[0006] It is desirable for removable gas generators to be easily coupled to the fuel cell system to create a gas flow path from the gas generator to the remainder of the fuel cell system without gas leaks at the coupling, and it is also desirable for the gas generator to be free of gas leaks when not coupled to the remainder of the fuel cell system. The coupling between the gas generator and the rest of the fuel cell system can include one or more valves. The valve(s) can be opened and closed manually, valve operation can be controlled by a control system, or the valve(s) can be opened and closed by an actuator that is operated by making or separating components of the coupling. The latter method can be used in quick disconnect couplings, for example, where the valve is opened when the gas generator is coupled to the rest of the system and closed when the gas generator is uncoupled.

[0007] Because the gas generator can contain gas under pressure, it may be desirable to provide means for relieving internal pressure before it becomes high enough to rupture the gas generator housing. A pressure relief vent can be incorporated into the gas generator for this purpose. Examples of pressure relief vents are found in U.S. Patent Publication No. 2006/0174951 Al, in which the pressure relief vent is located in a portion of the gas generator housing, and in U.S. Patent Publication No. 2008/0169207 Al, in which the pressure relief vent is incorporated into a valve assembly that also controls the flow of gas from the hydrogen generator.

[0008] Another example of a pressure relief vent incorporated into the valve assembly is found in U.S. Patent Publication No. 2005/0162122 Al. In this valve assembly, if the internal pressure reaches a predetermined level when the gas generator is not coupled to the rest of the fuel cell system, a burst disk opens to relieve the pressure. Gas is released through a portion of the same conduit through which gas flows when the gas generator is coupled to the rest of the fuel cell system.

[0009] An object of the present invention is to provide a gas generator that can be reliably sealed to prevent gas leaks when coupled to or uncoupled from a from a fuel cell system and that can provide a pressure relief vent when the gas generator is uncoupled.

SUMMARY

[0010] ~~The above objects are met and the above disadvantages of the prior art are overcome by the present invention, which includes~~ There is disclosed a gas generator that can be removed from the remainder of a fuel cell system and has an improved valve assembly. The valve assembly includes a gas outlet valve that can open when the gas generator is coupled to the fuel cell

system, close when the gas generator is uncoupled, and provide a pressure relief vent in a simple design with a small number of component parts.

[0011] Accordingly, a first aspect of the present invention is a ~~gas generator for supplying a gas to an apparatus. The gas generator includes a housing, a reactant contained within an interior portion of the housing and capable of reacting to produce a gas, and a gas outlet valve. The gas outlet valve includes a valve body, a valve seat, a moveable valve member, a biasing member, a gas inlet port, a gas outlet port, and a gas flow path through the valve body, the gas flow path including the gas inlet port and the gas outlet port. When the gas outlet valve is in a closed configuration and a pressure within the gas generator is below a threshold pressure, the moveable valve member is biased by the biasing member against the valve seat to block the outlet port. When the gas outlet valve is in a gas supplying configuration, the moveable valve member is displaced by an actuator, insertable into the gas outlet valve from outside the gas generator, such that the moveable valve member is separated from the valve seat and the outlet port is open so gas can be supplied through the gas flow path to the apparatus. When the gas outlet valve is in a pressure relief configuration, the pressure within the gas generator is at or above the threshold pressure, and the moveable valve member is separated from the valve seat and the outlet port is open so pressure can be released through the gas flow path to an external environment. The gas can flow through the same gas flow path when the valve is in both the gas supplying configuration and the pressure relief configuration.~~ gas generator for supplying a gas to an apparatus, the gas generator comprising a housing, a reactant contained within an interior portion of the housing and capable of reacting to produce a gas, and a gas outlet valve, wherein: the gas outlet valve comprises a valve body, a valve seat, a moveable valve member, a biasing member, a gas inlet port, a gas outlet port, and a gas flow path through the valve body, the gas flow path comprising the gas inlet port and the gas outlet port; when the gas outlet valve is in a closed configuration and a pressure within the gas generator is below a threshold pressure, the moveable valve member is biased by the biasing member against the valve seat to block the outlet port; when the gas outlet valve is in a gas supplying configuration, the moveable valve member is displaced by an actuator, insertable into the gas outlet valve from outside the gas generator, such that the moveable valve member is separated from the valve seat and the outlet port is open so gas can be supplied through the gas flow path to the apparatus; when the gas outlet valve is in a pressure relief configuration, the pressure within the gas generator is at or above the threshold pressure, and the moveable valve member is separated from the valve seat and the outlet port is open so pressure can be released through the gas flow path to an external environment; and the gas can flow through the same gas flow path when the valve is in both the gas supplying configuration and the pressure relief configuration.

[0012] Embodiments of the first aspect of the invention can include one or more of the following features:

- the biasing member comprises a spring;
- the gas outlet valve includes a seal member that forms a seal between the valve seat and the moveable valve member when the gas outlet valve is in the closed configuration;
- the moveable valve member includes a piston that is linearly moveable along a
- longitudinal axis of the valve;
- the gas generator has no additional pressure relief vent; and
- the gas produced includes hydrogen gas.

[0013] A second aspect of the invention is a fuel cell system including a gas generator as described above and a fuel cell stack.

The invention claimed is:

1. A gas generator for supplying a gas to an apparatus, the gas generator comprising housing, a reactant contained within an interior portion of the housing and capable of reacting to produce a gas, and a gas outlet valve, wherein:

the gas outlet valve comprises a valve body, a valve seat, a moveable valve member, a biasing member, a gas inlet port, a gas outlet port, and a gas flow path through the valve body, the gas flow path comprising the gas inlet port and the gas outlet port;

when the gas outlet valve is in a closed configuration and a pressure within the gas generator is below a threshold pressure, the moveable valve member is biased by the biasing member against the valve seat to block the outlet port;

when the gas outlet valve is in a gas supplying configuration, the moveable valve member is displaced by an actuator, insertable into the gas outlet valve from outside the gas generator, such that the moveable valve member is separated from the valve seat and the outlet port is open so gas can be supplied through the gas flow path to the apparatus;

when the gas outlet valve is in a pressure relief configuration, the pressure within the gas generator is at or above the threshold pressure, and the moveable valve member is separated from the valve seat and the outlet port is open so pressure can be released through the gas flow path to an external environment; and

the gas can flow through the same gas flow path when the valve is in both the gas supplying configuration and the pressure relief configuration.

2. The gas generator according to claim 1, wherein the biasing member comprises a spring.

3. The gas generator according to claim 1 or claim 2, wherein the gas outlet valve comprises a seal member that forms a seal between the valve seat and the moveable valve member when the gas outlet valve is in the closed configuration.

4. The gas generator according to any preceding claim, wherein the moveable valve member comprises a piston that is linearly moveable along a longitudinal axis of the valve.

5. The gas generator according to any preceding claim, wherein the gas generator has no additional pressure relief vent.

6. The gas generator according to any preceding claim, wherein the gas produced comprises hydrogen.

7. A fuel cell system comprising a gas generator according to any of preceding claim and a fuel cell stack.

8. The fuel cell system according to claim 7, wherein the fuel cell system further comprises a coupling between the gas generator and the fuel cell stack, and the coupling comprises the actuator that displaces the moveable valve member to open the gas outlet port when the gas outlet valve is in the gas supplying configuration.

9. The fuel cell system according to 8, wherein the actuator comprises a hollow tube in fluid communication with the fuel cell, a seal is formed between an outer surface of the tube and the valve seat when the actuator is inserted into the gas outlet valve, and gas exiting the gas outlet in the valve can enter the hollow tube.

10. The fuel cell system according to any of claims 7 to 9, wherein the gas generator comprises a valve assembly that comprises the gas outlet valve.

11. The fuel cell system according to claim 10, wherein the valve assembly comprises a plurality of valves.

12. The fuel cell system according to claim 10 or claim 11, wherein the valve assembly comprises a fluid outlet valve and a fluid inlet valve, and the fuel cell system comprises a pump disposed outside the gas generator and configured to transfer a fluid from the fluid outlet valve to the fluid inlet valve.

13. The fuel cell system according to any of claims 7 to 12, wherein the valve assembly comprises an upstanding wall projecting outward from the gas generator.

14. The fuel cell system according to claim 13, wherein the gas outlet valve is disposed radially inward of the upstanding wall.

15. The fuel cell system according to any preceding claim, wherein a coupling between the gas generator and the fuel cell stack comprises a sleeve, within which the actuator is recessed.

16. The fuel cell system according to claim 15, wherein an interaction between the sleeve and a radially outer surface of the upstanding wall of claim 14 provides alignment of the actuator with the gas outlet valve.

17. The fuel cell system according to any of claims 7 to 16, wherein the gas generator is user-removable.

Claims

1. A gas generator for supplying a gas to an apparatus, the gas generator comprising a housing, a reactant contained within an interior portion of the housing and capable of reacting to produce a gas, and a gas outlet valve, wherein:

the gas outlet valve comprises a valve body, a valve seat, a moveable valve member, a biasing member, a gas inlet port, a gas outlet port, and a gas flow path through the valve body, the gas flow path comprising the gas inlet port and the gas outlet port;

when the gas outlet valve is in a closed configuration and a pressure within the gas generator is below a threshold pressure, the moveable valve member is biased by the biasing member against the valve seat to block the outlet port;

when the gas outlet valve is in a gas supplying configuration, the moveable valve member is displaced by an actuator, insertable into the gas outlet valve from outside the gas generator, such that the moveable valve member is separated from the valve seat and the outlet port is open so gas can be supplied through the gas flow path to the apparatus;

when the gas outlet valve is in a pressure relief configuration, the pressure within the gas generator is at or above the threshold pressure, and the moveable valve member is separated from the valve seat and the outlet port is open so pressure can be released through the gas flow path to an external environment; and

the gas can flow through the same gas flow path when the valve is in both the gas supplying configuration and the pressure relief configuration.

2. The gas generator according to claim 1, wherein the biasing member comprises a spring.

3. The gas generator according to claim 1 or claim 2, wherein the gas outlet valve comprises a seal member that forms a seal between the valve seat and the moveable valve member when the gas outlet valve is in the closed configuration.

4. The gas generator according to any preceding claim, wherein the moveable valve member comprises a piston that is linearly moveable along a longitudinal axis of the valve.

5. The gas generator according to any preceding claim, wherein the gas generator has no additional pressure relief vent.

6. The gas generator according to any preceding claim, wherein the gas produced comprises hydrogen.

7. A fuel cell system comprising a gas generator according to any of preceding claim and a fuel cell stack.

8. The fuel cell system according to claim 7, wherein the fuel cell system further comprises a coupling between the gas generator and the fuel cell stack, and the coupling comprises the actuator that displaces the moveable valve member to open the gas outlet port when the gas outlet valve is in the gas supplying configuration.

9. The fuel cell system according to 8, wherein the actuator comprises a hollow tube in fluid communication with the fuel cell, a seal is formed between an outer surface of the tube and the valve seat when the actuator is inserted into the gas outlet valve, and gas exiting the gas outlet in the valve can enter the hollow tube.

10. The fuel cell system according to any of claims 7 to 9, wherein the gas generator comprises a valve assembly that comprises the gas outlet valve.

11. The fuel cell system according to claim 10, wherein the valve assembly comprises a plurality of valves.

12. The fuel cell system according to claim 10 or claim 11, wherein the valve assembly comprises a fluid outlet valve and a fluid inlet valve, and the fuel cell system comprises a pump disposed outside the gas generator and configured to transfer a fluid from the fluid outlet valve to the fluid inlet valve.

13. The fuel cell system according to any of claims 7 to 12, wherein the valve assembly comprises an upstanding wall projecting outward from the gas generator.

14. The fuel cell system according to claim 13, wherein the gas outlet valve is disposed radially inward of the upstanding wall.

15. The fuel cell system according to any preceding claim, wherein a coupling between the gas generator and the fuel cell stack comprises a sleeve, within which the actuator is recessed.

16. The fuel cell system according to claim 15, wherein an interaction between the sleeve and a radially outer surface of the upstanding wall of claim 14 provides alignment of the actuator with the gas outlet valve.

17. The fuel cell system according to any of claims 7 to 16, wherein the gas generator is user-removable.