Claims

Claim 1. A portable hydrogen proton exchange membrane fuel cell (PEMFC) system comprising a housing enclosing the following:

a proton exchange membrane fuel cell (PEMFC) stack;

a water storage vessel;

a magnesium hydride powder disposed in a hydrogen reactor vessel for the hydrogen reactor vessel;

a water pump disposed between the water storage vessel and the reactor vessel;

wherein the PEMFC stack, the water storage vessel and the reactor vessel are in fluid communication; and

a check valve disposed in a discharge line connecting the water pump to the reactor vessel, wherein the discharge line comprises a tubing with a predetermined rupture pressure range;

further comprising a cooling coil disposed in the water storage vessel to cool down hydrogen gas generated from an exothermic MgH_2 hydrolysis reaction of the magnesium hydride powder in the hydrogen reactor vessel;

further comprising a buffer tank and a recollection valve, wherein the buffer tank is in fluid communication with the cooling coil and the recollection valve is operable to recycle water condensed in the buffer tank via cooling of the hydrogen gas into the water storage vessel.

Claim 2. The system according to Claim 1, further comprising a purifying filter disposed in fluid communication with the buffer tank.

Claim 3. The system according to Claim 2, further comprising a supply valve disposed in fluid communication between the buffer tank and the purifying filter, wherein the supply valve is operable by a solenoid.

Claim 4. The system according to any one of Claims 1-3, wherein fluid communication for the hydrogen gas is formed in a manifold.

Claim 5. The system according to Claim 4, wherein the manifold further supports the check valve defined in Claim 1.

Claim 6. The system according to any one of preceding claims, wherein the reactor vessel has a double-wall construction, which interior of the double-wall is evacuated to a vacuum.

Claim 7. The system according to Claim 6, further comprising a vessel cap disposed for closing a mouth of the hydrogen reactor vessel.

Claim 8. The system according to Claim 6, further comprising heat insulation disposed on an exterior of the hydrogen reactor vessel and the vessel cap.

Claim 9. The system according to any one of the preceding claims, further comprising a controller, wherein the controller receives signals from a temperature sensor and a pressure sensor, and in response turns on a battery to supply electric power to a heater disposed in the hydrogen reactor vessel before voltage generated from the system exceeds voltage across the battery.

Claim 10. The system according to Claim 9, further comprising an electric outlet port, wherein the electric outlet port is controlled by the controller so that the hydrogen reactor vessel is hot-swappable when the system is operating and power supply at the electric outlet port is not interrupted.

Claim 11. A method of using a portable hydrogen proton exchange membrane fuel cell (PEMFC) system comprising:

connecting a water pump to supply water from a water storage vessel to a reactor vessel, wherein a pump discharge line comprises a tubing with a predetermined rupture pressure range and a check valve;

thermally insulating the reactor vessel with a vacuum double wall and, on an exterior of the hydrogen reactor vessel, surrounding the hydrogen reactor vessel with a thermal insulator;

hydrolysing a hydride powder disposed in the reactor vessel with a controlled amount of water supplied through the water pump to generate hydrogen gas on demand via exothermic MgH2 hydrolysis reaction pathway; and

directing the hydrogen gas to flow from an outlet of the reactor vessel to a PEMFC stack to generate electric power;

further comprising:

passing the hydrogen gas through a cooling coil disposed in the water storage vessel to cool the hydrogen gas to a predetermined temperature;

condensing water vapour in the hydrogen gas in a buffer tank, which buffer tank is disposed downstream of the cooling coil, so that the condensed water collected in the buffer tank is recycled back into the water storage vessel via a recollection solenoid valve;

Claim 12. The method according to Claim 11, further comprising:

purifying the hydrogen gas by passing the hydrogen gas through a purifying filter disposed downstream of the buffer tank.

Claim 13. The method according to any one of Claims 11-12, further regulating operation of the PEMFC with a controller, wherein the controller comprises an algorithm that responds adaptively to a utilization level remaining in the hydride powder.

Claim 14. The method according to Claim 13, wherein the battery allows hot-swapping of the hydrogen reactor vessel when the hydride powder is depleted and the system is still operating.

Claim 15. A portable hydrogen PEMFC apparatus comprising

the portable hydrogen PEMFC system of claim 1;

a hydrogen generation system;

a battery;

a casing;

a pouch;

where the PEMFC system further comprises a PEMFC controller, an LCD display and its controller, fluidic/electrical/communication and diagnosis interfaces, and a balance of plant components of the portable hydrogen PEMFC system;

where the PEMFC stack is based on an open cathode / closed anode fuel cell design and it produces power in the range of 0 to 20 Watts and has a nominal operational envelope of 10-20 Watts,

where the open cathode / closed anode PEMFC stack does not carry an external humidifier device and utilizes an electromechanical connection between the ends of the PEMFC stack in order to humidify the PEMFC

stack and the electromechanical connection is located on the PEMFC controller,

where the PEMFC controller manages the safe operation of the PEMFC system,

where the PEMFC stack manifold is used to integrate all of the PEMFC system components onto a common platform and as a single module form,

where the PEMFC balance of plant components are comprised of a fan, temperature sensor(s), pressure sensor(s), pressure regulator(s), purifying filter(s), supply and purge valve(s), and a PEMFC stack manifold,

where the operation of the hydrogen generator system is controlled based on the internal pressure of the fuel cell stack, hydrogen gas consumption of the fuel cell stack, and/or power output of the fuel cell stack,

where the hydrogen generator system is comprised of a hydride fuel cartridge, a water tank module, a hydrogen generation system controller, fluidic/electrical/communication interface components between the hydride fuel cartridge and water tank module;

where hydride fuel of the hydride fuel cartridge is comprised of magnesium hydride,

where the hydrolysis reaction is based on an exothermic MgH2 hydrolysis reaction pathway,

where fuel cartridge has the hydrogen storage capacity of 2.4 to 480 Wh, preferably 250 Wh to 350 Wh, more preferably 280 to 325 Wh, even more preferably around 300 Wh,

where the hydride fuel cartridge is comprised of a housing comprising a vacuum insulated double wall flask, a cover, a reactor manifold that contains all the essential fluidic/electrical/communication interfaces, temperature and pressure sensors, an electrically energized heating tube that is directly connected to a porous tube or porous structure for transferring and heating the water and then converting it into steam before introducing it into the magnesium hydride powder, porous tubes or porous structures to collect the generated hydrogen, and take the water out of the hydride fuel cartridge,

where the water tank module is comprised of the water storage tank medium, the water pump, a weighted clunk placed inside the water tank to transfer water to the hydride fuel cartridge in any orientation,

where fuel cartridge is hot-swappable and have quick-disconnect couplings at the fluidic interfaces for easy replacing,

where the hydrogen generation system controller manages the safe operation of the hydrogen generation system,

where the entire hydrogen generation system is assembled as a single module form,

where the battery is used to initiate the start-up sequence for the portable PEMFC apparatus, act as the primary power for the hydride reactor for the pre-heating period in order to start the hydrolysis reaction, and provide uninterruptable power during hot-swapping action of the hydride fuel cartridge,

where the casing's main function is to provide a form factor to integrate the fuel cell system and hydrogen generation inside a common housing,

where the pouch is used to carry the portable PEMFC apparatus over a soldier's body.

Claim 16. The apparatus according to Claim 15, further comprising

a main controller

the electromechanical connection is located on the main controller,

wherein the main controller is configured to manage the portable hydrogen PEMFC system,

wherein the main controller is configured to manage the hydrogen generation system.