CLAIMS

1. A solid oxide fuel cell (SOFC) system comprising:

an SOFC stack operating in a hot zone cavity;

a plurality of hot zone enclosure walls, enclosing the hot zone cavity formed as a first thermally conductive pathway, wherein the first thermally conductive pathway comprises one or more materials having a coefficient of thermal conductivity of 100 W/(m°K) or more at temperatures above 350 °C;

a plurality of outer enclosure walls, enclosing a region surrounding the hot zone enclosure walls, formed as a third thermally conductive pathway, wherein the third thermally conductive pathway comprises one or more materials having a coefficient of thermal conductivity of 100 W/(m°K) or more at temperatures above 350 °C;

one or more catalyzing cavity enclosure walls, enclosing a catalyzing cavity, formed as a fourth thermally conductive pathway wherein the fourth thermally conductive pathway is joined together and thermally conductively coupled with each of, the first thermally conductive pathway and the third thermally conductive pathway and wherein the one or more catalyzing cavity enclosure walls is made from a material having a coefficient of thermal conductivity of 50 W/(m°K) or less at temperatures above 350 °C.

2. The solid oxide fuel cell (SOFC) system of claim 1 wherein the each of the outer enclosure walls comprises an aluminum alloy having a coefficient of thermal conductivity of 140 W/(m°K) or more at temperatures above 350 °C.

3. The solid oxide fuel cell (SOFC) system of claim 1 wherein the hot zone enclosure walls comprise copper and any one of molybdenum, aluminum and nickel.

4. The solid oxide fuel cell (SOFC) system of claim 1 wherein surfaces of the hot zone enclosure walls that are exposed to an oxygen rich environment are coated with a protective layer to prevent oxidation.

5. The solid oxide fuel cell (SOFC) system of claim 1 further comprising:

an electronic controller comprising a digital data processor and associated digital data memory having one or more operating programs and digital logic control elements operating thereon;

a fuel input module comprising a hydrocarbon fuel supply, a fuel inlet conduit leading to a hydrocarbon fuel reformer configured to deliver a reformed hydrocarbon fuel to the SOFC stack, and a fuel supply valve, disposed along the fuel inlet conduit, operable by the electronic controller to open the fuel supply valve to deliver a flow of fuel to the fuel reformer and to close the fuel supply valve to prevent a flow of fuel from entering the fuel reformer; and

a thermal sensor, mounted to an external surface of one of the plurality of outer enclosure walls, operable to communicate a temperature signal, corresponding with a temperature of the external surface proximate to the thermal sensor, to the electronic controller;

wherein the electronic controller using one of the operating programs and digital logic control elements is operable to close the fuel supply valve when the thermal sensor indicates its temperature equals or exceeds a controller fail safe temperature stored in the memory.

6. The solid oxide fuel cell (SOFC) system of claim 5 further comprising;

a thermal fuse mounted to an external surface of one of the plurality of outer enclosure walls comprising a fusible link configured to melt when the temperature of the fusible link equals or exceeds a system fail safe temperature;

wherein the fusible link is electrically connected between a power source and the fuel supply valve;

wherein melting of the fusible link prevents power from reaching the fuel supply valve thereby causing the fuel supply valve to close.

7. The solid oxide fuel cell (SOFC) system of claim 1 wherein the plurality of outer enclosure walls comprises an open ended outer cylindrical side wall joined together with a disk shaped outer bottom wall and an opposing disk shaped top end flange.

8. The solid oxide fuel cell (SOFC) system of claim 1 further comprising

a fuel reformer module disposed within the cylindrical catalyzing cavity wherein the fuel reformer module comprises:

a fuel reactor body comprising a perimeter wall surrounding a fuel chamber and a reactor shield base wall attached to the perimeter wall, wherein the reactor shield base wall includes a plurality of base wall fuel passages extending there through, wherein fuel received into the fuel chamber exits the fuel chamber through the plurality of base wall fuel passages and passes therefrom a catalyzing body;

wherein the fuel reactor body is formed from a material having a coefficient of thermal conductivity of 140 W/(mºK) or greater at temperatures above 350 °C and wherein the perimeter wall is thermally conductively coupled to one of the plurality of outer enclosure walls.

9. The solid oxide fuel cell (SOFC) system of claim 1 further comprising:

an intermediate enclosure, enclosing a region surrounding the plurality of hot zone enclosure walls, disposed between the hot zone enclosure walls and the outer enclosure, enclosing the hot zone enclosure, comprising a plurality of intermediate enclosure walls, comprising a plurality of intermediate enclosure walls joined together to form a second continuous thermally conductive pathway comprising materials having a coefficient of thermal conductivity of 50 W/(m°K) or less, at temperatures above 350 °C, wherein the second continuous thermally conductive pathway is joined together and thermally conductively coupled with the third thermally conductive pathway is joined together and thermally conductively coupled with the outer enclosure walls that form the third thermally conductive pathway and with the one or more catalyzing cavity enclosure walls that forms the fourth thermally conductive pathway.

10. A solid oxide fuel cell (SOFC) system comprising:

an SOFC stack operating in a hot zone cavity; a hot zone enclosure enclosing the hot zone cavity comprising a plurality of hot zone enclosure walls joined together to form a first continuous thermally conductive pathway comprising materials having a coefficient of thermal conductivity of 140 W/(m° K) or more at temperatures above 350° C;

an intermediate enclosure enclosing a region surrounding the hot zone enclosure walls comprising a plurality of intermediate enclosure walls joined together to form a second continuous thermally conductive pathway comprising materials having a coefficient of thermal conductivity of 25 W/(m° K) or less at temperatures above 350° C;

an outer enclosure enclosing a region surrounding the intermediate enclosure walls comprising a plurality of outer enclosure walls joined together to form a third continuous thermally conductive pathway comprising materials having a coefficient of thermal conductivity of 140 W/(m° K) or more at temperatures above 350°C;

a thermal insulation layer surrounding the intermediate enclosure walls disposed between outside surfaces of the intermediate enclosure that forms the second continuous thermally conductive pathway and inside surfaces of the outer enclosure that forms the third continuous thermally conductive pathway;

an air gap formed between outside surfaces of the hot zone enclosure walls forming the first continuous thermally conductive pathway and inside surfaces of the intermediate enclosure walls forming the second continuous thermally conductive pathway; and

an annular catalyzing cavity enclosure wall enclosing a catalyzing cavity formed as a fourth continuous thermally conductive pathway comprising materials having a coefficient of thermal conductivity of 25 W/(m° K) or less at temperatures above 350° C, joined together with and thermally conductively connected to each of the first continuous thermally conductive pathway, the second continuously conductive pathway, and the third continuously conductive pathway.

11. The solid oxide fuel cell (SOFC) system of claim 10 wherein the first continuous thermally conductive pathway, the second continuous thermally conductive pathway, the third continuous thermally conductive pathway and the fourth thermally conductive pathway each have a different thermal mass and wherein a thermal mass of the fourth continuous thermally conductive pathway is less than a thermal mass of any of the first continuous thermally conductive pathway, the second continuous thermally conductive pathway, and the third continuous thermally conductive pathway.

12. The solid oxide fuel cell (SOFC) system of claim 10 wherein the outer enclosure walls that form the third continuous thermally conductive pathway are formed by enclosure walls made of an aluminum alloy.

13. The solid oxide fuel cell (SOFC) system of claim 12 wherein the aluminum alloy is aluminum 6061.

14. The solid oxide fuel cell (SOFC) system of claim 10 wherein the hot zone enclosure walls that form the first thermally conductive pathway comprises at least one wall portion formed from a material having a coefficient of thermal conductivity of 200 W/(m° K) or greater at temperatures above 350° C.

15. The solid oxide fuel cell (SOFC) system of claim 14 wherein the at least one hot zone enclosure wall portion is formed from an alloy comprising copper and any one of: molybdenum, aluminum, and nickel.

16. The solid oxide fuel cell (SOFC) system of claim 10 wherein the hot zone enclosure walls that form the first continuous thermally conductive pathway comprise copper and any one of molybdenum, aluminum, and nickel wherein surfaces of the hot zone enclosure walls that are exposed to an oxygen rich environment include a protective coating applied thereon to prevent oxidation.

17. The solid oxide fuel cell (SOFC) system of claim 8 wherein the fuel reactor body is formed from an aluminum alloy and wherein exposed surfaces of the fuel reactor body are uncoated.

18. The solid oxide fuel cell (SOFC) system of claim 8:

wherein the catalyzing body comprises a solid non-porous ceramic substrate formed to include a plurality of catalyst fuel passages passing longitudinally therethrough with each catalyst fuel passage including a catalyst coating provided on an inside surface thereof;

wherein the catalyst coating is selected to initiate an exothermic reaction with a hydrocarbon fuel that passes through each catalyst fuel passage;

wherein each of the plurality of base wall fuel passages is longitudinally aligned with a corresponding one of one of the plurality of catalyst fuel passages such that the hydrocarbon fuel exiting from each of the plurality of base wall fuel passages enters a

corresponding one of the plurality of catalyst fuel passages that is longitudinally aligned therewith;

wherein each of the plurality of base wall fuel passages is substantially identical and has a substantially constant circular cross-sectional area along its longitudinal length;

wherein each of the plurality of catalyst fuel passages is substantially identical and has a substantially constant square cross-sectional area along its longitudinal length; and,

wherein a ratio of the circular cross-sectional area of each circular base wall fuel passage to the square cross-sectional area of each square catalyst fuel passage is between 0.6 and 0.9.

19. The solid oxide fuel cell (SOFC) system of claim 9 further comprising:

a thermal insulation layer disposed between the outer enclosure and the intermediate enclosure in mating contact with inside surfaces of the outer enclosure walls;

an air gap formed between the intermediate enclosure and the hot zone enclosure, wherein the air gap comprises an exhaust fluid conduit in fluid communication with each of the hot zone enclosure and a system exhaust port.

20. The solid oxide fuel cell (SOFC) system of claim 1 wherein each of the first continuous thermally conductive pathway, the third continuous thermally conductive pathway, and the fourth thermally conductive pathway have a different thermal mass and wherein a thermal mass of the fourth continuous thermally conductive pathway is less than a thermal mass of either of the first continuous thermally conductive pathway and the third continuous thermally conductive pathway.

21. The solid oxide fuel cell (SOFC) system of claim 1 wherein the plurality of hot zone enclosure walls comprises:

an open ended cylindrical longitudinal side wall joined together with a disk-shaped bottom end wall and an opposing disk-shaped top end wall;

wherein each of the bottom end wall and the top end wall includes a disk-shaped core element, having a core thickness of 0.5 mm to 6.5 mm, fabricated from one of copper alone, molybdenum alone, an aluminum copper alloy, and a nickel copper alloy.

22. The solid oxide fuel cell (SOFC) system of claim 21 wherein each of the disk-shaped bottom end wall and the opposing disk-shaped top end wall includes a protective coating applied onto surfaces thereof that are exposed to an oxygen rich environment to prevent oxidation thereof.