CLAIMS

1. A process for recovering sulfur from a tail gas stream, the process comprising the steps of:

providing a tail gas stream to a chemical looping combustion (CLC) unit, where the tail gas stream comprises a sulfide component;

providing an oxygen carrier to the CLC unit, where the oxygen carrier comprises calcium carbonate;

providing an air stream to the CLC unit, where the air stream comprises oxygen; and

reacting the sulfide component in the CLC unit with the calcium carbonate and the oxygen to produce a product effluent, where the product effluent comprises calcium sulfate.

2. The process of claim 1, further comprising the steps of:

introducing the oxygen carrier to an air reactor of the CLC unit;

introducing the air stream to the air reactor of the CLC unit;

allowing the calcium carbonate to decompose in the air reactor to produce an air reactor effluent, the air reactor effluent comprises calcium oxide;

introducing the air reactor effluent to an air reactor separator, where the air reactor separator comprises a solid-gas separation unit;

separating calcium oxide from the air reactor effluent in the air reactor separator to produce an air reactor exhaust and an air reactor discharge, where the air reactor discharge comprises the calcium oxide;

introducing the air reactor discharge to a fuel reactor of the CLC unit;

introducing the tail gas stream to the fuel reactor;

reacting the calcium oxide and the hydrogen sulfide to produce a fuel reactor effluent, where the fuel reactor effluent comprises calcium sulfide and calcium carbonate;

introducing the fuel reactor effluent to a fuel reactor separator, where the fuel reactor separator comprises a solid-gas separation unit;

separating the calcium sulfide and calcium carbonate from the fuel reactor effluent in the fuel reactor separator to produce a flue gas exhaust and a fuel reactor discharge, where the fuel reactor discharge comprises the calcium sulfide and calcium carbonate;

introducing the fuel reactor discharge to the air reactor;

reacting the calcium sulfide and the oxygen in the air reactor to produce calcium sulfate; and

withdrawing a product effluent from the air reactor discharge, where the product effluent comprises a fraction of the calcium sulfate.

3. The process of claim 2, wherein the fuel reactor is operated at a fuel reaction pressure of atmospheric pressure, and further wherein the fuel reactor is operated at a fuel reaction temperature of 650 deg C.

4. The process of claim 2, wherein the air reactor is operated at an air reaction pressure of atmospheric pressure, and further wherein the air reactor is operated at an air reaction temperature of 900 deg C.

5. The process of claim 2, wherein the air reactor is a fluidized bed reactor packed with calcium carbonate, and further wherein the fuel reactor is a fluidized bed reactor packed with calcium carbonate.

6. The process of claim 1, further comprising the steps of:

introducing the oxygen carrier to a calciner unit of the CLC unit;

calcining the calcium carbonate in the oxygen carrier to produce a calciner effluent, where the calciner effluent comprises calcium oxide;

introducing the calciner effluent to a calciner separator, where the calciner separator comprises a solid-gas separation unit;

separating the calcium oxide from the calciner effluent in the calciner separator to produce a calciner exhaust and a calciner discharge;

introducing the calciner discharge to a fuel reactor of the CLC unit;

introducing the tail gas stream to the fuel reactor;

reacting the calcium oxide and the hydrogen sulfide to produce a fuel reactor effluent, where the fuel reactor effluent comprises calcium sulfide and calcium carbonate;

introducing the fuel reactor effluent to a fuel reactor separator, where the fuel reactor separator comprises a solid-gas separation unit;

separating the calcium sulfide and calcium carbonate from the fuel reactor effluent in the fuel reactor separator to produce a flue gas exhaust and a fuel reactor discharge, where the fuel reactor discharge comprises the calcium sulfide and calcium carbonate;

introducing the fuel reactor discharge to an air reactor of the CLC unit;

reacting the calcium sulfide and the oxygen in the air reactor to produce an air reactor effluent, where the air reactor effluent comprises calcium sulfate;

introducing the air reactor effluent to an air reactor separator, where the air reactor separator comprises a solid-gas separation unit;

separating calcium oxide from the air reactor effluent in the air reactor separator to produce an air reactor exhaust and an air reactor outlet, where the air reactor outlet comprises the calcium sulfate;

withdrawing a product effluent from the air reactor outlet, where the product effluent comprises a fraction of the calcium sulfate.

7. The process of claim 6, wherein the fuel reactor is operated at a fuel reaction pressure of atmospheric pressure, and further wherein the fuel reactor is operated at a fuel reaction temperature of 650 deg C.

8. The process of claim 6, wherein the air reactor is operated at an air reaction pressure of atmospheric pressure, and further wherein the air reactor is operated at an air reaction temperature of 900 deg C.

9. The process of claim 6, wherein the calciner unit is operated at a calciner reaction pressure of atmospheric pressure, and further wherein the calciner unit is operated at a calciner reaction temperature of 900 deg C.

10. The process of claim 6, wherein the air reactor is a fluidized bed reactor packed with calcium carbonate, and further wherein the fuel reactor is a fluidized bed reactor packed with calcium carbonate.

11. The process of claim 1, further comprising the steps of:

introducing the oxygen carrier to a calciner unit of the CLC unit;

calcining the calcium carbonate in the oxygen carrier to produce a calciner effluent, where the calciner effluent comprises calcium oxide;

introducing the calciner effluent to a calciner separator, where the calciner separator comprises a solid-gas separation unit;

separating the calcium oxide from the calciner effluent in the calciner separator to produce a calciner exhaust and a calciner discharge;

diverting a portion of the calciner discharge to produce a calciner slipstream;

introducing the calciner discharge to a fuel reactor of the CLC unit;

introducing the tail gas stream to the fuel reactor;

reacting the calcium oxide and the hydrogen sulfide to produce a fuel reactor effluent, where the fuel reactor effluent comprises calcium sulfide and calcium carbonate;

introducing the fuel reactor effluent to a fuel reactor separator, where the fuel reactor separator comprises a solid-gas separation unit;

separating the calcium sulfide and calcium carbonate from the fuel reactor effluent in the fuel reactor separator to produce a flue gas exhaust and a fuel reactor discharge, where the fuel reactor discharge comprises the calcium sulfide and calcium carbonate;

introducing the flue gas exhaust and the calciner slipstream to a reducing reactor of the CLC unit;

reacting the calcium oxide and hydrogen sulfide in the reducing reactor to produce a reducing reactor effluent;

separating the reducing reactor effluent in a reducing reactor separator to produce an exhaust gases stream and a reducing reactor discharge, where the reducing reactor separator comprises a solid-gas separation unit;

introducing the reducing reactor discharge to the calciner unit;

introducing the fuel reactor discharge to an air reactor of the CLC unit;

reacting the calcium sulfide and the oxygen in the air reactor to produce an air reactor effluent, where the air reactor effluent comprises calcium sulfate;

introducing the air reactor effluent to an air reactor separator, where the air reactor separator comprises a solid-gas separation unit;

separating calcium oxide from the air reactor effluent in the air reactor separator to produce an air reactor exhaust and an air reactor discharge, where the air reactor discharge comprises the calcium sulfate;

withdrawing a product effluent from the air reactor discharge, where the product effluent comprises a fraction of the calcium sulfate.

12. The process of claim 11, wherein the fuel reactor is operated at a fuel reaction pressure of atmospheric pressure, and further wherein the fuel reactor is operated at a fuel reaction temperature of 830 deg C.

13. The process of claim 11, wherein the air reactor is operated at an air reaction pressure of atmospheric pressure, and further wherein the air reactor is operated at an air reaction temperature of 900 deg C.

14. The process of claim 11, wherein the calciner unit is operated at a calciner reaction pressure of atmospheric pressure, and further wherein the calciner unit is operated at a calciner reaction temperature of 900 deg C.

15. The process of claim 11, wherein the reducing reactor is operated at a reducing pressure of atmospheric pressure, and further wherein the reducing reactor is operated at a reducing temperature of 650 deg C.

16. The process of claim 11, wherein the air reactor is a fluidized bed reactor packed with calcium carbonate, and further wherein the fuel reactor is a fluidized bed reactor packed with calcium carbonate.

17. The process of claim 1, further comprising the steps of:

introducing an acid gas stream to a sulfur recovery unit, where the acid gas stream comprises hydrogen sulfide;

introducing a sulfur recovery unit (SRU) air stream to the sulfur recovery unit, where the SRU air stream comprises oxygen;

introducing an SRU fuel stream to the sulfur recovery unit; and

reacting an amount of the hydrogen sulfide in the sulfur recovery unit with oxygen to produce an elemental sulfur stream and the tail gas stream.

18. The process of claim 1, further comprising the steps of:

introducing a sour gas feed to a gas sweetening unit, where the sour gas feed comprises hydrogen sulfide, product gases, and combinations of the same;

separating the hydrocarbons in the gas sweetening unit to produce a sales gas stream, where the sales gas stream comprises the product gases;

collecting the hydrogen sulfide and the other gases in the acid gas stream;

introducing the acid gas stream to a sulfur recovery unit, where the acid gas stream comprises hydrogen sulfide;

introducing a sulfur recovery unit (SRU) air stream to the sulfur recovery unit, where the SRU air stream comprises oxygen;

introducing an SRU fuel stream to the sulfur recovery unit; and

reacting an amount of the hydrogen sulfide in the sulfur recovery unit with oxygen to produce an elemental sulfur stream and the tail gas stream.

19. The process of claim 1, further comprising the steps of:

introducing a sour gas feed to a gas sweetening unit, where the sour gas feed comprises hydrogen sulfide, product gases, and combinations of the same;

separating the hydrocarbons in the gas sweetening unit to produce a sales gas stream, where the sales gas stream comprises the product gases;

collecting the hydrogen sulfide and the other gases in the acid gas stream;

introducing the acid gas stream to a membrane unit, where the membrane unit comprises a hydrogen sulfide selective membrane;

separating the hydrogen sulfide from the acid gas stream in the membrane unit to produce a hydrogen sulfide rich acid gas and a hydrogen sulfide lean acid gas, where the hydrogen sulfide rich acid gas comprises hydrogen sulfide;

introducing the hydrogen sulfide rich acid gas to a sulfur recovery unit;

introducing a sulfur recovery unit (SRU) air stream to the sulfur recovery unit, where the SRU air stream comprises oxygen;

introducing an SRU fuel stream to the sulfur recovery unit;

reacting an amount of the hydrogen sulfide in the sulfur recovery unit with oxygen to produce an elemental sulfur stream and a tail gas stream;

mixing the tail gas stream and the hydrogen sulfide lean acid gas to produce a mixed gas stream; and

introducing the mixed gas stream to the CLC unit.

20. A system for recovering sulfur from a tail gas stream, the system comprising:

an air reactor, where the air reactor operates at an air reaction temperature and an air reaction pressure, where the air reactor comprises a fluidized bed reactor, where the fluidized bed comprises calcium carbonate;

an air reactor separator fluidly connected to the air reactor and a fuel reactor, where the air reactor separator comprises a solid-gas separation unit;

the fuel reactor fluidly connected to the air reactor separator, where the fuel reactor operates at a fuel reaction temperature and fuel reaction pressure, where the fuel reactor comprises a fluidized bed reactor, where the fluidized bed comprises calcium carbonate; and

a fuel reactor separator fluidly connected to the fuel reactor and the air reactor, where the fuel reactor separator comprises a solid-gas separation unit.