Claims

What is claimed is:

1. A combustor system, comprising:

a combustor having a first end, a second end, an outer shell, an inner shell, and an annular volume formed between the outer shell and the inner shell extending from the first end to the second end;

a carbon dioxide inlet configured to introduce carbon dioxide to the combustor;

an oxygen inlet configured to introduce oxygen to the combustor;

a first mixing zone disposed in the combustor and configured to mix a first portion of any carbon dioxide introduced through the carbon dioxide inlet with at least a portion of any oxygen introduced through the oxygen inlet to produce a first mixture within the first mixing zone comprising oxygen and carbon dioxide;

a fuel inlet configured to introduce a fuel to the combustor;

a second mixing zone disposed in the combustor and configured to mix the first mixture and the fuel to produce a second mixture within the second mixing zone comprising oxygen, carbon dioxide, and fuel; and

a combustion zone configured to combust the second mixture to produce a combustion product, wherein a second portion of any carbon dioxide introduced through the carbon dioxide inlet flows through one or more apertures disposed through the inner shell and mixes with and cools the combustion product.

2. The system of claim 1, wherein:

the first portion of any carbon dioxide introduced through the carbon dioxide inlet flows through the annular volume of the combustor toward the first end of the combustor from the second end of the combustor;

wherein the oxygen inlet is positioned in the annular volume at a distance from the first end of the combustor configured to promote mixing of the first portion of any carbon dioxide introduced through the carbon dioxide inlet and the oxygen introduced through the oxygen inlet; and

wherein the fuel is introduced into the first end of the combustor.

3. The system of claim 2, wherein the oxygen inlet comprises a plurality of injector holes disposed through at least one of a wall of the combustor and a ring in the annular volume.

4. The system of claim 2, further comprising a secondary inner shell configured to prevent introduction of the oxygen introduced through the oxygen inlet through the inner shell, wherein the first mixing zone is positioned at a distance from the first end of the combustor and configured to promote mixing of the oxygen introduced through the oxygen inlet and the first portion of any carbon dioxide introduced through the carbon dioxide inlet.

5. The system of claim 1, wherein:

the oxygen inlet is positioned at the first end of the combustor;

the fuel is introduced into the first end of the combustor; and

a flow of the first mixture is from the first end of the combustor to the second end of the combustor.

6. The system of claim 5, further comprising a plurality of burners configured to perform a function selected from the group consisting of: introduce at least a portion of the oxygen introduced through the oxygen inlet to the second mixing zone, introduce the fuel to the second mixing zone, introduce at least a portion of the oxygen introduced through the oxygen inlet to the first mixing zone, and any combination thereof.

7. The system of claim 6, wherein any one or a portion of the plurality of burners is configured to be turned off to control a load of the combustor and generate a different oxygen-to-carbon dioxide ratio in each burner.

8. The system of any one of claims 2, 4, and 6, wherein the first mixture comprises a spatially varied ratio of oxygen-to-carbon dioxide configured to generate a hot zone in a portion of the combustion zone to increase flame stability therein.

9. The system of claim 8, further comprising at least one secondary oxygen inlet configured to spatially vary the ratio of oxygen-to-carbon dioxide in the first mixture.

10. The system of claim 8, further comprising a variable geometry mixing device positioned in the first mixing zone configured to spatially vary the ratio of oxygen-to-carbon dioxide in the first mixture.

11. The system of any one of claims 2, 4, and 6, further comprising a gas inlet configured to provide an anchor flame upstream of the combustion zone to increase flame stability in the combustion zone.

12. The system of any one of claims 2, 4, and 6, further comprising:

a mixing device positioned in the first mixing zone configured to enhance the mixing of the first mixture; and

a second mixing device positioned in the second mixing zone configured to create a low velocity region to increase flame stability in the combustion zone.

13. The system of claim 1, wherein the first mixing zone comprises a swirl inducer configured to introduce the oxygen into the carbon dioxide at an angle tangential to a flow path of the first portion of any carbon dioxide introduced through the carbon dioxide inlet to generate a swirling first mixture.

14. The system of claim 1, further comprising:

at least one cavity positioned in the second mixing zone configured to deliver at least a portion of the fuel to the combustion zone to produce a low-velocity region to enhance flame stability in the combustion zone, wherein the first portion of any carbon dioxide introduced through the carbon dioxide inlet flows through the annular volume of the combustor toward the first end of the combustor from the second end of the combustor to cool a wall of the at least one cavity, and wherein the first mixing zone is located near the first end of the combustor.

15. The system of claim 14, further comprising at least one secondary oxygen inlet in the at least one cavity to form a hot flame zone to increase flame stability in the combustion zone.

16. The system of claim 9, further comprising a controller to actively control the spatial variation of the oxygen concentration by controlling the ratio of oxygen flow through two or more of the oxygen inlet, the at least one secondary oxygen inlet, and the gas inlet.

17. A combustion burner system, comprising:

a combustor having a first end, a second end, an outer shell, an inner shell, a combustion burner comprising a burner face, and a combustion zone;

a carbon dioxide inlet, an oxygen inlet, and a fuel inlet; and

a mixing zone disposed within the combustor and configured to mix a first portion of any carbon dioxide introduced through the carbon dioxide inlet and at least a portion of any oxygen introduced through the oxygen inlet to produce a first mixture within the mixing zone comprising oxygen and carbon dioxide, wherein the first mixture comprises a spatially varied ratio of oxygen-to-carbon dioxide across the burner face configured to generate a hot zone in a combustion zone to increase flame stability in the combustion zone.

~~18. The system of claim 17~~, wherein the hot zone is located substantially in the center of the combustion zone.

19. The system of claim 18, further comprising at least one secondary oxygen inlet configured to spatially vary the ratio of oxygen-to-carbon dioxide in the first mixture.

20. The system of claim 19, further comprising a controller to actively control the spatial variation of the oxygen-to-carbon dioxide ratio by controlling the ratio of oxygen flow through the oxygen inlet and the at least one secondary oxygen inlet.

21. The system of claim 18, further comprising a variable geometry mixing device in the first mixing zone configured to spatially vary the ratio of oxygen-to-carbon dioxide.

22. The system of claim 20, further comprising:

an annular volume formed between the outer shell and the inner shell extending from the first end to the second end, wherein the first portion of any carbon dioxide introduced through the carbon dioxide inlet is configured to flow through the annular volume toward the first end of the combustor from the second end of the combustor, wherein the oxygen inlet is configured to deliver the oxygen introduced through the oxygen inlet to the first portion of any carbon dioxide introduced through the carbon dioxide inlet to produce the first mixture, and wherein the oxygen inlet is positioned in the annular volume at a distance from the first end of the combustor, wherein the distance is configured to promote mixing of the first mixture.

23. The system of claim 22, wherein the oxygen inlet comprises a plurality of injector holes disposed through at least one of a wall of the combustor and a ring in the annular volume.

24. The system of claim 23, further comprising a secondary inner shell configured to prevent introduction of the oxygen through the inner shell, wherein the oxygen inlet is positioned at a

distance from the first end of the combustor and configured to promote mixing of the first mixture.

25. The system of any one of claims 20 and 21, wherein the oxygen inlet and the fuel inlet are positioned at the first end of the combustor and a flow of the first mixture is from the first end of the combustor to the second end of the combustor.

26. The system of claim 17, wherein the combustion burner further comprises:

a central burner body having a plurality of tubes in a bundled arrangement disposed therein, wherein a first portion of the plurality of tubes are configured to carry the fuel and a second portion of the plurality tubes are configured to carry the oxygen;

an opening disposed through at least a portion of a side of the central burner body configured to permit the passage of the first portion of any carbon dioxide into a volume disposed between the plurality of tubes; and

a controller configured to modulate at least a flow rate of the oxygen across the second portion of the tubes configured to carry the oxygen to spatially vary the ratio of oxygen-to-carbon dioxide across the burner face.

27. The system of any one of claims 17, 22, and 26, further comprising a gas injection device configured to provide an anchor flame upstream of the combustion zone, the anchor flame being adapted to increase flame stability in the combustion zone.

28. A method for combusting a fuel in a combustion system, comprising:

mixing oxygen and carbon dioxide in a first mixing zone disposed within a combustor to produce a first mixture;

mixing the first mixture and a fuel in a second mixing zone disposed within the combustor to produce a second mixture; and

combusting at least a portion of the fuel in the second mixture to produce a combustion product.

29. The method of claim 28, applied to the combustor system of any one of claims 2, 4, 6, 13, and 14.

30. A method for combusting a fuel in a combustion system, comprising:

introducing oxygen and carbon dioxide to a burner face of a combustor; and

varying a spatial ratio of the oxygen to the carbon dioxide across the burner face to increase flame stability in the combustor.

31. The method of claim 30, applied to the combustor systems of any one of claims 17, 22, and 26.