

FORM 2

THE PATENTS ACT, 1970
(39 of 1970)
AND
THE PATENTS RULES, 2003

**COMPLETE
SPECIFICATION**

(See Section 10; rule 13)

TITLE OF THE INVENTION

**“APPARATUSES AND METHODS FOR CONTROLLING HEAT FOR RAPID
THERMAL PROCESSING”**

APPLICANT

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The following specification particularly describes
the invention and the manner in which
it is to be performed

CLAIMS

What is claimed is:

1. An apparatus (10) for controlling heat for rapid thermal processing of carbonaceous material, the apparatus (10) comprising:
 - 5 a reheater (14) configured to contain a fluidized bubbling bed that comprises an oxygen-containing gas (34), inorganic heat carrier particles, and char and to operate at combustion conditions effective to burn the char into ash and heat the inorganic heat carrier particles to form heated inorganic particles;
 - an inorganic particle cooler (15) in fluid communication with the reheater
10 (14) to receive a first portion (38) of the heated inorganic particles and configured to receive a cooling medium (52) for indirect heat exchange with the first portion (38) of the heated inorganic particles to form first partially-cooled heated inorganic particles (54), wherein the reheater (14) and the inorganic particle cooler (15) are cooperatively configured to combine the first partially-cooled heated inorganic
15 particles (54) with a second portion of the heated inorganic particles in the reheater (14) to form second partially-cooled heated inorganic particles; and
 - a reactor (12) in fluid communication with the reheater (14) to receive the second partially-cooled heated inorganic particles.
- 20 2. The apparatus (10) according to claim 1, wherein the cooling medium (52) comprises air and the inorganic particle cooler (15) is configured to indirectly exchange heat from the first portion (38) of the heated inorganic particles to the cooling medium (52) to form heated air, and wherein the apparatus (10) further
25 comprises a dryer (13) that is in fluid communication with the inorganic particle cooler (15) to receive the heated air, and wherein the dryer (13) is configured to receive the carbonaceous material and to remove water from the carbonaceous material with the heated air to form a water-depleted carbonaceous material, and wherein the reactor (12) is configured to receive the water-depleted carbonaceous material and to rapidly pyrolyze the water-depleted carbonaceous material with the
30 second partially-cooled heated inorganic particles.

3. An apparatus (10) for controlling heat for rapid thermal processing of carbonaceous material, the apparatus (10) comprising:

a reactor (12);

a reheater (14) in fluid communication with the reactor (12) to receive inorganic heat carrier particles and char, wherein the reheater (14) is configured to form a fluidized bubbling bed that comprises an oxygen-containing gas (34), the inorganic heat carrier particles, and the char and to operate at combustion conditions effective to burn the char into ash and heat the inorganic heat carrier particles to form heated inorganic particles; and

an inorganic particle cooler (15) in fluid communication with the reheater (14) and comprising a shell portion (44) and a tube portion (45) that is disposed in the shell portion (44), wherein the inorganic particle cooler (15) is configured such that the tube portion (45) receives a portion (38) of the heated inorganic particles and the shell portion (44) receives a cooling medium (52) for indirect heat exchange with the portion (38) of the heated inorganic particles to form partially-cooled heated inorganic particles (54) that are fluidly communicated to the reheater (14).

4. The apparatus (10) according to claim 3, wherein the tube portion (45) comprises a plurality of tubes (58) each having an outer surface and at least one cooling fin (60) that is disposed along the outer surface.

5. The apparatus (10) according to claim 3, wherein the tube portion (45) comprises a plurality of juxtaposed tubes (60) that are spaced apart and longitudinally disposed substantially parallel to a vertical axis.

6. The apparatus (10) according to claim 3, wherein the inorganic particle cooler (15) comprises:

an exchanger vessel (42) comprising the shell and tube portions (44, 45);

a lift riser (76) disposed downstream from the exchanger vessel (42); and

a sand-air distributor (84) disposed within the reheater (14) downstream from the lift riser (76), and wherein the lift riser (76) is configured to receive and

fluidly communicate the partially-cooled heated inorganic particles (54) to the sand-air distributor (84) and the sand-air distributor (84) is configured to distribute the partially-cooled heated inorganic particles (54) in the reheater (14).

5 7. The apparatus (10) according to claim 6, wherein the lift riser (76) has a lower portion (78) extending to an upper portion (82), the lower portion (78) is configured to receive the partially-cooled heated inorganic particles (54) and the upper portion (82) is fluidly coupled to the sand-air distributor (84), and wherein
10 the lift riser (76) comprises an air nozzle (80) that is positioned in the lower portion (78) and that is configured to direct the partially-cooled heated inorganic particles (54) through the lift riser (76) from the lower portion (78) to the upper portion (82) for introduction to the sand-air distributor (84).

15 8. The apparatus (10) according to claim 6, wherein the reheater (14) has a lower section (36) for containing the fluidized bubbling bed and comprises a gas distributor (86) that is disposed in the lower section (36) and that is configured to fluidly communicate the oxygen-containing gas (34) to the fluidized bubbling bed, and wherein the sand-air distributor (84) is disposed above the gas distributor (86).

20 9. The apparatus (10) according to claim 6, wherein the inorganic particle cooler (15) further comprises at least one bubble breaking grating (39) that is disposed upstream from the tube portion (45).

25 10. A method for controlling heat for rapid thermal processing of carbonaceous material, the method comprising the steps of:

 combining an oxygen-containing gas (34), inorganic heat carrier particles, and char at combustion conditions effective to burn the char into ash and heat the inorganic heat carrier particles to form heated inorganic particles;

30 indirectly exchanging heat from a first portion (38) of the heated inorganic particles to a cooling medium (52) to form first partially-cooled heated inorganic particles (54); and

combining the first partially-cooled heated inorganic particles (54) with a second portion of the heated inorganic particles to form second partially-cooled heated inorganic particles.

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