CLAIMS

1. A method for chemical looping with integrated hydrocarbon cracking comprising the steps of:

injecting at least one liquid hydrocarbon feed into a first reactor which operates under first reaction conditions to cause cracking of the least one liquid hydrocarbon feed in the presence of an oxygen carrier to produce a first product stream and petcoke which deposits on the oxygen carrier;

transferring the oxygen carrier with petcoke deposited thereon from the first reactor to a second reactor;

operating the second reactor under second reaction conditions to produce a second product stream and to reduce the oxygen carrier that has petcoke deposited thereon, wherein the second reaction conditions comprise a gasification process in which the petcoke deposited on the oxygen carrier reacts with steam and CO2 that is injected into the second reactor to form the second product stream, which comprises syngas, and whereby the oxygen carrier is reduced, and wherein the second reaction conditions further produce unburned gases containing sulfur;

delivering the second product stream, unburned gases, and the reduced oxygen carrier to a riser;

injecting a sulfur-absorbing material into a riser;

separating the reduced oxygen carrier from the unburned gases and second product stream in a separation section;

transferring at least a first portion of the reduced oxygen carrier to the first reactor, wherein the reduced oxygen carrier provides heat and energy which allows the first reactor to operate under the first reaction conditions;

transferring at least a second portion of the reduced oxygen carrier to a third reactor which operates under third reaction conditions to oxidize the reduced oxygen carrier; and

transferring the oxidized oxygen carrier from the third reactor back to the second reactor.

2. The method of claim 1, wherein the first reactor comprises a cracking reactor, the second reactor comprises a fuel reactor and the third reactor comprises an air reactor.

3. The method of claim 1, wherein the at least one liquid hydrocarbon feed comprises a heavy liquid fuel.

4. The method of claim 1, wherein the oxygen carrier comprises metal oxides.

5. The method of claim 4, wherein the metal oxides are disposed in a bed that is within the first reactor.

6. The method of claim 1, further comprising the step of splitting, in a splitter reactor, the first portion of the reduced oxygen carrier from the second reactor into one portion that is returned back to the first reactor and another portion that is returned to the second reactor, and maintaining, via the splitter reactor, the pressure balance between the first reactor and the second reactor by controlling circulation of the reduced oxygen carrier between the first reactor and the second reactor.

7. The method of claim 1, further comprising the step of splitting, in a splitter reactor, the oxidized oxygen carrier from the third reactor into a portion that is returned back to the second reactor and another portion that is returned back to the third reactor, and maintaining, via the splitter reactor, the pressure balance between the second reactor and the third reactor by controlling circulation of the oxidized oxygen carrier between the second reactor and the third reactor.

8. The method of claim 1, further comprising transferring the second product stream from the second reactor to a gas turbine for producing energy, wherein the second product stream includes syngas.

9. A process for chemical looping combustion with integrated hydrocarbon cracking, comprising the steps of:

injecting a heavy liquid fuel and metal oxides into a cracking reactor;

cracking the heavy fuel in the cracking reactor in the presence of the metal oxides to produce petroleum-based products and petcoke deposits on the metal oxides;

delivering the metal oxides with petcoke deposited thereon from the cracking reactor to a fuel reactor;

gasifying the metal oxides with petcoke deposited thereon in the fuel reactor in the presence of steam to produce a product gas stream, unburned gases, and reduced metal oxides;

delivering the product gas stream, unburned gases, and the reduced metal oxides from the fuel reactor to a riser;

injecting a sulfur-absorbing material into the riser;

separating the reduced metal oxides from the unburned gases and the product gas stream in a separation section;

delivering the separated reduced metal oxides to an air reactor; and

oxidizing the reduced metal oxides in the air reactor to produce oxidized metal oxides and flue gas, wherein the oxidized metal oxides are delivered back to the fuel reactor.

10. The process of claim 9, wherein the fuel reactor is one of a turbulent bed, fluidized bed, and circulating fluidized bed.

11. The process of claim 9, wherein the cracking reactor is one of a turbulent bed, fluidized bed, and circulating fluidized bed.

12. The process of claim 9, wherein the petroleum-based products comprise products selected from the group consisting of naphtha, gasoline, diesel fuel, petcoke, gas oil, and LPG.

13. The process of claim 9, further including the step of delivering the petroleum-based products from the cracking reactor to a separation device.

14. The process of claim 13, further including the step of recycling the petroleum-based products from the separation device to the cracking reactor to increase the yield of petcoke deposited on the reduced metal oxides.

15. The process of claim 9, wherein the product gas stream comprises CO and H_2.

16. The process of claim 15, wherein the product gas stream comprises syngas.

17. The process of claim 16, wherein the syngas is used in a combine cycle turbine to produce electricity.

18. The process of claim 9, wherein the unburned gases contains sulfur.

19. The process of claim 9, wherein the sulfur-absorbing material is limestone.

20. The process of claim 9, further including the steps of transporting the reduced metal oxides from the separation section to a splitter reactor, maintaining, via the splitter reactor,

the pressure balance between the cracking reactor and the fuel reactor by controlling circulation of the reduced metal oxides between the cracking reactor and the fuel reactor, and transporting portions of the reduced metal oxides from the splitter reactor to the cracking reactor and the fuel reactor.

21. The process of claim 9, further including the step of transporting the oxidized metal oxides and flue gas from the air reactor to a separation device, wherein the oxidized metal oxides are separated from the flue gas.

22. The process of claim 21, further including the steps transporting the oxidized metal oxides from the separation device to a splitter reactor, maintaining, via the splitter reactor, the pressure balance between the fuel reactor and the air reactor by controlling circulation of the oxidized metal oxides between the fuel reactor and the air reactor, and transporting portions of the oxidized metal oxides from the splitter reactor to the fuel reactor and the air reactor.

23. The process of claim 9, further including the step of injecting an air stream into the air reactor to oxidize the reduced oxygen carrier.

24. A system that integrates heavy fuel coking and chemical looping combustion comprising:

a source of heavy liquid fuel;

a cracking reactor in which the heavy liquid fuel and metal oxides are introduced, and the heavy liquid fuel undergoes a cracking reaction to form petroleum-based products and petcoke particles are deposited on the metal oxides;

a fuel reactor that is in fluid communication with the cracking reactor and receives the metal oxides with petcoke deposited thereon through a first conduit, the fuel reactor being configured for gasifying the metal oxides with petcoke deposits thereon with steam that is introduced into the fuel reactor resulting in the production of syngas, unburned gases, and reduced metal oxides;

a riser that is in fluid communication with the fuel reactor and receives the syngas, unburned gases, and the reduced metal oxides, and is in fluid communication with the cracking reactor such that a first portion of reduced metal oxides is transported from the riser to the cracking reactor and a second portion of reduced metal oxides is transported from the riser to the fuel reactor;

an air reactor that is in fluid communication with the fuel reactor through a second conduit and receives reduced metal oxides from the fuel reactor, the air reactor including an inlet for the introduction of air for oxidizing the reduced metal oxides to generate oxidized metal oxides and flue gases; and

a third conduit that fluidly connects the air reactor and the fuel reactor such that a first portion of the oxidized metal oxides is transported from the air reactor to the fuel reactor, and a second portion of the oxidized metal oxides is recycled back to the air reactor.

25. The system of claim 24, further including a separation device in fluid communication with the cracking reactor through a fourth conduit, the separation device receiving the petroleum-based products from the cracking reactor.

26. The system of claim 24, further including a separator in fluid communication with the riser through a fourth conduit, the separator receiving the syngas, the unburned gases, and the reduced metal oxides from the riser, separating the syngas unburned gases from the reduced metal oxides, and transporting the reduced metal oxides to the cracking reactor and the fuel reactor.

27. The system of claim 26, further including a splitter reactor for maintaining pressure balance between the cracking reactor and the fuel reactor, the splitter reactor being fluidly connected to the separator by a fifth conduit and through which the reduced metal oxides from the separator pass prior to being received by the cracking reactor and the fuel reactor.

28. The system of claim 24, further including a separator in fluid communication with the air reactor through a fourth conduit, the separator receiving the oxidized metal oxides and flue gases from the air reactor, separating the oxidized metal oxides from the flue gases, and transporting the oxidized metal oxides to the fuel reactor and the air reactor.

29. The system of claim 28, further including a splitter reactor for maintaining pressure balance between the fuel reactor and the air reactor, the splitter reactor being fluidly connected to the separator by a fifth conduit and through which the oxidized metal oxides from the separator pass prior to being received by the fuel reactor and the air reactor.