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A method for preparing an oil to be supplied to the cylinders of a two-stroke crosshead engine (1) with crossheads, cylinders in cylinder liners (2) and with a crankcase lubrication system operating with system oil. The method comprises determining the actual cylinder liner temperature, obtaining, determining or estimating the sulphur content of the fuel used by the engine (1), providing a first oil with a first TBN, such as for example used oil (60), providing a TBN increasing agent with a second TBN higher than the first TBN, blending the first oil with the TBN increasing agent in a controlled ratio to prepare the oil for supplying to the cylinders, adjusting the TBN of the oil for supplying to the cylinders by adjusting the ratio of first oil (60) and TBN increasing agent (61), and controlling the TBN of the oil for supplying to the cylinders in response to the actual sulphur content of the fuel used by the engine (1) and in response to the obtained, determined or estimated cylinder liner temperature.

Fortsættes ...

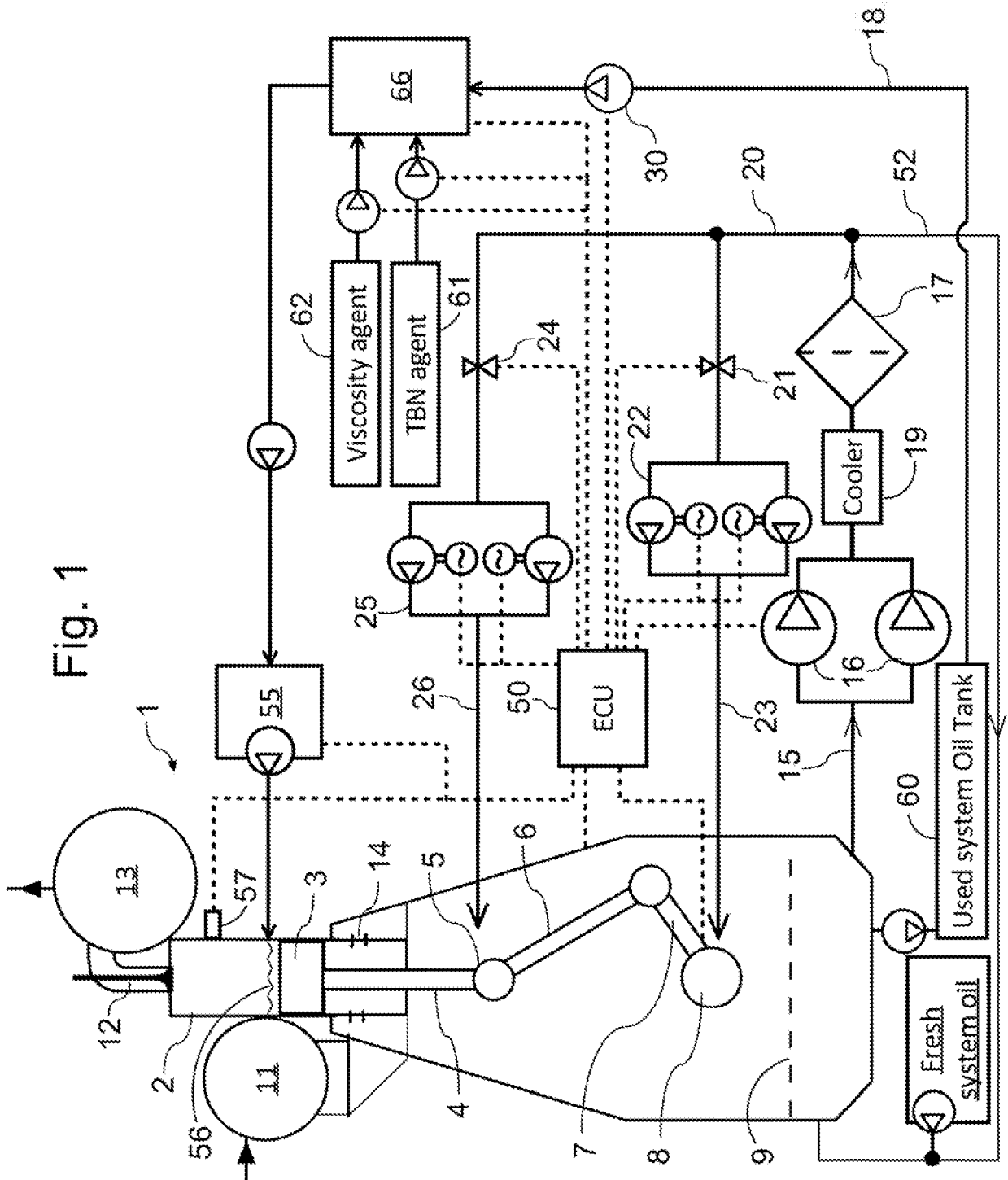


Fig. 1

METHOD AND APPARATUS FOR PREPARING AN OIL TO BE SUPPLIED TO
THE CYLINDERS OF A TWO-STROKE CROSSHEAD ENGINE

TECHNICAL FIELD

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The disclosure relates to a method for preparing an oil to be supplied to the cylinders of a two-stroke crosshead engine, in particular to a method for preparing such an oil on board of the marine vessel where the internal combustion engine is installed or on site at a power plant where the engine is used as a prime mover and to an apparatus for preparing an oil to be supplied to the cylinders of a two-stroke crosshead engine.

15 BACKGROUND

Of the oils that are used in the lubrication of a large two-stroke compression ignited internal combustion engine two stand out and are very different in chemical composition and physical properties from one another. The oil used in the crankcase lubrication system is referred to as system oil, and lubricates and cools the main, bottom end and crosshead bearings, the crosshead slippers, camshaft, bearings and followers, and the chain or gear drive. On modern engines the oil is also used to cool the piston undersides. The system oil is in general never fully replaced, but topped up over time to maintain its condition.

The oil used to lubricate the piston rings as they reciprocate in the cylinder liner and to neutralise the acids formed in the combustion chamber by the combustion of sulphur in the

fuel is referred to as cylinder oil. However, this oil is also denoted as the oil to be supplied to the cylinders.

5 Acid neutralisation is a critical property to protect the inner surface of the cylinder liner from the acids generated during combustion. The cylinder lubrication oil is a total-loss oil since it is consumed through combustion and scraped down in the lubrication process. The cylinder oil is depleted with each revolution of the main engine and replaced by fresh
10 oil cylinder through intermittent injections.

The oil that is supplied to the cylinders usually has an SAE (society of automotive engineering) viscosity equivalent grade of 50 and can have any total base number (TBN) between
15 5 and 150 for the neutralization of acid products generated during the combustion process. The TBN reflects the oil's reserve alkalinity, i.e. its ability to neutralize acidic materials. The TBN of an oil can e.g. be determined in accordance with the ASTM D2896 standard, which is a standard
20 test method for base number of petroleum products by potentiometric perchloric acid titration.

Typically system oil has an SAE viscosity grade of 30 with a relatively low TBN that is typically below 10.
25

These values are though merely by way of example, and may vary depending on the actual application-specific design of the systems that the oils are used in.

30 In recent years, there has been a trend towards blending the oil for delivering to the cylinders of the main engine on

board the marine vessel where the main engine is installed. Hereto, used system oil is withdrawn from the crankcase lubrication system and blended with a TBN agent or with a fresh cylinder oil with a high TBN to create a cylinder oil
5 with the appropriate lubrication characteristics (it is noted that there is no clear technical difference between a TBN agent that comprises one or more alkaline additives in oil and a fresh cylinder oil).

10 In recent years two-stroke crosshead engines have been operated for a large portion of their operation time at an engine load that is significantly below their maximum continuous rating. This is due to the fact that many freight ship companies choose to sail slower (slow steaming) than
15 before, which results in the main engines being operated well below the maximum continuous rating, since these marine vessels were originally constructed to sail at significantly higher speed.

20 The viscosity of the cylinder oil specified for a particular engine is generally selected such that the actual viscosity (dynamic (shear) viscosity) at the temperature of the cylinder liner where the cylinder oil is applied is optimal for the cylinder liner temperature at maximum engine load (100%
25 maximum continuous rating), i.e. sufficiently high for providing a proper lubrication of the piston rings against the inner surface of the cylinder liner at maximum engine load.

30 The viscosity of a cylinder oil in operation is affected by a number of factors. As temperature increases, the viscosity

of a fluid decreases, and vice-versa. During the operation of a two-stroke crosshead engine the temperature varies according to engine load and RPM (revolutions per minute). As engine load and RPM increase, the temperature also increases and hence the viscosity of the lubricating oil decreases.

Cylinder oil prepared in accordance with the above blend on board method typically (like any typical conventional cylinder oil) has a relatively low viscosity index (mono grade type oil), i.e. they have a relative large change in viscosity with temperature. Figs. 3 and 4 illustrate the relation between temperature and viscosity in centistokes (cSt) by way of example for a SAE 30 oil and an SAE 50 oil, both having a Viscosity Index (VI) of 97.

For a typical two-stroke crosshead engine the oil delivered to the cylinders should have a viscosity between approximately 1.5 and 3 cSt at the temperature of the cylinder liner. In such an engine, the cylinder liner temperature at the maximum continuous rating of the engine (maximum load) will typically be well above 200°C, e.g. 240 to 250°C. As can be seen in Fig. 4, this results in an effective viscosity for the SAE 50 oil at the temperature of the cylinder liner of just below 2 cSt, i.e. within the specified range of 1.5 to 3 cSt.

Present dosage regimes for cylinder oil are based on fuel sulphur content, i.e. a cylinder oil with a high TBN used when the engine runs on fuel with a high sulphur content and a cylinder oil with a lower TBN is used when the engine is running on fuel with less sulphur. Some engine manufacturers/developers recommend a BN 70 cylinder oil when

running on heavy fuel oil with more than 1.5% sulphur content and recommend a BN-40-50 cylinder oil when running on heavy fuel oil with less than 1.5% sulphur content. The feed rate of electronically controlled cylinder lubrication devices is typically proportional to the load, e.g. some engine manufacturers/developers recommend 0.7-0.8 g/kWh, others 0.65 g/kWh.

In known engines where the blending of the oil for delivering to the cylinders of the main engine is done locally by e.g. blending used oil with a TBN agent or a cylinder oil with a high TBN to create a cylinder oil with the appropriate lubrication characteristics the same principles are applied, i.e. the feed rate is proportional to the engine load and the TBN is selected in relation to sulphur content of the heavy fuel oil. For engines that use locally blended cylinder oil it is possible to react quicker to changes in the fuel sulphur content of the fuel since the TBN of the oil supplied to the cylinders can be readily adjusted in accordance with need.

The costs associated with cylinder oil form a significant part of the operating cost of an engine in e.g. a marine vessel or in a power plant.

US 2004/144355 discloses a marine diesel engine system including a diesel engine having a plurality of cylinders. The system also includes, proximate the engine, a primary engine lubricant and an additive selected from certain alkylamine-alkylphosphates, 500 TBN calcium sulfonate and mixtures thereof. A means for blending the lubricant and additives into a mixture for introduction into a cylinder is

provided. Thus lubricant properties may be modified depending upon engine conditions. Either of the sulphur content of the fuel or the sum of the temperature of the engine are used to modify the properties of the lubricant.

5

SUMMARY

Based upon this background it is an object to reduce the costs associated with cylinder oil for marine engines and power
10 plant engines.

This object is achieved in accordance with a first aspect by providing a method for preparing an oil to be supplied to the cylinders of a two-stroke crosshead engine with crossheads,
15 cylinders in cylinder liners and with a crankcase lubrication system operating with system oil, the method comprising:
obtaining, determining or estimating the actual cylinder liner temperature, obtaining, determining or estimating the sulphur content of the fuel used by the engine, providing a
20 first oil with a first TBN, such as for example used oil, providing a TBN increasing agent with a second TBN higher than the first TBN, blending the first oil with the TBN increasing agent in a controlled ratio to prepare the oil for supplying to the cylinders, adjusting the TBN of the oil for
25 supplying to the cylinders by adjusting the ratio of first oil and TBN increasing agent, and controlling the TBN of the oil for supplying to the cylinders in response to the actual sulphur content of the fuel used by the engine and in response to the obtained, determined or estimated cylinder liner
30 temperature by

The inventors realized that a constant TBN regardless of engine load is not always optimal. In particular, the inventors have arrived at the insight that the TBN number can be lowered at high cylinder liner temperatures that typically occur at high engine loads. By supplying an oil to the cylinders with a lower TBN at higher cylinder liner temperatures costs for TBN increasing agents are reduced and deposits from unconsumed TBN additives are avoided or at least reduced.

10

In a first possible implementation form of the first aspect the method further comprises determining a desired TBN for the oil for supplying to the cylinders taking into account the actual sulphur content of the fuel used by the engine (1) and taking into account the actual engine load, and controlling the controllable blender to blend the first oil with the TBN increasing agent at a blend ratio that results in a prepared oil for supplying to the cylinders with the desired TBN.

20

In a second possible implementation form of the first aspect the first threshold preferably being an engine load of approximately 50% to 60% of the maximum continuous rating of the engine.

25

In a third possible implementation form of the first aspect the method further comprises controlling the TBN of the oil for supplying to the cylinders at least for engine loads above a second threshold at a level that proportionally decreases with increasing engine load and proportionally increases with decreasing engine load with the second threshold preferably

30

being an engine load of approximately 50% of the maximum continuous rating of the engine.

In a fourth possible implementation form of the first aspect
5 the first oil is a fresh cylinder oil or a used oil, the used oil being for example used system oil withdrawn from the crankcase lubrication system.

In a fifth possible implementation form of the first aspect
10 the TBN increasing agent is an additive, an additive package, an oil or a cylinder oil with a TBN higher than the TBN of the first oil.

In a sixth possible implementation form of the first aspect
15 the method further comprises controlling the feed rate to the cylinders of the oil prepared by blending in response to the engine load, preferably controlling the feed rate proportionally to the engine load.

20 In a seventh possible implementation form of the first aspect blending the first oil with a TBN agent is a batch wise process or an in line blending process.

It is a further object to avoid operating the two-stroke
25 crosshead engine with a cylinder oil that is delivered to the cylinders with a viscosity that is higher than required at the actual temperature of the cylinder liner.

This further object is achieved in accordance with the eight
30 possible implementation form of the first aspect, wherein the method further comprises determining or estimating the actual

cylinder liner temperature of the cylinder liners of the engine (1), and determining a desired viscosity for the oil that is supplied to the cylinders at the determined cylinder liner temperature.

5

In a ninth possible implementation form of the first aspect preparing an oil for supplying to the cylinders comprises blending the first oil with a TBN agent and with a viscosity agent to obtain a viscosity adjusted oil for supplying to the
10 cylinders.

With this method the viscosity can be freely adjusted to an optimized combination to match engine design, engine performance and engine load. The system can either be blending
15 directly (in line blending) to each unit or blending to a day tank as batch blending.

In a tenth possible implementation form of the first aspect blending the prepared oil with the viscosity agent is an in
20 line blending process. The advantage of in-line blending is that the blends can be quickly adjusted to changes of engine load by adjusting the viscosity accordingly.

In an eleventh possible implementation form of the first
25 aspect preparing an oil for supplying to the cylinders comprises blending the first oil with a TBN agent or with a high TBN oil.

In a twelfth possible implementation form of the first aspect
30 blending the first oil with a TBN agent or with a high TBN oil is a batch wise process.

In a thirteenth possible implementation form of the first aspect determining the amount of viscosity agent to be added comprises calculating manually using a defined methodology or
5 determining using computer software programmed with appropriate algorithms or equations.

In a fourteenth possible implementation form of the first aspect the viscosity adjusting agent comprises fresh cylinder
10 oil, preferably a fresh cylinder oil with a high TBN, such as for example a TBN above 60.

In a fifteenth possible implementation form of the first aspect the viscosity modifying agent comprises a lubricating
15 oil such as a trunk piston engine oil, gear, hydraulic or turbine oil, base oil, recycled oil, or a high viscosity additive.

In an sixteenth possible implementation form of the first aspect determining a desired viscosity for the cylinder oil
20 comprises calculating manually using a defined methodology or determining using computer software programmed with appropriate algorithms or equations a desired viscosity for the cylinder oil for use in the cylinders at the determined
25 actual cylinder liner temperature.

In a seventeenth possible implementation form of the first aspect determining the actual cylinder liner temperature
30 comprises measuring the actual cylinder liner temperature at a defined point or averaged across the surface of the liner with a sensor in or at the cylinder liner surface.

In a eighteenth possible implementation form of the first aspect determining the actual cylinder liner temperature comprises obtaining the actual engine load and RPM
5 (revolutions per minute) and deriving an estimated cylinder liner temperature from the obtained engine load and RPM.

In a nineteenth possible implementation form of the first aspect deriving an estimated cylinder liner temperature
10 comprises calculating manually using a defined methodology or determining using computer software programmed with appropriate algorithms or equations using the engine load as the basis for calculating the estimated cylinder liner temperature.

15

In a twentieth possible implementation form of the first aspect determining the actual cylinder liner temperature comprises obtaining the actual cylinder jacket cooling water temperature and deriving an estimated cylinder liner
20 temperature from the obtained cylinder jacket cooling water temperature.

In a twenty-first possible implementation form of the first aspect the method further comprises determining or obtaining
25 a desired TBN value for the oil that is supplied to the cylinders, and applying a TBN modifying agent in the prepared oil to adjust the TBN of the oil supplied to the cylinders to the desired TBN value. With this feature the alkalinity (TBN) of the oil can be freely adjusted to match the fuel sulphur
30 level, engine design, engine performance and engine load.

In a twenty-second possible implementation form of the first aspect, the first oil is a used oil, preferably system oil withdrawn from the crankcase lubrication system.

5 The object above is also achieved according to a second aspect by providing an apparatus for preparing oil for supplying to the cylinders of a two-stroke crosshead engine with crossheads, cylinders in cylinder liners and with a crankcase lubrication system operating with system oil, the apparatus
10 comprising a source of first oil with a first TBN, such as for example used oil, a source of TBN increasing agent with a second TBN higher than the first TBN, a controllable blender configured to blend the first oil with the TBN increasing agent in a controllable blend ratio to prepare the oil for
15 supplying to the cylinders, an electronic control unit associated with the apparatus, the electronic control unit being informed of the actual cylinder liner temperature of the cylinders or of an estimate thereof, and of the sulphur content of the fuel used by the engine, the electronic control
20 unit being configured to adjust the TBN of the oil for supplying to the cylinders by adjusting the blend ratio of the first oil and the TBN increasing agent, the electronic control unit being configured to control the TBN of the oil for supplying to the cylinders prepared with the controllable
25 blender in response to the actual sulphur content of the fuel used by the engine and in response to the information on the actual engine load, and the electronic control unit is configured to control the TBN of the oil for supplying to the cylinders at least for cylinder liner temperatures or engine
30 loads above a second threshold at a level that decreases with

increasing engine load and increases with decreasing engine load.

In a first possible implementation form of the second aspect
5 information on the actual cylinder liner temperature is a measured temperature, a determined temperature or an estimated temperature, preferably a temperature estimated from the actual engine load.

10 In a second possible implementation form of the second aspect the electronic control unit is configured to determine a desired TBN for the oil for supplying to the cylinders taking into account the actual sulphur content of the fuel used by the engine and taking into account the actual engine load,
15 and wherein the electronic control unit is configured to control the controllable blender to blend the first oil with the TBN increasing agent at a blend ratio that results in a prepared oil for supplying to the cylinders with the desired TBN.

20

In a third possible implementation form of the second aspect the electronic control unit is configured to control the TBN of the oil for supplying to the cylinders at a first TBN for cylinder liner temperatures or engine loads below a first
25 threshold and to control the TBN of the oil for supplying to the cylinders at a second TBN lower than the first level for engine loads above the first threshold, the first threshold preferably being an engine load of approximately 50% to 60% of the maximum continuous rating of the engine.

30

In a fourth possible implementation form of the second aspect the second threshold is an engine load of approximately 50% of the maximum continuous rating of the engine.

5 In a fifth possible implementation form of the second aspect the electronic control unit is configured to control the TBN of the oil for supplying to the cylinders at least for cylinder liner temperatures or engine loads above a second threshold at a level that proportionally decreases with
10 increasing engine load and proportionally increases with decreasing engine load, the second threshold preferably being an engine load of approximately 50% of the maximum continuous rating of the engine.

15 In a sixth possible implementation form of the second aspect the first oil is a fresh cylinder oil or a used oil, the used oil being for example used system oil withdrawn from the crankcase lubrication system.

20 In a seventh possible implementation form of the second aspect the TBN increasing agent is an additive, an additive package, an oil or a cylinder oil.

In an eighth possible implementation form of the second aspect
25 the apparatus further comprises a cylinder oil dosage pump for feeding the oil for the cylinders of the engine to the cylinders of the engine, and wherein the electronic control unit is configured to control the feed rate of the cylinder dosage pump in response to the engine load, preferably
30 proportionally to the engine load.

In a ninth possible implementation form of the second aspect the method further comprises a source of viscosity agent, and the controllable blender being configured to blend the first oil, the TBN increasing agent and the viscosity agent in
5 individually controllable ratios to prepare the oil for supplying to the cylinders.

In a tenth possible implementation form of the second aspect the electronic control unit is connected to the controllable
10 blender, the electronic control unit further being configured to determine the amount or proportion of viscosity agent to be blended into the oil for supplying to the cylinders in order to obtain an oil with the desired viscosity, and the electronic control unit being configured to control the
15 controllable blender accordingly.

In an eleventh possible implementation form of the second aspect the oil for supplying to the cylinders has a controlled TBN and a controlled viscosity.
20

In a twelfth possible implementation form of the second aspect the viscosity agent is a fluid or oil with a high viscosity or is a viscosity increasing additive or wherein the viscosity agent is a fluid or oil with a low viscosity and is a viscosity
25 decreasing additive.

In a thirteenth possible implementation form of the second aspect the blender is an integral blender that is configured for blending the first oil, the high TBN oil or the high TBN
30 agent and the viscosity agent, preferably in a batch wise blending process.

In a fourteenth possible implementation form of the second aspect the blender comprises a TBN blender for blending the withdrawn system oil with the high TBN oil or the high TBN agent and a viscosity blender for blending the blend prepared with the TBN blender with a viscosity agent.

In a fifteenth possible implementation form of the second aspect, the first oil is a used oil, preferably system oil withdrawn from the crankcase lubrication system.

Further implementation forms are apparent from the dependent claims, the description and the figures. These and other aspects of the invention will be apparent from the embodiments described below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present disclosure, the invention will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 is a diagrammatic sectional view of a lubrication system for a two-stroke crosshead engine according to an example embodiment,

Fig. 2 is a diagrammatic sectional view of a lubrication system for a large two-stroke crosshead engine according to another example embodiment,

Fig. 3 is a diagram showing the relation between temperature and viscosity of two types of oil,

Fig. 4 is an enlarged detail of the diagram of Fig.3,

Fig. 5 is a diagram illustrating an example relation between a determined TBN value and engine load

Fig. 6 is a diagram illustrating another example relation between a determined TBN value and engine load, and

5 Fig. 7 is a diagram illustrating yet another example relation between a determined TBN value and engine load.

DETAILED DESCRIPTION

10 In the following detailed description, a lubrication system for a two-stroke engine crosshead engine will be described by the example embodiments. Fig. 1 diagrammatically shows a large low speed turbocharged two-stroke diesel engine 1 with a crankshaft 7 and crossheads 5 sectional view. Two-stroke
15 crosshead engines typically have between four and sixteen cylinders in line, carried by an engine frame 10. The engine 1 may e.g. be used as the main engine in an ocean going vessel, or as prime mover in a stationary power plant. At the maximum continuous rating of the engine the total output of
20 the engine may, for example, range from 5,000 to 110,000 kW.

The engine is a diesel (pressure ignited internal combustion) engine of the two-stroke uniflow type with scavenge ports 14 at the lower region of the cylinders 1 and an exhaust valve
25 12 at the top of the cylinders 1. The engine can be operated on various types of fuel, such as e.g. marine diesel, heavy fuel, or gas. The scavenge air is passed from the scavenge air receiver 11 to the scavenge ports 14 of the individual cylinders 2. A piston 3 in the cylinder liner 2 compresses
30 the scavenge air, fuel is injected and combustion follows and exhaust gas is generated. When an exhaust valve 12 is opened,

the exhaust gas flows through an exhaust duct associated with the cylinder concerned into the exhaust gas receiver 13 and onwards through a first exhaust conduit to a turbocharger (not shown), from which the exhaust gas flows away from the atmosphere. The turbocharger delivers pressurized scavenge air to a scavenge air conduit leading to the scavenge air receiver 11.

A piston rod 4 extends from the bottom of the piston to the crosshead 5. A connecting rod 6 connects the crosshead 5 to one of the throws of the crankshaft 7. The crankshaft 7 is rotation suspended in the engine frame and bedplate by the main bearings 8. A thrust bearing (not shown) is provided at the aft of the engine to accommodate the thrust created by a propeller (not shown) driven by the engine 1. The thrust bearing is supplied with lubrication oil by the same conduit that supplies the main bearings 8. In the main bearings 8 an oil film between the bearing surface and the journal surface carries the journal and prevents substantially any direct contact between the journal surface and the inside surface of the shells and provides lubrication. A flow of lubrication oil is supplied to the bearing surface. The lubrication oil film assists in cooling the main bearing.

Two-stroke crosshead engines include an array of components that are for lubrication and/or cooling purposes supplied with lubrication oil. All these components are provided with lubrication oil via the crankcase lubrication system except for the cylinders and piston rings which receive another type of oil from the cylinder oil system.

The crankcase lubrication system is essentially a closed loop lubrication system in which the system oil is recirculated. The crankcase lubrication system provides lubrication for cooling a range of components of the engine. For example, the crankshaft 7 is placed in an oil sump 9 that is provided in the lower part of the engine 1 and supplied with lubrication oil under pressure that is circulated through the oil sump 9. Other lubrication positions, such as bearings, etc. are separately provided with lubrication oil, as will be described in greater detail further below. The surplus leakage oil is collected in the oil pan 9. A lubrication oil supply loop is provided for supplying lubrication oil to all lubrication oil consumers. The lubrication oil supply loop includes a supply conduit 15 that starts at the oil sump 9. The supply conduit 15 includes two low-pressure pumps 16 arranged in parallel with respective electric drive motors for arranging the oil transport (although it is understood that there could be any other number of supply pumps). The supply conduit 15 also includes a cooler 19 for cooling the lubrication oil and a filter 17 for filtering out contamination. This can in one embodiment be a BøK 50µ filter.

The supply conduit 15 splits downstream of the filter 17 into an oil sump supply conduit 52 and a bearing supply conduit 20. The oil sump supply conduit 52 delivers filtered and cooled lubrication oil to the oil sump 9.

The bearing supply conduit 20 branches into a main bearing supply conduit 23 and a crosshead bearing supply conduit 26. The main bearing supply conduit 23 also provides the thrust bearing the aft of the engine 1 with lubrication oil.

The main bearing supply conduit 23 includes an electronically controlled valve 21 for controlling the flow. The main bearing supply conduit 23 also includes a feed pump 22. In the present
5 embodiment a pair of parallel feed pumps is shown, but it is understood that any number of pumps could be used, although a plurality of pumps is preferred for redundancy reasons. The feed pump 22 is driven by one or more electric drive motors. The main bearing supply conduit 23 delivers a substantially
10 constant flow of lubrication oil to the main bearings 8 during engine operation.

The crosshead bearing supply conduit 26 includes an electronically controlled valve 24 for controlling the flow.
15 The crosshead bearing supply conduit 26 also includes a feed pump 25. In the present embodiment a pair of parallel feed pumps are shown, but it is understood that any number of pumps could be used, although a plurality of pumps is preferred for redundancy reasons. The feed pump 25 is driven by one or more
20 electric drive motors. The crosshead bearing supply conduit 26 delivers a substantially constant flow of lubrication oil to the crosshead bearings during engine operation.

A portion of the system oil is withdrawn from the crankcase
25 lubrication system. Hereto, a feed pump transports an amount of system oil from the oil pan 9 to a used system oil tank 60. A cylinder oil system supply conduit 18 connects to the used system oil tank 60. The cylinder oil system supply conduit 18 includes a feed pump 30 for providing the cylinder
30 oil system with used system oil that has been withdrawn from the crankcase lubrication system.

In order to maintain a substantially constant amount of system oil while in the crankcase lubrication system, an approximately equal amount of fresh system oil as withdrawn therefrom is added to the crankcase lubrication system from a fresh oil system tank 17 using a feed pump that connects to the oil sump supply conduit 52. Thus, the system oil is continually replenished with fresh system oil, thereby rendering it practically unnecessary to completely replace the system oil in the crankcase lubrication system with fresh system oil.

The cylinder oil system includes a blender 66 that receives used system oil from the used system oil tank 60. In an embodiment (not shown) the blender receives a base oil instead or together with the system oil. The first or base oil can be any suitable oil such as recycled oils or auxiliary engine oil. In an embodiment of Fig. 1 the withdrawn system oil is supplied to the blender 66 continuously at a steady rate for in-line preparation of the oil to be delivered to the cylinders 2. In another embodiment the system oil is supplied to the blender intermittently for batch wise preparation of oil to be delivered to the cylinders 2; this embodiment is explained here below in more detail with respect to Fig. 2.

In the blender 66 the withdrawn system oil (first or base oil) is mixed or blended with the TBN agent and with the viscosity agent to prepare the oil to be supplied to the cylinders. The details of the blending process are described in detail further below. From the blender 66 the prepared oil, "cylinder oil" is transported by a feed pump to a

cylinder oil dosage pump 55. The cylinder oil dosage pump 55 ensures precise and correctly timed dosage of the cylinder oil to the individual cylinders 2. In an embodiment the electronic control unit 50 is operatively connected to the cylinder oil dosage pump 55 and configured to control the feed rate of cylinder oil delivered by dosage pump 55 to be proportional to the engine load. The oil to be supplied to the cylinders is delivered to the liner surface of the cylinder liner 2 to a plurality of cylinder lubrication holes through the wall of the cylinder liner. The cylinder lubrication holes are distributed around the circumference of the cylinder liner 2 at substantially equal height. The injection points are connected to one another by a lubrication line 56 that typically has a zigzag shape. The supply of the oil through lubrication holes and the lubrication line is precisely timed to occur when the piston 3 passes the lubrication line. Thereafter the piston rings distribute the oil over the running surface of the cylinder liner 2.

The blender 66 receives a TBN agent from a source of TBN agent 61 via a supply conduit that includes a supply pump. The source of TBN agent can be a tank with a dedicated TBN agent with a TBN for example up to 400, or a tank with an oil with a high TBN such as a fresh commercially available "cylinder oil" with a high TBN such as e.g. a TBN equal to or above 80 or equal or above 100.

The blender 66 also receives a viscosity agent from a source of viscosity agent 62 via a supply conduit that includes a supply pump. The source of viscosity agent can be a tank with a dedicated viscosity agent or a tank with an oil with a high

viscosity, such as an oil with a viscosity equal or above SAE 50 or equal to above SAE 60. The oil used as viscosity agent is preferably single grade SAE. Alternatively, the viscosity agent may have a low viscosity in order to reduce the viscosity of the blended oil, for example equal to or below SAE 30.

The system oil for the crankcase lubrication system is a high quality paraffinic base oil containing a number of performance additives. The alkalinity of the system oil (defined by its TBN number) must be sufficient to neutralize any strong acids formed from combustion of the fuel which may find their way into the crankcase.

The characteristics of an example of system oil for use in the crankcase lubrication system of a two-stroke crosshead engine are as follows:

	SAE No	30
20	Specific Gravity (15/15C)	0.894
	Flash Point min C	229
	Pour Point max C	-15
	Viscosity: cSt at 40C	108
	at 100C	11.8
25	Viscosity Index	97
	Total Base Number	5.3
	Sulphated Ash, % wt.	0.73

The total base number is an indication of the alkalinity of an oil in the milligrams of acid, expressed in equivalent

milligrams of potassium hydroxide (KOH), required to neutralize all basic constituents.

5 The oil delivered to the cylinders by the cylinder oil system must be thermally stable. The oil needs to be able to retain an oil film at the high surface temperatures of e.g. the piston rings and the cylinder liner 2. The oil delivered to the cylinders must have anti wear characteristics and detergents to minimize deposits on the pistons 3 and in the
10 ring grooves.

The oil delivered to the cylinders typically has a high TBN between 30 and 100 to neutralize the acids formed by the combustion of the sulphur in the fuel. The required TBN value
15 was in the prior art dependent only on the sulphur content in the fuel (which may vary) and was set at a value anywhere between e.g. 30 and 100. Alkaline additives can make up about a significant portion of the oil.

20 The viscosity of the oil delivered to the cylinders is relatively high (e.g. 21 cSt at 100°C for an SAE 50 oil) in order to lubricate effectively at the higher temperatures (e.g. 190°C) of the cylinder liner 2 resulting in a viscosity of approximately 3,2 cSt where the oil is applied.

25 The oil delivered to the cylinders is a "use once consumable". The oil is injected into the cylinder at a feed rate to give optimum protection against acid corrosion and microseizures (scuffing).

30

The characteristics of an example of oil for supplying to the cylinders of a two-stroke crosshead engine are as follows:

	SAE No	50
5	Specific Gravity (15°C)	0.942
	Flash Point °C	241
	Pour Point °C	-9
	Viscosity: cSt at 40°C	247
	cSt at 100°C	21
10	Viscosity Index	100
	Total Base Number (mg. KOH/g)	70

The list of viscosity agents includes but is not limited to:

- 15 Used and fresh finished lubricants such as hydraulic oils, turbine oils, monograde and multigrade engine oils, gear oils, base oils including naphthenic and paraffinic mineral oils (of Group I, II and III), synthetic polyalphaolefins (PAO), polymeric entities
- 20 such as polymethylmethacrylate (PMMA) and olefin copolymers (OCP) and mixtures thereof.

The source of viscosity agent may comprise a source of high viscosity agents for increasing the resulting viscosity and

25 a source of low viscosity agents for decreasing the resulting viscosity.

Adjusting the TBN preferably comprises adjusting at least one additive level or adding one or more additives, where the

30 additives comprise at least one base comprising basic salts of alkaline or earth alkaline elements, and/or detergents

and/or dispersants. Alternatively, adjusting the TBN comprises blending with a high TBN oil, such as a commercial cylinder oil with a high TBN value, e.g. with a TBN above 100.

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The alkaline/earth alkaline elements may be e.g. K, Na, Ca, Ba, Mg or the like. The basic salts may belong to the Inorganic chemical families of e.g. oxides, hydroxides, carbonates, sulphates or the like. The detergents may belong to the organic chemical families of e.g. sulfonates, salicylates, phenates, sulphophenates, Mannich-bases and the like. The dispersants may belong to the organic chemical families of succinimides or the like.

15 An electronic control unit 50 receives signals that contain information about the engine, such as specific temperatures and pressures, and operating conditions, such as the engine load and speed. The electronic control unit 50 is also connected, e.g. via signal cables to the feed pumps 22 for the main bearings, the control valve 21 in the main bearing supply conduit 23, the feed pumps 25 for the crosshead banks, control valve 24 in the crosshead bearing supply conduit 26 and to the control valve 24 in the crosshead bearing supply conduit 26.

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The electronic control unit 50 is also connected, e.g. via signal cables to the feed pumps that deliver the viscosity agent and the TBN agent to the mixer 66, both to the mixer 66 itself and to the cylinder oil dosage pump 55. Alternatively, 30 the mixer 66 may be provided with its own electronic control

unit (not shown), that carries out the functions that are described below that relates to the mixer 66.

5 The electronic control unit 50 is configured to determine the amount (flow rate) of lubrication oil that needs to be delivered to the main bearings 8. The electronic control unit 50 is also configured to determine the amount (flow rate) of lubrication oil that needs to be delivered to the crosshead bearings.

10

The electronic control unit 50 is also configured to or determine the required TBN for the oil that is delivered to the cylinders 2. Hereto, the electronic control unit 50 is in receipt of information on the fuel quality, i.e. sulphur content and of the cylinder liner temperature or an estimate thereof, e.g. an estimate of the cylinder liner temperature based on the engine load, and determines the required TBN e.g. from lookup tables stored in the electronic control unit 50 or by using an algorithm or equation stored in the electronic control unit 50, taking into account both the sulfur content of the fuel and the cylinder liner temperature or estimate thereof.

25 Fig. 5 is a diagram that shows an example of the relation between the TBN and the engine load as controlled by the electronic control unit 50 (in this example the engine load has been used to estimate the actual cylinder liner temperature). This example is for a fuel with a high sulfur content, i.e. approximately 3%. For engine loads below 50% of the maximum continuous rating of the engine the temperature of the cylinder liner 2 is relatively low and therefore a

relatively large amount of the water vapor in the combustion gas will condensate on the relatively cool cylinder liner 2 thereby causing a relatively high amount of acidic material originating from the sulfur in the fuel to be deposited on the cylinder liners 2. Therefore, a relatively high TBN of 120 is applied by the electronic control unit 50 for engine loads under 50% of the maximum continuous rating of the engine 1. With increasing engine load the cylinder liner temperature increases and the relative amount of water vapor that condensates on the relatively warm cylinder liners decreases. The electronic control unit 50 controls the TBN of the oil delivered to the cylinders accordingly and reduces the TBN value with increasing engine loads. In this example the relation between the desired TBN value and the engine load is proportional for engine loads above 50% of the maximum continuous rating of the engine 1. Thus, the TBN of the oil supplied to the cylinders is in this example approximately 120 at 50% engine load and approximately 70 at 100% engine load, with the TBN decreasing linearly proportional with the engine load for engine loads above 50% of the maximum continuous rating of the engine 1.

Fig. 6 is a diagram that shows an example of the relation between the TBN and the engine load as controlled by the electronic control unit 50 (in this example the engine load has been used to estimate the actual cylinder liner temperature). This example is for a fuel with a high sulfur content, i.e. approximately 1%. The TBN regime is essentially the same as for the example of Fig. 5, except that the electronic control unit 50 controls the TBN to be 80 when the engine load is below 50% of the engine's maximum continuous

rating and controls the TBN to go from 80 linearly to 55 with increasing engine load. The lower TBN levels when compared to the example in Fig. 5 are due to the lower sulfur content in the fuel.

5

Fig. 7 is a diagram that shows an example of the relation between the TBN and the engine load as controlled by the electronic control unit 50 (in this example the engine load has been used to estimate the actual cylinder liner temperature). This example is for a fuel with a high sulfur content, i.e. approximately 1%. The TBN regime is essentially the same as for the example of Fig. 6, except that the electronic control unit 50 controls the TBN to be 80 when the engine load is below 60% of the engine's maximum continuous rating and controls the TBN to be 60 when the engine load is above 60% of the engine's maximum continuous rating. In this example the TBN does not follow the actual need for alkaline material to be present on the cylinder liner as in the two previous embodiments but this example allow a more simple control and still improved results when compared to the constant TBN level used in the prior art.

The OEM (original engine manufacturer/developer) normally issues a service guideline that specifies the TBN to be used for a particular sulfur content of the fuel and specifies the amount of oil that is supplied to the cylinders, normally as a function of the engine load. In an example embodiment, the TBN can be chosen to match the TBN specified by the OEM for engine loads below 50 to 60% of the engine's maximum continuous rating, whilst a lower TBN is applied when the engine load is above 50 to 60% of the engine's maximum

continuous rating. However, the optimal TBN level can also be determined empirically for the various engine loads and the electronic control unit 50 is in an example embodiment programmed to apply the hence determined TBN level.

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The electronic control unit 50 is in receipt of a signal representative of the engine load. The engine load is a parameter that is indicative of the cylinder liner temperature. Alternatively, the electronic control unit is in receipt of a signal from the temperature sensor (not shown) that measures the jacket cooling water temperature. The jacket cooling water temperature is also indicative of the temperature of the cylinder liner and can be used as an alternative parameter by the electronic control unit 50. Alternatively, the electronic control unit is in receipt of a signal from a temperature sensor 57 in the cylinder liner. Based on the temperature of the cylinder liners, or on a parameter representative thereof the electronic control unit 50 is configured to determine the optimal viscosity for the oil that is delivered to the cylinders.

Alternatively, the electronic control unit 50 determines directly from the parameter that is indicative of the cylinder liner temperature the required proportions of withdrawn system oil, TBN agent and viscosity agent.

The electronic control unit 50 is configured to determine the required viscosity for the oil that is delivered to the cylinders 2. Hereto, the electronic control unit 50 is provided with an algorithm that determines the required proportions of withdrawn system oil, viscosity agent and TBN

agent that results in a prepared oil in the blender 66 that has the determined optimal TBN value and the determined optimal viscosity. The electronic control unit 50 is configured to control the blender 66 and optionally the feed pumps that deliver the withdrawn system oil, the viscosity agent and the TBN agent respectively to deliver the appropriate amounts of respective fluid to the blender 66 and to blend or mix the appropriate amount of the respective fluids in the blender 66, preferably in a continuous process.

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The electronic control unit 50 is configured to recalculate the required proportions of system oil, viscosity agent and TBN agent when the temperature of the cylinder liner changes and/or when the sulfur content of the fuel changes and to control the blender 66 and the feed pumps of the withdrawn system oil, of the TBN agent and of the viscosity agent accordingly.

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Fig. 2 illustrates another embodiment that is essentially identical to the embodiment that is described with reference to Fig. 1, except that there are two blenders: a TBN blender 67 and a viscosity blender 68. In Fig. 2 the viscosity blender 68 is downstream of the TBN blender 67 with a tank 63 in between. This allows batch wise production of an oil blend with an adjusted TBN value and storing this oil blend with the adjusted TBN value in the day tank 63 and allows online adaptation of the batch wise produced oil blend to the required viscosity value in the online viscosity blender 68.

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Changes to the sulphur content of the fuel are not frequent and can normally be foreseen well in advance. Thus, it is

normally not necessary to adjust the TBN value of the oil to be delivered to the cylinders quickly or unexpectedly and therefore a batch wise production is unproblematic. However, changes to the engine load could be caused by e.g. an
5 unexpected change in the weather or other conditions that are beyond control of the operator of the marine vessel. Therefore, it is advantageous that the adjustment of the viscosity is performed in an online blending process and allows for a quick and instantaneous adjustment of the
10 viscosity to actual operating conditions.

The invention has been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those
15 skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other
20 unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable
25 medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems.

30

The reference signs used in the claims shall not be construed as limiting the scope.

PATENTKRAV

1. Fremgangsmåde til fremstilling af en olie, der skal tilføres cylindrene i en totakts-krydshovedmotor (1) med krydshoveder (5), cylindre i cylinderforinger (2) og med et smøresystem til krumbaphuset, der fungerer med systemolie, hvilken fremgangsmåde omfatter:

- 10 - opnåelse, bestemmelse eller estimering af den aktuelle cylinderforingstemperatur,
- opnåelse, bestemmelse eller estimering af svovlindholdet i den olie, der anvendes af motoren (1),
- 15 - tilvejebringelse af en første olie med et første TBN, såsom for eksempel brugt olie (60),
- 20 - tilvejebringelse af et TBN-stigende middel med et andet TBN, der er højere end det første TBN,
- blanding af den første olie med det TBN-stigende middel i et styret forhold for at fremstille olien til tilførsel til cylindrene, og
- 25 - justering af TBN'et for olien til tilførsel til cylindrene ved justering af forholdet mellem den første olie (60) og det TBN-stigende middel (61), kendetegnet ved
- 30

5 - styring af TBN'et for olien til tilførsel til cylindrene som reaktion på det aktuelle svovlindhold i den olie, der anvendes af motoren (1), og som reaktion på den opnåede, bestemte eller estimerede cylinderforingstemperatur ved styring af TBN'et for olien til tilførsel til cylindrene mindst for cylinderforingstemperaturer eller motorbelastninger over en første tærskelværdi ved et niveau, der aftager med tiltagende motorbelastning og stiger med aftagende motorbelastning.

10 2. Fremgangsmåde ifølge krav 1, der endvidere omfatter:

20 - bestemmelse af et ønsket TBN for olien til tilførsel til cylindrene, hvor der tages højde for det aktuelle svovlindhold i den olie, der anvendes af motoren (1), og hvor der tages højde for den opnåede, bestemte eller estimerede cylinderforingstemperatur, og

25 - styring af den styrbare blandeanordning (66, 67, 68) til at blande den første olie med det TBN-stigende middel i et blandingsforhold, der resulterer i en fremstillet olie til tilførsel til cylindrene med det ønskede TBN.

30 3. Fremgangsmåde ifølge krav 1 eller 2, hvor motorbelastningen anvendes til at bestemme eller estimere den aktuelle cylinderforingstemperatur.

4. Fremgangsmåde ifølge krav 3, hvor den første tærskelværdi er en motorbelastning på omtrent 50 % til 60 % af motorens (1) maksimale konstante ydelse.

5 5. Fremgangsmåde ifølge krav 3, der endvidere omfatter styring af TBN'et for olien til tilførsel til cylindrene mindst for motorbelastninger eller cylinderforingstemperaturer over en anden tærskelværdi ved et niveau, der proportionelt aftager med tiltagende motorbelastning og proportionelt stiger med aftagende motorbelastning, hvor den anden tærskelværdi fortrinsvis er en motorbelastning på omtrent 50 % af motorens (1) maksimale konstante ydelse.

10 15 6. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 5, hvor den første olie er en ny cylinderolie eller en brugt olie, hvor den brugte olie for eksempel er brugt systemolie, der er taget fra krumtaphusets smøresystem.

20 25 7. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 6, hvor det TBN-stigende middel er et additiv, en additivpakke, en olie eller en cylinderolie med et TBN, der er højere end TBN'et for den første olie.

30 8. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 7, der endvidere omfatter styring af tilførselsraten til cylindrene af olien, der er fremstillet ved blandingen som reaktion på motorbelastningen, fortrinsvis styring af tilførselsraten proportionelt med motorbelastningen.

9. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 8, hvor blanding af den første olie med et TBN-middel er en batchvis proces eller en inline-blandingsproces.

5

10. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 9, der endvidere omfatter bestemmelse af en ønsket viskositet for den olie, der tilføres cylindrene ved den bestemte cylinderforingstemperatur.

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11. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 10, hvor fremstilling af en olie til tilførsel til cylindrene omfatter blanding af den første olie med et TBN-middel og med et viskositetsmiddel for at opnå en viskositetsjusteret olie til tilførsel til cylindrene.

15

12. Fremgangsmåde ifølge krav 10 eller 11, hvor bestemmelse af en mængde viskositetsmiddel, der skal tilsættes, omfatter manuel beregning ved anvendelse af en defineret metodologi eller bestemmelse ved anvendelse af computersoftware, der er programmeret med passende algoritmer eller ligninger.

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13. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 12, hvor det viskositetsjusterende middel omfatter ny cylinderolie, fortrinsvis en ny cylinderolie med et højt TBN, såsom for eksempel et TBN over 60.

30

14. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 13, hvor det viskositetsændrende middel omfatter en smøreolie, såsom en

trunkstempelmotorolie, gear-, hydraulik- eller turbineolie, basisolie, genbrugsolie eller et additiv med høj viskositet.

5 15. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 14, hvor bestemmelse af den aktuelle cylinderforingstemperatur omfatter måling af den aktuelle cylinderforingstemperatur ved et bestemt punkt, eller gennemsnitligt beregnet over overfladen af foringen med en sensor i eller ved cylinderforingens overflade (2).

10 16. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 15, hvor bestemmelse af den aktuelle cylinderforingstemperatur omfatter opnåelse den aktuelle motorbelastning og/eller o/m (omdrejninger pr. minut) og udledning af en estimeret cylinderforingstemperatur ud fra den opnåede motorbelastning og/eller o/m.

20 17. Fremgangsmåde ifølge krav 16, hvor udledning af en estimeret cylinderforingstemperatur omfatter manuel beregning ved anvendelse af en defineret metodologi eller bestemmelse ved anvendelse af computersoftware, der er programmeret med passende algoritmer eller ligninger, ved anvendelse af motorbelastningen som grundlag for beregning af den estimerede cylinderforingstemperatur.

30 18. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 17, hvor bestemmelse af den aktuelle cylinderforingstemperatur omfatter opnåelse den aktuelle cylinderkappekølevandstemperatur og

udledning af en estimeret cylinderforingstemperatur ud fra den opnåede cylinderkappekølevandstemperatur.

5 19. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 14, hvor fremgangsmåden udføres ombord på et skib eller på stedet, hvor totakts-krydshovedmotoren (1) er installeret.

10 20. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 19, der endvidere omfatter tilførsel af den TBN- og viskositetsjusterede olie til cylindrene (1).

15 21. Apparat til fremstilling af olie til tilførsel til cylindrene af en totakts-krydshovedmotor (1) med krydshoveder (5), cylindre i cylinderforinger (2) og med et smøresystem til kruntaphuset, der fungerer med systemolie, hvilket apparat omfatter:

20 - en kilde af første olie med et første TBN, såsom for eksempel brugt olie (60),

- en kilde af TBN-stigende middel med et andet TBN, der er højere end det første TBN,

25 - en styrbar blandedanordning (66, 67, 68), der er konfigureret til at blande den første olie med det TBN-stigende middel i et styrbart blandingsforhold for at fremstille olien til tilførsel til cylindrene,

30 - elektronisk styreenhed (50), der er forbundet med apparatet,

- hvor den elektroniske styreenhed (50) informeres om cylindrenes (2) aktuelle cylinderforingstemperatur eller om et estimat deraf, og om svovlindholdet i den olie, der anvendes af motoren (1),

5

- hvor den elektroniske styreenhed (50) er konfigureret til at justere TBN'et for olien til tilførsel til cylindrene ved at justere blandingsforholdet mellem den første olie (60) og det TBN-stigende middel (61), og

10

- hvor den elektroniske styreenhed (50) er konfigureret til at styre TBN'et for olien til tilførsel til cylindrene, der er fremstillet med den styrbare blandeordination (66, 67, 68) som reaktion på det aktuelle svovlindhold i den olie, der anvendes af motoren (1) og som reaktion på informationerne om den aktuelle motorbelastning, kendetegnet ved, at

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- den elektroniske styreenhed (50) er konfigureret til at styre TBN'et for olien til tilførsel til cylindrene mindst for cylinderforingstemperaturer eller motorbelastninger over en anden tærskelværdi ved et niveau, der aftager med tiltagende motorbelastning og stiger med aftagende motorbelastning.

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22. Apparat ifølge krav 21, hvor informationerne om den aktuelle cylinderforingstemperatur er en målt temperatur, en bestemt temperatur eller en estimeret

temperatur, fortrinsvis en temperatur, der er estimeret ud fra den aktuelle motorbelastning.

23. Apparat ifølge krav 21 eller 22, hvor:

5

- den elektroniske styreenhed (50) er konfigureret til at bestemme et ønsket TBN for olien til tilførsel til cylindrene, hvor der tages højde for det aktuelle svovlindhold i den olie, der anvendes af motoren (1), og hvor der tages højde for den aktuelle motorbelastning, og hvor

10

- den elektroniske styreenhed (50) er konfigureret til at styre den styrbare blandeordination (66, 67, 68) til at blande den første olie med det TBN-stigende middel i et blandingsforhold, der resulterer i en fremstillet olie til tilførsel til cylindrene med det ønskede TBN.

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24. Apparat ifølge et hvilket som helst af kravene 21 til 23, hvor den elektroniske styreenhed (50) er konfigureret til at styre TBN'et for olien til tilførsel til cylindrene (2) ved et første TBN for cylinderforingstemperaturer eller motorbelastninger under en første tærskelværdi og til at styre TBN'et for olien til tilførsel til cylindrene (2) ved et andet TBN, der er lavere end det første niveau for motorbelastninger over den første tærskelværdi.

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25. Apparat ifølge et hvilket som helst af kravene 21 til 23, hvor den første tærskelværdi fortrinsvis

er en motorbelastning på omtrent 50 % til 60 % af motorens (1) maksimale konstante ydelse.

5 26. Apparat ifølge et hvilket som helst af kravene 21 til 23, hvor den elektroniske styreenhed (50) er konfigureret til at styre TBN'et for olien til tilførsel til cylindrene (2) mindst for cylinderforingstemperaturer eller motorbelastninger over en anden tærskelværdi ved et niveau, der 10 proportionelt aftager med tiltagende motorbelastning og proportionelt stiger med aftagende motorbelastning, hvor den anden tærskelværdi fortrinsvis er en motorbelastning på omtrent 50 % af motorens (1) maksimale konstante ydelse.

15 27. Apparat ifølge et hvilket som helst af kravene 21 til 26, hvor den første olie er en ny cylinderolie eller en brugt olie, hvor den brugte olie for eksempel er brugt systemolie, der er taget fra krumtaphusets smøresystem. 20

28. Apparat ifølge et hvilket som helst af kravene 21 til 27, hvor det TBN-stigende middel er et additiv, en additivpakke, en olie eller en cylinderolie. 25

29. Apparat ifølge et hvilket som helst af kravene 21 til 28, hvor apparatet endvidere omfatter en cylinderoliedoseringspumpe (55) til tilførsel af olien til motorens (1) cylindre (2), og hvor den 30 elektroniske styreenhed (50) er konfigureret til at styre cylinderdoseringspumpens (55) tilførselsrate som reaktion på motorbelastningen, fortrinsvis proportionelt med motorbelastningen.

30. Apparat ifølge et hvilket som helst af kravene 21 til 29, der endvidere omfatter en kilde af viskositetsmiddel, og hvor den styrbare blande­anordning (66, 67, 68) er konfigureret til at blande den første olie, det TBN-stigende middel og viskositetsmidlet i individuelt styrbare forhold for at fremstille olien til tilførsel til cylindrene (2).

31. Apparat ifølge krav 30, hvor den elektroniske styreenhed (50) er forbundet med den styrbare blande­anordning (66), hvor den elektroniske styreenhed (50) endvidere er konfigureret til at bestemme mængden eller andelen af viskositetsmiddel, der skal blandes i olien til tilførsel til cylindrene for at opnå en olie med den ønskede viskositet, og hvor den elektroniske styreenhed (50) er konfigureret til at styre den styrbare blande­anordning (66) i overensstemmelse hermed.

32. Apparat ifølge krav 31, hvor olien til tilførsel til cylindrene (2) har et styret TBN og en styret viskositet.

33. Apparat ifølge et hvilket som helst af kravene 30 til 32, hvor viskositetsmidlet er et fluid eller en olie med en høj viskositet eller er et viskositetsforøgende additiv, eller hvor viskositetsmidlet er et fluid eller en olie med en lav viskositet og er et viskositetsreducerende additiv.

34. Apparat ifølge et hvilket som helst af kravene 30 til 33, hvor blande­anordningen er en integreret blande­anordning (66), der er konfigureret til at

blande den første olie, olien med højt TBN og midlet med højt TBN og viskositetsmidlet, fortrinsvis i en batchvis blandingsproces.

- 5 35. Apparat ifølge et hvilket som helst af kravene 30 til 34, hvor blandeanordningen omfatter en TBN-blandeanordning (67) til blanding af tilbagetrukket systemolie med olien med det høje TBN eller midlet med det høje TBN og en viskositetsblandeanordning
- 10 (68) til blanding af den blanding, der er fremstillet med TBN-blandeanordningen (67), med et viskositetsmiddel.

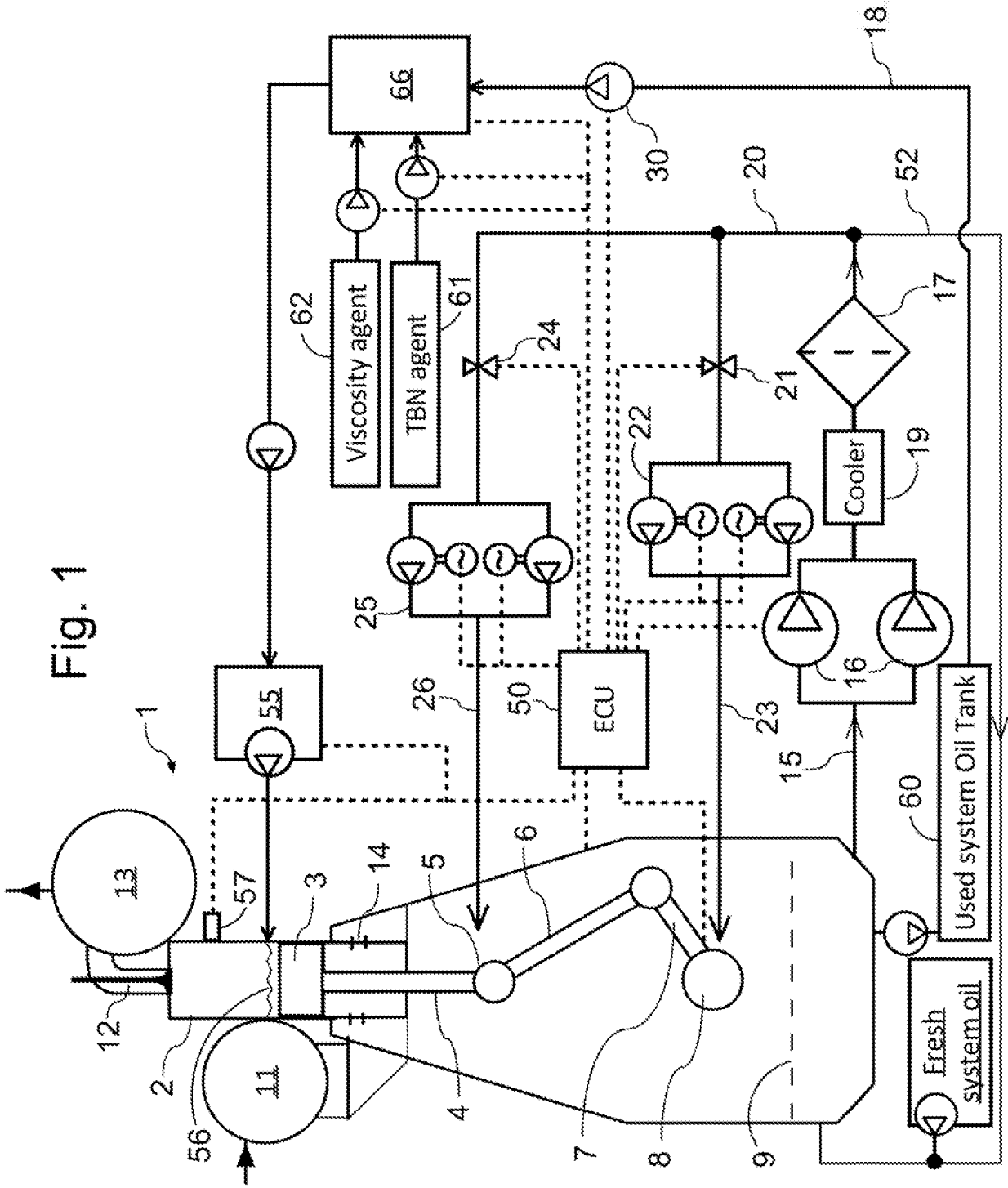


Fig. 1

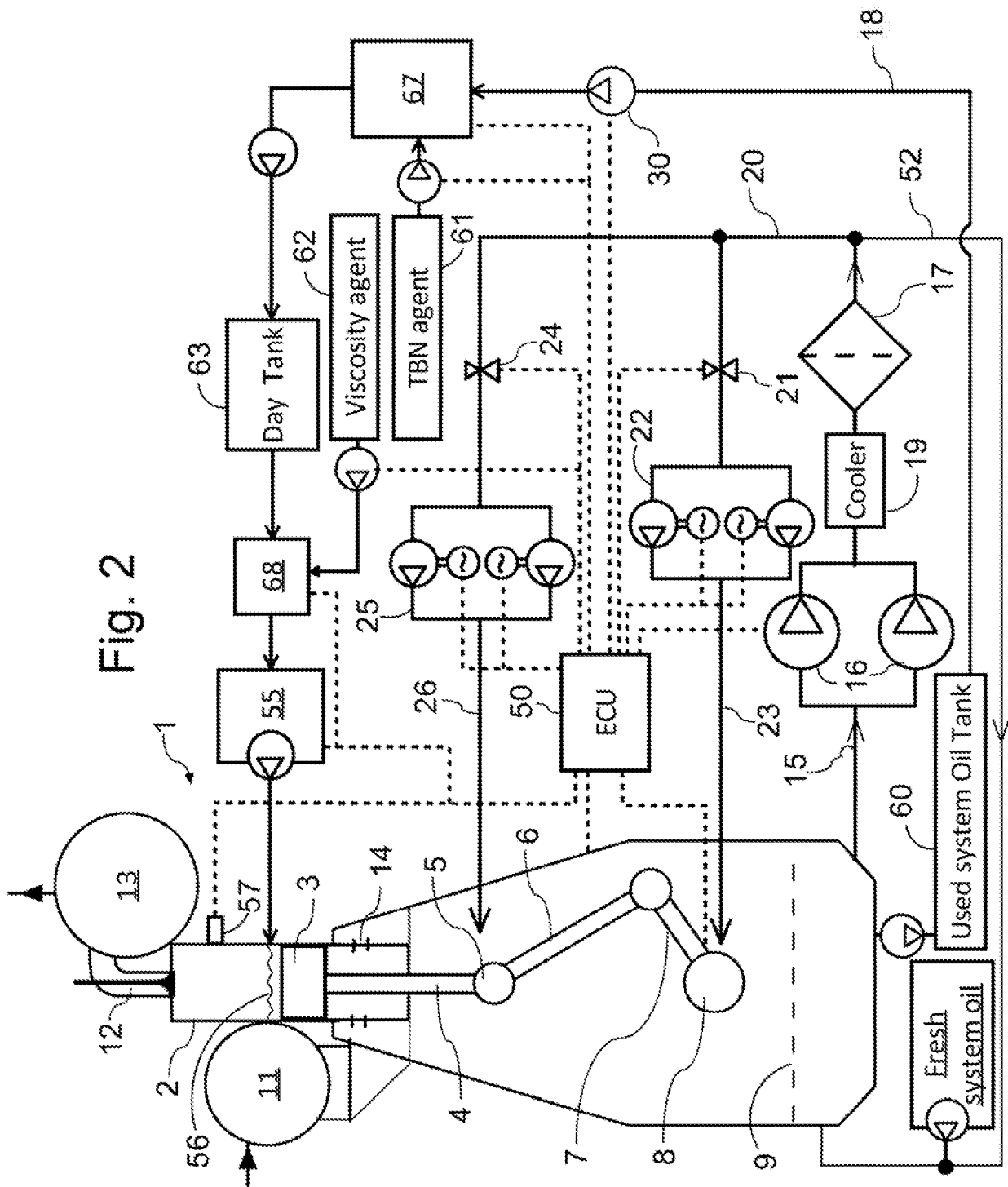
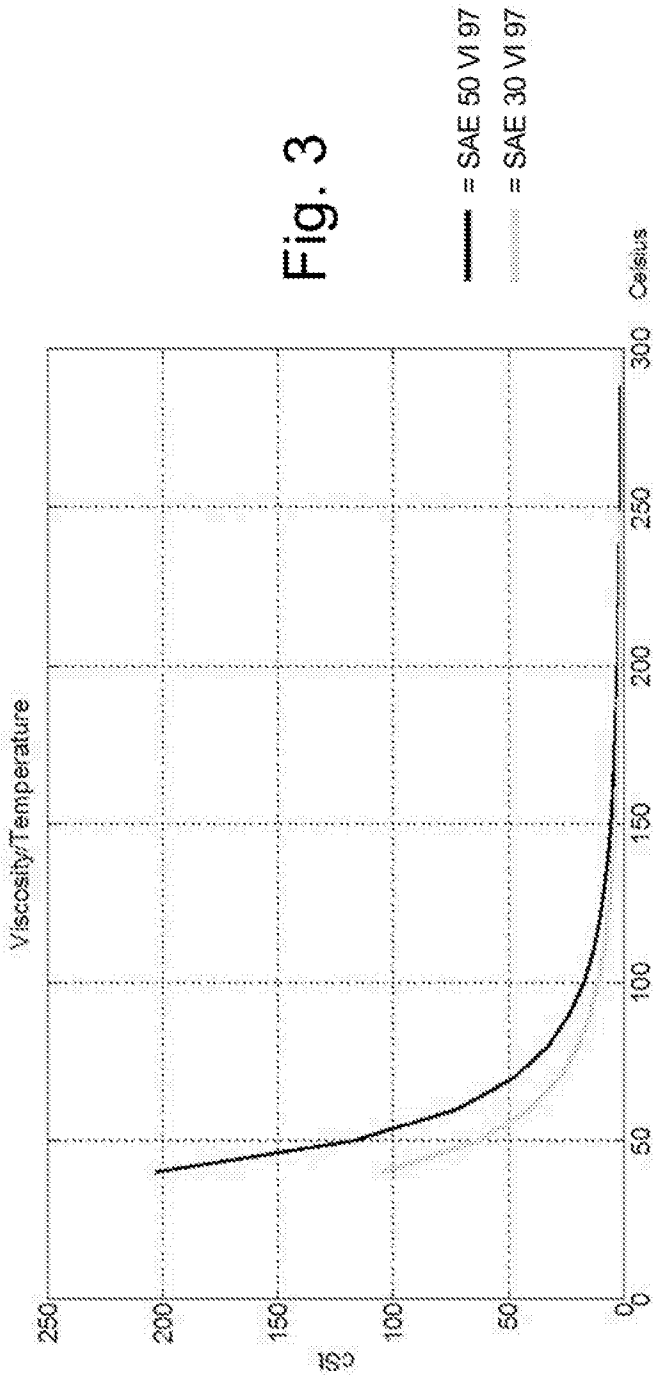
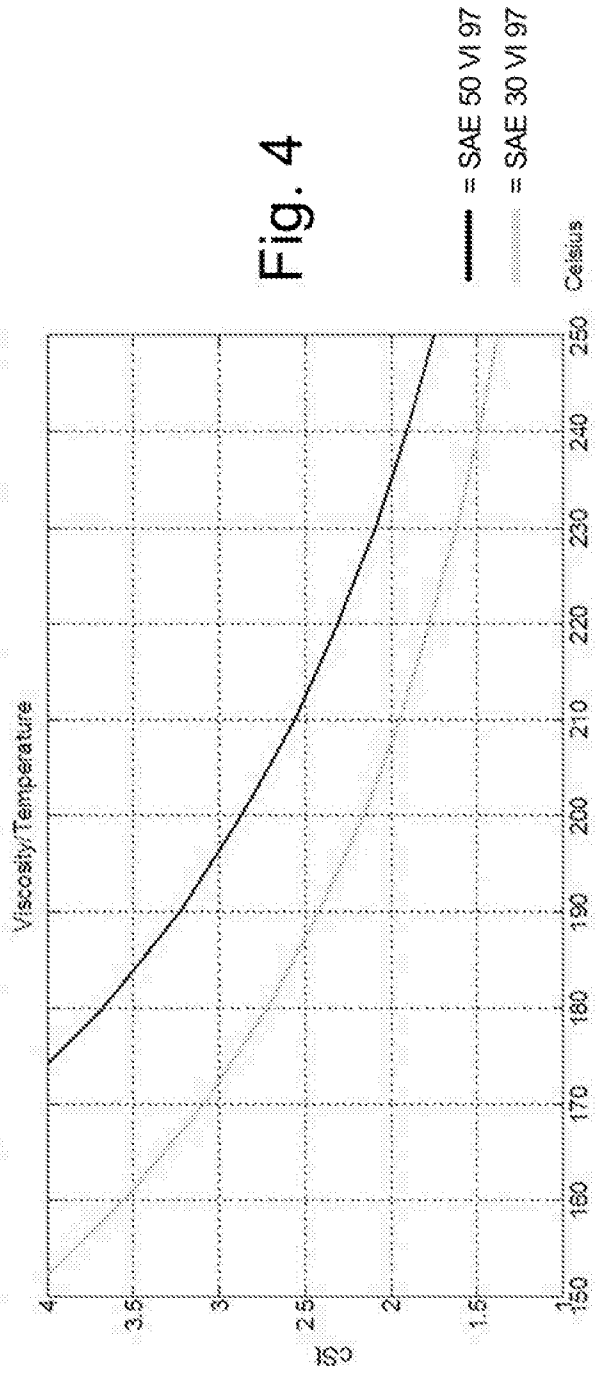


Fig. 3



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Fig. 4



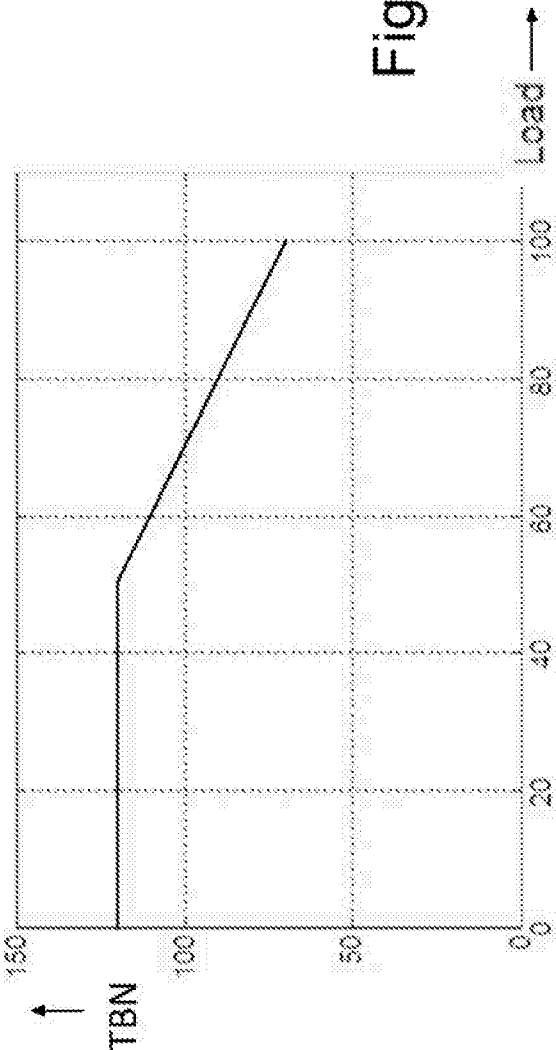


Fig. 5

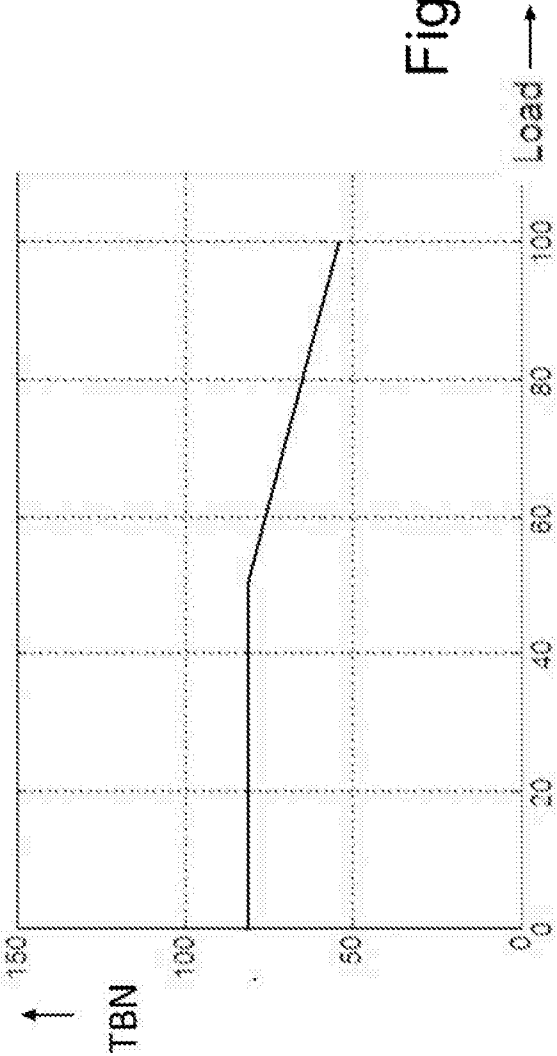


Fig. 6

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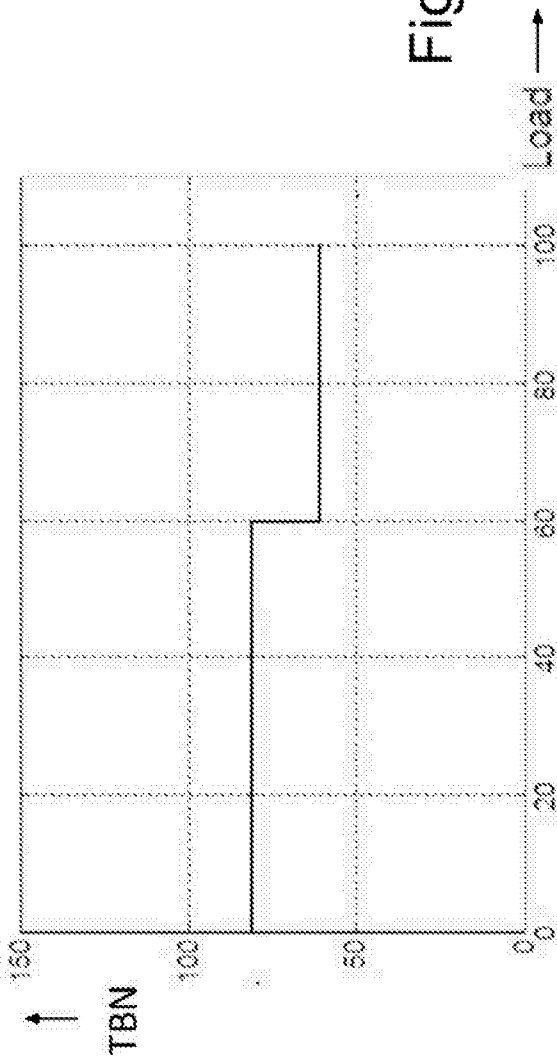


Fig. 7

SEARCH REPORT - PATENT		Application No. PA 2015 00647
1. <input type="checkbox"/> Certain claims were found unsearchable (See Box No. I).		
2. <input type="checkbox"/> Unity of invention is lacking prior to search (See Box No. II).		
A. CLASSIFICATION OF SUBJECT MATTER F 01 M 9/02 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) CPC&IPC: F01M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: IPC-classes as above.		
Electronic database consulted during the search (name of database and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
Y	US 2004/0144355 A1 (CARAY et al.) 29 July 2004 Whole document	1-35
Y	WO 03/072912 A1 (EXXONMOBIL RESEARCH & ENGINEERING COMPANY) 04 September 2003 Claims 6 -11, [0005], [0017] and Figure	1-3, 6, 10-11, 16-17, 21-22, 28, 30-33
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.		
*	Special categories of cited documents:	"P" Document published prior to the filing date but later than the priority date claimed.
"A"	Document defining the general state of the art which is not considered to be of particular relevance.	"T" Document not in conflict with the application but cited to understand the principle or theory underlying the invention.
"D"	Document cited in the application.	"X" Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.
"E"	Earlier application or patent but published on or after the filing date.	"Y" Document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"L"	Document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified).	"&" Document member of the same patent family.
"O"	Document referring to an oral disclosure, use, exhibition or other means.	
Danish Patent and Trademark Office Helgeshøj Allé 81 DK-2630 Taastrup Denmark Telephone No. +45 4350 8000 Facsimile No. +45 4350 8001		Date of completion of the search report 3 June 2016
		Authorized officer Birgitte Dragsted Horstmann Telephone No. +45 4350 8527

SEARCH REPORT - PATENT		Application No. PA 2015 00647
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
Y	WO 2015/036543 A1 (SHELL INT RESEARCH) 19 March 2015 Whole document	8, 29
Y	EP 2767578 A1 (LUKOIL MARINE LUBRICANTS LTD) 20 August 2014 Whole document	8, 29
Y	DE 202013012085U U1 (LUKOIL MARINE LUBRICANTS GERMANY GMBH) 29 April 2015 Whole document	8, 29
Y	EP 2497818 A1 (PETROCHINA CO LTD) 12 September 2012 Whole document	34

Box No. I Observations where certain claims were found unsearchable

This search report has not been established in respect of certain claims for the following reasons:

1. Claims Nos.:

because they relate to subject matter not required to be searched, namely:

2. Claims Nos.:

because they relate to parts of the patent application that do not comply with the prescribed requirements to such an extent that no meaningful search can be carried out, specifically:

3. Claims Nos.:

because of other matters.

Box No. II Observations where unity of invention is lacking prior to the search

The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:

SUPPLEMENTAL BOX

Continuation of Box [.]