Claims

1. A circulating fluidized bed syngas cooler system comprising:

an up to 1600°C syngas inlet stream;

circulating heat transfer media circulating in a dense fluid bed in communication with the syngas inlet stream, and circulating in multiple stages of internally circulating fluidized bed coolers in series;

a heat removal mechanism; and

a syngas outlet stream;

wherein at least a portion of the circulating heat transfer media transfers at least a portion of the heat from ~~up to 1600°C~~ the syngas inlet stream to the heat removal mechanism such that the temperature of the syngas outlet stream is at least 500°C cooler than the temperature of syngas inlet stream when operating at a syngas flow rate of approximately 90 m^3/s.

2. The syngas cooler system of Claim 1, wherein the temperature difference between the syngas inlet stream and the syngas outlet stream is ~~up~~ between 500°C to 1300°C.

3. The syngas cooler system of Claim 1, wherein the system operates up to approximately 1000 psi.

4. The syngas cooler system of Claim 1, wherein the circulating heat transfer media comprises solid particles having a mean particle size of between approximately 50 to 1000 μm.

5. The syngas cooler system of Claim 1, wherein the syngas superficial velocity is up to approximately 10 m/s.

6. The syngas cooler system of Claim 1, wherein the heat removal mechanism comprises heat transfer tubes.

7. The syngas cooler system of Claim 1, wherein the heat removal mechanism comprises heat transfer coils.

8. The syngas cooler system of Claim 1, wherein the heat removal mechanism generates steam.

9. The syngas cooler system of Claim 1, wherein the heat removal mechanism generates superheated steam.

10. The syngas cooler system of Claim 1, wherein circulating heat transfer media comprising an exiting mean particle size of 1000 μm or greater are removed from the system.

~~11. The syngas cooler system of Claim 10, wherein the exiting mean particle size is 1000 μm~~

11. The syngas cooler system of Claim 10, wherein at least a portion of the heat transfer media comprising an exiting mean particle size of 1000 μm or greater removed from the system is reduced in size, and at least a portion of the reduced sized heat transfer media returned to the system.

12. The syngas cooler system of Claim 11, ~~wherein the exiting mean particle size is 1000 μm; and~~

wherein the reduced sized heat transfer media has a mean particle size of approximately 200 to 400 μm.

13. ~~A circulating fluidized bed~~ The syngas cooler system of Claim 1, ~~comprising:~~

~~a syngas inlet stream;~~

~~circulating heat transfer media;~~

~~at least two fluidized bed coolers;~~

~~a heat removal mechanism; and~~

~~a syngas outlet stream;~~

~~wherein at least a portion of the circulating heat transfer media transfers at least a portion of the heat from up to 1600°C syngas inlet stream to the heat removal mechanism such that the~~

~~temperature of syngas outlet stream is at least 500°C and up to 1300°C cooler than the temperature of syngas inlet stream;~~

wherein the circulating heat transfer media comprises solids having a mean particle size of between approximately 50 to 1000 μm;

wherein at least a portion of the transfer media comprising a mean particle size of 1000 μm or greater is removed from the system; and

wherein a stream comprising oxygen, carbon dioxide and steam is injected into the syngas inlet stream to preferentially and partially oxidize tar components in the syngas.

14. ~~A multi-stage~~ The syngas cooler ~~for cooling high temperature syngas from a coal gasifier, the cooler~~ system of Claim 1 further comprising:

~~a dense fluid bed with imbedded cooling coils in communication with a hot syngas inlet stream;~~

a riser from which a portion of ~~a circulating bed of solids~~ heat transfer media enters the internally circulating fluidized bed coolers at different elevations and cooled ~~solids~~ heat transfer media flows back under gravity to the riser at a lower elevation and vent gas from the cooler flows to the riser at a higher elevation;

a cyclone to disengage syngas and ~~solids~~ heat transfer media with the cooler syngas ~~exiting the syngas cooler~~ outlet stream;

a downcomer to return cooler ~~solids~~ heat transfer media from the cyclone back to the riser; and

fluidizing gas to a lower portion of the downcomer and the dense fluid bed to segregate ~~solids~~ heat transfer media and facilitate removal of agglomerated ash.

15. The syngas cooler system of Claim 14, wherein the ~~hot~~ syngas ~~entering the cooler~~ inlet stream is cooled in successive steps as it flows through the riser ~~portion of the cooler~~.

16. The syngas cooler system of Claim 15, wherein ~~the syngas is initially cooled by contacting the solids~~ the heat removal mechanism comprises imbedded cooling coils in the dense fluid bed.

~~18. The syngas cooler of claim 17, wherein the cooled syngas is further cooled by contacting the circulating bed of solids at the bottom of the riser.~~

~~19. The syngas cooler of Claim 18, wherein the cooled syngas is further cooled by contacting cooler solids in the riser that return from fluid bed coolers in successive stages.~~

~~20. A multi-stage syngas cooler for cooling high temperature syngas from a coal gasifier, the cooler comprising:~~

~~a dense fluid bed with imbedded cooling coils in communication with an inlet hot syngas stream; and~~

~~multiple stages of internally circulating fluidized bed coolers in series.~~

17. The syngas cooler system of Claim ~~20~~ 1, wherein the syngas is successively cooled in different stages to temperatures appropriate for generating desired steam and hot boiler feedwater conditions with the heat removal mechanism comprising heat transfer surfaces imbedded in the ~~fluidized and~~ internally circulating fluidized bed coolers.

18. The syngas cooler system of Claim ~~20~~ 1 further comprising a riser where the syngas mixes and transfers heat energy to the circulating ~~bed of~~ heat transfer media comprising solids;

a disengagement section to disengage the syngas from the circulating ~~bed of~~ solids;

an annular space for circulating solids to flow down and transfer heat to the heat removal mechanism comprising imbedded heat transfer surfaces;

an aeration and seal mechanism to control the flow of circulating solids into the riser ~~section~~; and

a cone section that facilitates ~~internal~~ solids circulation and serves as a partition between ~~cooler~~ stages of the internally circulating fluidized bed coolers.

19. The syngas cooler system of Claim 18, wherein the cone section ~~comprising~~ comprises steam cooled coils with openings for a portion of syngas to pass through and provide aeration for solids in the annular space.

20. The syngas cooler system of Claim 18, wherein the syngas inlet stream ~~entering the cooler~~ is precooled and treated for fouling agents in an upstream stage, forming a hybrid cooler system with both external and internal circulation of solid particles.

21. The syngas cooler system of Claim 20, wherein the upstream stage comprises:

an eductor to inject relatively cooler solids from a last stage of the ~~multi-stage syngas~~ internally circulating fluidized bed coolers into a downflow cooler where the hot syngas inlet stream initially mixes with the injected relatively cooler solids;

a high pressure recycle syngas stream as the eductor motive fluid; and

a relatively cooler syngas exit stream from the downflow cooler comprising the syngas inlet stream that enters the multi-stage syngas cooler system for further cooling.

22. The syngas cooler system of Claim 20, wherein the upstream stage is a downflow cooler system that comprises:

a downflow conduit wherein the hot inlet syngas as it flows down mixes with cooler solids injected at different elevations;

a Presalter cyclone to disengage syngas from agglomerated solids;

a cooler with imbedded heat transfer surfaces to cool disengaged solids from the cyclone with the provision for withdrawal of agglomerated solids exceeding 1000 μm in size and the addition of make-up solids;

a lift conduit to lift cooled solids from the cooler with high pressure recycle syngas and inject into the downflow conduit at different elevations; and

a relatively cooler syngas exit stream from the cyclone comprising the syngas inlet stream that enters the multi-stage cooler system for further cooling.