CLAIMS

What is claimed is:

1. A regeneration method, comprising:

(a) conducting fuel through at least one first conduit and oxidant through at least one second conduit, the first and second conduits being located in a recuperation zone of a reactor system;

(b) combining and reacting at least a portion of the fuel with at least a portion of the oxidant in a mixing-distributing zone to produce heat and a first reaction product, the mixing-distributing zone being located (i) in the reactor system and (ii) downstream of the recuperation zone and upstream of a reaction zone, the mixing-distributing zone comprising a mixer-distributor having a ~~Maldistibution~~ Maldistribution $\leq$ 15.0%, a pressure drop $\leq$ 0.3 bar, and a combined fuel-oxidant flow rate $\geq$ 10.0 kg/hr; and

(c) conducting the reaction product through the reaction zone and transferring at least a portion of the heat from the reaction product to the reaction zone~~.~~;

wherein

(A) the mixer-distributor comprises a plurality of first orifices in a first location; at least one second orifice at a second location, the first location being upstream of the second location with respect to the fuel-oxidant flow; and a fuel-oxidant flow preventer for preventing fuel-oxidant flow through the mixer-distributor except via the orifices, the fuel-oxidant flow preventer comprising a first plate proximate to the first location and a second plate proximate to the second location, the first orifices being perforations in the first plate and the second orifice being a perforation in the second plate, wherein the number of orifices at the first location is greater than the number of orifices at the second location;

(B) (i) the first and second plates are of substantially circular cross-section;

(ii) the first plate has a cross-sectional area A_{p1} and the second plate has a cross-sectional area A_{p2}, A_{p1} being within +/- 10.0% of A_{p2};

(iii) the first plate has a cross-sectional area of the plurality of orifices A_{h1} and the second plate has a cross-sectional area of the substantially-centered orifice A_{h2}, A_{h1} being within +/- 10.0% of A_{h2};

(iv) $A_{p1} \leq 2.0\ A_{h1}$;

(v) the first plate has a thickness of T_{p1} and the second plate has a thickness T_{p2}, T_{p1} and T_{p2} are each $\leq 0.5 \cdot D_p$, where D_p is the effective plate diameter; and

(vi) a distance between the downstream face of first plate and the upstream face of second plate $S_{p1\text{-}p2}$ is in the range of $0.25 \cdot S_b$ to $5.0 \cdot S_b$, wherein S_b equals A_{h1} divided by the perimeter of plate 1; and

(C) the mixer-distributor further comprises third, fourth, and fifth perforated plates of substantially circular cross-section, the fifth plate being upstream of the first plate, the third plate being downstream of the second plate, and the fourth plate being downstream of the third plate, wherein

(i) the fifth plate has a number of perforations in the range of 3 to 6 times the number of perforations in the first plate, a cross-sectional area A_{p5} being within +/- 10.0% of A_p, a cross-sectional area of the plurality of orifices A_{h5} being within +/- 10.0% of A_{h1}, a thickness T_{p5} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of fifth plate and the upstream face of first plate $S_{p5\text{-}p1}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(ii) the third plate has substantially the same number of perforations as the first plate, with a cross-sectional area A_{p3} being within +/- 10.0% of A_{p1}, a cross-sectional area of the plurality of orifices A_{h3} being within +/- 10.0% of A_{h1}, a thickness T_{p3} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of second plate and the upstream face of third plate $S_{p2\text{-}p3}$ being within +/- 10.0% of $S_{p1\text{-}p2}$; and

(iii) the fourth plate has substantially the same number of perforations as the fifth plate, with a cross-sectional area A_{p4} being within +/- 10.0% of A_{p1}, a cross-sectional area of the plurality of orifices A_{h4} being within +/- 10.0% of A_{h1}, a thickness T_{p4} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of third plate and the upstream face of fourth plate $S_{p3\text{-}p4}$ being within +/- 10.0% of $S_{p1\text{-}p2}$.

2. The method of claim 1, wherein the mixer-distributor has a Maldistribution $\leq$ 10.0%, a pressure drop $\leq$ 0.1 bar, and a combined fuel-oxidant flow rate $\geq$ 100.0 kg/hr.

3. The method of ~~claims 1 or 2~~ claim 1, wherein the mixer-distributor has a Mixing Efficiency $\geq$ 75.0 wt. %.

4. The method of ~~any of claims 1-3~~ claim 1, wherein the mixer-distributor has a Temperature Variability $\leq$ 60.0°C.

5. The method of claim ~~4~~ 1, wherein the mixer-distributor includes swirling means having a swirl number in the range of from 0.1 to 1.3.

~~6. The method of any of claims 1-5, wherein the mixer-distributor comprises a plurality of first orifices in a first location; at least one second orifice at a second location, the first location being upstream of the second location with respect to the fuel-oxidant flow; and means for substantially preventing fuel-oxidant flow through the mixer-distributor except via the orifices, wherein the number of orifices at the first location is greater than the number of orifices at the second location.~~

~~7.~~6. The method of claim ~~6~~ 1, wherein (i) at least one orifice at the second location is substantially coaxial with the mixing-distributing zone and (ii) the number of orifices at the first location is in the range of 2 times to 8 times the number of orifices at the second location.

~~8. The method of claims 6 or 7, wherein the flow-preventing means comprise a first plate proximate to the first location and a second plate proximate to the second location, the first orifices being perforations in the first plate and the second orifice being a perforation in the second plate.~~

~~9.~~7. The method of ~~any of claims 6-8~~ claim 1, wherein the first and second plates are substantially parallel and coaxial, and wherein the second orifice is substantially coaxial with (i) the second plate and (ii) with the mixing-distributing zone.

~~10. The method of any of claims 6-9, wherein~~

~~(i) the first and second plates are of substantially circular cross-section;~~

~~(ii) A_{p1} is within +/- 10.0% of A_{p2};~~

~~(iii) A_{h1} is within +/- 10.0% of A_{h2};~~

~~(iv) $A_{p1} \geq 2.0 \cdot A_{h1}$;~~

~~(v) T_{p1} and T_{p2} are each $\leq 0.5 \cdot D_p$; and~~

~~(vi) S_{p1-p2} is in the range of $0.25 \cdot S_b$ to $5.0 \cdot S_b$.~~

~~11. The method of any of claims 6-10, wherein the mixer-distributor further comprises third, fourth, and fifth perforated plates of substantially circular cross-section, the fifth plate being upstream of the first plate, the third plate being downstream of the second plate, and the fourth plate being downstream of the third plate, wherein~~

~~(i) the fifth plate has a number of perforations in the range of 3 to 6 times the number of perforations in the first plate, with A_{p5} being within +/- 10.0% of A_{p1}, A_{h5} being within +/- 10.0% of A_{h1}, T_{p5} being within +/- 10.0% of T_{p1}, and $S_{p1\text{-}p5}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;~~

~~(ii) the third plate has substantially the same number of perforations as the first plate, with A_{p3} being within +/- 10.0% of A_{p1}, A_{h3} being within +/- 10.0% of A_{h1}, T_{p3} being within +/- 10.0% of T_{p1}, and $S_{p2\text{-}p3}$ being within +/- 10.0% of $S_{p1\text{-}p2}$; and~~

~~(iii) the fourth plate has substantially the same number of perforations as the fifth plate, with A_{p4} being within +/- 10.0% of A_{p1}, A_{h4} being within +/- 10.0% of A_{h1}, T_{p4} being within +/- 10.0% of T_{p1}, and $S_{p3\text{-}p4}$ being within +/- 10.0% of $S_{p1\text{-}p2}$.~~

~~12.~~8. The method of ~~any of claims 6-11~~ claim 1, wherein one or more of plates 1 - 5 comprise at least one of yttria, zirconia, alumina, or silica.

~~13.~~9. The method of ~~any of claims 1-12~~ claim 1, wherein the mixer-distributor has ~~an~~ a segment height L and a segment characteristic D and a L:D ratio in the range of from 0.5 to 1.5.

~~14.~~10. The method of ~~any of claims 1-13~~ claim 1, wherein the reacting heats at least a portion of the reactor to a temperature $\geq 1.40 \times 10^3$°C, the reacting occurring at a pressure ≥ 1.0 bar.

~~15.~~11. The method of ~~any of claims 1-14~~ claim 1, wherein the fuel is a mixture, the mixture comprising ≥ 10.0 wt. % hydrocarbon based on the weight of the mixture.

~~16.~~12. The method of ~~any of claims 1-15~~ claim 1, wherein the fuel comprises ≥ 25.0 wt. % methane based on the weight of the fuel.

~~17.~~13. The method of ~~any of claims 1-16~~ claim 1, wherein the oxidant comprises ≥ 10.0 wt. % molecular oxygen based on the weight of the oxidant.

~~18.~~14. The method of ~~any of claims 1-17~~ claim 1, further comprising conducting diluent through the second conduit during step (a).

~~19.~~15. The method of any of ~~claims 1-18~~ claim 1, wherein the mixer-distributor has a total volume ≤ 10.0% of the sum of (i) the mixing-distributing zone's volume, (ii) the recuperator zone's volume, and (iii) the reaction zone's volume.

~~20.~~16. The method of ~~any of claims 1-19~~ claim 1, wherein the reactor system produces unsaturated hydrocarbon by pyrolysis, the pyrolysis utilizing at least a portion of the heat.

~~21.~~17. A mixer-distributor for mixing and distributing a flow of fuel and oxidant in a mixing-distributing zone of a regenerative, reverse-flow reactor, the mixer-distributor comprising:

(a) at least one first baffle and a plurality of first orifices, the first baffle and plurality of first orifices being positioned at a first location in the mixer-distributor;

(b) at least one second baffle and at least one second orifice, the second baffle and second orifice being located at a second location in the mixer-distributor, wherein (i) the first location is upstream of the second location with respect to the fuel-oxidant flow and (ii) the first location has a greater number of orifices than the second location; and

(c) an inner boundary of the mixing-distributing zone, the inner boundary being either (i) connected to the first baffle's perimeter and the second baffle's perimeters or (ii) sufficiently proximate to the first and second baffles' perimeters to substantially prevent the flow through the mixing-distributing zone except via the first and second orifices~~.~~,

wherein

(A) the first baffle comprises a first perforated plate proximate to the first location and the second baffle comprises a second perforated plate proximate to the second location, the first plate's perforations being the first orifices and the second plate's perforations being the second orifices;

(B) at least one orifice at the second location is substantially coaxial with the mixing-distributing zone; and

(C) the number of orifices at the first location is in the range of 2 times to 8 times the number of orifices at the second location;

(D) the mixing-distributing zone is of substantially-uniform cross-sectional area, and wherein

(i) the first and second plates are substantially parallel plates that are coaxial and of substantially circular cross-section;

(ii) the first plate's perforations are of substantially-circular cross-sections and are equally-spaced along $R1_{p1}$;

(iii) the second orifice is substantially coaxial with (i) the second plate and (ii) the mixing-distributing zone;

(iv) the first plate has a cross-sectional area A_{p1} and the second plate has a cross-sectional area A_{p2}, A_{p1} being within +/- 10.0% of A_{p2};

(v) the first plate has a cross-sectional area of the plurality of orifices A_{h1} and the second plate has a cross-sectional area of the substantially-centered orifice A_{h2}, A_{h1} being within +/- 10.0% of A_{h2};

(vi) $A_{p1} \geq 2.0\ A_{h1}$;

(vii) the first plate has a thickness T_{p1} and the second plate has a thickness T_{p2}, T_{p1} and T_{p2} are each $\leq 0.5xD_p$, wherein D_p is the effective plate diameter; and

(viii) a distance between the downstream face of first plate and the upstream face of second plate $S_{p1\text{-}p2}$ is in the range of $0.25xS_b$ to $5.0xS_b$, wherein S_b equals A_{h1} divided by the perimeter of plate 1; and

(E) the mixer-distributor further comprises third, fourth, and fifth perforated plates of substantially-circular cross-section, the fifth plate being upstream of the first plate, the third plate being downstream of the second plate, and the fourth plate being downstream of the third plate, wherein

(i) the fifth plate has a number of perforations in the range of 3 to 6 times the number of perforations in the first plate, a cross-sectional area A_{p5} being within +/- 10.0% of A_{p1}, a cross-sectional area of the plurality of orifices A_{h5} being within +/- 10.0% of A_{h1}, a thickness T_{p5} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of fifth plate and the upstream face of first plate $S_{p5\text{-}p1}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(ii) the third plate has substantially the same number of perforations as the first plate, with a cross-sectional area A_{p3} being within +/- 10.0% of A_{p1}, a cross-sectional area of the plurality of orifices A_{h3} being within +/- 10.0% of A_{h1}, a thickness T_{p3} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of second plate and the upstream face of third plate $S_{p2\text{-}p3}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(iii) the fourth plate has substantially the same number of perforations as the fifth plate, with a cross-sectional area A_{p4} being within +/- 10.0% of A_{p1}, a cross-sectional area of the plurality of orifices A_{h4} being within +/- 10.0% of A_{h1}, a thickness T_{p4} being within +/- 10.0% of T_{p1}, and a distance between the downstream face of third plate and the upstream face of fourth plare $S_{p3\text{-}p4}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(iv) the mixer-distributor has a segment height L and a segment characteristic D and a L:D ratio in the range of from 0.5 to 1.5;

(v) the mixer-distributor includes swirling means having a swirl number in the range of from 0.1 to 1.3;

(vi) δ_1 is in the range of 0.0° to 30.0° and δ_2 is in the range of 0.0° to 60.0°; and

(vii) one or more of plates 1- 5 comprise at least one of yttria, zirconia, alumina, or silica.

~~22. The mixer-distributor of claim 21, wherein~~

~~(a) the first baffle comprises a first perforated plate proximate to the first location and the second baffle comprises a second perforated plate proximate to the second location, the first plate's perforations being the first orifices and the second plate's perforations being the second orifices;~~

~~(b) at least one orifice at the second location is substantially coaxial with the mixing-distributing zone; and~~

~~(c) the number of orifices at the first location is in the range of 2 times to 8 times the number of orifices at the second location.~~

~~23. The mixer-distributor of claims 21 or 22, wherein the mixing-distributing zone is of substantially uniform cross-sectional area, and wherein~~

(i) the first and second plates are substantially parallel plates that are coaxial and of substantially circular cross-section;

(ii) the first plate's perforations are of substantially circular cross-sections and are equally spaced along $R1_{p1}$;

(ii) the second orifice is substantially coaxial with (i) the second plate and (ii) the mixing-distributing zone;

(iii) A_{p1} is within +/- 10.0% of A_{p2};

(iv) A_{h1} is within +/- 10.0% of A_{h2};

(v) $A_{p1} \geq 2.0\ A_{h1}$;

(vi) T_{p1} and T_{p2} are each $\leq 0.5 \cdot D_p$; and

(vii) $S_{p1\text{-}p2}$ is in the range of $0.25 \cdot S_b$ to $5.0 \cdot S_b$.

24. The mixer-distributor of any of claims 21-23, wherein the mixer-distributor further comprises third, fourth, and fifth perforated plates of substantially circular cross-section, the fifth plate being upstream of the first plate, the third plate being downstream of the second plate, and the fourth plate being downstream of the third plate, wherein

(i) the fifth plate has a number of perforations in the range of 3 to 6 times the number of perforations in the first plate, with A_{p5} being within +/- 10.0% of A_{p1}, A_{h5} being within +/- 10.0% of A_{h1}, T_{p5} being within +/- 10.0% of T_{p1}, and $S_{p1\text{-}p5}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(ii) the third plate has substantially the same number of perforations as the first plate, with A_{p3} being within +/- 10.0% of A_{p1}, A_{h3} being within +/- 10.0% of A_{h1}, T_{p3} being within +/- 10.0% of T_{p1}, and $S_{p2\text{-}p3}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(iii) the fourth plate has substantially the same number of perforations as the fifth plate, with A_{p4} being within +/- 10.0% of A_{p1}, A_{h4} being within +/- 10.0% of A_{h1}, T_{p4} being within +/- 10.0% of T_{p1}, and $S_{p3\text{-}p4}$ being within +/- 10.0% of $S_{p1\text{-}p2}$;

(iv) the mixer-distributor an L:D ratio in the range of from 0.5 to 1.5;

(v) the mixer-distributor includes swirling means having a swirl number in the range of from 0.1 to 1.3;

(vi) δ_1 is in the range of 0.0° to 30.0° and δ_2 is in the range of 0.0° to 60.0°; and

(vii) one or more of plates 1–5 comprise at least one of yttria, zirconia, alumina, or silica.

25. A hydrocarbon conversion process, comprising:

(A) providing fuel and oxidant to a reactor, the reactor comprising at least one mixer-distributor;

(B) transferring the fuel and oxidant to the mixer-distributor in a fuel-oxidant flow-direction;

(C) mixing and distributing the fuel-oxidant flow in the mixer-distributor and exothermically reacting at least a portion of the oxidant with at least a portion of the fuel sufficient to heat at least a portion of the reactor to a temperature ≥ 800°C, the mixer-distributor comprising:

(i) at least one first baffle and a plurality of first orifices, the first baffle and plurality of first orifices being positioned at a first location in the mixer-distributor;

(ii) at least one second baffle and at least one second orifice, the second baffle and second orifice being located at a second location in the mixer-distributor, wherein (a) the first location is upstream of the second location with respect to the fuel-oxidant flow and (b) the first location has a greater number of orifices than the second location; and

(iii) an inner boundary of the mixing-distributing zone, the inner boundary being either (a) connected to the first baffle's perimeter and the second baffle's perimeters or (b) sufficiently proximate to the first and second baffles' perimeters to substantially prevent the fuel-oxidant flow through the mixing-distributing zone except via the first and second orifices;

(D) providing a first mixture to the heated reactor in a direction that is substantially the reverse of the fuel-oxidant flow direction, the first mixture comprising alkane; and

(E) exposing the first mixture to a temperature ≥ 800°C in the heated reactor and abstracting sufficient heat from the reactor to convert at least a portion of the first mixture's alkane to unsaturated hydrocarbon.