

Ship propulsion system and method for operating a ship propulsion system

The present invention relates to a ship propulsion system according to the preamble to claim 1. Furthermore, the invention relates to a method for operating a ship propulsion system according to the preamble to claim 9.

Ship propulsion systems which are subject-matter of this disclosure may drive a basically arbitrarily designed ship alone or in conjunction with another propulsion system. Such a ship propulsion system may be an auxiliary diesel engine, for example, which may be provided in addition to a propulsion system that burns crude oil for driving the ship.

A generic ship propulsion system comprises at least an internal combustion engine for propelling a ship, wherein the internal combustion engine has a combustion chamber for burning a fossil fuel, in particular a diesel fuel.

A generic method for operating a ship propulsion system comprises the steps of propelling a ship with at least one internal combustion engine. For this, a fossil fuel, for example a diesel fuel, is introduced into a combustion chamber of the internal combustion engine.

Starting from known ship propulsion systems there is a need, in particular due to ever more stringent emission regulations, to design the combustion process of the internal combustion engine such that particularly low emission levels are reached. Simultaneously the efficiency of the internal combustion engine should be particularly high.

KR 2011 0119055 A, US 2012/0067304 A1, EP 2 602 358 A1, US 2006/0179819 A1, and WO 2008/033107 A2 describe internal combustion engines with which hydrogen

gas and oxygen gas are used for reducing pollutants in the exhaust. In US 2012/0067304 A1 and US 2006/0179819 A1, for example, the hydrogen gas and oxygen gas are produced in an electrolysis unit.

It may be regarded as an **object** of the invention to provide a ship propulsion system and a method for operating a ship propulsion system in which an internal combustion engine operates with a particularly high efficiency and has particularly low emissions.

This object is solved with the ship propulsion system comprising the features of claim 1 and with the method for operating a ship propulsion system comprising the features of claim 9. Advantageous variants of the inventive ship propulsion system and the inventive method are subject-matter of the dependent claims and are also explained in the following description.

The ship propulsion system of the above-referenced kind comprises, according to the invention, an electrolysis chamber for producing hydrogen gas and oxygen gas, and a vacuum pump for drawing off the hydrogen gas and the oxygen gas from the electrolysis chamber. Furthermore, a gasification tank is provided with volatile organic compounds, in particular methanol or ethanol, received and gasified therein, i.e., they are at least partially transferred into a gaseous state. Additionally a supply line for supplying a gas mixture to the combustion chamber is provided, the gas mixture including gasified organic compounds (that is a part of the volatile organic compounds that is transferred into the gaseous state) and at least a part of the hydrogen gas and the oxygen gas produced in the electrolysis chamber. The supply line and the gasification tank are hence arranged such that a gas mixture as defined above is supplied to the combustion chamber during operation of the ship propulsion system.

The method of the above-referenced kind comprises, according to the invention: producing hydrogen gas and oxygen gas in an electrolysis chamber, drawing off the hydrogen gas and the oxygen gas from the electrolysis chamber with a vacuum pump, gasifying volatile organic compounds, in particular methanol or ethanol, in a gasification tank, and supplying a gas mixture comprising gasified organic compounds and at least a part of the hydrogen gases and oxygen gases produced in the electrolysis chamber into the combustion chamber.

As an important idea of the invention, hydrogen gas and oxygen gas produced by electrolysis are only supplied into the combustion chamber together with gaseous volatile organic compounds, that means in particular together with gasified methanol and/or ethanol. Such a gas mixture can reduce production of NO_x and may cause a particularly fast combustion of diesel in the combustion chamber. A fast combustion can produce a higher pressure at a defined point in time, which eventually allows for a more efficient power transmission.

The gas mixture is always supplied in addition to a fossil fuel / fossil energy carrier into the combustion chamber and burnt there. The larger released energy fraction, for example at least 70% or at least 90%, comes from the fossil fuel, for example a diesel fuel. The supplemental gas mixture thus does not mainly serve as a replacement for an energy source but helps in causing a desired combustion process. In this way it is possible to produce fewer pollutants / emissions and furthermore the combustion process can take place faster which makes a more efficient force transmission possible.

The volatile organic compounds may in principle be a specific organic compound or a mixture of different organic compounds. The term "volatile" organic compounds may be understood as all organic compounds that are mainly gaseous at room temperature and/or have a boiling point below 100°C or below 200°C or 300°C . Organic compounds may in particular be hydrocarbons and/or all compounds that consist predominantly of hydrogen and carbon atoms. Examples of such organic compounds are alkanols (such as methanol and ethanol) or alkanes (such as methane or ethane).

The gasification tank may in principle be understood as any container in which volatile organic compounds are contained. There, at least part of the volatile organic compounds can be transferred from a liquid state into a gaseous state. The vacuum pump and the gasification tank may be preferably arranged such that the hydrogen gas and the oxygen gas are at least partially transported by the vacuum pump from the electrolysis chamber into the gasification tank. The gas mixture is thus produced in the gasification tank. The supply line may thus start at the gasification tank and may transport the gas mixture from there in the direction of the combustion chamber.

The gasification tank may thus comprise an inlet connected with the electrolysis chamber, and an outlet to output organic compounds that have been gasified (have been transferred into gaseous state) as well as hydrogen and oxygen gas that is being

passed through. The gasification tank may further comprise a filling opening for refilling liquid organic compounds, for example ethanol.

It may be preferably to supply hydrogen gas and oxygen gas into the gasification tank through several nozzles which are provided in a lower part/portion of the gasification tank. In particular, the lower half or the lower quarter of the gasification tank may be regarded as the lower part. This introduction in the lower part advantageously leads to a stronger gasification. By using several nozzles, the introduced gases may flow through the gasification tank more evenly distributed, which is again advantageous for a stronger gasification.

The supply line as such may extend to the combustion chamber. However, in principle it is sufficient if the supply line connects with a supply device / means that leads the gas mixture to the combustion chamber. It is preferred that the supply line connects with an air inlet manifold component / air drawing component of the internal combustion engine.

In the invention, a turbocharger is provided and the supply line is designed such that the gas mixture can be supplied to the combustion chamber via a compressor of the turbocharger. As an advantage, the combustion chamber and directly neighbouring components of the inventive ship propulsion system may be built similarly as in conventional ship propulsion systems. Furthermore this embodiment of the invention allows for particularly efficient control of the amount of the gas mixture supplied into the combustion chamber. This is explained further below in greater detail.

The electrolysis chamber may generally be understood as any device that produces hydrogen gas and oxygen gas, in particular H_2 and O_2 , by using electrical energy. A starting substance of the electrolysis may be water or a hydrous/aqueous mixture. It may be preferred if the electrolysis chamber and a supply system / line system from the electrolysis chamber to the gasification tank are designed such that the produced hydrogen gas and oxygen gas are jointly or unseparated transported as oxyhydrogen. With a comparably simple construction this allows an exact timing of ignition in the combustion engine by introducing the oxyhydrogen.

The vacuum pump may be a pump / compressor of a generally arbitrary kind. It creates a low pressure / reduced pressure which sucks hydrogen gas and oxygen gas out of the electrolysis chamber. The vacuum pump may also consist of several pump units. This is

in particular of advantage if the produced hydrogen gas and oxygen gas are separately sucked off, i.e., not as oxyhydrogen.

In addition to transporting hydrogen gas and oxygen gas from the electrolysis chamber, the vacuum pump may also enhance the efficiency of the electrolysis chamber. It is desirable for an electrolysis that electrodes of the electrolysis chamber are surrounded by liquid electrolyte. Cavitation or bubble production, i.e., gases such as produced hydrogen gas and oxygen gas, hamper the electrolysis and make higher temperatures necessary. This can be avoided in a preferred variant of the invention in which the vacuum pump produces a reduced pressure in the electrolysis chamber, in particular a pressure below 1 bar, in particular between 200 mbar and 700 mbar, in particular between 300 mbar and 600 mbar or between 340 mbar and 580 mbar. Such a comparably low pressure allows operating the electrolysis chamber at a temperature below 40°C, in particular at 38 to 39°C which increases efficiency of the electrolysis.

The vacuum pump can be operated to suck as much gas (in particular produced hydrogen and oxygen gas) out of the electrolysis chamber so that at most a quarter of the electrolysis chamber, preferably at most 10 % of the electrolysis chamber, is filled with gas during operation of the electrolysis chamber.

The internal combustion engine of the ship propulsion system may be an engine designed in a principally known way which provides heat energy and thus motion energy for propulsion of the ship by combusting an (in particular fossil) energy carrier. An example of a fossil energy carrier is diesel, i.e., a diesel fuel, wherein the exact composition of the diesel fuel may be variable in substantially known ways.

The ship propulsion system may also comprise an exhaust filter for cleaning exhaust, for example a soot particle filter. Cleaning the exhaust gas filter is important for a preferably high life span of the exhaust filter. This can be achieved with oxygen gas. If oxygen is added to the exhaust upstream of the exhaust gas filter, it can act as a radical at the filter and can thus assist in cleansing the filter. This is accomplished in a preferred embodiment of the invention. A separator, for example a diaphragm, may be provided for separating the hydrogen gas and the oxygen gas which can be produced in the electrolysis chamber. Furthermore, a line / conduit is provided for supplying a part of the oxygen gas to the exhaust filter, wherein the gas mixture that is supplied through the supply line to the combustion chamber may comprise the remaining oxygen gas (i.e.,

the part of the oxygen gas that is not led to the exhaust filter) and the hydrogen gas as well as the gasified organic compounds.

Separating the produced oxygen gas and hydrogen gas may be carried out at in principle any location. It is also possible to supply oxygen gas and hydrogen gas from the electrolysis chamber unseparated to the combustion chamber, while a part of this oxygen-hydrogen mixture (i.e., the mixture of oxygen gas and hydrogen gas) is channeled off into a separate line and is only there separated with the separator into oxygen gas and—separated from the oxygen gas—hydrogen gas.

The electrolysis chamber is supplied with an electrical current with which the hydrogen gas and oxygen gas are produced in the electrolysis chamber. Furthermore, water is introduced from which the hydrogen gas and oxygen gas are produced. Preferably a controller is provided and configured to control the electrical current and/or a water introduction into the electrolysis chamber and/or a pumping power of the vacuum pump in dependence from a momentary property of an operation of the internal combustion engine. The control may in particular be carried out such that the amount of introduced gas mixture is the larger, the larger the amount of fossil fuel is which is supplied to the combustion chamber. The produced gas mixture thus does not serve as a replacement for a fossil fuel / energy carrier. The gas mixture is rather used as an additive which influences the combustion process in a desired way. The controller may set the electrical current and the pumping power in particular such that a relation of injected diesel to introduced gas mixture is substantially constant, i.e., substantially independent from an injection rate and an injected amount of diesel. "Substantially constant" may be regarded as comprising variations of up to 10%, preferably not more than 5%, of the aforementioned relation.

In a preferred variant, the controller is configured to use a boost pressure in an intake manifold of the internal combustion engine as the momentary property of the internal combustion engine operation, in dependence of which the electrical current and/or the pumping power are controlled. The boost pressure indicates a gas / air pressure in an intake path / intake manifold of the internal combustion engine. The controller may be configured to set the electrical current and the pumping power the larger, the higher the boost pressure. Instead of the boost pressure, it is possible to use another pressure dependent thereon for the control, for example an exhaust pressure, in particular up-

stream of the turbo charger. For obtaining the boost pressure and/or another pressure used for the control, appropriate pressure sensors may be provided. Instead of the pressure, another quantity associated with the engine power may be used for the control, for example a motor speed. However, it may be the case that using such electrical signals renders errors more likely compared to a control based on the (boost) pressure.

It may be preferred that additionally an air compressor for transporting air / gas into the gasification tank is provided. The air may be ambient air, in particular a mixture of any gases. The more air is pumped into the gasification tank, the larger is the amount of gasified organic compounds. This increases the amount of the produced gas mixture. This is desirable when the internal combustion engine combusts fossil fuels with a particularly high rate and consequently a particularly large amount of produced gas mixture should be added.

For adding a larger amount of produced gas mixture in case of a larger amount of supplied fossil fuel, it may be preferable to operate the vacuum pump with increasing pumping power if the boost pressure raises. It may be provided that the vacuum pump is operated with maximal pumping power when the boost pressure reaches a predefined boost pressure threshold. If the boost pressure passes above that predefined boost pressure threshold, it would be desirable to add an even larger amount of gas mixture. The amount of oxygen gas and hydrogen gas is limited due to the vacuum pump and the electrolysis chamber, however, a larger amount of gasified organic compounds may be added by means of the air compressor. It may thus be provided that the air compressor is operated additionally when the boost pressure raises above the predefined boost pressure threshold. In particular, a power of the air compressor may be set the higher, the more the boost pressure raises above the predefined boost pressure threshold. In these cases, the vacuum pump is always operated with maximum pumping power. Due to the air compressor the composition of the gas mixture changes; however, this is still better than an insufficient amount of available gas mixture. In this control, instead of the boost pressure also another pressure may be used which depends on the boost pressure (for example an exhaust pressure). Furthermore, instead of the boost pressure another quantity / property may be used which increases with raising engine power, for example the engine speed.

It may be preferably that a storage tank is provided and connected with the gasification tank. The storage tank includes organic compounds and serves for filling the gasification tank. A gas mixture produced in the gasification tank should have a desired relation between oxyhydrogen and organic compounds, and to this end the gasification tank should not be excessively large. Nevertheless, a sufficiently large amount of organic compounds should be available / carried along, to which end a volume of the storage tank may be at least 3 times, preferably at least 5 times as large as a volume of the gasification tank.

Introducing the gas mixture may advantageously trigger ignition of a fossil fuel introduced into the combustion chamber. The combustion can take place faster due to the gas mixture which comprises oxyhydrogen. It may be preferred if an ignition timing is caused at a crankshaft angle of less than 20° , in particular between 17° and 19° , in particular between $17,5^\circ$ and $18,5^\circ$, before the top dead center (of a piston of the internal combustion engine). This ignition timing can be defined and set by the timing of the introduction of the gas mixture into the combustion chamber. In this variant the ignition timing occurs tighter before the top dead center than usually. Such a late ignition timing can be chosen because the invention provides for a particularly fast combustion. At a desired point in time it is thus possible to create a larger pressure.

The invention also relates to a ship comprising a ship propulsion system as described herein.

Variants of the method of the invention result from the intended use of the described embodiments of the ship propulsion system. Furthermore, preferred embodiments of the ship propulsion system of the invention, in particular its controller, may be configured to carry out the described variants of the method of the invention.

Further advantages and features of the invention will be described hereinbelow with reference to the accompanying schematic figures, wherein:

Fig. 1 is a schematic representation of an embodiment of a ship propulsion system of the invention, and

Fig. 2 is a schematic representation of a further embodiment of a ship propulsion system of the invention.

Fig. 1 shows schematically an embodiment of a ship propulsion system 100 according to the invention. It may be part of a ship according to the invention (not depicted). In addition to the ship propulsion system 100, the ship may comprise another propulsion system, for example a combustion engine for crude oil. Furthermore, the ship may comprise several ship propulsion systems 100 which may be each formed as described below.

As main components, the ship propulsion system 100 comprises an electrolysis chamber 20 for producing hydrogen gas and oxygen gas, a gasification tank 30 for gasifying volatile organic compounds, and an internal combustion engine 50, which is supplied with fossil fuel as well as the produced hydrogen gas, the oxygen gas and the gaseous organic compounds.

By adding this gas mixture, the combustion of diesel or another fossil fuel may take place faster and the amount of pollutants or emissions output in the exhaust gas is reduced.

As a first step, water or another starting material is converted in the electrolysis chamber 20 with the help of electrical energy into hydrogen gas, oxygen gas and possibly further components.

The produced hydrogen gas and the produced oxygen gas are transported via a supply system or line system 28. These two gases may in particular be provided as a mixture, i.e., oxyhydrogen. For transportation a vacuum pump 25 is provided in the supply system 28. The vacuum pump 25 produces a reduced pressure in the electrolysis chamber 20, thus sucking off the oxygen gas and the hydrogen gas.

Furthermore, the reduced pressure in the electrolysis chamber 20 reduces the amount of electrolyte (which is present in the electrolysis chamber 20) that transfers from the liquid state into a gaseous state. In this way, the efficiency of the electrolysis chamber 20 can be increased.

The supply system 28 supplies the oxygen gas and the hydrogen gas to the gasification tank 30. Organic compounds such as methanol and/or ethanol are provided in the gasification tank 30 and experience a surface gasification due to introduction of the hydrogen gas and the oxygen gas. To this end the hydrogen gas and the oxygen gas are introduced into the gasification tank 30 in a lower part thereof, in particular at its bottom. A

gas mixture is thus formed within the gasification tank 30, comprising at least hydrogen gas, oxygen gas and gasified organic compounds, in particular methanol and / or ethanol. This gas mixture is then forwarded via a supply line 38. Instead of forwarding the oxyhydrogen through the gasification tank 30, it is alternatively also possible to direct gaseous organic compounds out of the gasification tank and only then bring it together with the oxyhydrogen.

The size of the gasification tank 30 may be chosen such that a desired amount of organic compounds is transferred into the gaseous state and forms a mixture with hydrogen gas and oxygen gas, when the hydrogen gas and oxygen gas is passed through the gasification tank 30. A ship comprising the ship propulsion system of the invention shall carry larger amounts than possible with the gasification tank, and to this end a storage tank 32 may be provided. The storage tank 32 supplies organic compounds to the gasification tank 30 and is not itself supplied with produced hydrogen gas or oxygen gas. A level sensor may be provided at the gasification tank 30 with which introduction of organic compounds from the storage tank 32 into the gasification tank 30 may be controlled.

The supply line 38 leads the produced gas mixture from the gasification tank 30 to a compressor 42 of a turbocharger 40. The gas mixture may be transported to the compressor 42 together with ambient air. For this merging, a corresponding line may be provided (not depicted). The gas mixture is led from the turbocharger 40 into a combustion chamber 52 of the internal combustion engine 50. In the combustion chamber 52 the gas mixture ignites and causes combustion of injected fossil fuel, for example injected diesel fuel.

Exhaust gases are guided from the combustion chamber 52 via an exhaust line 54 to an exhaust turbine 44 of the turbocharger 40. A pressure of the exhaust gas is thus used by the exhaust turbine 44 to transport the gas mixture with the compressor 42 in the direction of the internal combustion engine 50. Downstream of the exhaust turbine 44, the exhaust gas reaches an optional exhaust filter 60.

A supply of the gas mixture into the combustion chamber 52 shall be increased if the amount of injected/introduced fossil fuel increases. For this purpose, inter alia, the turbocharger 40 is used. The compressor 42 of the turbocharger 40 is driven by the exhaust turbine 44. The exhaust turbine 44 drives the compressor 42 with more power if

an exhaust pressure at the exhaust turbine 44 increases. If only small amounts of fuel are combusted in the combustion chamber 52, it follows that the pressure at the exhaust turbine 44 is small and the compressor 42 only produces a small suction in the supply line 38. If, on the other hand, larger amounts of diesel are combusted in the combustion chamber 52, then the compressor 42 will cause a stronger suction of gas mixture from the supply line 38.

Furthermore, the amount of the produced gas mixture may be controlled according to demand. To this end, controller 10 may be provided which may in particular be configured to adjust an electrical current through the electrolysis chamber 20 and may thus set the amount of hydrogen gas and oxygen gas to be produced. Furthermore, the controller 10 may control the vacuum pump 25 and may thus set the amount of hydrogen gas and oxygen gas that is transported from the electrolysis chamber 20 into the gasification tank 30. For increasing the amount of produced gas mixture, a larger electrical current and a higher pumping power of the vacuum pump 25 may be set. The amount of produced gas mixture may be set the larger, the higher the rate or amount of injected diesel into the combustion chamber 52. The boost pressure of the internal combustion engine 50 may be used as a measure for this. The controller 10 may thus be configured to increase the pumping power of the vacuum pump 25 and the electrical current in the electrolysis chamber 20 with increasing boost pressure. Pressure measuring means for this purpose may be provided. In the depicted example, pressure measuring means 12 are provided which measure an exhaust pressure upstream of the turbocharger 40. Also this exhaust pressure may be used for controlling the produced amount of gas mixture.

It may be desired to supply even larger amounts of gas mixture to the turbocharger 40 or the internal combustion engine 50 as can be achieved with a maximum current through the electrolysis chamber 20 and a maximum pumping power of the vacuum pump 25. In particular for such a case, an additional air compressor 35 may be provided. The air compressor 35 pumps air, in particular ambient air, into the gasification tank 30 and thus causes an increased gasification of the organic compounds. It may be desired if a line of the air compressor 35 and the line system 28 end at the vacuum pump 25 into a common line so that air from the air compressor 35 and hydrogen gas and oxygen gas produced by the electrolysis are let via the same nozzles into the gasification tank 30. In other variants, however, it may be preferred that the air from the air com-

pressor 35 and the produced hydrogen gas and oxygen gas reach the gasification tank 30 through separate lines.

The controller 10 also set a pumping power of the air compressor 35. It may be provided that the air compressor 35 is only operated when the electrolysis chamber 20 is supplied with a maximum current and the vacuum pump 25 operates with maximum pumping power.

It may also be preferable if gas can only be introduced into the gasification tank 30 through the air compressor 35 and not through the vacuum pump 25. In this way the amount of organic compounds introduced into the internal combustion engine 50 is adjustable independent from the amount of oxyhydrogen supplied to the internal combustion engine.

For cleaning exhaust filter 60 particularly efficiently, it may be supplied with oxygen gas from the electrolysis chamber 20. In the depicted embodiment, a line 62 is provided for this purpose which leads from electrolysis chamber 20 to exhaust filter 60. Depending on the exemplary embodiment, a design of electrolysis chamber 20 may be preferred in which either oxygen gas is guided through line 62 separated from and without the hydrogen gas, or oxygen gas and hydrogen gas are together transported through line 62.

By supplying the produced gas mixture to the fossil energy carrier in the combustion chamber 52, a particularly fast combustion is made possible. This allows ignition to take place very shortly before a top dead center of the piston of the internal combustion engine 50 which makes a higher efficiency possible. Furthermore, the amount of produced pollutants in the exhaust is reduced.

A further embodiment of a ship propulsion system 100 according to the invention is shown schematically in Fig. 2. Components with the same reference numerals as in Fig. 1 may be built similarly and have the same effect as described with respect to Fig. 1, or vice versa.

As important components, the ship propulsion system 100 comprises again an electrolysis chamber 20, a gasification tank 30 and a turbo charger 40 as well as an internal combustion engine 50.

As described with respect to Fig. 1, the electrolysis chamber 20 produces hydrogen gas and oxygen gas. Together with gaseous volatile hydrocarbons from the gasification tank 30, the hydrogen gas and oxygen gas are supplied via the turbo charger 40 to the internal combustion engine 50.

A storage tank 32 is furthermore depicted which includes a supply of volatile hydrocarbons, in particular a supply of ethanol or in general other volatile organic compounds. These can be adjustably introduced into the gasification tank 30 via a line 31.

Furthermore, an air supply 33 for supplying compressed air into the gasification tank 30 is shown. This air supply 33 is important for producing larger amounts of gaseous volatile hydrocarbons in the gasification tank 30, in order to supply larger amounts of gaseous volatile hydrocarbons to the turbo charger 40 and the internal combustion engine 50. The compression of air may be achieved with the air compressor which is not shown here.

Whereas compressed ambient air, i.e., a mixture of mostly nitrogen and oxygen, may be introduced into the gasification tank 30 with the air supply 33, it is also possible to provide a CO₂ tank 36 from which CO₂ can be supplied into the gasification tank 30, controlled with a valve 37.

The electrolysis chamber 20 may connect to a condensate trap 21 or condensate accumulator 21 in which electrolyte and the produced mixture of hydrogen and oxygen may be separated.

The electrolyte condensates in the condensate trap 21 and can then be pumped back into the electrolysis chamber 20 with an electrolyte circulation pump 15. The condensate trap 21 thus advantageously protects the internal combustion engine 50 against entry of liquids. Gaseous hydrogen and oxygen gases are, in contrast, drawn out of the condensate trap 21 with the vacuum pump 25.

The oxyhydrogen (that is the produced hydrogen and oxygen gases) transported with the vacuum pump 25 are transported together with hydrocarbons or other organic compounds out of the gasification tank 30 and via a line 28 to a diaphragm 39 of the turbo charger 40.

Water can be directed through a water inlet 23 into the electrolysis chamber 20 where it is converted into hydrogen gas and oxygen gas. The electrolyte circulation pump 15 can also be used for transporting water from the water inlet 23 to the electrolysis chamber 20, which allows an easier and cost-efficient setup. As shown, a water line from the water inlet 23 and an electrolyte line from the condensate trap 21 may lead to a common line which in turn leads to the electrolyte circulation pump 15.

The electrolysis chamber 20 which produces the easily ignitable oxyhydrogen may be arranged in an explosion-proof area 19. This explosion-proof area 19 may in particular be formed by an air-tight casing and/or may comprise galvanically separated transmitters for electrical signals. Besides the electrolysis chamber 20, also the gasification tank 30, the condensate trap 21 and the vacuum pump 25 may be arranged in this explosion-proof area 19. To avoid an undue large size of the explosion-proof area 19, the storage tank 32, in contrast, is preferably arranged outside the explosion-proof area 19. The turbo charger 40 and its diaphragm 39 are also arranged outside the explosion-proof area 19.

The ship propulsion system of the invention allows to operate an internal combustion engine particularly efficiently by adding oxyhydrogen and additional volatile organic compounds. Furthermore, production of pollutants / emissions is thus reduced.

CLAIMS

1. Ship propulsion system, comprising

- an internal combustion engine (50) for propelling a ship,
- wherein the internal combustion engine (50) has a combustion chamber (52) for burning a fossil fuel, in particular a diesel fuel,
- an electrolysis chamber (20) for producing hydrogen gas and oxygen gas,
- a turbocharger (40),
- a supply line (38), which is designed so that a gas mixture can be conveyed via a compressor (42) of the turbocharger (40) to the combustion chamber (52), the gas mixture including at least a part of the hydrogen gas and the oxygen gas, and

characterised in that

- a vacuum pump (25) is provided for drawing off the hydrogen gas and the oxygen gas from the electrolysis chamber (20),
- a gasification tank (30) with volatile organic compounds received therein, in particular methanol or ethanol, is provided,
- an air supply (33) for supplying compressed air into the gasification tank (30) is provided, and in addition to the turbocharger (40) there is an air compressor (35) for pumping air into the gasification tank (30),

the gas mixture, which is guided via the supply line (38) and the turbo charger (40) to the combustion chamber (52), also includes gasified organic compounds from the gasification tank (30).

2. Ship propulsion system according to claim 1,

characterised in that

the vacuum pump (25) and the gasification tank (30) are arranged so that the hydrogen gas and the oxygen gas can be conveyed at least partially through the vacuum pump (25) from the electrolysis chamber (20) into the gasification tank (30) to produce the gas mixture.

3. Ship propulsion system according to claim 1 or 2,
characterised in that
the electrolysis chamber (20) and a pipeline system are formed from
the electrolysis chamber (20) to the gasification tank (30) so that
hydrogen gas and oxygen gas can be conveyed, unseparated, as
oxyhydrogen.
4. Ship propulsion system according to one of claims 2 or 3,
characterised in that
the hydrogen gas and oxygen gas conveyed into the gasification tank
(30) are introduced via a plurality of nozzles in a lower part of the
gasification tank (30).
5. Ship propulsion system according to one of claims 1 to 4,
characterised that
a storage tank (32) is provided and connected to the gasification tank
(30) for filling the gasification tank (30) with organic compounds.
6. Ship propulsion system according to one of claims 1 to 5,
characterised in that
the electrolysis chamber (20) is supplied with an electric current,
through which the hydrogen gas and the oxygen gas are obtained in
the electrolysis chamber (20), and
there are control means (10), which are configured to control the
electric current and / or an introduction of water into the electrolysis
chamber (20) and / or a pumping capacity of the vacuum pump (25) in
dependence on a momentary property of an internal combustion
engine operation.
7. Ship propulsion system according to claim 6,
characterised in that
the control means (10) are configured to use, as a momentary property
of the internal combustion engine operation in dependence on which

the electric current, the water introduction and / or the pumping capacity of the vacuum pump (25) are controlled, a boost pressure of the internal combustion engine (50), and
the control means (10) are configured to set the electric current and the pumping capacity to be higher, the higher the boost pressure is.

8. Ship,
comprising a ship propulsion system according to one of claims 1 to 7.
9. Method for operating a ship propulsion system,
wherein a ship is propelled with an internal combustion engine (50)
and, for this, a fossil fuel is introduced into a combustion chamber (52)
of the internal combustion engine (50),
wherein, in an electrolysis chamber (20), hydrogen gas and oxygen
gas are produced,
wherein a gas mixture is conveyed via a compressor (42) of a
turbocharger (40) to the combustion chamber (52), the gas mixture
including at least a part of the hydrogen gas and the oxygen gas,
characterised in that
with a vacuum pump (25), the hydrogen gas and the oxygen gas are
drawn off from the electrolysis chamber (20),
in a gasification tank (30), volatile organic compounds, in particular
methanol or ethanol, are gasified,
an air supply (33) for supplying compressed air into the gasification
tank (30) is provided, and with an air compressor (35), which is
provided in addition to the turbocharger (40), air is pumped into the
gasification tank (30),
the gas mixture, which is guided via the turbocharger (40) to the
combustion chamber (52), also includes gasified organic compounds
from the gasification tank (30).
10. Method according to claim 9,
characterised in that

in the electrolysis chamber (20), a reduced pressure is generated by the vacuum pump (25), in particular a pressure below 1 bar, in particular between 200 mbar and 700 mbar, in particular between 300 mbar and 600 mbar.

11. Method according to claim 9 or 10,
characterised in that
the vacuum pump (25) draws off so much gas from the electrolysis chamber (20) that, during operation of the electrolysis chamber (20), at most a quarter of the electrolysis chamber (20) is filled with gas.
12. Method according to one of claims 9 to 11,
characterised in that
an ignition timing is effected at a crankshaft angle of less than 20°, in particular between 17° and 19°, in particular between 17.5° and 18.5°, before top dead centre.
13. Method according to one of claims 9 to 12,
characterised in that
the vacuum pump (25) is operated with maximum pumping capacity when a parameter for an engine operation, in particular a boost pressure of the internal combustion engine (50), reaches a predefined threshold value, and
in addition the air compressor (35) is operated, which pumps air into the gasification tank (30), when the parameter exceeds the predefined threshold value.