(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 December 2025 (11.12.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/252739 A1

(51) International Patent Classification:
F02B 37/00 (2006.01) *H01M 8/04089* (2016.01)
B60L 50/70 (2019.01) *F02M 25/12* (2006.01)
F02D 19/02 (2006.01) *F02M 31/18* (2006.01)
F02M 21/02 (2006.01) *F02M 53/02* (2006.01)
F02M 21/06 (2006.01)

(21) International Application Number:
PCT/EP2025/065352

(22) International Filing Date:
03 June 2025 (03.06.2025)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
24179680.4 03 June 2024 (03.06.2024) EP

(71) Applicant: **ACCELLERON SWITZERLAND LTD.** [CH/CH]; Bruggerstrasse 71a, 5400 Baden (CH).

(72) Inventors: **HARDY, Gilles**; Hardstrasse 30, 8570 Weinfelden (CH). **RÜMMELE, Florian**; Kartäuserstraße 124, 79104 Freiburg (DE).

(74) Agent: **ZIMMERMANN & PARTNER PATENTANWÄLTE MBB**; Josephspitalstr. 15, 80331 München (DE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UY, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST,

(54) Title: POWER GENERATING SYSTEM COMPRISING AN HYDROGEN SUPPLY SYSTEM

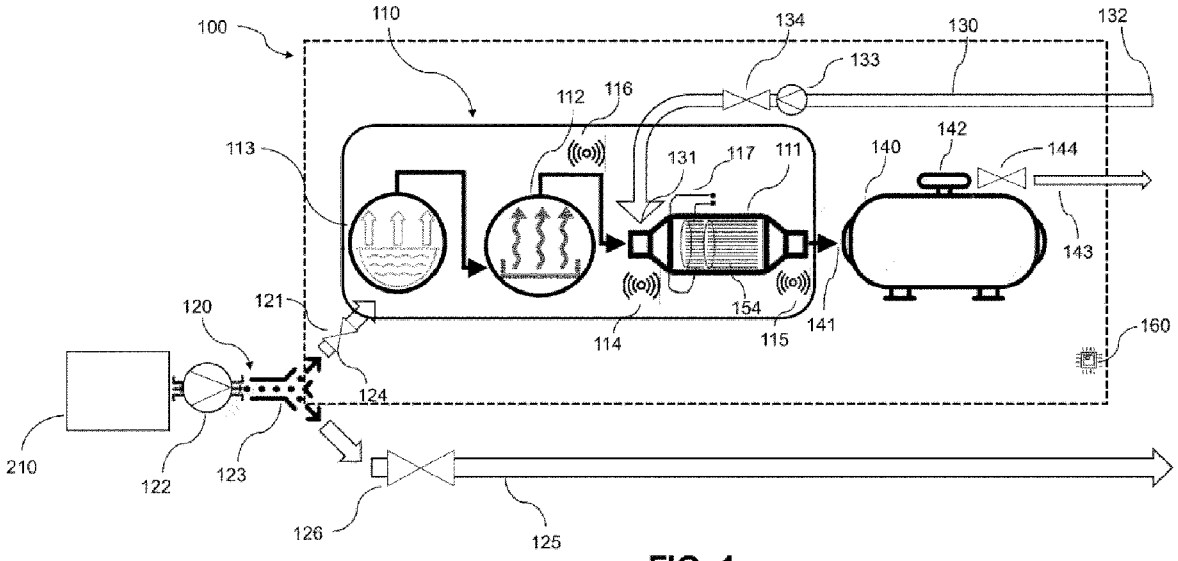


FIG. 1

(57) Abstract: A hydrogen supply system (100) for a power generating system (200, 300) is described. The power generating system comprises an intake manifold (220) and a turbocharging system (240) for supplying charged air to the intake manifold (220). The hydrogen supply system (100) comprises a reformer device (110) comprising a reformer (111), the reformer device (110) configured to supply a power generator (201, 301) with hydrogen. Further described herein is a power generating system (200, 300) comprising the hydrogen supply system and a turbocharging system.

[Continued on next page]

WO 2025/252739 A1

SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

POWER GENERATING SYSTEM COMPRISING AN HYDROGEN SUPPLY SYSTEM

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to a hydrogen supply system for a power generating system, and a power generating system comprising a hydrogen supply system.

BACKGROUND

[0002] In recent years, power generating systems with power generators such as internal combustion engines or fuel cells have been developed which utilise fuel reformers. A fuel reformer with a primary fuel such as ammonia or methanol allows for producing a reformed gas mixture including a certain amount of hydrogen. In case of the power generator being an internal combustion engine, the reformed gas mixture can be used as a combustion promoter at cold start or at part load operations, for example.

[0003] The reformed gas mixture produced in a reformer is oftentimes produced for later use and is stored in a gas tank. The reformed gas mixture may leave the fuel reformer at a high temperature (e.g. 400 °C). The low gas density at such an elevated temperature makes it difficult to store the gas. Furthermore, injecting the hot gas mixture directly into the intake system of the power generator causes major risks of backfiring issues. In order to efficiently store the reformed gas and in order to ensure safe handling of the hydrogen gas, the reformed gas is stored at an elevated pressure, e.g. such as 5 bars or more, and at a moderate or cold temperature, such as at ambient temperature. Likewise, power generators typically require a pressurised flow

of the reformed gas, i.e. the gas mixture oftentimes needs to be provided at an elevated pressure, e.g. such as 5 bars or more.

[0004] Prior art methods of cracking the primary fuel, such as ammonia, into hydrogen and nitrogen in the reformer are carried out at ambient pressure and temperatures of 290 °C or more. The reformed gas mixture, which typically is composed of H_2, N_2, H_2O, remaining unoxidised primary fuel and possibly CO_2 (e.g. in the case of methanol as primary fuel) can be later compressed and cooled down for storage in the gas tank or for continuously injecting the gas mixture into the intake air passage of the power generator, such as the internal combustion engine.

[0005] One drawback of prior art power generating systems is that the entire process of operating the reformer, including the steps of evaporating the primary fuel, further heating up and reforming the primary fuel, and preparing the reformed gas for storage or injection into the power generator is not energy efficient. A considerable loss of energy occurs, diminishing the thermal efficiency of the entire system and causing a substantial rise in temperature. In addition, prior art reformers used for power generating systems are rather bulky, which requires a lot of space in the power generating system and increases the costs for packaging.

[0006] There is a continuous demand for power generating systems. In particular, there is a need for power generating systems which allow to generate and store a reformed gas mixture in an energy efficient manner. In particular, there is a need for power generating systems with a decreased size.

SUMMARY

[0007] In light of the above, a hydrogen supply system according to independent claim 1 is provided. Further aspects, advantages, and features are

apparent from the dependent claims, the description, and the accompanying drawings.

[0008] According to an aspect of the present disclosure, a hydrogen supply system for a power generating system is provided. The power generating system includes an intake manifold and a turbocharging system for supplying charged air to the intake manifold. The hydrogen supply system includes a reformer device including a reformer. The reformer device is configured to supply a power generator of the power generating system with hydrogen. The hydrogen supply system further includes a fuel supply line configured for fluid communication with a fuel supply. The fuel supply line is in fluid communication with the reformer device for supplying fuel to the reformer device. The hydrogen supply system includes an air supply line configured for fluid communication with the intake manifold for receiving the charged air from the intake manifold. The air supply line is in fluid communication with the reformer device for supplying the reformer device with the charged air. The air supply line further includes a compressing device upstream of the reformer device. The compressing device is configured to increase the pressure of the charged air received from the intake manifold.

[0009] The air is supplied to the reformer device at an elevated pressure. For example, the charged air provided by the turbocharging system may have a pressure of up to 5 bars. The compressing device further increases the pressure of the charged air received or receivable from the turbocharging system. Illustratively, the charged air pressure may be increased from about 5 bars (upstream of the compressing device) to about 10 bars (downstream of the compressing device). The compressing device is not particularly limited and may be any kind of compressing device capable of further compressing charged air (i.e. air which has a pressure above ambient pressure).

[0010] The intake manifold or air intake manifold is to be understood as the space for receiving the charged air compressed by a compressor of the

turbocharging system. Typically, the intake manifold extends from an outlet of the compressor of the turbocharger to an injection system of the power generator. A fluid connection between the air supply line and the compressor of the turbocharging system may be established anywhere along the air intake manifold. Preferably, a pickoff or splitter for diverting a portion of the charged air flowing through the air intake manifold is arranged proximate the injection system of the power generator. In other words, the charged air may be picked off close to the power generator, and/or at a distance from the compressor. In addition, a charged air cooler may be located downstream of the compressor and/or may be connected to the intake manifold.

[0011] Operating the hydrogen supply system with a charged air supply has several advantages. The higher gas pressure decreases the volumetric flow and thus the gas velocity through the reformer device. This allows to reduce the size of the reformer device. In addition, the reformed gas mixture obtained from the reformer device may already have a pressure, which is sufficient for efficient storage and/or direct injection into the intake manifold of the power generating system. According to a preferred embodiment, the hydrogen supply system does not include a further compressing device downstream of the reforming device. The energy efficiency of the hydrogen supply system of the present disclosure is substantially improved by not needing to compress the reformed gas mixture downstream of the reformer device for further use. The compressing device of the hydrogen supply system requires limited energy as it benefits from a lower pressure ratio in view of the turbocharging system already providing charged air at an elevated pressure. According to an alternative embodiment, the hydrogen supply system or the power generating system described in more detail below, include a second compressing device downstream of the reformer. This additional compressing device may allow to adapt or fine tune the pressure of reformed gas to a pressure level desired for the power generator.

[0012] In a preferred embodiment, the reformer is an autothermal reformer. The reformer utilises an autothermal reforming process (ATR), which includes an exothermal reaction between the fuel (also sometimes referred to as "primary" fuel), such as ammonia or methanol, and oxygen to produce partially oxidised fuel to release thermal energy. The thermal energy released in the exothermic reaction may allow for increasing the temperature of the gases (e.g. the primary fuel) and maintaining the gases at an elevated temperature. The autothermal reformer allows for substantially reducing the amount of external power required to evaporate, heat up and reform the primary fuel. The autothermal may additionally be configured to be operated in a "non-autothermal" mode, for example by shutting off a supply of (charged) air.

[0013] The fuel supply may correspond to a tank or a similar kind of container. Alternatively, the fuel supply may be an external source providing a continuous flow of fuel, such as via a piping or conduit system. In some embodiments, the fuel supply may not be considered as part of the fuel supply system, and the fuel supply line is fluidly connectable with the fuel supply or configured to establish a fluid connection to the fuel supply. In other embodiments, the fuel supply may be regarded as being part of the hydrogen supply system or the power generating system described in more detail below. In this case, the fuel supply line may be fluidly connected to the fuel supply or may be in fluid communication with the fluid supply. The fuel is typically in a liquid state. The fuel may be ammonia, ethanol or methanol, for example.

[0014] According to an embodiment, the reformer device may include an evaporator. The evaporator is particularly beneficial in case the fuel supplied by the fuel supply has a low vapour pressure, is liquid or even solid. The evaporator is configured to supply gaseous fuel to the reformer or to a pre-heater described further below. The evaporator is in fluid communication with the fuel supply line. The evaporator may be arranged downstream of the fuel supply, and/or upstream of the reformer. The evaporator is in fluid

communication with the reformer. For example, the reformer device may include a gas line connecting the evaporator with the reformer or with the pre-heater described further below. The evaporator may include one or more heaters. In one illustrative embodiment, the evaporator includes an electric heating and/or a heat exchanger as described in more detail below. Preferably, the evaporator includes two different means for evaporating the fuel, such as an electric heating and/or a heat exchanger. The heat exchanger may be provided as primary source for evaporating the fuel. Beneficially, the electric heater can be used temporarily in addition to the heat exchanger in case the heat provided by the heat exchanger is not sufficient to evaporate the fuel. The heater(s) may be arranged within the evaporator. In case the fuel provided by the fuel supply is already gaseous and/or has a high vapour pressure, the reformer device may not include an evaporator.

[0015] According to an embodiment, the reformer device may include a pre-heater. The pre-heater is configured to supply heated gaseous fuel to the reformer. The pre-heater is arranged downstream of the fuel supply and upstream of the reformer. In case the reforming device includes the evaporator, the pre-heater may be arranged downstream of the evaporator. The pre-heater may further increase the temperature of the (gaseous) fuel. For example, the pre-heater 112 may be configured to heat up the fuel to at least 250 °C or to at least 300 °C or even up to at least 350-450 °C. The pre-heater is in fluid communication with the fuel supply line. The pre-heater may be in fluid communication with the reformer and/or the evaporator. For example, the reformer device may include a gas line connecting the evaporator with the pre-heater and/or a gas line connecting the pre-heater with the reformer.

[0016] The pre-heater may be a device provided separate from the reformer. For example, each of the reformer and the pre-heater may be provided in separate enclosures or casings, and both of the devices are fluidly connected to the each other. Alternatively, the pre-heater may be considered as an upstream portion of the reformer. The pre-heater and the reformer may be

arranged in one housing. The pre-heater and the reformer may be arranged in line, such that a flow of gaseous fuel may first flow through the pre-heater and subsequently through the reformer. In yet alternative embodiments, the pre-heater may be dispensed with entirely. For example, this may be the case if the fuel source provides gaseous fuel at a sufficiently high temperature or in case the evaporator (if present) provides gaseous fuel at a sufficiently high temperature.

[0017] The pre-heater may include one or more heaters. In one illustrative embodiment, the pre-heater includes an electric heating and/or a heat exchanger as described in more detail below. Preferably, the pre-heater includes two different means for heating the (gaseous) fuel, such as an electric heating and/or a heat exchanger. The heat exchanger may be provided as primary source for heating the fuel. Beneficially, the electric heater can be used temporarily in addition to the heat exchanger in case the heat provided by the heat exchanger is not sufficient to heat the (gaseous) fuel or during start-up. The heater(s) may be arranged within the pre-heater.

[0018] A fluid connection between the air supply line and the reformer device is preferably established downstream of the evaporator and/or downstream of the pre-heater and/or upstream of the reformer. The air supply line may include an air supply-reformer interface arranged upstream of the reformer. For example, the air supply-reformer interface may be arranged in the housing of the reformer or in the gas line connecting the pre-heater with the reformer.

[0019] According to an embodiment, the reformer includes a heater or heating for heating up and maintaining a temperature of the gas mixture contained within the reformer. The gas mixture may include charged air, and fuel. Preferably, the heater is an electric heater. The heater may be configured to heat the gas mixture contained within the reformer to at least 300 °C, preferably to at least 400 °C. The temperature in the reformer may be selected

depending on a desired conversion rate of fuel to hydrogen at a given pressure. For example, having a pressure of 10 bar within the reformer may lead to a conversion rate in excess of 90% at a temperature of approximately 400 °C. Illustratively, the electric heater may be arranged in the reformer and have a honey comb structure.

[0020] The reformer may further include a catalyst for catalysing the reforming reaction(s). For example, the catalyst may be a ruthenium-based catalyst, or a noble-metal based catalyst. The endothermic oxidation reaction as well as the reforming reaction (hydrogen generation) may take place on the same catalyst. According to one embodiment, the electric heating and the catalyst may be integrally formed with each other. Preferably, the electric heating is coated with the catalyst. Integrating the catalyst into the heater allows for reducing the size of the reformer. The catalyst may be disposed on an external surface of the heater, for example on an external surface of the honey comb structure.

[0021] The hydrogen supply system may further include a reformed-gas tank or hydrogen tank, in particular for storing reformed gas produced by the reformer device. The reformed gas may include hydrogen. Preferably the reformed gas is mainly composed of hydrogen, such as at least of 50% hydrogen. The reformed gas can contain other gases such as reagent gases that have not been consumed (fuel, nitrogen, oxygen) as well as other product gases or intermediate gases generated in the reforming process.

[0022] The reformed-gas tank may be arranged downstream of the reformer device, in particular downstream of the reformer. The reformed-gas tank is preferably in fluid communication with the reformer and/or fluidly connected or fluidly connectable to an intake manifold of the power generating device. The intake manifold may be the air intake manifold or another intake manifold, such as a fuel intake manifold. The reformed-gas tank may include a reformed-gas tank inlet and the reformer may include a reformer outlet. The

reformed-gas tank inlet and the reformer outlet may be fluidly connected to each other. For example, the hydrogen supply system may include a reformed gas line connecting the reformed-gas tank, in particular the reformed-gas tank inlet and the reformer outlet. The reformed-gas tank may include a reformed-gas tank outlet and the power generating system may include an intake manifold inlet. The reformed-gas tank outlet and the intake manifold inlet may be fluidly connected to each other. For example, the hydrogen supply system or the power generating system may include a reformed gas supply connecting the reformed-gas tank, in particular the reformed-gas tank outlet, and the intake manifold, in particular the intake manifold inlet. Alternatively, the reformer may be directly connected to the power generator such that the reformed gas may be injected from the reformer into the power generator without storing the reformed gas. Preferably, the reformed gas is first cooled down before being injected into power generator. In another embodiment, the hydrogen supply system has a first gas line connected or connectable with the intake manifold of the power generator and a second line connected with the reformed gas tank.

[0023] As described above, the reformed gas generated in the reformer and supplied to the reformed-gas tank has an elevated pressure, such as 10 bar, and therefore does not need to be further compressed for storage or later use in the power generating system. The hydrogen supply system preferably does not include a compressing device downstream of the reformer for compressing the reformed gas.

[0024] The reformed gas may be advantageously cooled down before storage in the reformed gas tank or cooled down within the reformed gas tank. This allows for enhancing storage efficiency and minimising the risk of backfiring or premature ignition of hydrogen beyond the tank. In addition, cooling the reformed gas is beneficial in case the power generator is an internal combustion engine and reformed gas is used for cold start operation as well as during transient operation as hydrogen can extend the flammability

limits of fuel-air mixtures, making it easier to burn the mixture across a wider range of concentrations. The hydrogen supply system may include one or more coolers for cooling the reformed gas. In one illustrative embodiment, the hydrogen supply system includes a heat exchanger as described in more detail below. The heat exchanger may be connected to a cold source to allow for cooling the reformed gas. Preferably, the cooler, in particular the heat exchanger, may be configured to cool the reformed gas to about 20-25 °C. The cooler, in particular the heat exchanger, may be arranged within the reformed gas tank or upstream of the reformed gas tank, such as in the reformed gas line.

[0025] In one embodiment, the hydrogen supply system further includes a control unit. The control unit may be configured to control operation of the hydrogen supply system including the reformer and/or the compressing device. For example, the control unit may be configured to control any of the above-described heaters or coolers. In addition, the hydrogen supply system may include various means for regulating flow of fluids and/or various sensors. The control unit may be configured to monitor and/or control operation of any of the aforementioned components.

[0026] In one implementation, the hydrogen supply system includes an air supply valve arranged in the air supply line, in particular arranged upstream of the air supply-reformer interface and/or downstream of the compressing device. The air supply valve allows for controlling a flow of charged air to the reformer device. The control unit may be configured to control the air supply valve.

[0027] In one implementation, the hydrogen supply system includes a fuel supply valve. The fuel supply valve is preferably arranged in the fuel supply line, in particular arranged upstream of the reformer and downstream of the fuel supply. The fuel supply valve is preferably arranged upstream of the evaporator. The fuel supply valve allows for controlling a flow of fuel to the

reformer device, typically a flow of liquid fuel to the evaporator. The control unit may be configured to control the fuel supply valve.

[0028] In one implementation, the fuel supply line or the fuel supply includes a fuel pump, such as a pressure regulating pump to convey the fuel in the fuel supply line. The control unit may be configured to control the fuel pump. The fuel pressure inside the reformer can be set by the control unit based on controlling the fuel pump and/or the fuel supply valve.

[0029] In one implementation, the hydrogen supply system further includes a reformed-gas supply valve. The reformed-gas supply valve may be arranged downstream of the reformed-gas tank, in particular in the gas line connecting the reformed-gas tank and the power generating system. The reformed-gas supply valve allows for controlling a flow of reformed gas to the power generator. The control unit may be configured to control the reformed-gas supply valve.

[0030] In one implementation, the hydrogen supply system further includes one or more pressure sensors. Illustratively, the hydrogen supply system may include a (first) pressure sensor arranged upstream of the reformer and/or downstream of the pre-heater. The (first) pressure sensor may be in fluid communication with the gas line connecting the pre-heater and the reformer. The (first) pressure sensor may be configured for sensing or monitoring the pressure of the gaseous fuel. The control unit may be configured to control a temperature in the evaporator and/or the pre-heater and/or control the flow of fuel, for example by controlling the fuel supply valve, based on the sensed fuel pressure. A conversion rate of the fuel (e.g. ammonia or methanol) may depend upon the pressure level in the fuel reformer. The control unit may be configured to maintain the fuel pressure at a predetermined pressure level to achieve a high conversion efficiency.

[0031] Additionally, the hydrogen supply system may include several pressure sensors. For example, a further (e.g. second) pressure sensor may be

arranged upstream of the pre-heater and downstream of the evaporator. A further (e.g. third) pressure sensor may be arranged in the air supply line, such as downstream of the compressing device and/or upstream of the air supply-reformer interface. The control unit may be configured to control a compression ratio of the compressing device based on a sensed charged air pressure.

[0032] In one implementation, the hydrogen supply system further includes one or more temperature sensors. The reformer device may include a first or inflow temperature sensor arranged upstream of the reformer or in an upstream portion of the reformer. The inflow temperature sensor is preferably arranged downstream of the evaporator and/or downstream of the pre-heater. The inflow temperature sensor allows for sensing or monitoring a temperature of one or more of the gases in the reformer, such as the fuel or the charged air or a fuel-charged air mixture. The control unit may be configured to control any of above-described heaters based on the sensed inflow temperature. A conversion rate of the fuel (e.g. ammonia or methanol) may depend upon the temperature of the gases in the fuel reformer. The control unit may be configured to maintain the temperature at a predetermined temperature to achieve a high conversion efficiency. Furthermore, the control unit may be configured to maintain the temperature below a predetermined threshold temperature for safety reasons.

[0033] The reformer device may include a second or outflow temperature sensor arranged downstream of the reformer or in a downstream portion of the reformer. The outflow temperature sensor may be arranged upstream of the reformed-gas tank. The outflow temperature sensor allows for sensing or monitoring a temperature of the reformed gas exiting the reformer. The control unit may be configured to control any of above-described heaters based on the sensed outflow temperature. Additionally, or alternatively, the control unit may be configured to control the cooler based on the sensed outflow temperature. The control unit may be configured to adjust the cooling

of the reformed gas to ensure that the temperature drops below a predetermined threshold temperature for safety reasons.

[0034] In one implementation, the reformed-gas tank has a purging valve for draining liquid, in particular water. After cooling down the reformed gas, for example to ambient temperature, some of the components of the reformed gas may liquify and may accumulate or amass at the bottom of the reformed-gas tank. The purging valve may allow for releasing or draining any liquid components contained in the reformed-gas tank. The control unit may be configured to control operation of the purging valve.

[0035] The control unit may be configured to monitor each of the parameters sensed by the sensors and control each of the abovementioned pumps, compressors, valves, as well as heaters and coolers to maximise conversion efficiency of the reforming process while ensuring safe operation and while optimising energy efficiency.

[0036] According to an embodiment, the hydrogen supply system includes a heat transfer system. The heat transfer system allows for transferring heat by means of one or more heat exchangers. In order to generate hydrogen in the reformer at a high conversion rate, the hydrogen supply system of the present disclosure utilises a substantial amount of energy for heating purposes in the reformer device. In order to efficiently store the reformed gas, and in order to reduce or eliminate safety risks due to high-temperature hydrogen gas, the hydrogen supply system utilises a substantial amount of energy for cooling the reformed gas. Beneficially, the heat transfer system allows for heat transfer between the aforementioned heating and cooling systems and therefore substantially increases the energy efficiency of the hydrogen supply system.

[0037] According to an embodiment, the heat transfer system includes a first heat exchanger configured to cool gas received from the reformer device by a heat transfer fluid. The first heat exchanger may correspond to the heat

exchanger described above relating to cooling of the reformed gas. The first heat exchanger may also be referred to as a cooler. The heat transfer fluid, when flowing into the first heat exchanger, may have a temperature substantially below the temperature of the reformed gas, such as ambient temperature or lower. The first heat exchanger is preferably disposed upstream of or within the reformed-gas tank. The heat transfer system is preferably configured to transfer heat from the reformed gas to the fuel upstream of the reformer based on the heat transfer fluid and the first heat exchanger.

[0038] According to an embodiment, the heat transfer system includes at least one further (second, third, ...) heat exchanger. The further heat exchanger may be disposed upstream of or within the reformer device. The further heat exchanger is preferably configured to heat fuel by means of a heat transfer fluid. The further heat exchanger may also be referred to as a (first, second,...) heater. The further heat exchanger may correspond to any of the heat exchangers described above related to heating in the reformer device (evaporator, pre-heater, reformer). The heat transfer fluid utilised in the first heat exchanger and the heat transfer fluid utilised in the at least one further heat exchanger may be the same or may be different fluids.

[0039] The heat transfer system may be generally configured such that the thermal energy is transferred from the reformed gas to the fuel or fuel-charged air mixture. Preferably, the first heat exchanger and the further heat exchanger are thermally connected.

[0040] In one embodiment, the heat transfer system is configured to transfer thermal energy from the heat transfer fluid utilised in the first heat exchanger to the heat transfer fluid utilised in the at least one further heat exchanger. For example, an additional heat exchanger may be provided to exchange heat between the heat transfer fluids. In this embodiment, the heat transfer system

may include two separate heat transfer fluid circuits, which are thermally coupled to each other.

[0041] According to another embodiment, the first heat exchanger is in fluid communication with the further heat exchanger. It is to be understood that with "fluid communication" it is meant a fluid communication between the first and the further heat exchanger via the heat transfer fluid (the first and the further heat exchanger may additionally be in fluid communication due to fluid flow through the reformer and into the reformed-gas tank). In this embodiment, the first and the further heat exchanger utilise the same heat transfer fluid. The hydrogen supply system may include a single heat transfer fluid circuit. The heat transfer fluid may be conveyed from the first heat exchanger to the at least one further heat exchanger and/or vice versa.

[0042] The heat transfer system preferably defines a fluid circuit for continuously circulating heat transfer fluid between the first heat exchanger and the at least one further heat exchanger. Typically, the heat transfer system includes a first heat transfer fluid line for supplying heat transfer fluid to the first heat exchanger and a second heat transfer fluid line for draining heat transfer fluid from the first heat exchanger. A downstream end of the first heat transfer fluid line may connected to an inlet of the first heat exchanger. An upstream end of the second heat transfer fluid line may connected to an outlet of the first heat exchanger.

[0043] The heat transfer system may further include a pump for circulating heat transfer fluid. The pump may be arranged within the second heat transfer fluid line.

[0044] The at least one further heat exchanger may include a second heat exchanger disposed within the pre-heater and/or a third heat exchanger disposed within the evaporator. In case the pre-heater is dispensed with or in case the pre-heater does not include a heat exchanger, the heat exchanger disposed within the evaporator may also be referred to as second heat

exchanger. The at least one further heat exchanger may include a fourth heat exchanger disposed within the reformer.

[0045] In case the heat transfer system only includes two heat exchangers, the first and second heat transfer fluid lines may be both connected to the second heat exchanger.

[0046] In case the heat transfer system includes three or more heat exchangers, the heat transfer fluid may preferably be conveyed in series from one heat exchanger to another heat exchanger. Illustratively, the heat transfer system may be configured to continuously circulate heat transfer fluid or thermal fluid from the first heat exchanger (e.g. arranged within the reformed-gas tank) to the second heat exchanger of the pre-heater, from the second heat exchanger of the pre-heater to the third heat exchanger of the evaporator, and from the third heat exchanger of the evaporator to the first heat exchanger.

[0047] For example, an upstream end of the first heat transfer fluid line may connected to an outlet of the third heat exchanger. The heat transfer system may include a third heat transfer fluid line for conveying heat transfer fluid from the second heat exchanger to the third heat exchanger. For example, an upstream end of the third heat transfer fluid line may be connected to an outlet of the second heat exchanger and a downstream end of the third heat transfer fluid line may be connected to an inlet of the third heat exchanger. A downstream end of the second heat transfer fluid line may be connected to an inlet of the second heat exchanger.

[0048] In an embodiment, the heat transfer system is configured to exchange thermal energy with an external cold source. This embodiment may be particularly beneficial in case the heat transfer fluid is not cold enough to sufficiently cool down the reformed gas by means of the first heat exchanger. This may be the case if the at least one further heat exchanger does not sufficiently cool the heat transfer fluid before entering the first heat

exchanger. For example, the external cold source may be a river, an outdoor water tank, or the sea.

[0049] In one exemplary embodiment, the heat transfer system includes an external heat exchanger for exchanging thermal energy between the heat transfer fluid and the external cold source. The external heat exchanger may be arranged upstream of the first heat exchanger. The external heat exchanger may have a fluid connection to the first heat transfer fluid line. Typically, the external heat exchanger is not arranged within any of the heat transfer fluid lines. The first heat transfer fluid line may include an upstream bypass or upstream bifurcation for diverting at least a portion of the heat transfer fluid into and through the external heat exchanger and a downstream bypass or downstream bifurcation for directing the heat transfer fluid back to the first heat transfer fluid line. This allows for selectively controlling the cooling by means of the external cold source such that the heat transfer fluid is not cooled down more than required. The heat transfer system may further include an upstream valve at the upstream bifurcation or upstream of the external heat exchanger and/or a downstream valve at the downstream bifurcation or downstream of the external heat exchanger. The control unit may be configured to control the upstream valve and/or the downstream valve based on a temperature sensed by the one or more temperature sensors.

[0050] In another embodiment, the heat transfer system is configured to exchange thermal energy with a heat source. The heat source is preferably exhaust gas of the power generating system, but alternatively can be an external heat source, such as excess heat generated by a factory or the like. This embodiment may be particularly beneficial in case the heat transfer fluid is not hot enough to sufficiently heat up the fuel by means of the further heat exchanger(s). This may be the case if the first heat exchanger does not sufficiently heat up the heat transfer fluid before flowing into the further heat exchanger. In case the heat is derived from exhaust gas, the exhaust gas may be picked off directly from an exhaust gas manifold of the power generating

system or may be picked off downstream of a turbine of the turbocharging system.

[0051] In one exemplary embodiment, the heat transfer system includes an exhaust gas heat exchanger for exchanging thermal energy between the heat transfer fluid and the exhaust gas. The exhaust gas heat exchanger may be arranged downstream of the first heat exchanger. The exhaust gas heat exchanger may have a fluid connection to the second heat transfer fluid line. Typically, the exhaust gas heat exchanger is not arranged within any of the heat transfer fluid lines. The second heat transfer fluid line may include an upstream bypass or upstream bifurcation for diverting at least a portion of the heat transfer fluid into and through the exhaust gas heat exchanger and a downstream bypass or downstream bifurcation for directing the heat transfer fluid back to the second heat transfer fluid line. This allows for selectively controlling the heating by means of the hot exhaust gas such that the heat transfer fluid is not warmed up more than required. The heat transfer system may further include an upstream exhaust valve at the upstream bifurcation or upstream of the exhaust gas heat exchanger and/or a downstream exhaust valve at the downstream bifurcation or downstream of the exhaust gas heat exchanger. The control unit may be configured to control the upstream exhaust valve and/or the downstream exhaust valve based on a temperature sensed by the one or more temperature sensors.

[0052] The control unit may be configured to control operation of the heat transfer system. The control unit may be configured to control the pump for circulating heat transfer fluid and/or any of the aforementioned valves for diverting heat transfer fluid to the exhaust gas heat exchanger and/or the external heat exchanger, in particular based on a temperature sensed by the one or more temperature sensors.

[0053] According to another aspect of the present disclosure, a hydrogen supply system for a power generating system is provided. The power

generating system includes an intake manifold and a turbocharging system for supplying charged air to the intake manifold. The hydrogen supply system includes a reformer device including an autothermal reformer. The reformer device is configured to supply a power generator of the power generating system with hydrogen. The hydrogen supply system further includes a fuel supply line configured for fluid communication with a fuel supply. The fuel supply line is in fluid communication with the reformer device for supplying fuel to the reformer device. The hydrogen supply system includes an air supply line in fluid communication with the reformer device for supplying the reformer device with air. The hydrogen supply system further includes a heat transfer system including a first heat exchanger configured to cool gas received from the reformer device by a heat transfer fluid. The heat transfer system may be provided according to any the embodiments of the present disclosure. Optionally, the air may be charged air. The air supply line may be configured for fluid communication with the intake manifold for receiving the charged air from the intake manifold. The air supply line may further include a compressing device upstream of the reformer device. The compressing device may be configured to increase the pressure of the charged air received from the intake manifold.

[0054] According to another aspect of the present disclosure, a power generating system is provided. The power generating system includes the hydrogen supply system according to any embodiment of the present disclosure. The power generating system further includes a turbocharging system, a power generator, an intake manifold and an exhaust manifold.

[0055] The turbocharging system includes at least one turbine and at least one compressor. The at least one turbine of the turbocharging system is configured to receive exhaust gas from the exhaust manifold. The turbine is fluidically and mechanically connected to the exhaust manifold at a downstream end thereof. Each turbine of the turbocharging system can have a variable geometry device including a variable nozzle and/or a multi-entry,

wherein at least one entry is configured to be closed, or at least partially closed.

[0056] The compressor of the turbocharging system is configured to provide the intake manifold with charged air. The compressor is fluidically and mechanically connected to the intake manifold at an upstream end thereof.

[0057] The turbocharging system of the present disclosure may be a single stage turbocharging system or a multistage turbocharging system, with, for each stage, at least one turbine and at least one compressor. The turbocharging system may be an electric turbocharger including an electric machine. The turbocharging system may include a heat exchanger downstream of the turbine.

[0058] The compressor and the turbine may be connected via a shaft. Further, the at least one electric machine can be arranged between the compressor and the turbine. Alternatively, the at least one electric machine can be arranged on the compressor side and coupled to the compressor.

[0059] The turbocharging system can be a shafted turbocharger. A "shafted turbocharger" can be understood as a turbocharger, where the compressor and the turbine are mechanically connected via a shaft. Alternatively, the turbocharging system can be a non-shafted turbocharger. A "non-shafted turbocharger" can be understood as a turbocharger, where the compressor and the turbine are not mechanically connected or mechanically coupled. In other words, in a non-shafted turbocharger, the compressor and the turbine are typically configured to operate independently and are not connected by a central shaft. Instead, the compressor and the turbine can be arranged in close proximity, e.g., within the same housing or assembly, but do not share a common shaft connecting them.

[0060] The intake manifold may be fluidly and/or mechanically connected to the air supply line. The air supply line may include an air supply-intake manifold interface connected to the intake manifold. The compressing device may be arranged upstream of the air supply-reformer interface and downstream of the air supply-intake manifold interface.

[0061] According to an embodiment, the power generator is an internal combustion engine having one or more combustion chambers. The internal combustion engine may be in fluid communication with the reformed-gas supply line, in particular in fluid communication with the reformed-gas tank. Preferably, the fuel supply line is fluidly connected to the intake manifold. The internal combustion engine may utilise hydrogen or reformed gas as a main fuel. Preferably, the reformer device may be configured to supply the internal combustion engine with hydrogen for promoting combustion at cold start or at partial load operations. The internal combustion engine may utilise another type of fuel as its main fuel, such as ammonia or methanol. The internal combustion engine may also be a dual fuel engine, utilising a first type of fuel, such as ammonia or methanol, and a second type of fuel, such as diesel. The reformed gas may be provided as a combustion promoter.

[0062] The fuel supply may be fluidically connected to the internal combustion engine. The fuel supply line may include a bifurcation or splitting portion. The fuel supply line may have a reformer fuel supply branch and a power generator fuel supply branch. The reformer fuel supply branch may be fluidly connected to the reformer device and/or the power generator fuel supply branch may be fluidly connected to the power generator, such as the internal combustion engine. The power generator fuel supply branch may include a power generator supply valve. The power generator fuel supply branch may be directly connected to the cylinders of the internal combustion engine, such as through a high-pressure injection system to achieve diffusion combustion. Alternatively, the power generator fuel supply branch may be connected to the intake manifold for premixed combustion.

[0063] According to an embodiment, the power generator is a fuel cell. The fuel cell is in fluid communication with the reformed-gas supply line, in particular the reformed-gas tank. The fuel cell may include a fuel supply interface connected to the reformed-gas supply line. The fuel cell may be any kind of fuel cell, but preferably is a high or mid-temperature fuel cell, such as a solid oxide fuel cell, a molten-carbonate fuel cell, or a protonic ceramic fuel cell. Alternatively, the fuel cell may also be any other type of fuel cell, for example a low-temperature or a high-temperature Proton Exchange Membrane Fuel Cell. In case the power generator is a fuel cell, the reformed gas provided by the hydrogen supply system may correspond to a main fuel supply.

[0064] The power generating system may further include a control unit or power generator control unit. The control unit may be configured to control operation of the power generating system. The control unit of the hydrogen supply system may be a separate device than the power generator control unit, with both control units being operatively connected to each other. For example, the power generator control unit may be configured to send a hydrogen demand signal or reformed gas demand signal to the control unit of the hydrogen supply system. The power generator control unit may be configured to control the power generator supply valve. In other implementations, the control unit of the hydrogen supply system is a portion or a subunit of the power generator control unit.

[0065] The power generating system may include a plurality of power generators, such as a plurality of internal combustion engines, or a plurality of fuel cells or a combination of fuel cells and internal combustion engines. The hydrogen supply system is preferably configured to provide reformed gas to each of the power generators of the power generating system.

[0066] The power generating system of the present disclosure may be particularly utilised in the fields of power generation, and marine applications.

[0067] Those skilled in the art will recognise additional features and advantages upon reading the following detailed description, and upon viewing the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] The components in the Figures are not necessarily to scale, instead emphasis being placed upon illustrating the principles of the invention. Moreover, in the Figures, like reference signs designate corresponding parts. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

Fig. 1 shows a schematic view of a hydrogen supply system according to embodiments described herein;

Fig. 2 shows a schematic view of a hydrogen supply system according to embodiments described herein;

Fig. 3 shows a schematic view of power generating system including an internal combustion engine according to further embodiments described herein;

Fig. 4 shows a schematic view of power generating system including a fuel cell according to further embodiments described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0069] Reference will now be made in detail to the various embodiments, one or more examples of which are illustrated in each figure. Each example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with any other embodiment to yield yet a further embodiment. It is intended that the present disclosure includes such modifications and variations.

[0070] Within the following description of the drawings, the same reference numbers refer to the same or to similar components. Generally, only the differences with respect to the individual embodiments are described. Unless specified otherwise, the description of a part or aspect in one embodiment can apply to a corresponding part or aspect in another embodiment as well.

[0071] With exemplary reference to Figure 1, a hydrogen supply system 100 is described. The hydrogen supply system 100 includes a reformer device 110. The reformer device 110 includes an autothermal reformer 111 and may optionally include a pre-heater 112 and an evaporator 113.

[0072] The hydrogen supply system 100 further includes an air supply line 130. The air supply line 130 is connectable or connected to a power generating device (not shown in Figure 1), and receives charged air from the power generating device. The air supply line 130 has an air supply-intake manifold interface 132 for connecting the air supply line 130 to the power generating system. The air is preferably charged by a turbocharging system (not shown in Figure 1), and may have a pressure of 5 bar, for example. The air supply line 130 further includes a compressing device or compressor 133 arranged within the air supply line 130. The compressing device 133 further compresses the charged air, for example up to a pressure of about 10 bar. The air supply line 130 may further include an air supply valve 134 for controlling the flow of charged air through the air supply line 130. The air supply valve

134 is preferably arranged downstream of the compressing device 133. The air supply line 130 includes an air supply-intake manifold interface 131 for connecting the air supply line 130 to the reformer 111.

[0073] The hydrogen supply system 100 includes a fuel supply line 120 for supplying fuel to the reformer device 110. In the embodiment shown in Figure 1, the fuel is liquid ammonia. The fuel supply line 120 is configured to receive fuel from a fuel supply 210. The fuel supply line 120 is connectable or connected to the fuel supply 210. The fuel supply line 120 further includes a fuel pump 122 for pumping fuel through the fuel supply line 120 and a fuel supply valve 121 for controlling the flow of fuel through the fuel supply line 120. The fuel supply 120 is connected to the reformer device 110. In the embodiment shown in Figure 1, the fuel supply line 120 is connected to the evaporator 113. Furthermore, the fuel supply line 120 may be a manifold including different lines. For example, the fuel supply line 120 may include a splitter or bifurcation 123 having a reformer fuel supply branch 124 connected to the reformer device 110 and a power generator fuel supply branch 125 connectable to the power generating system. The power generator fuel supply branch 125 may include a power generator supply valve 126 for controlling the flow of fuel to the power generating system.

[0074] The evaporator 113 may receive the fuel in liquid form from the fuel supply line 120 and is configured to evaporate the fuel to generate gaseous fuel. The reformer device 110 includes a gas line connecting the evaporator 113 and the pre-heater 112, such that gaseous fuel flows from the evaporator 113 to the pre-heater 112. The pre-heater 112 is configured to heat up the fuel to at least 250 °C or to at least 300 °C or even up to at least 350-450 °C. The reformer device 110 further includes a gas line connecting the pre-heater 112 and the autothermal reformer 111, such that gaseous fuel flows from the pre-heater 112 to the reformer 111.

[0075] In the reformer 111, a gas mixture including the fuel and the charged air are reformed to generate a reformed gas including hydrogen. The reformer 111 includes a heater 117 for heating or maintaining the fuel-charged air mixture at an elevated temperature. Preferably, the heater is an electric heater 117. A catalyst 154 or catalyst brick may be arranged within the reformer 111. The catalyst 154 may be disposed on the heater 117, for example provided as a coating on the heater, or downstream of the heater 117.

[0076] The hydrogen supply system 100 further includes a reformed-gas tank 140. A gas line may connect an outlet of the reformer 111 with a reformed-gas tank inlet 141. A reformed-gas supply line 143 is connected to the reformed-gas tank 140 via a reformed-gas tank outlet 142. The reformed-gas supply line 143 is connectable or connected to the power generating system, such as the intake manifold. The reformed-gas tank 140 further includes a reformed-gas supply valve 144, for example arranged in the reformed-gas supply line 143.

[0077] The hydrogen supply system 100 may include one or more sensors. An inflow temperature sensor 114 may be arranged upstream of the reformer 111 and/or an outflow temperature sensor 115 may be arranged downstream of the reformer 111. One or more pressure sensors 116 may be provided, in particular in the fuel supply line 120 and/or in the air supply line 130 as well as in any of the evaporator 113, the pre-heater 112, or the reformer 111. For instance, a pressure sensor 116 may be provided to measure the pressure of the heated gaseous fuel downstream of the pre-heater 112.

[0078] The hydrogen supply system 100 further includes a control unit 160. The control unit 160 may be configured to control operation of the hydrogen supply system 100, such as any of the valves, sensors, pumps, compressors and heaters.

[0079] With exemplary reference to Figure 2, a hydrogen supply system 100 is described. The hydrogen supply system 100 illustrated in Figure 2

corresponds to that illustrated in Figure 1, but contains several further optional features.

[0080] The hydrogen supply system 100 shown in Figure 2 includes a heat transfer system 150. The heat transfer system 150 includes a first heat exchanger 161 for cooling down the reformed gas in the reformed-gas tank 140, such as to approximately ambient temperature. The heat exchanger 161 preferably includes a tube or pipe through which a working fluid or heat transfer fluid is conveyed to cool down the reformed-gas. The heat transfer fluid preferably flows in a circulating manner.

[0081] The heat transfer system 150 further includes a second heat exchanger 153 disposed within the pre-heater 112 and a third heat exchanger 155 disposed within the evaporator 113. The second and third heat exchangers 153, 155 are configured to heat up liquid or gaseous fuel. The heat exchangers 153, 155 preferably include a tube or pipe through which a working fluid or heat transfer fluid is conveyed to heat up the fuel. The heat transfer fluid preferably flows in a circulating manner. In addition, the evaporator 113 may include an electric heater 118 and/or the pre-heater 112 may include an electric heater 119.

[0082] The heat transfer system 150 defines a closed fluid circuit. The heat transfer system 150 includes a pump 158 for circulating heat transfer fluid through the first, second and third heat exchangers 161, 153, 155.

[0083] The heat transfer system 150 includes a first heat transfer fluid line 151 which connects an outlet of the third heat exchanger 153 within the evaporator 113 with a first heat exchanger inlet 157 of the first heat exchanger 161. The heat transfer system 150 includes a second heat transfer fluid line 152 which connects a first heat exchanger outlet 156 of the first heat exchanger 161 with an inlet of the second heat exchanger 153. The pump 158 for circulating heat transfer fluid may be arranged in the second heat transfer fluid line 152. The heat transfer system 150 further includes a third heat

transfer fluid line 159 which connects an outlet of the second heat exchanger 153 with an inlet of the third heat exchanger 155.

[0084] Additionally, the heat transfer system 150 may include an external heat exchanger 162 for exchanging heat between the heat transfer fluid and a cold external fluid, such as a river. The external heat exchanger 162 may include a first external cold source interface 164 for receiving the external fluid, and a second external cold source interface 165 for draining the external fluid. The first heat transfer fluid line 151 may include an upstream bypass or upstream bifurcation for diverting at least a portion of the heat transfer fluid into and through the external heat exchanger 162 and a downstream bypass or downstream bifurcation for directing the heat transfer fluid back to the first heat transfer fluid line 151. The heat transfer system 150 may further include an upstream valve at the upstream bifurcation or upstream of the external heat exchanger 162 and a downstream valve at the downstream bifurcation or downstream of the external heat exchanger 162.

[0085] Additionally, or alternatively, the heat transfer system 150 may include an exhaust gas heat exchanger 163 for exchanging heat between the heat transfer fluid and exhaust gas. Typically, exhaust gas may be diverted from the exhaust manifold of the power generating system or from downstream of a turbine of a turbocharging system of the power generating system to the exhaust gas heat exchanger 163. The exhaust gas heat exchanger 163 may include a first exhaust gas interface 166 for receiving the exhaust gas, and a second exhaust gas interface 167 for draining the exhaust gas. The second heat transfer fluid line 152 may include an upstream bypass or upstream bifurcation for diverting at least a portion of the heat transfer fluid into and through the exhaust gas heat exchanger and a downstream bypass or downstream bifurcation for directing the heat transfer fluid back to the second heat transfer fluid line 152. The heat transfer system 150 may further include an upstream exhaust valve at the upstream bifurcation or upstream of the exhaust gas heat exchanger 163 and/or a downstream exhaust valve at the

downstream bifurcation or downstream of the exhaust gas heat exchanger 163.

[0086] The reformed-gas tank 140 may further include a purging valve 145 for draining liquid, in particular water. The purging valve allows for releasing or draining any liquid components contained in the reformed-gas tank 140.

[0087] With exemplary reference to Figure 3, a power generating system 200 is described. The power generating system 200 includes the hydrogen supply system 100 according to any embodiment described herein.

[0088] The power generating system 200 includes a power generator, the power generator being an internal combustion engine 201. The power generating system 200 includes an intake manifold 220 and an exhaust gas manifold 250 fluidly connected to the internal combustion engine 201.

[0089] The power generating system 200 further includes a turbocharging system 240 having a compressor 241 and a turbine 242 which may be mechanically connected to each other by means of a shaft. The exhaust gas manifold 250 is connected to a turbine inlet 244 of the turbine. The intake manifold 220 is connected to a compressor outlet 245 of the compressor 241. The compressor 241 is configured to provide charged air to the intake manifold 220. The turbocharging system 240 may include one or more heat exchangers, such as a heat exchanger 243 disposed within the air intake manifold 220.

[0090] The air intake manifold 220 is fluidly connected to the air supply line 130 of the hydrogen supply system 100. For example, a portion of the charged air may be diverted from the intake manifold 220 by means of an air supply line 280 of the power generating system 200, which is connected to the air supply line 130 of the hydrogen supply system 100.

[0091] The reformed gas supply line 143 is fluidly connected to the internal combustion engine 201. For example, the reformed gas supply line 143 may be connected to a reformed-gas supply line 270 of the power generating system 200 which is connected to the air intake manifold 220.

[0092] The power generator fuel supply branch 125 may be directly connected to the cylinders of the internal combustion engine 201 via a fuel supply line 260 of the power generating system 200, such as through a high-pressure injection system to achieve diffusion combustion. Alternatively, the power generator fuel supply branch 125 may be connected to the intake manifold 220 for premixed combustion.

[0093] The power generating system 200 includes an internal combustion engine (ICE) controller or ICE control unit 230. The ICE controller 230 may be configured to control operation of the power generating system 200. Although Figure 3 shows the ICE control unit 230 and the control unit 160 as separate devices, it is to be understood that the power generating system may include a single control unit or any other number of control units for controlling operation of the power generating system.

[0094] With exemplary reference to Figure 4, a power generating system 300 according to another embodiment is described. The power generating system 300 includes the hydrogen supply system 100 according to any embodiment described herein.

[0095] The power generating system 200 includes a power generator, the power generator being a fuel cell 301. The power generating system 300 includes an intake manifold 320 and an exhaust gas manifold 350 fluidly connected to the fuel cell 301.

[0096] The power generating system 300 further includes a turbocharging system 340 having a compressor 341 and a turbine 342 which may be mechanically connected to each other by means of a shaft. The exhaust

manifold 350 is connected to a turbine inlet of the turbine 342. The intake manifold 320 is connected to a compressor outlet of the compressor 341. The compressor 341 is configured to provide charged air to the intake manifold 320. The turbocharging system 340 may include one or more heat exchangers, such as a heat exchanger 343 disposed within the air intake manifold 320. The heat exchanger 343 may be configured to exchange between exhaust gas from downstream of the turbine 342 and charged air from downstream of the compressor 341.

[0097] The air intake manifold 320 is fluidly connected to the air supply line 130 of the hydrogen supply system 100. For example, a portion of the charged air may be diverted from the intake manifold 320 by means of an air supply line 380 of the power generating system 300, which is connected to the air supply line 130 of the hydrogen supply system 100.

[0098] The reformed gas supply line 143 is fluidly connected to the fuel cell 301. For example, the reformed gas supply line 143 may be connected to a reformed-gas supply line 370 of the power generating system 300 which may be connected to a (fuel) intake manifold.

[0099] Although Figure 4 shows the power generator fuel supply branch 125 being present, the power generator fuel supply branch 125 may not be connected the fuel cell 301 or dispensed with entirely.

[00100] Further, although Figure 4 does not show any control units, the power generating system 300 may include a fuel cell controller or fuel cell control unit (or broadly, a power generator controller). The fuel cell controller may be configured to control operation of the power generating system 300.

[00101] While the foregoing is directed to embodiments, other and further embodiments may be devised without departing from the basic scope, and the scope is determined by the claims that follow.

REFERENCE NUMERALS

100	hydrogen supply system
110	reformer device
111	reformer
112	pre-heater
113	evaporator
114	inflow temperature sensor
115	outflow temperature sensor
116	pressure sensor
117	electric heater reformer
118	electric heater evaporator
119	electric heater pre-heater
120	fuel supply line
121	fuel supply valve
122	fuel pump
123	bifurcation
124	reformer fuel supply branch
125	power generator fuel supply branch
126	power generator supply valve
130	air supply line
131	air supply-reformer interface
132	air supply-intake manifold interface
133	compressing device
134	air supply valve

140	reformed-gas tank
141	reformed-gas tank inlet
142	reformed-gas tank outlet
143	reformed-gas supply line
144	reformed-gas supply valve
145	purging valve
150	heat transfer system
151	first heat transfer fluid line
152	second heat transfer fluid line
153	second heat exchanger for pre-heater
154	catalyst
155	third heat exchanger for evaporator
156	first heat exchanger outlet
157	first heat exchanger inlet
158	pump for circulating heat transfer fluid
159	third heat transfer fluid line
160	control unit
161	first heat exchanger
162	external heat exchanger
163	exhaust gas heat exchanger
164	first external cold source interface
165	second external cold source interface
166	first exhaust gas interface
167	second exhaust gas interface

200, 300	power generating system
201	internal combustion engine
210, 310	fuel supply
220, 320	air intake manifold
230	ICE controller

240, 340	turbocharging system
241, 341	compressor of turbocharging system
242, 342	turbine
243, 343	heat exchanger
244	turbine inlet
245	compressor outlet
250, 350	exhaust gas manifold
260	fuel supply line
270, 370	reformed-gas supply line
280, 380	air supply line
301	fuel cell

CLAIMS

1. A power generating system (200, 300) comprising an intake manifold (220), a power generator, an exhaust manifold, a turbocharging system (240, 340) for supplying charged air to the intake manifold (220, 320), and a hydrogen supply system (100), the hydrogen supply system (100) comprising:

a reformer device (110) comprising a reformer (111), the reformer device (110) configured to supply the power generator (201, 301) with hydrogen;

a fuel supply line (120) configured for fluid communication with a fuel supply (210); the fuel supply line being in fluid communication with the reformer device (110) for supplying fuel to the reformer device (110);

an air supply line (130) configured for fluid communication with the intake manifold (220, 320) for receiving the charged air from the intake manifold (220, 320); the air supply line being in fluid communication with the reformer device (110) for supplying the reformer device with the charged air;

wherein the air supply line (130) further includes a compressing device (133) upstream of the reformer device (110), the compressing device (133) configured to increase the pressure of the charged air received from the intake manifold (220, 320).

2. The power generating system (200, 300) of claim 1, wherein the reformer (111) includes an electric heater (117), configured to heat a gas mixture contained within the reformer (111) to at least 300 °C, preferably to at least 400 °C.

3. The power generating system (200, 300) of claim 2, wherein the electric heater (117) is coated with a catalyst (154).

4. The power generating system (200, 300) of any preceding claim, further comprising a reformed-gas tank (140), the reformed-gas tank having a reformed-gas tank inlet (141) in fluid communication with an outlet of the reformer device (110) and a reformed-gas tank outlet (142) configured for fluid communication with the power generating system (200, 300).

5. The power generating system (200, 300) of claim 4, wherein the hydrogen supply system (100) further comprises a heat transfer system (150) including a first heat exchanger (161) configured to cool gas received from the reformer device (110) by a heat transfer fluid, in particular wherein the first heat exchanger (161) is disposed upstream of or within the reformed-gas tank (140).

6. The power generating system (200, 300) of claim 5, wherein the heat transfer system (150) includes at least one further heat exchanger (153, 155) disposed upstream of or within the reformer device (110), the further heat exchanger being in particular configured to heat a fluid or fluid mixture by a heat transfer fluid, wherein the first heat exchanger (161) and the further heat exchanger are thermally connected.

7. The power generating system (200, 300) of claim 6, wherein the first heat exchanger (161) is in fluid communication with the further heat exchanger (153, 155).

8. The power generating system (200, 300) of claim 6 or 7, wherein the reformer device (110) includes a pre-heater (112) in fluid communication with the fuel supply line (120), and configured to supply heated fuel to the reformer (111), wherein the at least one further heat exchanger includes a second heat exchanger (153) disposed within the pre-heater (112).

9. The power generating system (200, 300) of any one of claims 6 to 8, wherein the reformer device (110) includes an evaporator (113) in fluid communication with the fuel supply line (120), the evaporator being configured to supply gaseous fuel to the pre-heater (112) or the reformer (111), wherein the at least one further heat exchanger includes a third heat exchanger (155) disposed within the evaporator (112).

10. The power generating system (200, 300) of any one of claims 6 to 9, wherein the heat transfer system (150) defines a fluid circuit for continuously circulating heat transfer fluid between the first heat exchanger (161) and the at least one further heat exchanger (153, 155), in particular wherein the heat transfer system (150) is configured to continuously circulate heat transfer fluid from the first heat exchanger (161) of the reformed-gas tank (140) to the second heat exchanger of the pre-heater (112), from the second heat exchanger of the pre-heater (112) to the third heat exchanger of the evaporator (113), and from the third heat exchanger of the evaporator (113) to the first heat exchanger (161) of the reformed-gas tank (140).

11. The power generating system (200, 300) of any one of claims 5 to 10, wherein the heat transfer system (150) includes an external heat exchanger (162) for exchanging heat between the heat transfer fluid and an external cold source; and/or wherein the heat transfer system (150) includes an exhaust gas heat exchanger (163) for exchanging heat between the heat transfer fluid and exhaust gas.

12. The power generating system (200, 300) of any one of claims 4 to 11, wherein the reformed-gas tank (140) has a purging valve (145) for draining liquid.

13. The power generating system (200, 300) of any preceding claim, further comprising a control unit (160), and

a) wherein the hydrogen supply system (100) further includes a pressure sensor (116), preferably arranged upstream of the reformer (111), for sensing a fuel pressure, wherein the fuel supply line (120) further includes a fuel supply valve (121), and wherein the control unit (160) is configured to control the fuel supply valve (121) based on the sensed fuel pressure; and/or

b) wherein the reformer device (110) comprises at least one temperature sensor (114, 115), preferably arranged upstream of the reformer (111), for sensing a temperature of the fuel or the charged air or a fuel-charged air mixture, and wherein the control unit (160) is configured to control the electric heater (117) and/or the heat transfer system (150) based on the sensed temperature; and/or

c) wherein the hydrogen supply system (100) further comprises a reformed-gas supply valve (144), preferably arranged downstream of the reformed-gas tank (140), and wherein the control unit (160) is configured to control the reformed-gas supply valve (144) to set a flow of reformed gas supplied to the power generator (201, 301); and/or

d) wherein the hydrogen supply system (100) further comprises an air supply valve (134), preferably arranged upstream of the reformer device (110), and wherein the control unit (160) is configured to control the air supply valve (134) to set a flow of charged air supplied to the reformer device (110).

14. The power generating system (200) of any one of claims 4 to 12, wherein the power generator is an internal combustion engine (201) having a combustion chamber, wherein the internal combustion engine (201) is in fluid communication with the reformed-gas tank outlet (142).

15. The power generating system (300) of any one of claims 4 to 12, wherein the power generator is a fuel cell (301), the fuel cell being in fluid communication with the reformed-gas tank outlet (142).

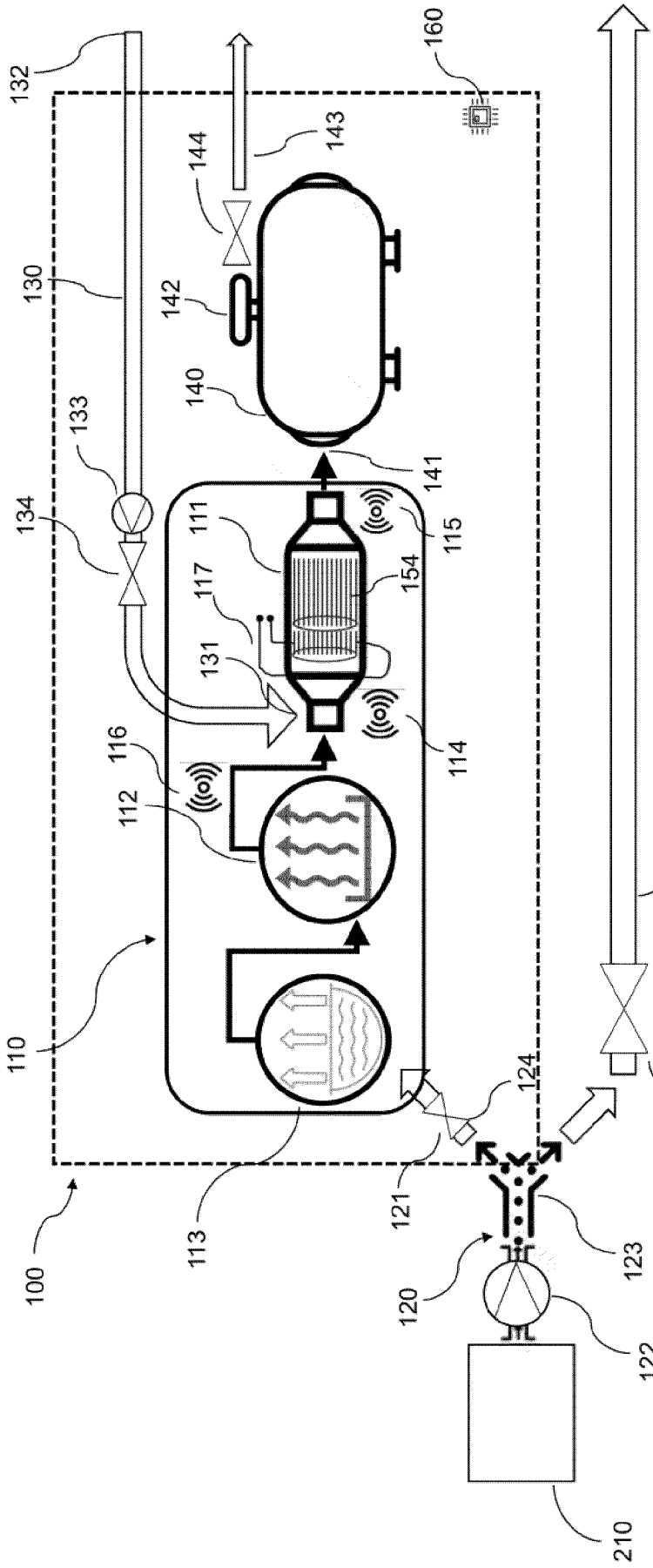

132
160
143
144
130
142
140
133
141
134
111
115
154
117
131
114
116
112
110
125
124
126
121
113
123
100
120
122
210

FIG. 1

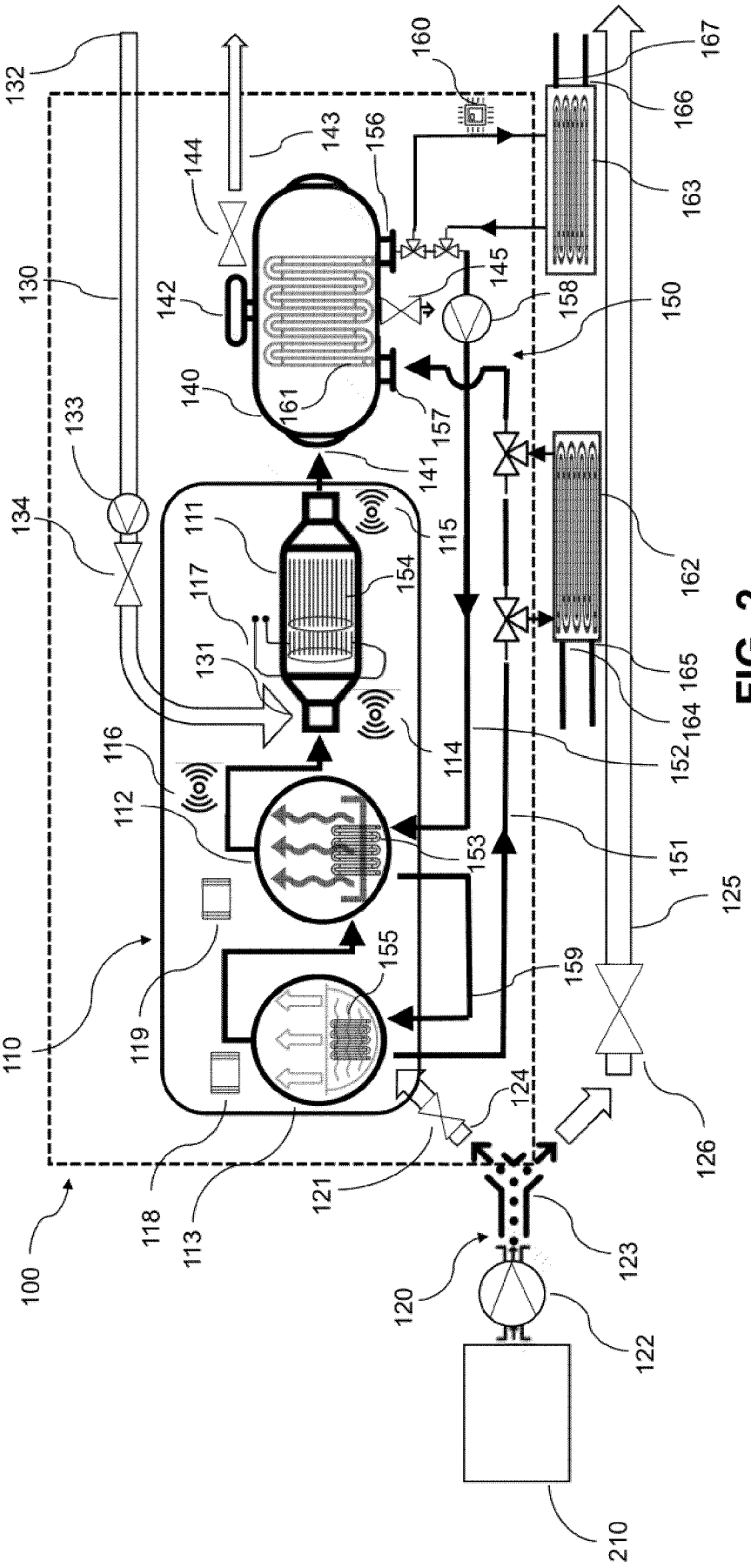

100
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
130
131
132
133
134
140
141
142
143
144
145
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
210

FIG. 2

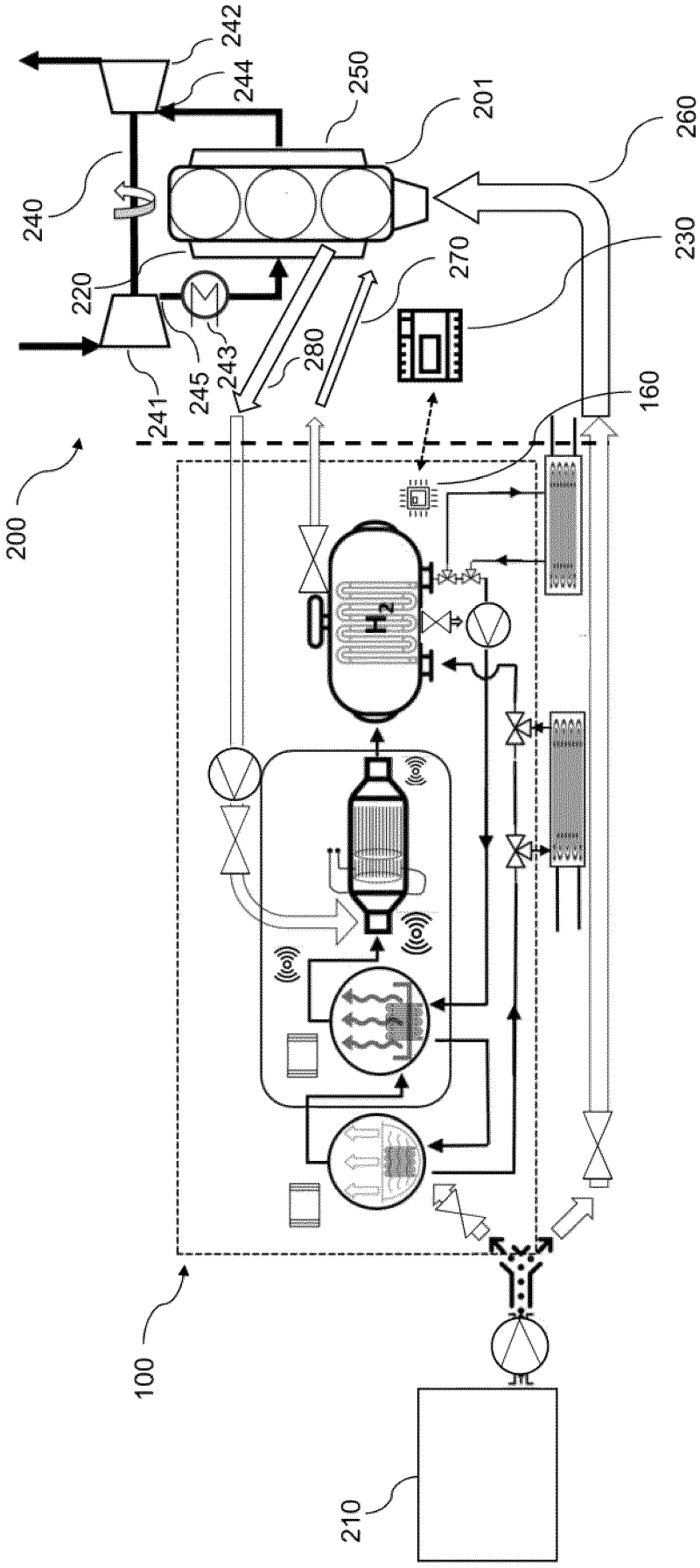

242
244
250
201
260
240
230
220
270
280
243
245
241
160
200
H_2
100
210

FIG. 3

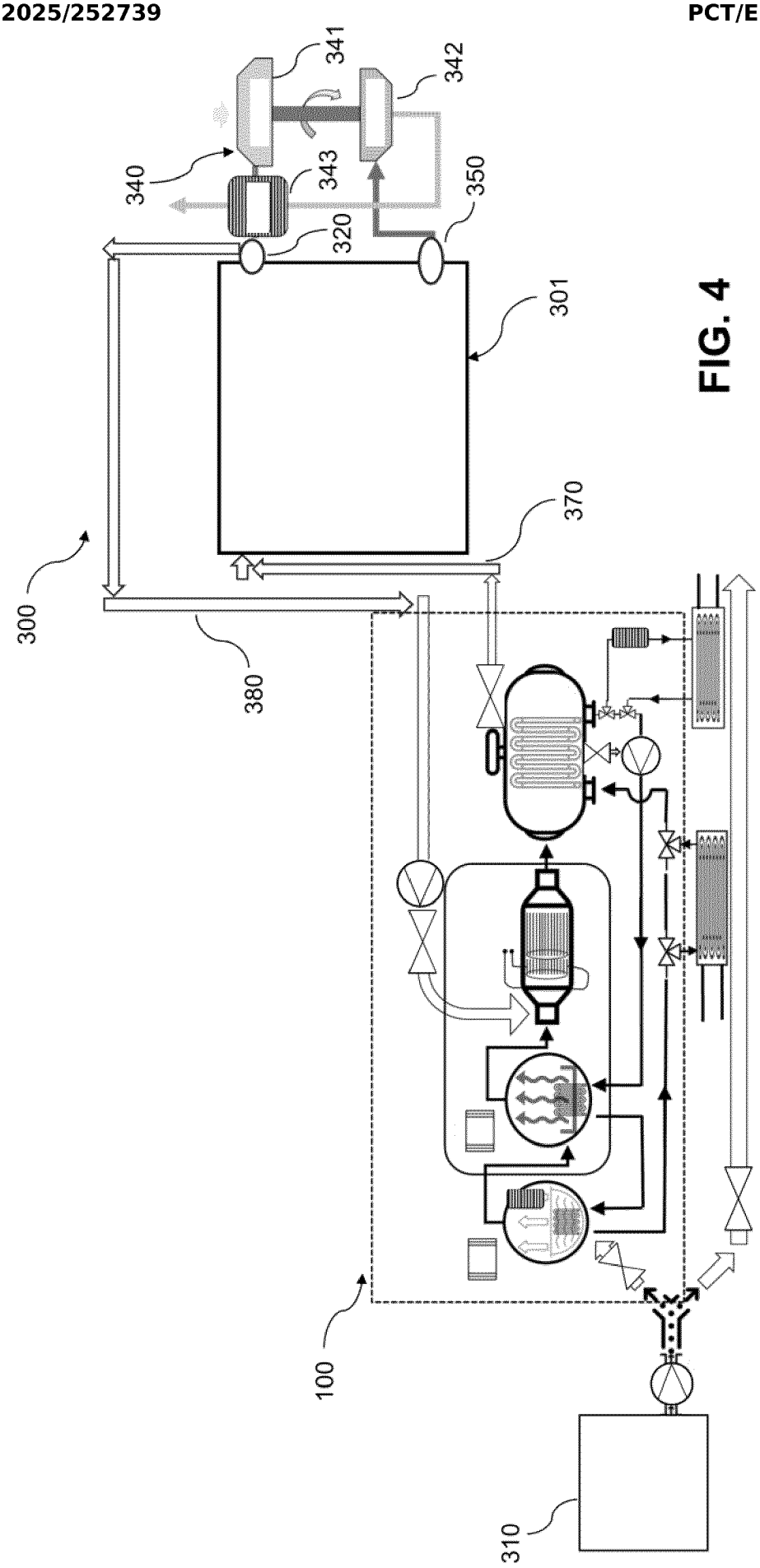


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2025/065352

A. CLASSIFICATION OF SUBJECT MATTER

INV. F02B37/00 B60L50/70 F02D19/02 F02M21/02 F02M21/06
H01M8/04089
ADD. F02M25/12 F02M31/18 F02M53/02

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)

F02B F02D H01M B60L F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/283959 A1 (ASO KOJI [JP] ET AL) 24 November 2011 (2011-11-24) abstract figures 1, 4-8 paragraph [0019] - paragraph [0055] -----	1-15
X	US 11 125 188 B2 (CATERPILLAR INC [US]) 21 September 2021 (2021-09-21) abstract figures 1-3 column 2 - column 5 -----	1,4-11, 13-15
A	US 9 708 973 B2 (GEN ELECTRIC [US]) 18 July 2017 (2017-07-18) abstract figures 1-3 column 1 - column 6 -----	1-15

-/--

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 July 2025	28/07/2025

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Juvenelle, Cyril

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2025/065352

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006/042565 A1 (HU HAORAN [US]) 2 March 2006 (2006-03-02) abstract figures 1-3 paragraph [0012] - paragraph [0028]	1-15
A	US 2022/170433 A1 (TAKEUCHI YOSHITAKA [JP]) 2 June 2022 (2022-06-02) abstract figures 1-3 paragraph [0015] - paragraph [0077]	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2025/065352

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011283959 A1	24-11-2011	CN 102906409 A	30-01-2013
		EP 2573376 A1	27-03-2013
		JP 5310945 B2	09-10-2013
		JP WO2011145434 A1	22-07-2013
		US 2011283959 A1	24-11-2011
		WO 2011145434 A1	24-11-2011
US 11125188 B2	21-09-2021	NONE	
US 9708973 B2	18-07-2017	DE 102013111130 A1	24-04-2014
		US 2014109844 A1	24-04-2014
US 2006042565 A1	02-03-2006	US 2006042565 A1	02-03-2006
		WO 2006021852 A1	02-03-2006
US 2022170433 A1	02-06-2022	AU 2019445332 A1	28-10-2021
		CN 113631806 A	09-11-2021
		JP 7163853 B2	01-11-2022
		JP 2020172906 A	22-10-2020
		US 2022170433 A1	02-06-2022
		WO 2020208876 A1	15-10-2020