CLAIMS

1. A method to recover sulfur from hydrogen sulfide in an acid gas feed, the method comprising the steps of:

introducing the acid gas feed to a combustion furnace, where the acid gas feed comprises hydrogen sulfide;

introducing an air feed to the combustion furnace, where the air feed comprises oxygen;

reacting the hydrogen sulfide and oxygen in the combustion furnace to produce a furnace effluent stream, where the furnace effluent stream comprises hydrogen sulfide, elemental sulfur, sulfur dioxide, and water vapor;

introducing the furnace effluent to a waste heat boiler;

transferring heat from the furnace effluent to a water feed to produce a boiler effluent and a steam outlet;

introducing the boiler effluent to a sulfur condenser;

reducing the temperature of the boiler effluent in the sulfur condenser to produce a sulfur stream and a non-condensed gases, where the sulfur stream comprises elemental sulfur, where the non-condensed gases comprises hydrogen sulfide, sulfur dioxide, and water vapor;

introducing the non-condensed gases to a first water adsorber, where the first water adsorber comprises a first molecular sieve;

separating the water vapor from the non-condensed gases stream in the first water adsorber to produce a first recovered water stream and a first dehydrated stream, where the first recovered water stream comprises water, where the first dehydrated stream comprises hydrogen sulfide, sulfur dioxide, and combinations of the same;

introducing the first dehydrated stream into a first hydrogenation reactor;

introducing a hydrogen feed to the first hydrogenation reactor, where the hydrogen feed comprises hydrogen gas;

reacting the sulfur dioxide and the hydrogen gas to produce hydrogen sulfide in the first hydrogenation reactor to produce a reduced stream, where the reduced stream comprises hydrogen sulfide;

introducing the reduced stream to a reactor furnace;

introducing an air stream to the reactor furnace, where the air stream comprises oxygen;

introducing a fresh feed to the reactor furnace, where the fresh feed comprises hydrogen sulfide;

reacting the hydrogen sulfide and oxygen in the reactor furnace to produce a reactor effluent, where the reactor effluent comprises hydrogen sulfide, elemental sulfur, sulfur dioxide, and water vapor;

introducing the reactor effluent to a heat recovery boiler;

transferring heat from the reactor effluent to a water stream to produce a cooled effluent and a steam stream;

introducing the cooled effluent to a sulfur cooler;

reducing the temperature of the cooled effluent in the sulfur cooler to produce a recovered sulfur stream and a gases stream, where the recovered sulfur stream comprises elemental sulfur, where the gases stream comprises hydrogen sulfide, sulfur dioxide, and water vapor;

introducing the gases stream to a second water adsorber, where the second water adsorber comprises a second molecular sieve;

separating the water vapor from the gases stream in the second water adsorber to produce a second recovered water stream and a second dehydrated stream, where the second recovered water stream comprises water, where the second dehydrated stream comprises hydrogen sulfide and sulfur dioxide;

introducing the second dehydrated stream into a second hydrogenation reactor;

introducing a hydrogen stream to the second hydrogenation reactor, where the hydrogen stream comprises hydrogen gas;

reacting the sulfur dioxide and the hydrogen gas to produce hydrogen sulfide in the second hydrogenation reactor to produce a treated tail gas stream, where the treated tail gas stream comprises hydrogen sulfide; and

recycling the treated tail gas stream to the combustion furnace.

2. The method of claim 1, where a total conversion is determined.

3. The method of claim 2, where the total conversion exceeds 99 % by weight.

4. The method of claim 1, where the first molecular sieve comprises zeolite-3A, and further where the second molecular sieve comprises zeolite-3A.

5. The method of claim 1, where a temperature in the combustion furnace is between 1800 deg F. and 2500 deg F., and further where a temperature in the reaction furnace is between 1800 deg F. and 2500 deg F.

6. The method of claim 1, where a temperature in the sulfur condenser is between 100 deg F. and 200 deg F., and further where a temperature in the sulfur cooler is between 100 deg F. and 200 deg F.

7. The method of claim 1, where a temperature in first water adsorber is between 75 deg C. and 170 deg C., and further where a temperature in the second water adsorber is between 75 deg C. and 170 deg C.

8. The method of claim 1, where the first dehydrated stream comprises a concentration of water of less than 1 ppm, and further where the second dehydrated stream comprises a concentration of water less than 1 ppm.

9. The method of claim 1, where a temperature in the first hydrogenation reactor is between 220 deg C. and 310 deg C., and where a temperature in the second hydrogenation reactor is between 220 deg C. and 310 deg C.

10. A system to recover sulfur from hydrogen sulfide in an acid gas stream, the system comprising:

a combustion furnace, the combustion furnace configured to convert the hydrogen sulfide to elemental sulfur to produce a furnace effluent, wherein the furnace effluent comprises elemental sulfur, hydrogen sulfide, sulfur dioxide, and water vapor;

a waste heat boiler fluidly connected to the combustion furnace, the waste heat boiler configured to remove heat from the furnace effluent to produce a boiler effluent;

a sulfur condenser fluidly connected to the waste heat boiler, the sulfur condenser configured to condense the elemental sulfur in boiler effluent to produce a sulfur stream and a non-condensed gases, where the non-condensed gases is in the absence of elemental sulfur, where the non-condensed gases comprises water vapor;

a first water adsorber fluidly connected to the sulfur condenser, the first water adsorber configured to remove water from the non-condensed gases to produce a first recovered water stream and a first dehydrated stream, where the first water adsorber comprises a first molecular sieve, where the first dehydrated stream is in the absence of water vapor, where the first dehydrated stream comprises sulfur dioxide;

a first hydrogenation reactor fluidly connected to the first water adsorber, the first hydrogenation reactor configured to convert sulfur dioxide to hydrogen sulfide in the presence of hydrogen gas;

a reactor furnace fluidly connected to the first hydrogenation reactor, the reactor furnace configured to convert hydrogen sulfide to elemental sulfur in the presence of oxygen and sulfur dioxide;

a heat recovery boiler fluidly connected to the reactor furnace, the heat recovery boiler configured to remove heat from the reactor effluent to produce a boiler effluent;

a sulfur cooler fluidly connected to the heat recovery boiler, the sulfur cooler configured to condense the elemental sulfur in reactor effluent to produce a recovered sulfur stream and a gases stream, where the gases stream is in the absence of elemental sulfur, where the gases stream comprises water vapor;

a second water adsorber fluidly connected to the sulfur condenser, the second water adsorber configured to remove water from the non-condensed gases to produce a second recovered water stream and a second dehydrated stream, where the second water adsorber comprises a second molecular sieve, where the second dehydrated stream is in the absence of water vapor, where the second dehydrated stream comprises sulfur dioxide; and

a second hydrogenation reactor fluidly connected to the second water adsorber, the second hydrogenation reactor configured to convert sulfur dioxide to hydrogen sulfide in the presence of hydrogen gas to produce a treated tail gas stream, where the second hydrogenation reactor is fluidly connected to the combustion furnace, where the treated tail gas stream is recycled to the combustion furnace.

11. The system of claim 10, where a total conversion is determined.

12. The system of claim 11, where the total conversion exceeds 99 % by weight.

13. The system of claim 10, where the first molecular sieve comprises zeolite-3A, and further where the second molecular sieve is zeolite-3A.

14. The system of claim 10, where a temperature in the combustion furnace is between 1800 deg F. and 2500 deg F., and further where a temperature in the reaction furnace is between 1800 deg F. and 2500 deg F.

15. The system of claim 10, where a temperature in the sulfur condenser is between 100 deg F. and 200 deg F., and further where a temperature in the sulfur cooler is between 100 deg F. and 200 deg F.

16. The system of claim 10, where a temperature in first water adsorber is between 75 deg C. and 170 deg C., and further where a temperature in the second water adsorber is between 75 deg C. and 170 deg C.

17. The method of claim 10, where the first dehydrated stream comprises a concentration of water of less than 1 ppm, and further where the second dehydrated stream comprises a concentration of water less than 1 ppm.

18. The method of claim 10, where a temperature in the first hydrogenation reactor is between 220 deg C. and 310 deg C., and where a temperature in the second hydrogenation reactor is between 220 deg C. and 310 deg C.