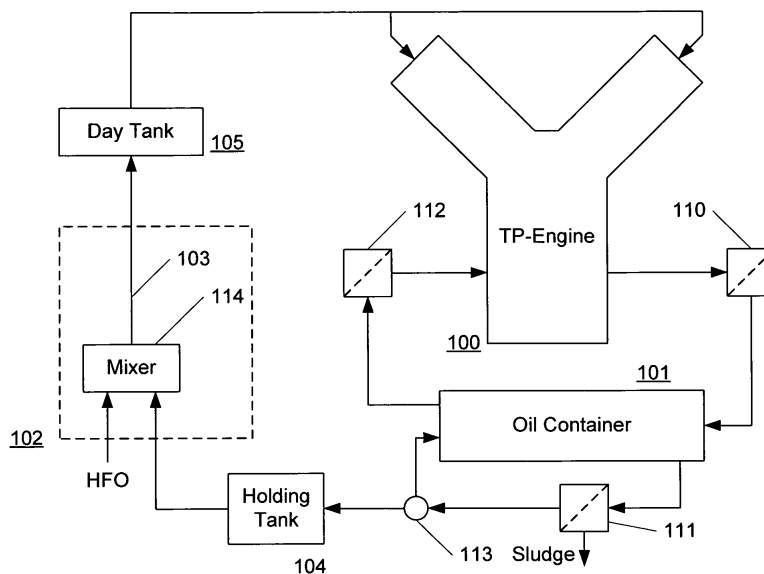
(54) **Improved fuel efficiency for trunk piston four-stroke diesel engines**

(57) The present invention relates to a system (and corresponding method) for reducing fuel consumption in a four-stroke trunk piston diesel engine, the system comprising: a replenishment system (102) connected to receive engine oil from a four-stroke trunk piston diesel engine (100) and to receive replenishment oil (HFO), where the replenishment system (102) is configured for mixing the engine oil and the replenishment oil resulting in a mixed oil (103) that is introduced into the engine (100).

In this way, the typical degradation process of the

engine oil is slowed by replenishing it the adverse effects associated with the degradation process are reduced or slowed or even avoided in a very simple way. Thus, the replenishment system provides enhanced and consistent performance of the initial engine oil resulting in greatly reduced component wear and equipment lifecycle cost. Even further, a more environmentally friendly system is provided since less waste in the form of spent oil is produced as the usability period of time for the engine oil is prolonged.

Thus great economical savings and environmental improvements are achieved.



**Figure 3**

**Description****FIELD OF THE INVENTION**

**[0001]** The invention relates to a system for reducing fuel consumption in a four-stroke trunk piston diesel engine. Further, the invention relates to a method of reducing fuel consumption in a four-stroke trunk piston diesel engine.

**BACKGROUND OF THE INVENTION**

**[0002]** Diesel engines used onboard certain types of vessels and/or used in certain stationary applications are typically of the well known two-stroke type or of the well known four-stroke type.

**[0003]** Two-stroke cross-head engines used in marine and/or stationary applications are equipped with two separate lubricating oil systems. One lubricating system comprises so-called system oil/system lubricant that normally is used for lubrication and cooling of the engine's bearings and e.g. oil-cooled pistons as well as for activation and/or control of various valves or the like. The other lubricating system comprises an all-loss lubricant (cylinder oil/cylinder lubricant) that normally is used for lubrication of the engine's cylinders, piston rings and piston skirt.

**[0004]** Four-stroke trunk piston diesel engines, however, typically use only a single oil type for lubrication and cooling. Such engines are typically used as secondary/auxiliary or propulsion engines on ships, or in stationary power generation or liquid/gas transmission applications. Such oils typically have a SAE viscosity of about 30 or 40.

**[0005]** Trunk piston engine oils are constantly affected by exposure to the combustion process whereby the useful properties of the trunk piston engine oil is degraded over time as the oil become more and more spent until finally the oil will have to be either replenished or completely changed. This degradation process cannot be reversed or halted by separators or the like.

**[0006]** Contaminations caused by engine and part wear, particle pollution (e.g. from combustion by-products), oxidation, hydrolysis, etc. further degrade the quality of the oil over time in addition to the oil degrading simply from being used, which speeds up the degradation process. The degradation process in effect increases the viscosity of the engine oil. A diesel engine's frictional loss is mainly of a viscose character. An increase in the viscosity of the engine oil will therefore result in diminished operating efficiency, increased fuel consumption, decreased engine efficiency, increased component wear and increased emissions.

**[0007]** The performance level of the oil is typically measured periodically and may not go beyond certain limits if the oiled component's condition should not be jeopardized. When the engine oil is approaching its condemning limit it will have to be replenished or changed.

Changing the oil is usually done by debunkered the oil, which is a costly process, or storing the oil as waste for later burning resulting in emissions.

**[0008]** To prolong the usable time of oils used in such engines, suited additives and/or additive packages are added to the base oil in order to obtain a fully formulated oil. Such blending is typically done at dedicated land based blend plants and the fully formulated oil has to be delivered to a ship or an offshore plant for use in the engines. The addition of additives or additive packages increases the cost of the engine oil significantly.

**OBJECT AND SUMMARY OF THE INVENTION**

**[0009]** It is an object of the present invention to provide a system for and a corresponding method of reducing fuel consumption in a trunk piston diesel engine that solves the above-mentioned (and other) shortcomings. A further object is to provide this in a cost-effective and simplified way that requires little modifications of existing systems.

**[0010]** These objects, among others, are achieved by a system for reducing fuel consumption in a four-stroke trunk piston diesel engine, the system comprising: a replenishment system connected to receive engine oil from a four-stroke trunk piston diesel engine and to receive replenishment oil, where the replenishment system is configured for mixing the engine oil and the replenishment oil resulting in a mixed oil that is introduced into the engine.

**[0011]** Since the degradation process of the engine oil effectively is slowed by replenishing it the above mentioned adverse effects of the degradation process are reduced or slowed or even avoided in a simple way. Thus, the replenishment system provides enhanced and consistent performance of the initial engine oil resulting in greatly reduced component wear and equipment lifecycle cost. Even further, a more environmentally friendly system is provided since less waste in the form of spent oil is produced as the usability period of time for the engine oil is prolonged.

**[0012]** Further, the normal engine oil need not contain so many additives since it is replenished whereby cheaper engine oil (since it do not need to contain additives or additive packages) can be used without compromising the efficiency of the engine.

**[0013]** The efficiency of the engine is also increased as it in a longer period of time uses oil having a lower viscosity.

**[0014]** Thus great economical savings and environmental improvements are achieved.

**[0015]** Further, the addition of a replenishment system according to the present invention only requires minor adaptation of existing systems.

**[0016]** In one embodiment, the replenishment system comprises a mixing unit receiving the replenishment oil and the engine oil and mixing them according to a predetermined rate resulting in the mixed oil.

**[0017]** In one embodiment, the replenishment system is configured for mixing the engine oil and the replenishment oil on a continuous, near-continuous or intermittent basis.

**[0018]** In one embodiment, the replenishment system is configured for introducing the mixed oil to the engine on a continuous, near-continuous or intermittent basis.

**[0019]** In one embodiment, a rate for mixing the engine oil and the replenishment oil is dependent on at least one measured actual condition of the oil, where the rate of mixing is automatically adjusted in response to the at least one actual condition of the oil.

**[0020]** In one embodiment, the replenishment oil comprises one or more additives and/or additive packages comprising one or more selected from the group of a Calcium detergent, an alkali metal detergent, an alkali-earth metal detergent, an anti-wear additive, a dispersant, a friction modifier, and anti-oxidants.

**[0021]** In one embodiment, the engine is used in marine or stationary applications.

**[0022]** In one embodiment, the engine is used offshore, on-site or in a land based plant.

**[0023]** In one embodiment, the replenishment oil is selected from the group of:

- a heavy fuel oil,
- bunker oil, and
- residual fuel oil.

**[0024]** The present invention also relates to a method reducing fuel consumption in a four-stroke trunk piston diesel engine, which corresponds to the system of the present invention.

**[0025]** More specifically, the invention relates to a method of reducing fuel consumption in a four-stroke trunk piston diesel engine, the method comprising the steps:

- receiving engine oil from a four-stroke trunk piston diesel engine and receiving replenishment oil in a replenishment system, and
- mixing the engine oil and the replenishment oil resulting in a mixed oil that is introduced into the engine.

**[0026]** Advantageous embodiments of the method according to the present invention are defined in the subclaims and described in detail in the following. The embodiments of the method correspond to the embodiments of the system and have the same advantages for the same reasons.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0027]** These and other aspects of the invention will be apparent from and elucidated with reference to the illustrative embodiments shown in the drawing, in which:

Figure 1 illustrates a schematic block diagram of a prior art four-stroke trunk piston engine system;

Figure 2 illustrates a schematic block diagram of a four-stroke trunk piston engine system according to one embodiment of the present invention; and

Figure 3 illustrates a schematic block diagram of a preferred embodiment of a replenishment system according to one embodiment of the present invention.

### DESCRIPTION OF PREFERRED EMBODIMENTS

**[0028]** Figure 1 illustrates a schematic block diagram of a prior art four-stroke trunk piston engine system. Shown is a typical prior art four-stroke trunk piston engine (100) connected to its oil system responsible for cycling through the engine during use thereby cooling and lubricating the engine (100) and other parts of the system.

**[0029]** Oil being tapped from the engine (100) is typically passed through a first filter (110) by a pump (not shown) or the like where the filter (110) is responsible for removing small particles, insolubles, wear debris, etc.

After this, the oil is passed to an engine oil container (101) or the like. Connected to the oil container (101) is a separator or filter (111) (forth only denoted separator) that receives some of the oil from the container (101) and removes dirt, wear debris from engine components, water caused by hydrolysis, etc. typically by spinning. The separator (111) may also remove unwanted chemical compounds like  $\text{CaSO}_4$ , etc. The resulting unwanted materials are removed from the system as waste or sludge.

Oil is taken from the oil container (101) and passed through another filter (112) removing small particles, insolubles, debris, etc. and water and other materials of different density SG e.g. the same or, as preferred, a different technique (e.g. using a centrifuge mechanism) than the first filter (110) before being introduced into the engine (100) for use again.

As mentioned earlier, the oil is degraded by this process causing decreased engine efficiency, increased fuel consumption, etc. When the oil is approaching its condemning limit it will have to be replenished or changed and is discarded as waste and stored for later de-bunkering or burning.

Figure 2 illustrates a schematic block diagram of a four-stroke trunk piston engine system according to one embodiment of the present invention. The illustrated system comprises a four-stroke diesel piston engine (100), a first filter (110), an oil container (101), a separator (111) and another filter (112) connected and corresponding to the ones shown and described in connection with Figure 1.

Further shown is a replenishment system (102) according to an embodiment of the present invention. The replenishment system (102) is connected to receive

some of the engine oil after leaving the engine (100) e.g. via a three-way valve (113) or some other flow and/or rate controlling means.

**[0034]** Preferably, the replenishment system (102) receives engine oil after it has proceeded through the separator (111) so it is cleaner than if it was tapped directly from the oil container (101). Alternatively, the replenishment system (102) could receive engine oil directly from the oil container (101) whereby the three-way valve (113) is not needed or from another place in the engine system.

**[0035]** The replenishment system (102) mixes replenishment oil (e.g. heavy fuel oil (HFO), residual fuel oil, bunker oil or the like) received from an adequate source (like a container, tank or the like) with the received engine oil thereby creating a mix of oil (103) that effectively is less spent as it is mixed with fresh or fresher oil. The mixed oil (103) is then introduced into the engine in addition to the engine oil being introduced normally as described in connection with Figure 1 from the oil container (101).

**[0036]** The mixed oil (103) may be supplied to the engine (100) on a continuous, near-continuous or intermittent basis.

**[0037]** In one embodiment, the replenishment oil (HFO, residual fuel oil, bunker oil, etc.) also comprises one or more additives and/or additive packages. The additives may e.g. comprise a Calcium detergent, alkali metal(s) detergent(s), alkali-earth metal detergent(s), anti-wear additives, dispersants, friction modifiers, anti-oxidants, etc. improving the engine/system condition and/or efficiency in some way or another.

**[0038]** The replenishment system (102) may be configured for mixing the engine oil and the replenishment oil on a continuous, near-continuous or intermittent basis.

**[0039]** Since the degradation process of the engine oil effectively is slowed by replenishing it the above mentioned adverse effects of the degradation process are reduced or slowed or even avoided. Thus, the replenishment system provides enhanced and consistent performance of the initial engine oil resulting in greatly reduced component wear and equipment lifecycle cost. Even further, a more environmentally friendly system is provided since less waste in the form of spent oil is produced as the usability period of time for the engine oil is prolonged.

**[0040]** Further, the normal engine oil need not contain so many additives since it is replenished whereby cheaper engine oil (since it do not need to contain additives or additive packages) can be used without compromising the efficiency of the engine.

**[0041]** The efficiency of the engine is also increased as it in a longer period of time uses oil having a lower viscosity.

**[0042]** Further, the addition of a replenishment system according to the present invention only requires minor adaptation of existing systems.

**[0043]** The engine (100) according to the present invention can e.g. be used in marine or stationary applications, both on-shore and off-shore.

**[0044]** Figure 3 illustrates a schematic block diagram of a preferred embodiment of a replenishment system according to one embodiment of the present invention. Shown is an engine system corresponding to the one in Figure 2 with the addition of a more detailed embodiment of the replenishment system (102). In this embodiment, the replenishment system (102) comprises a mixing or blending unit (114) (forth only referred to as mixing unit) or the like that receives the engine oil via the three way valve (113) from the separator (111) (or alternatively directly from the oil container (101) and fresh (or at least less spent oil than the engine oil) heavy fuel oil (HFO), bunker oil, residual fuel oil, etc. The mixing unit (114) mixes the HFO and the spent engine oil resulting in the less spent mixed oil (113) that is introduced into the engine (100).

**[0045]** The mixing unit (114) can be any standard mixing unit capable of mixing oils at the required rates

**[0046]** In a preferred embodiment, the rate of mixing is dependent on at least one measured actual condition of the oil. The measured condition could e.g. be the pollution level or condemning level of the engine oil. In a preferred embodiment, the rate of mixing is automatically adjusted in response to at least one actual condition of the oil that preferably also is measured automatically and provided to the mixing unit (114).

**[0047]** A holding tank (104) or the like may be inserted between the mixing (114) and the rest of the engine system (101/111). This holding tank (104) may act as a reservoir of engine oil coming from the separator (111). This may be useful if the rate of introducing the mixed oil (113) into the engine is not the same as the rate of engine oil passing through the separator (111). Further, since additional oil is added to the system thereby increasing the total volume of oil it may be necessary to have extra storage capacity if the oil container (101) is not of an adequate size.

**[0048]** An additional tank (105) may also be inserted after the mixing unit (114) for holding the mixed oil (113) before it is introduced into the engine (100). The additional tank (105) may e.g. be a 'day' or holding tank that is emptied into the engine whenever operations requires it, which simplifies the process of introducing the mixed oil (103) into the engine. Other rates of introducing the mixed oil (113) into the engine may be just as applicable.

**[0049]** In this way, the typical degradation process of the engine oil is slowed by replenishing it the adverse effects associated with the degradation process are reduced or slowed or even avoided in a very simple way. Thus, the replenishment system provides enhanced and consistent performance of the initial engine oil resulting in greatly reduced component wear and equipment lifecycle cost. Even further, a more environmentally friendly system is provided since less waste in the form of spent oil is produced as the usability period of time for the engine oil is prolonged. Additionally, great economical savings and environmental improvements are achieved.

**[0050]** In the claims, any reference signs placed be-

tween parentheses shall not be constructed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

### Claims

1. A system for reducing fuel consumption in a four-stroke trunk piston diesel engine, the system comprising:
  - a replenishment system (102) connected to receive engine oil from a four-stroke trunk piston diesel engine (100) and to receive replenishment oil (HFO), where the replenishment system (102) is configured for mixing the engine oil and the replenishment oil resulting in a mixed oil (103) that is introduced into the engine (100).
2. A system according to claim 1, wherein the replenishment system comprises a mixing unit (114) receiving the replenishment oil and the engine oil and mixing them according to a predetermined rate resulting in the mixed oil (103).
3. A system according to claims 1 - 2, wherein the replenishment system (102) is configured for mixing the engine oil and the replenishment oil on a continuous, near-continuous or intermittent basis.
4. A system according to claims 1 - 3, wherein the replenishment system (102) is configured for introducing the mixed oil (103) to the engine (100) on a continuous, near-continuous or intermittent basis.
5. A system according to claims 1 - 4, wherein a rate for mixing the engine oil and the replenishment oil is dependent on at least one measured actual condition of the oil, where the rate of mixing is automatically adjusted in response to the at least one actual condition of the oil.
6. A system according to claims 1 - 5, wherein the replenishment oil (HFO) comprises one or more additives and/or additive packages comprising one or more selected from the group of a Calcium detergent, an alkali metal detergent, an alkali-earth metal detergent, an anti-wear additive, a dispersant, a friction modifier, and anti-oxidants.
7. A system according to claims 1 - 6, wherein said engine (100) is used in marine or stationary applications.
8. A system according to claims 1 - 7, wherein said engine (100) is used offshore, on-site or in a land based plant.
9. A system according to claims 1 - 8, wherein the replenishment oil is selected from the group of:
  - a heavy fuel oil (HFO),
  - bunker oil, and
  - residual fuel oil.
10. A method of reducing fuel consumption in a four-stroke trunk piston diesel engine (100), the method comprising the steps:
  - receiving engine oil from a four-stroke trunk piston diesel engine (100) and receiving replenishment oil (HFO) in a replenishment system (102), and
  - mixing the engine oil and the replenishment oil resulting in a mixed oil (103) that is introduced into the engine (100).
11. A method according to claim 10, wherein the replenishment system comprises a mixing unit (114) receiving the replenishment oil and the engine oil and mixing them according to a predetermined rate resulting in the mixed oil (103).
12. A method according to claims 10 - 11, wherein the replenishment system (102) mixes the engine oil and the replenishment oil on a continuous, near-continuous or intermittent basis.
13. A method according to claims 10 - 12, wherein the replenishment system (102) introduces the mixed oil (103) to the engine (100) on a continuous, near-continuous or intermittent basis.
14. A method according to claims 10 - 13, wherein a rate for mixing the engine oil and the replenishment oil is dependent on at least one measured actual condition of the oil, where the rate of mixing is automatically adjusted in response to the at least one actual condition of the oil.
15. A method according to claims 10 - 14, wherein the replenishment oil (HFO) comprises one or more additives and/or additive packages comprising one or more selected from the group of a Calcium detergent, an alkali metal detergent, an alkali-earth metal detergent, an anti-wear additive, a dispersant, a friction modifier, and anti-oxidants.
16. A method according to claims 10 - 15, wherein said engine (100) is used in marine or stationary applications.
17. A method according to claims 10-16, wherein said engine (100) is used offshore, on-site or in a land

based plant.

18. A method according to claims 10 - 17, wherein the replenishment oil is selected from the group of:

- a heavy fuel oil (HFO),
- bunker oil, and
- residual fuel oil.

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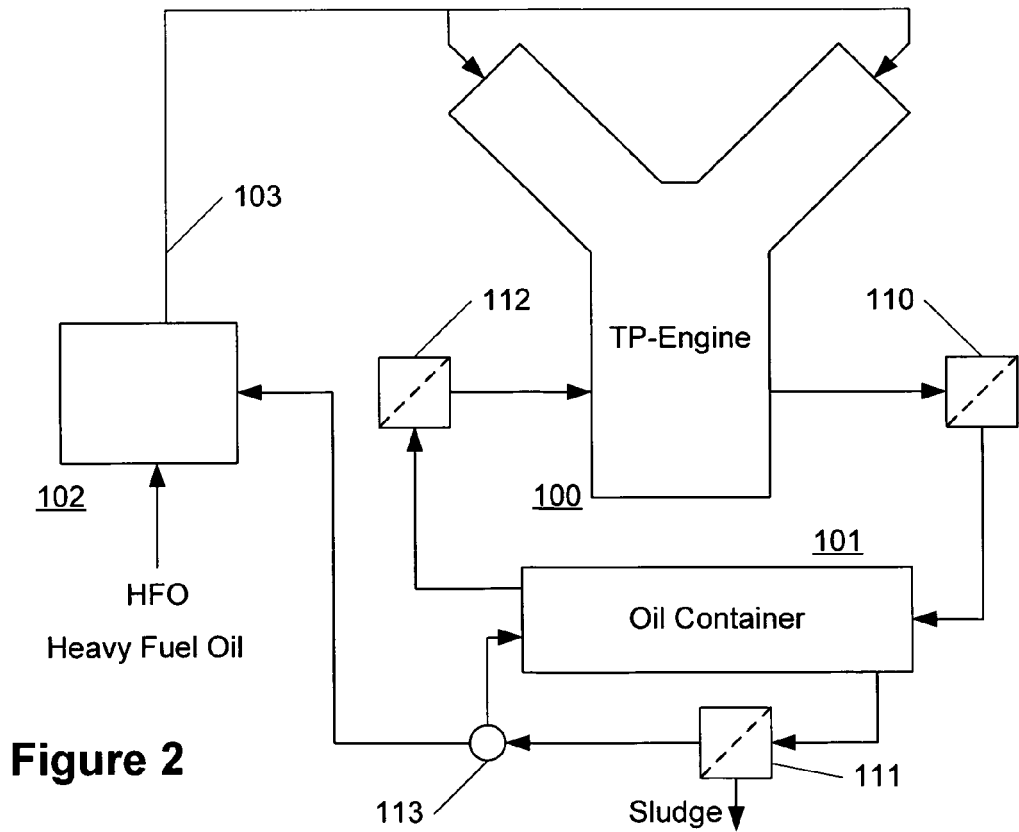
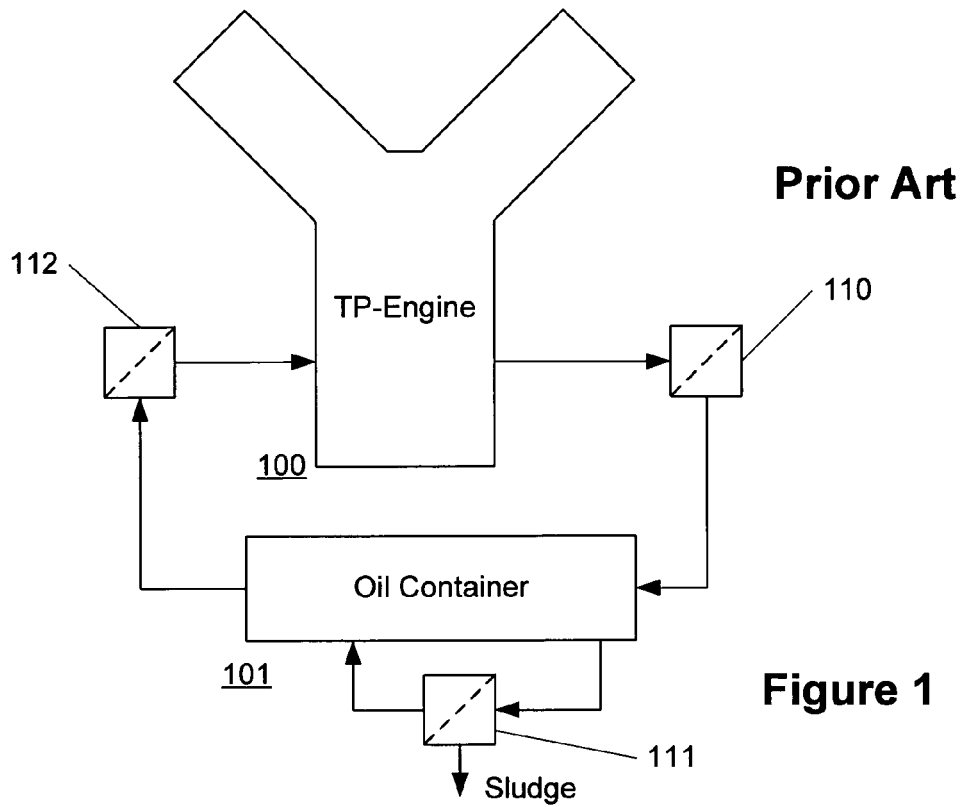
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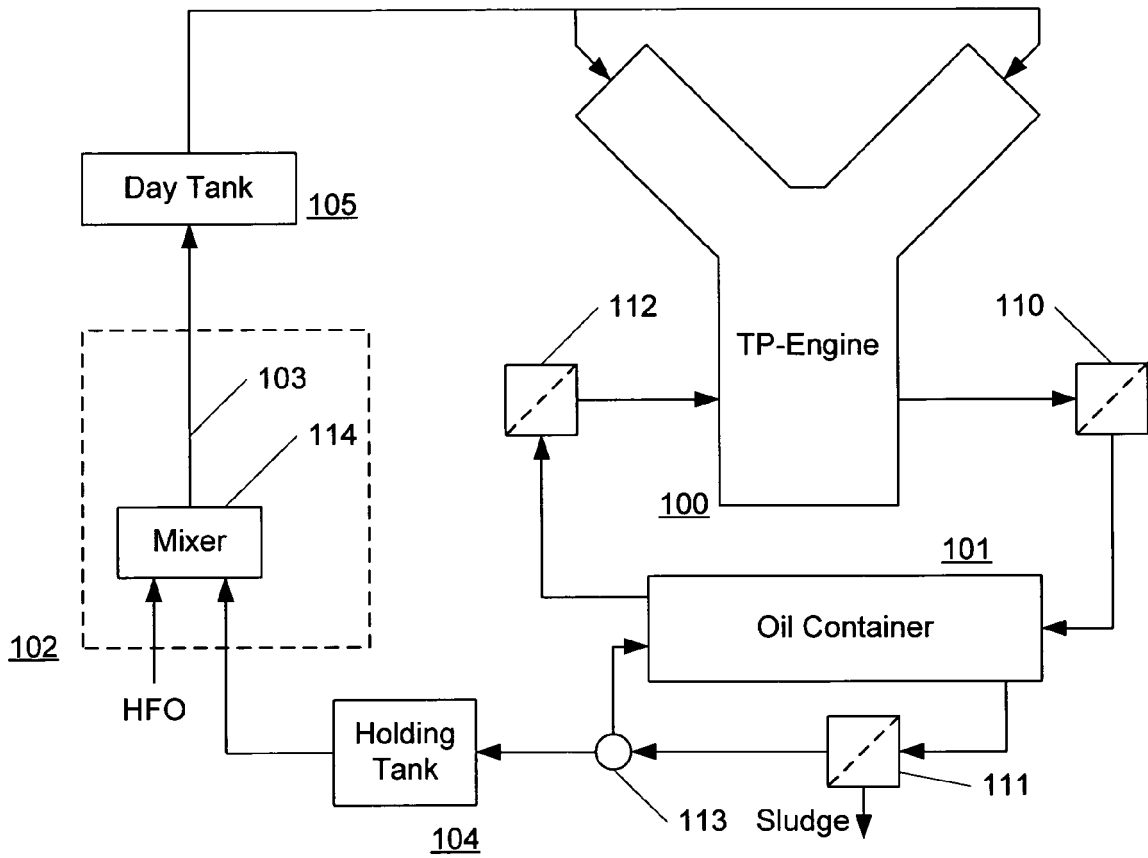


Figure 3



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.82 (F04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 05 38 8102

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
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