

CLAIMS:

1. A steam generator comprising:
 - a pressure vessel;
 - a gas inlet to the pressure vessel, arranged to receive hydrogen and oxygen under pressure;
 - an ignition means within the pressure vessel, arranged to ignite hydrogen and oxygen received at the gas inlet;
 - a steam outlet for the outlet of steam from the pressure vessel;
 - a water jacket in or on the pressure vessel;
 - a water inlet arranged to receive water under pressure and feed it to said water jacket; and,
 - a water outlet positioned within the pressure vessel between the gas inlet and the steam outlet,

wherein, in use: water received at the water inlet passes along said water jacket to provide cooling of the pressure vessel and is output at said water outlet to provide a water spray and/or film that mixes with the ignited hydrogen and oxygen to vaporize the water spray and/or film, the water outlet comprising a body around which gas flows, when flowing from the gas inlet to the steam outlet.
2. A steam generator according to claim 1, wherein the pressure vessel comprises a double-walled construction, forming the water jacket therebetween.
3. A steam generator according to claim 1 or 2, wherein the pressure vessel comprises a combustion zone within which the ignition means is mounted, the combustion zone being configured to receive hydrogen and oxygen from the gas inlet, and to mix said gases together during the combustion process.
4. A steam generator according to any of the preceding claims, wherein the pressure vessel comprises a water outlet zone within which the water outlet is mounted.

5. A steam generator according to claims 3 and 4, wherein the water outlet is arranged at a tip of a bullet-shaped portion, the bullet-shaped portion being mounted concentrically within the pressure vessel, along a central axis of the pressure vessel, with the tip facing the combustion zone.
- 5 6. A steam generator according to any of the preceding claims, wherein the water outlet comprises a nozzle.
7. A steam generator according to claim 6, wherein the water outlet comprises a plurality of channels for creating an array of water.
8. A steam generator according to claim 7, wherein the array is a radial fan,
10 extending generally radially of a principal axis of the pressure vessel.
9. A steam generator according to any of the preceding claims, wherein the water outlet comprises molybdenum.
10. A steam generator according to any of the preceding claims, wherein the ignition means comprises a glow plug.
- 15 11. A steam generator according to any of the preceding claims, wherein the steam outlet is at an opposite end of the pressure vessel to the gas inlet.
12. A steam generator according to any of the preceding claims, wherein the steam outlet incorporates a valve control means.
13. A steam generator according to claim 12, wherein the valve control means is a
20 De Laval nozzle.
14. A steam generator according to any of the preceding claims, wherein the gas inlet comprises a gas mixing nozzle for mixing gases as they pass therethrough.

15. A steam generator according to claim 14, wherein the gas mixing nozzle comprises a plurality of longitudinal grooves for mixing the gases.

16. A steam generator according to any of claims 1 to 13, wherein the gas inlet comprises two separate paths, one for hydrogen and one for oxygen, so arranged that the
5 hydrogen and oxygen mix within the pressure vessel as they are output from the gas inlet.

17. A steam generator according to any of the preceding claims, wherein the pressure vessel is substantially cylindrical.

18. A steam generator according to any one of the preceding claims, wherein the
10 pressure vessel incorporates a mixing zone that provides a space within which gases in the vessel are mixed, in use.

19. A steam generator according to claims 3 and 18, wherein the water outlet is positioned between the combustion zone and the mixing zone.

20. A steam generation system comprising a steam generator, a gas supply system
15 for the generator, a water supply system for the generator, and a controller for the steam generation system, wherein:

the steam generator comprises:

inputs for hydrogen gas, oxygen gas, a purge gas and water;

an igniter arranged to ignite hydrogen and oxygen within the generator; and

20 an output for pressurised steam generated by the ignition of hydrogen and oxygen within the generator:

the gas supply system comprises a first, high-pressure stage and a second, low-pressure stage, in which:

the first, high-pressure stage is arranged to receive hydrogen, oxygen and purge gas under pressure and to supply those gases to the second, low-pressure stage under reduced pressure;

5 the second, low-pressure stage is arranged to receive the gases from the first, high-pressure stage under reduced pressure and to supply those gases to the steam generator:

the water supply system is arranged to supply water under pressure to the steam generator: and

10 the controller is arranged to control operation of the steam generation system in Prime, Run and Shutdown phases, in which:

in the Prime phase, hydrogen gas and oxygen gas are introduced into the first, high-pressure stage and pressure of the hydrogen and oxygen is allowed to build up in the first, high-pressure stage;

15 in the Run phase, hydrogen gas and oxygen gas are introduced into the second, low-pressure stage at a lower pressure than that prevailing in the first, high-pressure stage; the hydrogen and oxygen gases are then supplied into the steam generator where they are ignited by the igniter; and water is supplied into the steam generator to be mixed with the ignited gases; and

20 in the Shutdown phase, the supply of hydrogen and oxygen gases to the steam generator is ceased, the supply of water to the steam generator is ceased, and a purge gas is supplied to the gas supply system and the steam generator to purge the gas supply system and the steam generator of hydrogen and oxygen gases.

21. A steam generation system according to claim 20 wherein, in the Prime phase, respective low-flow valves are initially opened to allow the pressure of the hydrogen
25 and oxygen to build up gradually; and subsequently, respective high-flow valves are opened to allow the pressure of the hydrogen and oxygen to build up more quickly.

22. A steam generation system according to claim 20 or 21 wherein, in the Run phase, the controller calculates, from measurements of temperature, pressure and mass flow of hydrogen and oxygen, a stoichiometric mass ratio of oxygen to hydrogen; and controls valves in the system to maintain said stoichiometric mass ratio at a desired level.

23. A steam generation system according to claim 22 wherein, in the Run phase, the controller monitors water mass flow and either hydrogen or oxygen mass flow; and adjusts those mass flows to achieve a desired overall mass flow through the steam generator.

24. A steam generation system according to any of claims 20 to 23, wherein operation of the steam generation system is controlled by user actuation of a Start Button and a Shutdown Button.

25. A steam generation system according to claim 24 wherein, in use, the Prime phase is started by a first actuation of the Start Button.

26. A steam generation system according to claim 24 or 25 wherein, in use, the Run phase is started by actuation of the Start Button after completion of the Prime phase.

27. A steam generation system according to claim 24, 25 or 26 wherein, in use, the steam generation system enters a Standby condition upon actuation of the Start Button during the Run phase.

28. A steam generation system according to any of claims 20 to 27, comprising at least one indicator to indicate at least one of successful completion of the Prime phase; successful activation of the Run phase; and a Fault condition.

29. A steam generation system according to any of claims 20 to 28, wherein the controller is operative to detect fault conditions comprising one or more of the following at or within a predetermined time:

pressure within the system falling outside a predetermined limit;
flow rate within the system falling outside a predetermined limit;
temperature within the system falling outside a predetermined limit; and
electrical ignition current supplied to the steam generator falling outside a
predetermined limit.

30. A steam generation system according to any claims 20 to 29, wherein the controller is operative to initiate the Shutdown phase upon a fault condition being detected.

31. A steam generation system according to any of claims 20 to 30, wherein the generator is in accordance with any of claims 1 to 19.

32. A steam generator or steam generation system substantially as hereinbefore described with reference to the accompanying drawings.

33. A turbine generator incorporating at least one steam generator or steam generation system according to any of the preceding claims.